Real demonstration results of BEM performance simulation using BIM-SPEED Toolset

Deliverable 4.2 – Energy Performance Report – Antony demo

Deliverable Report: Final version, issue date on 31st October 2022

BIM-SPEED
Harmonised Building Information Speedway for Energy-Efficient Renovation

This research project has received funding from the European Union's Programme H2020-NMBP-EEB-2018 under Grant Agreement no 820553.

ENERGY REPORT - ANTONY

Deliverable 4.2 – Energy Performance Report

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Colophon

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1. General information

1.1 Building description

Antony democase is a residential building located in the centre of Antony (France) in a densely urbanized context. The building is one of the four buildings of allée de Villemilan et rue des Nations Unies and can be characterized by its rectangular floor plan. The building is a series of 4 adjacent individual building units with unique entrances/staircase and share 3 pairwise common walls. Below the aerial photo of the site with an indicative view of the urban context.

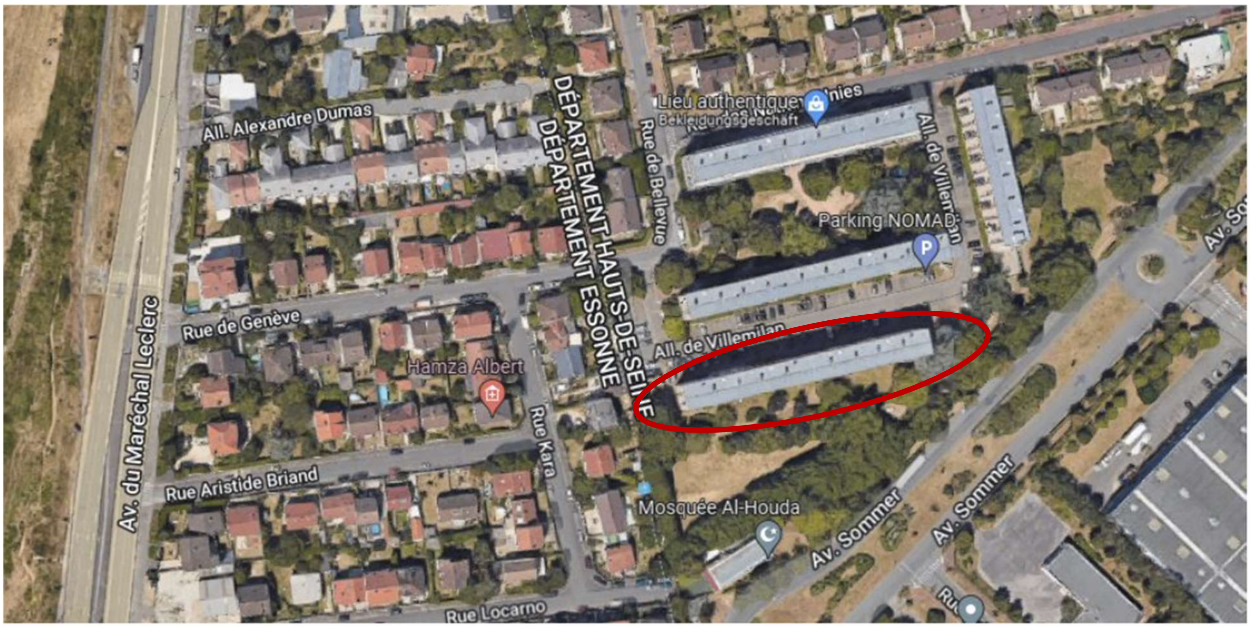


Figure 1: Aerial view of the urban context

The buildings are built with concrete (20cm) with Polystyrene insulation of 10 cm. Glazing are double Glazing from 1990-2005. Heating and dwelling hot water are provided by two gas boilers that supply the 4 buildings. This complex is rated epd D.

Figure 2: external view of the building

Following a brief summary of the demo general data.

Table 1: Summary of general data

General information	
Location	Antony (France)
Use category	Residential Apartment
Building type	Panel Building
Construction year	1963
Renovation year	Not applicable
Number of floors	4
Number of apartments/units	32

1.2 GIS and environmental data

Antony is situated in the outskirts of Paris and hence is included in the PARIS__ORLY :: 71490 :: IWEC weather file by Energy plus.

Table 2: Summary of general environmental data

General information	
Location	Antony (France)
Weather file	PARIS__ORLY :: 71490 :: IWEC
Altitude [m]	99 m
Latitude [degrees]	48.731972
Longitude [degrees]	2.303889

Error! Reference source not found., shows the Average High and Low Temperature in Paris throughout the year.

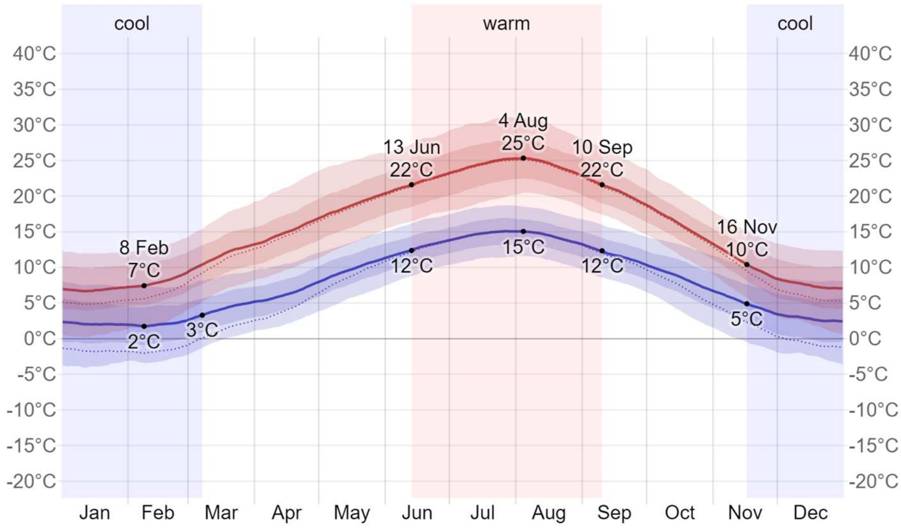


Figure 3: External temperature imported into the BEM model

2. Energy modelling

2.1 Modelling workflow

The original BIM (ifc) file of the building was detected with several geometrical issues due to lack of interoperability between BIM tools. Hence, the geometry of the building was exported as digital floor plans and recreated using the Design Builder software v7.0.2.004 traditionally.

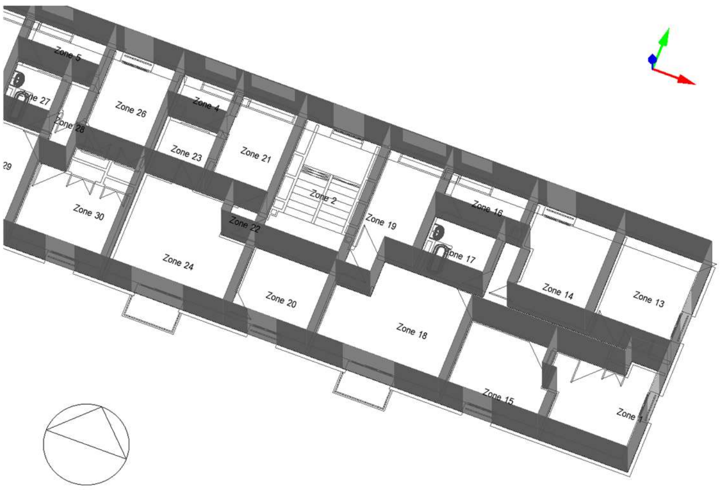


Figure 4: 3D BIM modelling from 2D plan and defining zone

The shadings and thermal zones were cross checked with the ifc file and recreated. The HVAC systems were defined in accordance with the available documentation for Antony.

Using an Energy Plus v9.2 plug-in for Design Builder, a baseline (as built) BEM model was created in the idf file format.

2.2 Auditing procedures and data collection

Specific data have been collected both to develop a complete BIM model and suitable BEM. Site surveys on the demo have been carried out by Immobiliere 3F and specific documents have been investigated to retrieve all the required data to characterise the thermal behaviour of the building. Particularly, the thermal images of the facades and closures (Figure 5) have been useful, from the analysis of a thermographic survey conducted in 2019. However, the camera used for thermal imaging was not made explicit in the Report.

2.3 Description of BEM's technical features

Antony BEM consists of 32 dwellings, a not-heated basement and a not-heated attic.

2.3.1 Envelope components and materials

The following table summarises the thermal characteristics of the construction elements.

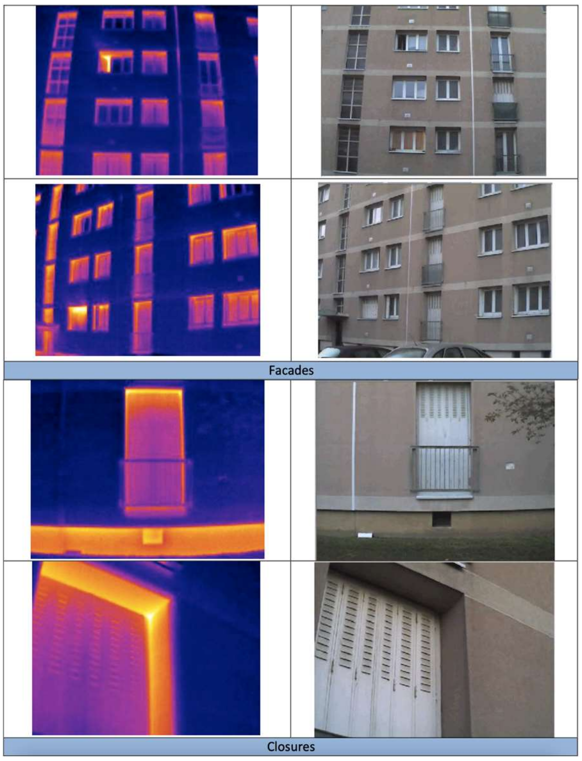


Figure 5: Thermal images of Facade and Closure

Table 3: Building Components thermal characteristics

	 **Scenario 1** Unrenovated state (ID 1)
External glazing type	Double glazing Ug=2,9
External window adjacent shading	No Shading
External walls*	Masonry with external thermal insulation composite system
Insulation	EPS, lightweight (0.06 m)
Total thickness	0.28 m
U-Value	0.60 W/m^{2}K
Below grade walls*	Reinforced concrete (Unconditioned space)
Roofs*	Reinforced concrete
Insulation	PUR foam (0.04 m)
Total thickness	0.41 m
U-Value	0.57 W/m^{2}K
Ground floors*	Reinforced concrete (Unconditioned space)

2.3.2 HVAC systems

The building is equipped with a central heating condensing boiler and hot water radiators in each flat as shown in the following table.

Table 4: Building HVAC system characteristics

	Scenario 1 Unrenovated state (ID 1)
HVAC System options	Hot Water Radiator
HVAC Heat Supplier options	Condensation boiler (gas)
Dedicated OutdoorAir System options	No
DOAS Cooling Coil Type options	-
DOAS Heating Coil Type options	-
DOAS Heat Recovery Type options	-

Below the operating schedule modeled for the heating system.

Apartment building: Daily heat schedule

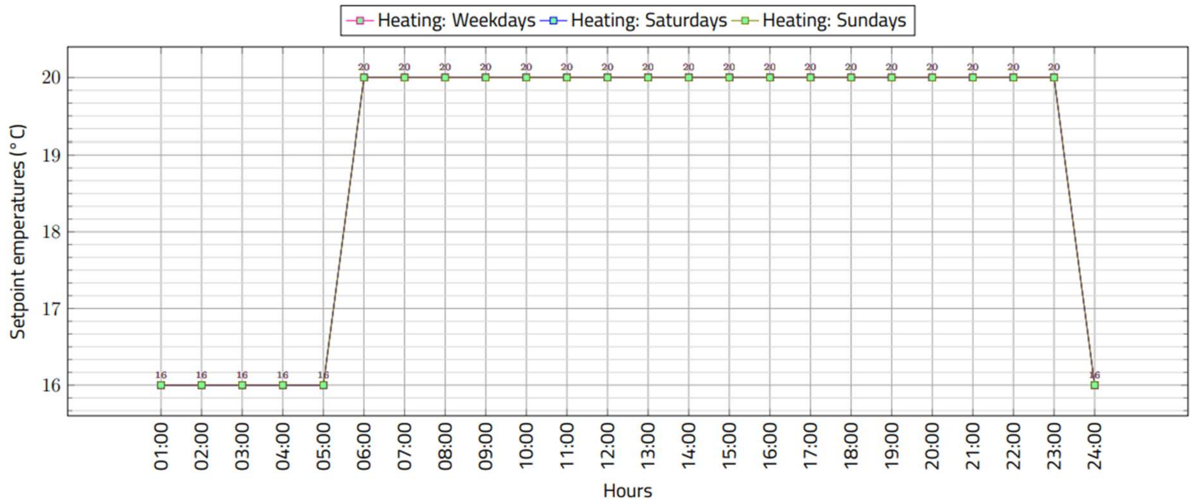


Figure 6: Heating system operating program

2.3.3 Occupancy, lighting and equipment patterns

Relevant operating schedules and occupational patterns have been assumed based on standard residential uses and on a few information collected from the users. Following figures show a few of the patterns set for the Antony BEM.

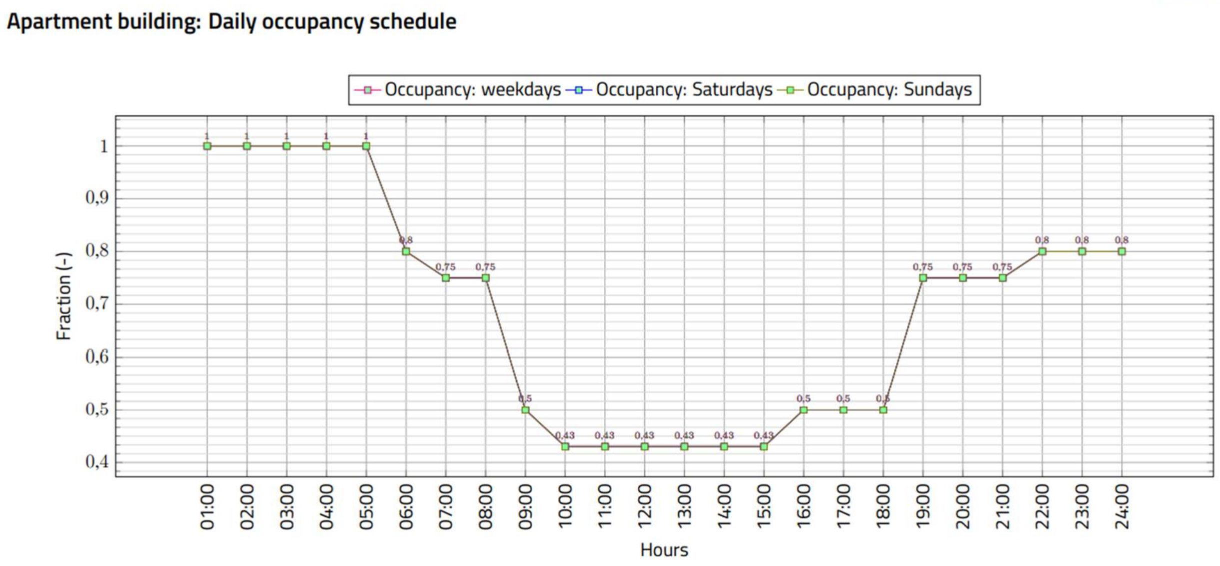


Figure 7: Occupancy schedule

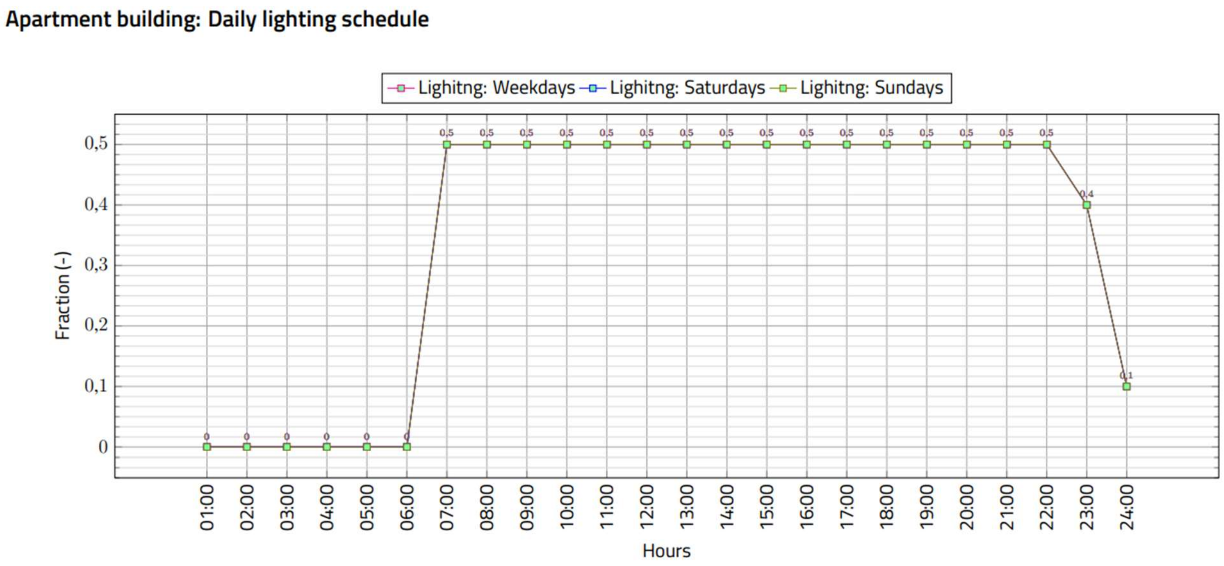


Figure 8: Lighting schedule

3. Building energy performance simulation results

3.1 General considerations

The high energy consumption of the building is mainly due to the poor thermal insulation properties of the building envelope both for what concern opaque elements, walls and slabs are not insulated with thermal transmittance varying between 0.35 – 1.93 W/mqK, and windows characterised by thermal transmittance varying between 2.69 – 3.18 W/mqK.

3.2 Energy KPIs

The following Energy KPI have been calculated according to D4.1 descriptions.

BS.OPED: Operational Primary Energy Demand

The primary energy demand has been calculated from the total energy consumption at consumption point and multiplied by the conversion factor (specific for France) for final energy to primary energy.

Table 5: BS.OPED Operational Primary Energy Demand

BS.OPED: Operational Primary Energy Demand	
Ep [kWh/m^2]	59,65

BS.TED: Total Energy Demand

The table below summarises the results obtained from the calculation of the heating energy demand (there is no cooling for the Antony demo) of each occupied zone, as well as the total energy demand of the building.

Table 6: BS.TED Total Energy Demand

BS.TED: Total Energy Demand	
Q_{HEAT} [kWh/m^{2}year]	20,46
Q_{TOTAL} [kWh/m^{2}year]	**58,66**

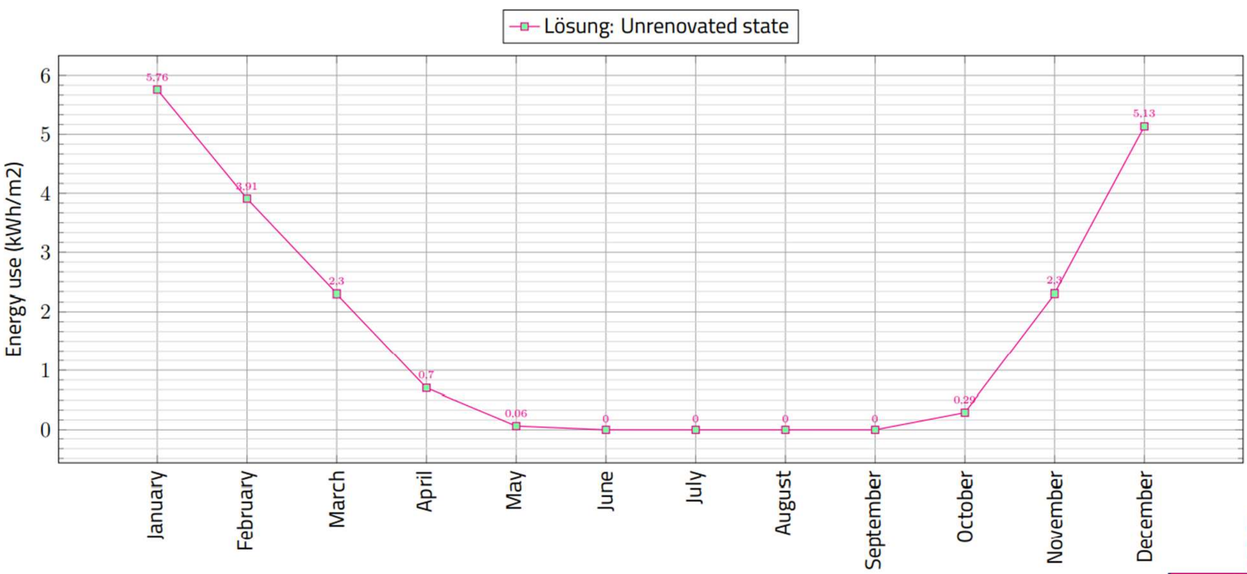
The following table shows the results of the total heat transferred by transmission and ventilation, the total internal heat, and the energy required for heating and cooling for each calculation zone of the building.

BS.TEC: Total Energy Consumption

Following table summarises Primary energy consumption for heating and domestic hot water production.

Table 7: BS.TEC Total Energy Consumption

BS.TEC: Total Energy Consumption	
EP_{heat}[kWh/m^2]	20,46
EP_{cool}[kWh/m^2]	Cooling not present
EP_{light}[kWh/m^2]	Not relevant for the demo
EP_{dhw}[kWh/m^2]	10,75
EP_{TOT}[kWh/m^2]	**58,66**



4. Building renovation scenarios

To perform and assess multiple energy simulations for building renovation scenarios, the MTB Optimisation tool has been applied.

4.1 Renovation scenarios proposed

For the Antony democase, a total of 4000 possible combinations of renovations scenarios were designed and simulations were performed on them. 4 renovations scenarios were eventually chosen. Two of them have having optimal performance with respect to energy and the other two with respect to cost.

For the Antony democase, the following building renovation elements have been assessed according to Task 7.1 premises.

Figure 9: distribution of energy consumption throughout the year for heating uses

- External glazing type – Double glazing and wooden frames in poor condition
- External walls – Non sustainable material and High U-value
- Roofs – Low thickness and High U-value

4.2 Optimisation set-up: planning variants considered

The following table summarizes the optimization setting applied to the Antony BEM model. For each type of intervention, different solutions were examined, making the characteristic parameters vary between a certain range of values.

Table 8 Options considered for Optimisation

INSULATIONS OPTIONS	Conductivity
EPS_Polystirene_(Lightweight)	0.034
XPS_Extruded_polystyrene	1.034
PUR_foam	2.034
Mineral_insulation_Stone_Wool_(rolls)	3.034
Mineral_insulation_Mineral_wool	4.034
Wood_derivatives_woodwool	5.034

GLAZING	U-values	Visible transmitance	SGHC
ECLAZ glazing Saint Gobain	0.7	0.77	0.6
Triple Pilkington glass units 4 mm Optitherm S1A outer pane /12 mm argon /4 mm Optifloat Clear /12 mm argon /4 mm inner pane	0.7	0.64	0.4
4 mm Pilkington Optitherm S1	0.9	0.65	0.47

Verbundfenster 062	0.62	0.55	0.35
Double Silver Sputter Coat LoE Outer Lite	1	0.62	0.35
Pilkington Solar E outer lite and Pilkington Energy Advantage LoE inner lite	1.3	0.49	0.41

Shading system considered:

- Interior Blind with low reflectivity slats
- Exterior Shade roll_medium translucent
- Exterior Blind with high reflectivity slats
- Exterior Blind with medium reflectivity slats
- Exterior Blind_High Reflectivity Slats_30_Overheating
- Exterior Blind_Medium Reflectivity Slats_30_Overheating
- Exterior Blind_Low Reflectivity Slats_30_Overheating
- Exterior Blind_High Reflectivity Slats_45_Overheating
- Exterior Blind_Medium Reflectivity Slats_45_Overheating
- Exterior Blind_Low Reflectivity Slats_45_Overheating
- Exterior Blind_High Reflectivity Slats_60_Overheating
- Exterior Blind_Medium Reflectivity Slats_60_Overheating
- Exterior Blind_Low Reflectivity Slats_60_Overheating
- Exterior Blind_High Reflectivity Slats_90_Overheating
- Exterior Blind_Medium Reflectivity Slats_90_Overheating
- Exterior Blind_Low Reflectivity Slats_90_Overheating
- Exterior Blind_High Reflectivity Slats_135_Overheating
- Exterior Blind_Medium Reflectivity Slats_135_Overheating
- Exterior Blind_Low Reflectivity Slats_135_Overheating

HVAC system considered:

- Hot water baseboards
- Hot water underground heating
- Condensation boiler (gas)
- District heating ---> they should check if that is available in Antony
- DHW: Central condensation boiler (gas)
- DHW: District heating ---> they should check if that is available in Antony

PV system considered:

- No photovoltaic

- Photovoltaic efficiency 0.15 – 0.17 – 0.19 – 0.21
- Area covered: 20% - 120%
- Battery type: No battery – 6kW – 8kW – 10kW – 12kW – 14kW – 16kW – 32kW – 48kW – 64 kW

Total number of theoretical combinations of these options is 82,080,000.

4.3 Optimisation results: optimal ranges of potential solutions

Following the specific optimization set-up of the project, the theoretical number of possible renovation scenarios to be assessed is ca. 82 Million. Out of these, 4000 scenarios have been automatically simulated and assessed, controlled by an evolutionary optimization algorithm. This process took a computation time of approx. 70 hrs (70 hrs 36 min on a server cluster with 288 cores and 470 GB RAM involving server costs of approx. 200 €).
Figure 10 shows the Pareto-graph of simulates renovation scenarios, sorted by construction costs and energy demand. The solution space includes renovation scenarios with resulting end energy demands between 2 – 43 kWh/(m² year) and construction costs between EUR 120.000 and EUR 170.000.The points within the red circle represent a range of optimal solutions reducing both energy demand and construction costs.

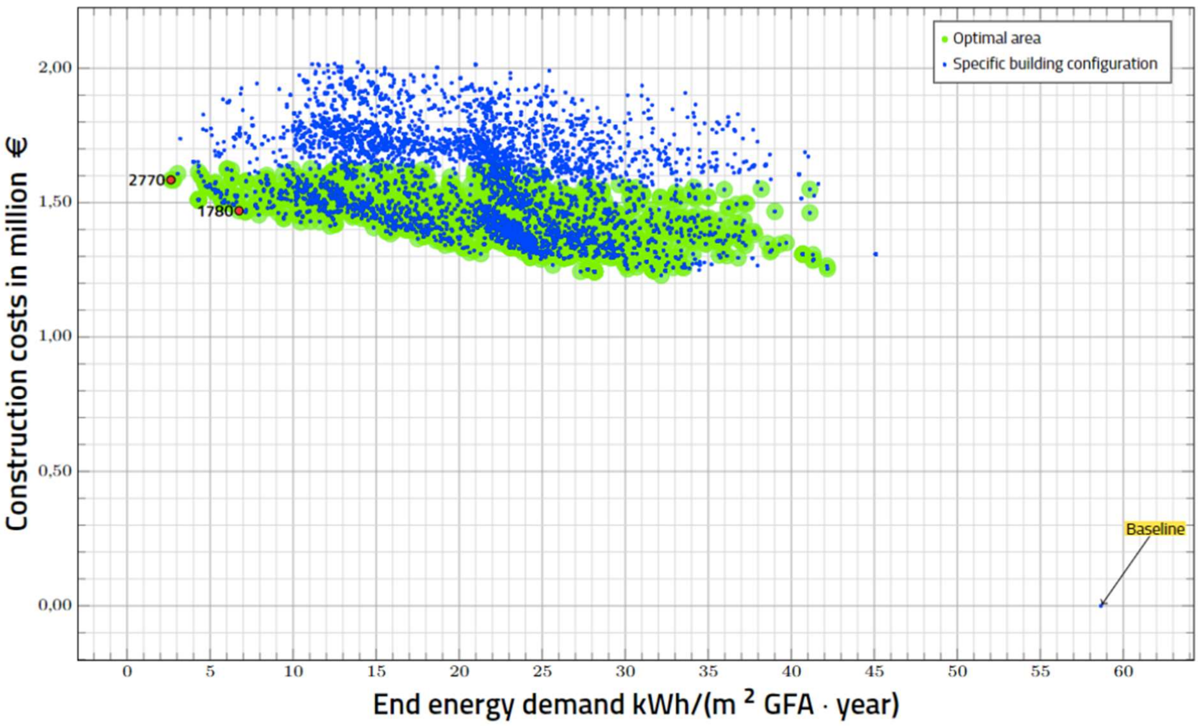


Figure 10 Pareto-graph of simulates renovation scenarios

Out of this solution space, four renovation scenarios have been identified as among optimal solutions:

- Energy-optimal: Two solutions with best results in end energy demand, while still having a good costs and comfort performance (ID 1780 & ID 2770)
- Cost-optimal: Two solutions with best results in cost performance, while still having a good energy and comfort performance (ID 1473 & ID 3939)

Those two Energy-optimal renovation alternatives are being described in the following.

4.4 Scenarios 1: description and results

Scenario 1 (ID 1780) has been identified as an energy-optimal renovation scenario. In comparison with all simulated renovation scenarios, this scenario has a very good end energy demand, while still having a good costs and comfort performance. Its configuration and its simulation results are described in the following tables.

Table 9: Renovation setup for the energy-optimal scenario 1 (ID 1780)

Type of intervention	Optimisation settings and ranges of variation	
External walls insulation	Insulation material: Stone wool Total thickness of external wall U-Value	0,18 m 0,40 m 0,17 W/m²K
Roof insulation	Insulation material: Mineral wool Total thickness U-Value	0,17 m 0,54 m 0,14 W/m²K
Windows replacement	Glazing type: Triple glazing, Low-E PVC frame	Ug = 0,7
Shading system	Exterior blind high reflectivity slats 90°	
HVAC	Heat distribution: Hot water underfloor heating Heat supply: Condensation boiler (gas)	

Sustainability insights

	AI-generated solution (ID 1780)
Primary energy consumption	-4.13 kWh/(m^2 · a)
Energy demand for cooling	0.00 kWh/(m^2 · a)
Energy demand for domestic hot water	3.79 kWh/(m^2 · a)
Electricity demand	-13.59 kWh/(m^2 · a)
Energy demand for heating	16.55 kWh/(m^2 · a)
Energy demand total	6.74 kWh/(m^2 · a)
PV electricity production	19.62 kWh/(m^2 · a)
Carbon dioxide emissions	-1.78 kg CO_2/(m^2 · a)
Embodied carbon dioxide	0.30 kg CO_2/(m^2 · a)
Specific transmittance heat losses	0.39 W/(m^2 · K)
Average U-value of opaque components	0.16 W/(m^2 · K)
Average U-value of transparent components	1.22 W/(m^2 · K)
Reused domestic water	0.00 l/(m^2 · a)
Savings through water-saving fittings	0.00 l/(m^2 · a)
Total water consumption	1,131.24 l/(m^2 · a)

Figure 11: Screenshot from the energy optimisation report 1 with energy related KPIs

The following KPIs have been calculated:

BS.OPED: Operational Primary Energy Demand

Table 10: BS.OPED Operational Primary Energy Demand

BS.OPED: Operational Primary Energy Demand	
Ep [kWh/m^2]	-4,13

BS.TED: Total Energy Demand

Table 11: BS.TED Total Energy Demand

BS.TED: Total Energy Demand	
Q_{TOT} [kWh/m²year]	**6,74**

BS.TEC: Total Energy Consumption (and sub KPIs; Energy consumption for heating, cooling, lighting, DHW)

Table 12: BS.TEC Total Energy Consumption

BS.TEC: Total Energy Consumption	
EP_{heat}[kWh/m²]	16,55
EP_{cool}[kWh/m²]	0.00 (Cooling not present)
EP_{light}[kWh/m²]	Not relevant for the demo
EP_{dhw}[kWh/m²]	3,79
EP_{TOT}[kWh/m²]	**6,74**

BS.TES: Total Energy savings

Table 13: BS.TES Total Energy Savings

BS.TES: Total Energy Savings			
	Baseline	**Scenario 01**	**SAVING**
EP_{heat}[kWh/m²]	20,46	16,55	3,91
EP_{cool}[kWh/m²]	Cooling not present		
EP_{light}[kWh/m²]	Not relevant for the demo		
EP_{dhw}[kWh/m²]	10,75	3,79	6,96
EP_{TOT}[kWh/m²]	**58,66**	**6,74**	**51,92**

4.5 Scenarios 2: description and results

Scenario 2 (ID 2770) has been identified as an energy-optimal renovation scenario. In comparison with all simulated renovation scenarios, this scenario has a very good end energy demand, while still having a good costs and comfort performance. Its configuration and its simulation results are described in the following tables.

Table 14: Renovation setup for the energy-optimal scenario 2 (ID 2770)

Type of intervention	Optimisation settings and ranges of variation	
External walls insulation	Insulation material: Mineral wool Total thickness of external wall U-Value	0,27 m 0,49 m 0,12 W/m²K
Roof insulation	Insulation material: Mineral wool Total thickness U-Value	0,26 m 0,63 m 0,09 W/m²K
Windows replacement	Glazing type: Triple glazing, Low-E PVC frame	Ug = 0,7
Shading system	Exterior blind high reflectivity slats 135°	

HVAC	Heat distribution: Hot water underfloor heating Heat supply: Condensation boiler (gas)	

Sustainability insights

	AI-generated solution (ID 2770)
Primary energy consumption	-10.28 kWh/(m^2 · a)
Energy demand for cooling	0.00 kWh/(m^2 · a)
Energy demand for domestic hot water	3.34 kWh/(m^2 · a)
Electricity demand	-15.51 kWh/(m^2 · a)
Energy demand for heating	14.82 kWh/(m^2 · a)
Energy demand total	2.64 kWh/(m^2 · a)
PV electricity production	21.68 kWh/(m^2 · a)
Carbon dioxide emissions	-3.24 kg CO_2/(m^2 · a)
Embodied carbon dioxide	0.66 kg CO_2/(m^2 · a)
Specific transmittance heat losses	0.36 W/(m^2 · K)
Average U-value of opaque components	0.13 W/(m^2 · K)
Average U-value of transparent components	1.22 W/(m^2 · K)
Reused domestic water	0.00 l/(m^2 · a)
Savings through water-saving fittings	0.00 l/(m^2 · a)
Total water consumption	1,131.24 l/(m^2 · a)

Figure 12: Screenshot from the energy optimisation report 2 with energy related KPIs

The following KPIs have been calculated:

BS.OPED: Operational Primary Energy Demand

Table 15: BS.OPED Operational Primary Energy Demand

BS.OPED: Operational Primary Energy Demand	
Ep [kWh/m^2]	-10,28

BS.TED: Total Energy Demand

Table 16: BS.TED Total Energy Demand

BS.TED: Total Energy Demand	
Q_{TOT} [kWh/m^{2}year]	**2,64**

BS.TEC: Total Energy Consumption (and sub KPIs; Energy consumption for heating, cooling, lighting, DHW)

Table 17: BS.TEC Total Energy Consumption

BS.TEC: Total Energy Consumption	
EP_{heat}[kWh/m^2]	14,82
EP_{cool}[kWh/m^2]	0.00 (Cooling not present)
EP_{light}[kWh/m^2]	Not relevant for the demo
EP_{dhw}[kWh/m^2]	3,34
EP_{TOT}[kWh/m^2]	**2,64**

BS.TES: Total Energy savings

Table 18: BS.TES Total Energy Savings

BS.TES: Total Energy Savings			
	Baseline	Scenario 02	SAVING
EP_{heat}[kWh/m²]	20,46	14,82	5,64
EP_{cool}[kWh/m²]	Cooling not present		
EP_{light}[kWh/m²]	Not relevant for the demo		
EP_{dhw}[kWh/m²]	10,75	3,34	7,41
EP_{TOT}[kWh/m²]	**58,66**	**2,64**	**56,02**

4.6 Scenarios 3: description and results

Scenario 3 (ID 1473) has been identified as an energy-optimal renovation scenario. In comparison with all simulated renovation scenarios, this scenario has a very good end energy demand, while still having a good costs and comfort performance. Its configuration and its simulation results are described in the following tables.

Table 19: Renovation setup for the energy-optimal scenario 3 (ID 1473)

Type of intervention	Optimisation settings and ranges of variation	
External walls insulation	Insulation material: Stone wool Total thickness of external wall U-Value	0,18 m 0,40 m 0,18 W/m²K
Roof insulation	Insulation material: Mineral wool Total thickness U-Value	0,20 m 0,57 m 0,12 W/m²K
Windows replacement	Glazing type: Triple glazing, Low-E PVC frame	Ug = 0,7
Shading system	Exterior blind high reflectivity slats 135°	
HVAC	Heat distribution: Hot water underfloor heating Heat supply: Condensation boiler (gas)	

Sustainability insights

	AI-generated solution (ID 1473)
Primary energy consumption	19.48 kWh/($m^2 \cdot a$)
Energy demand for cooling	0.00 kWh/($m^2 \cdot a$)
Energy demand for domestic hot water	3.75 kWh/($m^2 \cdot a$)
Electricity demand	−1.53 kWh/($m^2 \cdot a$)
Energy demand for heating	16.67 kWh/($m^2 \cdot a$)
Energy demand total	18.89 kWh/($m^2 \cdot a$)
PV electricity production	6.01 kWh/($m^2 \cdot a$)
Carbon dioxide emissions	4.15 kg CO_2/($m^2 \cdot a$)
Embodied carbon dioxide	0.46 kg CO_2/($m^2 \cdot a$)
Specific transmittance heat losses	0.39 W/($m^2 \cdot K$)
Average U-value of opaque components	0.17 W/($m^2 \cdot K$)
Average U-value of transparent components	1.22 W/($m^2 \cdot K$)
Reused domestic water	0.00 l/($m^2 \cdot a$)
Savings through water-saving fittings	0.00 l/($m^2 \cdot a$)
Total water consumption	1,131.24 l/($m^2 \cdot a$)

Figure 13: Screenshot from the cost optimisation report 1 with energy related KPIs

The following KPIs have been calculated:

BS.OPED: Operational Primary Energy Demand

Table 20: BS.OPED Operational Primary Energy Demand

BS.OPED: Operational Primary Energy Demand	
Ep [kWh/m^2]	-19,48

BS.TED: Total Energy Demand

Table 21: BS.TED Total Energy Demand

BS.TED: Total Energy Demand	
Q_{TOT} [kWh/m^2year]	**18,89**

BS.TEC: Total Energy Consumption (and sub KPIs; Energy consumption for heating, cooling, lighting, DHW)

Table 22: BS.TEC Total Energy Consumption

BS.TEC: Total Energy Consumption	
EP_{heat}[kWh/m^2]	16,67
EP_{cool}[kWh/m^2]	0.00 (Cooling not present)
EP_{light}[kWh/m^2]	Not relevant for the demo
EP_{dhw}[kWh/m^2]	3,75
EP_{TOT}[kWh/m^2]	**18,89**

BS.TES: Total Energy savings

Table 23: BS.TES Total Energy Savings

BS.TES: Total Energy Savings			
	Baseline	Scenario 03	SAVING
EP_{heat}[kWh/m^2]	20,46	16,67	3,79
EP_{cool}[kWh/m^2]	Cooling not present		
EP_{light}[kWh/m^2]	Not relevant for the demo		
EP_{dhw}[kWh/m^2]	10,75	3,75	7
EP_{TOT}[kWh/m^2]	**58,66**	**18,89**	**39,77**

4.7 Scenarios 4: description and results

Scenario 4 (ID 3939) has been identified as an energy-optimal renovation scenario. In comparison with all simulated renovation scenarios, this scenario has a very good end energy demand, while still having a good costs and comfort performance. Its configuration and its simulation results are described in the following tables.

Table 24: Renovation setup for the energy-optimal scenario 4 (ID 3939)

Type of intervention	Optimisation settings and ranges of variation	
External walls insulation	Insulation material: MIneral wool Total thickness of external wall U-Value	0,16 m 0,38 m 0,18 W/m²K
Roof insulation	Insulation material: Mineral wool Total thickness U-Value	0,26 m 0,63 m 0,12 W/m²K
Windows replacement	Glazing type: Triple glazing, Low-E PVC frame	Ug = 0,7
Shading system	Exterior blind high reflectivity slats 30°	
HVAC	Heat distribution: Hot water underfloor heating Heat supply: Condensation boiler (gas)	

Sustainability insights

	AI-generated solution (ID 3939)
Primary energy consumption	31.56 kWh/($m^2 \cdot a$)
Energy demand for cooling	0.00 kWh/($m^2 \cdot a$)
Energy demand for domestic hot water	3.27 kWh/($m^2 \cdot a$)
Electricity demand	3.94 kWh/($m^2 \cdot a$)
Energy demand for heating	18.44 kWh/($m^2 \cdot a$)
Energy demand total	25.65 kWh/($m^2 \cdot a$)
PV electricity production	0.00 kWh/($m^2 \cdot a$)
Carbon dioxide emissions	7.14 kg CO_2/($m^2 \cdot a$)
Embodied carbon dioxide	0.24 kg CO_2/($m^2 \cdot a$)
Specific transmittance heat losses	0.64 W/($m^2 \cdot K$)
Average U-value of opaque components	0.46 W/($m^2 \cdot K$)
Average U-value of transparent components	1.22 W/($m^2 \cdot K$)
Reused domestic water	0.00 l/($m^2 \cdot a$)
Savings through water-saving fittings	0.00 l/($m^2 \cdot a$)
Total water consumption	1,131.24 l/($m^2 \cdot a$)

Figure 14: Screenshot from the cost optimisation report 2 with energy related KPIs

The following KPIs have been calculated:

BS.OPED: Operational Primary Energy Demand

Table 25: BS.OPED Operational Primary Energy Demand

BS.OPED: Operational Primary Energy Demand	
Ep [kWh/m^2]	-31,56

BS.TED: Total Energy Demand

Table 26: BS.TED Total Energy Demand

BS.TED: Total Energy Demand	
Q_{TOT} [kWh/m^2year]	**25,65**

BS.TEC: Total Energy Consumption (and sub KPIs; Energy consumption for heating, cooling, lighting, DHW)

Table 27: BS.TEC Total Energy Consumption

BS.TEC: Total Energy Consumption	
EP_{heat}[kWh/m^2]	18,44
EP_{cool}[kWh/m^2]	0.00 (Cooling not present)
EP_{light}[kWh/m^2]	Not relevant for the demo
EP_{dhw}[kWh/m^2]	3,27
EP_{TOT}[kWh/m^2]	**25,65**

BS.TES: Total Energy savings

Table 28: BS.TES Total Energy Savings

BS.TES: Total Energy Savings			
	Baseline	Scenario 04	SAVING
EP_{heat}[kWh/m²]	20,46	18,44	2,02
EP_{cool}[kWh/m²]	Cooling not present		
EP_{light}[kWh/m²]	Not relevant for the demo		
EP_{dhw}[kWh/m²]	10,75	3,27	7,48
EP_{TOT}[kWh/m²]	**58,66**	**25,65**	**33,01**