Erasmus+ Project ID: 2023-1-ES01-KA220-HED-000156652

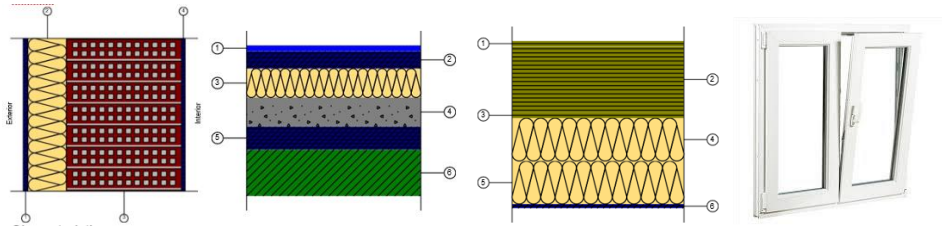
This Erasmus+ Project has been funded with support from the European Commission. This publication reflects the views only of the authors, and the European Commission and Erasmus+ National Agencies cannot be held responsible for any use which may be made of the information contained therein

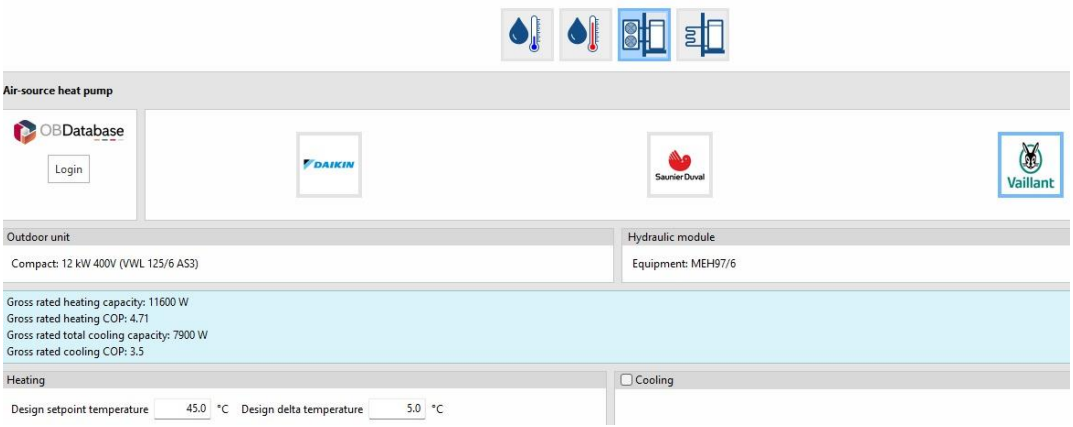
Romanian Case Study

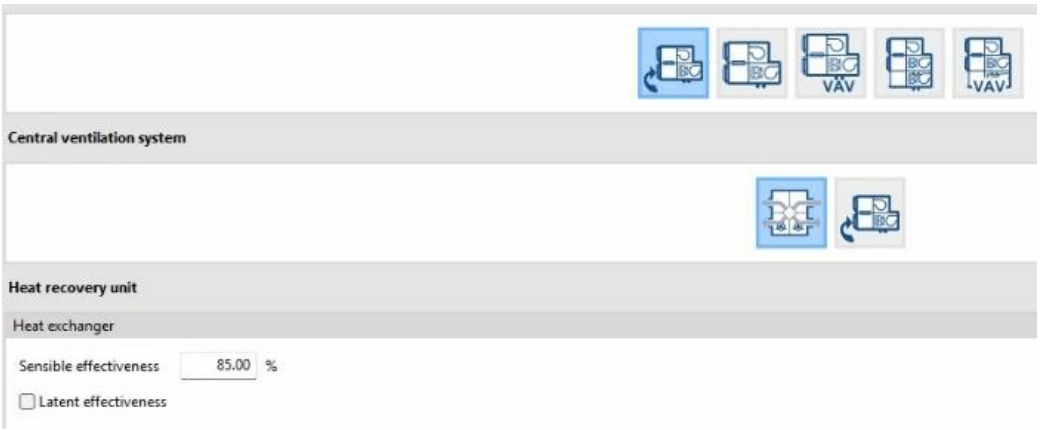
Part II: Analysis of the improvement measures

1. Case Results II. Energy consumption and Energy Rating of the alternatives to improve the building

- Case 1: Improved envelope (insulating the exterior walls with 15 cm mineral wool, the upper floor with 30 cm mineral wool and insulating the slab floors with 10 cm extruded polystyrene, triple glazed windows (U=0.8 W/m^{2}K), air-water heat pump, mechanical ventilation, underfloor heating







Energy consumption of the technical services of the building

BUILDING (Su= 332.39 m²)

Technical Services	EF		EP_{tot}		EP_{nren}	
	(kWh/year) (kWh/m²-year)	(kWh/m²-year)	(kWh/year)	(kWh/m²-year)	(kWh/year)	(kWh/m²-year)
Heating	31695.16	95.36	37463.68	112.71	37368.62	112.43
ACS	20969.03	63.09	49654.65	149.39	40973.36	123.27
Ventilation	567.78	1.71	1344.51	4.04	1109.51	3.34
Lighting	4286.70	12.90	10150.77	30.54	8376.16	25.20
	57518.67	173.05	98613.60	296.68	87827.64	264.23

where:

Su: Usable living area included in the thermal envelope, m².

EF: Final energy consumed by technical service at point of consumption.

EPtot: Total primary energy consumption.

EPnren: Primary energy consumption of non-renewable origin.

Final energy consumption of the building. Monthly results.

		Jan (kWh)	Feb (kWh)	Mar (kWh)	Apr (kWh)	May (kWh)	Jun (kWh)	Jul (kWh)	Aug (kWh)	Sep (kWh)	Oct (kWh)	Nov (kWh)	Dec (kWh)	Year (kWh/year)	kWh/m²-year)
BUILDING (Su= 332.39 m²)															
Energy demand	**Heating**	4609.7	3952.9	2696.4	838.6	54.1	–	8.9	–	672.2	1478.1	3287.2	4919.0	22517.0	67.7
	DHW	1700.8	1536.2	1700.8	1645.9	1700.8	1645.9	1700.8	1700.8	1645.9	1700.8	1645.9	1700.8	20025.5	60.2
	TOTAL	6310.5	5489.1	4397.2	2484.5	1754.9	1645.9	1709.7	1700.8	2318.1	3178.9	4933.1	6619.8	42542.5	128.0
Diesel C (Substitution system)	**Heating**	6459.3	5544.9	3824.0	1198.0	77.2	–	10.2	–	957.4	2100.1	4629.9	6894.2	31695.1	95.4
	Cooling	–	–	–	–	–	–	–	–	–	–	–	–	–	
	DHW	–	–	–	–	–	–	–	–	–	–	–	–	–	
Electricity	**Heating**	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Cooling	–	–	–	–	–	–	–	–	–	–	–	–	–	
	DHW	1780.9	1608.6	1780.9	1723.5	1780.9	1723.5	1780.9	1780.9	1723.5	1780.9	1723.5	1780.9	20969.1	63.1
	Ventilation	66.6	57.9	63.7	60.8	66.6	60.8	–	–	–	66.6	63.7	60.8	567.8	1.7
	Humidity control	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Lighting	503.0	437.4	481.2	459.3	503.0	459.3	–	–	–	503.0	481.2	459.3	4286.7	12.9
	$C_{ef,...}$	8809.9	7648.8	6149.8	3441.6	2427.8	2243.6	1791.1	1780.9	2680.9	4450.7	6898.3	9195.3	57518.7	173.0

where:

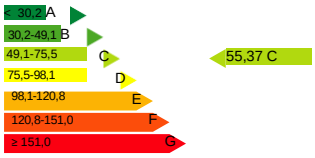
Su: Usable living area included in the thermal envelope, m².

$C_{ef,total}$: Energy consumption at point of consumption (final energy), kWh/m²-year.

Energy rating of the building: Case 1 Improvement.

Climate zone	E1	Use	Other uses

1. ENERGY RATING OF THE BUILDING IN TERMS OF EMISSIONS

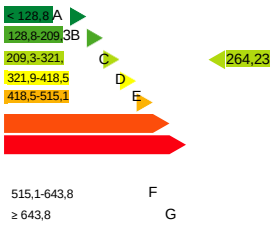
OVERALL INDICATOR	PARTIAL INDICATORS			
	HEATING		DHW	
	Heating emissions [kgCO₂/m²-year].	B	DHW emissions [kgCO₂/m²-year].	E
	29.66		20.88	
	COOLING		LIGHTING	
Global emissions [kgCO /m²-year][1]	Cooling emissions [kgCO₂/m²-year].	A	Lighting emissions [kgCO₂/m²-year].	E
	0		4.27	

The overall rating of the building is expressed in terms of carbon dioxide released into the atmosphere as a result of the building's energy consumption.

	kgCO2/m²-year	kgCO2-year
CO2 emissions from electricity consumption	25.72	8547.58
CO2 emissions from other fuels	29.66	9857.19

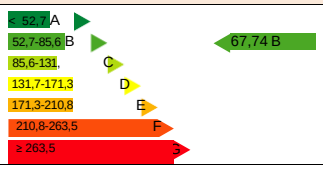
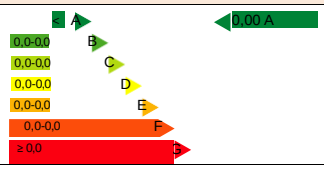
2. ENERGY RATING OF THE BUILDING IN TERMS OF NON-RENEWABLE PRIMARY ENERGY CONSUMPTION

Non-renewable primary energy means energy consumed by the building from non-renewable sources that has not undergone any conversion or transformation process.

OVERALL INDICATOR	PARTIAL INDICATORS			
	HEATING		DHW	
	Primary energy heating [kWh/m²-year]	B	Primary energy DHW [kWh/m²-yr]	E
	112.43		123.27	
	COOLING		LIGHTING	
Overall non-renewable primary energy consumption [kWh/m²-year][1]	Primary energy cooling [kWh/m²-year]	A	Primary energy lighting [kWh/m²-year].	E
	0		25.2	

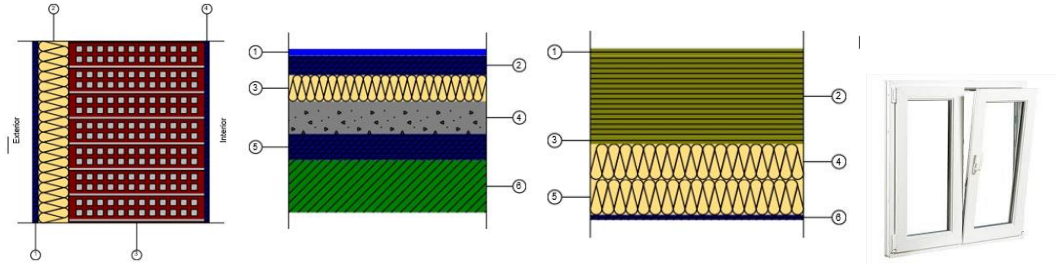
3. PARTIAL RATING OF HEATING AND COOLING ENERGY DEMAND

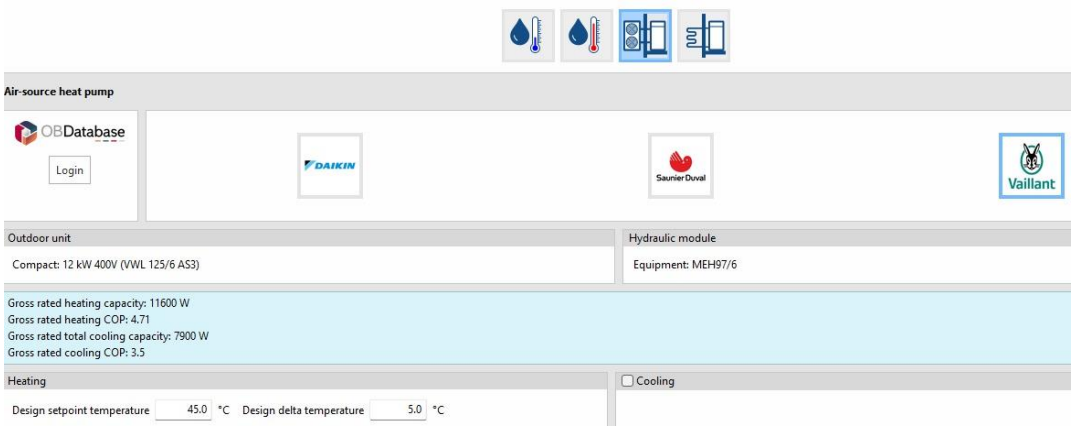
The heating and cooling energy demand is the energy required to maintain the internal comfort conditions of the building.

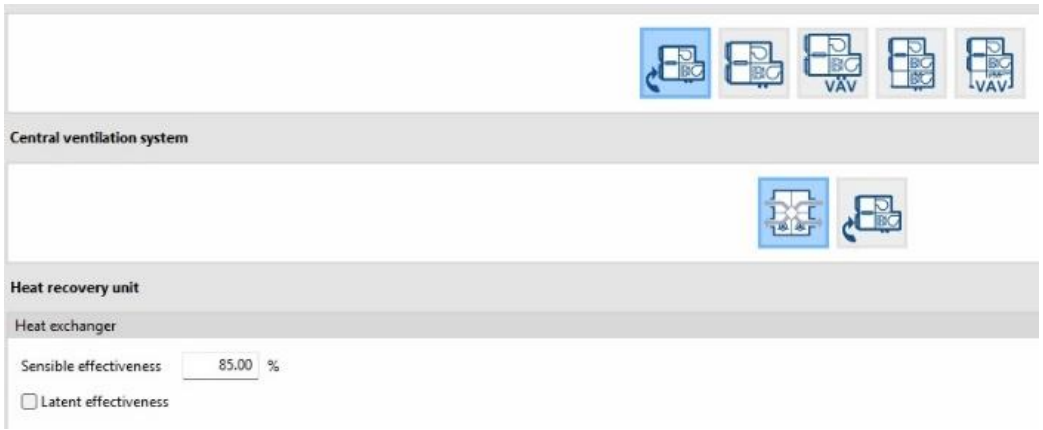
HEATING DEMAND	COOLING DEMAND
	
Heating demand [kWh/m²-year].	Cooling demand [kWh/m²-year].

1 The global indicator is the result of the sum of the partial indicators plus the value of the indicator for auxiliary consumption, if any (only tertiary buildings, ventilation, pumping, etc.). Self-consumed electricity is only deducted from the global indicator, not from the partial values.

- Case 2: Improved envelope (insulating the exterior walls with 10 cm mineral wool, the upper floor with 20 cm mineral wool and insulating the slab floors with 8 cm extruded polystyrene, triple glazed windows), air-water heat pump, mechanical ventilation, underfloor heating







Energy consumption of the technical services of the building

BUILDING (Su= 332.39 m²)

Technical Services	EF		EP_{tot}		EP_{nren}	
	(kWh/year) (kWh/m²-year)	(kWh/m²-year)	(kWh/year)	(kWh/m²-year)	(kWh/year)	(kWh/m²-year)
Heating	31041.55	93.39	36691.22	110.39	36598.15	110.11
ACS	20969.03	63.09	49654.65	149.39	40973.36	123.27
Ventilation	567.78	1.71	1344.51	4.04	1109.51	3.34
Lighting	4286.70	12.90	10150.77	30.54	8376.16	25.20
	56865.06	171.08	97841.14	294.36	87057.17	261.92

where:

Su: Usable living area included in the thermal envelope, m².

EF: Final energy consumed by technical service at point of consumption.

EPtot: Total primary energy consumption.

EPnren: Primary energy consumption of non-renewable origin.

Final energy consumption of the building. Monthly results.

		Jan (kWh)	Feb (kWh)	Mar (kWh)	Apr (kWh)	May (kWh)	Jun (kWh)	Jul (kWh)	Aug (kWh)	Sep (kWh)	Oct (kWh)	Nov (kWh)	Dec (kWh)	Year (kWh/year)	kWh/m²-year)
BUILDING (S_u= 332.39 m²)															
Energy demand	Heating	4424.2	3828.3	2868.1	871.9	85.8	0.5	22.8	--	743.7	1485.6	3232.8	4741.8	22055.2	66.4
	DHW	1700.8	1638.2	1700.8	1646.9	1700.8	1646.9	1700.8	1700.8	1646.9	1700.8	1646.9	1700.8	20025.6	60.2
	TOTAL	6125.0	5364.5	4368.9	2517.8	1786.4	1646.4	1723.6	1700.8	2389.6	3186.3	4878.8	6442.4	42080.8	126.6
Diesel C (Substitution system)	Heating	6195.1	5369.0	3771.8	1245.6	93.2	--	29.5	--	1060.9	2082.9	4553.0	6640.6	31041.5	93.4
	Cooling	--	--	--	--	--	--	--	--	--	--	--	--	--	
	DHW	--	--	--	--	--	--	--	--	--	--	--	--	--	
Electricity	Heating	--	--	--	--	--	--	--	--	--	--	--	--	--	
	Cooling	--	--	--	--	--	--	--	--	--	--	--	--	--	
	DHW	1780.9	1608.6	1780.9	1723.5	1780.9	1723.5	1780.9	1780.9	1723.5	1780.9	1723.5	1780.9	20969.1	63.1
	Ventilation	66.6	57.9	63.7	60.8	66.6	60.8	--	--	--	66.6	63.7	60.8	567.8	1.7
	Humidity control	--	--	--	--	--	--	--	--	--	--	--	--	--	
	Lighting	503.0	437.4	481.2	459.3	503.0	459.3	--	--	--	503.0	481.2	459.3	4286.7	12.9
	$C_{ef,total}$	3645.7	7473.0	6097.6	3489.2	2443.8	2243.6	1310.4	1780.8	2784.4	4433.6	6821.4	8841.6	58886.1	171.1

where:

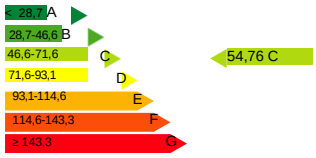
Su: Usable living area included in the thermal envelope, m².

$C_{ef,total}$: Energy consumption at point of consumption (final energy), kWh/m²-year.

Energy rating of the building: Case 2 Improvement.

Climate zone	E1	Use	Other uses

1. ENERGY RATING OF THE BUILDING IN TERMS OF EMISSIONS

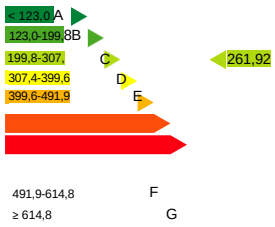
OVERALL INDICATOR	PARTIAL INDICATORS			
	HEATING		DHW	
	Heating emissions [kgCO₂/m²-year].	B	DHW emissions [kgCO₂/m²-year].	E
	29.04		20.88	
	COOLING		LIGHTING	
Global emissions [kgCO /m²-year][1]	Cooling emissions [kgCO₂/m²-year].	A	Lighting emissions [kgCO₂/m²-year].	E
	0		4.27	

The overall rating of the building is expressed in terms of carbon dioxide released into the atmosphere as a result of the building's energy consumption.

	kgCO2/m²-year	kgCO2-year
CO2 emissions from electricity consumption	25.72	8547.58
CO2 emissions from other fuels	29.04	9653.92

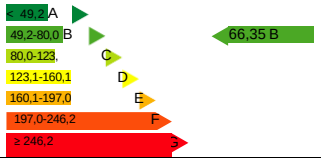
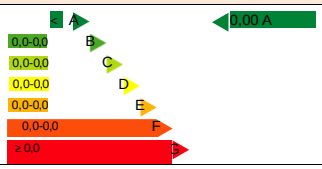
2. ENERGY RATING OF THE BUILDING IN TERMS OF NON-RENEWABLE PRIMARY ENERGY CONSUMPTION

Non-renewable primary energy means energy consumed by the building from non-renewable sources that has not undergone any conversion or transformation process.

OVERALL INDICATOR	PARTIAL INDICATORS			
	HEATING		DHW	
	Primary energy heating [kWh/m²-year]	B	Primary energy DHW [kWh/m²-yr]	E
	110.11		123.27	
	COOLING		LIGHTING	
Overall non-renewable primary energy consumption [kWh/m²-year][1]	Primary energy cooling [kWh/m²-year] [kWh/m²-year].	A	Primary energy lighting [kWh/m²-year].	E
	0		25.2	

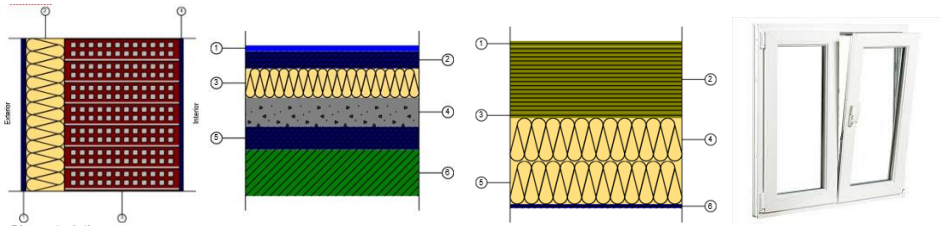
3. PARTIAL RATING OF HEATING AND COOLING ENERGY DEMAND

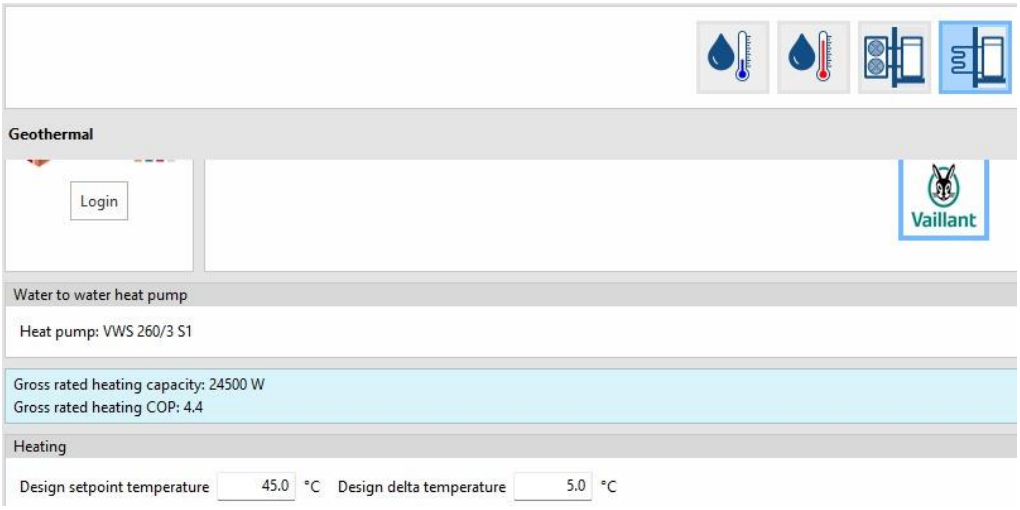
The heating and cooling energy demand is the energy required to maintain the internal comfort conditions of the building.

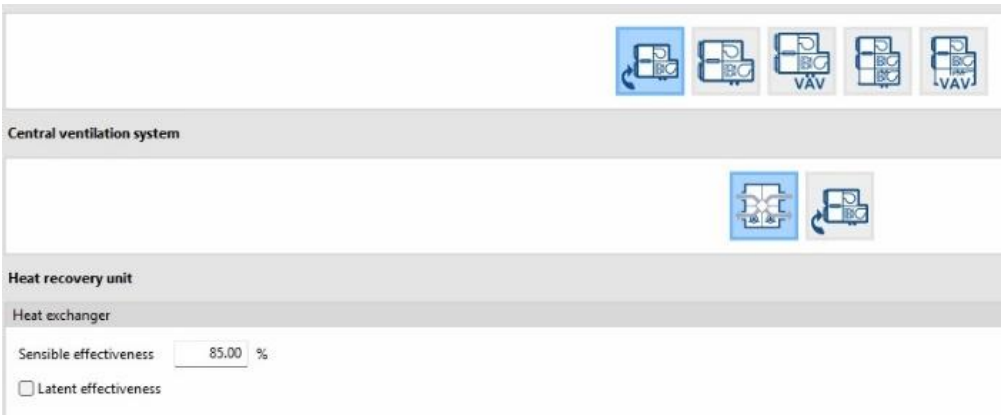
HEATING DEMAND	COOLING DEMAND
	
Heating demand [kWh/m²-year].	Cooling demand [kWh/m²-year].

1 The global indicator is the result of the sum of the partial indicators plus the value of the indicator for auxiliary consumption, if any (only tertiary buildings, ventilation, pumping, etc.). Self-consumed electricity is only deducted from the global indicator, not from the partial values.

- Case 3: Improved envelope (insulating the exterior walls with 15 cm mineral wool, the upper floor with 30 cm mineral wool and insulating the slab floors with 10 cm extruded polystyrene, triple glazed windows), water/ground-water heat pump, mechanical ventilation, underfloor heating







Energy consumption of the technical services of the building

BUILDING (S_u= 332.39 m²)

Technical services	EF		EP_{tot}		EP_{nren}	
	(kWh/year)	(kWh/m²-year)	(kWh/year)	(kWh/m²-year)	(kWh/year)	(kWh/m²-year)
Heating	27893.02	83.92	32969.48	99.19	32885.72	98.94
DHW	20969.03	63.09	49654.65	149.39	40973.36	123.27
Ventilation	567.78	1.71	1344.51	4.04	1109.51	3.34
Lighting	4286.70	12.90	10150.77	30.54	8376.16	25.20
	53716.53	161.61	94119.73	283.16	83345.07	250.75

where:

Su: Usable living area included in the thermal envelope, m².

EF: Final energy consumed by technical service at point of consumption.

EPtot: Total primary energy consumption.

EPnren: Primary energy consumption of non-renewable origin.

Final energy consumption of the building. Monthly results.

		Jan (kWh)	Feb (kWh)	Mar (kWh)	Apr (kWh)	May (kWh)	Jun (kWh)	Jul (kWh)	Aug (kWh)	Sep (kWh)	Oct (kWh)	Nov (kWh)	Dec (kWh)	Year (kWh/year)	kWh/m²-year)
BUILDING (S_U = 332.39 m²)															
Energy demand	**Heating**	**4049.6**	**3494.1**	**2366.2**	**697.8**	**37.6**	**–**	**2.2**	**–**	**594.1**	**1272.1**	**2921.5**	**4362.1**	**19797.4**	**59.6**
	DHW	**1700.8**	**1536.2**	**1700.8**	**1645.9**	**1700.8**	**1645.9**	**1700.8**	**1700.8**	**1645.9**	**1700.8**	**1645.9**	**1700.8**	**20025.5**	**60.2**
	TOTAL	**5750.4**	**5030.3**	**4067.0**	**2343.8**	**1738.4**	**1645.9**	**1703.0**	**1700.8**	**2240.1**	**2972.9**	**4567.4**	**6062.9**	**39822.8**	**119.8**
Diesel C (Substitution system)	**Heating**	5679.6	4905.5	3363.0	996.9	53.7	–	1.1	–	845.8	1810.3	4124.0	6113.1	27893.0	83.9
	Cooling	–	–	–	–	–	–	–	–	–	–	–	–	–	
	DHW	–	–	–	–	–	–	–	–	–	–	–	–	–	
Electricity	**Heating**	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Cooling	–	–	–	–	–	–	–	–	–	–	–	–	–	
	DHW	1780.9	1608.6	1780.9	1723.5	1780.9	1723.5	1780.9	1780.9	1723.5	1780.9	1723.5	1780.9	20969.1	63.1
	Ventilation	66.6	57.9	63.7	60.8	66.6	60.8	–	–	–	66.6	63.7	60.8	567.8	1.7
	Humidity control	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Lighting	503.0	437.4	481.2	459.3	503.0	459.3	–	–	–	503.0	481.2	459.3	4286.7	12.9
	$Cef_{,MM}$	**8030.2**	**7009.5**	**5688.9**	**3240.5**	**2404.3**	**2243.6**	**1782.0**	**1780.9**	**2569.3**	**4160.9**	**6392.3**	**8414.2**	**53716.6**	**161.6**

where:

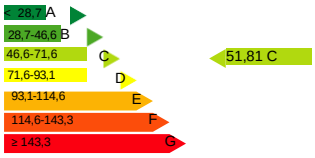
Su: Usable living area included in the thermal envelope, m².

Cef,total: Energy consumption at point of consumption (final energy), kWh/m²-year.

Energy rating of the building: Case 3 Improvement.

Climate zone	E1	**Use**	Other uses

1. ENERGY RATING OF THE BUILDING IN TERMS OF EMISSIONS

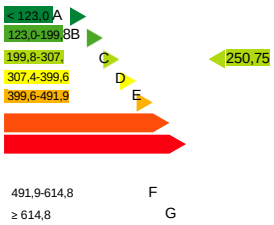
OVERALL INDICATOR	PARTIAL INDICATORS			
	HEATING		**DHW**	
	Heating emissions [kgCO₂/m²-year].	**B**	DHW emissions [kgCO₂/m²-year].	**E**
	26.1		**20.88**	
	COOLING		**LIGHTING**	
Global emissions [kgCO₂ /m²-year]	Cooling emissions [kgCO₂/m²-year].	**A**	Lighting emissions [kgCO₂/m²-year].	**E**
	0		**4.27**	

The overall rating of the building is expressed in terms of carbon dioxide released into the atmosphere as a result of the building's energy consumption.

	kgCO2/m²-year	kgCO2-year
CO2 emissions from electricity consumption	25.72	8547.58
CO2 emissions from other fuels	26.10	8674.73

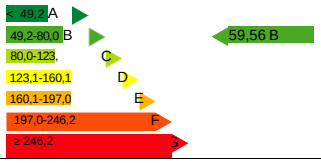
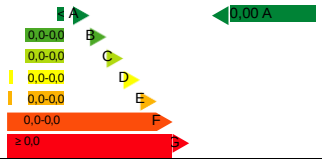
2. ENERGY RATING OF THE BUILDING IN TERMS OF NON-RENEWABLE PRIMARY ENERGY CONSUMPTION

Non-renewable primary energy means energy consumed by the building from non-renewable sources that has not undergone any conversion or transformation process.

OVERALL INDICATOR	PARTIAL INDICATORS			
	HEATING		**DHW**	
	Primary energy heating [kWh/m²-year]	**B**	Primary energy DHW [kWh/m²-yr]	**E**
	98.94		**123.27**	
	COOLING		**LIGHTING**	
Overall non-renewable primary energy consumption [kWh/m²-year][1]	Primary energy cooling [kWh/m²-year].	**A**	Primary energy lighting [kWh/m²-year].	**E**
	0		**25.2**	

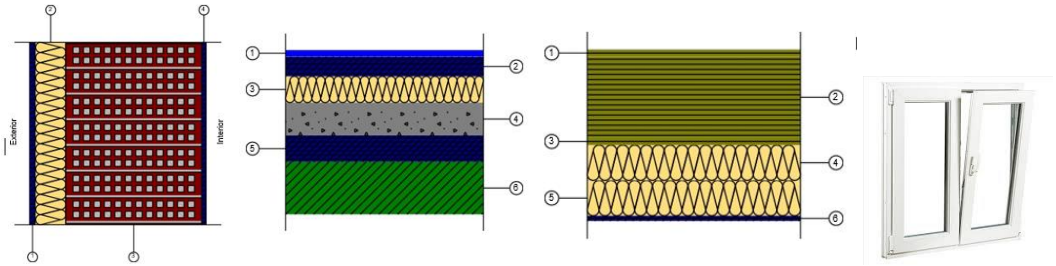
3. PARTIAL HEATING AND COOLING ENERGY DEMAND RATING

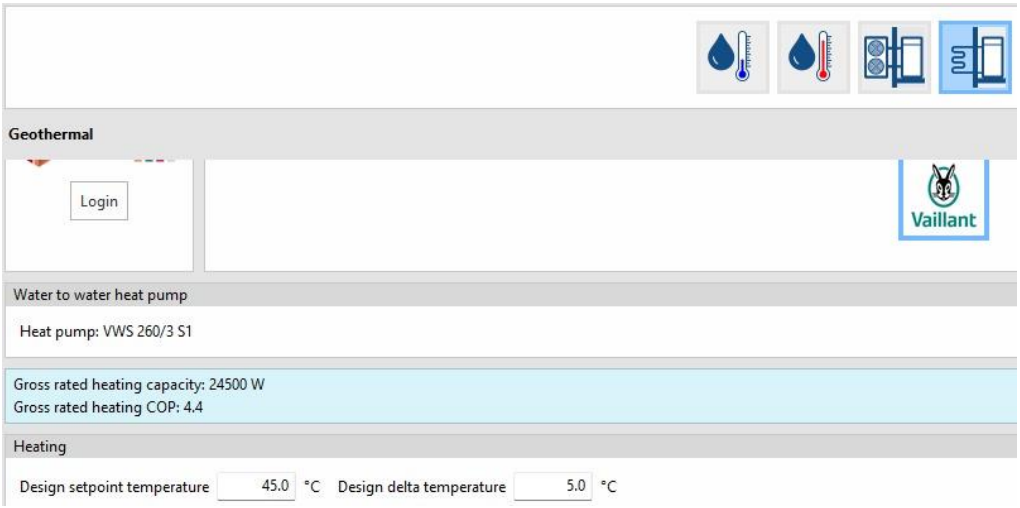
The energy demand for heating and cooling is the energy required to maintain the internal comfort conditions of the building.

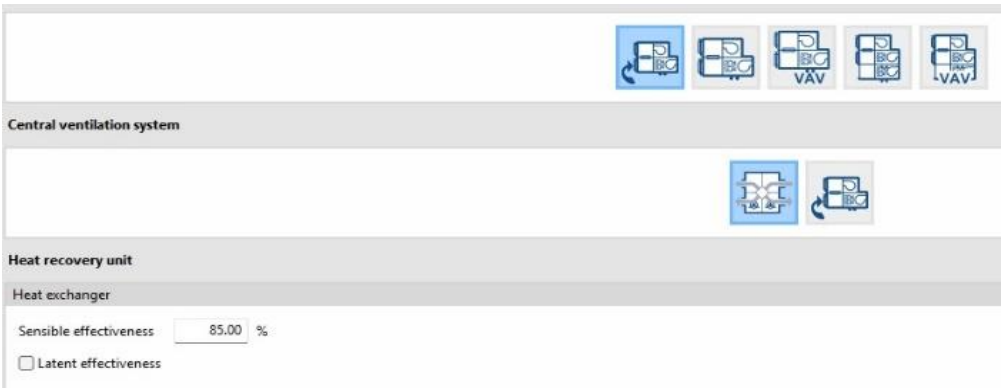
HEATING DEMAND	COOLING DEMAND
	
Heating demand [kWh/m²-year].	Cooling demand [kWh/m²-year].

1 The global indicator is the result of the sum of the partial indicators plus the value of the indicator for auxiliary consumption, if any (only tertiary buildings, ventilation, pumping, etc.). Self-consumed electricity is only deducted from the global indicator, not from the partial values.

- **Case 4: Improved envelope (insulating the exterior walls with 10 cm mineral wool, the upper floor with 20 cm mineral wool and insulating the slab floors with 8 cm extruded polystyrene, triple glazed windows), water/ground-water heat pump, mechanical ventilation, underfloor heating**







Energy consumption of the technical services of the building

BUILDING (Su= 332.39 m²)

Technical services	EF		EP_{tot}		EP_{nren}	
	(kWh/year) (kWh/m²-year)	(kWh/m²-year)	(kWh/year)	(kWh/m²-year)	(kWh/year)	(kWh/m²-year)
Heating	31041.55	93.39	36691.22	110.39	36598.15	110.11
ACS	20969.03	63.09	49654.65	149.39	40973.36	123.27
Ventilation	567.78	1.71	1344.51	4.04	1109.51	3.34
Lighting	4286.70	12.90	10150.77	30.54	8376.16	25.20
	56865.06	171.08	97841.14	294.36	87057.17	261.92

where:

Su: Usable living area included in the thermal envelope, m².

EF: Final energy consumed by technical service at point of consumption.

EPtot: Total primary energy consumption.

EPnren: Primary energy consumption of non-renewable origin.

Final energy consumption of the building. Monthly results.

		Jan (kWh)	Feb (kWh)	Mar (kWh)	Apr (kWh)	May (kWh)	Jun (kWh)	Jul (kWh)	Aug (kWh)	Sep (kWh)	Oct (kWh)	Nov (kWh)	Dec (kWh)	Year (kWh/year)	kWh/m²-year)
BUILDING (A_u = 332.39 m²)															
Energy demand	**Heating**	**4424.2**	**3828.3**	**2658.1**	**871.9**	**65.6**	**0.5**	**22.8**	**--**	**743.7**	**1465.5**	**3232.8**	**4741.6**	**22055.2**	**66.4**
	DHW	**1700.8**	**1536.2**	**1700.8**	**1645.9**	**1700.8**	**1645.9**	**1700.8**	**1700.8**	**1645.9**	**1700.8**	**1645.9**	**1700.8**	**20025.5**	**60.2**
	TOTAL	**6125.0**	**5364.5**	**4358.9**	**2517.8**	**1766.4**	**1646.4**	**1723.6**	**1700.8**	**2389.6**	**3166.3**	**4878.8**	**6442.4**	**42080.6**	**126.6**
Diesel C (Substitution system)	**Heating**	6195.1	5369.0	3771.8	1245.6	93.2	--	29.5	--	1060.9	2082.9	4553.0	6640.6	31041.5	93.4
	Cooling	--	--	--	--	--	--	--	--	--	--	--	--	--	
	DHW	--	--	--	--	--	--	--	--	--	--	--	--	--	
Electricity	**Heating**	--	--	--	--	--	--	--	--	--	--	--	--	--	
	Cooling	--	--	--	--	--	--	--	--	--	--	--	--	--	
	DHW	1780.9	1608.6	1780.9	1723.5	1780.9	1723.5	1780.9	1780.9	1723.5	1780.9	1723.5	1780.9	20969.1	63.1
	Ventilation	66.6	57.9	63.7	60.8	66.6	60.8	--	--	--	66.6	63.7	60.8	567.8	1.7
	Humidity control	--	--	--	--	--	--	--	--	--	--	--	--	--	
	Lighting	503.0	437.4	481.2	459.3	503.0	459.3	--	--	--	503.0	481.2	459.3	4286.7	12.9
	$Cef_{,total}$	**8545.7**	**7473.0**	**6097.6**	**3489.2**	**2443.8**	**2243.6**	**1810.4**	**1780.9**	**2784.4**	**4433.5**	**6821.4**	**8941.6**	**56865.1**	**171.1**

where:

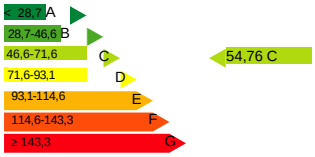
Su: Usable living area included in the thermal envelope, m².

$Cef_{,total}$: Energy consumption at point of consumption (final energy), kWh/m²-year.

Energy rating of the building: Case 4 Improvement.

Climate zone	E1	Use	Other uses

1. ENERGY RATING OF THE BUILDING IN TERMS OF EMISSIONS

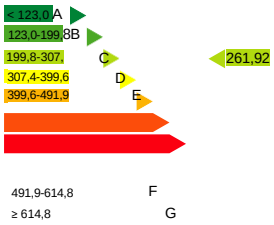
OVERALL INDICATOR	PARTIAL INDICATORS			
	HEATING		DHW	
	Heating emissions [kgCO₂/m²-year].	B	DHW emissions [kgCO₂/m²-year].	E
	29.04		20.88	
	COOLING		LIGHTING	
Global emissions [kgCO /m²-year][1]	Cooling emissions [kgCO₂/m²-year]	A	Lighting emissions [kgCO₂/m²-year]	E
	0		4.27	

The overall rating of the building is expressed in terms of carbon dioxide released into the atmosphere as a result of the building's energy consumption.

	kgCO2/m²-year	kgCO2-year
CO2 emissions from electricity consumption	25.72	8547.58
CO2 emissions from other fuels	29.04	9653.92

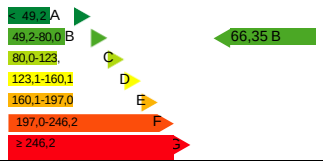
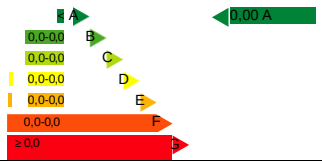
2. ENERGY RATING OF THE BUILDING IN TERMS OF NON-RENEWABLE PRIMARY ENERGY CONSUMPTION

Non-renewable primary energy means energy consumed by the building from non-renewable sources that has not undergone any conversion or transformation process.

OVERALL INDICATOR	PARTIAL INDICATORS			
	HEATING		DHW	
	Primary energy heating [kWh/m²-year]	B	Primary energy ACS [kWh/m²-yr]	E
	110.11		123.27	
	COOLING		LIGHTING	
Overall non-renewable primary energy consumption [kWh/m²-year][1]	Primary energy cooling [kWh/m²-year].	A	Primary energy lighting [kWh/m²-year].	E
	0		25.2	

3. PARTIAL HEATING AND COOLING ENERGY DEMAND RATING

The energy demand for heating and cooling is the energy required to maintain the internal comfort conditions of the building.

HEATING DEMAND	COOLING DEMAND
	
Heating demand [kWh/m²-year].	Cooling demand [kWh/m²-year].

1 The global indicator is the result of the sum of the partial indicators plus the value of the indicator for auxiliary consumption, if any (only tertiary buildings, ventilation, pumping, etc.). Self-consumed electricity is only deducted from the global indicator, not from the partial values.

2. Analysis of Results. Emissions, Energy Consumption and Energy Rating of the cases

Comparison of results

Final energy consumption (kWh/m2·year)

Technical Services	Case 0 Initial situation	Case 1 Imp 1	Case 2 Imp 2	Case 3 Imp 3	Case 4 Imp 4
Heating	311.69	95.36	93.39	83.92	93.39
DHW	63.09	63.09	63.09	63.09	63.09
Lighting	12.9	12.9	12.9	12.9	12.9
Ventilation	-	1.71	1.71	1.71	1.71
TOTAL	387.68	173.05	171.08	161.61	171.08

Legend

Imp 1- Improvement 1: Improved thermal envelope (exterior walls with 15 cm mineral wool, the upper floor with 30 cm mineral wool and the slab floors with 10 cm extruded polystyrene) + triple glazed windows+ air-water heat pump

Imp 2- Improvement 2: Improved thermal envelope (exterior walls with 10 cm mineral wool, the upper floor with 20 cm mineral wool and the slab floors with 8 cm extruded polystyrene) + triple glazed windows+ air-water heat pump

Imp 3- Improvement 3: Improved thermal envelope (exterior walls with 15 cm mineral wool, the upper floor with 30 cm mineral wool and the slab floors with 10 cm extruded polystyrene) + triple glazed windows+ water-water heat pump

Imp 4- Improvement 4: Improved thermal envelope (exterior walls with 10 cm mineral wool, the upper floor with 20 cm mineral wool and the slab floors with 8 cm extruded polystyrene) + triple glazed windows+ water-water heat pump

Total primary energy consumption (kWh/m2·year)

Technical Services	Case 0 Initial situation	Case 1 Imp 1	Case 2 Imp 2	Case 3 Imp 3	Case 4 Imp 4
Heating	340.81	112.71	110.39	99.19	110.39
DHW	149.39	149.39	149.39	149.39	149.39
Lighting	30.54	30.54	30.54	30.54	30.54
Ventilation	-	4.04	4.04	4.04	4.04
TOTAL	340.81	112.71	110.39	99.19	110.39

Legend

Imp 1- Improvement 1: Improved thermal envelope (exterior walls with 15 cm mineral wool, the upper floor with 30 cm mineral wool and the slab floors with 10 cm extruded polystyrene) + triple glazed windows+ air-water heat pump

Imp 2- Improvement 2: Improved thermal envelope (exterior walls with 10 cm mineral wool, the upper floor with 20 cm mineral wool and the slab floors with 8 cm extruded polystyrene) + triple glazed windows+ air-water heat pump

Imp 3- Improvement 3: Improved thermal envelope (exterior walls with 15 cm mineral wool, the upper floor with 30 cm mineral wool and the slab floors with 10 cm extruded polystyrene) + triple glazed windows+ water-water heat pump

Imp 4- Improvement 4: Improved thermal envelope (exterior walls with 10 cm mineral wool, the upper floor with 20 cm mineral wool and the slab floors with 8 cm extruded polystyrene) + triple glazed windows+ water-water heat pump

Total primary energy consumption from non-renewable origin (kWh/m2·year)

Technical Services	**Case 0** **Initial situation**	**Case 1** **Imp 1**	**Case 2** **Imp 2**	**Case 3** **Imp 3**	**Case 4** **Imp 4**
Heating	35.96	112.43	110.11	98.94	110.11
DHW	123.27	123.27	123.27	123.27	123.27
Lighting	25.2	25.2	25.2	25.2	25.2
Ventilation	-	3.34	3.34	3.34	3.34
TOTAL	184.43	264.24	261.92	250.75	261.92

Legend

Imp 1- Improvement 1: Improved thermal envelope (exterior walls with 15 cm mineral wool, the upper floor with 30 cm mineral wool and the slab floors with 10 cm extruded polystyrene) + triple glazed windows+ air-water heat pump

Imp 2- Improvement 2: Improved thermal envelope (exterior walls with 10 cm mineral wool, the upper floor with 20 cm mineral wool and the slab floors with 8 cm extruded polystyrene) + triple glazed windows+ air-water heat pump

Imp 3- Improvement 3: Improved thermal envelope (exterior walls with 15 cm mineral wool, the upper floor with 30 cm mineral wool and the slab floors with 10 cm extruded polystyrene) + triple glazed windows+ water-water heat pump

Imp 4- Improvement 4: Improved thermal envelope (exterior walls with 10 cm mineral wool, the upper floor with 20 cm mineral wool and the slab floors with 8 cm extruded polystyrene) + triple glazed windows+ water-water heat pump

Building Emissions (kgCO2/m2·year)

Technical Services	Case 0 Initial situation	Case 1 Imp 1	Case 2 Imp 2	Case 3 Imp 3	Case 4 Imp 4
CO2 from electricity	29.52	25.72	25.72	25.72	25.72
CO2 from other fuels	5.37	29.66	29.04	26.1	29.04
TOTAL	34.9	55.37	54.76	51.81	54.76
Energy Rating	B	C	C	C	C

Legend

Imp 1- Improvement 1: Improved thermal envelope (exterior walls with 15 cm mineral wool, the upper floor with 30 cm mineral wool and the slab floors with 10 cm extruded polystyrene) + triple glazed windows+ air-water heat pump

Imp 2- Improvement 2: Improved thermal envelope (exterior walls with 10 cm mineral wool, the upper floor with 20 cm mineral wool and the slab floors with 8 cm extruded polystyrene) + triple glazed windows+ air-water heat pump

Imp 3- Improvement 3: Improved thermal envelope (exterior walls with 15 cm mineral wool, the upper floor with 30 cm mineral wool and the slab floors with 10 cm extruded polystyrene) + triple glazed windows+ water-water heat pump

Imp 4- Improvement 4: Improved thermal envelope (exterior walls with 10 cm mineral wool, the upper floor with 20 cm mineral wool and the slab floors with 8 cm extruded polystyrene) + triple glazed windows+ water-water heat pump