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

Deliverable 4.2 – Energy Performance Report – Massy demo

Deliverable Report: Final version, issue date on XXXXX

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

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ENERGY REPORT - MASSY

Deliverable 4.2 – Energy Performance Report

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Colophon

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1. General information

1.1 Building description

Massy democase is a residential building located in *avenue de la rèpublique* 91300, Massy, France. Most of the building belongs to a private social housing company 3F and built in 1965. The company does not own the whole building: stairwells 11 and 13 are owned by the lessor RLF.

It consists of 10 floors, a ground floor and a basement with a total of 101 housings. At the beginning of 80s a few renovation works were done on the building. Then in the 90s, halls are restructured and finally in 2017 an important renovation was launched by company 3F, which produced the BIM model of the building.

The building is characterized by a reinforced concrete structure, insulated walls (6cm of polystyrene) and double glazing. Heating and dwelling hot water are provided by a heating network that distribute energy to this building and other surrounding buildings.

The building features are summarized below:

- the facades have thin exterior insulation(6cm)
- windows frames are in PVC of old generation but in good conditions with metal shutters on the ground floor and 1st floor
- the electrical system of the flats was renovated in the 80s.
- the building's energy label is D based on the EPDs.
- mechanical ventilation is provided (self-adjusting ventilation)
- lack of insulation on the floors
- underperforming insulation on the walls
- underperforming windows
- deterioration of the waterproofing on the terrace
- absence of airlock at R+10

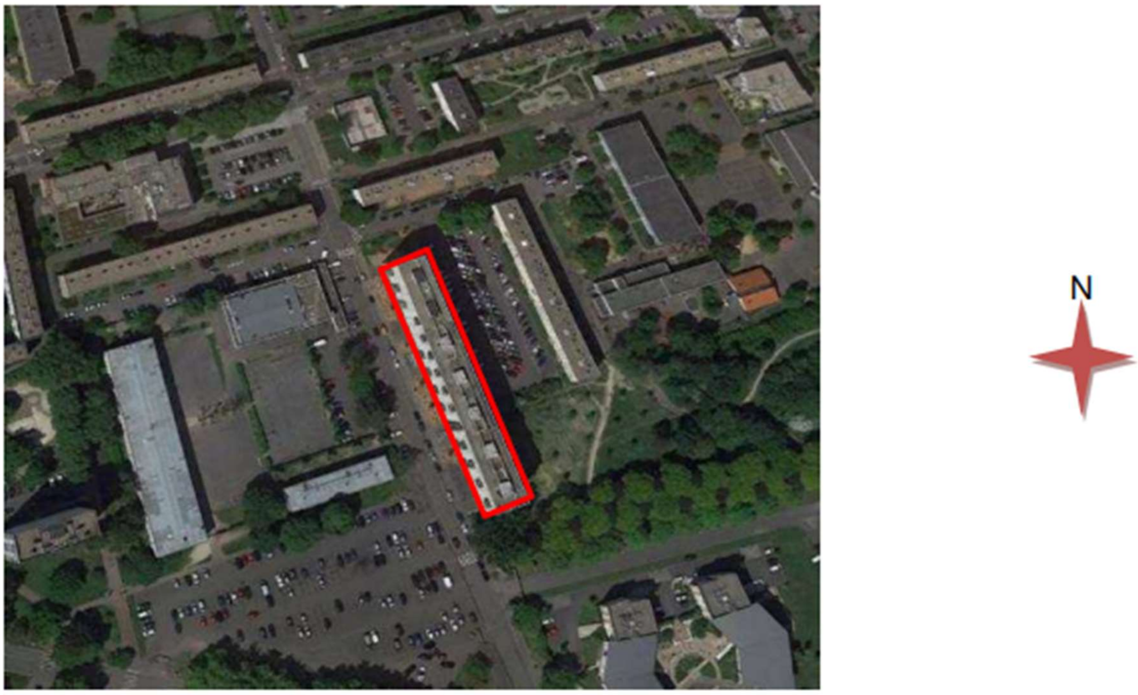


Figure 1: Aerial view of the urban context and building location

Figure 2: External view of the building

Table 1: Summary of general data

General information	
Location	Massy (France)
Use category	Residential
Building type	Single building for social housing
Construction year	1965
Renovation year	2017
Number of floors	Basement+ground floor+10
Number of apartments/units	101

1.2 GIS and environmental data

Massy is not included in the available weather file list of DesignBuilder. Therefore, the weather data obtained from Paris Orly Airport for 2019 is used. Used weather station is close to the building and given information below shows the properties of the weather station.

Altitude: 89

Latitude: 48.7168

Longitude: 2.3843

Stationindex:79

Below graph is obtained via DesignBuilder software.

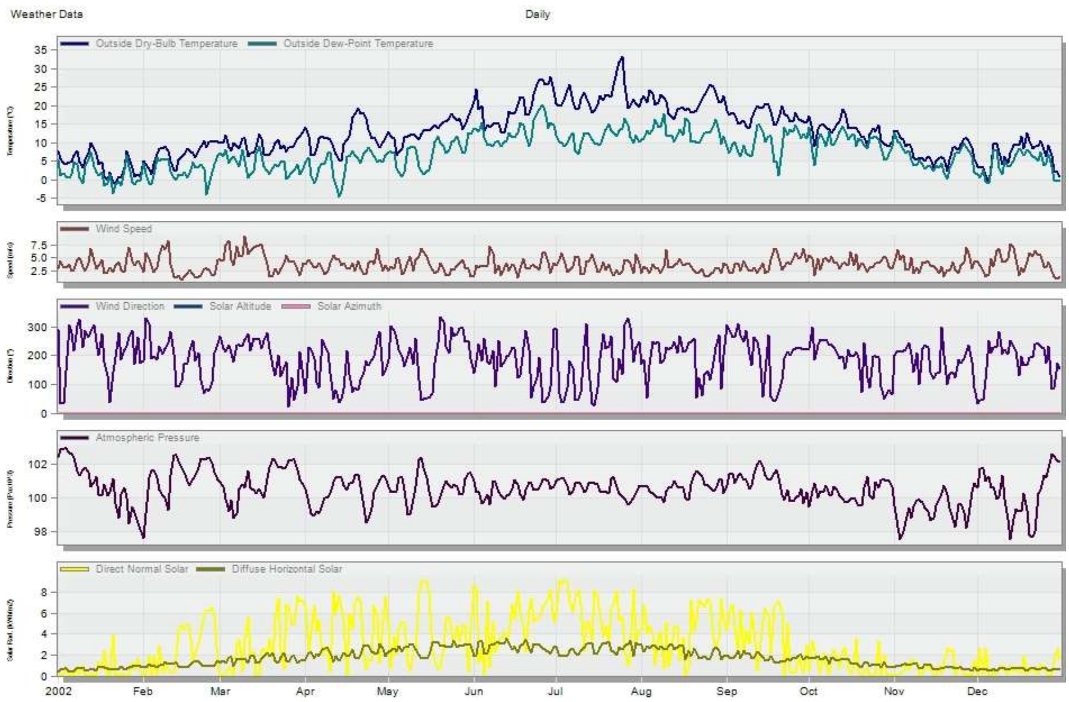


Figure 3: Used weather data in the BEM model

Temperature of the soil in the table below is the mean value of measured temperature of the ground at 100cm depth for each hour in a year.

Table 2: Summary of general environmental data

General information	
Location	Massy (France)
Weather file	2019.epw
Altitude [m]	88
Latitude [degrees]	48°44’2.89’’ N
Longitude [degrees]	2°17’44.11’’E
Undistributed temp. of the soil [°C]	11.88
Network water temperature [°C]	-

2. Energy modelling

2.1 BIM-to-BEM procedure and software tools used

To obtain the baseline BEM model DesignBuilder software is used and the building is modeled from scratch by implementing necessary zones and surfaces. After that, by using tools and algorithms developed by the company Metabuild, different renovation scenarios are created automatically.

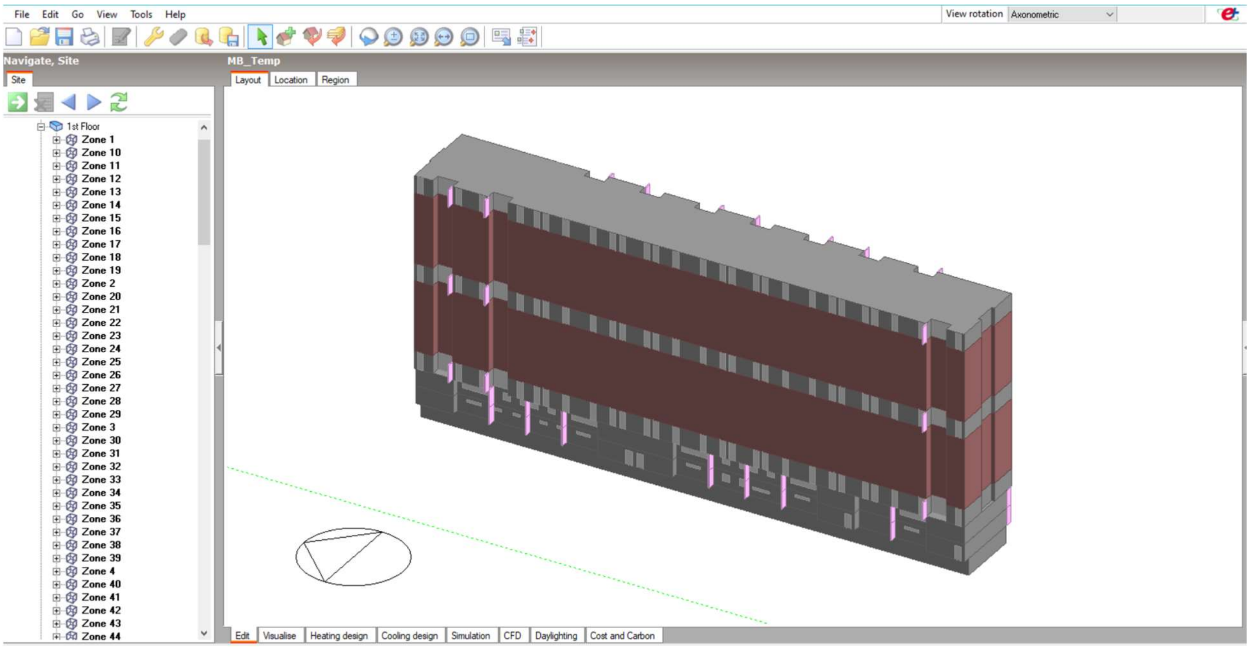


Figure 4: Massy demo - DesignBuilder

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 ALTEREA and specific documents have been investigated to retrieve all the required data to characterise the thermal behaviour of the building.

There was not any heating/DHW network audit report available, but since the networks were all original (56 years old), corrosion and risk of breakage have been supposed to be the main problems. Sampling and metallographic analysis of the networks were carried out by ALTEREA.

2.3 Description of BEM's technical features

Massy BEM consists of basement, ground floor and 10 floors. Since the floors other 1st floor have similar configurations, they are created by zone multiplier method which decreases the demand of GPU power for the simulation to be conducted. To reflect the impact of shading for the energy calculations, component blocks are defined whenever an element is not used to separate zones but rather exists due to the architectural concerns.

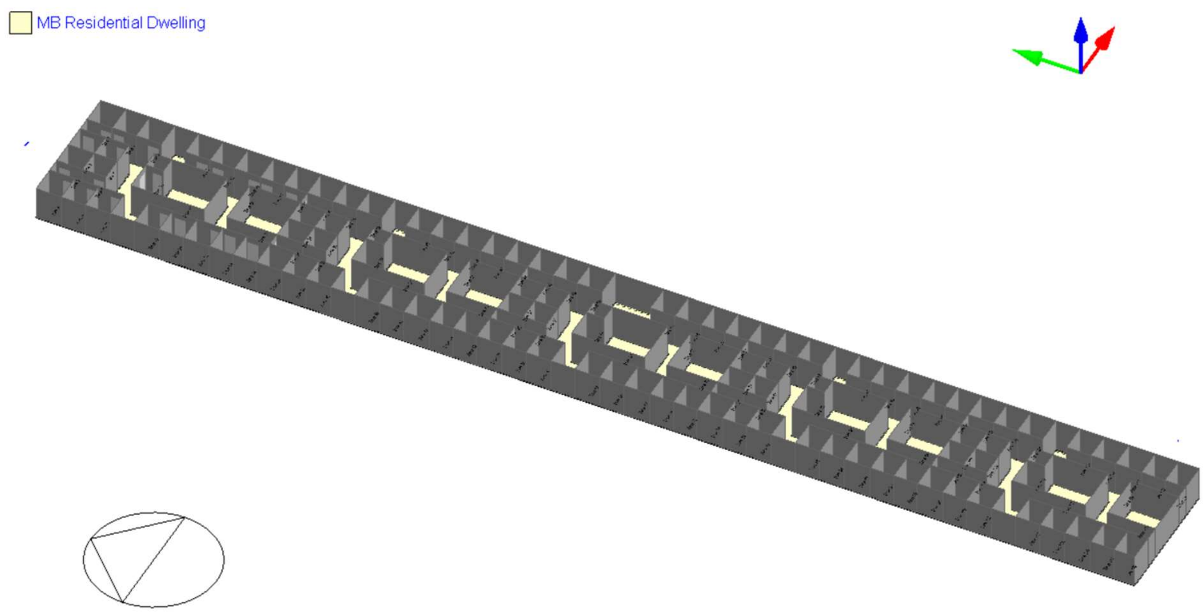


Figure 5: Massy demo basement- DesignBuilder

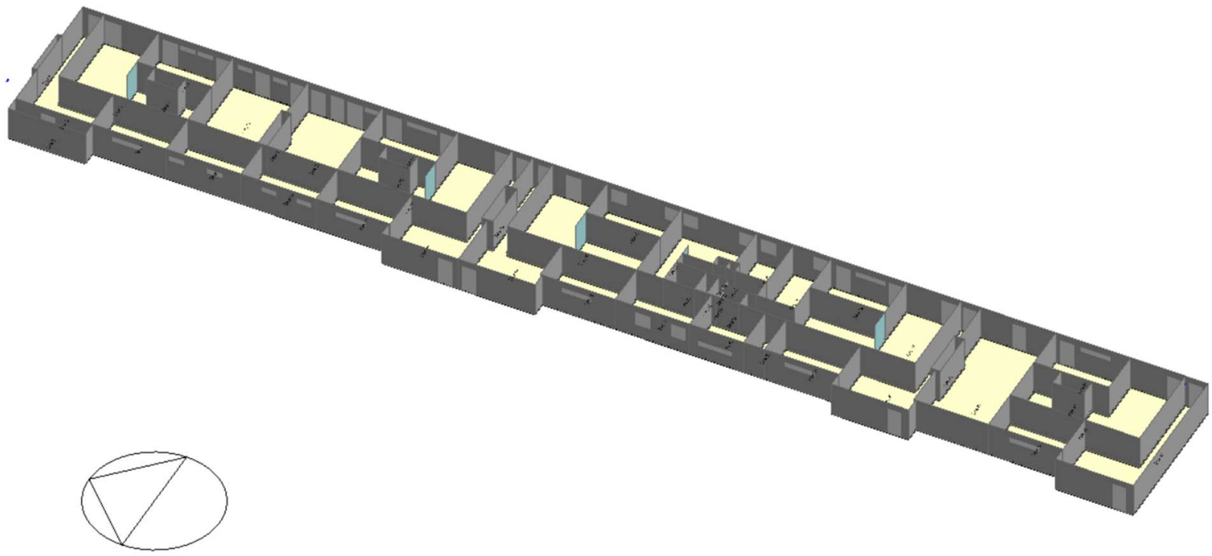


Figure 6: Massy demo ground floor - DesignBuilder

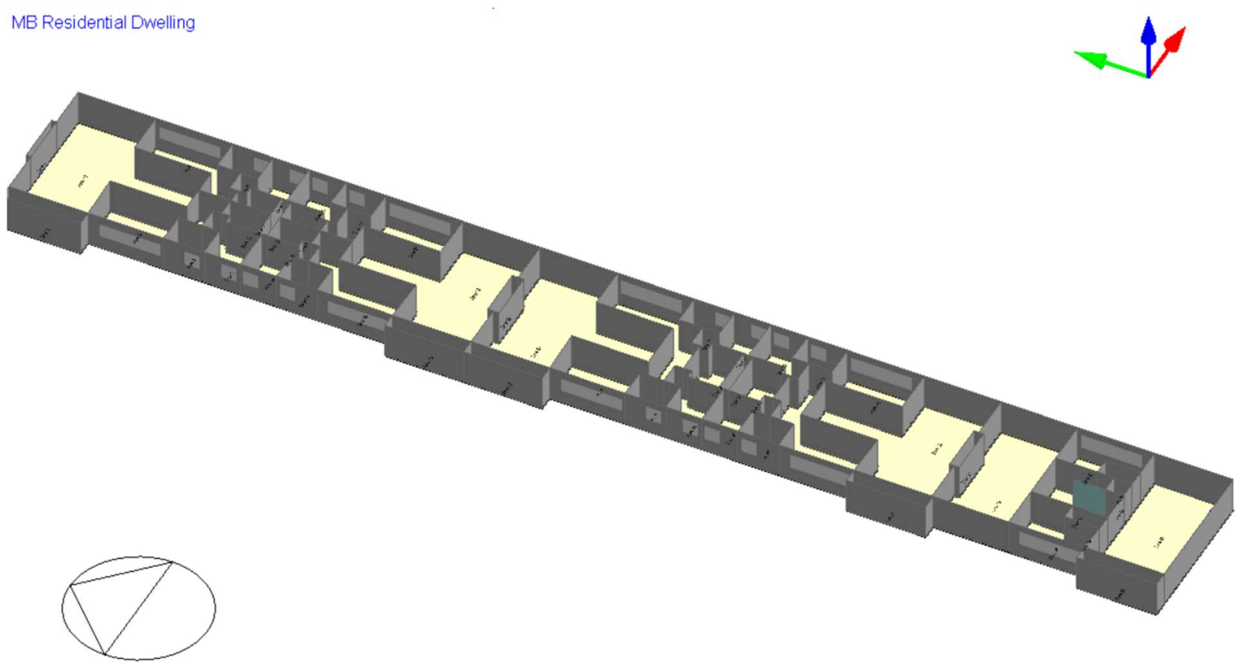


Figure 7: Massy demo 1st floor - DesignBuilder

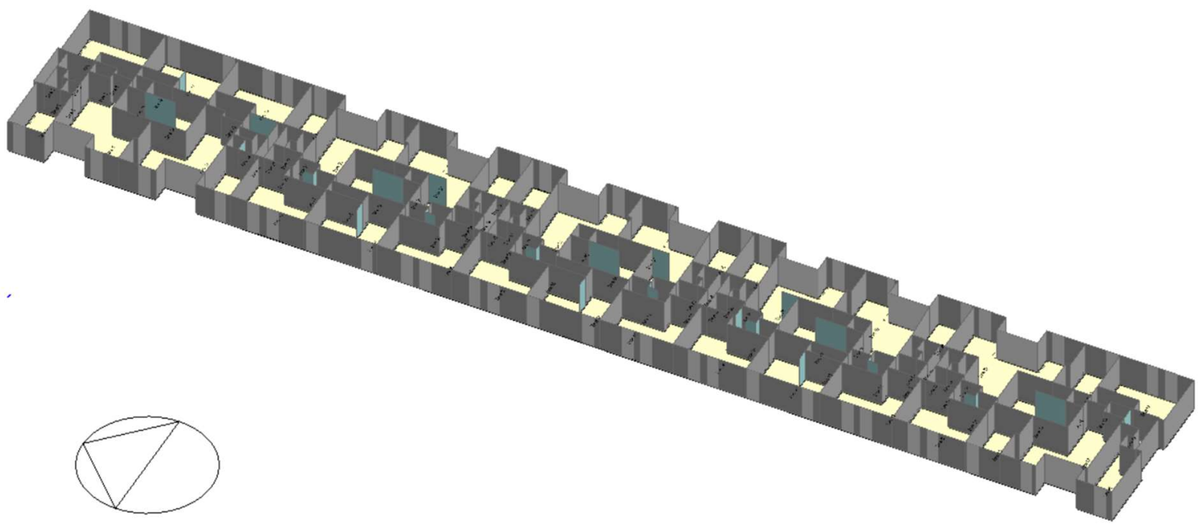


Figure 8: Massy demo other floors - DesignBuilder

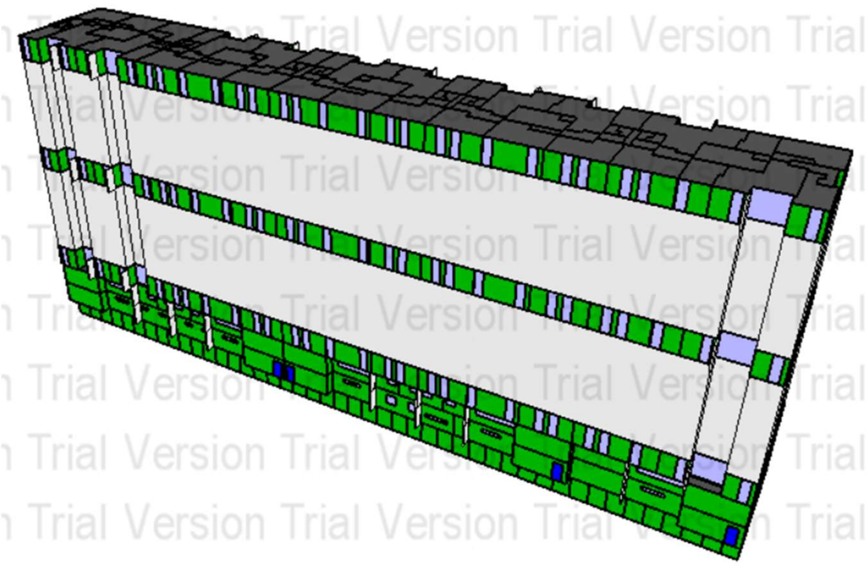


Figure 9: 3D graphical representation of the Massy BEM

2.3.1 Envelope components and materials

The construction systems were created within the Massy BEM to characterise the thermal behaviour of the building. Table 4 summarises all the materials implemented within the BEM.

Table 3: Materials

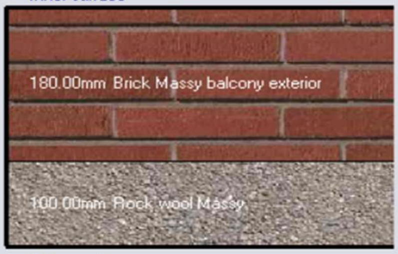
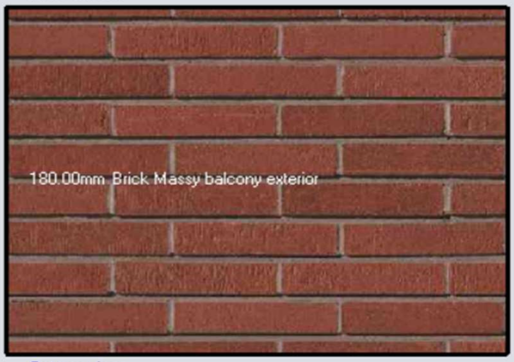
Material	*ρ*	**λ**	**RT**	**Cp**
Rock wool	25	0.04	2.5	1450
Brick exterior	775	0.4	0.2965	840
Concrete	2400	2.5	0.072	1000
Gypsum	1200	0.43	0.15	1000
Reinforced concrete	2300	2.3	0.15	1000
PUR foam	35	0.026	0.15	1590
Plaster	1000	0.4	0.15	1000
Mineral fibre/wool	140	0.038	0.15	840
Concrete tiles	2100	1.5	0.15	1000

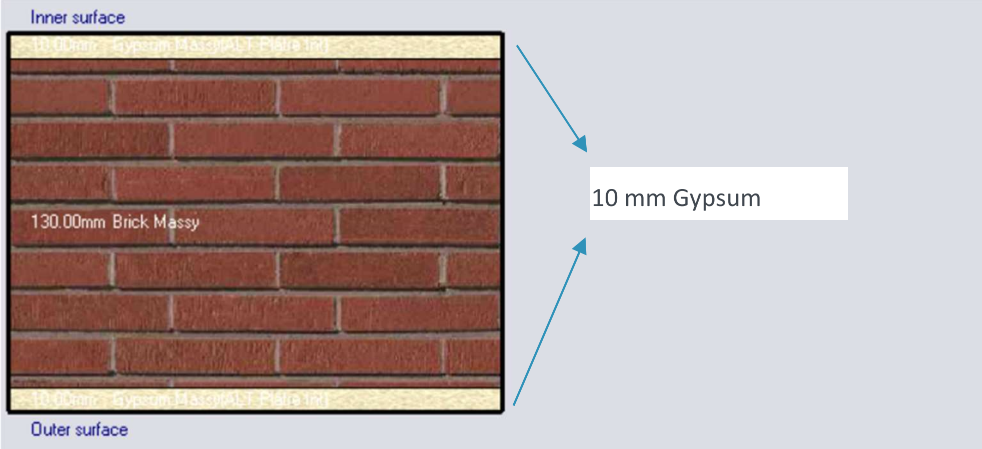
Used abbreviations

ρ Density kg/m^3
λ *Thermal conductivity W/(m*K)*
RT *Thermal resistance (m^2*K/W)*
Cp *Specific heat (J/kg*K)*

Within Table 4 all the construction systems created for the Massy BEM using the DesignBuilder.

Table 4: Construction systems

Exterior wall Massy 280 brick	**Cross Section** Inner surface  Outer surface **Inner surface** Convective heat transfer coefficient (W/m2-K) 3.075 Radiative heat transfer coefficient (W/m2-K) 4.617 Surface resistance (m2-K/W) 0.130 **Outer surface** Convective heat transfer coefficient (W/m2-K) 19.870 Radiative heat transfer coefficient (W/m2-K) 5.130 Surface resistance (m2-K/W) 0.040 **No Bridging** U-Value surface to surface (W/m2-K) 0.400 R-Value (m2-K/W) 2.670 U-Value (W/m2-K) 0.375 **With Bridging (BS EN ISO 6946)** Thickness (m) 0.2800 Upper resistance limit (m2-K/W) 2.670 Lower resistance limit (m2-K/W) 2.670
Exterior wall Massy 180	Inner surface  Outer surface **Inner surface** Convective heat transfer coefficient (W/m2-K) 3.075 Radiative heat transfer coefficient (W/m2-K) 4.617 Surface resistance (m2-K/W) 0.130 **Outer surface** Convective heat transfer coefficient (W/m2-K) 3.075 Radiative heat transfer coefficient (W/m2-K) 4.617 Surface resistance (m2-K/W) 0.130 **No Bridging** U-Value surface to surface (W/m2-K) 10000.000 R-Value (m2-K/W) 0.260 U-Value (W/m2-K) 3.845 **With Bridging (BS EN ISO 6946)** Thickness (m) 0.1800 Upper resistance limit (m2-K/W) 0.260 Lower resistance limit (m2-K/W) 0.260

<table>
<tr>
<td>Interior wall Massy brick 150</td>
<td>


Inner surface
Convective heat transfer coefficient (W/m2-K) 2.152
Radiative heat transfer coefficient (W/m2-K) 5.540
Surface resistance (m2-K/W) 0.130
Outer surface
Convective heat transfer coefficient (W/m2-K) 2.152
Radiative heat transfer coefficient (W/m2-K) 5.540
Surface resistance (m2-K/W) 0.130
No Bridging
U-Value surface to surface (W/m2-K) 5.089
R-Value (m2-K/W) 0.457
U-Value (W/m2-K) 2.191
With Bridging (BS EN ISO 6946)
Thickness (m) 0.1500
Upper resistance limit (m2-K/W) 0.457
Lower resistance limit (m2-K/W) 0.457
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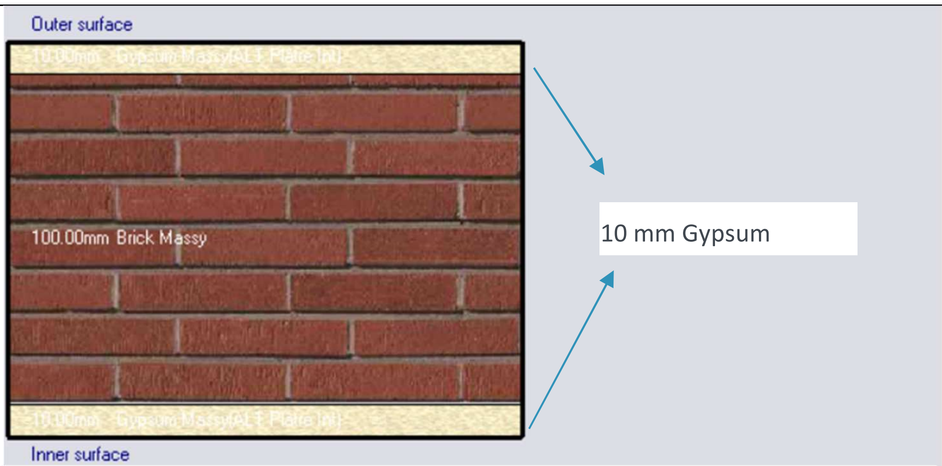
<tr>
<td>Interior wall Massy brick 120</td>
<td>


Inner surface
Convective heat transfer coefficient (W/m2-K) 2.152
Radiative heat transfer coefficient (W/m2-K) 5.540
Surface resistance (m2-K/W) 0.130
Outer surface
Convective heat transfer coefficient (W/m2-K) 2.152
Radiative heat transfer coefficient (W/m2-K) 5.540
Surface resistance (m2-K/W) 0.130
No Bridging
U-Value surface to surface (W/m2-K) 2.915
R-Value (m2-K/W) 0.603
U-Value (W/m2-K) 1.658
With Bridging (BS EN ISO 6946)
Thickness (m) 0.1200
Km - Internal heat capacity (KJ/m2-K) 12.0000
Upper resistance limit (m2-K/W) 0.603
Lower resistance limit (m2-K/W) 0.603
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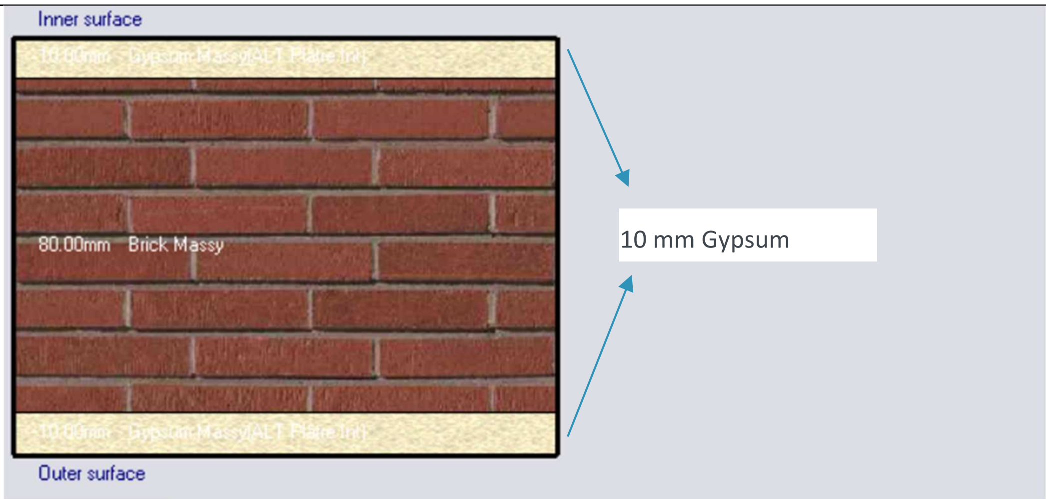
Interior wall Massy brick 100



Inner surface	
Convective heat transfer coefficient (W/m2-K)	2.152
Radiative heat transfer coefficient (W/m2-K)	5.540
Surface resistance (m2-K/W)	0.130
Outer surface	
Convective heat transfer coefficient (W/m2-K)	2.152
Radiative heat transfer coefficient (W/m2-K)	5.540
Surface resistance (m2-K/W)	0.130
No Bridging	
U-Value surface to surface (W/m2-K)	2.915
R-Value (m2-K/W)	0.603
U-Value (W/m2-K)	1.658
With Bridging (BS EN ISO 6946)	
Thickness (m)	0.1000
Upper resistance limit (m2-K/W)	0.603
Lower resistance limit (m2-K/W)	0.603

MB Flat Roof EnEV 2016

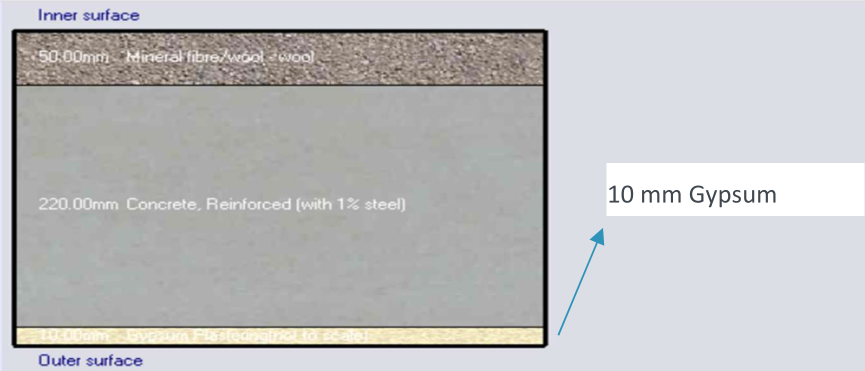
Inner surface	
Convective heat transfer coefficient (W/m2-K)	4.460
Radiative heat transfer coefficient (W/m2-K)	5.540
Surface resistance (m2-K/W)	0.100
Outer surface	
Convective heat transfer coefficient (W/m2-K)	19.870
Radiative heat transfer coefficient (W/m2-K)	5.130
Surface resistance (m2-K/W)	0.040
No Bridging	
U-Value surface to surface (W/m2-K)	0.405
R-Value (m2-K/W)	2.609
U-Value (W/m2-K)	0.383
With Bridging (BS EN ISO 6946)	
Thickness (m)	0.4300
Upper resistance limit (m2-K/W)	2.609
Lower resistance limit (m2-K/W)	2.609

MB Ground Floor EnEV 2016

Cross Section

Inner surface	
Convective heat transfer coefficient (W/m2-K)	0.342
Radiative heat transfer coefficient (W/m2-K)	5.540
Surface resistance (m2-K/W)	0.170
Outer surface	
Convective heat transfer coefficient (W/m2-K)	19.870
Radiative heat transfer coefficient (W/m2-K)	5.130
Surface resistance (m2-K/W)	0.040
No Bridging	
U-Value surface to surface (W/m2-K)	7.667
R-Value (m2-K/W)	0.340
U-Value (W/m2-K)	2.937
With Bridging (BS EN ISO 6946)	
Thickness (m)	0.3000
Upper resistance limit (m2-K/W)	0.340
Lower resistance limit (m2-K/W)	0.340

MB Internal Floor EnEV 2016



Inner surface	
Convective heat transfer coefficient (W/m2-K)	0.342
Radiative heat transfer coefficient (W/m2-K)	5.540
Surface resistance (m2-K/W)	0.170
Outer surface	
Convective heat transfer coefficient (W/m2-K)	4.460
Radiative heat transfer coefficient (W/m2-K)	5.540
Surface resistance (m2-K/W)	0.100
No Bridging	
U-Value surface to surface (W/m2-K)	0.696
R-Value (m2-K/W)	1.706
U-Value (W/m2-K)	0.586
With Bridging (BS EN ISO 6946)	
Thickness (m)	0.2800
Upper resistance limit (m2-K/W)	1.706
Lower resistance limit (m2-K/W)	1.706

2.3.2 HVAC systems

The HVAC heat supplier of the building is a condensation boiler (gas) and the used system is hot water radiators. Building's ventilation system is the self-adjusting controlled mechanical ventilation. Stale air is extracted through galvanized ducts connected to boxes located on the roof terrace.

Figure 10: Ventilation and the galvanized ducts

The production of heating and DHW is ensured instantly by a heat substation connected to the Massy urban heating network operating at 64% renewable energy. The service substation is located in a neighboring building and supplies several residences.

2.3.3 Occupancy, lighting and equipment patterns

Relevant operating schedules and occupational patterns have been assumed based on standard residential uses and following figures are taken from the report generated by MTB tool. These are used for the calculation of energy outputs.

People per m^2 floor area: 0.0417

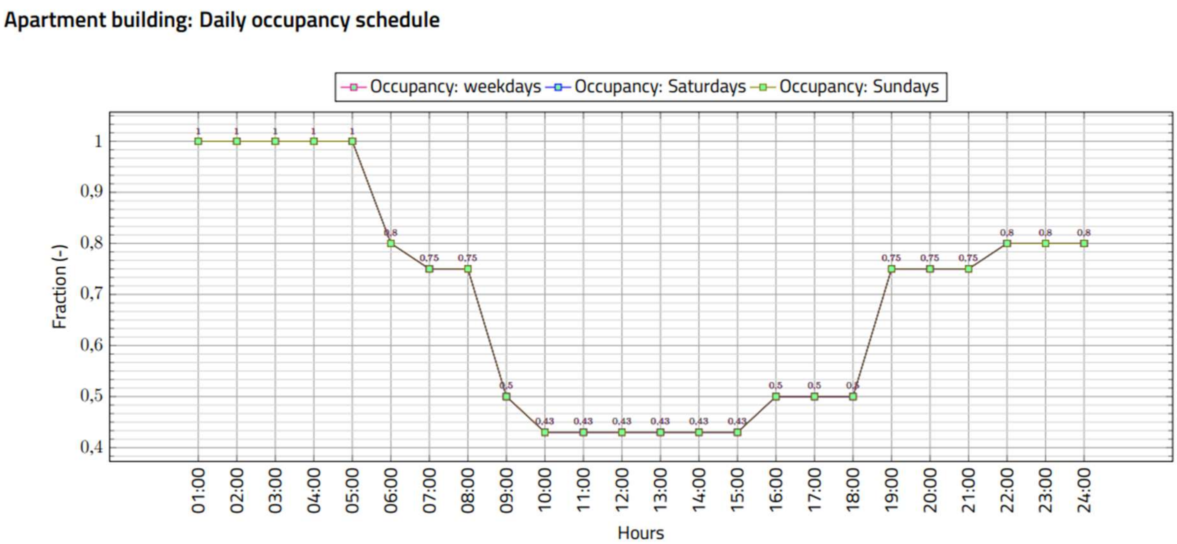


Figure 11: Daily occupancy schedule

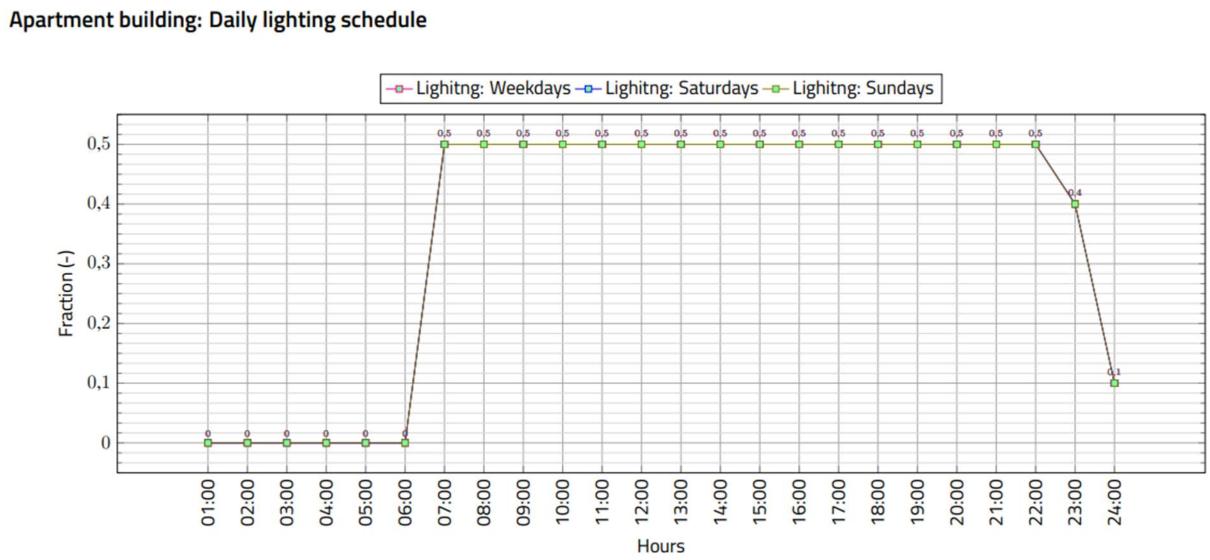


Figure 12: Daily lighting schedule

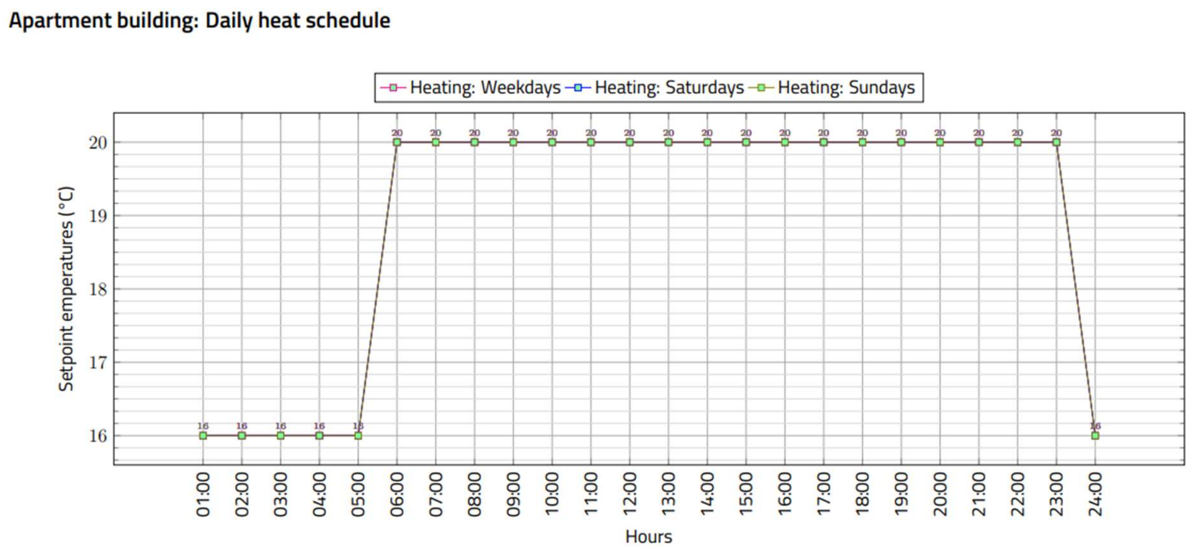


Figure 13: Daily heating schedule

3. BEM calibration

The BEM has not been calibrated with the BIM SPEED new procedure (sufficiently detailed data were not available from both the energy bills side and the energy model side).

4. Building energy performance simulation results

4.1 General considerations

The share of energy loss in the building linked to exterior walls and thermal bridges is relatively low and can be explained by the good compactness of the building. The openings represent 28% of losses and the room air distribution is responsible %28 of losses. Below can be seen the whole loss distribution.

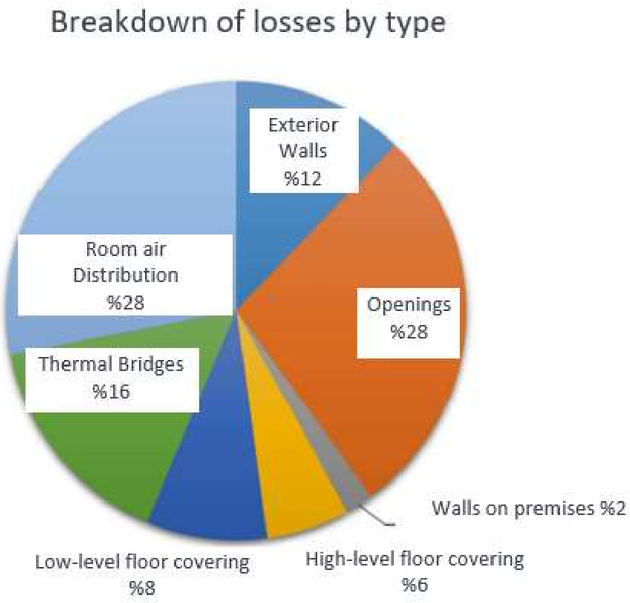


Figure 14: Breakdown of losses

The replacement of openings can create improvements in the thermal performance of the envelope. Also, replacing the existing ventilation with a humidity sensitive system will reduce energy losses related room air distribution.

4.2 Energy KPIs

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. According to the generated report of the MTB Tool, it is calculated as,

Table 5: BS.OPED Operational Primary Energy Demand

BS.OPED: Operational Primary Energy Demand	
Ep [kWh/m^2*a]	61.02

BS.TED: Total Energy Demand

Total energy demand of the building is obtained as follows,

Table 6: Table 6: BS.TED Total Energy Demand

BS.TED: Total Energy Demand	
Energy demand for cooling [kWh/m^2*a]	not present
Energy demand for domestic hot water [kWh/m^2*a]	10.01
Electricity demand[kWh/m^2*a]	3.87
Energy demand for heating[kWh/m^2*a]	41.34
Energy demand total[kWh/m^2*a]	55.22

BS.TEC: Total Energy Consumption

Total Energy Consumption has been calculated directly using the simulation engine of MTB.

Table 7: BS.TEC Total Energy Consumption

BS.TEC: Total Energy Consumption	
EP [kWh/m^2]	55.22

General results of the simulation are given below.

Table 8: Base BEM simulation results

Investment costs	0.00 Mio. €
Operating costs	1.87 €/(m^2 GFA · month
Life cycle costs	15.70 Mio. €
Gross surface (GFA)	10,038.59 m^2
Residential surface	9,811.30 m^2
Surface efficiency (UA/GFA)	97.74%
Rental income	43.63 Mio. €
Primary energy	61.02 kWh/(m^2 GFA · a)
CO_2-Balance	13.67 kg CO_2/(m^2 GFA ·
Daylight comfort	Score: 4/10
Thermal comfort	Score: 6/10
Air quality	Score: 5/10

5. Building renovation scenarios

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

5.1 Renovation scenarios proposed

For the Massy democase, the following building renovation elements have been assessed.

- External walls (indoor) insulation

- Windows replacement (incl. shading system)
- Energy generation
- Boilers replacement

5.2 Optimisation set-up: planning variants considered

Used primary energy factors in the simulations are given below.

Table 9: Primary factors

Primary energy factor electricity	1.95
Primary energy factor Verdrängungsstrom	2.8
Specific CO2 Emissions from electricity (kg/MWh)	490
Primary energy factor of district heating	0.3
Specific CO2 Emissions from district heating (kg/MWh)	54.6
Primary energy factor of gas	1.1
Specific CO2 Emissions from gas (kg/MWh)	240
Thermal bridge surcharge flat rate (W/m²K)	0.1

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

Table 10: Optimisation setting – Intervention, ranges of variation and number of options

Type of intervention	Optimisation settings and ranges of variation	Number of options
External walls insulation	Insulation Types: (1) Stone wool (λ 0,035 W/mK); (2) Mineral wool (λ 0,032 W/mK); (3) Wood derivates wood wool (λ from 0,038 W/mK)	3
	Thickness options: 1 cm – 30 cm in 10 regular steps (1, 4, 7, 11, 14, 17, 20, 23, 27, 30 cm)	10
Roof insulation	Insulation Types: (1) Stone wool (λ 0,035 W/mK); (2) Mineral wool (λ 0,032 W/mK); (3) PUR foam (λ 0,026 W/mK)	3
	Thickness options: 1 cm – 32 cm in 10 regular steps (1, 4, 7, 11, 14, 18, 21, 25, 29, 32 cm)	10
Windows replacement	U-values from 1,9 to 0,62 kWh/m²K (steps: 1,9; 1,3; 0,9; 0,7; 0,62) 0,7: Low-E,PVC frame; argon an optical enhancement panes Double glazing with argon and double-coated sputter LoE no change in windows dimensions	7
Shading system	(1) Interior blind with low reflectivity slats; (2) Exterior shade roll medium translucent; (3) Exterior blinds w. low/med/high reflectivity and 30°-135° angle (4) No shading	21

Energy generation(Photovoltaic)	Type: (1) No PV (2) PV polycrystalline, eff. 0.15 (3) PV polycrystalline, eff. 0.17 (4) PV monocrystalline, eff. 0.19 (5) PV monocrystalline, eff. 0.21 Photovoltaic surface: (1) 20 (2) 50 Battery type: (1) Lithium iron phosphate batteries (2) Saltwater batteries	5 2
HVAC	Heat distribution: (1) Hot water radiator; (2) Hot water underfloor heating Heat supply: (1) Condensation boiler	2 1
	Total number of theoretical combinations	**10.260.000**

5.3 Ranges of optimal solutions

Following the specific optimization set-up of the project, the theoretical number of possible renovation scenarios to be assessed is 10,26 Million. Out of these, 4.080 scenarios have been automatically simulated and assessed, controlled by an evolutionary optimization algorithm. This process took a computation time of approx. 146hrs (146hrs 25min on a server cluster with 288 cores and 470 GB RAM).

Figure 15 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 5 – 42 kWh/(m² year) and construction costs between EUR 2.200.000 and EUR 3.800.000.

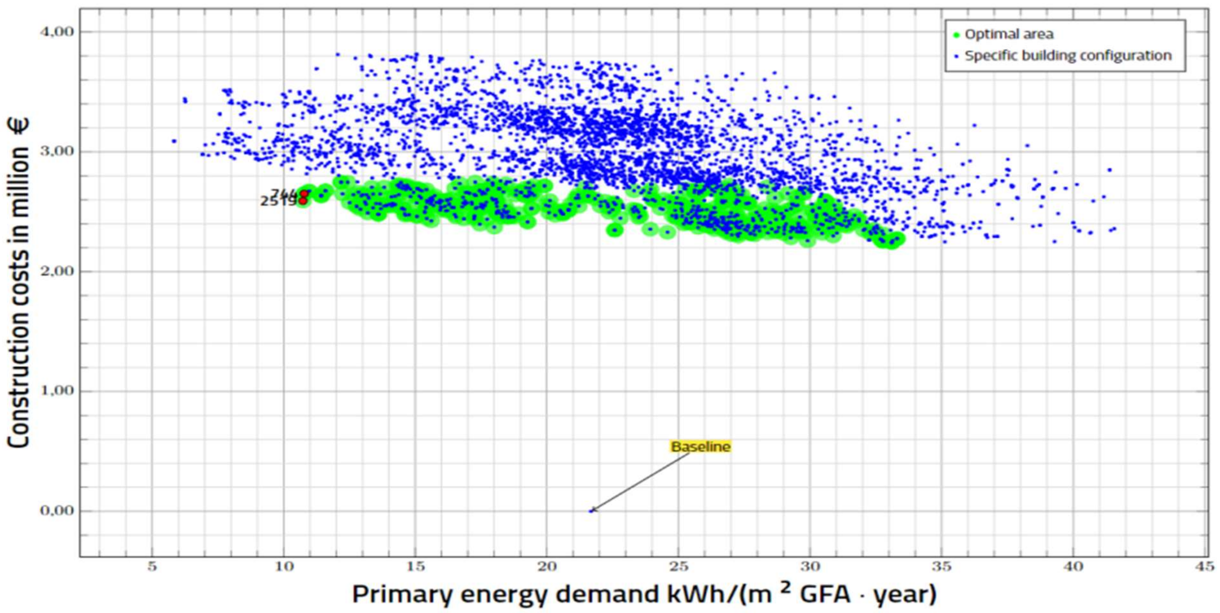


Figure 15: Pareto-graph of simulates renovation scenarios

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 2519 & ID 744)
- Cost-optimal: Two solutions with best results in cost performance, while still having a good energy and comfort performance (ID 2172 & ID 47)

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

5.4 Scenarios 1: description and results

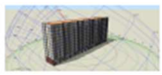
Scenario 1 (ID 2519) has been identified as an energy-optimal renovation scenario. In comparison with all simulated renovation scenarios, this scenario has a very good end energy demand, while still having a good costs and comfort performance (17). Its configuration and its simulation results are described in the following tables.

Table 11: Renovation setup for the energy-optimal scenario 1 (ID 2519)

Type of intervention	Optimisation settings and ranges of variation	
External walls insulation	Insulation material: Stone wool Total thickness of external wall U-Value	0,21 m 0,43 m 0,16 W/m²K
Roof insulation	Insulation material: Mineral wool Total thickness U-Value	0,26 m 0,63 m 0,11 W/m²K
Windows replacement	Glazing type: Triple glazing, Low-E, PVC frame	Ug = 0,7
Shading system	Exterior blind low reflectivity slats 45◦	
Energy generation(Photovoltaic)	Type: PV monocrystalline, eff. 0.19 Battery type: Lithium iron phosphate batteries	 70 kWh
HVAC	Heat distribution: Hot water underfloor heating	

Figure 16: Energy related KPIs from the optimization report

Sustainability insights



	AI-generated solution (ID 2519)
Primary energy consumption	10.73 kWh/(m² · a)
Energy demand for cooling	0.00 kWh/(m² · a)
Energy demand for domestic hot water	4.82 kWh/(m² · a)
Electricity demand	−6.09 kWh/(m² · a)
Energy demand for heating	15.73 kWh/(m² · a)
Energy demand total	14.46 kWh/(m² · a)
PV electricity production	11.31 kWh/(m² · a)

The following KPIs have been calculated:

BS.OPED: Operational Primary Energy Demand

Table 12: BS.OPED Operational Primary Energy Demand

BS.OPED: Operational Primary Energy Demand	
Ep [kWh/m²]	10,73

BS.TED: Total Energy Demand

Table 13: BS.TED Total Energy Demand

BS.TED: Total Energy Demand	
Q_{TOT} [kWh/m²year]	14,46

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

Table 14: BS.TEC Total Energy Consumption

BS.TEC: Total Energy Consumption	
EP_{heat}[kWh/m²]	15,73
EP_{cool}[kWh/m²]	0.00 (Cooling not present)
EP_{light}[kWh/m²]	Not relevant for the demo
EP_{dhw}[kWh/m²]	4,82
EP_{TOT}[kWh/m²]	**14,46**

Table 15: BS.TES Total Energy Savings

BS.TES: Total Energy Savings			
	Baseline	Scenario 01	SAVING
EP_{heat}[kWh/m²]	41.34	15,73	25,61
EP_{cool}[kWh/m²]	Cooling not present		
EP_{light}[kWh/m²]	Not relevant for the demo		
EP_{dhw}[kWh/m²]	10,01	4,82	5,19
EP_{TOT}[kWh/m²]	**55.22**	**14,46**	**40,76**

5.5 Scenarios 2: description and results

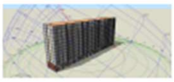
Scenario 2 (ID 744) has been identified as an energy-optimal renovation scenario. In comparison with all simulated renovation scenarios, this scenario has a very good end energy demand, while still having a good costs and comfort performance (**Error! Reference source not found.**). Its configuration and its simulation results are described in the following tables.

Table 16: Renovation setup for the energy-optimal scenario 1 (ID 744)

Type of intervention	Optimisation settings and ranges of variation	
External walls insulation	Insulation material: Mineral wool Total thickness of external wall U-Value	0,24 m 0,46 m 0,13 W/m²K
Roof insulation	Insulation material: Mineral wool Total thickness U-Value	0,23 m 0,60 m 0,13 W/m²K
Ground floor insulation	Insulation material: EPS Total thickness U-Value	0,18 m 0,49 m 3,75 W/m²K
Windows replacement	Glazing type: Triple glazing, argon and optical enhancement panes no change in windows dimensions	Ug = 0,7
Shading system	Exterior blind high reflectivity slats 60°	

Energy generation(Photovoltaic)	Type: PV monocrystalline, eff. 0.21 Battery type: Lithium iron phosphate batteries	82 kWh
HVAC	Heat distribution: Hot water radiator	

Sustainability insights



	AI-generated solution (ID 744)
Primary energy consumption	10.78 $kWh/(m^2 \cdot a)$
Energy demand for cooling	0.00 $kWh/(m^2 \cdot a)$
Energy demand for domestic hot water	4.55 $kWh/(m^2 \cdot a)$
Electricity demand	-7.14 $kWh/(m^2 \cdot a)$
Energy demand for heating	17.92 $kWh/(m^2 \cdot a)$
Energy demand total	15.32 $kWh/(m^2 \cdot a)$
PV electricity production	12.50 $kWh/(m^2 \cdot a)$

Figure 17: Energy related KPIs from the optimization report

The following KPIs have been calculated:

BS.OPED: Operational Primary Energy Demand

Table 17: BS.OPED Operational Primary Energy Demand

BS.OPED: Operational Primary Energy Demand	
Ep [kWh/m^2]	10,78

BS.TED: Total Energy Demand

Table 18: BS.TED Total Energy Demand

BS.TED: Total Energy Demand	
Q_{TOT} [kWh/m^2year]	15,32

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

Table 19: BS.TEC Total Energy Consumption

BS.TEC: Total Energy Consumption	
EP_{heat}[kWh/m^2]	17,92
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]	4,55
EP_{TOT}[kWh/m^2]	**15,32**

Table 20:   Table 20: BS.TES Total Energy Savings

BS.TES: Total Energy Savings			
	Baseline	Scenario 02	SAVING
EP_{heat}[kWh/m^2]	41,34	17,92	23,42
EP_{cool}[kWh/m^2]	Cooling not present		
EP_{light}[kWh/m^2]	Not relevant for the demo		
EP_{dhw}[kWh/m^2]	10,01	4,55	5,46
EP_{TOT}[kWh/m^2]	**55,22**	**15,32**	**39,9**

6. Time reduction evaluation

The time reduction evaluation for the BIM-to-BEM process is not relevant from the Massy democase as the BEM was created with a traditional process using directly BEM software and not starting from a BIM model.