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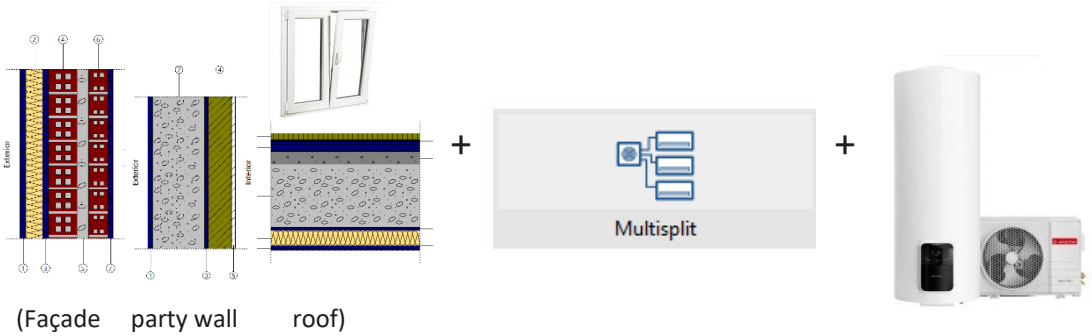
Spanish Case Study

Part II: Analysis of improvement measures

3.9. Case Results II. Energy Consumption and Energy rating of the alternatives to improve the building.

- **Case 3: Improvement 1 of the Initial situation case 1. Improved envelope 6 cm Insolation + PVC Double glazed windows with argon gas + H & AC direct expansion multi-split System + DHW heat pump.**



(Façade party wall roof)

(PVC Double glazed windows with argon gas. U= 1.7 W/m²·K)

Energy consumption of the building's technical services

BUILDING (S_u = 116.38 m²)

Technical Services	EF		EP_{tot}		EP_{nren}	
	(kWh/year)	(kWh/m²·year)	(kWh/year)	(kWh/m²·year)	(kWh/year)	(kWh/m²·year)
Heating	1092.34	9.39	1513.58	13.01	601.66	5.17
Cooling	380.28	3.27	900.52	7.74	743.06	6.38
DHW	2268.50	19.49	3137.72	26.96	1241.61	10.67
	3741.11	32.15	5551.83	47.71	2586.34	22.22
Requirements of the Spanish standard kWh/m²·year				<80.00 **OK!**	kWh/m²·year	<55.00 **OK!**

where:

S_u: *Living area included in the thermal envelope, m².*

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

EP_{tot}: *Total primary energy consumption.*

EP_{nren}: *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)	Year (kWh/m²·año)
BUILDING (S_u = 116.38 m²)															
Energy demand	**Heating**	**338.9**	**226.1**	**173.1**	**21.0**	**12.1**	--	--	--	--	--	**23.8**	**270.0**	**1065.0**	**9.2**
	Cooling	--	--	--	--	--	**136.2**	**361.3**	**445.3**	**204.9**	--	--	--	**1147.7**	**9.9**
	DHW	**208.6**	**188.4**	**204.4**	**193.1**	**191.0**	**176.7**	**174.1**	**169.9**	**172.6**	**187.4**	**193.7**	**208.6**	**2268.5**	**19.5**
	TOTAL	**547.5**	**414.5**	**377.4**	**214.1**	**203.2**	**312.9**	**535.4**	**615.2**	**377.5**	**187.4**	**217.4**	**478.6**	**4481.1**	**38.5**
Electricity	**Heating**	96.1	64.3	49.4	6.2	3.5	0.6	1.6	1.9	0.9	--	6.8	76.7	307.9	2.6
	Cooling	0.7	0.5	0.4	0.0	0.0	45.0	119.5	145.8	67.9	--	0.0	0.6	380.3	3.3
	DHW	58.4	52.8	57.2	54.1	53.5	49.5	48.8	47.6	48.4	52.5	54.3	58.4	635.4	5.5
	Ventilation	--	--	--	--	--	--	--	--	--	--	--	--	--	
	Humidity control	--	--	--	--	--	--	--	--	--	--	--	--	--	
	Lighting	--	--	--	--	--	--	--	--	--	--	--	--	--	
Environment	**Heating**	249.9	166.6	127.2	15.3	8.9	--	--	--	--	--	17.5	199.0	784.4	6.7
	Cooling	--	--	--	--	--	--	--	--	--	--	--	--	--	

	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·año)
DHW	150.2	135.6	147.1	139.0	137.5	127.2	125.3	122.3	124.3	134.9	139.4	150.2	1633.1	14.0
$C_{ef,total}$	**555.3**	**419.8**	**381.4**	**214.6**	**203.5**	**222.3**	**295.1**	**317.6**	**241.4**	**187.4**	**218.0**	**484.8**	**3741.1**	**32.1**

where:

S_u: *Living area included in the thermal envelope, m².*

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

Energy rating of the building: Case 3. Improvement 1 of case 1.

Climatic zone (eq.)	B3	**Use**	Private residential

ENERGY RATING OF THE BUILDING IN EMISSIONS

1.

GLOBAL INDICATOR	PARTIAL INDICATORS			
< 5,5 A 5,5-10,4 B 10,4-17,5 C 17,5-28,1 D 28,1-54,9 E 54,9-64,3 F ≥ 64,3 G 3,77 A	**HEATING**		**DHW**	
	Heating emissions [$kgCO_2/m^2$·year]	**A**	DHW emissions [$kgCO_2/m^2$·year]	**C**
	0.88		**1.81**	
	COOLING		**LIGHTING**	
Global emissions[$kgCO_2/m^2$·year][1]	Cooling emissions [$kgCO_2/m^2$·year]	**A**	Lighting emissions [$kgCO_2/m^2$·year]	**-**
2.	**1.08**		**-**	

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

	$kgCO_2/m^2$·year	**$kgCO_2$·year**
CO2 emissions from electricity consumption	3.76	438.13
CO2 emissions from other fuels	0.00	0.00

ENERGY RATING OF THE BUILDING IN NON-RENEWABLE PRIMARY ENERGY CONSUMPTION

3.

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

4.

GLOBAL INDICATOR	PARTIAL INDICATORS			
< 23,8 A 23,8-45,1 B 45,1-76,2 C 76,2-122,1 D 122,1-229,6 E 229,6-268,6 F ≥ 268,6 G 22,22 A	**HEATING**		**DHW**	
	Primary energy heating [kWh/m²·year]	**A**	DHW Primary energy [kWh/m²·year]	**E**
	5.17		**10.67**	
	COOLING		**LIGHTING**	
Global consumption of non-renewable primary energy[kWh/m²·year][1]	Primary energy cooling [kWh/m²·year]	**A**	Primary energy lighting [kWh/m²·year]	**-**
	6.39		**-**	

PARTIAL RATING OF HEATING AND COOLING ENERGY DEMAND

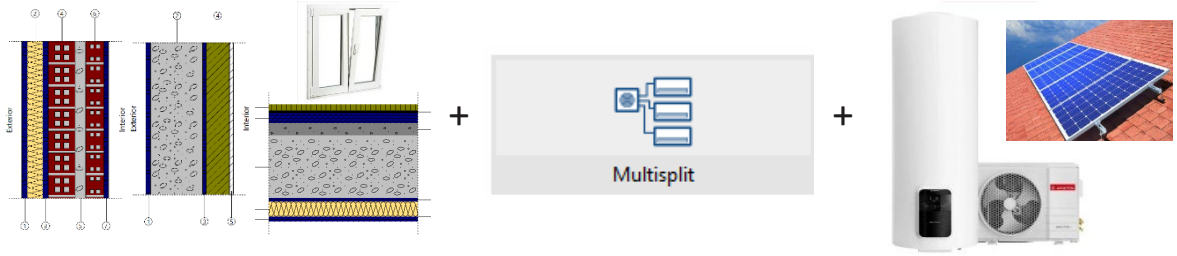
The energy demand for heating and cooling is the energy needed to maintain the building's internal comfort conditions.

5.

HEATING DEMAND	COOLING DEMAND
< 9,7 A 9,7-18,4 B 18,4-31,1 C 31,1-49,9 D 49,9-83,6 E 83,6-102,8 F ≥ 102,8 G 9,15 A	< 10,0 A 10,0-14,3 B 14,3-20,4 C 20,4-29,7 D 29,7-36,7 E 36,7-45,1 F ≥ 45,1 G 9,86 A
6. 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: Improvement 2 of the Initial situation case 1. Improved envelope 6 cm Insolation + PVC Double glazed windows with argon gas +H & AC direct expansion multi-split System + DHW heat pump + Photovoltaic panels. (Case 3+ Photovoltaic panels)**



(Façade party wall roof)
(PVC Double glazed windows with argon gas. U= 1.7 W/m²·K)

Energy consumption of the building's technical services

BUILDING (S_u = 116.38 m²)

Technical Services	EF		EP_{tot}		EP_{nren}	
	(kWh/year)	(kWh/m²·year)	(kWh/year)	(kWh/m²·year)	(kWh/year)	(kWh/m²·year)
Heating	1092.34	9.39	1092.30	9.39	--	--
Cooling	380.28	3.27	380.32	3.27	--	--
DHW	2268.50	19.49	2268.51	19.49	--	--
	3741.11	32.15	3741.13	32.15	--	--
Requirements of the Spanish standard kWh/m²·year				<80.00 **OK!**	kWh/m²·year	<55.00 **OK!**

where:

S_u: Living area included in the thermal envelope, m².
EF: Final energy consumed by the technical service at the point of consumption.
EP_{tot}: Total primary energy consumption.
EP_{nren}: 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)	Year (kWh/m²·año)
BUILDING (S_u = 116.38 m²)															
Energy demand	**Heating**	**338.9**	**226.1**	**173.1**	**21.0**	**12.1**	**--**	**--**	**--**	**--**	**--**	**23.8**	**270.0**	**1065.0**	**9.2**
	Cooling	**--**	**--**	**--**	**--**	**--**	**136.2**	**361.3**	**445.3**	**204.9**	**--**	**--**	**--**	**1147.7**	**9.9**
	DHW	**208.6**	**188.4**	**204.4**	**193.1**	**191.0**	**176.7**	**174.1**	**169.9**	**172.6**	**187.4**	**193.7**	**208.6**	**2268.5**	**19.5**
	TOTAL	**547.5**	**414.5**	**377.4**	**214.1**	**203.2**	**312.9**	**535.4**	**615.2**	**377.5**	**187.4**	**217.4**	**478.6**	**4481.1**	**38.5**
Electricity	**Heating**	96.1	64.3	49.4	6.2	3.5	0.6	1.6	1.9	0.9	--	6.8	76.7	307.9	2.6
	Cooling	0.7	0.5	0.4	0.0	0.0	45.0	119.5	145.8	67.9	--	0.0	0.6	380.3	3.3
	DHW	58.4	52.8	57.2	54.1	53.5	49.5	48.8	47.6	48.4	52.5	54.3	58.4	635.4	5.5
	Ventilation	--	--	--	--	--	--	--	--	--	--	--	--	--	
	Humidity control	--	--	--	--	--	--	--	--	--	--	--	--	--	
	Lighting	--	--	--	--	--	--	--	--	--	--	--	--	--	
Environment	**Heating**	249.9	166.6	127.2	15.3	8.9	--	--	--	--	--	17.5	199.0	784.4	6.7
	Cooling	--	--	--	--	--	--	--	--	--	--	--	--	--	
	DHW	150.2	135.6	147.1	139.0	137.5	127.2	125.3	122.3	124.3	134.9	139.4	150.2	1633.1	14.0
	$C_{ef,total}$	**555.3**	**419.8**	**381.4**	**214.6**	**203.5**	**222.3**	**295.1**	**317.6**	**241.4**	**187.4**	**218.0**	**484.8**	**3741.1**	**32.1**

where:

S_u: Living area included in the thermal envelope, m².
$C_{ef,total}$: Energy consumption at the point of consumption (final energy), kWh/m²·year.

Energy rating of the building: Case 4. Improvement 2 of case 1.

Climatic zone (eq.)	B3	**Use**	Private residential

ENERGY RATING OF THE BUILDING IN EMISSIONS

1.

GLOBAL INDICATOR	PARTIAL INDICATORS			
< 5,5 A 5,5-10,4 B 10,4-17,5 C 17,5-28,1 D 28,1-54,9 E 54,9-64,3 F ≥ 64,3 G 0,00 A	**HEATING**		**DHW**	
	Heating emissions [kgCO₂/m²·year]	**A**	DHW emissions [kgCO₂/m²·year]	**C**
	0		**0**	
	COOLING		**LIGHTING**	
Global emissions[kgCO₂/m²·year][1]	Cooling emissions [kgCO₂/m²·year]	**A**	Lighting emissions [kgCO₂/m²·year]	**-**
	0		**-**	

2.

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

	kgCO₂/m²·year	**kgCO₂·year**
CO2 emissions from electricity consumption	0.00	0.00
CO2 emissions from other fuels	0.00	0.00

ENERGY RATING OF THE BUILDING IN NON-RENEWABLE PRIMARY ENERGY CONSUMPTION

3.

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

4.

GLOBAL INDICATOR	PARTIAL INDICATORS			
< 23,8 A 23,8-45,1 B 45,1-76,2 C 76,2-122,1 D 122,1-229,6 E 229,6-268,6 F ≥ 268,6 G 0,00 A	**HEATING**		**DHW**	
	Primary energy heating [kWh/m²·year]	**A**	DHW Primary energy [kWh/m²·year]	**E**
	0		**0**	
	COOLING		**LIGHTING**	
Global consumption of non-renewable primary energy[kWh/m²·year][1]	Primary energy cooling [kWh/m²·year]	**A**	Primary energy lighting [kWh/m²·year]	**-**
	0		**-**	

PARTIAL RATING OF HEATING AND COOLING ENERGY DEMAND

The energy demand for heating and cooling is the energy needed to maintain the building's internal comfort conditions.

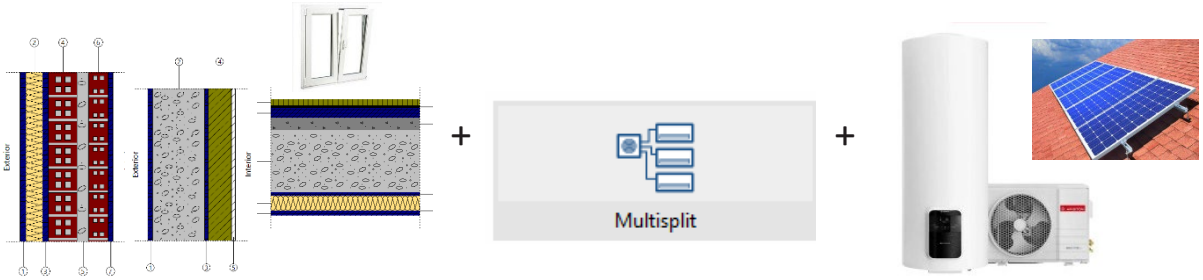
5.

HEATING DEMAND	COOLING DEMAND
< 9,7 A 9,7-18,4 B 18,4-31,1 C 31,1-49,9 D 49,9-83,6 E 83,6-102,8 F ≥ 102,8 G 9,15 A	< 10,0 A 10,0-14,3 B 14,3-20,4 C 20,4-29,7 D 29,7-36,7 E 36,7-45,1 F ≥ 45,1 G 9,86 A
Heating demand[kWh/m²·year]	Cooling demand[kWh/m²·year]

6.

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 5: Improvement 3 of the Initial situation case 1. Improved envelope 10 cm Insolation + PVC Double glazed windows with argon gas + H & AC direct expansion multisplit System + DHW heat pump + Photovoltaic panels. (Case 4 but with 10 cm of insulation layer in the enveloped) .**



(Façade party wall roof)
(PVC Double glazed windows with argon gas. U= 1.7 W/m²·K)
(Case 4 but with 10 cm of insulation layer in the enveloped) .

Energy consumption of the building's technical services

BUILDING (S_u = 116.38 m²)

Technical Services	EF		EP_{tot}		EP_{nren}	
	(kWh/year)	(kWh/m²·year)	(kWh/year)	(kWh/m²·year)	(kWh/year)	(kWh/m²·year)
Heating	748.17	6.43	748.18	6.43	--	--
Cooling	365.77	3.14	365.77	3.14	--	--
DHW	2268.50	19.49	2268.51	19.49	--	--
	3382.44	29.06	3382.46	29.07	--	--
Requirements of the Spanish standard kWh/m²·year				<80.00 **OK!**	kWh/m²·year	<55.00 **OK!**

where:

S_u: *Living area included in the thermal envelope, m².*
EF: *Final energy consumed by the technical service at the point of consumption.*
EP_{tot}: *Total primary energy consumption.*
EP_{nren}: *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)	Year (kWh/m²·año)
BUILDING (S_u = 116.38 m²)															
Energy demand	**Heating**	**245.4**	**162.3**	**123.8**	**6.4**	**3.5**	**--**	**--**	**--**	**--**	**--**	**4.8**	**181.4**	**727.7**	**6.3**
	Cooling	**--**	**--**	**--**	**--**	**--**	**130.5**	**343.7**	**427.4**	**202.6**	**--**	**--**	**--**	**1104.3**	**9.5**
	DHW	**208.6**	**188.4**	**204.4**	**193.1**	**191.0**	**176.7**	**174.1**	**169.9**	**172.6**	**187.4**	**193.7**	**208.6**	**2268.5**	**19.5**
	TOTAL	**454.0**	**350.7**	**328.2**	**199.5**	**194.5**	**307.2**	**517.9**	**597.3**	**375.2**	**187.4**	**198.5**	**390.0**	**4100.5**	**35.2**
Electricity	**Heating**	70.1	46.4	35.7	1.9	1.0	0.6	1.5	1.8	0.9	--	1.4	51.9	213.4	1.8
	Cooling	0.5	0.3	0.3	0.0	0.0	42.7	114.2	140.2	67.1	--	0.0	0.4	365.8	3.1
	DHW	78.4	70.8	76.8	72.6	71.8	66.4	65.5	63.9	64.9	70.5	72.8	78.4	852.8	7.3
	Ventilation	--	--	--	--	--	--	--	--	--	--	--	--	--	
	Humidity control	--	--	--	--	--	--	--	--	--	--	--	--	--	
	Lighting	--	--	--	--	--	--	--	--	--	--	--	--	--	
Environment	**Heating**	180.6	119.4	90.8	4.6	2.6	--	--	--	--	--	3.5	133.4	534.8	4.6
	Cooling	--	--	--	--	--	--	--	--	--	--	--	--	--	
	DHW	130.2	117.6	127.5	120.5	119.2	110.3	108.7	106.0	107.7	117.0	120.9	130.2	1415.7 12.2	
	$C_{ef,total}$	**459.8**	**354.6**	**331.0**	**199.6**	**194.6**	**219.9**	**289.9**	**311.9**	**240.7**	**187.4**	**198.6**	**394.3**	**3382.4**	**29.1**

where:

S_u: *Living area included in the thermal envelope, m².*
$C_{ef,total}$: *Energy consumption at the point of consumption (final energy), kWh/m²·year.*

Energy rating of the building: Case 5. Improvement 3 of case 1.

Climatic zone (eq.)	B3	**Use**	Private residential

ENERGY RATING OF THE BUILDING IN EMISSIONS

1.

GLOBAL INDICATOR		PARTIAL INDICATORS			
< 5,5 A 5,5-10,4 B 10,4-17,5 C 17,5-28,1 D 28,1-54,9 E 54,9-64,3 F ≥ 64,3 G 0,00 A		**HEATING**		**DHW**	
		Heating emissions [kgCO₂/m²·year]	**A**	DHW emissions [kgCO₂/m²·year]	**C**
		0		**0**	
		COOLING		**LIGHTING**	
Global emissions[kgCO₂/m²·year][1]		Cooling emissions [kgCO₂/m²·year]	**A**	Lighting emissions [kgCO₂/m²·year]	**-**
		0		**-**	

2.

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

	kgCO₂/m²·year	**kgCO₂·year**
CO2 emissions from electricity consumption	0.00	0.00
CO2 emissions from other fuels	0.00	0.00

ENERGY RATING OF THE BUILDING IN NON-RENEWABLE PRIMARY ENERGY CONSUMPTION

3.

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

4.

GLOBAL INDICATOR		PARTIAL INDICATORS			
< 23,8 A 23,8-45,1 B 45,1-76,2 C 76,2-122,1 D 122,1-229,6 E 229,6-268,6 F ≥ 268,6 G 0,00 A		**HEATING**		**DHW**	
		Primary energy heating [kWh/m²·year]	**A**	DHW Primary energy [kWh/m²·year]	**E**
		0		**0**	
		COOLING		**LIGHTING**	
Global consumption of non-renewable primary energy[kWh/m²·year][1]		Primary energy cooling [kWh/m²·year]	**A**	Primary energy lighting [kWh/m²·year]	**-**
		0		**-**	

PARTIAL RATING OF HEATING AND COOLING ENERGY DEMAND

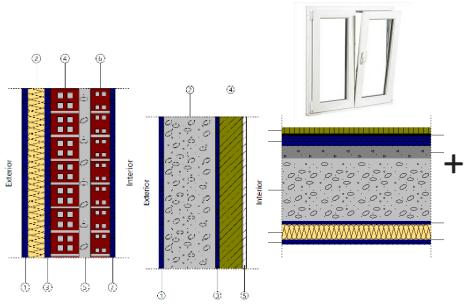
The energy demand for heating and cooling is the energy needed to maintain the building's internal comfort conditions.

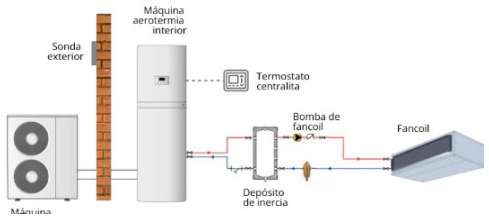
5.

HEATING DEMAND	COOLING DEMAND
< 9,7 A 9,7-18,4 B 18,4-31,1 C 31,1-49,9 D 49,9-83,6 E 83,6-102,8 F ≥ 102,8 G 6,25 A	< 10,0 A 10,0-14,3 B 14,3-20,4 C 20,4-29,7 D 29,7-36,7 E 36,7-45,1 F ≥ 45,1 G 9,49 A
6. 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 6: Improvement 4 of the Initial situation case 1. Improved envelope 6 cm Insolation + PVC Double glazed windows with argon gas + H & AC and DHW Aerothermal with fan coils + Photovoltaic panels**





(Façade party wall roof) Aerothermal system with fan coils
(PVC Double glazed windows with argon gas. U= 1.7 W/m²·K)

Energy consumption of the building's technical services

BUILDING (S_u = 116.38 m²)

Technical Services	EF		EP_{tot}		EP_{nren}	
	(kWh/year)	(kWh/m²·year)	(kWh/year)	(kWh/m²·year)	(kWh/year)	(kWh/m²·year)
Heating	1065.16	9.15	1065.19	9.15	--	--
Cooling	258.28	2.22	258.24	2.22	--	--
DHW	2268.52	19.49	2268.51	19.49	--	--
	3591.95	30.87	3591.94	30.86	--	--
Requirements of the Spanish standard kWh/m²·year				<80.00 **OK!**	kWh/m²·year	<55.00 **OK!**

where:

S_u: Living area included in the thermal envelope, m².
EF: Final energy consumed by the technical service at the point of consumption.
EP_{tot}: Total primary energy consumption.
EP_{nren}: 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)	Year (kWh/m²·año)
BUILDING (S_u = 116.38 m²)															
Energy demand	**Heating**	**338.9**	**226.1**	**173.1**	**21.0**	**12.1**	**--**	**--**	**--**	**--**	**--**	**23.8**	**270.0**	**1065.1**	**9.2**
	Cooling	**--**	**--**	**--**	**--**	**--**	**136.2**	**361.3**	**445.3**	**204.9**	**--**	**--**	**--**	**1147.6**	**9.9**
	DHW	**208.6**	**188.4**	**204.4**	**193.1**	**191.0**	**176.7**	**174.1**	**169.9**	**172.6**	**187.4**	**193.7**	**208.6**	**2268.5**	**19.5**
	TOTAL	**547.5**	**414.5**	**377.5**	**214.1**	**203.2**	**312.9**	**535.4**	**615.2**	**377.5**	**187.4**	**217.5**	**478.6**	**4481.2**	**38.5**
Electricity	**Heating**	86.2	57.0	43.8	5.4	2.9	0.4	1.1	1.3	0.6	--	6.0	68.1	272.8	2.3
	Cooling	0.7	0.5	0.4	0.1	0.0	26.5	83.0	97.4	49.0	--	0.1	0.6	258.3	2.2
	DHW	47.3	42.7	46.3	43.8	43.3	40.1	39.5	38.5	39.1	42.5	43.9	47.3	514.4	4.4
	Ventilation	--	--	--	--	--	--	--	--	--	--	--	--	--	
	Humidity control	--	--	--	--	--	--	--	--	--	--	--	--	--	
	Lighting	--	--	--	--	--	--	--	--	--	--	--	--	--	
Environment	**Heating**	251.7	168.4	128.7	15.6	9.2	--	--	--	--	--	17.7	201.1	792.3	6.8
	Cooling	--	--	--	--	--	--	--	--	--	--	--	--	--	
	DHW	161.3	145.7	158.0	149.3	147.7	136.6	134.6	131.4	133.5	144.9	149.8	161.3	1754.1	
	$C_{ef,total}$	**547.2**	**414.3**	**377.2**	**214.1**	**203.2**	**203.6**	**258.2**	**268.6**	**222.2**	**187.4**	**217.5**	**478.4**	**3592.0**	**30.9**

where:

S_u: Living area included in the thermal envelope, m².
$C_{ef,total}$: Energy consumption at the point of consumption (final energy), kWh/m²·year.

Energy rating of the building: Case 6. Improvement 4 of case 1.

Climatic zone (eq.)	B3	**Use**	Private residential

ENERGY RATING OF THE BUILDING IN EMISSIONS

1.

GLOBAL INDICATOR		PARTIAL INDICATORS			
< 5,5 A 5,5-10,4 B 10,4-17,5 C 17,5-28,1 D 28,1-54,9 E 54,9-64,3 F ≥ 64,3 G 0,00 A		**HEATING**		**DHW**	
		Heating emissions [kgCO₂/m²·year]	**A**	DHW emissions [kgCO₂/m²·year]	**C**
		0		**0**	
		COOLING		**LIGHTING**	
Global emissions[kgCO₂/m²·year][1]		Cooling emissions [kgCO₂/m²·year]	**A**	Lighting emissions [kgCO₂/m²·year]	**-**
		0		**-**	

2.

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

	kgCO₂/m²·year	**kgCO₂·year**
CO2 emissions from electricity consumption	0.00	0.00
CO2 emissions from other fuels	0.00	0.00

ENERGY RATING OF THE BUILDING IN NON-RENEWABLE PRIMARY ENERGY CONSUMPTION

3.

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

4.

GLOBAL INDICATOR		PARTIAL INDICATORS			
< 23,8 A 23,8-45,1 B 45,1-76,2 C 76,2-122,1 D 122,1-229,6 E 229,6-268,6 F ≥ 268,6 G 0,00 A		**HEATING**		**DHW**	
		Primary energy heating [kWh/m²·year]	**A**	DHW Primary energy [kWh/m²·year]	**E**
		0		**0**	
		COOLING		**LIGHTING**	
Global consumption of non-renewable primary energy[kWh/m²·year][1]		Primary energy cooling [kWh/m²·year]	**A**	Primary energy lighting [kWh/m²·year]	**-**
		0		**-**	

PARTIAL RATING OF HEATING AND COOLING ENERGY DEMAND

The energy demand for heating and cooling is the energy needed to maintain the building's internal comfort conditions.

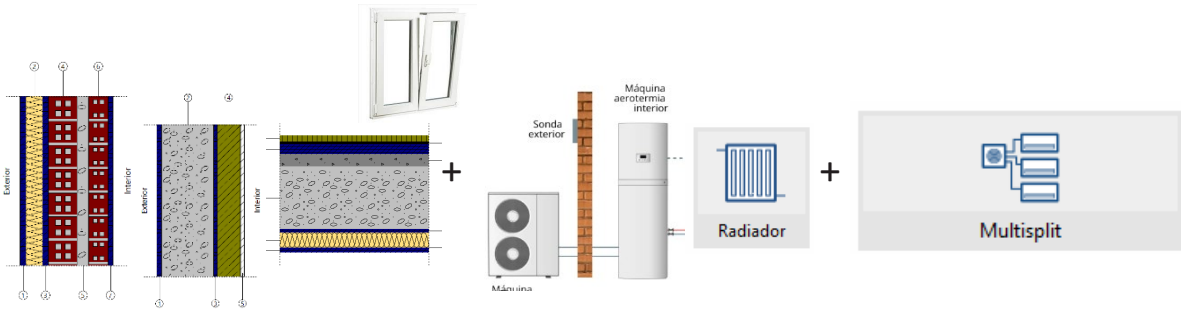
5.

HEATING DEMAND	COOLING DEMAND
< 9,7 A 9,7-18,4 B 18,4-31,1 C 31,1-49,9 D 49,9-83,6 E 83,6-102,8 F ≥ 102,8 G 9,15 A	< 10,0 A 10,0-14,3 B 14,3-20,4 C 20,4-29,7 D 29,7-36,7 E 36,7-45,1 F ≥ 45,1 G 9,86 A
Heating demand[kWh/m²·year]	Cooling demand[kWh/m²·year]

6.

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 7: Improvement 1 of the Initial situation case 2. Improved envelope 6 cm Insolation + Aerothermal with radiators for Heating and DHW + Cooling with direct expansion multi-split system.**



(Façade party wall roof) + Aerothermal heating system with radiators + AC direct expansion system.
(PVC Double glazed windows with argon gas. U= 1.7 W/m²·K)

Energy consumption of the building's technical services

BUILDING (S_u = 116.38 m²)

Technical Services	EF		EP_{tot}		EP_{nren}	
	(kWh/year)	(kWh/m²·year)	(kWh/year)	(kWh/m²·year)	(kWh/year)	(kWh/m²·year)
Heating	1074.53	9.23	1428.16	12.27	505.19	4.34
Cooling	308.59	2.65	730.72	6.28	602.94	5.18
DHW	2268.52	19.49	2969.10	25.51	1000.60	8.60
	3651.64	31.38	5127.98	44.06	2108.73	18.12
Requirements of the Spanish standard kWh/m²·year				<80.00 **OK!**	kWh/m²·year	<55.00 **OK!**

where:

S_u: Living area included in the thermal envelope, m².
EF: Final energy consumed by the technical service at the point of consumption.
EP_{tot}: Total primary energy consumption.
EP_{nren}: 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)	Year (kWh/m²·año)
BUILDING (S_u = 116.38 m²)															
Energy demand	**Heating**	**339.0**	**226.2**	**173.1**	**21.2**	**12.2**	**--**	**--**	**--**	**--**	**--**	**24.0**	**270.1**	**1065.8**	**9.2**
	Cooling	**--**	**--**	**--**	**--**	**--**	**136.5**	**361.7**	**445.6**	**205.1**	**--**	**--**	**--**	**1148.8**	**9.9**
	DHW	**208.6**	**188.4**	**204.4**	**193.1**	**191.0**	**176.7**	**174.1**	**169.9**	**172.6**	**187.4**	**193.7**	**208.6**	**2268.5**	**19.5**
	TOTAL	**547.6**	**414.6**	**377.5**	**214.3**	**203.2**	**313.2**	**535.8**	**615.5**	**377.7**	**187.4**	**217.7**	**478.7**	**4483.2**	**38.5**
Electricity	**Heating**	79.9	52.9	40.5	5.0	2.8	1.0	2.7	3.2	1.6	--	5.6	63.2	258.5	2.2
	Cooling	0.0	0.0	0.0	0.0	--	36.7	97.3	119.0	55.6	--	0.0	0.0	308.6	2.7
	DHW	47.1	42.5	46.1	43.6	43.1	39.9	39.3	38.4	39.0	42.3	43.7	47.1	512.1	4.4
	Ventilation	--	--	--	--	--	--	--	--	--	--	--	--	--	
	Humidity control	--	--	--	--	--	--	--	--	--	--	--	--	--	
	Lighting	--	--	--	--	--	--	--	--	--	--	--	--	--	
Environment	**Heating**	259.2	173.3	132.6	16.2	9.4	--	--	--	--	--	18.3	206.9	816.0	7.0
	Cooling	--	--	--	--	--	--	--	--	--	--	--	--	--	
	DHW	161.5	145.9	158.2	149.5	147.9	136.8	134.8	131.6	133.7	145.1	150.0	161.5	1756.4 15.1	
	$C_{ef,total}$	**547.7**	**414.7**	**377.6**	**214.3**	**203.2**	**214.4**	**274.0**	**292.1**	**229.8**	**187.4**	**217.7**	**478.7**	**3651.6**	**31.4**

where:

S_u: Living area included in the thermal envelope, m².
$C_{ef,total}$: Energy consumption at the point of consumption (final energy), kWh/m²·year.

Energy rating of the building: Case 7. Improvement 1 of case 2.

Climatic zone (eq.)	B3	Use	Private residential

ENERGY RATING OF THE BUILDING IN EMISSIONS

1.

GLOBAL INDICATOR	PARTIAL INDICATORS			
< 5,5 A 5,5-10,4 B 10,4-17,5 C 17,5-28,1 D 28,1-54,9 E 54,9-64,3 F ≥ 64,3 G 3,07 A	HEATING		DHW	
	Heating emissions [kgCO₂/m²·year]	A	DHW emissions [kgCO₂/m²·year]	C
	0.74		1.46	
	COOLING		LIGHTING	
Global emissions[kgCO₂/m²·year][1]	Cooling emissions [kgCO₂/m²·year]	A	Lighting emissions [kgCO₂/m²·year]	-
	0.88		-	

2.

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

	kgCO₂/m²·year	kgCO₂·year
CO2 emissions from electricity consumption	3.07	357.21
CO2 emissions from other fuels	0.00	0.00

ENERGY RATING OF THE BUILDING IN NON-RENEWABLE PRIMARY ENERGY CONSUMPTION

3.

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

4.

GLOBAL INDICATOR	PARTIAL INDICATORS			
< 23,8 A 23,8-45,1 B 45,1-76,2 C 76,2-122,1 D 122,1-229,6 E 229,6-268,6 F ≥ 268,6 G 18,12 A	HEATING		DHW	
	Primary energy heating [kWh/m²·year]	A	DHW Primary energy [kWh/m²·year]	E
	4.34		8.6	
	COOLING		LIGHTING	
Global consumption of non-renewable primary energy[kWh/m²·year][1]	Primary energy cooling [kWh/m²·year]	A	Primary energy lighting [kWh/m²·year]	-
	5.18		-	

PARTIAL RATING OF HEATING AND COOLING ENERGY DEMAND

The energy demand for heating and cooling is the energy needed to maintain the building's internal comfort conditions.

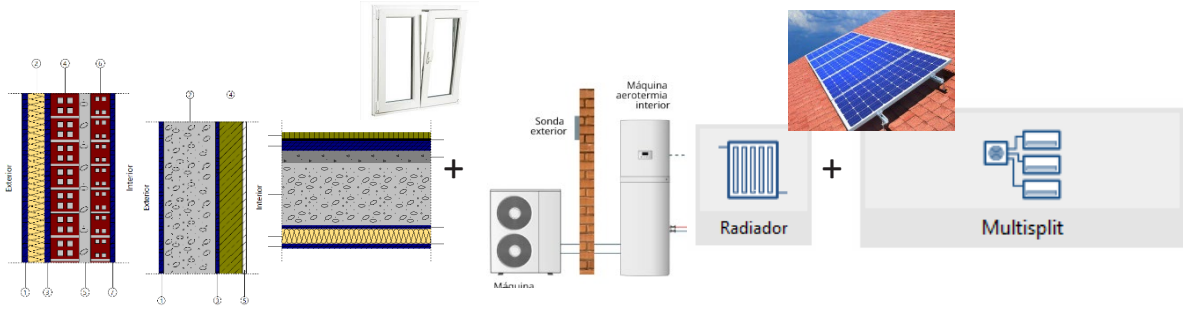
5.

HEATING DEMAND	COOLING DEMAND
< 9,7 A 9,7-18,4 B 18,4-31,1 C 31,1-49,9 D 49,9-83,6 E 83,6-102,8 F ≥ 102,8 G 9,16 A	< 10,0 A 10,0-14,3 B 14,3-20,4 C 20,4-29,7 D 29,7-36,7 E 36,7-45,1 F ≥ 45,1 G 9,87 A
Heating demand[kWh/m²·year]	Cooling demand[kWh/m²·year]

6.

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 8 : Improvement 2 of the Initial situation case 2. Improved envelope 6 cm Insolation + Aerothermal with radiators for Heating and DHW + Cooling with direct expansion multi-split system + Photovoltaic panels.**



(Façade party wall roof) + Aerothermal heating system with radiators + Cooling multisplit direct expansion system.
(PVC Double glazed windows with argon gas. U= 1.7 W/m²·K)
(Case 7+ PV panels)

Energy consumption of the building's technical services

BUILDING (S_u = 116.38 m²)

Technical Services	EF		EP_{tot}		EP_{nren}	
	(kWh/year)	(kWh/m²·year)	(kWh/year)	(kWh/m²·year)	(kWh/year)	(kWh/m²·year)
Heating	1074.53	9.23	1074.50	9.23	--	--
Cooling	308.59	2.65	308.63	2.65	--	--
DHW	2268.52	19.49	2268.51	19.49	--	--
	3651.64	31.38	3651.64	31.38	--	--
Requirements of the Spanish standard kWh/m²·year				<80.00 **OK!**	kWh/m²·year	<55.00 **OK!**

where:

S_u: Living area included in the thermal envelope, m².
EF: Final energy consumed by the technical service at the point of consumption.
EP_{tot}: Total primary energy consumption.
EP_{nren}: 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)	Year (kWh/m²·año)
BUILDING (S_u = 116.38 m²)															
Energy demand	**Heating**	**339.0**	**226.2**	**173.1**	**21.2**	**12.2**	**--**	**--**	**--**	**--**	**--**	**24.0**	**270.1**	**1065.8**	**9.2**
	Cooling	**--**	**--**	**--**	**--**	**--**	**136.5**	**361.7**	**445.6**	**205.1**	**--**	**--**	**--**	**1148.8**	**9.9**
	DHW	**208.6**	**188.4**	**204.4**	**193.1**	**191.0**	**176.7**	**174.1**	**169.9**	**172.6**	**187.4**	**193.7**	**208.6**	**2268.5**	**19.5**
	TOTAL	**547.6**	**414.6**	**377.5**	**214.3**	**203.2**	**313.2**	**535.8**	**615.5**	**377.7**	**187.4**	**217.7**	**478.7**	**4483.2**	**38.5**
Electricity	**Heating**	79.9	52.9	40.5	5.0	2.8	1.0	2.7	3.2	1.6	--	5.6	63.2	258.5	2.2
	Cooling	0.0	0.0	0.0	0.0	--	36.7	97.3	119.0	55.6	--	0.0	0.0	308.6	2.7
	DHW	47.1	42.5	46.1	43.6	43.1	39.9	39.3	38.4	39.0	42.3	43.7	47.1	512.1	4.4
	Ventilation	--	--	--	--	--	--	--	--	--	--	--	--	--	
	Humidity control	--	--	--	--	--	--	--	--	--	--	--	--	--	
	Lighting	--	--	--	--	--	--	--	--	--	--	--	--	--	
Environment	**Heating**	259.2	173.3	132.6	16.2	9.4	--	--	--	--	--	18.3	206.9	816.0	7.0
	Cooling	--	--	--	--	--	--	--	--	--	--	--	--	--	
	DHW	161.5	145.9	158.2	149.5	147.9	136.8	134.8	131.6	133.7	145.1	150.0	161.5	1756.4	15.1
	$C_{ef,total}$	**547.7**	**414.7**	**377.6**	**214.3**	**203.2**	**214.4**	**274.0**	**292.1**	**229.8**	**187.4**	**217.7**	**478.7**	**3651.6**	**31.4**

where:

S_u: Living area included in the thermal envelope, m².
$C_{ef,total}$: Energy consumption at the point of consumption (final energy), kWh/m²·year.

Energy rating of the building: Case 8. Improvement 2 of case 2.

Climatic zone (eq.)	B3	Use	Private residential

ENERGY RATING OF THE BUILDING IN EMISSIONS

1.

GLOBAL INDICATOR	PARTIAL INDICATORS			
< 5,5 A 5,5-10,4 B 10,4-17,5 C 17,5-28,1 D 28,1-54,9 E 54,9-64,3 F ≥ 64,3 G 0,00 A	HEATING		DHW	
	Heating emissions [kgCO₂/m²·year]	A	DHW emissions [kgCO₂/m²·year]	C
	0		0	
	COOLING		LIGHTING	
Global emissions[kgCO₂/m²·year][1]	Cooling emissions [kgCO₂/m²·year]	A	Lighting emissions [kgCO₂/m²·year]	-
	0		-	

2.

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

	kgCO₂/m²·year	kgCO₂·year
CO2 emissions from electricity consumption	0.00	0.00
CO2 emissions from other fuels	0.00	0.00

ENERGY RATING OF THE BUILDING IN NON-RENEWABLE PRIMARY ENERGY CONSUMPTION

3.

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

4.

GLOBAL INDICATOR	PARTIAL INDICATORS			
< 23,8 A 23,8-45,1 B 45,1-76,2 C 76,2-122,1 D 122,1-229,6 E 229,6-268,6 F ≥ 268,6 G 0,00 A	HEATING		DHW	
	Primary energy heating [kWh/m²·year]	A	DHW Primary energy [kWh/m²·year]	E
	0		0	
	COOLING		LIGHTING	
Global consumption of non-renewable primary energy[kWh/m²·year][1]	Primary energy cooling [kWh/m²·year]	A	Primary energy lighting [kWh/m²·year]	-
	0		-	

PARTIAL RATING OF HEATING AND COOLING ENERGY DEMAND

The energy demand for heating and cooling is the energy needed to maintain the building's internal comfort conditions.

5.

HEATING DEMAND	COOLING DEMAND
< 9,7 A 9,7-18,4 B 18,4-31,1 C 31,1-49,9 D 49,9-83,6 E 83,6-102,8 F ≥ 102,8 G 9,16 A	< 10,0 A 10,0-14,3 B 14,3-20,4 C 20,4-29,7 D 29,7-36,7 E 36,7-45,1 F ≥ 45,1 G 9,87 A
Heating demand[kWh/m²·year]	Cooling demand[kWh/m²·year]

6.

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.

3.10. Analysis of Results. Emissions, Energy Consumption and Energy rating of the cases

Comparison of results

Final energy consumption (kWh/m2·year). Part I

Technical Services	Case 1 Initial situation 1	Case 3 Imp 1+Imp 2	Case 4 Imp 1+Imp 2+Imp 3	Case 5 Imp 6+Imp 2+ Imp 3	Case 6 Imp 1+ Imp 3+ Imp 4
Heating	55.93	9.39	9.39	6.43	9.15
Cooling	4.07	3.27	3.27	3.14	2.22
DHW	64.18	19.49	19.49	19.49	19.49
	124.19	32.15	32.15	29.06	30.87

Legend

BIS - Building initial situation

Imp 1- Improvement 1: Improved thermal envelope (6 cm isolation layer) + double glassed windows

Imp 2- Improvement 2: DHW heat pump

Imp 3- Improvement 3: Photovoltaic panels

Imp 4 - Improvement 4: Aerothermal Heating and Cooling system with Fancoils

Imp 5 - Improvement 5: Aerothermal heating and DHW system (for radiators)

Imp 6 - Improvement 6: Improved thermal envelope with 10 cm of isolation layer + double glassed windows

Final energy consumption (kWh/m2·year). Part II

Technical Services	Case 2 Initial situation 2	Case 7 Imp 1+Imp 5	Case 8 Imp 1+Imp 3+Imp 5
Heating	68.63	9.23	9.23
Cooling	4.55	2.65	2.65
DHW	24.37	19.49	19.49
	97.54	31.38	31.38

Total primary energy consumption (kWh/m2·year) Part I

Technical Services	Case 1 Initial situation 1	Case 3 Imp 1+Imp 2	Case 4 Imp 1+Imp 2+Imp 3	Case 5 Imp 6+Imp 2+ Imp 3	Case 6 Imp 1+ Imp 3+ Imp 4
Heating	76.12	13.01	9.39	6.43	9.15
Cooling	9.64	7.74	3.27	3.14	2.22
DHW	151.99	26.96	19.49	19.49	19.49
	237.75	47.71	32.15	29.07	30.86

Legend

BIS - Building initial situation

Imp 1- Improvement 1: Improved thermal envelope (6 cm isolation layer) + double glassed windows

Imp 2- Improvement 2: DHW heat pump

Imp 3- Improvement 3: Photovoltaic panels

Imp 4 - Improvement 4: Aerothermal Heating and Cooling system with Fancoils

Imp 5 - Improvement 5: Aerothermal heating and DHW system (for radiators)

Imp 6 - Improvement 6: Improved thermal envelope with 10 cm of isolation layer + double glassed windows

Total primary energy consumption (kWh/m2·year) Part II

Technical Services	Case 2 Initial situation 2	Case 7 Imp 1+Imp 5	Case 8 Imp 1+Imp 3+Imp 5
Heating	82.76	12.27	9.23
Cooling	10.77	6.28	2.65
DHW	29.12	25.51	19.49
	122.65	44.06	31.38

Primary energy consumption of non-renewable origin (kWh/m2·year) Part I

Technical Services	Case 1 Initial situation 1	Case 3 Imp 1+Imp 2	Case 4 Imp 1+Imp 2+Imp 3	Case 5 Imp 6+Imp 2+ Imp 3	Case 6 Imp 1+ Imp 3+ Imp 4
Heating	28.84	5.17	0.00	0.00	0.00
Cooling	7.95	6.38	0.00	0.00	0.00
DHW	125.42	10.67	0.00	0.00	0.00
	162.21	22.22	0.00	0.00	0.00
Energy rating	**E**	**A**	**A**	**A**	**A**

Legend

BIS - Building initial situation

Imp 1- Improvement 1: Improved thermal envelope (6 cm isolation layer) + double glassed windows

Imp 2- Improvement 2: DHW heat pump

Imp 3- Improvement 3: Photovoltaic panels

Imp 4 - Improvement 4: Aerothermal Heating and Cooling system with Fancoils

Imp 5 - Improvement 5: Aerothermal heating and DHW system (for radiators)

Imp 6 - Improvement 6: Improved thermal envelope with 10 cm of isolation layer + double glassed windows

Primary energy consumption of non-renewable origin (kWh/m2·year) Part II

Technical Services	Case 2 Initial situation 2	Case 7 Imp 1+Imp 5	Case 8 Imp 1+Imp 3+Imp 5
Heating	81.84	4.34	0.00
Cooling	8.89	5.18	0.00
DHW	29.00	8.60	0.00
	119.73	18.12	0.00
Energy rating	**D**	**A**	**A**

Building Emissions (kgCO2/m2·year) Part I

Technical Services	Case 1 Initial situation 1	Case 3 Imp 1+Imp 2	Case 4 Imp 1+Imp 2+Imp 3	Case 5 Imp 6+Imp 2+ Imp 3	Case 6 Imp 1+ Imp 3+ Imp 4
CO2 from electricity	27.48	3.76	0.00	0.00	0.00
CO2 from other fuels	0.00	0.00	0.00	0.00	0.00
	27.48	3.76	0.00	0.00	0.00
Energy rating	**D**	**A**	**A**	**A**	**A**

Legend

BIS - Building initial situation

Imp 1- Improvement 1: Improved thermal envelope (6 cm isolation layer) + double glassed windows

Imp 2- Improvement 2: DHW heat pump

Imp 3- Improvement 3: Photovoltaic panels

Imp 4 - Improvement 4: Aerothermal Heating and Cooling system with Fancoils

Imp 5 - Improvement 5: Aerothermal heating and DHW system (for radiators)

Imp 6 - Improvement 6: Improved thermal envelope with 10 cm of isolation layer + double glassed windows

Building Emissions (kgCO2/m2·year) Part II

Technical Services	Case 2 Initial situation 2	Case 7 Imp 1+Imp 5	Case 8 Imp 1+Imp 3+Imp 5
CO2 from electricity	1.73	3.07	0.00
CO2 from other fuels	23.19	0.00	0.00
	24.92	3.07	0.00
Energy rating	**D**	**A**	**A**