Methodologies in the Scope of streamSAVE+ Priority Actions

Annex IV of Deliverable D2.1

Version N°1

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Content

1. Introduction

For the methodologies falling under the scope of 5 PAs to be developed, the bottom-up calculation methodologies already available within the Member States are summarized in this Annex. A template has been designed to collect the data in a uniform format, including the following elements:

- Description of the action.
- Formula and standardized calculation values for final energy savings
- Formula and standardized calculation values for primary energy savings
- Formula and standardized calculation values for greenhouse gas savings
- Overview of costs related to the action
- Methodological aspects

The information presented in this report is based on a comprehensive review conducted by all partners, covering all identified bottom-up methodology catalogues in Member States and insights from recent project reports. The data was gathered from the following sources:

- Existing catalogues within Member States, serving as the primary source of information.
- Existing methodologies for savings calculation and energy consumption reduction developed by previous projects, such as multEE and EMEEES, as well as other relevant initiatives, scientific literature, grey reports, and guidance materials on bottom-up methodologies for energy savings assessment.

The chapters are organized by the 5 Priority Actions (PA), such as:

- Deep renovations in buildings
- IT equipment in data centres
- Cooling in data centres
- Heat recovery in ventilation
- Public traffic management

To distinguish between the different methodologies, the heading titles of the chapters and sub-chapters provide information about the methodology and from which Member State it was collected.

2. Deep Renovations in Buildings

2.1. Major renovations of residential buildings - Austria

An existing building is renovated to a better thermal standard through various structural measures (e.g. facade thermal insulation, window replacement). After the renovation, the building falls below the energy performance indicator requirements for major renovations according to OIB guideline 6.

2.1.1 Calculation of Final Energy Savings

Formula

This formula calculates yearly savings.

$$FES = n \times GFA \times \left(\left(HD_{Ref} + HWHD \right) \times EC_{Ref} - \left(HD_{Eff} + HWHD \right) \times EC_{Eff} \right) \times rb \times so \times fr \qquad (1)$$

Rebound (rb), spill-over (so) and free-rider (fr) effects are not taken into account in the formula.

Table 1 – Parameters used in the formula for mayor renovations of residential buildings

Parameter	Description
FES	Final energy savings [kWh/a]
n	Number of single-family houses or number of residential units [-]
GFA	Heated gross floor area per utilisation unit [m²]
HD_{Ref}	Area-specific heating demand of unrenovated building with reference climate [kWh/m²a] corresponds to the HDRK figure from the energy certificate before the renovation was carried out
HD_{Eff}	Area-specific heating demand of renovated building with reference climate [kWh/m²a], corresponds to the HDRK figure from the energy certificate after the renovation was carried out
HWHD	Area-specific hot water heat demand [kWh/m²a]
EC_{Ref}	Effort coefficient of the heating system in the unrenovated building [-]
EC_{Eff}	Effort coefficient of the heating system in the renovated building [-]

Standardized Calculation Values

There is no standard value for the number of residential units and the heating demand of new buildings.

The following reference values distinguish between the following building types:

- SFH: single-family house
- MFH: multi-family house, large-volume residential building

Table 2 – Major renovation of residential buildings - general parameters

Parameter	Value	Unit
Lifetime	30	Years

Table 3 – Major renovation of residential buildings – building- and heating system parameters

Parameter	SFH	MFH	Unit
GFA	175	89	m²
HD_{Ref}	158,9	98,7	kWh/m²a
HD_{Eff}	56	40,7	kWh/m²a
HWHD	7,7	10,2	kWh/m²a
EC_{Ref}	1,66	1,70	-

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EC_{Eff}	2,11	2,42	-
rb	1	1	-
so	1	1	-
fr	1	1	-

2.1.2 Calculation of Primary Energy Savings

There is no information regarding primary energy savings calculations available.

Formula

No formula available for this methodology.

Standardized Calculation Values

No calculation values available for this methodology.

2.1.3 Calculation of Greenhouse Gas Savings

There is no information regarding the greenhouse gas savings calculations available.

Formula

No formula available for this methodology.

Standardized Calculation Values

No calculation values available for this methodology.

2.1.4 Overview of Costs Related to the Action

No information on cost-effectiveness available for this methodology.

Cost-Effectiveness

No formula available for this methodology.

Standardized Values

No calculation values available for this methodology.

2.1.5 Methodological Aspects

The methodology and formulas have been taken from an officially published legal document – it is a regulation of the Federal Minister for Climate Action, Environment, Energy, Mobility, Innovation and Technology on specifying the assessment and eligibility of energy efficiency measures. The initial language of the document is German.

The original document is available under:
https://www.ris.bka.gv.at/eli/bgbl/II/2024/28

2.1.6 Bibliography

Verordnung der Bundesministerin für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie: Konkretisierung der Bewertung und Anrechenbarkeit von Energieeffizienzmaßnahmen (Energieeffizienz-Maßnahmenverordnung – EEff-MV), BGBl. II Nr. 28/2024 (2024). https://www.ris.bka.gv.at/eli/bgbl/II/2024/28

2.2. Retrofitting of single building components in residential buildings – Austria

The thermal standard of a residential building is improved by individual structural measures (e.g. facade renovation).

2.2.1 Calculation of Final Energy Savings

Formula

This formula calculates yearly savings.

$$FES = n \times A_{comp} \times (U_{Ref} - U_{Eff}) \times HD_{RC} \times f_{conv} \times EC_{Ref} \times rb \times so \times fr \qquad (2)$$

Rebound (rb), spill-over (so) and free-rider (fr) effects are not taken into account in the formula.

Table 4 – Parameters used in the formula for renovations of individual building components in - residential buildings

Parameter	Description
FES	Final energy savings [kWh/a]
n	Number of building components [-]
A_{comp}	Average area of an improved building component [m²]
U_{Ref}	Heat transfer coefficient of the unrenovated building component [W/m²K]
U_{Eff}	Heat transfer coefficient of the renovated component [W/m²K]
HD_{RC}	Heating days of the reference climate [Kd/a]
f_{conv}	Factor for converting units to kilowatt hours [kh/d]
EC_{Ref}	Effort coefficient of the heating system in the unrenovated building [-]

Standardized Calculation Values

The standard values are distinguished between the following use cases:

Building type:

- Single-family house (SFH)
- Multi-family house (MFH)

Building component:

- Exterior wall
- Cellar ceiling
- Top storey ceiling
- Roof surface
- Windows
- Exterior doors

Table 5 – Major renovation of residential buildings: building- and heating system parameters

Parameter	Value	Unit
Lifetime	30	Years
A_{comp}	Real Value	m²
HD_{RC}	3.400	Kd/a
f_{conv}	0,024	Kh/d
U_{Ref}		
Exterior wall	0,90	W/m²K
Cellar ceiling	0,73	W/m²K
Top storey ceiling	0,52	W/m²K
Roof surface	0,55	W/m²K
Windows	2,52	W/m²K
Exterior doors	2,42	W/m²K

U_{Eff}		
Exterior wall	0,27	W/m²K
Cellar ceiling	0,30	W/m²K
Top storey ceiling	0,15	W/m²K
Roof surface	0,15	W/m²K
Windows	1,06	W/m²K
Exterior doors	1,29	W/m²K
EC_{Ref}		
Single-family house (SFH)	1,66	-
Multi-family house (MFH)	1,70	-
rb	1	-
so	1	-
fr	1	-

2.2.2 Calculation of Primary Energy Savings

There is no information regarding primary energy savings calculations available.

Formula

No formula available for this methodology.

Standardized Calculation Values

No calculation values available for this methodology.

2.2.3 Calculation of Greenhouse Gas Savings

There is no information regarding the greenhouse gas savings calculations available.

Formula

No formula available for this methodology.

Standardized Calculation Values

No calculation values available for this methodology

2.2.4 Overview of Costs Related to the Action

No information on cost-effectiveness available for this methodology.

Cost-Effectiveness

No formula available for this methodology.

Standardized Values

No calculation values available for this methodology

2.2.5 Methodological Aspects

The methodology and formulas have been taken from an officially published legal document – it is a regulation of the Federal Minister for Climate Action, Environment, Energy, Mobility, Innovation and Technology on specifying the assessment and eligibility of energy efficiency measures. The initial language of the document is German.

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2.2.6 Bibliography

Verordnung der Bundesministerin für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie: Konkretisierung der Bewertung und Anrechenbarkeit von Energieeffizienzmaßnahmen (Energieeffizienz-Maßnahmenverordnung – EEff-MV), BGBl. II Nr. 28/2024 (2024). https://www.ris.bka.gv.at/eli/bgbl/II/2024/28

2.3. Major renovations of non-residential buildings - Austria

An existing non-residential building is renovated to a better thermal standard through various structural measures (e.g. facade thermal insulation, window replacement). After the renovation, the building falls below the energy performance indicator requirements for major renovation according to OIB Guideline 6. The heating system is not changed during the renovation.

2.3.1 Calculation of Final Energy Savings

Formula

This formula calculates yearly savings.

$$FES = n \times GFA \times ((HD_{Ref} + HWHD) \times EC_{Ref} - \left(HD_{Eff} + HWHD\right) \times EC_{Eff}) \times rb \times so \times fr \qquad (3)$$

Rebound (rb), spill-over (so) and free-rider (fr) effects are not taken into account in the formula.

Table 6 – Parameters used in the formula for mayor renovations of non-residential buildings

Parameter	Description
FES	Final energy savings [kWh/a]
n	Number of non-residential buildings [-]
GFA	Heated gross floor area per utilisation unit [m²]
HD_{Ref}	Area-specific heating demand of unrenovated building with reference climate [kWh/m²a] corresponds to the HDRK figure from the energy certificate before the renovation was carried out
HD_{Eff}	Area-specific heating demand of renovated building with reference climate [kWh/m²a], corresponds to the HDRK figure from the energy certificate after the renovation was carried out
HWHD	Area-specific hot water heat demand [kWh/m²a]
EC_{Ref}	Effort coefficient of the heating system in the unrenovated building [-]
EC_{Eff}	Effort coefficient of the heating system in the renovated building [-]

Standardized Calculation Values

Table 7 – Indicative values for major renovation of non-residential buildings

Parameter	Value	Unit
Lifetime	30	Years
GFA	Real value	m²
HD_{Ref}	Real value	kWh/m²a
HD_{Eff}	Real value	kWh/m²a
HWHD	Real value	kWh/m²a
EC_{Ref}	Real value	-
EC_{Eff}	Real value	-
rb	1	-
so	1	-

fr	1	-

2.3.2 Calculation of Primary Energy Savings

There is no information regarding primary energy savings calculations available.

Formula

No formula available for this methodology.

Standardized Calculation Values

No calculation values available for this methodology.

2.3.3 Calculation of Greenhouse Gas Savings

There is no information regarding the greenhouse gas savings calculations available.

Formula

No formula available for this methodology.

Standardized Calculation Values

No calculation values available for this methodology

2.3.4 Overview of Costs Related to the Action

No information on cost-effectiveness available for this methodology.

Cost-Effectiveness

No formula available for this methodology.

Standardized Values

No calculation values available for this methodology.

2.3.5 Methodological Aspects

The methodology and formulas have been taken from an officially published legal document – it is a regulation of the Federal Minister for Climate Action, Environment, Energy, Mobility, Innovation and Technology on specifying the assessment and eligibility of energy efficiency measures. The initial language of the document is German.

The original document is available under:
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2.3.6 Bibliography

Verordnung der Bundesministerin für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie: Konkretisierung der Bewertung und Anrechenbarkeit von Energieeffizienzmaßnahmen (Energieeffizienz-Maßnahmenverordnung – EEff-MV), BGBl. II Nr. 28/2024 (2024). https://www.ris.bka.gv.at/eli/bgbl/II/2024/28

2.4. Retrofitting of single building components in non-residential buildings - Austria

The thermal standard of a building is improved by individual structural measures (e.g. facade renovation).

2.4.1 Calculation of Final Energy Savings

Formula

This formula calculates yearly savings.

$$FES = n \times A_{comp} \times (U_{Ref} - U_{Eff}) \times HD_{RC} \times f_{conv} \times EC_{Ref} \times rb \times so \times fr \quad (4)$$

Rebound (rb), spill-over (so) and free-rider (fr) effects are not taken into account in the formula.

Table 8 – Parameters used in the formula for renovations of individual building components in non-residential buildings

Parameter	Description
FES	Final energy savings [kWh/a]
n	Number of building components [-]
A_{comp}	Average area of an improved building component [m²]
U_{Ref}	Heat transfer coefficient of the unrenovated building component [W/m²K]
U_{Eff}	Heat transfer coefficient of the renovated component [W/m²K]
HD_{RC}	Heating days of the reference climate [Kd/a]
f_{conv}	Factor for converting units to kilowatt hours [kh/d]
EC_{Ref}	Effort coefficient of the heating system in the unrenovated building [-]

Standardized Calculation Values

The standard values are distinguished between the following use cases:

- Exterior wall
- Cellar ceiling
- Top storey ceiling
- Roof surface
- Windows
- Exterior doors

Table 9 – Major renovation of non-residential buildings: building- and heating system parameters

Parameter	Value	Unit
Lifetime	30	Years
A_{comp}	Real value	m²
HD_{RC}	3.400	Kd/a
f_{conv}	0,024	Kh/d
U_{Ref}		
Exterior wall	0,90	W/m²K
Cellar ceiling	0,73	W/m²K
Top storey ceiling	0,52	W/m²K
Roof surface	0,55	W/m²K
Windows	2,52	W/m²K
Exterior doors	2,42	W/m²K
U_{Eff}		
Exterior wall	0,27	W/m²K
Cellar ceiling	0,30	W/m²K
Top storey ceiling	0,15	W/m²K
Roof surface	0,15	W/m²K
Windows	1,06	W/m²K
Exterior doors	1,29	W/m²K
EC_{Ref}	Real value	-
rb	1	-
so	1	-

fr	1	-

2.4.2 Calculation of Primary Energy Savings

There is no information regarding primary energy savings calculations available.

Formula

No formula available for this methodology.

Standardized Calculation Values

No calculation values available for this methodology.

2.4.3 Calculation of Greenhouse Gas Savings

There is no information regarding the greenhouse gas savings calculations available.

Formula

No formula available for this methodology.

2.4.4 Standardized Calculation Values

No calculation values available for this methodology.

2.4.5 Overview of Costs Related to the Action

No information on cost-effectiveness available for this methodology.

Cost-Effectiveness

No formula available for this methodology.

Standardized Values

No calculation values available for this methodology

2.4.6 Methodological Aspects

The methodology and formulas have been taken from an officially published legal document – it is a regulation of the Federal Minister for Climate Action, Environment, Energy, Mobility, Innovation and Technology on specifying the assessment and eligibility of energy efficiency measures. The initial language of the document is German.

The original document is available under:
https://www.ris.bka.gv.at/eli/bgbl/II/2024/28

2.4.7 Bibliography

Verordnung der Bundesministerin für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie: Konkretisierung der Bewertung und Anrechenbarkeit von Energieeffizienzmaßnahmen (Energieeffizienz-Maßnahmenverordnung – EEff-MV), BGBl. II Nr. 28/2024 (2024). https://www.ris.bka.gv.at/eli/bgbl/II/2024/28

2.5. Integral renovation of existing residential buildings and buildings of the service sector – Croatia

Integrated building renovation refers to projects that simultaneously improve the building envelope and the heating system.

The unit energy savings in final consumption are calculated as the difference between the ratio of the specific heat demand of the buildings and the efficiency of the heating system 'before' and 'after' the implementation of the EE measures. The 'before' situation is given by the parameters of each building (e.g. from energy performance certificate of design documentation) or reference values can be used depending on the period of construction of the building and the requirements of the regulations at that time. The values of the specific heat demand of the buildings should be corrected according to the heating degree day.

The total annual energy savings in final consumption for a building are determined by multiplying the unit energy savings by the building area.

Application area: The method is applied for existing residential and non-residential buildings, for projects where both EE measures on building envelope and building technical systems has been applied. It can be also used for projects where only actions on building envelope were undertaken and the system efficiency remained the same.

Boundary conditions: The method is used for residential buildings and non-residential buildings from service sector.

2.5.1 Calculation of Final Energy Savings

Formula

This formula calculates cumulative savings:

$$TFES = \left(\sum_{i=1}^{N} UFES_i\right) \times A_i \times rb \times so \times fr \times lt \qquad (5)$$

Unit annual savings are calculated using this formula:

$$UFES = \frac{SHD_{init}}{\eta_{init}} - \frac{SHD_{new}}{\eta_{new}}$$

Table 10 – Parameters used in the formula for final energy savings

Parameter	Description
TFES	Total final energy savings [kWh/a]
UFES	Unit annual final energy savings [kWh/a]
A_i	Total useful area of a building [m^2]
rb	Factor to calculate a rebound effect (=1)
so	Factor to calculate a spill-over effect (=1)
fr	Factor to calculate a free-rider effect (=1)
lt	Factor for the lifetime of savings [a]
SHD_{init}	Specific annual heat demand for heating a building before implementing the EE measure [kWh/m^2]
SHD_{new}	Specific annual heat demand for heating a building after implementing the EE measure [kWh/m^2]
η_{init}	Efficiency of the old heating system before the implementation of the EE measure [-]
η_{new}	Efficiency of the old heating system after the implementation of the EE measure [-]

Standardized Calculation Values

In the absence of project-specific data, indicative values should be used for SHD and η. Data on the total useful area of a building must be real data.

Table 11 – Indicative values for calculation of final energy savings

Parameter	Value	Unit
rb	1	-

so	1	-
fr	1	-
lt	16,247	a

Period of construction and climate zone	Building type	Continental area			Coastal area		
		until 1970	1970-2005	after 2006	until 1970	1970-2005	after 2006.
		kWh/m²					
SHD_{init}	Family house	220	160	80	130	90	60
	Multi-apartment building	150	110	80	100	90	50
	Office building	150	110	60	90	70	40
	Educational building	140	120	60	80	70	40
	Hotels and restaurants	140	130	75	90	80	50
	Hospitals	180	140	70	100	80	65
	Sports halls	210	180	110	130	110	80
	Shopping	150	90	70	80	60	40
	Other	200	140	60	120	80	50
SHD_{new}	Family house	75			58		
	Multi-apartment building	75			46		
	Office building	52			38		
	Educational building	47			32		
	Hotels and restaurants	70			33		
	Hospitals	54			60		
	Sports halls	90			59		
	Shopping	60			36		
	Other	50			46		

Part of heating system	Efficiency before – η_{init}	Efficiency (market) – $\eta_{average}$	Minimal efficiency of new equipment – η_{new}
Heat production (boiler) - η_{boiler}	0,840	0,900	0,940
Heat distribution - η_{dis}	0,930	0,950	0,970
Heat emission - η_{em}	0,780	0,830	0,930

The sources for all standardized values are listed in the Rulebook on the System for Monitoring, Measurement, and Verification of Energy Savings (Annex B. table 1 and 2). They are determined based on cost-optimal calculations for reference buildings, in line with EPBD.

2.5.2 Calculation of Primary Energy Savings

Formula

The following formula is used to calculate the annual primary energy savings:

$$\text{APES} = \frac{TFES}{lt} \times PEF_{fuel} \qquad (6)$$

Table 12 – Parameters used in the formula for primary energy savings

Parameter	Description
APES	Annual primary energy savings [kWh/a]
TFES	Total final energy savings [kWh/a]
PEF_{fuel}	Primary Energy Factor for fuel used for heating [dmnl]
lt	Factor for the lifetime of savings [a]

The above formula is valid if there was no change in fuels for heating. If there was a fuel swich, than the primary energy consumption before and after is calculated using SHD, η and PEF values, and the difference represents the primary energy savings.

If multiple fuels are used for heating, it is necessary to determine the primary energy factor according to the share of each fuel in the production of heat.

If data on the fuel used is not known, it is necessary to use the emission factor for natural gas.

Standardized Calculation Values

Primary energy factors (and emission factors) are published in the *Rulebook on the System for Monitoring, Measurement, and Verification of Energy Savings* (Annex I, table 2. The use of these published factors is considered common practice in the country. This means that the factors, once published, are widely accepted and applied in relevant energy saving programs, ensuring consistency and adherence to the established legal framework for monitoring and verifying energy savings.

Table 13 – Indicative values for calculation of primary energy savings

Fuel /energy carrier	Primary energy factor				Emission fator
	Total	Renewable component	Non-renewable component	Import component	tCO_2/GWh $kgCO_2$/MWh
Hard coal	**1,033**	0,00002	1,033	0,00001	349,44
Brown coal	**1,050**	0,00003	1,050	0,00002	359,35
Lignite	**1,081**	0,00004	1,081	0,00003	385,17
Fuel wood	**1,106**	1,0001	0,106	0,00004	28,09
Wood briquettes	**1,183**	1,0528	0,099	0,0307	27,84
Biomass pellets	**1,173**	1,0488	0,096	0,0284	26,80
Biomass chips	**1,183**	1,0363	0,126	0,0211	34,45
Charcoal	**1,171**	1,1301	0,041	0,0000	11,00
Solar energy	**1,000**	1,0000	0,000	0,0000	0,00
Energy from environment	**1,000**	1,0000	0,000	0,0000	0,00
Natural gas	**1,059**	0,001	1,057	0,001	213,64
LPG	**1,128**	0,002	1,124	0,001	255,19
Gasoline	**1,130**	0,002	1,126	0,001	280,09
Petroleum	**1,021**	0,00001	1,021	0,00001	264,31
Jet fuel	**1,151**	0,003	1,147	0,002	295,13
Diesel	**1,057**	0,001	1,056	0,000	281,39
Extra light fuel oil	**1,137**	0,003	1,133	0,001	300,36

Fuel oil	**1,113**	0,002	1,110	0,001	307,41
Electricity	**1,498**	0,610	0,532	0,356	158,57
District heating	**1,571**	0,291	1,265	0,014	275,30

2.5.3 Calculation of Greenhouse Gas Savings

Formula

If available, please include information regarding the greenhouse gas savings calculations.

Bellow you can find an example.

$$GHGSAV = \frac{TFES}{lt} \times f_{GHG,fuel} \times 10^{-6} \qquad (7)$$

Table 14 – Parameters used in the formula for greenhouse gas savings

Parameter	Description
GHGSAV	Greenhouse gas savings [t CO_2 p.a.]
TFES	Total final energy savings [kWh/a]
$f_{GHG,fuel}$	Emission factor for fuel used for heating [g CO_2/kWh]
lt	Factor for the lifetime of savings [a]

Standardized Calculation Values

Standardised calculation values are given in Table 13.

2.5.4 Overview of Costs Related to the Action

No information on cost-effectiveness available for this methodology.

2.5.5 Methodological Aspects

The calculation of savings is based on the difference of a building's performance (specific heating demand end efficiency of the heating system) before and after the implementation of the EE measures.

The methodology for calculating savings is published as part of the *Rulebook on system for monitoring, measurement and verification of energy savings* and it is officially published legal document. Using of this published methodology is common practice in Croatia.

Standardized calculation values for SHD and η are only to be used if actual data for relevant project documentation is not available.

The language of the methodology is Croatian.

2.5.6 Bibliography

Ministry of Economy and Sustainable Development (2021), *Rulebook on system for monitoring, measurement and verification of energy savings*, NN 98/2021, https://narodne-novine.nn.hr/clanci/sluzbeni/2021_09_98_1772.html

Ministry of Economy and Sustainable Development (2022), *Regulation on Amendments and Supplements to the Rulebook on system for monitoring, measurement and verification of energy savings*, NN 30/2022, https://narodne-novine.nn.hr/clanci/sluzbeni/2022_03_30_370.html

2.6. Energy upgrade of the building envelope in buildings of the residential and tertiary sectors – Cyprus

This calculation methodology aims at improving the thermal energy supply as well as the reduction in space heating & cooling demand. It applies to specific interventions (technical measures) for the building envelope of the residential and tertiary sectors.

2.6.1 Calculation of Final Energy Savings

Formula

BU equation

$$\mathrm{TFES} = \sum^{n_{\mathrm{renov\_building}}} A_{\mathrm{heated\_area}} * (\mathrm{EPC}_{\mathrm{before\_energy\_cert}} - \mathrm{EPC}_{\mathrm{after\_energy\_cert}})$$

Table 15 – Parameters used in the formula for final energy savings

Parameter	Description
TFES	Total final energy savings [kWh/a]
A_{heated_area}	Heated surface area of each renovated building [m^2]
$EPC_{before\_energy\_cert}$	Final energy consumption (based on EPC) prior to energy efficiency interventions [kWh/m^2]
$EPC_{after\_energy\_cert}$	Final energy consumption (based on EPC) after the energy efficiency interventions [kWh/m^2]
$n_{renov\_building}$	Number of renovated buildings

Standardized Calculation Values

Each obligated party must define the following parameters: A_{heated_area}, $EPC_{before\_energy\_cert}$, $EPC_{after\_energy\_cert}$ for each of the renovated building separately based on the issued Energy Performance Certificates.

2.6.2 Calculation of Primary Energy Savings

No information is provided

2.6.3 Calculation of Greenhouse Gas Savings

No information is provided

2.6.4 Overview of Costs Related to the Action

No information is provided

2.6.5 Methodological Aspects

Bottom-up equation incorporated into the official adopted catalogue with BU-methodologies through the Decree 212/2024 within the framework of the EEOs:

https://www.energy.gov.cy/assets/modules/wnp/articles/202304/192/editor/kdp2122024.pdf

The adopted catalogue with BU-methodologies has been drafted in Greek language.

2.6.6 Bibliography

https://www.energy.gov.cy/assets/modules/wnp/articles/202304/192/editor/kdp2122024.pdf

2.7. Insulation measures applied to structural elements (roofs) of existing residential & tertiary sector buildings – Cyprus

This calculation methodology aims at calculating the final energy savings from the insulation of the structural elements for existing buildings of residential and tertiary sector.

2.7.1 Calculation of Final Energy Savings

Formula

BU equation

$$\mathrm{TFES} = \left(\frac{\left(U_{\text{value\_init\_roof}} - U_{\text{value\_new\_roof}}\right) * HDD * 24 * a_h * \frac{1}{b_h} * c_h}{1000} + \frac{\left(U_{\text{value\_init\_roof}} - U_{\text{value\_new\_roof}}\right) * CDD * 24 * a_c * \frac{1}{b_c} * c_c}{1000} \right) * A$$

Table 3 – Parameters used in the formula for final energy savings

Parameter	Description
TFES	Total final energy savings per year [kWh/a]
A	Heated surface area of roof for each of the renovated building [m^2]
HDD	Heating degree days [k.day/year]
CDD	Cooling degree days [k.day/year]
$U_{value\_init\_roof}$	Coefficient of roof thermal transmittance prior to energy efficiency interventions [W/m^{2}K]
$U_{value\_new\_roof}$	Coefficient of roof thermal transmittance after the energy efficiency interventions [W/m2K]]
a_h	Correction factor depending upon the building climatic zone for space heating purposes
b_h	Correction factor depending upon the performance of heating system and of available fuel
c_h	Operating intermittently coefficient depending upon the non-continuous operation of the heating system
a_c	Correction factor depending upon the building climatic zone for space cooling purposes
b_c	Correction factor depending upon the performance of cooling system
c_c	Operating intermittently coefficient depending upon the non-continuous operation of the cooling system

Note: The same equation can also be used for insulating buildings' external walls and windows.

Standardized Calculation Values

For space heating	
a_h	1
b_h	For heating resistance is 0.95 and for fossil fuel boiler is 0.6
c_h	0.5
For space cooling	
a_c	1
b_c	2.5
c_c	0.58

2.7.2 Calculation of Primary Energy Savings

No information is provided

2.7.3 Calculation of Greenhouse Gas Savings

No information is provided

2.7.4 Overview of Costs Related to the Action

No information is provided

2.7.5 Methodological Aspects

Bottom-up equation incorporated into the official adopted catalogue with BU-methodologies through the Decree 212/2024 within the framework of the EEOs:

https://www.energy.gov.cy/assets/modules/wnp/articles/202304/192/editor/kdp2122024.pdf

The adopted catalogue with BU-methodologies has been drafted in Greek language.

2.7.6 Bibliography

https://www.energy.gov.cy/assets/modules/wnp/articles/202304/192/editor/kdp2122024.pdf

2.8. Methodology used to calculate savings from deep renovation measures & implementation of specific energy efficiency measures in public sector buildings – Cyprus

This calculation methodology aims at calculating the final energy savings from deep renovation measures as well as the implementation of specific measures in the public sector buildings.

2.8.1 Calculation of Final Energy Savings

Formula

$$\mathrm{TFES} = \left(\mathrm{P}_{\mathrm{aver}_{\mathrm{con}_\mathrm{b}}} - \mathrm{P}_{\mathrm{ver}_{\mathrm{con}_\mathrm{a}}}\right) * A$$

Table 4 – Parameters used in the formula for final energy savings

Parameter	Description
TFES	Final energy savings per year [kWh]
$P_{\text{aver\_con\_b}}$	Final energy consumption of public building (offices, hospital, education institutions) prior to energy efficiency interventions [kWh/m^2/yr]
$P_{\text{aver\_con\_a}}$	Final energy consumption of public building (offices, hospital, education institutions) after the energy efficiency interventions [kWh/m^2/yr]
A	Total heated surface area of the public building (m^2)

Standardized Calculation Values

No information is provided

2.8.2 Calculation of Primary Energy Savings

No information is provided

2.8.3 Calculation of Greenhouse Gas Savings

No information is provided

2.8.4 Overview of Costs Related to the Action

No information is provided

2.8.5 Methodological Aspects

Bottom-up equation incorporated into the official adopted catalogue with BU-methodologies through the Decree 212/2024 within the framework of the EEOs:

https://www.energy.gov.cy/assets/modules/wnp/articles/202304/192/editor/kdp2122024.pdf

The adopted catalogue with BU-methodologies has been drafted in Greek language.

2.8.6 Bibliography

https://www.energy.gov.cy/assets/modules/wnp/articles/202304/192/editor/kdp2122024.pdf

2.9. Energy assessment (according to legislature) - deep renovations in residential and non-residential buildings – Czech Republic

The Czech Republic does not have a dedicated methodology or catalogue only for deep renovations. The Czech Republic has a summary document "Methodology for reporting energy savings from alternative policy measure pursuant to Article 7(9) of the Energy Efficiency Directive (2012/27/EU) [Update 2020]" issued by the Czech Ministry of Industry and Trade. The document provides an overview of methodologies and approaches for reporting energy savings for different types and categories of measures.

It includes a list of policy measures (in particular grant programmes on which the Czech Republic relies most extensively), showing the method of calculating savings, the lifetime of savings and the savings reporting tool.

The savings reporting tools include 5 main categories:

1. Building Energy Performance Certificate
2. Energy Assessment
3. Energy audit
4. Energy service contract with guarantee
5. Other - independent body reports (for transport) and other expert assessments

Individual support programmes provide further details, but the principle is more or less the same in all cases and depends mainly on the above-mentioned tools.

Anyway, the first 4 categories are mainly governed by legislation and technical standards (mostly harmonised standards). The overarching legal document is Law Act No 406/2000 on energy management (but this one only gives general requirements), which is followed by a number of decrees that already introduce specific procedures, calculations and methods, or specify which technical standards are to be used. Energy performance certificates are governed by Decree 264/2020 on the energy performance of buildings, Energy assessments are governed by Decree No. 141/2021 Coll. on energy assessment and on data recorded in the Energy Consumption Monitoring System and Energy audits are anchored in Decree No. 140/2021 Coll. on energy audit.

These regulations form the basic framework for calculating the energy performance of a building, the energy management of an organisation or an energy saving measure. However, none of the above tools or legislation specify deep renovations. This is due to the absence of a definition of deep renovation in the Czech Republic (the definition was missing also at EU level). And the latest Directive (EU) 2024/1275 of 24 April 2024 on the energy performance of buildings (recast), which has already defined deep renovations, has not yet been transposed into Czech legislation.

Some guidance for deep renovation has been provided, for example, by a study by BPIE, which looked at the definition and identified deep renovation as a state where baseline energy consumption is reduced by at least 60% or a certain, relatively low, level of consumption is achieved.

Thus, the definition of deep renovation tended to be determined by individual subsidy programmes, if it was defined at all. For example, the OP TAK (Operational Programme “Competitiveness Technologies and Applications 2021-2027”) in the second call for energy savings set as deep renovation a condition (respectively there are two levels of renovation and the second one is more stringent and complex and therefore could be considered as a "deep" renovation), when the energy consumption from non-renewable energy sources in the building after renovation will be lower than 80 kWh/m_2*year and at the same time the total primary energy consumption or emissions have been reduced by 30% plus meeting other conditions. The Operational Programme Environment (OPE), on the other hand, set a 40% reduction in non-renewable energy and other conditions to be met (again, it has two levels of renovation, and this is the more stringent one). Therefore, determining when renovations are deep renovation is not quite easy in the Czech Republic.

Application area:

All end-use sectors

Buildings, both residential and non-residential

Scope - Depending on the required document for determining the energy performance of the building before and after the renovation, the scope of the building performance assessment is determined. The thermal performance of the building envelope and the technical systems of the building, excluding appliances, are always assessed. In the case of an energy audit, the building's appliances and other technologies (not relevant to the technical systems of the building, i. e. manufacturing lines) are also assessed. An energy audit can also assess buildings that are not legally subject to a conventional energy performance assessment (i.e. buildings without a regulated indoor environment).

Final energy, Primary energy from non-renewable energy sources and newly total primary energy are addressed.

Boundary conditions:

System boundary of the building

2.9.1 Calculation of Final Energy Savings

The calculation of energy performance shall follow the procedures and technical standards set out in the legislation. The main technical standards used for the calculation of energy performance is ISO 52016-1 Energy performance of buildings, EN 15316-1 energy performance of buildings and related standards in the series.

The calculation procedure for the energy performance certificate of a building is based on a theoretical calculation, under standardised conditions and the calculation is often ex-ante. It is therefore not presented in detail here.

In the case of energy assessments, audits and Energy service contracts with guarantees, the measured energy consumption of the current state is used and the day-rate method can be applied to obtain a standardised state. The energy consumption after renovation is calculated according to the procedures of the above-mentioned standards. At the same time, in the case of the use of subsidies from support programmes, the achievement of the target state shall be verified periodically during the sustainability of the project on the basis of actual consumption.

Formula

The formula below reflects the general procedure for determining renovation savings.

This formula calculates first-year (annual) energy savings.

$$TFES = (FEC_{before} - FEC_{after}) \times rb \times so \times fr \times lt = (\sum_{i=1}^{n} E_{i,before} - \sum_{i=1}^{n} E_{i,after}) \times rb \times so \times fr \times lt \quad (8)$$

(This is not an official formula, but just a formula derived from commonly used principles for the needs of this deliverable.)

Table 16 – Parameters used in the formula for final energy savings

Parameter	Description
TFES	Total final energy savings [kWh/a]
FEC_{before}	Final energy consumption before implementation of the action [kWh/a]
FEC_{after}	Final energy consumption after implementation of the action [kWh/a]
$E_{i,\ before}$	Final energy consumption of an individual energy carrier (e.g. electricity, natural gas, coal, ambient energy, etc.) before implementation of the action [kWh/a]
$E_{i,\ after}$	Final energy consumption of an individual energy carrier (e.g. electricity, natural gas, coal, ambient energy, etc.) before implementation of the action [kWh/a]
rb	Factor to calculate a rebound effect (=1) [dmnl]
so	Factor to calculate a spill-over effect (=1) [dmnl]
fr	Factor to calculate a free-rider effect (=1) [dmnl]
lt	Factor for the lifetime of savings (=1) [dmnl]

Standardized Calculation Values

Some standardised values are given in the technical standards (both harmonised and national) used to calculate the energy performance of a building or in a Decree 264/2020 on the energy performance of buildings. These values are not reported below.

The Czech Republic uses hourly standardised data of climatic conditions and operating conditions for the calculation within the energy performance certificate: https://mpo.gov.cz/cz/energetika/energeticka-ucinnost/prohlaseni-k-vyuzivani-hodinovych-klimatickych-dat-pri-vypoctu-energeticke-narocnosti-budov--270834/

2.9.2 Calculation of Primary Energy Savings

Formula

Same as for final energy in chapter 2.9.1, only the relevant primary energy factors are applied to the individual energy carriers.

The following formula is used to calculate the annual primary energy savings:

$$\mathrm{APES} = (FEC_{before} - FEC_{after}) \times rb \times so \times fr \times lt = (\sum_{i=1}^{n} E_{i,before} * PEF_i - \sum_{i=1}^{n} E_{i,after} * PEF_i) \times rb \times so \times fr \times lt \quad (9)$$

(This is not an official formula, but just a formula derived from commonly used principles for the needs of this deliverable.)

Table 17 – Parameters used in the formula for primary energy savings

Parameter	Description
APES	Annual primary energy savings [kWh/a]
PEC_{before}	Primary energy consumption before implementation of the action [kWh/a]

PEC_{after}	Primary energy consumption after implementation of the action [kWh/a]
$E_{i,\ before}$	Final energy consumption of an individual energy carrier (e.g. electricity, natural gas, coal, ambient energy, etc.) before implementation of the action [kWh/a]
$E_{i,\ after}$	Final energy consumption of an individual energy carrier (e.g. electricity, natural gas, coal, ambient energy, etc.) before implementation of the action [kWh/a]
PEF_i	Primary Energy Factor of an individual energy carrier (e.g. electricity, natural gas, coal, ambient energy, etc.) [dmnl]
rb	Factor to calculate a rebound effect (=1) [dmnl]
so	Factor to calculate a spill-over effect (=1) [dmnl]
fr	Factor to calculate a free-rider effect (=1) [dmnl]
lt	Factor for the lifetime of savings (=1) [dmnl]

Standardized Calculation Values

Same as for final energy in chapter 0.

The Decree 264/2020 on the energy performance of buildings sets out Primary Energy Factors from non-renewable energy sources for individual energy carriers.

The Ministry of Industry and Trade lists primary energy factors for total primary energy on its website (https://mpo.gov.cz/cz/energetika/uspory-energie/aktuality/stanovisko-ministerstva-prumyslu-a-obchodu-k-vypoctu-spotreby-primarni-energie-v-energetickem-posudku--276396/).

2.9.3 Calculation of Greenhouse Gas Savings

The calculation of the emission production and subsequent GHG savings is based on the calculation of the final energy consumption of the building, where the energy carriers are multiplied by emission factors.

Formula

The following formula is used to calculate the annual GHG emissions:

$$\begin{aligned} GHGSAV &= (GHG_{before} - GHG_{after}) \times rb \times so \times fr \times lt \\ &= (\sum_{i=1}^{n} E_{i,before} * f_{\mathrm{GHG,i}} - \sum_{i=1}^{n} E_{i,after} * f_{\mathrm{GHG,i}}) \times rb \times so \times fr \times lt \end{aligned} \qquad (10)$$

(This is not an official formula, but just a formula derived from commonly used principles for the needs of this deliverable.)

Table 18 – Parameters used in the formula for greenhouse gas savings

Parameter	Description
GHGSAV	Greenhouse gas savings [t CO_2 / year]
GHG_{before}	Greenhouse gas production before implementation of the action [t CO_2 /year]
GHG_{after}	Greenhouse gas production after implementation of the action [t CO_2 / year]
$E_{i,\ before}$	Final energy consumption of an individual energy carrier (e.g. electricity, natural gas, coal, ambient energy, etc.) before implementation of the action [MWh/a]
$E_{i,\ after}$	Final energy consumption of an individual energy carrier (e.g. electricity, natural gas, coal, ambient energy, etc.) before implementation of the action [MWh/a]
$f_{GHG,i}$	Emission factor of an individual energy carrier (e.g. electricity, natural gas, coal, ambient energy, etc.) [t CO_2/MWh]
rb	Factor to calculate a rebound effect (=1) [dmnl]
so	Factor to calculate a spill-over effect (=1) [dmnl]
fr	Factor to calculate a free-rider effect (=1) [dmnl]
lt	Factor for the lifetime of savings (=1) [dmnl]

Standardized Calculation Values

There is a table with emission coefficients in Annex 9 of the Decree No. 141/2021 Coll. on energy assessment and on data recorded in the Energy Consumption Monitoring System (same values are provided in Annex 8 of the Decree 140/2021 Coll. on energy audit. Carbon emission factors indicate the amount of carbon or carbon dioxide per unit of energy in the fuel being burned. Other emission factors follow the IPCC 2006 methodology.

Table 19 – Emission factors according to the Decree No. 141/2021 and Decree 140/2021 Coll

Fuel or energy	t CO_2/MWh
coal	0.330
lignite	0.352
coke	0.385
lignite briquettes	0.346
fuel oil and other gas oil	0.267
Low sulphur fuel oil (up to 1 wt.% sulphur)	0.279
high sulphur fuel oil (above 1 % sulphur by weight)	0.279
natural gas	0.200
Liquefied petroleum gas (LPG)	0.237
electricity	0.860

The above emission factor for electricity is valid for electricity only from fossil fuels as of 2018. Value can be replaced by a more up-to-date factor calculated by the Ministry of Industry and Trade, which also takes into account other energy sources (https://mpo.gov.cz/cz/energetika/statistika/elektrina-a-teplo/hodnota-emisniho-faktoru-co2-z-vyroby-a-spotreby-elektriny--286666/).

2.9.4 Overview of Costs Related to the Action

Cost-Effectiveness

Costs are calculated individually based on the parameters and scope of the energy-saving measure. Costs for each type of measure are obtained from suppliers or taken from the price systems of ÚRS and RTS, which contain catalogues with indicative prices of construction works.

For the calculation and subsequent cost-benefit evaluation, the standard economic methods are used:

- simple payback time,
- discounted payback time,
- net present value and
- internal rate of return.

The specific choice depends on the complexity of the energy saving measure and the requirements of the financial support programme. The specific choice depends on the complexity of the energy saving measure and the requirements of the financial support programme that has been used. Commonly, net present value and internal rate of return are used (this is, for example, required in energy assessments and audits). The programs may then have a condition such that the resulting value must be less than or greater than the set benchmark.

Net present value over the evaluation period

$$NPV_{TH} = \sum_{t=1}^{Tn} CF_t * (1+r)^{-t} - IN + \sum_{X=1}^{n} N_{ZUX,Th} \quad (11)$$

The internal rate of return (IRR) is calculated from the condition:

$$0 = \sum_{t=1}^{Tn} CF_t * (1+r)^{-t} - IN + \sum_{X=1}^{n} N_{ZUX,Th} \qquad (12)$$

The real payback period Td, the payback period of the investment assuming a discount rate, is calculated from the condition:

$$I_p = \sum_{t=1}^{Td} CF_t * (1+r)^{-t} \qquad (13)$$

The residual value of the equipment at the end of the evaluation period:

For cases where the useful life Tž of the equipment or structure coincides with the evaluation period Th of the project, Nzu,Th = 0. In the case of the evaluation of projects with a different lifetime Tž from the evaluation period Th, the residual value of the equipment or structure shall be determined according to the following formula:

$$N_{ZU,Th} = \frac{IN_r * (T_{\check{Z}} - T_{ZU})}{T_{\check{Z}}} * (1+r)^{-Th} \qquad (14)$$

Table 20 – Parameters used in the estimation of cost-effectiveness

Parameter	Description
CF_t	cash flows (cash flow) including investments in individual years [thous. CZK]
r	the discount rate stated dimensionlessly (for example, r = 3% = 0,03),
Td	real (discounted) payback period [thous. CZK]
I_p	total planned investment [thous. CZK]
V	revenues (income, sales, savings) resulting from the implementation of the evaluated project in year t [thous. CZK]
IN	implementation costs (investment funds from own sources) of the evaluated equipment or construction in year 0 [thous. CZK]
$IN_{r,t}$	reinvestment and one-off renewal expenditure in year t, corresponds to the renewal investment in the equipment or building in year Tž+1 [thous. CZK]
IN_r	the last counted reinvestment INr,t of the assessed installation or structure [thous. CZK]
Np	operating expenditure excluding depreciation (overheads, materials, fuel, energy, water, repairs, maintenance, servicing, wages, other) in year t [thous. CZK]
Nzu,Th	residual value of the equipment or building at the end of the evaluation period Th [thous. CZK]
t	year of the project evaluation since the start of the evaluation [years]
Tž	lifetime of the equipment or construction or parts thereof being evaluated [years]
Th	project evaluation period [years]
Tzu	time from the last counted reinvestment INr of the equipment or structure under evaluation to the end of the evaluation period Th. For the case where the project evaluation period Th is shorter than the lifetime of the equipment Tž (i.e. no replacement reinvestment in the equipment during the whole value period), Tzu = Th. [years]

Standardized Values

Standardised values may be set individually according to the conditions of the policy support measure.

Otherwise, for energy assessments, the standard values are set out in Annex 8 of Decree No. 141/2021 Coll. on energy assessment and on data recorded in the Energy Consumption Monitoring System. For energy audits, the default values are set out in Annex 7 to Decree No. 140/2021 Coll. on energy audit. In the case of building energy performance certificates, the standardised values are based on the requirement of the subsidy programme.

2.9.5 Methodological Aspects

Methodology was taken from officially published legal documents and is a common practice in the Czech Republic. Alternatively, the methodology was developed based on a principle commonly used (calculation of savings based on the difference between the existing state and the state after reconstruction).

- Decree No. 141/2021 Coll. on energy assessment and on data recorded in the Energy Consumption Monitoring System: https://www.zakonyprolidi.cz/cs/2021-141;
- Decree No. 140/2021 Coll. on energy audit: https://www.zakonyprolidi.cz/cs/2021-140;
- Act No 406/2000 on energy management: https://www.zakonyprolidi.cz/cs/2000-406;
- Decree 264/2020 on the energy performance of buildings: https://www.zakonyprolidi.cz/cs/2020-264;
- Methodology for reporting energy savings from alternative policy measure pursuant to Article 7(9) of the Energy Efficiency Directive (2012/27/EU) [Update 2020]: https://www.mpo.cz/cz/energetika/energeticka-ucinnost/strategicke-dokumenty/metodika-vykazovani-uspor-energie-z-alternativnich-politickych-opatreni--176331.

Language of the original document as well as used legal documents is Czech.

The method of calculating savings depends on the instrument used and can include deemed savings (in the case of calculations based on building energy performance certificates), metered savings (when verifying compliance with project indicators supported by financial instruments), scaled savings or a combination (in the case of energy assessments and audits).

2.9.6 Bibliography

Collective of authors. (2020). Methodology for reporting energy savings from alternative policy measures. *Prague: Ministry of Industry and Trade*. Retrieved from: https://mpo.gov.cz/cz/energetika/energeticka-ucinnost/strategicke-dokumenty/metodika-vykazovani-uspor-energie-z-alternativnich-politickych-opatreni--176331

2.10. Global renovation of a residential building – France

The methodology is applied for a complete thermal renovation of an existing multi-family residential building. The approach involves determining and implementing an optimised package of works from a technical and economic perspective. This operation cannot be combined with other operations that may lead to the issuance of energy-saving certificates for works related to heating, domestic hot water production, ventilation, building envelope insulation, or building automation and control systems.

For each category of work included in the comprehensive renovation project and listed in items 1° to 16° of Section I of Article 1 of Decree No. 2014-812 of 16 July 2014, issued for the application of the second paragraph of Section 2 of Article 200 quater of the General Tax Code and the last paragraph of Section 2 of I of Article 244 quater U of the same code, the professional carrying out the operation must hold a quality mark in accordance with the requirements set out in Article 2 of the same decree and the texts issued for its application. This quality mark corresponds to works covered either by item 17° of Section I of Article 1 of the aforementioned decree or by one of the categories mentioned in items 1° to 16° of Section I of the same decree corresponding to the works performed.

An energy audit must be conducted before the comprehensive renovation of the building. This energy audit must comply with the provisions of Article 8 of the decree of 17 November 2020, which defines the technical characteristics and implementation procedures for eligible energy transition grant-funded works and services. It must be carried out by a person meeting the conditions specified in Section VII of Article 2 of the decree of 14 January 2020 concerning the energy transition grant.

However, for buildings not subject to Law No. 65-557 of 10 July 1965 defining the status of co-ownership of built properties, an energy audit may be conducted as defined by the decree of 4 May 2022. This decree establishes the content of the regulatory energy audit in mainland France, as required by Article L. 126-28-1 of the Construction and Housing Code. The audit must be conducted before thermal renovation works by a person meeting the conditions stipulated in Decree No. 2022-780 of 4 May 2022, which relates to the energy audit mentioned in Article L. 126-28-1 of the Construction and Housing Code.

The works must achieve a minimum overall energy performance level for the building, as determined by the energy audit, meeting the following two criteria:

- The annual conventional primary energy consumption after renovation, relative to the habitable surface area of the dwellings, must be below 331 kWh/m² per year for heating, cooling, domestic hot water production, lighting, and auxiliary systems for heating, cooling, hot water, and ventilation.
- The energy savings must be at least 35% compared to the annual conventional primary energy consumption before the works for the uses mentioned above.

The annual greenhouse gas emissions after renovation, relative to the habitable surface area of the building, must be equal to or lower than the initial emissions before the works.

The proof of completion must include a list of the works carried out along with their performance levels.

- The specific supporting documents required for the operation are:
- The summary report of the energy audit, along with any updates, specifying the conventional primary and final energy consumption data (without deducting self-consumed or exported electricity production), both before and after the renovation. It must also indicate the energy savings achieved through the renovation and the annual quantities of greenhouse gases emitted before and after the works, all relative to the habitable surface area of the building. The report must specify the name and version number of the calculation software used.
- The list of recommended works with their performance levels and their correspondence with the actual works carried out. This document must be dated and signed by the beneficiary, the professional who conducted the energy audit, and each professional responsible for implementing or supervising any part of the operation, ensuring the required energy performance levels are met.
- The list of companies that performed the renovation works, indicating the nature of these works and the reference of their qualification or certification when required.

If the implemented works differ from those initially recommended, the energy audit must be updated based on the actual works performed.

The summary report of the energy audit, along with any updates, must be dated and signed by the service provider who carried out the audit. It must include the following values:

- The conventional energy consumption (in kWh/m² per year) of the building (without deducting self-consumed or exported electricity production), specifying the considered energy uses:
  - Primary energy before renovation: $C_{initial}$
  - Primary energy after renovation: $C_{project}$
  - Final energy before renovation: $C_{initial}$
  - Final energy after renovation: $C_{project}$
- CO_2 emissions expressed in kg CO_2 equivalent per m² per year:
  - Before renovation
  - After renovation
- The habitable surface area of the renovated building, expressed in m² (S_{hab}).

2.10.1 Calculation of Final Energy Savings

Formula

The following equation calculates cumulative final energy savings.

$$TFES = (C_{initial} - C_{project}) \times S_{hab} \tag{15}$$

The parameters used in the formula for final energy savings are presented in Table 21.

Table 21 – Parameters used in the formula for final energy savings

Parameter	Description
$TFES$	Total final energy savings [kWh]
$C_{initial}$	Initial energy consumption of final energy [kWh/m² per year]
$C_{project}$	Projected energy consumption of final energy after the renovation [kWh/m² per year]
S_{hab}	Habitable surface area of the building after renovation [m²] Any additional habitable surface resulting from new interior conversions of the existing building—such as the conversion of basements, attics, or any other space—as well as any new extensions, is not included in the calculation

Standardized Calculation Values

No calculation values are available for this methodology.

2.10.2 Calculation of Primary Energy Savings

Formula

The methodology does not include any formula to calculate primary energy savings.

Standardized Calculation Values

No calculation values are available for this methodology.

2.10.3 Calculation of Greenhouse Gas Savings

Formula

The methodology does not include any formula to calculate Greenhouse Gas Savings.

Standardized Calculation Values

No calculation values are available for this methodology.

2.10.4 Overview of Costs Related to the Action

Cost-Effectiveness

No information on cost-effectiveness is available for this methodology.

Standardized Values

No calculation values are available for this methodology.

2.10.5 Methodological Aspects

The original document is in French, being an official document from the Ministry of Ecological Transition published with the reference BAR-TH-145.

In France the energy savings targets, and action are recorded in kWh cumac of final energy, cumac being the contraction of “cumulative and actualized” and given by the following equation.

$$kWh_{cumac} = TFES \times DC \tag{16}$$

The parameters used in the formula are presented in Table 22 and the indicative values are in Table 23.

Table 22 – Parameters used in the formula for final energy savings

Parameter	Description
kWh_{cumac}	Total final energy savings [kWh]
DC	Discount coefficient

Table 23 – Indicative values for calculation of energy savings certificates

Parameter	Value
Lifetime	30 [years]
DC(4%)	17.292

2.10.6 Bibliography

Opérations standardisées d’économies d’énergie | Ministère du Partenariat avec les territoires et de la Décentralisation Ministère de la Transition écologique, de l’Énergie, du Climat et de la Prévention des risques Ministère du Logement et de la Rénovation urbaine. (n.d.). Ministère Du Partenariat Avec Les Territoires Et De La Décentralisation Ministère De La Transition Écologique, De L’Énergie, Du Climat Et De La Prévention Des Risques Ministère Du Logement Et De La Rénovation Urbaine. https://www.ecologie.gouv.fr/politiques-publiques/operations-standardisees-deconomies-denergie#scroll-nav__7

2.11. Global renovation of a detached house – France

The methodology is applied for a complete thermal Renovation of an existing single-family home. The approach involves determining and implementing an optimised package of works from both a technical and economic perspective. This operation cannot be combined with other operations that may lead to the issuance of energy-saving certificates for works related to heating, domestic hot water production, ventilation, building envelope insulation, or building automation and control systems.

For each category of work included in the comprehensive renovation project and listed in items 1° to 16° of Section I of Article 1 of Decree No. 2014-812 of 16 July 2014, issued for the application of the second paragraph of Section 2 of Article 200 quater of the General Tax Code and the last paragraph of Section 2 of I of Article 244 quater U of the same code, the professional carrying out the operation must hold a quality certification in accordance with the requirements set out in Article 2 of the same decree and the related application texts. This quality certification applies to works either under item 17° of Section I of Article 1 of the decree or one of the categories mentioned in items 1° to 16° of Section I of the same decree corresponding to the works performed.

Before the works commence, one of the following energy audits must be carried out:

- An energy audit as defined in Article 8 of the decree of 17 November 2020, which specifies the technical characteristics and implementation methods for energy transition grant-funded works and services. The audit must be carried out by a professional meeting the conditions outlined in Section VII of Article 2 of the decree of 14 January 2020 concerning the energy transition grant.
- An energy audit as defined by the decree of 4 May 2022, which establishes the content of the regulatory energy audit for mainland France under Article L. 126-28-1 of the Construction and Housing Code. This audit must be conducted by a professional meeting the conditions set forth in Decree No. 2022-780 of 4 May 2022 relating to the energy audit specified in Article L. 126-28-1 of the Construction and Housing Code.

The renovation works must achieve a minimum overall energy performance level for the home, as determined by the energy audit, meeting the following two criteria:

- The annual conventional primary energy consumption after renovation, relative to the habitable surface area of the home, must be less than 331 kWh/m² per year.
- Energy savings of at least 35% compared to the annual conventional primary energy consumption before the works.

The annual greenhouse gas emissions after renovation, relative to the habitable surface area of the home, must be equal to or lower than the initial emissions before the works.

The proof of completion must include a list of the works carried out and their performance levels.

The following specific supporting documents must be provided:

- The summary report of the energy audit, including any updates, specifying the conventional primary and final energy consumption data (without deducting self-consumed or exported electricity production), both before and after the renovation. It must also detail the energy savings achieved, the annual greenhouse gas emissions before and after the works, and all values must be reported relative to the habitable surface area of the home. The report must include the name and version number of the calculation software used for the operation.
- The list of recommended works, including their performance levels and the correspondence with the actual works carried out. This document must be dated and signed by the beneficiary, the professional who conducted the energy audit, and each professional responsible for executing or supervising any part of the operation, ensuring compliance with the required energy performance levels.
- The list of companies that performed the renovation works, specifying the nature of the works and the reference of their qualification or certification, if required.

If the actual works performed differ from the initially recommended works, the energy audit must be updated to reflect the works effectively carried out.

The summary report of the energy audit, including any updates, must be dated and signed by the service provider responsible for the audit. It must include the following values:

- The conventional energy consumption (in kWh/m² per year) of the building (without deducting self-consumed or exported electricity production), specifying the considered energy uses:
  - Primary energy before renovation: $C_{initial}$
  - Primary energy after renovation: $C_{project}$
  - Final energy before renovation: $C_{initial}$
  - Final energy after renovation: $C_{project}$
- CO_2 emissions expressed in kg CO_2 equivalent per m² per year:
  - Before renovation
  - After renovation
- The habitable surface area of the renovated building, expressed in m² (S_{hab}).

2.11.1 Calculation of Final Energy Savings

Formula

The following equation calculates cumulative final energy savings.

$$TFES = (C_{initial} - C_{project}) \times S_{hab} \tag{17}$$

The parameters used in the formula for final energy savings are presented in Table 24.

Table 24 – Parameters used in the formula for final energy savings

Parameter	Description
$TFES$	Total final energy savings [kWh]
$C_{initial}$	Initial energy consumption of final energy [kWh/m² per year]
$C_{project}$	Projected energy consumption of final energy after the renovation [kWh/m² per year]
S_{hab}	Habitable surface area of the building after renovation [m²] Any additional habitable surface resulting from new interior conversions of the existing building—such as the conversion of basements, attics, or any other space—as well as any new extensions, is not included in the calculation

Standardized Calculation Values

No calculation values are available for this methodology.

2.11.2 Calculation of Primary Energy Savings

Formula

The methodology does not include any formula to calculate primary energy savings.

Standardized Calculation Values

No calculation values are available for this methodology.

2.11.3 Calculation of Greenhouse Gas Savings

Formula

The methodology does not include any formula to calculate Greenhouse Gas Savings.

Standardized Calculation Values

No calculation values are available for this methodology.

Co-funded by the
European Union

2.11.4 Overview of Costs Related to the Action

Cost-Effectiveness

No information on cost-effectiveness is available for this methodology.

Standardized Values

No calculation values are available for this methodology.

2.11.5 Methodological Aspects

The original document is in French, being an official document from the Ministry of Ecological Transition published with the reference BAR-TH-164.

In France the energy savings targets, and action are recorded in kWh cumac of final energy, cumac being the contraction of “cumulative and actualized” and given by the following equation.

$$kWh_{cumac} = TFES \times DC \quad (18)$$

The parameters used in the formula are presented in Table 25 and the indicative values are in Table 26.

Table 25 – Parameters used in the formula for final energy savings

Parameter	Description
kWh_{cumac}	Total final energy savings [kWh]
DC	Discount coefficient

Table 26 – Indicative values for calculation of energy savings certificates

Parameter	Value
Lifetime	30 [years]
DC(4%)	17.292

2.11.6 Bibliography

Opérations standardisées d’économies d’énergie | Ministère du Partenariat avec les territoires et de la Décentralisation Ministère de la Transition écologique, de l’Énergie, du Climat et de la Prévention des risques Ministère du Logement et de la Rénovation urbaine. (n.d.). Ministère Du Partenariat Avec Les Territoires Et De La Décentralisation Ministère De La Transition Écologique, De L’Énergie, Du Climat Et De La Prévention Des Risques Ministère Du Logement Et De La Rénovation Urbaine. https://www.ecologie.gouv.fr/politiques-publiques/operations-standardisees-deconomies-denergie#scroll-nav__7

2.12. Insulation of attics or roofs– France

The methodology is applied for the installation of thermal insulation in the floor of unused attic spaces or under the pitched roof in existing tertiary sector premises designated for professional use.

Conditions for the Issuance of Certificates:

- The insulation installation must be carried out by a professional.
- The thermal resistance (R) of the installed insulation must be ≥ 6 m².K/W for insulation applied to the floor of unused attics or under the pitched roof.
- The thermal resistance is assessed according to:
  - NF EN 12664, NF EN 12667, or NF EN 12939 for non-reflective insulation.

- NF EN 16012+A1 for reflective insulation.

Additional Requirements:

- A vapour barrier or another equivalent system must be installed where necessary to protect the insulation materials from moisture transfer, ensuring the performance of the construction.
- A minimum waiting period of seven full days must be observed between the date of acceptance of the quotation and the start date of the works (insulation installation).
- A project cannot commence less than twelve months after a previously initiated project involving the same building and the same beneficiary.

The proof of completion must mention:

- The installation of attic or roof insulation.
- The surface area of the installed insulation.
- The thermal resistance of the installed insulation, assessed according to one of the relevant standards mentioned above, depending on the type of insulation.
- Any necessary adjustments required for the insulation installation, such as:
    - Casing or protective screens around chimneys and recessed lighting fixtures.
    - A rigid raised frame above the access hatch.
    - A vapour barrier or an equivalent system where required to protect the insulation from moisture transfer, ensuring long-term performance.

If the above details are not provided, the proof of completion must instead include:

- The brand and reference of the installed insulation material.
- The surface area of the installed insulation material.
- A document issued by the manufacturer or by an organisation established in the European Economic Area (EEA), accredited under NF EN ISO/IEC 17065 by the French Accreditation Committee (COFRAC) or another accreditation body that is a signatory of the relevant European multilateral agreement.

This document must certify that the installed material (brand and reference) is a thermal insulation product and must specify its thermal properties, including:

- Thermal resistance (R-value), or
- Thermal conductivity and thickness, assessed according to one of the relevant standards mentioned above, depending on the type of insulation.

If the document specifies a validity date, it remains valid up to one year after its expiration date. For insulation materials available in different thicknesses, if the proof of completion does not explicitly state the thermal resistance, it must indicate the installed thickness.

2.12.1 Calculation of Final Energy Savings

Formula

The following equation calculates cumulative final energy savings.

$$TFES = S_A \times cf \times I_A \tag{19}$$

The parameters used in the formula for final energy savings are presented in Table 27.

Table 27 – Parameters used in the formula for final energy savings

Parameter	Description
$TFES$	Total final energy savings [kWh]

S_A	Savings in kWh cumac per m² of insulation [kWh/m²]
cf	Corrective factor [%]
I_A	Surface of insulation [m^2]

Standardized Calculation Values

Table 28 and
Table 29 present the indicative values for the calculation of final energy savings.

Table 28 – Indicative values for the savings in kWh cumac per m² of insulation in different climatic regions

Parameter	Climatic Region	Value
S_A	H1	2600
	H2	2100
	H3	1400

Table 29 – Indicative values for corrective factor for different sectors

Sector	cf
Offices, Education, Retail	0.6
Hospitality and Catering	0.7
Healthcare	1.2
Other Sectors	0.6

2.12.2 Calculation of Primary Energy Savings

Formula

The methodology does not include any formula to calculate primary energy savings.

Standardized Calculation Values

No calculation values are available for this methodology.

2.12.3 Calculation of Greenhouse Gas Savings

Formula

The methodology does not include any formula to calculate Greenhouse Gas Savings.

Standardized Calculation Values

No calculation values are available for this methodology.

2.12.4 Overview of Costs Related to the Action

Cost-Effectiveness

No information on cost-effectiveness is available for this methodology.

Standardized Values

No calculation values are available for this methodology.

2.12.5 Methodological Aspects

The original document is in French, being an official document from the Ministry of Ecological Transition published with the reference BAT-EN-101.

In France the energy savings targets, and action are recorded in kWh cumac of final energy, cumac being the contraction of "cumulative and actualized" and given by the following equation

$$kWh_{cumac} = TFES \times DC \tag{20}$$

The parameters used in the formula are presented in Table 30 and the indicative values are in Table 31

Table 30 – Parameters used in the formula for final energy savings

Parameter	Description
kWh_{cumac}	Total final energy savings [kWh]
DC	Discount coefficient

Table 31 – Indicative values for calculation of energy savings certificates

Parameter	Value
Lifetime	30 [years]
$DC(4\%)$	17.292

2.12.6 Bibliography

Opérations standardisées d'économies d'énergie | Ministère du Partenariat avec les territoires et de la Décentralisation Ministère de la Transition écologique, de l'Énergie, du Climat et de la Prévention des risques Ministère du Logement et de la Rénovation urbaine. (n.d.). Ministère Du Partenariat Avec Les Territoires Et De La Décentralisation Ministère De La Transition Écologique, De L'Énergie, Du Climat Et De La Prévention Des Risques Ministère Du Logement Et De La Rénovation Urbaine. https://www.ecologie.gouv.fr/politiques-publiques/operations-standardisees-deconomies-denergie#scroll-nav__7

2.13. Insulation of walls – France

The methodology is applied for the installation of thermal insulation insulating cladding (either composite or on a framework) on walls, either from the interior or the exterior in existing tertiary sector premises designated for professional use.

Conditions for the Issuance of Certificates:

- The installation must be carried out by a professional.
- The thermal resistance (R-value) of the installed insulation must be ≥ 3.7 m^2.K/W.
- The thermal resistance is assessed according to:
  - NF EN 12664, NF EN 12667, or NF EN 12939 for non-reflective insulation.
  - NF EN 16012+A1 for reflective insulation.

The proof of completion must mention:

- The installation of wall insulation.
- The surface area of the installed insulation.
- The thermal resistance (R-value) of the installed insulation, assessed according to one of the relevant standards mentioned above.

If the above details are not provided, the proof of completion must instead include:

- The brand and reference of the installed insulation material.
- The surface area of the installed insulation material.

- A document issued by the manufacturer or by an organisation established in the European Economic Area (EEA), accredited under NF EN 45011 by the French Accreditation Committee (COFRAC) or another accreditation body that is a signatory of the relevant European multilateral agreement (European co-operation for Accreditation - EA).

This document must certify that the installed material (brand and reference) is a thermal insulation product and must specify its thermal properties, including:

- Thermal resistance (R-value), or
- Thermal conductivity and thickness, assessed according to one of the relevant standards mentioned above.

If the document includes a validity date, it remains valid up to one year after its expiration date.

For insulation materials available in different thicknesses, if the proof of completion does not explicitly state the thermal resistance, it must indicate the installed thickness.

2.13.1 Calculation of Final Energy Savings

Formula

The following equation calculates cumulative final energy savings.

$$TFES = S_A \times cf \times I_A \tag{21}$$

The parameters used in the formula for final energy savings are presented in Table 32.

Table 32 – Parameters used in the formula for final energy savings

Parameter	Description
$TFES$	Total final energy savings [kWh]
S_A	Savings in kWh cumac per m² of insulation [kWh/m²]
cf	Corrective factor [%]
I_A	Surface of insulation [m²]

Standardized Calculation Values

Table 33 and
Table 34 present the indicative values for the calculation of final energy savings.

Table 33 – Indicative values for the savings in kWh cumac per m² of insulation in different climatic regions and fuels

Parameter	Climatic Region	Electricity	Fuel
S_A	H1	3000	4800
	H2	2500	3900
	H3	1600	2600

Table 34 – Indicative values for corrective factor for different sectors

Sector	cf
Offices, Education, Retail	0.6
Hospitality and Catering	0.7
Healthcare	1.3
Other Sectors	0.6

2.13.2 Calculation of Primary Energy Savings

Formula

The methodology does not include any formula to calculate primary energy savings.

Standardized Calculation Values

No calculation values are available for this methodology.

2.13.3 Calculation of Greenhouse Gas Savings

Formula

The methodology does not include any formula to calculate Greenhouse Gas Savings.

Standardized Calculation Values

No calculation values are available for this methodology.

2.13.4 Overview of Costs Related to the Action

Cost-Effectiveness

No information on cost-effectiveness is available for this methodology.

Standardized Values

No calculation values are available for this methodology.

2.13.5 Methodological Aspects

The original document is in French, being an official document from the Ministry of Ecological Transition published with the reference BAT-EN-102.

In France the energy savings targets, and action are recorded in kWh cumac of final energy, cumac being the contraction of “cumulative and actualized” and given by the following equation(16).

$$kWh_{cumac} = TFES \times DC \tag{22}$$

The parameters used in the formula are presented in Table 35 and the indicative values are in Table 36.

Table 35 – Parameters used in the formula for final energy savings

Parameter	Description
kWh_{cumac}	Total final energy savings [kWh]
DC	Discount coefficient

Table 36 – Indicative values for calculation of energy savings certificates

Parameter	Value
Lifetime	30 [years]
$DC(4\%)$	17.292

2.13.6 Bibliography

Opérations standardisées d’économies d’énergie | Ministère du Partenariat avec les territoires et de la Décentralisation Ministère de la Transition écologique, de l’Énergie, du Climat et de la Prévention des risques Ministère du Logement et de la Rénovation urbaine. (n.d.). Ministère Du Partenariat Avec Les Territoires Et De La Décentralisation Ministère De La Transition Écologique, De L’Énergie, Du Climat Et

De La Prévention Des Risques Ministère Du Logement Et De La Rénovation Urbaine. https://www.ecologie.gouv.fr/politiques-publiques/operations-standardisees-deconomies-denergie#scroll-nav__7

2.14. Energy upgrade of the building envelope in buildings of the residential and tertiary sectors – Greece

This calculation methodology aims at improving the thermal energy supply as well as the reduction in space heating & cooling demand. It applies to specific interventions (technical measures) for the building envelope of the residential and tertiary sectors.

2.14.1 Calculation of Final Energy Savings

Formula

Method: Scaled savings

$$TFES = \sum^{n_{renov\_building}} A_{heated\_area} * (EPC_{before\_energy\_cert} - EPC_{after\_energy\_cert}) \quad (23)$$

Table 37 – Parameters used in the formula for final energy savings

Parameter	Description
TFES	Total final energy savings [kWh/a]
A_{heated_area}	Heated surface area of each renovated building [m^2]
$EPC_{before\_energy\_cert}$	Final energy consumption (based on EPC) prior to energy efficiency interventions [kWh/m^2]
$EPC_{after\_energy\_cert}$	Final energy consumption (based on EPC) after the energy efficiency interventions [kWh/m^2]
$n_{renov\_building}$	Number of renovated buildings

Standardized Calculation Values

Each obligated party must define the following parameters: A_{heated_area}, $EPC_{before\_energy\_cert}$, $EPC_{after\_energy\_cert}$ for each of the renovated building separately based on the issued Energy Performance Certificates.

2.14.2 Calculation of Primary Energy Savings

No information is provided

2.14.3 Calculation of Greenhouse Gas Savings

No information is provided

2.14.4 Overview of Costs Related to the Action

No information is provided

2.14.5 Methodological Aspects

Bottom-up equation incorporated into the official adopted catalogue with BU-methodologies within the framework of the EEOs: http://www.cres.gr/obs/yliko.html

The adopted catalogue with BU-methodologies has been drafted in Greek language.

Co-funded by the
European Union

2.14.6 Bibliography

http://www.cres.gr/obs/yliko.html

2.15. Simplified accounting for complex renovation of a condominium in two steps using a factor "k"– Hungary

The measure can be applied to both thermally non-renovated and thermally renovated apartment buildings (TH) that still operate with an outdated heating system. The deep renovation of these apartment buildings can be done in two steps.

a) In the first step, thermal renovation is necessary, if the building has not yet been thermally renovated.

The condition for settlement according to the catalogue sheet is the completion and verification of the following thermal renovation level or compliance:

A condominium is considered thermally renovated if the average heat transfer coefficients of its external boundary structures meet at least the requirements specified in Annex 1 of the ÉKM Decree for the structures listed below:

- provide external walls with thermal insulation, U≤ 0.24 [W/m2,K]
- replace windows and doors with 3-layer thermal insulation glazing, U≤ 1.1 [W/m2,K]
- thermal insulation of ceilings and attic structures, U≤ 0.17 [kWh/m2,K]
- it is not required, but it is advisable to insulate floors, plinths, and surfaces bordering unheated paces, if possible.

b) In the second step, the complex heat supply system, heating and DHW supply system are modernized, with one of the following options:

b.1. reconstruction or design of the central boiler house and heating distribution system

- boiler replacement in accordance with the required value
- heating circulation pump replacement with speed control
- heating main pipe and distribution pipe modernization with insulation, replacement of mass flow control fittings (string regulators) or hydraulic re-balancing of existing ones
- heating control system modernization, especially for outdoor temperature-dependent control
- creation of consumption-proportional metering

b.2. connection to an efficient district heating network, if it is created during the modernization of the consumer system or already has the following:

- modern insulated heating main and distribution lines, mass flow control fittings (string regulators)
- thermostatic radiator valves
- DHW circulation system

The measure can be implemented:

a) If there are no technical obstacles to a complete thermal renovation, with the following exceptions.
   If the apartment building is a listed building and/or has an attic, an individual energy certificate or individual audit is required. If a structure with a U value different from the requirement is constructed for the external boundary structures, an individual energy certificate or audit is required to calculate the final energy savings.
b) If the space required for the reconstruction of the complex heat supply system (boiler room, heat centre) can be provided in the building.

The most important data of the old building and old heat supply system that is the subject of the measure shall be recorded according to the Table below.

Table 38 – Nominal technical data and operating characteristics of the electric motors subject to the measure

A	B	C	D
Number of rows	**Technical parameter**	**Old**	**New**
1	Heat generator manufacturer		
2	Heat generator type		
3	Date of commissioning of old heat generator	in case of early replacement	-
4	DHW production unit		
5	DHW production unit type		
6	Heating system technical solution according to Table 42		
7	n = number of buildings		
8	l = number of residential units		
9	A_N = heated floor area of the building [m^2]		

The expected lifetime of the measure in the case of replacing a condensing boiler in a thermally renovated building (≥30 kW) is 25 years. The expected lifetime of the measure is 20 years in all other cases.

The annual decrease rate of the energy savings in the case of the application of the measure is 0.1%.

The start of the eligibility of the measure is the day following the successful trial operation or the date of activation of the investment.

Documents required to verify the final energy savings that can be accounted for are as follows:

a) Date of commissioning or year of manufacture of the replaced gas boiler (in case of early replacement)
b) Document certifying the manufacturer and type of the newly installed gas boiler
c) In case of connection to district heating, the documents referred to in points a) and b) are not required or are not available
d) Document certifying the number of residential units (k) in the building (in particular, the founding document,
e) Declaration of the joint representative, owner
f) Document certifying the heated floor area of the building [m2]
g) Documents certifying that during the thermal renovation, or in the event of its existence, the external boundary structures comply with at least the heat transfer requirement (in particular, energy certification or energy calculations, or other documents certifying)
h) Documents certifying the complex renovation and commissioning of the heating system (in particular, the new gas boiler commissioning protocol, the system adjustment protocol, documents confirming the technical parameters of the installed system components, quality certificates or other documents)
i) Calculation of the final energy savings [GJ/year].

2.15.1 Calculation of Final Energy Savings

The final energy savings are based on the calculation of the required specific annual energy input (E [kWh/m^{2}a]). This energy input must be input into the system in order to ensure the specific net annual heat energy demand for heating (q_F [kWh/m^{2}a]) and the specific net annual energy demand for domestic hot water production (q_{HMV} [kWh/m^{2}a]). The so-called energy efficiency factor (k) expresses the efficiency of the system:

$$k = \frac{E}{q_F + q_{HMV}}$$

whereas:

E: specific heat and electricity demand of the building for heating and DHW production, which also includes the losses of the entire system (specific final energy consumption) [kWh/m2a]

qF: specific net heating energy demand [kWh/m^{2}a]

qHMV: specific net DHW energy demand [kWh/m^{2}a]

Formula

The eligible savings of the measure are the sum of the final energy savings calculated independently in the first (1st) step and the second (2nd) step:

ΔE = ΔE1st step + ΔE2nd step

Calculation of eligible energy savings for thermal renovation of the entire building

$$\Delta E1st\ step = A_N \times \left(E_{old,1} - E_{old,2}\right) \times rb \times so \times fr \times lt$$
$$E_{old,1} = k_{old,1} \times (q_{F,1} + q_{HMV})$$
$$E_{old,2} = k_{old,2} \times (q_{F,1} + q_{HMV}) \quad (24)$$

Table 39 – Parameters used in the formula for final energy savings

Parameter	Description
A_N	Total heated floor area of a building [m^2]
rb	Factor to calculate a rebound effect (=1)
so	Factor to calculate a spill-over effect (=1)
fr	Factor to calculate a free-rider effect (=1)
lt	Factor for the lifetime of savings [a]
$E_{old,1}$	annual specific energy consumption of a thermally non-renovated building with an existing, old heat supply system (baseline), according to column 1 of Table 3 [kWh/$m2$,a]
$E_{old,2}$	annual specific energy consumption of a thermally renovated building with an existing, old heat supply system, according to column 2 Table 3 [kWh/$m2$,a]
q_{F1}	specific net annual energy demand for heating, for a thermally non-renovated building (independent of the heat generator and the heating system) [kWh/m2, a]
q_{F2}	specific net annual energy demand for heating, for a thermally renovated building (independent of the heat generator and the heating system) [kWh/m2, a]
q_{HMV}	specific net annual energy demand for domestic hot water (DHW) production (does not depend on the DHW production method and the design of the supply system) [kWh/m2, a]
$k_{old,1}$	energy efficiency factor of the old heating and DHW system of a thermally non-renovated building
$k_{old,2}$	energy efficiency factor of the old heating and DHW system of a thermally renovated building

If the increase in the efficiency of the heat supply system only affects the heating system, then the value q_{HMV} = 0 must be taken into account in the calculation, if only the DHW production, then q_F = 0.

In the second step, it is assumed that following the thermal renovation of the apartment building, or in case the building is thermally fine, the heating and DHW systems of the building are subject to a complex renovation in accordance. The calculation of energy savings can be done by taking into account three different cases:

Early replacement of the heating system during the early replacement period

$$\Delta E2nd\ step = A_N \times \left(E_{old,2} - E_{new}\right) \times rb \times so \times fr \times lt$$
$$E_{old,2} = k_{old,2} \times (q_{F,2} + q_{HMV}) \quad (25)$$
$$E_{new} = k_{new} \times (q_{F,2} + q_{HMV})$$

Table 40 – Parameters used in the formula for final energy savings

Parameter	Description
A_N	Total heated floor area of a building [m^2]
rb	Factor to calculate a rebound effect (=1)
so	Factor to calculate a spill-over effect (=1)
fr	Factor to calculate a free-rider effect (=1)
lt	Factor for the lifetime of savings [a]
$E_{old,2}$	annual specific energy consumption of a thermally renovated building with an existing, old heat supply system, according to column 2 Table 3 [$kWh/m2,a$]
E_{new}	annual specific energy consumption of the thermally renovated building after the heat supply system has been renovated (state after the measures of step 2) [$kWh/m2,a$]
q_{F2}	specific net annual energy demand for heating, for a thermally renovated building (independent of the heat generator and the heating system) [kWh/m2, a]
q_{HMV}	specific net annual energy demand for domestic hot water (DHW) production (does not depend on the DHW production method and the design of the supply system) [kWh/m2, a]
$k_{old,2}$	energy efficiency factor of the old heating and DHW system of a thermally renovated building
k_{new}	energy efficiency factor achieved by complex renovation of the heat supply in a thermally renovated building

Replacement of the heating system after the useful life of the replaced boiler

$$\Delta E2nd\ step, excess = A_N \times \left(E_{ref} - E_{new}\right) \times rb \times so \times fr \times lt$$
$$\Delta E2nd\ step, excess = A_N \times k_{new} \times \left(\frac{c_{k,ref}}{c_{k,new}} - 1\right) \times (q_{F,2} + q_{HMV}) \quad (26)$$

Table 41 – Parameters used in the formula for final energy savings

Parameter	Description
A_N	Total heated floor area of a building [m^2]
rb	Factor to calculate a rebound effect (=1)
so	Factor to calculate a spill-over effect (=1)
fr	Factor to calculate a free-rider effect (=1)
lt	Factor for the lifetime of savings [a]
E_{ref}	annual specific energy consumption of a thermally renovated building with a reference boiler [$kWh/m2,a$]
E_{new}	annual specific energy consumption of the thermally renovated building after the heat supply system has been renovated (state after the measures of step 2) [$kWh/m2,a$]

q_{F2}	specific net annual energy demand for heating, for a thermally renovated building (independent of the heat generator and the heating system) [kWh/m2, a]
q_{HMV}	specific net annual energy demand for domestic hot water (DHW) production (does not depend on the DHW production method and the design of the supply system) [kWh/m2, a]
k_{ref}	energy efficiency factor of a thermally renovated building with a new heating and DHW system reference boiler
k_{new}	energy efficiency factor achieved by complex renovation of the heat supply in a thermally renovated building

Thermal renovation and complex heating system modernization

- Taking into account early replacement of the heat generator and in the case of connection to district heating

$$\Delta E1st, 2nd\ step, early = \Delta E1st\ step + \Delta E2nd\ step, early$$
$$\Delta E1st, 2nd\ step, early = A_N \times [k_{old,1} \times (q_{F,1} + q_{HMV}) - k_{new} \times (q_{F,2} + q_{HMV})] \quad (27)$$

- For a period beyond the useful life of the old boiler

$$\Delta E1st, 2nd\ step, excess = \Delta E1st\ step + \Delta E2nd\ step, excess$$
$$\Delta E1st, 2nd\ step, excess = A_N \times [(E_{old,1} - E_{old,2}) + (E_{ref} - E_{new})] \quad (28)$$

Standardized Calculation Values

The reference values corresponding to the minimum energy efficiency requirement shall be established in accordance with Commission Regulation (EU) No 813/2013 and Commission Regulation (EU) 2015/1188.

The reference value for the gas boiler shall be taken into account for this measure.

The efficiency factors for the complex heat supply system and the performance factors of the heat generators are included *in Table 42.*

Table 42 – Indicative values for calculation of final energy savings

Parameter	Value	Unit
rb	1	-
so	1	-
fr	1	-
lt	1	a

A	B	C	D	E	F	G	H
Number of rows	**Steps**	**Factor**	**Heat and DHW generator**	**Thermally non-renovated building**		**Thermally renovated building**	
1				TH<10	TH≥10	TH<10	TH≥10
2							
3		q_{F1}	kWh/m2 ,a	140	96,4		
4		q_{F2}	kWh/m2 ,a			52	39
5		q_{HMV}	kWh/m2 ,a	27,5		27,5	
6	1st step	$k_{old,1}$	old central boiler DHW individual electric boiler	1,32	1,33		
7		$k_{old,2}$				1,43	1,45
8		$k_{old,1}$	old central boiler DHW individual instantaneous water heater	1,34	1,37		
9		$k_{old,2}$				1,5	1,55
10		$k_{old,1}$	old central boiler central DHW storage	1,37	1,43		
11		$k_{old,2}$				1,52	1,56
12		$k_{old,1}$	gas convector DHW electric boiler	1,39	1,45		
13		$k_{old,2}$				1,42	1,48
14	2nd step	$C_{k,old}$	old central gas boiler power factor	1,2	1,15	1,2	1,15
24		$C_{k,ref}$	EU min. gas boiler power factor			1,16	1,16
16		$C_{k,new}$	New condensing gas boiler performance factor			1,01	1,01
17		k_{new}	complex heat supply system with condensing boiler + thermal renovation	n.a.	n.a.	1,18	1,2
18		k_{new}	efficient district heating + thermal renovation	n.a.	n.a.	1,17	1,19

2.15.2 Calculation of Primary Energy Savings

Formula

The following formula is used to calculate the annual primary energy savings:

$$APES = \frac{TFES}{lt} \times PEF_{fuel} \qquad (29)$$

Table 43 – Parameters used in the formula for primary energy savings

Parameter	Description
APES	Annual primary energy savings [kWh/a]
TFES	Total final energy savings [kWh/a]
PEF_{fuel}	Primary Energy Factor for fuel used for heating [dmnl]
lt	Factor for the lifetime of savings [a]

The above formula is valid if there was no change in fuels for heating.

If multiple fuels are used for heating, it is necessary to determine the primary energy factor according to the share of each fuel in the production of heat.

If data on the fuel used is not known, it is necessary to use the emission factor for natural gas.

Standardized Calculation Values

Primary energy factors (and emission factors) are published in the *Regulation laying down the review of energy buildings* (Annex 7). The use of these published factors is considered common practice in the country. This means that the factors, once published, are widely accepted and applied in relevant energy saving programs, ensuring consistency and adherence to the established legal framework for monitoring and verifying energy savings.

Table 44 – Indicative values for calculation of primary energy savings

			Primary energy factor			Emission factor
1	**Energy carrier**		**Non-renewable component**	**Renewable component**	**Total**	**f_{CO2eq} (g/kWh)**
2	Fossil fuels	Solid	1.1	0	1.1	456
3		Liquid	1.1	0	1.1	308
4		Gas	1.1	0	1.1	297
5	Organic Fuels	Solid	0.6	0.6	1.2	40
6		Solid	0.2	1.0	1.2	40
7		Liquid	0.5	1	1.5	70
8		Gas	0.4	1	1.4	83
9	Electricity		2.3	0,3	2.6	455
10	District Heat		1,38	0	1,38	374
11	Remote cooling		1,38	0	1,38	374
12	Waste heat		0	0	0	0
13	Solar energy	PV Electricity	0	1	1	74
14		Thermal	0	1	1	25
15	Wind		0	1	1	12

16	Environmental heat	Geo-, Aero-, Hydrothermal	0	1	1	27
17	Your export (elected) electricity	Exported to the network	2.3	0,3	2.6	455
18		Transferring to consumers not covered by the Regulation	2.3	0,3	2.6	455

2.15.3 Calculation of Greenhouse Gas Savings

Formula

$$GHGSAV = TFES \times f_{GHG,fuel} \times 10^{-6} \qquad (30)$$

Table 45 – Parameters used in the formula for greenhouse gas savings

Parameter	Description
GHGSAV	Greenhouse gas savings [t CO_2 p.a.]
TFES	Total final energy savings [kWh/a]
$f_{GHG,fuel}$	Emission factor for fuel used for heating [g CO_2/kWh]

Standardized Calculation Values

Standardised calculation values are given in **Table 13**.

2.15.4 Overview of Costs Related to the Action

No information on cost-effectiveness available for this methodology.

2.15.5 Methodological Aspects

The principle of calculation is based on the difference in energy recovery between the old and new heat recovery units.

The Hungarian Energy and Public Utility Regulatory Authority (MEKH) is the regulatory body of the energy and public utility market, supervising the national economy's sectors of strategic importance. The MEKH has established and reviews each year the EEOS catalogue, which lists the types of energy efficiency measures or investments that can be accounted in a simplified way. This Catalogue is published as the Annex of **17/2020.(XII. 21.) MEKH Decree** on data reporting on end-use energy savings.

Data on factors for calculation of primary energy savings and GHG emission savings are prescribed by the Ministry of Construction and Transport in Regulation laying down the energy characteristics of buildings.

Each catalogue sheet contains a description of the energy efficiency measure; the method and content of recording the baseline and post-measure status; the eligible lifetime and the level of degradation; a description of the performance factors and the principles for their calculation, the formula for calculating the annual savings; the documents to be submitted and other relevant information to support the accounting. For the time being, the catalogue contains 51 sheets in 5 categories.

All documents are available in Hungarian language.

Co-funded by the
European Union

2.15.6 Bibliography

The Hungarian Energy and Public Utility Regulatory Authority (2020): *17/2020.(XII. 21.) MEKH Decree on data reporting on end-use energy savings*, https://njt.hu/jogszabaly/2020-17-20-5Z.

9/2023. (V. 25.) NCM Regulation laying down the energy characteristics of buildings, https://njt.hu/jogszabaly/2023-9-20-8X

2.16. Methodology for Calculating Energy Savings from Buildings' Thermal Properties Improvement – Latvia

This methodology estimates the energy savings achieved through building envelope improvements, specifically wall insulation, roof insulation, and window replacement. It follows an ex-ante approach and utilizes standardized values for heat transfer coefficients (U-values) in energy-efficient and non-efficient building elements. Due to variations in climate conditions and building energy efficiency, these values are not included in the methodology. For heating degree days calculation, it is recommended to use the Latvian building standard *LBN 003-19 "Būvklimatoloģija"* (applicable only to the Latvian region).

2.16.1 Calculation of Final Energy Savings

Formula

This formula calculates cumulative final energy savings resulting from buildings thermal properties improvement:

$$TFES = (U - U_{eff}) \times a \times HDD \times 0.024 \times \frac{1}{\eta} \times y \times rb \times so \times fr \qquad (31)$$

Table 46 – Parameters used in the formula for calculating energy savings from buildings thermal properties improvement

Parameter	Description
TFES	The total final energy savings over the lifetime [kWh]
a	Area of the renovated building element [m^2]
HDD	The number of days of heating degrees in average climatic conditions [-]
U	Typical building element U-value: heat transfer coefficient [W/m^2K]
U_{eff}	U-value of energy efficient building element: heat transfer coefficient [W/m^2K]
η	The efficiency of the heating system in a typical building [-]
y	The lifetime of the measure [-]
rb	Factor to calculate a rebound effect (=1)
so	Factor to calculate a spill-over effect (=1)
fr	Factor to calculate a free-rider effect (=1)

Standardized Calculation Values

Table 47 – Indicative values for calculation of final energy savings resulting from buildings thermal properties improvement

Parameter	Value	Unit
η	0.8	-

Parameter	Value	Unit
y (wall / roof insulation)	20	years
Y (windows replacement)	30	years

2.16.2 Calculation of Primary Energy Savings

No information on primary energy savings available for this methodology.

2.16.3 Calculation of Greenhouse Gas Savings

No information on greenhouse gas savings available for this methodology.

2.16.4 Overview of Costs Related to the Action

No information on costs related to the action available for this methodology.

2.16.5 Methodological Aspects

The methodology uses the expected savings (ex-ante) method, as outlined in Sub-paragraph 2.4 of Regulation No. 660 (18 October 2022), and relies on default values from the State Construction Control Bureau's Catalogue of Energy Savings. This catalogue is part of the energy efficiency monitoring system and provides standardized energy-saving measures with achievable savings values.

This methodology was taken from the Catalogue “Energy savings catalogue developed by the Ministry of Economics” / “Ekonomikas ministrijas izstrādātais enerģijas ietaupījumu katalogs”: https://www.bvkb.gov.lv/lv/zinojumi-un-metodiskie-materiali [in Latvian language]

2.16.6 Bibliography

1. Būvniecības valsts kontroles birojs (2022). Document “Energy savings catalogue developed by the Ministry of Economics” / “Ekonomikas ministrijas izstrādātais enerģijas ietaupījumu katalogs”. https://www.bvkb.gov.lv/lv/zinojumi-un-metodiskie-materiali
2. Ministru kabinets (2019). Legislative act Regulations on Latvian Building Code LBN 003-19 "Būvklimatoloģija". https://likumi.lv/ta/id/309453-noteikumi-par-latvijas-buvnormativu-lbn-003-19-buvklimatologija

2.17. Methodology for calculating energy savings from renovation / modernisation of residential buildings – Lithuania

The building renovation project is aimed at enhancing energy efficiency by modernizing building systems and structures. Key measures include upgrading insulation, replacing outdated heating systems with sustainable alternatives, and installing energy-efficient windows and doors. The project aims to reach energy efficiency class B, reduce energy consumption by not less than 40 %, lower utility costs, and improve overall living comfort. Supported by government incentives, these efforts contribute significantly to sustainability goals, reducing the building's carbon footprint while increasing its value and longevity.

This methodology provides a structured approach to calculating energy savings from building renovation projects, ensuring compliance with STR 2.01.02:2016. The energy savings calculation involves assessing the impact of renovation measures on the building’s energy consumption and comparing it with the baseline condition.

2.17.1 Calculation of Final Energy Savings

The calculation of final energy savings involves determining the difference in energy consumption before and after renovation. Data is being collected from utility bills, smart meters, and energy audits over at least one year to account for seasonal variations.

Formula

This formula calculates first-year savings. The calculation of final energy savings during the modernization of buildings is based on comparing the energy consumption before and after modernization, considering factors such as improved energy efficiency and reduced energy losses. The achieved energy performance class of the building is determined in the building's energy performance certificate. The reduction in calculated thermal energy consumption (for heating and hot water preparation) is determined based on the difference in total thermal energy consumption (for heating and hot water preparation) specified in the **energy performance certificates** issued before and after the implementation of building renovation (modernization) measures.

$$\Delta Q = \left(Q_{before} - Q_{after}\right) \times rb \times so \times fr \qquad (32)$$

Table 48 – Parameters used in the formula for calculating final energy savings from renovation / modernisation of residential buildings

Parameter	Description
ΔQ	Total final energy savings [MWh/year]
Q_{before}	Annual final energy consumption of the building before modernization [MWh/year]
Q_{after}	Annual final energy consumption of the building after modernization [MWh/year]
rb	Factor to calculate a rebound effect (=1)
so	Factor to calculate a spill-over effect (=1)
fr	Factor to calculate a free-rider effect (=1)

2.17.2 Calculation of Primary Energy Savings

Primary energy savings account for the total energy used, including generation, transmission, and distribution losses. No information on primary energy savings available for this methodology.

2.17.3 Calculation of Greenhouse Gas Savings

Formula

Determine the energy source used for heating and hot water (e.g., natural gas, electricity, biomass, district heating).

$$\Delta CO_2 = \Delta E \times EF$$

In case of multiple energy sources used, emissions are calculated separately for each source and the results summed:

$$\Delta CO_2 = \sum_{i=1}^{n} (\Delta E_i \times EF_i)$$

Table 49 – Parameters used in the formula for greenhouse gas savings

Parameter	Description
ΔCO_2	Annual CO_2 emissions reduction [t CO_2/year]
ΔE	Total final energy savings [MWh/year]
EF	Emission factor of the energy source [t CO_2/MWh]
n	Number of different energy sources [-]
i	i-th energy source [-]

Standardized Calculation Values

Table 50 – Indicative values for calculation of greenhouse gas emission factor (EF) by fuel type

Parameter * (Emission Factor EF)	Value	Unit
Fuel oil	0,29	kg CO_2/kWh
Coal	0,36	kg CO_2/kWh
Natural gas	0,22	kg CO_2/kWh
Biofuels (wood, straw, biogas, bio-oil, etc.)	0,04	kg CO_2/kWh
Wind farms	0	kg CO_2/kWh
Electricity produced in hydroelectric power plants	0,01	kg CO_2/kWh
Peat	0,36	kg CO_2/kWh
Liquefied gas	0,22	kg CO_2/kWh

2.17.4 Overview of Costs Related to the Action

No information on cost-effectiveness available for this methodology.

2.17.5 Methodological Aspects

In Lithuania, the calculation of energy savings for building modernization is primarily regulated by the following document: STR 2.01.02:2016 “Energy Performance of Buildings: Design and Certification”. https://www.e-tar.lt/portal/lt/legalAct/2c182f10b6bf11e6aae49c0b9525cbbb/asr [in Lithuanian language]

2.17.6 Bibliography

1. Ministry of Environment of the Republic of Lithuania (2016). STR 2.01.02:2016 Energy Performance of Buildings: Design and Certification, No.: D1-754. Consolidated version 2024-05-01. Register of legal acts. https://www.e-tar.lt/portal/lt/legalAct/2c182f10b6bf11e6aae49c0b9525cbbb/asr .
2. Ministry of Energy of Republic of Lithuania (2016). Description of the Procedure for Calculating and Monitoring Energy Savings from Energy Efficiency Measures (Energijos Vartojimo Efektyvumo Didinimo Priemonių Sutaupytos Energijos Apskaičiavimo Ir Priežiūros Tvarkos Aprašas), No. 1-320. Register of legal acts. https://www.e-tar.lt/portal/lt/legalAct/c3eb4b20bbb911e688d0ed775a2e782a/asr
3. Ministry of Energy of Republic of Lithuania (2023). Methodology for Conducting a Detailed Energy and Energy Resource Consumption Audit in Buildings (Išsamiojo Energijos Ir Energijos Išteklių

Vartojimo Audito Atlikimo Pastatuose Metodika), No.: 1-90. Register of legal acts. https://e-tar.lt/portal/lt/legalAct/ceaa5620cf0111ed9978886e85107ab2

2.18. Deep renovations in residential non-residential buildings - Poland

The Poland does not have a dedicated methodology or catalogue only for deep renovations. The Poland has a summary document "Annex 3 to the EPCIP: Description of efficiency improvement measures and PEF ratio in networks" (Annex to the draft of the National energy and climate plan from 2023) issued by Ministry of Climate and Environment. The document provides an overview and notification details of Policy measures to achieve the required end-use energy savings referred to in Article 8 paragraph 1 of Directive 2023/1791. This includes description of measures along with the calculation methods, approaches or formulas.

Some of these measures support the topics of the new priority actions, so the description of their calculation methods can be partly used for the purposes of this deliverable or as inspiration.

In case of deep renovations, there are several measures that address this topic or at least address renovations in general. These are "The Thermomodernisation and Renovation Fund (TERMO programme)" and "Improving the Energy Efficiency of Housing Buildings". In the case of the public sector, this is measure "Energy efficient Public Sector" that supports investments in the comprehensive (deep) energy renovation of public sector buildings. These three measures address actions that are part of renovations. Therefore, projects achieving a certain complexity of renovation will fall under the category of deep renovation.

However, the problem is the very definition of deep renovation. Some information about deep renovations can be found in Poland Long-Term Building Renovation Strategy. It is worth noting that Poland, according to the document, significantly supports deep renovations. Anyway, according to definition: "*Deep energy renovation – energy renovation meeting the energy savings and thermal insulation requirements set forth by the Technical Conditions Regulation, and if technically and economically feasible, such that leads to achieving values of the annual non-renewable primary energy demand factor lower than those specified by the Technical Conditions Regulation*."

From the text: "*Firstly, energy renovation is divided into 'shallow' and 'deep', with deep renovation meaning that, once specific actions are completed, the building will attain performance consistent with the applicable requirements of Regulation of the Minister of Infrastructure of 12 April 2002 on the technical conditions to be met by buildings and their siting*[1]*, hereinafter also referred to as the Technical Conditions Regulation, so that it becomes a nearly zero-energy building.*"

Based on an initial analysis of Technical Conditions Regulation[2], it can be assumed that the scope of the renovations is to achieve the minimum energy requirements for buildings or to reach the standard applicable from 31 December 2020.

The strategy also states that some support programmes can also use other definitions (e. g. comprehensive deep energy renovation), which are then explained within the description of the instrument. For example, Regional Operational Programmes should give preference to activities aimed at achieving a 60% energy saving ratio and renovations with ratio below 25 % are not eligible (page 75-76). For the analysis of renovation scenarios, the strategy considers that deep renovations reach a PEF of up to 50 kWh/(m^2-year) (page 110). Thus, the definition of deep renovation does not seem to be clearly set.

Anyway, the above-mentioned measures use an energy audit as a tool to determine savings. The energy audit is anchored in the Energy Efficiency Act 2016, to which the Energy Efficiency Ordinance of the

[1] Journal of Laws 2019, item 1065, as amended. Details in section X Energy saving and thermal insulation (page 88) and Annex 2 on the thermal insulation requirements and other energy savings requirements.

[2] The Act refers to other regulations and standards that have not been analysed at this time. At the same time, further updates and regulations on technical requirements for buildings have been issued in recent years.

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Minister of Climate and Environment of 12 April 2022 amending the Ordinance on the detailed scope and manner of drawing up an energy efficiency audit and methods for calculating energy savings was issued in 2022.

Application area:

- End-use sectors – residential and public
- Buildings, both residential and non-residential
- Scope - building envelope and technical systems
- Primary and final energy

Boundary conditions:

- System boundary of the building, but no specifics known

For details see Annex 3 to the EPCIP: Description of efficiency improvement measures and PEF ratio in networks.

2.18.1 Calculation of Final Energy Savings

Two types of calculations can be used to calculate energy savings, as described below.

According to the measure "**The Thermomodernisation and Renovation Fund (TERMO programme)**":

> *"The final energy savings of each thermomodernisation project are determined by an ex-ante method (estimated savings), calculated and reported in the mandatory energy audit.*
>
> *Energy audit is a study defining the scope and technical parameters and economic energy renovation projects, indicating the optimal solution, in particular from the point of view of the costs of implementing the project and energy savings. The audit is the basis for obtaining the right to thermomodernisation premium and is also the basis for the construction project for the project being implemented.*
>
> *The amount of energy consumption is determined on the basis of an energy audit of the building, which sets out the basic parameters of the energy efficiency improvement project, including the average annual final energy savings expressed in toe per year."*

According to the measure "**Improving the Energy Efficiency of Housing Buildings**":

> *As regards the implementation of contracts under the Programme for the Improvement of Energy Efficiency in Housing Buildings, data on energy savings achieved at final customers are collected by the WFOŚiGW and by the JST. In view of the fact that the programme provides for the implementation of different projects, two possible methods of calculating energy savings are used: estimated and scaled savings.*
>
> *The amount of energy consumption is determined on the basis of an energy audit of the building or, where justified, a simplified energy audit of the building, i.e. the ecological effect indicator is calculated. On the basis of the above, the basic parameters of the energy efficiency improvement project shall be determined, including the average annual final energy savings.*
>
> *Final energy savings calculated on the basis of a simplified methodology for estimating the ecological effect, which is prepared each time for a given priority and on the basis of the Regulation of the Minister for Climate and the Environment of 22 November 2021 on reference values for final energy savings for energy efficiency improvement projects and on the method of calculating these values (Journal Of Laws 2021, item 2172). The relevant methodology has been developed taking into account the seasonal efficiency of heat generators and the non-renewable primary energy input factor. The data for the estimates were adopted on the basis of available literature and the Regulation of the Minister for Infrastructure and Development of 27 February 2015 on the methodology for determining the energy performance of a building*

or part of a building and energy performance certificates (Journal Of Laws 2015, item 376). On this basis, average indicators of achievement of the target (i.e. reduction in final energy consumption) in relation to 1 m² of floor area have been established for each of the projects implemented under the programme. In order to monitor progress towards the final energy savings target, the following formula shall be used:" (formula is below).

According to the measure "**Energy efficient Public Sector**":

"The amount of energy consumption is determined on the basis of an energy audit of the building or, where justified, a simplified energy audit of the building, i.e. the ecological effect indicator is calculated. On the basis of the above, the basic parameters of the energy efficiency improvement project shall be determined, including the average annual final energy savings.

...

In order to implement the project, a pre-implementation energy audit is required, which will determine the scope of the modernisation. The chosen option of the project must take into account the criterion of economic efficiency, i.e. the expenditure relating to the achieved energy demand reduction effects). Moreover, for projects other than the renovation of buildings, an energy efficiency audit for the project is required, e.g. for retrofitting lighting systems. The verification of the stated objectives and of the investment outcomes (beyond the ESCO formula) must be confirmed by an ex-post audit after the completed investment."

Formula

The formula according to the measure "**The Thermomodernisation and Renovation Fund (TERMO programme)**". The energy savings resulting from the TERMO programme shall be calculated on the basis of this formula. Correction factors for the rebound, spill-over, and free-rider effects are not taken in the account. This formula calculates first-year / annual savings.

$$O_{FTiR} = \sum_{i=1}^{N} o_i \qquad (33)$$

Table 51 – Parameters used in the formula for final energy savings

Parameter	Description
O_{FTiR}	Annual average final energy savings [ktoe/year]
o_i	Energy savings resulting from the energy audit for each of thermo-modernisation projects carried out [toe/year]
N	Number of investments [dmnl]

The formula according to the measure "**Improving the Energy Efficiency of Housing Buildings**". Correction factors for the rebound, spill-over, and free-rider effects are not taken in the account. This formula calculates first-year savings.

This formula calculates first-year savings.

$$R_F = A * \omega \qquad (34)$$

Table 52 – Parameters used in the formula for final energy savings

Parameter	Description
R_F	reference value for final energy savings [ktoe/year]
A	a controlled air temperature area [m²]

ω	final energy saving factor for the replacement of a heat source in a residential building [toe/m²]

"*Taking into account that the programme also assumes the possibility of implementing the project on the basis of an energy audit, which estimates... the final energy savings for the Housing Buildings Energy Efficiency Programme are calculated using the formula*":

$$O_{PEEBM} = R_f + other\ savings \tag{35}$$

Table 53 – Parameters used in the formula for final energy savings

Parameter	Description
O_{PEEBM}	final energy savings [ktoe/year]
Other savings	other final energy savings resulting from the estimated method, i.e. energy audits or energy efficiency carried out as part of the implementation of the project [ktoe/year]

The formula according to the measure "**Energy efficient Public Sector**" is not provided.

Standardized Calculation Values

No details provided for this methodology.

Standardised values may be included in other documents or legal documents as the calculation of the energy performance of buildings is carried out by energy audits, which are regulated by law.

2.18.2 Calculation of Primary Energy Savings

No details provided for this methodology.

Standardized Calculation Values

No details provided for this methodology.

Legal documents on energy audits may provide standardised values. For example Journal of Laws 2023, item 1220 on the announcement of the unified text of the Decree of the Minister of Energy on the detailed scope and manner of drawing up an energy efficiency audit and methods of calculating energy savings contains Values of the input coefficient of non-renewable primary energy for individual energy carriers.

2.18.3 Calculation of Greenhouse Gas Savings

No details provided for this methodology.

2.18.4 Overview of Costs Related to the Action

No details provided for this methodology.

2.18.5 Methodological Aspects

Methodology was taken from officially published documents and from legal documents. Document "Annex 3 to the EPCIP: Description of efficiency improvement measures and PEF ratio in networks" is available in English and Polish. Legislative documents are available in postal language.

For residential buildings

Within "TERMO programme":

- method of estimated savings based on the energy audit.

Within "Improving the Energy Efficiency of Housing Buildings":

- method of estimated savings based on the energy audit and
- method of scaled savings based on average values for the reference building based on a large sample of beneficiaries.

For public buildings:

According to the document, possible methods for calculating energy savings are:

- estimated savings based on the energy audit,
- scaled savings based on average values for the reference building (e.g. for lighting) with simplified energy audit and
- measured savings in case of projects other than thermomodernisation project, where the investment must be completed by an as-built energy efficiency audit verifying the investment assumptions.

The energy audit is anchored in the Energy Efficiency Act 2016, to which the Energy Efficiency Ordinance of the Minister of Climate and Environment of 12 April 2022 amending the Ordinance on the detailed scope and manner of drawing up an energy efficiency audit and methods for calculating energy savings was issued in 2022.

According to the Poland - Draft updated NECP 2021-2030 - Annex 3 "*The detailed methodology for the implementation of the energy audit is set out in the Regulation of the Minister for Infrastructure of 17 March 2009 on the detailed scope and forms of energy audit and part of the renovation audit, model audit sheets and the algorithm for assessing the cost-effectiveness of thermomodernisation project (Journal of Laws 2022, item 2816). The energy audit of the building shall take into account external factors affecting energy consumption. These factors concern, inter alia, the location (the climate zone of Poland) and the location of the building, the operating conditions. The energy audit takes into account energy losses (penetration and ventilation), energy needs for heating, cooling, lighting and domestic hot water, and solar and domestic gains. The energy audit defines the technical (energy savings) and economic impact of thermomodernisation projects. The energy audit shall be drawn up on the basis of relevant European standards, technical documentation of the building, on-site vision, available measurements of energy consumption and media, and the proposed improvements are based on the knowledge and practice of an energy auditor that takes into account the best available technologies and the costs of materials and services.*"

2.18.6 Bibliography

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2.19. Improvements in the thermal performance of residential buildings - Slovakia

These measures take into account significant single-family dwelling renovations. The primary goals of are to enhance the technical characteristics of building systems and the thermal performance of structures. Every project is evaluated separately. Major renovations must be carried out in accordance with an energy performance certificate. The building's minimum energy performance criteria should be met when it undergoes significant renovations if technically, operationally, and financially possible.

The calculation of total energy savings is based on the difference between the building's original and new conditions. Therefore, in single-family buildings, any savings generated by replacing existing light sources are excluded from the energy savings based on energy performance certificate data.

Deep renovation of apartment buildings requires a minimum of 35% reduction in heating requirements and takes into account improvements in the thermal performance of the building and other energy efficiency measures, such as the thermal insulating aspects of building cladding, investments in boiler rooms, exchanger stations, micro cogeneration, the regulation of central and local heating systems, secondary heat measurements, insulation of energy distribution systems, efficient heating sources, energy-efficient hot water production, the use of alternative energy sources in buildings, and measures derived from the Thermal Energy Act in relation to connection with district heating.

2.19.1 Calculation of Final Energy Savings

Formula

Energy savings are calculated ex ante depending on the building's original and new state. It is determined based on a project evaluation of the energy required for space heating, drawn up by a professionally competent person and according to technical standards (in particular STN EN ISO 13790/NA, STN EN 15603, STN 730540) by reference to the building's existing and proposed thermal performance, or by calculation based on a sample project. In apartment building, it is also possible to evaluate space heating and hot water distribution systems using ex post savings assessed after project execution, taking into consideration the amount to which the building is used, as well as climatic conditions.

Savings are calculated using the energy certifications database (INFOREG) as the difference between the building's energy requirements in its original condition and after renovation, based on the energy performance certificate. In the case of applying the calculation-based method to a sample project, the savings are estimated using the same specific energy savings per 1 m^2 of a family house as the sample project.

Estimates are used when no data on the initial condition of renovated buildings is available. Then, energy savings are calculated using the average energy requirements for the structure in its original condition (based on the year of construction and the technical specifications applicable to the specified building category at the time). The average number for the building's original condition corresponds to the upper limit of energy class D (Ministry of Transport and Construction Implementing Decree No. 364/2012).

The calculation of energy requirements for single-family houses takes into account the average degree days applicable throughout Slovakia, as well as other technical factors provided in the appropriate technical standards (namely STN EN ISO 13790/NA, STN EN 15603, and STN 730540).

For apartment buildings energy consumption data is provided by apartment building owners/managers in accordance with Section 11(2) of Act No 321/2014 on energy efficiency. Savings are calculated as the difference between average energy consumption over the three years prior to the implementation of the energy efficiency measure and energy consumption in the year following the implementation of the measure.

This formula calculates first-year savings.

$$\mathrm{ÚS}_{\mathrm{i}_{\mathrm{plan/actual}}} = (\mathrm{P}_{\mathrm{before}} - P_{after}) \times CPP \qquad (36)$$

Table 54 – Parameters used in the formula for final energy savings

Parameter	Description
$ÚS_{i\_plan/actual}$	Planned or actual final energy savings in the year of building renovation [kWh/a]
P_{before}	Energy requirement for the building prior to renovation [kWh/(m^2.a)]
P_{after}	Energy requirement for the building after renovation, by reference to energy performance certificate data [kWh/(m^2.a)]
CPP	Total floor area of the building in energy performance certificate [m^2]

In the case of building apartments, the energy requirement for the building prior to renovation is usually an average per last three years and the final anergy savings are accounted as a sum over all technical improvements. The total energy savings are calculated as the sum of the final energy savings of all technical measures provided.

2.19.2 Calculation of Primary Energy Savings

Formula

No details provided for this methodology.

Standardized Calculation Values

No details provided for this methodology.

2.19.3 Calculation of Greenhouse Gas Savings

Formula

No details provided for this methodology.

Standardized Calculation Values

No details provided for this methodology.

2.19.4 Overview of Costs Related to the Action

Cost-Effectiveness

No details provided for this methodology.

Standardized Values

No details provided for this methodology.

2.19.5 Methodological Aspects

The methodology is based on the official monitoring methodology by the Slovak Government to calculate energy savings obtained by qualified projects to receive subsidies. The Slovak Innovation and Energy Agency operates the energy efficiency monitoring system in accordance with Decision No. 1/2015 of the Slovak Republic's Ministry of Economy. It monitors primary and final energy consumption in sectors according to the Integrated National Energy and Climate Plan for 2021-2030 and evaluates energy efficiency measures for the purpose of demonstrating the implementation of the energy savings plan by 2030. The conditions for operating the monitoring system are set out in Act No. 321/2014 Coll. on Energy Efficiency and on Amendments to Certain Acts, which entered into force on 1 December 2014: https://minzp.sk/files/oblasti/politika-zmeny-klimy/ets/schema-sp-mof-teplarne-final_en.pdf

The energy efficiency monitoring system is intended to serve as a source of information for the state and the public. The state will obtain data on the basis of which it will be able to consider where to direct potential financial assistance. The public will be able to compare the real results of projects in a specific area in the accessible part. This methodology is only available in the Slovak language: https://www.economy.gov.sk/uploads/files/EirowzB0.pdf

2.19.6 Bibliography

The Slovak Innovation and Energy Agency (2023). Methodology tables for energy efficiency measures (by sector) for years 2021-2030. Bratislava: Ministry of Industry and Trade. Retrieved from: https://www.economy.gov.sk/uploads/files/EirowzB0.pdf

2.20. Improvements in the thermal performance of non-residential buildings - Slovakia

This calculation method is published separately for office buildings, hotels and restaurants, retail and wholesale, sports halls and other sports-related buildings, as well as public buildings such as hospitals and healthcare facilities, administration offices, schools, social and community facilities, cultural facilities, and emergency services. However, the calculating formula remains the same, and any differences are noted below.

Savings from improved thermal performance of buildings are only considered if a major renovation is undertaken in accordance with an issued energy performance. The measure considers energy savings, which indicate the difference in heat required for space heating between the original and new conditions of the structure.

The complex deep renovation also includes other related measures that are intended to reduce energy needs to the level of low-energy buildings, ultra-low-energy buildings, and buildings with almost zero energy needs. These include modernizing heating/air conditioning systems, hot water systems, lighting, and elevators to reduce energy consumption; installing measurement and control systems; switching to an efficient district heating system for the heat supply; insulating hot water distribution systems; supporting the replacement of outdated boilers in individual heating with more energy-efficient ones; installing renewable energy sources (RES) for energy consumption in the building; hydraulic regulation of heating, including thermoregulation valves; and hydraulic regulation and insulation of hot water distribution systems.

2.20.1 Calculation of Final Energy Savings

Formula

Methods for calculating energy savings include calculations based on a sample project or ex ante of projected savings comparing the original and new condition of a building. These calculations are based on a project evaluation of the heat required for space heating, which is prepared by a professionally competent person in accordance with technical standards (specifically STN EN ISO 13790/NA, STN EN 15603, and STN 730540). When a calculation based on a sample project is used, the savings are computed using the same energy savings per 1m^2 as in the sample project.

In specific cases, ex post-measured savings may also be provided. These are measured both before and after the project has been implemented, accounting for climatic impacts and facility utilization levels. After the project implementation is finished, the intermediary body continues monitoring on the real savings for five years.

When calculating energy savings for projects where measured data on energy consumption after the implementation of the measure is not yet available, expert estimates will be used in the preparation of the project by professionally qualified persons (energy auditors or designers) according to the type of project, namely, determining energy consumption after the implementation of the measure by applying proportional energy savings based on knowledge of the current state.

If there is no data on the initial state of renovated buildings, the average heat requirements for space heating that apply to the building in its original condition will be utilized to calculate energy savings, based on the year of construction and the technical norms in effect for the building category at the time. According to the Implementing Decree of the Ministry of Transport and Construction No

364/2012, the average value for the building's initial state corresponds to the highest limit of energy class D.

The average degree days that apply to Slovakia as a whole as well as other technical coefficients listed in the relevant technical standards—specifically, STN EN ISO 13790/NA, STN EN 15603, and STN 730540—are used to determine the amount of heat needed for space heating.

This formula calculates first-year savings.

$$ÚS_{i_{plan/actual}} = (P_{before} - P_{after}) \times CPP \tag{37}$$

Table 55 – Parameters used in the formula for final energy savings

Parameter	Description
$ÚS_{i\_plan/actual}$	Planned or actual final energy savings in the year of building renovation [kWh/a]
P_{before}	Heat required for the space heating of a building prior to renovation [kWh/(m^2.a)]
P_{after}	Heat required for space heating in the building after renovation after renovation, by reference to energy performance certificate data [kWh/(m^2.a)]
CPP	Total floor area of the building in energy performance certificate [m^2]

Standardized Calculation Values

No calculation values available for this methodology.

2.20.2 Calculation of Primary Energy Savings

Formula

No details provided for this methodology.

Standardized Calculation Values

No details provided for this methodology.

2.20.3 Calculation of Greenhouse Gas Savings

Formula

No details provided for this methodology.

Standardized Calculation Values

No details provided for this methodology.

2.20.4 Overview of Costs Related to the Action

Cost-Effectiveness

No details provided for this methodology.

Standardized Values

No details provided for this methodology.

2.20.5 Methodological Aspects

The methodology is based on the official monitoring methodology by the Slovak Government to calculate energy savings obtained by qualified projects to receive subsidies. The Slovak Innovation and Energy Agency operates the energy efficiency monitoring system in accordance with Decision No. 1/2015 of the Slovak Republic's Ministry of Economy. It monitors primary and final energy consumption in sectors according to the Integrated National Energy and Climate Plan for 2021-2030 and evaluates energy efficiency measures for the purpose of demonstrating the implementation of the energy savings plan by 2030. The conditions for operating the monitoring system are set out in Act No. 321/2014 Coll. on Energy Efficiency and on Amendments to Certain Acts, which entered into force on 1 December 2014: https://minzp.sk/files/oblasti/politika-zmeny-klimy/ets/schema-sp-mof-teplarne-final_en.pdf

The energy efficiency monitoring system is intended to serve as a source of information for the state and the public. The state will obtain data on the basis of which it will be able to consider where to direct potential financial assistance. The public will be able to compare the real results of projects in a specific area in the accessible part. This methodology is only available in the Slovak language: https://www.economy.gov.sk/uploads/files/EirowzB0.pdf

2.20.6 Bibliography

The Slovak Innovation and Energy Agency (2023). Methodology tables for energy efficiency measures (by sector) for years 2021-2030. Bratislava: Ministry of Industry and Trade. Retrieved from: https://www.economy.gov.sk/uploads/files/EirowzB0.pdf

2.21. Deep renovation of residential and non-residential buildings – Slovenia

The term “deep renovation” refers to the coordinated implementation of energy efficiency measures on the building envelope (e.g. facade, roof, floors, window replacement) and on technical building systems (e.g. heating, cooling, ventilation, air conditioning, domestic hot water systems), in such a way that all economically justified potential for energy renovation is utilized to the greatest technically feasible extent. The main advantage of a deep approach is the possibility to optimize individual measures collectively in a single, large-scale operation. This also optimizes energy savings, which is not achievable with partial energy renovations or uncoordinated implementation of individual components. The energy savings resulting from a deep renovation of a building are calculated using the method defined by the regulation governing efficient energy use in buildings. The savings are determined as the difference in annual heating energy demand of the building before and after the renovation.

2.21.1 Calculation of Final Energy Savings

Formula

The energy savings are assessed based on the type of new heating system (e.g. boiler or heat pump – HP), or taking into account a deep renovation of the thermal substation (TS), or by connecting the building to a district heating (DH) system, specifically:

– when a boiler is used in the new heating system:

$$TFES_{dr,boiler} = \left(\frac{RTE_{old}}{\eta_{old}} - \frac{RTE_{new}}{\eta_{new}}\right) \cdot A \qquad (38)$$

– when a heat pump is used in the new heating system:

<u>Conventional heat pump</u>

$$TFES_{dr,HP} = \left(\frac{RTE_{old}}{\eta_{old}} - \frac{K_{EL} \cdot RTE_{new}}{\eta_{HP} \cdot SPF}\right) \cdot A \qquad (39)$$

<u>Gas and Sorption gas heat pump</u>

$$TFES_{dr,HP} = \left(\frac{RTE_{old}}{\eta_{old}} - \frac{RTE_{new}}{\eta_{HP} \cdot SPF}\right) \cdot A \qquad (40)$$

Hybrid heat pump

$$TFES_{dr,HP} = \left(\frac{RTE_{old}}{\eta_{old}} - RTE_{new} \cdot \left(\frac{0.55 \cdot K_{EL}}{\eta_{HP} \cdot SPF} + \frac{0.45}{\eta_{new,boiler}}\right)\right) \cdot A \qquad (41)$$

– when a comprehensively renovated thermal substation (TS) is used in the new heating system:

$$TFES_{dr,TS} = \left(\frac{RTE_{old}}{\eta_{TS,old}} - \frac{RTE_{new}}{\eta_{TS,new}}\right) \cdot A \qquad (42)$$

– when the building is connected to the district heating (DH) system:

$$TFES_{dr,DH} = \left(\frac{RTE_{old}}{\eta_{old}} - \frac{RTE_{new}}{\eta_{DH}}\right) \cdot A \qquad (43)$$

All formulas are used to calculate the yearly savings.

Table 56 – Parameters used in the formula for final energy savings

Parameter	Description
$TFES_{(dr,boiler)}$	Total final energy savings [kWh/year] due to deep renovation of the building, if a hot water boiler is used in the new heating system
$TFES_{(dr,HP)}$	Total final energy savings [kWh/year] due to deep renovation of the building, if a heat pump is used in the new heating system
$TFES_{(dr,TS)}$	Total final energy savings [kWh/year] due to deep renovation of the building, if a comprehensively renovated thermal substation (TS) is used in the new heating system
$TFES_{(dr,DH)}$	Total final energy savings [kWh/year] due to deep renovation of the building, if the building is connected to the district heating (DH) system
RTE_{old}	Annual heating demand of the building, calculated for the state before deep energy renovation, in accordance with the method defined by the regulation governing efficient energy use in buildings, or using the PHPP methodology (Detailed methodological calculation of the building's energy performance characteristics, in accordance with SIST EN ISO 52016-1: 2017 (Passive House Institute (PHI), Darmstadt, Germany)) [kWh/m²year]
RTE_{new}	Annual heating demand of the building, calculated for the state after deep energy renovation, in accordance with the method defined by the regulation governing efficient energy use in buildings, or using the PHPP methodology (Detailed methodological calculation of the building's energy performance characteristics, in accordance with SIST EN ISO 52016-1: 2017 (Passive House Institute (PHI), Darmstadt, Germany)) [kWh/m²year]
K_{EL}	Conversion factor for electricity
SPF	Seasonal performance factor of the heat pump (SPF)
η_{old}	The annual operating efficiency of the old (replaced) heating system is based on the assumption that it is an old hot water boiler. The efficiency value is determined according to DIN 4702-8, taking into account not only the average standardized efficiency for old boilers, but also the efficiency of the pipe network (distribution) and the efficiency of the control system: $$\eta_{old} = \eta_k \cdot \eta_c \cdot \eta_r = 0.72 \cdot 0.97 \cdot 0.94 = 0.66$$

<table>
<tr><td></td><td>Where η_k is the standardized efficiency of the boiler, which takes into account the actual operating characteristics of the boiler (actual load), is defined as the ratio between the annual energy consumed (Q_H) and the annual heat output of the boiler (Q_P) under partial load conditions of the heating system. The standardized value for an old boiler is 0.72 (DIN 4702-8);
η_c is efficiency of the pipe distribution system – the standardized value for the old system is 0.97 (DIN 4702-8); and η_r is control system efficiency – the standardized value for the old system is 0.94 (DIN 4702-8).</td></tr>
<tr><td>η_{new}</td><td>Annual operating efficiency of the new boiler heating system according to DIN 4702-8 is calculated using the following equation:

$$\eta_{new} = \eta_k \cdot \eta_c \cdot \eta_r$$

where the appropriate values from the table below are used.
<table>
<tr><td>Boiler type</td><td>Fuel type</td><td>η_k</td><td>η_c</td><td>η_r</td><td>η_{new}</td></tr>
<tr><td>Low-temperature</td><td>LFO, NG, Wood biomass</td><td>0.90</td><td>0.98</td><td>0.95</td><td>0.84</td></tr>
<tr><td>Condensing boiler</td><td>LFO</td><td>0.99</td><td>0.98</td><td>0.95</td><td>0.92</td></tr>
<tr><td>Condensing boiler0.90</td><td>NG, LPG</td><td>1.04</td><td>0.98</td><td>0.95</td><td>0.97</td></tr>
</table></td></tr>
<tr><td>η_{HP}</td><td>Annual operating efficiency of the new heating system with a heat pump – the standardized value is 0.93.</td></tr>
<tr><td>$\eta_{TS,new}$</td><td>Annual operating efficiency of the new heating system with a condensing boiler as part of a hybrid heat pump – the standardized value from the above table is 0.97.</td></tr>
<tr><td>$\eta_{TS,old}$</td><td>Annual operating efficiency of the old heating system with a thermal substation (TP) – according to the equation below, the standardized value is 0.82.</td></tr>
<tr><td>η_{DH}</td><td>Annual operating efficiency of the new heating system with a comprehensively renovated thermal substation (TP) – according to the equation below, the standardized value is 0.93.</td></tr>
<tr><td>A</td><td>Conditioned floor area [m²] of the building.</td></tr>
</table>

Standardized Calculation Values

The table below presents default and standardized values for key parameters used in energy performance calculations of heating systems, particularly for assessing energy savings from deep renovation projects. These values are based on national and international guidelines (e.g., DIN 4702-8, ISO standards) and represent typical efficiencies and assumptions for various system configurations.

Table 57 – Indicative values for calculation of final energy savings

<table>
<tr><th>Parameter</th><th>Value</th><th>Unit</th></tr>
<tr><td>K_{EL}</td><td>The default value is 2; in the case of on-site electricity generation, the value is 1</td><td>/</td></tr>
<tr><td>SPF</td><td><table>
<tr><td>HP type</td><td>Conventional HP</td><td>Gas HP</td><td>Sorption gas HP</td><td>Hybrid HP</td></tr>
<tr><td>air-to-water</td><td>2.8</td><td>1.5</td><td>1.2</td><td>3.6</td></tr>
<tr><td>water-to-water</td><td>3.5</td><td>-</td><td>1.6</td><td>-</td></tr>
<tr><td>ground-to-water</td><td>4.0</td><td>-</td><td>1.6</td><td>-</td></tr>
</table></td><td>/</td></tr>
<tr><td>η_{old}</td><td>0.66</td><td>/</td></tr>
</table>

<table>
<tr><td rowspan="4">η_{new}</td><td>Boiler type</td><td>Fuel type</td><td>η_{new}</td><td rowspan="4">/</td></tr>
<tr><td>Low-temperature</td><td>LFO, NG, Wood biomass</td><td>0.84</td></tr>
<tr><td>Condensing boiler</td><td>LFO</td><td>0.92</td></tr>
<tr><td>Condensing boiler0.90</td><td>NG, LPG</td><td>0.97</td></tr>
<tr><td>η_{HP}</td><td colspan="3">0.93</td><td>/</td></tr>
<tr><td>$\eta_{TS,new}$</td><td colspan="3">0.97</td><td>/</td></tr>
<tr><td>$\eta_{TS,old}$</td><td colspan="3">0.82</td><td>/</td></tr>
<tr><td>η_{DH}</td><td colspan="3">0.93</td><td>/</td></tr>
</table>

2.21.2 Calculation of Greenhouse Gas Savings

Formula

Savings or reduction of CO_2 emissions (GHGSAV) is calculated using the following equations:

– when a boiler is used in the new heating system:

$$GHGSAV_{dr,boiler} = \left(\frac{RTE_{old}}{\eta_{old}} \cdot ef_{old} - \frac{RTE_{new}}{\eta_{new}} \cdot ef_{new}\right) \cdot A \tag{44}$$

– when a heat pump is used in the new heating system:

<u>Conventional, gas and sorption heat pump</u>

$$GHGSAV_{dr,HP} = \left(\frac{RTE_{old}}{\eta_{old}} \cdot ef_{old} - \frac{RTE_{new}}{\eta_{HP} \cdot SPF} \cdot ef_{HP}\right) \cdot A \tag{45}$$

<u>Hybrid heat pump</u>

$$GHGSAV_{HP} = \left(\frac{RTE_{old}}{\eta_{old}} \cdot ef_{old} - RTE_{new} \cdot \left(\frac{0.55 \cdot ef_{HP}}{\eta_{HP} \cdot SPF} + \frac{0.45 \cdot ef_{new}}{\eta_{new,boiler}}\right)\right) \cdot A \tag{46}$$

– when a comprehensively renovated thermal substation (TS) is used in the new heating system:

$$GHGSAV_{dr,TS} = \left(\frac{RTE_{old}}{\eta_{TS,old}} - \frac{RTE_{new}}{\eta_{TS,new}}\right) \cdot ef_{TS} \cdot A \tag{47}$$

– when the building is connected to the district heating (DH) system:

$$GHGSAV_{dr,DH} = \left(\frac{RTE_{old}}{\eta_{old}} - \frac{RTE_{new}}{\eta_{DH}}\right) \cdot ef_{DH}\, A \tag{48}$$

Table 58 – Parameters used in the formula for greenhouse gas savings

Parameter	Description
ef_{old}	Emission factor [kg CO_2/kWh] for the fuel or energy source used in the old heating system, as defined in national regulation.
ef_{new}	Emission factor [kg CO_2/kWh] for the fuel or energy source used in the new heating system with a boiler, as defined in national regulation.

ef_{HP}	Emission factor [kg CO_2/kWh] for the fuel or energy source used for the heat pump (HP), as defined in national regulation.
ef_{TS}	Emission factor [kg CO_2/kWh] for the fuel or energy source used in the new heating system with a condensing boiler as part of a hybrid heat pump, as defined in national regulation.
ef_{DH}	Emission factor [kg CO_2/kWh] for the fuel or energy source used for district heating (DH), as defined in national regulation.

Standardized Calculation Values

The tables below present standardized CO_2 emission factors used for calculating emission reductions in household sector. These values apply to different energy sources—including fuels, electricity, and district heating—as well as transport fuels. They serve as the basis for consistent and comparable estimations of carbon savings in building renovation and energy efficiency projects.

Table 59 – Indicative values for calculation of greenhouse gas savings

Parameter	Value	Unit
Natural Gas	0.20	kg CO_2/kWh
Light fuel oil	0.27	kg CO_2/kWh
Wood Biomass	0.00	kg CO_2/kWh
Electricity	0.49	kg CO_2/kWh
District heating	0.32	kg CO_2/kWh
Sectoral average for fuel	0.09	kg CO_2/kWh
Motor gasoline	69.30	t CO_2/TJ
Diesel fuel	74.10	t CO_2/TJ

2.21.3 Overview of Costs Related to the Action

No information on cost effectiveness available for this methodology.

2.21.4 Methodological Aspects

To use this method, comprehensive data on the condition of the building before and after renovation is required, along with a precise and complete calculation of the building's energy performance.

If possible, data should be collected on the heating systems (both old and new), specifically:

– the type of energy source used by the old and new systems (natural gas, wood, electricity, etc.),

– the type of the new heating system (condensing technology, type or kind of heating elements, etc.),

– the age of the replaced heating equipment (boilers).

Based on more detailed data, CO_2 emissions savings calculations can be further differentiated according to the type of energy source and the type or kind of heating equipment.

The methodology is included in the national catalogue (Rules on the methods for determining energy savings) in Slovene.

2.21.5 Bibliography

Uradni list RS, št. 57/21 – ZURE, Rules on the methods for determining energy savings, p. 1–5: https://pisrs.si/pregledPredpisa?id=PRAV14191

3. IT Equipment in Data Centres

3.1. Energy assessment (according to legislature) - Data centres - IT equipment– Czech Republic

The Czech Republic does not have a dedicated methodology or catalogue only for calculation of energy savings from IT equipment in Data centres. The Czech Republic has a summary document "Methodology for reporting energy savings from alternative policy measure pursuant to Article 7(9) of the Energy Efficiency Directive (2012/27/EU) [Update 2020]" issued by the Czech Ministry of Industry and Trade. The document provides an overview of methodologies and approaches for reporting energy savings for different types and categories of measures.

It includes a list of policy measures (in particular grant programmes on which the Czech Republic relies most extensively), showing the method of calculating savings, the lifetime of savings and the savings reporting tool.

The savings reporting tools include 5 main categories:

1. Building Energy Performance Certificate
2. Energy Assessment
3. Energy audit
4. Energy service contract with guarantee
5. Other - independent body reports (for transport) and other expert assessments

Individual support programmes provide further details, but the principle is more or less the same in all cases and depends mainly on the above-mentioned tools.

Anyway, the first 4 categories are mainly governed by legislation and technical standards (mostly harmonised standards). The overarching legal document is Law Act No 406/2000 on energy management (but this one only gives general requirements), which is followed by a number of decrees that already introduce specific procedures, calculations and methods, or specify which technical standards are to be used. Energy performance certificates are governed by Decree 264/2020 on the energy performance of buildings, Energy assessments are governed by Decree No. 141/2021 Coll. on energy assessment and on data recorded in the Energy Consumption Monitoring System and Energy audits are anchored in Decree No. 140/2021 Coll. on energy audit.

Energy assessments and energy audits can be used to calculate savings from equipment in data centres. At the same time, the energy efficiency of equipment must comply with other legislation, such as eco-design requirements.

Application area:

All end-use sectors

Equipment

Scope – all technologies

Boundary conditions:

System boundary of the building – data centre

3.1.1 Calculation of Final Energy Savings

The calculation of energy performance shall follow the procedures and technical standards set out in the legislation, in particular in Decree No. 141/2021 Coll. on energy assessment and on data recorded in the Energy Consumption Monitoring System and in Decree No. 140/2021 Coll. on energy audit. Decrees may refer to technical standards (harmonised and national).

The calculation for IT equipment will work mainly with electricity energy carrier, however a general formula is presented below.

Formula

The formula below reflects the general procedure for determining the savings from the replacement of IT equipment in data centres.

This formula calculates first-year (annual) energy savings.

$$\begin{aligned} TFES &= (FEC_{before} - FEC_{after}) \times rb \times so \times fr \times lt \\ &= (\sum_{i=1}^{n} E_{i,before} - \sum_{i=1}^{n} E_{i,after}) \times rb \times so \times fr \times lt \end{aligned} \quad (49)$$

(This is not an official formula, but just a formula derived from commonly used principles for the needs of this deliverable.)

Table 60 – Parameters used in the formula for final energy savings

Parameter	Description
TFES	Total final energy savings [kWh/a OR kWh/1000h of operation]
FEC_{before}	Final energy consumption before implementation of the action [kWh/a OR kWh/1000h of operation]
FEC_{after}	Final energy consumption after implementation of the action [kWh/a OR kWh/1000h of operation]
$E_{i,\ before}$	Final energy consumption of an individual energy carrier (mainly electricity) before implementation of the action [kWh/a OR kWh/1000h of operation]
$E_{i,\ after}$	Final energy consumption of an individual energy carrier (mainly electricity) before implementation of the action [kWh/a OR kWh/1000h of operation]
rb	Factor to calculate a rebound effect (=1) [dmnl]
so	Factor to calculate a spill-over effect (=1) [dmnl]
fr	Factor to calculate a free-rider effect (=1) [dmnl]
lt	Factor for the lifetime of savings (=1) [dmnl]

Standardized Calculation Values

No calculation values available for this methodology.

3.1.2 Calculation of Primary Energy Savings

Formula

Same as for final energy in chapter 3.1.1, only the relevant primary energy factors are applied to the individual energy carriers. Consumption for IT equipment will be mainly in electricity.

The following formula is used to calculate the annual primary energy savings:

$$\begin{aligned} \mathrm{APES} = {} & (FEC_{before} - FEC_{after}) \times rb \times so \times fr \times lt \\ &= (\sum_{i=1}^{n} E_{i,before} * PEF_i - \sum_{i=1}^{n} E_{i,after} * PEF_i) \times rb \times so \times fr \times lt \end{aligned} \quad (50)$$

(This is not an official formula, but just a formula derived from commonly used principles for the needs of this deliverable.)

Table 61 – Parameters used in the formula for primary energy savings

Parameter	Description
APES	Annual primary energy savings [kWh/a OR kWh/1000h of operation]

PEC_{before}	Primary energy consumption before implementation of the action [kWh/a OR kWh/1000h of operation]
PEC_{after}	Primary energy consumption after implementation of the action [kWh/a OR kWh/1000h of operation]
$E_{i,\ before}$	Final energy consumption of an individual energy carrier (mainly electricity) before implementation of the action [kWh/a OR kWh/1000h of operation]
$E_{i,\ after}$	Final energy consumption of an individual energy carrier (mainly electricity) before implementation of the action [kWh/a OR kWh/1000h of operation]
PEF_i	Primary Energy Factor of an individual energy carrier (mainly electricity) [dmnl]
rb	Factor to calculate a rebound effect (=1) [dmnl]
so	Factor to calculate a spill-over effect (=1) [dmnl]
fr	Factor to calculate a free-rider effect (=1) [dmnl]
lt	Factor for the lifetime of savings (=1) [dmnl]

Standardized Calculation Values

The Decree 264/2020 on the energy performance of buildings sets out Primary Energy Factors from non-renewable energy sources for individual energy carriers.

The Ministry of Industry and Trade lists primary energy factors for total primary energy on its website (https://mpo.gov.cz/cz/energetika/uspory-energie/aktuality/stanovisko-ministerstva-prumyslu-a-obchodu-k-vypoctu-spotreby-primarni-energie-v-energetickem-posudku--276396/).

3.1.3 Calculation of Greenhouse Gas Savings

The calculation of the emission production and subsequent GHG savings is based on the calculation of the final energy consumption of the IT equipment, where the energy carriers (mainly for electricity) are multiplied by emission factors.

Formula

The following formula is used to calculate the annual GHG emissions:

$$\begin{aligned} GHGSAV &= (GHG_{before} - GHG_{after}) \times rb \times so \times fr \times lt \\ &= \left(\sum_{i=1}^{n} E_{i,before} * f_{\mathrm{GHG,i}} - \sum_{i=1}^{n} E_{i,after} * f_{\mathrm{GHG,i}}\right) \times rb \times so \times fr \times lt \end{aligned} \quad (51)$$

(This is not an official formula, but just a formula derived from commonly used principles for the needs of this deliverable.)

Table 62 – Parameters used in the formula for greenhouse gas savings

Parameter	Description
GHGSAV	Greenhouse gas savings [t CO_2 / year]
GHG_{before}	Greenhouse gas production before implementation of the action [t CO_2 /year]
GHG_{after}	Greenhouse gas production after implementation of the action [t CO_2 / year]
$E_{i,\ before}$	Final energy consumption of an individual energy carrier (e.g. electricity, natural gas, coal, ambient energy, etc.) before implementation of the action [MWh/a]
$E_{i,\ after}$	Final energy consumption of an individual energy carrier (e.g. electricity, natural gas, coal, ambient energy, etc.) before implementation of the action [MWh/a]
$f_{GHG,i}$	Emission factor of an individual energy carrier (e.g. electricity, natural gas, coal, ambient energy, etc.) [t CO_2/MWh]
Rb	Factor to calculate a rebound effect (=1) [dmnl]
So	Factor to calculate a spill-over effect (=1) [dmnl]
Fr	Factor to calculate a free-rider effect (=1) [dmnl]

Lt	Factor for the lifetime of savings (=1) [dmnl]

Standardized Calculation Values

There is a table with emission coefficients in Annex 9 of the Decree No. 141/2021 Coll. on energy assessment and on data recorded in the Energy Consumption Monitoring System (same values are provided in Annex 8 of the Decree 140/2021 Coll. on energy audit.

3.1.4 Overview of Costs Related to the Action

No Overview of Costs Related available for this methodology.

3.1.5 Methodological Aspects

No details provided for this methodology.

3.1.6 Bibliography

Collective of authors. (2020). Methodology for reporting energy savings from alternative policy measures. *Prague: Ministry of Industry and Trade*. Retrieved from: https://mpo.gov.cz/cz/energetika/energeticka-ucinnost/strategicke-dokumenty/metodika-vykazovani-uspor-energie-z-alternativnich-politickych-opatreni--176331

4. Cooling in Data Centres

4.1. Energy assessment (according to legislature) - Data centres - Cooling– Czech Republic

Methodology is based on the same principle as described in chapter 3.1.

All of the listed tools can be used to calculate the energy savings from cooling, but the most common will be the use of energy assessments.

Application area:

- All end-use sectors
- Scope – all building technologies

Boundary conditions:

- System boundary of the building – data centre

4.1.1 Calculation of Final Energy Savings

The calculation of energy performance shall follow the procedures and technical standards set out in the legislation, in particular in Decree No. 141/2021 Coll. on energy assessment and on data recorded in the Energy Consumption Monitoring System and in Decree No. 140/2021 Coll. on energy audit. Decrees may refer to technical standards (harmonised and national).

The calculation for cooling systems will work mainly with electricity and possibly natural gas energy carriers, however a general formula is presented below.

Formula

The formula below reflects the general procedure for determining the savings from cooling systems in data centres.

This formula calculates first-year (annual) energy savings.

$$TFES = (FEC_{before} - FEC_{after}) \times rb \times so \times fr \times lt$$
$$= (\sum_{i=1}^{n} E_{i,before} - \sum_{i=1}^{n} E_{i,after}) \times rb \times so \times fr \times lt \qquad (52)$$

(This is not an official formula, but just a formula derived from commonly used principles for the needs of this deliverable.)

Table 63 – Parameters used in the formula for final energy savings

Parameter	Description
TFES	Total final energy savings [kWh/a]
FEC_{before}	Final energy consumption before implementation of the action [kWh/a]
FEC_{after}	Final energy consumption after implementation of the action [kWh/a]
$E_{i, before}$	Final energy consumption of an individual energy carrier (mainly electricity) before implementation of the action [kWh/a]
$E_{i, after}$	Final energy consumption of an individual energy carrier (mainly electricity) before implementation of the action [kWh/a]
rb	Factor to calculate a rebound effect (=1) [dmnl]
so	Factor to calculate a spill-over effect (=1) [dmnl]
fr	Factor to calculate a free-rider effect (=1) [dmnl]
lt	Factor for the lifetime of savings (=1) [dmnl]

Standardized Calculation Values

No calculation values available for this methodology.

4.1.2 Calculation of Primary Energy Savings

Formula

Same as for final energy in chapter 4.1.1, only the relevant primary energy factors are applied to the individual energy carriers. Consumption for IT equipment will be mainly in electricity.

The following formula is used to calculate the annual primary energy savings:

$$\text{APES} = (FEC_{before} - FEC_{after}) \times rb \times so \times fr \times lt$$
$$= (\sum_{i=1}^{n} E_{i,before} * PEF_i - \sum_{i=1}^{n} E_{i,after} * PEF_i) \times rb \times so \times fr \times lt \quad (53)$$

(This is not an official formula, but just a formula derived from commonly used principles for the needs of this deliverable.)

Table 64 – Parameters used in the formula for primary energy savings

Parameter	Description
APES	Annual primary energy savings [kWh/a]
PEC_{before}	Primary energy consumption before implementation of the action [kWh/a]
PEC_{after}	Primary energy consumption after implementation of the action [kWh/a]
$E_{i, before}$	Final energy consumption of an individual energy carrier (mainly electricity) before implementation of the action [kWh/a]
$E_{i, after}$	Final energy consumption of an individual energy carrier (mainly electricity) before implementation of the action [kWh/a]
PEF_i	Primary Energy Factor of an individual energy carrier (mainly electricity) [dmnl]
rb	Factor to calculate a rebound effect (=1) [dmnl]
so	Factor to calculate a spill-over effect (=1) [dmnl]
fr	Factor to calculate a free-rider effect (=1) [dmnl]
lt	Factor for the lifetime of savings (=1) [dmnl]

Standardized Calculation Values

The Decree 264/2020 on the energy performance of buildings sets out Primary Energy Factors from non-renewable energy sources for individual energy carriers.

The Ministry of Industry and Trade lists primary energy factors for total primary energy on its website (https://mpo.gov.cz/cz/energetika/uspory-energie/aktuality/stanovisko-ministerstva-prumyslu-a-obchodu-k-vypoctu-spotreby-primarni-energie-v-energetickem-posudku--276396/).

4.1.3 Calculation of Greenhouse Gas Savings

The calculation of the emission production and subsequent GHG savings is based on the calculation of the final energy consumption of the cooling system, where the energy carriers (mainly electricity, possibly natural gas) are multiplied by emission factors.

Formula

The following formula is used to calculate the annual GHG emissions*:*

$$GHGSAV = (GHG_{before} - GHG_{after}) \times rb \times so \times fr \times lt = (\sum_{i=1}^{n} E_{i,before} * f_{\mathrm{GHG,i}} - \sum_{i=1}^{n} E_{i,after} * f_{\mathrm{GHG,i}}) \times rb \times so \times fr \times lt \qquad (54)$$

(This is not an official formula, but just a formula derived from commonly used principles for the needs of this deliverable.)

Table 65 – Parameters used in the formula for greenhouse gas savings

Parameter	Description
GHGSAV	Greenhouse gas savings [t CO_2 / year]
GHG_{before}	Greenhouse gas production before implementation of the action [t CO_2 /year]
GHG_{after}	Greenhouse gas production after implementation of the action [t CO_2 / year]
$E_{i,\ before}$	Final energy consumption of an individual energy carrier (e.g. electricity, natural gas, coal, ambient energy, etc.) before implementation of the action [MWh/a]
$E_{i,\ after}$	Final energy consumption of an individual energy carrier (e.g. electricity, natural gas, coal, ambient energy, etc.) before implementation of the action [MWh/a]
$f_{GHG,i}$	Emission factor of an individual energy carrier (e.g. electricity, natural gas, coal, ambient energy, etc.) [t CO_2/MWh]
Rb	Factor to calculate a rebound effect (=1) [dmnl]
So	Factor to calculate a spill-over effect (=1) [dmnl]
Fr	Factor to calculate a free-rider effect (=1) [dmnl]
Lt	Factor for the lifetime of savings (=1) [dmnl]

Standardized Calculation Values

There is a table with emission coefficients in Annex 9 of the Decree No. 141/2021 Coll. on energy assessment and on data recorded in the Energy Consumption Monitoring System (same values are provided in Annex 8 of the Decree 140/2021 Coll. on energy audit.

For details see chapter 0.

4.1.4 Overview of Costs Related to the Action

No Overview of Costs Related available for this methodology.

4.1.5 Methodological Aspects

No details provided for this methodology.

4.1.6 Bibliography

Collective of authors. (2020). Methodology for reporting energy savings from alternative policy measures. *Prague: Ministry of Industry and Trade*. Retrieved from: https://mpo.gov.cz/cz/energetika/energeticka-ucinnost/strategicke-dokumenty/metodika-vykazovani-uspor-energie-z-alternativnich-politickych-opatreni--176331

4.2. Hot aisle and cold aisle containment system in a data centre – France

The methodology is applied for hot aisle and cold aisle containment systems in internal or hosting Data Centres, whether new or existing.

Note: A Data Centre is a physical site that houses IT infrastructure (servers, routers, switches, hard drives, etc.) responsible for storing and distributing data over an internal network or via the Internet. This does not refer to IT rooms where operators manually enter or process data.

The rearrangement or replacement of server racks does not qualify for a new issuance of energy savings certificates (CEE) for hot and cold aisle containment if the initial or a previous setup had already implemented such containment.

In the case of a Data Centre expansion, only the new section is eligible for CEE issuance, based on the electrical power required for cooling production for the expansion, as determined in the dimensioning study.

Conditions for the Issuance of Certificates:

- The installation must be carried out by a professional.
- The containment system must separate hot and cold airflow using rigid and airtight partitions.
- After installation, the supply air temperature must be measured at each supply point and must not be lower than 22°C.

The installation of the containment system must be based on a preliminary dimensioning study, which must be:

- Conducted before installation.
- Dated and signed by a professional or an engineering firm.

This study must include:

- The company name and address of the beneficiary.
- The site address, if different from the beneficiary's address.
- A description of IT infrastructure before and after the works, including air conditioning systems (cooling units and cold battery power).
- Airflow modeling simulations before and after the works.
- Hotspot locations before and after the works.
- A dated layout plan of server racks and associated containment systems.
- The supply air temperature before and after the works and the measurement points for these temperatures.

The installation must follow the recommendations outlined in the dimensioning study.

The proof of completion must confirm:

- The installation of a hot and cold aisle containment system using rigid and airtight partitions.
- The supply air temperature before and after the works.

If these details are not provided, the proof must instead include:

- The brand and reference of the installed equipment.
- A document from the manufacturer certifying that the installed equipment (brand and reference) is a rigid and airtight partition system enabling hot and cold aisle containment.
- The supply air temperature before and after the works.

The specific supporting document for this operation is the preliminary dimensioning study, which defines the containment system setup for the installation.

4.2.1 Calculation of Final Energy Savings

Formula

The following equation calculates cumulative final energy savings.

$$TFES = S_{PT} \times \Delta T \times P \tag{55}$$

The parameters used in the formula for final energy savings are presented in Table 66.

Table 66 – Parameters used in the formula for final energy savings

Parameter	Description
$TFES$	Total final energy savings [kWh]
S_{PT}	Savings per nominal power and temperature gain [kWh/(kW°C)]
ΔT	Setpoint temperature gain [°C]
P	Nominal electrical power of the cooling unit (or cooling coils) [kW]

The electrical power to be considered is the one specified on the nameplate of the compressor(s) or, if unavailable, the power indicated in a manufacturer-issued document.

In cases where the cooling production unit does not exclusively supply the Data Centre, the nominal electrical power to be considered is that of the installed cooling coil(s).

ΔT represents either the average increase in the setpoint temperature (°C) of the chilled water production supplying the water loop of the CRAC (Computer Room Air Conditioning) units or the average increase in the cooling coil temperature (°C) for direct expansion systems.

Standardized Calculation Values

Table 67 present the indicative values for the calculation of final energy savings.

Table 67 – Indicative values for the savings in kWh cumac per m² of insulation in different climatic regions and fuels

Parameter	Value	Unit
S_{PT}	1500	kWh/(kW°C

4.2.2 Calculation of Primary Energy Savings

Formula

The methodology does not include any formula to calculate primary energy savings.

Standardized Calculation Values

No calculation values are available for this methodology.

4.2.3 Calculation of Greenhouse Gas Savings

Formula

The methodology does not include any formula to calculate Greenhouse Gas Savings.

Standardized Calculation Values

No calculation values are available for this methodology.

4.2.4 Overview of Costs Related to the Action

Cost-Effectiveness

No information on cost-effectiveness is available for this methodology.

Standardized Values

No calculation values are available for this methodology.

4.2.5 Methodological Aspects

The original document is in French, being an official document from the Ministry of Ecological Transition published with the reference BAR-TH-153.

In France the energy savings targets, and action are recorded in kWh cumac of final energy, cumac being the contraction of "cumulative and actualized" and given by the following equation.

$$kWh_{cumac} = TFES \times DC \quad (56)$$

The parameters used in the formula are presented in Table 68 and the indicative values are in Table 69.

Table 68 – Parameters used in the formula for final energy savings

Parameter	Description
kWh_{cumac}	Total final energy savings [kWh]
DC	Discount coefficient

Table 69 – Indicative values for calculation of energy savings certificates

Parameter	Value
Lifetime	15 [years]
$DC(4\%)$	11.118

4.2.6 Bibliography

Opérations standardisées d'économies d'énergie | Ministère du Partenariat avec les territoires et de la Décentralisation Ministère de la Transition écologique, de l'Énergie, du Climat et de la Prévention des risques Ministère du Logement et de la Rénovation urbaine. (n.d.). Ministère Du Partenariat Avec Les Territoires Et De La Décentralisation Ministère De La Transition Écologique, De L'Énergie, Du Climat Et De La Prévention Des Risques Ministère Du Logement Et De La Rénovation Urbaine. https://www.ecologie.gouv.fr/politiques-publiques/operations-standardisees-deconomies-denergie#scroll-nav__7

4.3. Freecooling by cooling water replacing a chiller for air conditioning – France

The methodology is applied for the installation or integration of a freecooling systems using cooling water into an existing or new air conditioning system, replacing a chiller unit. This system enables the cooling of a hydronic air conditioning network by utilizing outside air.

The system may consist of:

- A new air-cooled cooler, with or without a heat exchanger.
- A new cooling tower (TAR) with heat exchangers.

In all cases, the system must include automation and regulation controls.

Conditions for the Issuance of Certificates:

- The installation must be carried out by a professional.
- The installed freecooling system must be sized to cover 100% of the nominal cooling demand whenever the outside temperature is at least 3°C lower than the setpoint temperature.

The installation of the freecooling system must be based on a preliminary dimensioning study, which must be:

- Conducted before installation.
- Dated and signed by a professional or an engineering firm.

This study must include:

- The building's cooling needs, depending on the time of year.
- A description of the installations before and after the works.
- A description of the installed equipment used for cooling the water as a replacement for the chiller unit.
- Justification that the installed system can cover 100% of the building's nominal cooling demand.
- The characteristics of the cooling unit (brand, reference, and nominal electrical power in kW for both single-compressor and multi-compressor units).
- An evaluation of the expected energy savings, considering the predicted system operation (hours of operation, load rates, etc.).

The proof of completion must confirm:

- The installation of a freecooling system using cooling water and outside air.

If these details are not provided, the proof must instead include:

- The brand and reference of the installed equipment.
- A document from the manufacturer certifying that the installed equipment (brand and reference) is a freecooling system using cooling water and outside air.

The specific supporting document for this operation is the preliminary dimensioning study, defining the freecooling system installation, replacing a chiller unit and utilizing outside air.

4.3.1 Calculation of Final Energy Savings

Formula

The following equation calculates cumulative final energy savings.

$$TFES = S_{PT} \times P \times mc \tag{57}$$

The parameters used in the formula for final energy savings are presented in Table 70

Table 70 – Parameters used in the formula for final energy savings

Parameter	Description
$TFES$	Total final energy savings [kWh]
S_P	Savings per nominal power [kWh/kW)]
P	Nominal electrical power of the cooling production unit [kW]
mc	Multiplication coefficient [%]

The setpoint temperature of the hydraulic network corresponds to the supply temperature of the cooling production unit.

The nominal power represents the nominal electrical power (in kW) listed on the nameplate of the single-compressor or multi-compressor unit connected to the freecooling system for the relevant setpoint temperature range of the network. If unavailable, the power indicated in a manufacturer-issued document for the single-compressor or multi-compressor unit connected to the freecooling system for the relevant setpoint temperature range should be used. The power of backup compressors should not be included in the calculation.

A cooling production unit can only qualify for a single issuance of energy savings certificates for the installation of a freecooling system.

Standardized Calculation Values

Table 71 and
Table 72 present the indicative values for the calculation of final energy savings.

Table 71 – Indicative values for the savings per nominal power in different climatic regions and setpoint temperature ranges

Parameter	Climatic Region	Setpoint temperature ranges [15°C; 18°C[	[18°C; 20°C]
S_P	H1	5100	6400
	H2	4200	5900
	H3	3000	4700

Table 72 – Indicative values for multiplication coefficient

Sector	mc
Air conditioning outside Data Centres	1
Air conditioning inside Data Centres	4.5

4.3.2 Calculation of Primary Energy Savings

Formula

The methodology does not include any formula to calculate primary energy savings.

Standardized Calculation Values

No calculation values are available for this methodology.

4.3.3 Calculation of Greenhouse Gas Savings

Formula

The methodology does not include any formula to calculate Greenhouse Gas Savings.

Standardized Calculation Values

No calculation values are available for this methodology.

4.3.4 Overview of Costs Related to the Action

Cost-Effectiveness

No information on cost-effectiveness is available for this methodology.

Standardized Values

No calculation values are available for this methodology.

4.3.5 Methodological Aspects

The original document is in French, being an official document from the Ministry of Ecological Transition published with the reference BAR-TH-156.

In France the energy savings targets, and action are recorded in kWh cumac of final energy, cumac being the contraction of “cumulative and actualized” and given by the following equation.

$$kWh_{cumac} = TFES \times DC \tag{58}$$

The parameters used in the formula are presented in Table 73 and the indicative values are in Table 74.

Table 73 – Parameters used in the formula for final energy savings

Parameter	Description
kWh_{cumac}	Total final energy savings [kWh]
DC	Discount coefficient

Table 74 – Indicative values for calculation of energy savings certificates

Parameter	Value
Lifetime	14 [years]
DC(4%)	10.563

4.3.6 Bibliography

Opérations standardisées d'économies d'énergie | Ministère du Partenariat avec les territoires et de la Décentralisation Ministère de la Transition écologique, de l'Énergie, du Climat et de la Prévention des risques Ministère du Logement et de la Rénovation urbaine. (n.d.). Ministère Du Partenariat Avec Les Territoires Et De La Décentralisation Ministère De La Transition Écologique, De L'Énergie, Du Climat Et De La Prévention Des Risques Ministère Du Logement Et De La Rénovation Urbaine. https://www.ecologie.gouv.fr/politiques-publiques/operations-standardisees-deconomies-denergie#scroll-nav__7

4.4. Improvement of the energy efficiency of a data centre – Luxemburg

Improving the energy performance of a data centre or transferring an existing infrastructure to a more energy-efficient data centre, results in a reduction of the "Power Usage Effectiveness" (PUE) indicator, which is defined as the ratio between the energy consumed by the data centre and the energy consumed by the computing processes.

This measure applies to the industrial and tertiary sectors. The savings are applicable to an existing infrastructure operating in a data centre, that are then transferred to another data centre, optimised for energy efficiency.

- The method for measuring the PUE (Power Usage Effectiveness) indicator must be sufficiently accurate. This indicator is calculated in accordance with the "PUE Category 2" model or better, as defined in the document "Recommendations for Measuring and Reporting Overall Data Centre Efficiency - Version 1 – Measuring PUE at Dedicated Data Centres, 15 July 2010," The Green Grid, 2010. The referenced definition requires the consideration of energy consumption over a 12-month period;
- The energy boundary takes into account all energy sources supplying a data centre, is clearly defined, and remains unchanged between the "before" and "after" situations;
- The methods for determining energy consumption and PUE must be the same in both the "before" and "after" situations;
- The IT load level (E_{IT}) must not vary significantly after the implementation of the measure.

4.4.1 Calculation of Final Energy Savings

Formula

This formula calculates first-year savings.

$$VEEP = E_{IT} \times (PUE_{before} - PUE_{after}) \qquad (59)$$

Table 75 – Parameters used in the formula for final energy savings

Parameter	Description
VEEP	Annual volume of energy savings produced by the measure [MWh]
PUEbefore	Power Usage Effectiveness before
PUEafter	Power Usage Effectiveness after
E_{IT}	The energy consumption of computing processes over a 12-month period, in MWh

Standardized Calculation Values

Calculation values have been provided for the Power Usage Effectiveness to be used in case the PUE_{after} is not determined, or in case of a new data centre. The values are obtained by linear interpolation.

Table 76 – Indicative values for calculation of final energy savings

Parameter	Value	Year
PUEref	1,57	2021
	1,56	2022
	1,55	2023
	1,54	2024
	1,53	2025
	1,52	2026
	1,51	2027
	1,50	2028
	1,49	2029
	1,48	2030

4.4.2 Calculation of Primary Energy Savings

No information available on the calculation of primary energy savings.

4.4.3 Calculation of Greenhouse Gas Savings

No information available regarding the greenhouse gas savings calculations.

4.4.4 Overview of Costs Related to the Action

No information available on cost related to the action and/or on the cost-effectiveness calculation.

4.4.5 Methodological Aspects

There is a formula for determining PUE_{before} and PUE_{after}. As indicated, calculation values have been provided in case the PUE_{after} could not be determined or in case of a new data centre. It is mentioned that, in the case of infrastructure transfers, it is necessary to ensure that there is no double counting of the energy savings achieved through the implementation of the measure. Lifetime of the measure is 5 years.

This methodology was published in the Luxemburg catalogue on standardised measures (Annex II), which is annexed to the Grand-Ducal Regulation of June 3, 2021 relating to the functioning of the energy efficiency obligation mechanism. The document is published in French.

4.4.6 Bibliography

https://legilux.public.lu/filestore/eli/etat/leg/rmin/2021/06/15/a458/jo/fr/pdfa/eli-etat-leg-rmin-2021-06-15-a458-jo-fr-pdfa.pdf

5. Heat Recovery in Ventilation

5.1. Energy assessment (according to legislature) - Heat recovery & ventilation – Czech Republic

Methodology is based on the same principle as described in chapter 4.1

All of the listed tools can be used to calculate the energy savings from cooling, but the most common will be the use of energy assessments (both for heat recovery and ventilation) and Building Energy Performance Certificates in case of ventilation.

Application area:

- All end-use sectors
- Scope –building technologies

Boundary conditions:

- System boundary of the building

5.1.1 Calculation of Final Energy Savings

Formula

This formula calculates first-year (annual) energy savings.

$$TFES = (FEC_{before} - FEC_{after}) \times rb \times so \times fr \times lt$$
$$= (\sum_{i=1}^{n} E_{i,before} - \sum_{i=1}^{n} E_{i,after}) \times rb \times so \times fr \times lt \quad (60)$$

(This is not an official formula, but just a formula derived from commonly used principles for the needs of this deliverable.)

Table 77 – Parameters used in the formula for final energy savings

Parameter	Description
TFES	Total final energy savings [kWh/a]
FEC_{before}	Final energy consumption before implementation of the action [kWh/a]
FEC_{after}	Final energy consumption after implementation of the action [kWh/a]
$E_{i,\ before}$	Final energy consumption of an individual energy carrier (e.g. electricity, natural gas, coal, ambient energy, etc.) before implementation of the action [kWh/a]
$E_{i,\ after}$	Final energy consumption of an individual energy carrier (e.g. electricity, natural gas, coal, ambient energy, etc.) before implementation of the action [kWh/a]
rb	Factor to calculate a rebound effect (=1) [dmnl]
so	Factor to calculate a spill-over effect (=1) [dmnl]
fr	Factor to calculate a free-rider effect (=1) [dmnl]
lt	Factor for the lifetime of savings (=1) [dmnl]

Standardized Calculation Values

No calculation values available for this methodology.

5.1.2 Calculation of Primary Energy Savings

Formula

Same as described in chapter 5.1.1, only the relevant primary energy factors are applied to the individual energy carriers.

Co-funded by the
European Union

The following formula is used to calculate the annual primary energy savings:

$$\mathrm{APES} = (FEC_{before} - FEC_{after}) \times rb \times so \times fr \times lt = (\sum_{i=1}^{n} E_{i,before} * PEF_i - \sum_{i=1}^{n} E_{i,after} * PEF_i) \times rb \times so \times fr \times lt \qquad (61)$$

(This is not an official formula, but just a formula derived from commonly used principles for the needs of this deliverable.)

Table 78 – Parameters used in the formula for primary energy savings

Parameter	Description
APES	Annual primary energy savings [kWh/a]
PEC_{before}	Primary energy consumption before implementation of the action [kWh/a]
PEC_{after}	Primary energy consumption after implementation of the action [kWh/a]
$E_{i, before}$	Final energy consumption of an individual energy carrier (e.g. electricity, natural gas, coal, ambient energy, etc.) before implementation of the action [kWh/a]
$E_{i, after}$	Final energy consumption of an individual energy carrier (e.g. electricity, natural gas, coal, ambient energy, etc.) before implementation of the action [kWh/a]
PEF_i	Primary Energy Factor of an individual energy carrier (e.g. electricity, natural gas, coal, ambient energy, etc.) [dmnl]
rb	Factor to calculate a rebound effect (=1) [dmnl]
so	Factor to calculate a spill-over effect (=1) [dmnl]
fr	Factor to calculate a free-rider effect (=1) [dmnl]
lt	Factor for the lifetime of savings (=1) [dmnl]

Standardized Calculation Values

The Decree 264/2020 on the energy performance of buildings sets out Primary Energy Factors from non-renewable energy sources for individual energy carriers.

The Ministry of Industry and Trade lists primary energy factors for total primary energy on its website (https://mpo.gov.cz/cz/energetika/uspory-energie/aktuality/stanovisko-ministerstva-prumyslu-a-obchodu-k-vypoctu-spotreby-primarni-energie-v-energetickem-posudku--276396/).

5.1.3 Calculation of Greenhouse Gas Savings

The calculation of the emission production and subsequent GHG savings is based on the calculation of the final energy consumption of the building, where the energy carriers are multiplied by emission factors.

Formula

The following formula is used to calculate the annual GHG emissions:

$$GHGSAV = (GHG_{before} - GHG_{after}) \times rb \times so \times fr \times lt = (\sum_{i=1}^{n} E_{i,before} * f_{\mathrm{GHG,i}} - \sum_{i=1}^{n} E_{i,after} * f_{\mathrm{GHG,i}}) \times rb \times so \times fr \times lt \qquad (62)$$

(This is not an official formula, but just a formula derived from commonly used principles for the needs of this deliverable.)

Table 79 – Parameters used in the formula for greenhouse gas savings

Parameter	Description
GHGSAV	Greenhouse gas savings [t CO_2 / year]

GHG_{before}	Greenhouse gas production before implementation of the action [t CO_2 /year]
GHG_{after}	Greenhouse gas production after implementation of the action [t CO_2 / year]
$E_{i,\ before}$	Final energy consumption of an individual energy carrier (e.g. electricity, natural gas, coal, ambient energy, etc.) before implementation of the action [MWh/a]
$E_{i,\ after}$	Final energy consumption of an individual energy carrier (e.g. electricity, natural gas, coal, ambient energy, etc.) before implementation of the action [MWh/a]
$f_{GHG,i}$	Emission factor of an individual energy carrier (e.g. electricity, natural gas, coal, ambient energy, etc.) [t CO_2/MWh]
rb	Factor to calculate a rebound effect (=1) [dmnl]
so	Factor to calculate a spill-over effect (=1) [dmnl]
fr	Factor to calculate a free-rider effect (=1) [dmnl]
lt	Factor for the lifetime of savings (=1) [dmnl]

Standardized Calculation Values

There is a table with emission coefficients in Annex 9 of the Decree No. 141/2021 Coll. on energy assessment and on data recorded in the Energy Consumption Monitoring System (same values are provided in Annex 8 of the Decree 140/2021 Coll. on energy audit.

Overview of Costs Related to the Action

No Overview of Costs Related available for this methodology.

5.1.4 Methodological Aspects

No details provided for this methodology.

5.1.5 Bibliography

Collective of authors. (2020). Methodology for reporting energy savings from alternative policy measures. *Prague: Ministry of Industry and Trade*. Retrieved from: https://mpo.gov.cz/cz/energetika/energeticka-ucinnost/strategicke-dokumenty/metodika-vykazovani-uspor-energie-z-alternativnich-politickych-opatreni--176331

5.2. Single flow ventilation with constant modulated air flow - France

The methodology is applied for the installation of a single-flow mechanical ventilation system with either a constant airflow rate or a modulated airflow rate in existing premises in the tertiary sector.

Mechanical ventilation is considered modulated if the ventilation airflow rate is variable and controlled based on occupancy detection or proportionally adjusted according to the number of occupants (using CO_2 detection or presence sensors, single- or multi-zone).

The modulated single-flow mechanical ventilation system must have a valid technical approval from the Commission responsible for issuing Technical Approvals (CCFAT) at the date of operation initiation or possess equivalent performance and quality characteristics established by an organization located in the European Economic Area and accredited under NF EN ISO/IEC 17065 by the French Accreditation Committee (COFRAC) or another accreditation body that is a signatory to the relevant European multilateral agreement within the framework of European accreditation coordination.

The ventilation unit must have an electrical power consumption of 0.3 W/(m³/h) or less at the nominal airflow rate.

Proof of completion of the operation must include:

- The installation of a single-flow mechanical ventilation system with either a constant or modulated (proportional or presence detection-based) airflow rate.
- The electrical power consumption of the ventilation unit at the nominal airflow rate.

If these details are not provided, the proof of operation must specify the installed equipment along with its brand and model references and be accompanied by one or more documents issued by the manufacturer confirming that the installed equipment constitutes a single-flow mechanical ventilation system with either a constant or modulated (proportional or presence detection-based) airflow rate. One of these documents must specify the electrical power consumption of the ventilation unit at the nominal airflow rate.

In the case of a modulated single-flow mechanical ventilation system (proportional or presence detection-based), the specific supporting document for the operation is the technical approval from the Commission responsible for issuing Technical Approvals (CCFAT), valid at the date of operation initiation, or equivalent supporting evidence.

5.2.1 Calculation of Final Energy Savings

Formula

The following equation calculates cumulative final energy savings.

$$TFES = S_A \times S \times cf \tag{63}$$

The parameters used in the formula for final energy savings are presented in Table 80.

Table 80 – Parameters used in the formula for final energy savings

Parameter	Description
$TFES$	Total final energy savings [kWh]
S_A	Savings per area of ventilated surface [kWh/kW)]
S	Ventilated surface [m^2]
cf	Correction factor [%]

Standardized Calculation Values

Table 81 to
Table 86 present the indicative values for the calculation of final energy savings.

Table 81 – Indicative values for the savings per area of ventilated surface in different climatic regions (proportional modulated single-flow mechanical ventilation system)

Parameter	Climatic Region	hWh
S_A	H1	770
	H2	630
	H3	420

Table 82 – Indicative values for corrective factor for different sectors (proportional modulated single-flow mechanical ventilation system)

Sector	cf
Offices	0.48
Education	1.00
Food services	0.59
Other premises	0.54

Table 83 – Indicative values for the savings per area of ventilated surface in different climatic regions (presence-detection modulated single-flow mechanical ventilation system)

Parameter	Climatic Region	hWh
S_A	H1	690
	H2	560
	H3	380

Table 84 – Indicative values for corrective factor for different sectors (presence-detection modulated single-flow mechanical ventilation system)

Sector	cf
Offices	0.4.
Education	1.00
Food services	0.45
Other premises	0.51

Table 85 – Indicative values for the savings per area of ventilated surface in different climatic regions (constant airflow single-flow mechanical ventilation system)

Parameter	Climatic Region	hWh
S_A	H1	400
	H2	330
	H3	220

Table 86 – Indicative values for corrective factor for different sectors (constant airflow single-flow mechanical ventilation system)

Sector	cf
Offices	0.40
Education	1.00
Food services	0.53
Other premises	0.58

5.2.2 Calculation of Primary Energy Savings

Formula

The methodology does not include any formula to calculate primary energy savings.

Standardized Calculation Values

No calculation values are available for this methodology.

5.2.3 Calculation of Greenhouse Gas Savings

Formula

The methodology does not include any formula to calculate Greenhouse Gas Savings.

Standardized Calculation Values

No calculation values are available for this methodology.

5.2.4 Overview of Costs Related to the Action

Cost-Effectiveness

No information on cost-effectiveness is available for this methodology.

Standardized Values

No calculation values are available for this methodology.

5.2.5 Methodological Aspects

The original document is in French, being an official document from the Ministry of Ecological Transition published with the reference BAT-TH-125.

In France the energy savings targets, and action are recorded in kWh cumac of final energy, cumac being the contraction of "cumulative and actualized" and given by the following equation.

$$kWh_{cumac} = TFES \times DC \tag{64}$$

The parameters used in the formula are presented in Table 87 and the indicative values are in Table 88.

Table 87 – Parameters used in the formula for final energy savings

Parameter	Description
kWh_{cumac}	Total final energy savings [kWh]
DC	Discount coefficient

Table 88 – Indicative values for calculation of energy savings certificates

Parameter	Value
$Lifetime$	17 [years]
DC(4%)	13.599

5.2.6 Bibliography

Opérations standardisées d'économies d'énergie | Ministère du Partenariat avec les territoires et de la Décentralisation Ministère de la Transition écologique, de l'Énergie, du Climat et de la Prévention des risques Ministère du Logement et de la Rénovation urbaine. (n.d.). Ministère Du Partenariat Avec Les Territoires Et De La Décentralisation Ministère De La Transition Écologique, De L'Énergie, Du Climat Et De La Prévention Des Risques Ministère Du Logement Et De La Rénovation Urbaine. https://www.ecologie.gouv.fr/politiques-publiques/operations-standardisees-deconomies-denergie#scroll-nav__7

5.3. Double flow mechanical ventilation with constant or modulated air flow exchanger - France

The methodology is applied for the installation of a presence-detection modulated dual-flow mechanical ventilation system does not apply to rooms with a volume exceeding 250 m³ in existing premises in the tertiary sector.

Installation of a dual-flow mechanical ventilation system, with a heat exchanger, either with a constant airflow rate or a modulated airflow rate.

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Mechanical ventilation is considered modulated if the ventilation airflow rate is variable and controlled based on presence detection or proportionally adjusted according to the number of occupants (using CO_2 detection or presence sensors, single- or multi-zone).

The modulated dual-flow mechanical ventilation system must have a valid technical approval from the Commission responsible for issuing Technical Approvals (CCFAT) at the date of operation initiation or possess equivalent performance and quality characteristics established by an organization located in the European Economic Area and accredited under NF EN ISO/IEC 17065 by the French Accreditation Committee (COFRAC) or another accreditation body that is a signatory to the relevant European multilateral agreement within the framework of European accreditation coordination.

The heat exchanger efficiency must be ≥ 75% according to NF EN 13053 or NF EN 308 standards.

An exchanger certified under Eurovent Certified Performance for Air-to-Air Plate Heat Exchangers (AAHE) or Regenerative Heat Exchangers (AARE), or possessing equivalent performance and quality characteristics, established by an organization located in the European Economic Area and accredited under NF EN ISO/IEC 17065 by COFRAC or another accreditation body that is a signatory to the relevant European multilateral agreement, is deemed to satisfy this requirement.

The ventilation unit's electrical power consumption must be ≤ 0.35 W/(m³/h) per fan at the nominal airflow rate (including filters and heat exchangers).

Proof of completion of the operation must include:

The installation of a dual-flow mechanical ventilation system with either a constant or modulated airflow rate (proportional or presence-detection based).

- The heat exchanger efficiency, measured according to NF EN 13053 or NF EN 308, or referenced through the Eurovent Certified Performance for Air-to-Air Plate Heat Exchangers (AAHE) or Regenerative Heat Exchangers (AARE) certification of the equipment.
- The electrical power consumption of the ventilation unit at the nominal airflow rate.

If these details are not provided, the proof of operation must specify the installed equipment along with its brand and model references and be accompanied by one or more documents issued by the manufacturer confirming that the installed equipment constitutes a dual-flow mechanical ventilation system with a heat exchanger, operating with a constant or modulated airflow rate (proportional or presence-detection based).

These documents must specify:

- The heat exchanger efficiency, measured according to NF EN 13053 or NF EN 308, or referenced through the Eurovent Certified Performance certification for AAHE or AARE exchangers, or an equivalent certification.
- The electrical power consumption of the ventilation unit at the nominal airflow rate.

In the case of a modulated dual-flow ventilation system (proportional or presence-detection based), the specific supporting document for the operation is the technical approval from the CCFAT, valid at the date of operation initiation, or equivalent supporting evidence.

5.3.1 Calculation of Final Energy Savings

Formula

The following equation calculates cumulative final energy savings.

$$TFES = S_A \times S \times cf \qquad (65)$$

The parameters used in the formula for final energy savings are presented in Table 89.

Table 89 – Parameters used in the formula for final energy savings

Parameter	Description
$TFES$	Total final energy savings [kWh]
S_A	Savings per area of ventilated surface [kWh/kW)]
S	Ventilated surface [m^2]
cf	Correction factor [%]

Standardized Calculation Values

Table 90 to
Table 95 present the indicative values for the calculation of final energy savings.

Table 90 – Indicative values for the savings per area of ventilated surface in different climatic regions (proportional modulated dual-flow mechanical ventilation system)

Parameter	Climatic Region	hWh
S_A	H1	1000
	H2	830
	H3	560

Table 91 – Indicative values for corrective factor for different sectors (proportional modulated dual-flow mechanical ventilation system)

Sector	cf
Offices	0.53
Education	1.00
Food services	0.68
Sport	0.22
Other premises	0.71
Rooms with a volume greater than 250 m^3	1.88

Table 92 – Indicative values for the savings per area of ventilated surface in different climatic regions (presence-detection modulated dual-flow mechanical ventilation system)

Parameter	Climatic Region	hWh
S_A	H1	970
	H2	800
	H3	530

Table 93 – Indicative values for corrective factor for different sectors (presence-detection modulated dual-flow mechanical ventilation system)

Sector	cf
Offices	0.51
Education	1.00
Food services	0.63
Sport	0.17
Other premises	0.71

Table 94 – Indicative values for the savings per area of ventilated surface in different climatic regions (constant airflow dual-flow mechanical ventilation system)

Parameter	Climatic Region	hWh
S_A	H1	850
	H2	700
	H3	460

Table 95 – Indicative values for corrective factor for different sectors (constant airflow dual-flow mechanical ventilation system)

Sector	cf
Offices	0.48
Education	1.00
Food services	0.61
Sport	0.52
Other premises	0.71
Rooms with a volume greater than 250 m³	1.44

5.3.2 Calculation of Primary Energy Savings

Formula

The methodology does not include any formula to calculate primary energy savings.

Standardized Calculation Values

No calculation values are available for this methodology.

5.3.3 Calculation of Greenhouse Gas Savings

Formula

The methodology does not include any formula to calculate Greenhouse Gas Savings.

Standardized Calculation Values

No calculation values are available for this methodology.

5.3.4 Overview of Costs Related to the Action

Cost-Effectiveness

No information on cost-effectiveness is available for this methodology.

Standardized Values

No calculation values are available for this methodology.

5.3.5 Methodological Aspects

The original document is in French, being an official document from the Ministry of Ecological Transition published with the reference BAT-TH-126.

In France the energy savings targets, and action are recorded in kWh cumac of final energy, cumac being the contraction of “cumulative and actualized” and given by the following equation.

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$$kWh_{cumac} = TFES \times DC \quad (66)$$

The parameters used in the formula are presented in Table 96 and the indicative values are in Table 97.

Table 96 – Parameters used in the formula for final energy savings

Parameter	Description
kWh_{cumac}	Total final energy savings [kWh]
DC	Discount coefficient

Table 97 – Indicative values for calculation of energy savings certificates

Parameter	Value
Lifetime	17 [years]
DC(4%)	13.599

5.3.6 Bibliography

Opérations standardisées d'économies d'énergie | Ministère du Partenariat avec les territoires et de la Décentralisation Ministère de la Transition écologique, de l'Énergie, du Climat et de la Prévention des risques Ministère du Logement et de la Rénovation urbaine. (n.d.). Ministère Du Partenariat Avec Les Territoires Et De La Décentralisation Ministère De La Transition Écologique, De L'Énergie, Du Climat Et De La Prévention Des Risques Ministère Du Logement Et De La Rénovation Urbaine. https://www.ecologie.gouv.fr/politiques-publiques/operations-standardisees-deconomies-denergie#scroll-nav__7

5.4. Replacing a heat recovery unit integrated into a ventilation system – Hungary

The measure only includes the calculation of the final energy savings achieved by heating heat recovery, while the final energy savings of cooling heat recovery must be calculated with an individual audit.

The measure can be implemented in residential buildings (family houses, condominiums), hotels, educational buildings, healthcare buildings, office buildings, industrial buildings.

The technical characteristics of the old/replaced heat recovery unit affected by the modernization and the new, installed heat recovery unit must be documented according to Table below.

Table 98 – Nominal technical data and operating characteristics of the electric motors subject to the measure

A	B	C	D
Number of rows	Technical parameter	Old	New
1	Manufacturer		
2	Type		
3	Date of first commissioning of the old heat recovery unit	in case of early replacement	-
4	n_{LT} air change rate during the operating time of the ventilation system [1/h]		

5	η_{new} efficiency of the heat recovery unit built into the ventilation system according to Commission Regulation (EU) No 1253/2014 [-]		
6	Z_{LT} thousandth of the operating time of the ventilation system during the heating season [kh/a]		
7	t_{bef} average temperature of the supply air during the heating season [°C]		
8	V ventilated volume, calculated according to internal dimensions [m^3]		

Documents required to verify the eligible final energy savings are:

a) Technical data sheet or other document certifying the nominal heat recovery efficiency of the old heat recovery unit, η_{old} [%], or other document (in case of early replacement).
b) Document certifying the date of first commissioning of the old heat recovery unit (in case of early replacement).
c) Technical data sheet or other document certifying the heat recovery efficiency of the new heat recovery unit.
d) Document credibly certifying the actual implementation of the energy efficiency measure (in particular implementation documentation, technical acceptance-handover protocol, declaration by the contractor, technical inspector, responsible technical manager, certificate of performance, invoices supporting the implementation of the investment). In the case of project-specific assessments, the values used must be documented and supported in a verifiable manner.
e) Calculation of the final energy savings [GJ/year].

The start of eligibility of the measure is the date of commissioning of the new heat recovery unit.

5.4.1 Calculation of Final Energy Savings

When calculating the final energy savings achieved by replacing an existing heat recovery unit, the lifetime of the replaced (old) heat recovery unit (17 years) must be taken into account.

a) If the old heat recovery unit to be replaced has not yet reached the end of its expected average lifetime, the measure is considered an early replacement.
b) If the lifetime of the old heat recovery unit to be replaced exceeds 17 years, the energy consumption of the new equipment must be compared with the minimum requirements set out in the Commission Regulation on the eco-design of the given equipment. The excess energy savings is the amount by which the energy consumption of the new equipment is less than the reference consumption that meets the minimum eco-design requirements.

Formula

Annual energy savings calculated from the difference in energy recovery between the old and new heat recovery unit. These formulas calculate first-year savings.

Early replacement

$$TFES = \Delta E_{early/year} \times rb \times so \times fr \times lt$$
$$TFES = 0{,}35 \cdot V \cdot n_{LT} \cdot \ (\eta_{new} - \eta_{old}) \ \cdot Z_{LT} \cdot \ (t_{bef} - 4) \ \times rb \times so \times fr \times lt \qquad (67)$$

$$\Delta E_{early/year} = 0{,}35 \cdot V \cdot n_{LT} \cdot \ (\eta_{new} - \eta_{old}) \ \cdot Z_{LT} \cdot \ (t_{bef} - 4) \ \times \frac{3{,}6}{1000} [GJ/year] \qquad (68)$$

Table 99 – Parameters used in the formula for unit annual energy savings

Parameter	Description
$TFES$	Total final energy savings [kWh/year]
rb	Factor to calculate a rebound effect
so	Factor to calculate a spill-over effect
fr	Factor to calculate a free-rider effect (=1)
lt	Factor for the lifetime of savings
n_{LT}	air change rate during the operating time of the ventilation system [1/h]
η_{new}	efficiency of the heat recovery unit built into the ventilation system according to Commission Regulation (EU) No 1253/2014 [-]
η_{old}	efficiency of the existing heat recovery unit, if not supported by documents, the default value is 70%, while for heat recovery units with a transfer medium 65%. In case there was no heat recovery unit in the old system, its value is 0
Z_{LT}	thousandth of the operating time of the ventilation system during the heating season [kh/a]
t_{bef}	average temperature of the supply air during the heating season [°C]
V	ventilated volume, calculated according to internal dimensions [m^3]

Replacement after the end of lifetime of old equipment

Annual energy savings ($\Delta E_{excess/year}$) calculated from the difference in energy demand of the old heat recovery unit and the new heat recovery unit: The energy savings ($\Delta E_{excess/year}$) eligible under an energy measure shall be the part of the minimum heat recovery efficiency (η_{ref}) above the requirements set out in Commission Regulation (EU) No 1253/2014.

$$TFES = \Delta E_{excess/year} \times rb \times so \times fr \times lt$$
$$TFES = 0{,}35 \cdot V \cdot n_{LT} \cdot \ (\eta_{new} - \eta_{ref}) \ \cdot Z_{LT} \cdot \ (t_{bef} - 4) \ \times rb \times so \times fr \times lt \qquad (69)$$

$$\Delta E_{early/year} = 0{,}35 \cdot V \cdot n_{LT} \cdot \ (\eta_{new} - \eta_{ref}) \ \cdot Z_{LT} \cdot \ (t_{bef} - 4) \ \times \frac{3{,}6}{1000} [GJ/year] \qquad (70)$$

Table 100 – Parameters used in the formula for unit annual energy savings

Parameter	Description
$TFES$	Total final energy savings [kWh/year]
rb	Factor to calculate a rebound effect
so	Factor to calculate a spill-over effect
fr	Factor to calculate a free-rider effect (=1)
lt	Factor for the lifetime of savings
n_{LT}	air change rate during the operating time of the ventilation system [1/h]
η_{new}	efficiency of the heat recovery unit built into the ventilation system according to Commission Regulation (EU) No 1253/2014 [-]

η_{ef}	Minimum heat recovery efficiency according to Commission Regulation (EU) No 1253/2014 on eco-design [-]. Heat recovery units have an efficiency of 73%, while heat recovery units with a transfer medium have an efficiency of 68%
Z_{LT}	thousandth of the operating time of the ventilation system during the heating season [kh/a]
t_{bef}	average temperature of the supply air during the heating season [°C]
V	ventilated volume, calculated according to internal dimensions [m^3]

The additional fan electricity demand resulting from the increase in the ventilation system resistance (Δp_{LT}) in the case of heat exchanger replacement shall not be taken into account in the simplified calculation. If there was no heat exchanger in the system originally, the calculation of energy savings due to the additional fan electricity demand shall be supported by an individual audit.

Standardized Calculation Values

The minimum heat recovery efficiency (η_{ref}) of heat exchangers is 73%, while that of heat exchangers with a transfer medium is 68% according to Commission Regulation (EU) No 1253/2014, and the air resistance must not exceed the maximum resistance value set out in the MSZ EN 13053:2006 standard.

5.4.2 Calculation of Primary Energy Savings

Formula

The following formula is used to calculate the annual primary energy savings:

$$\mathrm{APES} = TFES \times PEF_{Electricity} \tag{71}$$

Table 101 – Parameters used in the formula for primary energy savings

Parameter	Description
APES	Annual primary energy savings [kWh/a]
TFES	Total final energy savings [kWh/a]
$PEF_{Electricity}$	Primary Energy Factor for electricity [dmnl]

Standardized Calculation Values

Table 102 – Indicative values for calculation of primary energy savings

Parameter	Value	Unit
$PEF_{Electricity}$	2.6	-

5.4.3 Calculation of Greenhouse Gas Savings

Formula

$$GHGSAV = TFES \times f_{GHG,electricity} \times 10^{-6} \tag{72}$$

Table 103 – Parameters used in the formula for greenhouse gas savings

Parameter	Description
GHGSAV	Greenhouse gas savings [t CO_2 p.a.]
TFES	Total final energy savings [kWh/a]

$f_{GHG,electricity}$	Emission factor for electricity [g CO_2/kWh]

Standardized Calculation Values

Table 104 – Indicative values for calculation of greenhouse gas savings

Parameter	Value	Unit
$f_{GHG,electricity}$	0.455	kg CO_2/kWh

5.4.4 Overview of Costs Related to the Action

Cost-Effectiveness

No information on cost-effectiveness available for this methodology.

Standardized Values

No information on cost-effectiveness available for this methodology.

5.4.5 Methodological Aspects

The principle of calculation is based on the difference in energy recovery between the old and new heat recovery units.

The Hungarian Energy and Public Utility Regulatory Authority (MEKH) is the regulatory body of the energy and public utility market, supervising the national economy's sectors of strategic importance. The MEKH has established and reviews each year the EEOS catalogue, which lists the types of energy efficiency measures or investments that can be accounted in a simplified way. This Catalogue is published as the Annex of **17/2020.(XII. 21.) MEKH Decree** on data reporting on end-use energy savings.

Data on factors for calculation of primary energy savings and GHG emission savings are prescribed by the Ministry of Construction and Transport in Regulation laying down the energy characteristics of buildings.

Each catalogue sheet contains a description of the energy efficiency measure; the method and content of recording the baseline and post-measure status; the eligible lifetime and the level of degradation; a description of the performance factors and the principles for their calculation, the formula for calculating the annual savings; the documents to be submitted and other relevant information to support the accounting. For the time being, the catalogue contains 51 sheets in 5 categories.

All documents are available in Hungarian language.

5.4.6 Bibliography

The Hungarian Energy and Public Utility Regulatory Authority (2020): *17/2020.(XII. 21.) MEKH Decree on data reporting on end-use energy savings*, https://njt.hu/jogszabaly/2020-17-20-5Z.

9/2023. (V. 25.) NCM Regulation laying down the energy characteristics of buildings, https://njt.hu/jogszabaly/2023-9-20-8X

5.5. Methodology for Calculating Energy Savings from Installation of a Ventilation System with Heat Recovery - Latvia

5.5.1 Calculation of Final Energy Savings

Formula

This formula calculates final energy savings resulting from installation of a ventilation system with heat recovery (installation of a recuperator):

$$TFES_y = n \times A \times b \times L \times t \times c \times \rho \times \Delta t \times \eta$$
$$TFES = TFES_y \times y \qquad (73)$$

Table 105 – Parameters used in the formula for calculating energy savings from installation of a ventilation system with heat recovery (installation of a recuperator):

Parameter*	Description
TFES	The total final energy savings over the lifetime [kWh]
n	Number of heat recovery units installed
A	Total conditioned area of the building [m2]
b	Height of the ventilated room (from floor to ceiling) [m]
L	Air exchange rate [h-1]
t	Duration of ventilation system operation per year [h/year]
c	Specific heat capacity of air [kWh/kg K]
ρ	Air density [kg/m3]
Δt	Difference between indoor and outdoor air temperatures (average value) during the heating season [°C]
η	Heat recovery coefficient
$TFES_y$	Energy savings per year [kWh/year]
y	Event life cycle [years]

* Since the catalog does not provide alphabetical values for parameters, for the sake of clarity, we set alphabetical indicators for each parameter.

Standardized Calculation Values

Table 106 – Indicative values for calculation of final energy savings resulting from buildings thermal properties improvement

Parameter	Value	Unit
η	0.8	-
y (wall / roof insulation)	20	years
Y (windows replacement)	30	years

5.5.2 Calculation of Primary Energy Savings

No information on primary energy savings available for this methodology.

5.5.3 Calculation of Greenhouse Gas Savings

No information on greenhouse gas savings available for this methodology.

5.5.4 Overview of Costs Related to the Action

No information on costs related to the action available for this methodology.

5.5.5 Methodological Aspects

The methodology uses the expected savings (ex-ante) method, as outlined in Sub-paragraph 2.4 of Regulation No. 660 (18 October 2022), and relies on default values from the State Construction Control

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Bureau's Catalogue of Energy Savings. This catalogue is part of the energy efficiency monitoring system and provides standardized energy-saving measures with achievable savings values.

This methodology was taken from the Catalogue "Energy savings catalogue developed by the Ministry of Economics" / "Ekonomikas ministrijas izstrādātais enerģijas ietaupījumu katalogs": https://www.bvkb.gov.lv/lv/zinojumi-un-metodiskie-materiali [in Latvian language]

5.5.6 Bibliography

1. Būvniecības valsts kontroles birojs (2022). Document "Energy savings catalogue developed by the Ministry of Economics" / "Ekonomikas ministrijas izstrādātais enerģijas ietaupījumu katalogs". https://www.bvkb.gov.lv/lv/zinojumi-un-metodiskie-materiali
2. Ministru kabinets (2019). Legislative act Regulations on Latvian Building Code LBN 003-19 "Būvklimatoloģija". https://likumi.lv/ta/id/309453-noteikumi-par-latvijas-buvnormativu-lbn-003-19-buvklimatologija

5.6. Methodology for calculating energy savings from heat recovery & ventilation – Lithuania

The energy savings from installing heat recovery unit in mechanical ventilation system can be calculated using the formula for calculating the monthly heat demand of a mechanical air supply system, specified in Methodology for conducting a comprehensive energy and energy resource consumption audit in buildings.

5.6.1 Calculation of Final Energy Savings

Formula

The energy savings from installing heat recovery unit will be the difference between heat demand of a mechanical air supply system with recuperator and without.

$$TFES = Q_{mv,i,m} - Q_{mv,i,m,R}$$

$$Q_{mv,i,m} = \frac{10^{-6} \times L_{s,mv,i} \times \rho_a \times c_{p,a} \times (\theta_{s,mv,i} - Q_{mv,i,m,R}) \times (1 - 0) \times (z_m - 1) \times 24 \times h_{wo,mv,i}}{168 + Q_{tl,mv,i,m}}$$

$$Q_{mv,i,m,R} = \frac{10^{-6} \times L_{s,mv,i} \times \rho_a \times c_{p,a} \times (\theta_{s,mv,i} - Q_{mv,i,m,R}) \times (1 - \eta_{hr,mv,i}) \times (z_m - 1) \times 24 \times h_{wo,mv,i}}{168 + Q_{tl,mv,i,m}} \quad (74)$$

Table 107 – Parameters used in the formula for calculating energy savings from installing heat recovery unit

Parameter	Description
TFES	Monthly energy savings from installing heat recovery unit [MWh/month]
$Q_{mv,i,m,R}$	Monthly heat demand of the mechanical air supply system with recuperator, [MWh/month]
$Q_{mv,i,m}$	Monthly heat demand of the mechanical air supply system without recuperator, [MWh/month]
$L_{s,mv,i}$	System supply air flow*, [m³/h]
ρ_a	Air density**, [kg/m³]
$c_{p,a}$	Specific heat of air***, [Wh/kg/K]
$\theta_{s,mv,i}$	System supply air temperature****, [°C]

$\theta_{e,m}$	Average monthly outdoor air temperature, [°C]
$\eta_{hr,mv,i}$	System heat recovery efficiency*****
z_m	Number of days in a month
$h_{wo,mv,i}$	Weekly number of operating hours of the system, [h]
$Q_{tl,mv,i,m}$	System technical heat losses******, [MWh]

* In existing systems, it is determined using available means (direct measurement or using existing air handling equipment), in planned systems – normative; if the system air flow is variable, the average supply air flow must be determined by calculations and reasonable assumptions, also taking into account whether the air flow is controlled depending on the indoor air quality.

** Accepted value 1,2 kg/m³.

*** Accepted value 0,278 Wh/kg/K.

**** Value must be determined by measuring.

***** When calculating heat demand of a mechanical air supply system without recuperator, this parameter is accepted value "0".

****** Determined according to the standard: LST EN 16798-5-1:2017. Energy performance of buildings. Ventilation of buildings. Part 5-1. Methods for calculating the energy demand of ventilation and air-conditioning systems (Modules M5-6, M5-8, M6-5, M6-8, M7-5, M7-8). Method 1. Distribution and production. Lithuanian Standardization Department., 2017.

Calculation of Primary Energy Savings

No information on primary energy savings available for this methodology.

5.6.2 Calculation of Greenhouse Gas Savings

Formula

Determine the energy source used for heating (e.g., natural gas, electricity, biomass, district heating).

$$\Delta CO_2 = \Delta E \times EF$$

In case of multiple energy sources used, emissions are calculated separately for each source and the results summed:

$$\Delta CO_2 = \sum_{i=1}^{n} (\Delta E_i \times EF_i) \quad (75)$$

Table 108 – Parameters used in the formula for greenhouse gas savings

Parameter	Description
ΔCO_2	Annual CO_2 emissions reduction [t CO_2/year]
ΔE	Total final energy savings [MWh/year]
EF	Emission factor of the energy source* [t CO_2/MWh]
n	Number of different energy sources [-]
i	i-th energy source [-]

* Emission factor values established in Technical Construction Regulation STR 2.01.02:2016 "Design and Certification of Energy Performance of Buildings" [2], table No. 2.18.

Standardized Calculation Values

Table 109 – Indicative values for calculation of greenhouse gas emission factor (EF) by fuel type

Parameter * (Emission Factor EF)	Value	Unit
Fuel oil	0,29	kg CO_2/kWh
Coal	0,36	kg CO_2/kWh
Natural gas	0,22	kg CO_2/kWh
Biofuels (wood, straw, biogas, bio-oil, etc.)	0,04	kg CO_2/kWh
Wind farms	0	kg CO_2/kWh
Electricity produced in hydroelectric power plants	0,01	kg CO_2/kWh
Peat	0,36	kg CO_2/kWh
Liquefied gas	0,22	kg CO_2/kWh

* Full list of emission factors by type of energy is presented in Technical Construction Regulation STR 2.01.02:2016 "Design and Certification of Energy Performance of Buildings" [2], table No. 2.18.

5.6.3 Overview of Costs Related to the Action

No information on cost-effectiveness available for this methodology.

5.6.4 Bibliography

1. Ministry of Energy of the Republic of Lithuania (2023). Methodology for conducting a comprehensive energy and energy resource consumption audit in buildings, No.: 1-90. Register of legal acts. https://www.e-tar.lt/portal/lt/legalAct/ceaa5620cf0111ed9978886e85107ab2
2. Ministry of Environment of the Republic of Lithuania (2024). Technical Construction Regulation STR 2.01.02:2016 "Design and Certification of Energy Performance of Buildings", No.: D1-131. Register of legal acts. https://www.e-tar.lt/portal/lt/legalAct/2c182f10b6bf11e6aae49c0b9525cbbb/asr

5.7. Implementation of Controlled Mechanical Ventilation with Heat Recovery – Luxemburg

Heat losses due to ventilation are reduced by implementing controlled mechanical ventilation with heat recovery. The measure applies to existing residential buildings and existing functional (non-residential) buildings. The methodology applies to three situations:

Case a) Implementation of a controlled mechanical ventilation system with heat recovery for residential building.

Case b) Implementation of a controlled mechanical ventilation system with heat recovery for functional building.

Case c) Implementation of a heat recovery system or improvement of the efficiency of the heat recovery system of an existing controlled mechanical ventilation system for a residential or functional building.

The calculation methodology consists of the following steps: 1) identification of specific useful energy savings, 2) reference energy surface area / airflow rate of the mechanical ventilation system (VMC), 3) consideration of the heat production system, and 4) calculation of the annual volume of energy savings.

Lifetime of the measure is 25 years.

5.7.1 Calculation of Final Energy Savings

Formula case a) and b)

First, Q_c is established by identifying the specific useful energy savings and multiplying these by the mechanically ventilated energy reference area for case a) residential buildings, or by the (projected) airflow rate of the controlled mechanical ventilation for case b) functional building. Then e_c is identified according to table 1.

This formula calculates first-year savings.

$$VEEP = \frac{Q_c \times e_c - q_v \times V}{1000} \quad (76)$$

Table 110 – Parameters used in the formula for final energy savings

Parameter	Description
VEEP	Annual volume of energy savings produced by the measure [MWh]
Qc	Useful energy savings in kWh/year
ec	Expense factor for heat production for heating
qv	Specific electricity consumption of fans: 2 kWh/(m³/h) a for residential buildings and 2.4 kWh/(m³/h) a for functional (non-residential) buildings.
V	(Projected) airflow rate of the controlled mechanical ventilation system, in m³/h

Formula case c)

First, the useful energy savings Q_c are calculated according to a specific formula that compares the efficiency of the heat recovery system of the controlled mechanical ventilation in the original and improved situation, multiplied by the (projected) airflow rate of the controlled mechanical ventilation system. Then e_c is identified according to table 1.

This formula calculates first-year savings.

$$VEEP = \frac{Q_c \times e_c}{1000} \quad (77)$$

Table 111 – Parameters used in the formula for final energy savings

Parameter	Description
VEEP	Annual volume of energy savings produced by the measure [MWh]
PUEbefore	Power Usage Effectiveness before
PUEafter	Power Usage Effectiveness after
E_{IT}	The energy consumption of computing processes over a 12-month period, in MWh

Standardized Calculation Values

Calculation values have been provided for the e_c, expenditure factor for heat production for heating, depending on the heat production system.

Table 112 – Indicative values for calculation of final energy savings

Heat production system	e_c
Constant temperature boiler	$1.13 \leq 1.633 \cdot An$^−0.04282 ≤ 1.38
Low temperature boiler	$1.08 \leq 1.209 \cdot An$^−0.01283 ≤ 1.15
Condensing boiler (radiators)	$1.01 \leq 1.094 \cdot An$^−0.00922 ≤ 1.05

Condensing boiler (underfloor heating)	$0.98 \leq 1.019 \cdot An^{-0.00463} \leq 1.00$
Electric heating (direct / accumulation)	1.00
Electric heat pump ground/water (radiators)	0.27
Electric heat pump ground/water (underfloor heating)	0.23
Electric heat pump air/water (radiators)	0.37
Electric heat pump air/water (underfloor heating)	0.30
Gas heat pump water/water (underfloor heating)	0.46
Gas heat pump water/water (radiators)	0.54
Gas heat pump ground/water (underfloor heating)	0.54
Gas heat pump ground/water (radiators)	0.61
Gas heat pump air/water (underfloor heating)	0.66
Gas heat pump air/water (radiators)	0.77
Log wood boiler	1.75
Pellet boiler with only indirect heat release	1.38
Pellet boiler with both direct and indirect heat release	1.48
District heating	1.01

The energy reference area of the building in m^2, A_n, can be found in the energy performance certificate. In the absence of the energy performance certificate, the energy reference area may either be calculated by an accredited organization, estimated using the simplified indicative values from Section VIII, or calculated in a simplified manner according to the formula provided.

As an alternative to these default values, the expenditure factors e_c may be determined in accordance with the DIN 4701-10 standard, provided that the framework conditions defined by the amended Grand-Ducal regulation of 30 November 2007 concerning the energy performance of residential buildings are respected.

5.7.2 Calculation of Primary Energy Savings

No information available on the calculation of primary energy savings.

5.7.3 Calculation of Greenhouse Gas Savings

No information available regarding the greenhouse gas savings calculations.

5.7.4 Overview of Costs Related to the Action

No information available on cost related to the action and/or on the cost-effectiveness calculation.

5.7.5 Methodological Aspects

There are specific formulas to establish Qc in each of the cases. For a case a) and b) a difference is made between residential and non-residential. For residential, the specific useful energy savings are expressed relative to the mechanically ventilated reference energy surface area of the residential building, while for non-residential, the specific useful energy savings are expressed relative to the airflow rate of the controlled mechanical ventilation system in the functional building. If the actual airflow rate is not available, the projected airflow rate may be used instead.

Additionally, in cases where the measure is applied to a residential building containing between 1 and 35 dwellings, and the characteristics are unknown or cannot be determined within a reasonable expenditure of time or resources: it is possible, though not mandatory, to use the simplified indicative values from Table 2 corresponding to six typical cases in Luxembourg.

Lifetime of the measure is 25 years.

This methodology was published in the Luxemburg catalogue on standardised measures (Annex II), which is annexed to the Grand-Ducal Regulation of June 3, 2021 relating to the functioning of the energy efficiency obligation mechanism. The document is published in French.

5.7.6 Bibliography

https://legilux.public.lu/filestore/eli/etat/leg/rmin/2021/06/15/a458/jo/fr/pdfa/eli-etat-leg-rmin-2021-06-15-a458-jo-fr-pdfa.pdf

5.8. Heat recovery systems in buildings – Slovenia

The calculation of energy savings is based on the amount of heat transferred to the supply air from the warm air exiting the building. The savings are determined based on the area of the building where the ventilation system operates, using standardized values for the air exchange rate, as well as the system's operating time during the heating season, room height, the temperature difference between the exhaust air and the outside air, the heat recovery efficiency, and the air density.

5.8.1 Calculation of Final Energy Savings

Formula

Energy savings from the installation of a ventilation system with waste heat recovery are calculated using the following equation:

$$TFES_i = \frac{A \cdot h \cdot \beta \cdot t \cdot c \cdot \rho \cdot \Delta T \cdot \eta \cdot N}{3600} \qquad (78)$$

All formulas are used to calculate the yearly savings.

Table 113 – Parameters used in the formula for final energy savings

Parameter	Description
PE_i	Energy savings [kWh/year] due to the utilization of waste heat in ventilation systems (recuperation)
A	Area of the building [m^2] to which the central ventilation system applies, or building area, if local ventilation units are installed
h	Height [m] of rooms (from floor to ceiling)
β	Air exchange rate [h^{-1}]
t	Operating time [h] of the ventilation system during the heating season (3000 h)
c	Specific heat of air (1 kJ / kg K)
ρ	Air density (1.2 kg/m^3)
ΔT	Difference between indoor air temperature and average outdoor temperature of air during the heating season (18 K)
η	Recovery rate (0.7)
N	Number of ventilation units (central system N = 1, system with up to 4 local units)

Considering the above normalized values, the energy savings are calculated according to the equation:

$$TFES_i = 15.750 \cdot A \cdot N \qquad (79)$$

Standardized Calculation Values

The following standardized parameters are used in the calculation of energy savings resulting from the installation of a ventilation system with heat recovery. These values represent typical conditions for residential buildings and reflect assumptions about room geometry, ventilation performance, operating duration, temperature differences, and system efficiency.

Table 114 – Indicative values for calculation of greenhouse gas savings

Parameter	Value	Unit
A - Area of the building [m^2]	103 m^2 for a dwelling in single-family buildings and 60 m^2 for dwelling in multi-apartment buildings	m^2
h - Height [m] of rooms (from floor to ceiling	2.5 m	m
β - Air exchange rate	0.5	h^{-1}
Operating hours	3000	h
ΔT - Difference between indoor air temperature and average outdoor temperature of air during the heating season	18	K
η – Recovery rate	0.7	/

5.8.2 Calculation of Greenhouse Gas Savings

Formula

Reduction of CO_2 emissions (ZEC) is calculated using the following equation:

$$GHGSAV = TFES_i \cdot ef \qquad (80)$$

Table 115 – Parameters used in the formula for greenhouse gas savings

Parameter	Description
ef	Emission factor [kg CO_2/year] for the fuel or energy source used in heating system, as defined in national regulation.

Standardized Calculation Values

The tables below present standardized CO_2 emission factors used for calculating emission reductions in household sector. These values apply to different energy sources—including fuels, electricity, and district heating—as well as transport fuels. They serve as the basis for consistent and comparable estimations of carbon savings in building renovation and energy efficiency projects.

Table 116 – Indicative values for calculation of greenhouse gas savings

Parameter	Value	Unit
Natural Gas	0.20	kg CO_2/kWh
Light fuel oil	0.27	kg CO_2/kWh
Wood Biomass	0.00	kg CO_2/kWh
Electricity	0.49	kg CO_2/kWh
District heating	0.32	kg CO_2/kWh
Sectoral average for fuel	0.09	kg CO_2/kWh
Motor gasoline	69.30	t CO_2/TJ
Diesel fuel	74.10	t CO_2/TJ

5.8.3 Overview of Costs Related to the Action

No information on cost effectiveness available for this methodology.

5.8.4 Methodological Aspects

To use this method, data on the number of ventilation units and the building area must be known (taking into account certain conditions and standardized values).

5.8.5 Bibliography

Uradni list RS, št. 57/21 – ZURE, Rules on the methods for determining energy savings, p. 1–5: https://pisrs.si/pregledPredpisa?id=PRAV14191

6. Public Traffic Management

6.1. Methodology used to calculate savings from the use of GPSs in vehicles – Cyprus

This calculation methodology aims at calculating the final energy savings from the use of GPSs in vehicles.

6.1.1 Calculation of Final Energy Savings

Formula

BU equation

$$ES_{total} = n * EC_{avg} * f_{sav} - EC_{Rebund} \quad (81)$$

Table 4 – Parameters used in the formula for final energy savings

Parameter	Description
ES_{total}	Final energy savings per year [kWh]
n	Number of vehicles equipped with GPS
EC_{avg}	Final energy consumption of the vehicles for all the travelled distances [kWh]
f_{sav}	Energy savings factor [%]
EC_{Rebund}	Final energy consumption of the vehicles due to the rebound effect [kWh]

Standardized Calculation Values

Parameter	Value
f_{sav}	1%
Final energy consumption – passenger vehicles	Average milage annually: 11,708 km Unitary fuel consumption: 7.37 lt/100km Unitary energy consumption: 0.67 kwh/km
Final energy consumption – Light Duty Vehicles	Average milage annually: 14,643 km Unitary fuel consumption: 8.11 lt/100km Unitary energy consumption: 0.81 kwh/km
Final energy consumption – Heavy Duty Vehicles	Average milage annually: 24,275 km Unitary fuel consumption: 24.32 lt/100km Unitary energy consumption: 2.43 kwh/km
Final energy consumption - Buses	Average milage annually: 32,500 km Unitary fuel consumption: 33.57 lt/100km Unitary energy consumption: 3.36 kwh/km

6.1.2 Calculation of Primary Energy Savings

No information is provided

6.1.3 Calculation of Greenhouse Gas Savings

No information is provided

6.1.4 Overview of Costs Related to the Action

No information is provided

6.1.5 Methodological Aspects

Bottom-up equation incorporated into the official adopted catalogue with BU-methodologies through the Decree 212/2024 within the framework of the EEOs:

https://www.energy.gov.cy/assets/modules/wnp/articles/202304/192/editor/kdp2122024.pdf

The adopted catalogue with BU-methodologies has been drafted in Greek language.

6.1.6 Bibliography

https://www.energy.gov.cy/assets/modules/wnp/articles/202304/192/editor/kdp2122024.pdf

6.2. Public Traffic Management - Poland

The Poland does not have a dedicated methodology or catalogue only for Public traffic management. The Poland has a summary document "Annex 3 to the EPCIP: Description of efficiency improvement measures and PEF ratio in networks" issued by Ministry of Climate and Environment. The document provides an overview and notification details of Policy measures to achieve the required end-use energy savings referred to in Article 8 paragraph 1 of Directive 2023/1791. This includes description of measures along with the calculation methods.

Some of these measures support the topics of the new priority actions, so the description of their calculation methods can be partly used for the purposes of this deliverable or as inspiration.

In case of Public traffic management, there is measure "Development of public transport in cities", that address this topic. This measure includes infrastructural investments: adaptation, construction, reconstruction and extension of the urban transport network, including overall development of linear infrastructure and Intelligent transport system (ITS) along with other actions in public transport sector.

Another source of information can be the National Energy Efficiency Action Plan for Poland from 2017, where is chapter "Bottom-up calculations of final energy savings are presented". Chapter includes the measure "Operational Programme Infrastructure and Environment (OPI&E) – Measure 8.3 Development of intelligent transport systems" for which the calculation algorithm is given. However, it is not clear whether the measures listed here are still in place in the period 2021-2030 (e.g. as follow-up programmes).

Application area:

End-use sectors - transport sector

Scope – All means of public transport including infrastructure

Final energy in toe per year

Boundary conditions:

No details provided for this methodology.

6.2.1 Calculation of Final Energy Savings

According to Annex 3 "*In line with the requirements on methods and rules for calculating energy savings set out in Annex V, point 1, of the Energy Efficiency Directive 2023/EU, a methodology for estimating energy savings (i.e. deemed savings) and scaled savings (i.e. scaled savings) has been adopted.*

The energy savings resulting from the proposed energy efficiency improvement measure are expressed in final energy toe per year."

However, no other details are provided for this methodology. Annex 3 provides only a summary formula, which focuses more on the number of new electric and vehicles powered by alternative fuels (this area has already been described under one of the priority actions of the previous StreamSave project). However, it does not quantify other energy saving opportunities. A sample calculation for other potential savings is not provided within the Annex 3.

Therefore, the calculation methodology from the National Energy Efficiency Action Plan for Poland from 2017, for measure "Operational Programme Infrastructure and Environment (OPI&E) – Measure 8.3 Development of intelligent transport systems" is presented.

Formula

The formula according to the measure "Operational Programme Infrastructure and Environment (OPI&E) – Measure 8.3 from NEEAP 2017.

This formula calculates first-year savings.

$$O_{ITS} = \sum_{i=1}^{m} (2 + \rho_i) \sum_{j=1}^{n} \varphi * w_{ITS} * k_{jITS} \qquad (82)$$

Note: This is an older formula that may no longer be valid or used.

Table 117 – Parameters used in the formula for final energy savings

Parameter	Description
O_{ITS}	Annual average final energy savings [ktoe/year]
φ	Primary/final energy conversion factor [dmnl]
w_{ITS}	Unitary primary energy savings relative to investment expenditure [ktoe/EUR]
k_{jITS}	Investment expenditure on projects related to traffic management systems and freight transport optimisation [EUR/year]
ρ_i	Coefficient of change in allocation for programme for the years 2014- 2020 relative to 2007-2013 programme [dmnl]

6.2.2 Calculation of Primary Energy Savings

No details provided for this methodology.

6.2.3 Calculation of Greenhouse Gas Savings

No details provided for this methodology.

6.2.4 Overview of Costs Related to the Action

No details provided for this methodology.

6.2.5 Methodological Aspects

The calculation methodology refers to the Energy Saving Directive but does not provide further details. In addition, the methodology states that the calculation of energy savings is expressed in final energy in toe/year.

6.2.6 Bibliography

Collective of authors. (2024). Poland - Draft updated NECP 2021-2030 - Annex 3. *Warsaw: Ministerstwo Klimatu i Środowiska*. Retrieved from: https://commission.europa.eu/publications/poland-draft-updated-necp-2021-2030_en

6.3. Support for public passenger transport – Slovakia

Slovakia lacks a specific methodology or catalogue only for deep renovations. It is included as part of the overall support for public transportation. The goal of this measure is to establish conditions for sustainable mobility by systemically integrating individual transportation systems and improving their management. The main principle is to modernize city rail infrastructure and develop integrated passenger transport terminals with the goal of making public passenger transportation more appealing while mitigating the negative effects.

In particular, the related actions are building and updating public transportation lines, including priority elements; updating and modernizing mobile public transportation vehicles and means (such as alternatively powered buses and the associated charging and charging infrastructure); building and updating public transportation infrastructure (such as transfer terminals, stops, and parking lots, as well as the introduction of public transportation priority measures); building and updating the technical framework for managing public transportation vehicles; and offering tariff, information, and dispatching systems.

6.3.1 Calculation of Final Energy Savings

Formula

The methodology for calculating energy savings is based on comparing fuel consumption for annual performance before and after the implementation of the project. The calculation will be used on a regular basis to evaluate the achievement of the intended energy savings values of this measure, taking into consideration the measure's actual implemented projects and the actual measured energy savings.

The calculation follows Decree No. 327/2015 Coll. Annex No. 3. The financial mechanism administrator determines the savings and submits them to the Slovak Innovation and Energy Agency (SIEA) for evaluation. Energy savings are calculated using a survey-based methodology. The total of the cumulative energy savings achieved as a result of implementing all energy efficiency improvement measures will be used to determine the energy savings necessary to reach the final consumer's energy savings target for each year, using the formula here.

This formula calculates first-year savings.

$$USPS = (psps - frps) \times pse \times fse \tag{83}$$

Table 118 – Parameters used in the formula for final energy savings

Parameter	Description
USPS	Energy saving based on a survey for the purpose of surveying the achievement of energy savings [kWh]
psps	Number of final consumers participating in the survey
frps	Number of final consumers participating in the survey who will not implement any energy efficiency improvement measures
pse	Average energy consumption of the subject of the energy efficiency improvement measure [kWh]
fse	Energy saving factor

Standardized Calculation Values

The number of final consumers participating in the survey who do not implement any energy efficiency improvement measures is calculated using the formula:

$$frps = 0.99 \times psps \qquad (84)$$

Where frps is the number of final consumers participating in the survey who will not implement any energy efficiency improvement measures, psps is the number of final consumers participating in the survey.

The energy factor, which is shown in the table below, is based on the mean of our survey.

Table 119 – Energy saving factor

Survey method	Energy saving factor
Assistance centres	0.5 %
Telephone survey	0.25 %
Internet survey	0.25 %

6.3.2 Railway transport

Long-distance passenger transportation and suburban transportation with concentrated traffic flows on important routes offer the most potential for rail transportation expansion and service enhancement. Sustainable freight transportation, new technologies and innovations like automation, alternative fuels infrastructure and interoperability are some of the ways to increase energy efficiency in the rail transport. These measures also include the modernization and development of key nodes on the TEN-T. Continuous development of the ERTMS and ETCS systems, the GSM-R railway notification and communication system increase the interoperability of lines.

6.3.3 Calculation of Primary Energy Savings

Formula

The basic approach is the same as for Support for public passenger transport.

Standardized Calculation Values

The basic approach is the same as for Support for public passenger transport.

6.3.4 Calculation of Greenhouse Gas Savings

Formula

No details provided for this methodology.

Standardized Calculation Values

No details provided for this methodology.

6.3.5 Overview of Costs Related to the Action

Cost-Effectiveness

No details provided for this methodology.

Standardized Values

No details provided for this methodology.

6.3.6 Methodological Aspects

The methodology is based on the official monitoring methodology by the Slovak Government to calculate energy savings obtained by qualified projects to receive subsidies. The Slovak Innovation and Energy Agency operates the energy efficiency monitoring system in accordance with Decision No. 1/2015 of the Slovak Republic's Ministry of Economy. It monitors primary and final energy consumption in sectors according to the Integrated National Energy and Climate Plan for 2021-2030 and evaluates energy efficiency measures for the purpose of demonstrating the implementation of the energy savings plan by 2030. The conditions for operating the monitoring system are set out in Act No. 321/2014 Coll. on Energy Efficiency and on Amendments to Certain Acts, which entered into force on 1 December 2014: https://minzp.sk/files/oblasti/politika-zmeny-klimy/ets/schema-sp-mof-teplarne-final_en.pdf

The energy efficiency monitoring system is intended to serve as a source of information for the state and the public. The state will obtain data on the basis of which it will be able to consider where to direct potential financial assistance. The public will be able to compare the real results of projects in a specific area in the accessible part. This methodology is only available in the Slovak language: https://www.economy.gov.sk/uploads/files/EirowzB0.pdf

6.3.7 Bibliography

The Slovak Innovation and Energy Agency (2023): *Methodology tables for energy efficiency measures (by sector) for years 2021-2030*. Bratislava. Retrieved from: https://www.economy.gov.sk/uploads/files/EirowzB0.pdf

The Ministry of Economy of the Slovak Republic (2015): *Decree of the Ministry of Economy of the Slovak Republic on the calculation and fulfillment of energy efficiency targets (327/2015).* Bratislava. Retrieved from: https://www.slov-lex.sk/ezbierky/pravne-predpisy/SK/ZZ/2015/327/

List of tables

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