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EASI ZERo

Deliverable	**ENVELOPE MATERIAL SYSTEM WITH LOW IMPACT FOR ZERO ENERGY RENOVATION AND CONSTRUCTION**

Deliverable	**D6.1**
Deliverable name	**Use case buildings baseline, BIM modelling and monitoring plan**
Deliverable description	In the design and pre-construction stages, BIM simulation method are reported to assess and improve the performances of buildings. According to building global situation and use, the best green building designs are described as results of task 6.1. A monitoring plan for each use case is disclosed, with definition of KPIs, scope and boundaries of metering system, precision and reliability, responsibilities of data gathering, timing.

WP	6	Validation in real use cases
Task	6.1	Use cases' baseline definition and BIM model design

Dissemination level[1]	PU
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[1] Dissemination level: **PU** = Public, fully open, **SEN** = Sensitive, limited under the conditions of the Grant Agreement

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1. Executive summary

1.1 *Description of the Deliverable content and objectives*

The first objective of this deliverable is to present the three selected buildings for conducting simulations, called "use cases". The report includes for each building the geographical location and climatic condition, as well as the envelope characteristics, the heating and ventilation systems, and also a list of energy-using equipment.
The report also presents the proposed instrumentation plan to assess building's current energy performance.
Finally, this deliverable shows some screenshots of the modelling of the building. The models will subsequently be calibrated based on measured energy consumption data.

1.2 *Deviation from objectives, corrective action*

This report is issued with a three months delay. A new delivery data has been set-up in the project amendment validated in February 2024 referenced 101091531-3.
Difficulties were encountered in confirming the three use cases as initially described in the program. We present these issues case by case hereafter.

- Use case n°1: the municipal office building in Würzburg (Germany) cannot be considered for the realisation of thermodynamic simulation and performance monitoring. Renovation work has started before the project launch.
- Use case n°2: the residential building in Lyon (France) was not available anymore; a housing tower located next to Paris (France) was selected as a new use case in collaboration with an intermediate housing provider.
- Use case n°3: the renovation of the heritage building in Bronnbach was not considered by the owner and the actual situation of the building does not allow monitoring. This latter building suffered from an important lack of data that prevent accuracy of modelling work. A single family wooden house in Norway was selected to replace this heritage building.

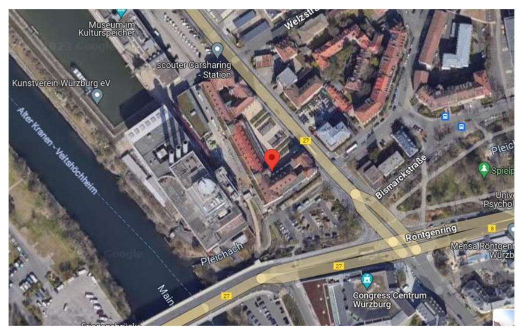
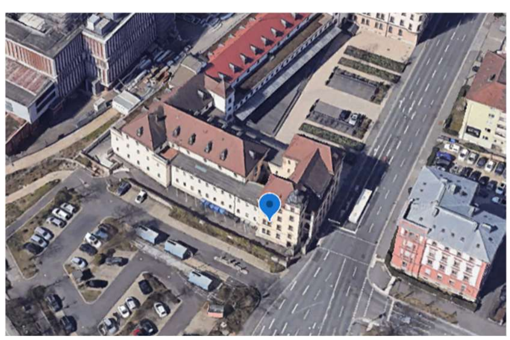
2. Building baseline

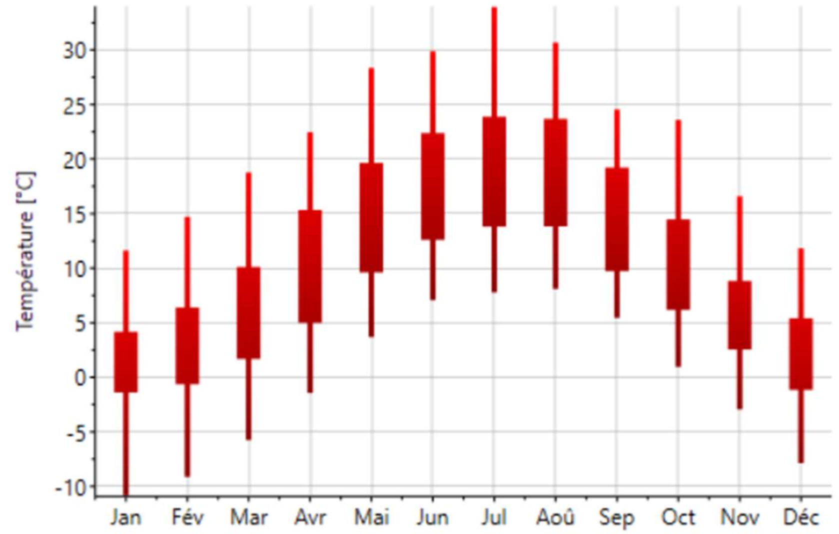
2.1 *Use case n°1: Würzburg (DE)*

2.1.1 General information

Location	Würzburg, Germany 
Year of construction	1903
Uses	Office Building
Total heated area [m²]	6 000
Number of floors	Ground floor + 3 storeys
Number of basements	1
Specification	Renovation in progress

2.1.2 Geographic and climate data

Satellite view	 
Aerial view	
Weather Station:	Wuerzburg
Altitude [m] :	178

Average temperatures from 2000 to 2019 from the Meteonorm database used in Pleiades software	

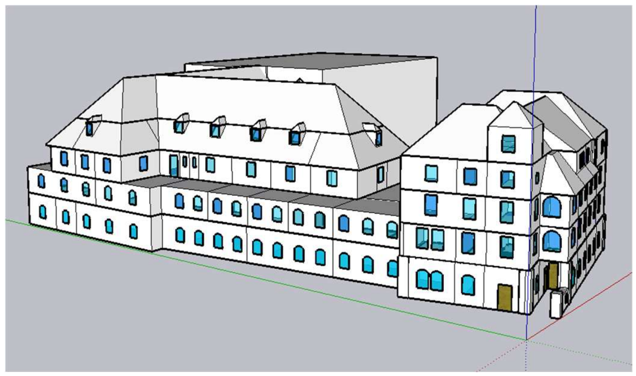
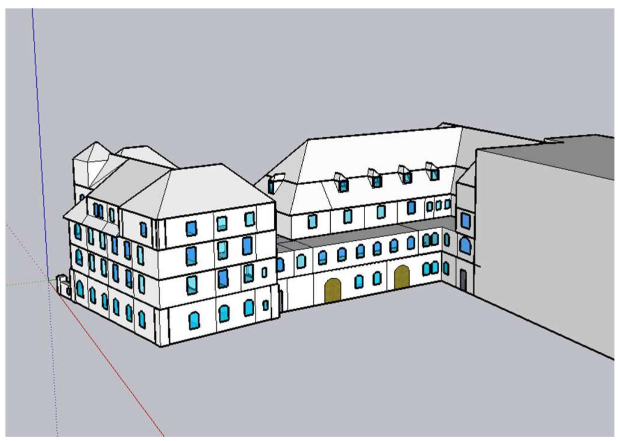
2.1.3 Building envelope characteristics

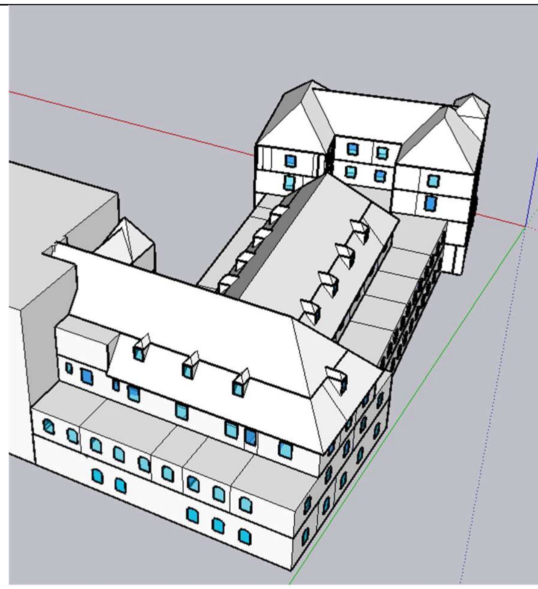
Opaque envelope	Exterior Walls: 400 mm to 550 mm of bricks without insulation Roof (lost attic space): concrete slab without insulation Ground floor over basement: concrete slab without insulation
Exterior joinery	Mostly PVC double glazing Manual external roller shutters on some windows. Mostly no solar protection.

2.1.4 Building system characteristics

Heating	
Production	Gas boiler
Emission	Hot water radiators
Air conditioning	
Production	No air-conditioning system
Emission	No air-conditioning system
Ventilation	
No ventilation system, only window ventilation was available	
DHW production	
No DHW production	
Lighting Type	
Halogen bulbs	
Equipment installation	
Computers, printers, desk lamps, screens, coffee makers, fridge, …	
Type of equipment present using renewable energy	
None	

2.1.5 BIM Modelling

Thermal simulation software	Pleiades 6.23.9.3 and Sketchup The 3D model is created using Sketchup and then imported into the Pleiades data processing software. All information regarding the walls, joinery, lighting, heating, cooling, ventilation, domestic hot water systems, and thermal bridges is directly entered into Pleiades and assigned to the corresponding element of the model. The goal is to accurately represent the building in order to propose representative energy optimizations in a future phase of the project.
Screenshot	 

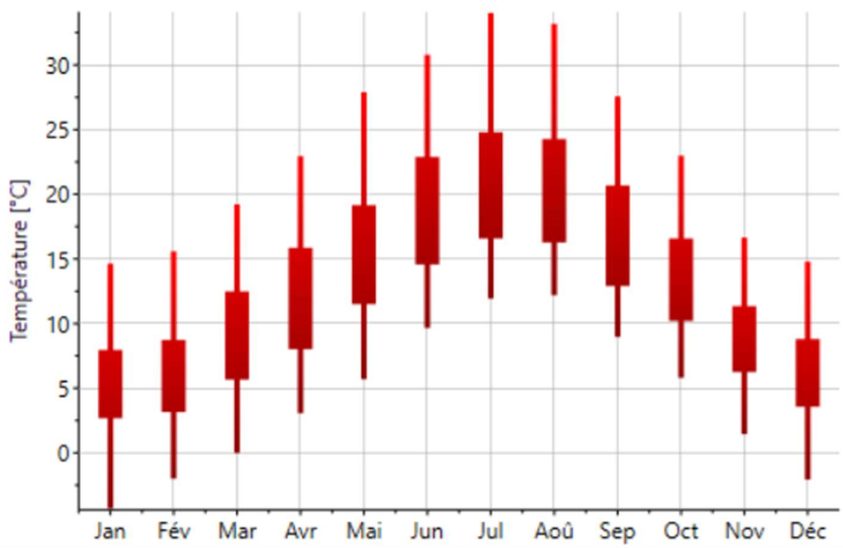
	

2.2 *Use case n°2: Gennevilliers (FR)*

2.2.1 General information

Location	Gennevilliers, France	
Year of construction	1982	
Uses	Social Housing	
Total heated area (m²)	6 802 m²	
Number of floors	Ground floor + 15 storeys	
Number of basements	2	
Specification	96	

2.2.2 Geographic and climate data

Satellite view	 
Aerial view	
Weather Station:	Paris-Montsouris
Altitude [m] :	29
Average temperatures from 2000 to 2019 from the Meteonorm database used in Pleiades software	

2.2.3 Building envelope characteristics

Opaque envelope	Exterior Walls: 200 mm of concrete with 20 mm of polystyrene Exterior Walls on balconies: 200 mm of breeze block without insulation Roof: 170 mm of concrete with 60 mm of polystyrene Ground floor over basement: 170 mm of concrete with 60 mm of wood fibre insulation on the underside of the floor

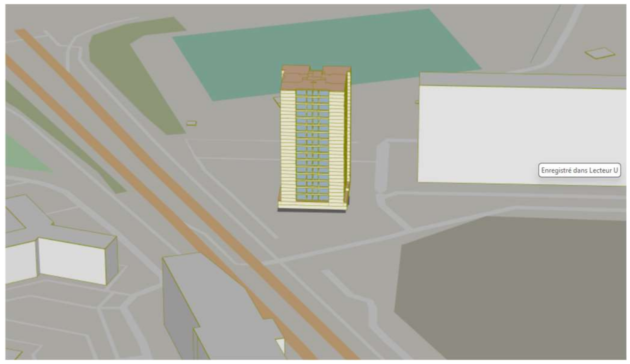
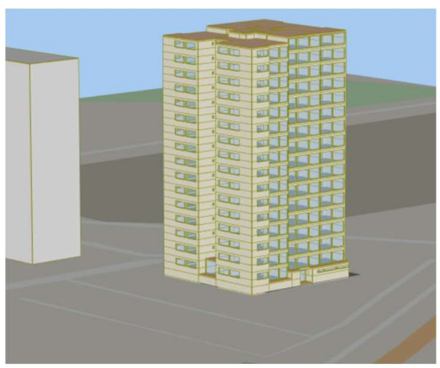
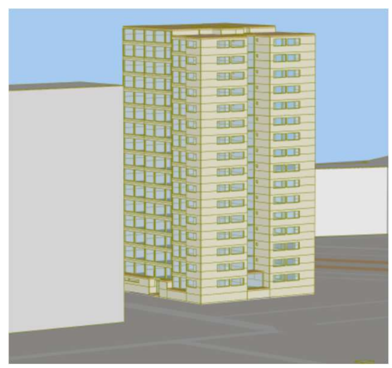
Exterior joinery	PVC double glazing 4/12(air)/4 External manual roller shutters on ground floor No solar protection on other floors The building's entrance door is single-glazed metal

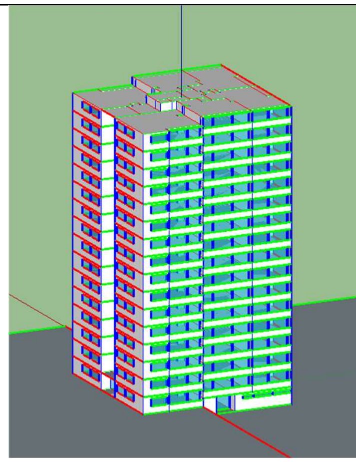
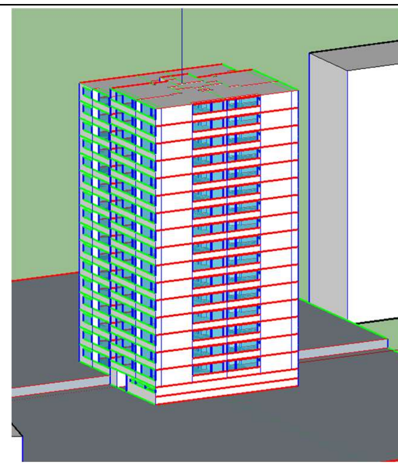
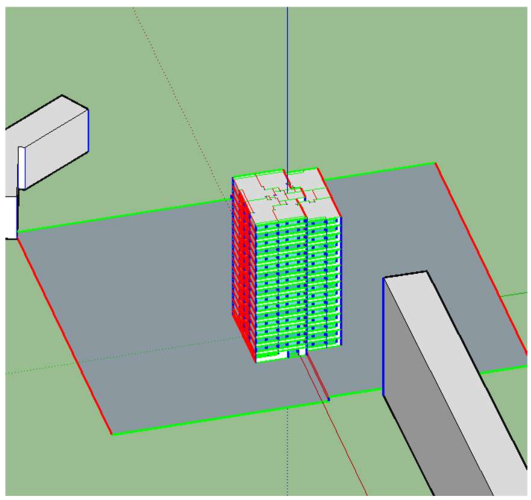
2.2.4 Building system characteristics

Heating	
Production	Substation connected to a district heating network. The CO2-equivalent per kWh energy obtained from the distribution network is weighed with 0.110 kg/kWh, and its share of renewable energy will be at least at least 60%.
Emission	Hot water radiators fitted with single head valves. The heating network temperature will be 65/55°C.
Air conditioning	
Production	No air-conditioning system
Emission	No air-conditioning system
Ventilation	
Centralised single-flow type. It ensures the hygienic treatment of the accommodation. The air is renewed via air inlet modules integrated into the joinery. Extraction takes place in wet rooms (kitchen, bathroom, WC). This type of ventilation results in constant airflow rates and does not adapt to the occupancy of the rooms in the dwelling.	
DHW production	
Domestic hot water is collective and is produced by the boiler room on the basement. Storage volume: 4 000 L Total number of balloons: 2 - DHW distribution is centralised, - Circulation pump on level -1, - The insulation jackets are 10 cm thick glass wool and are in good condition.	
Lighting Type	
The building's corridors are lit by fluorescent lights controlled by presence detection on a timer. These obsolete luminaires are no longer suitable for areas with frequent passageways and a high on/off cycle. The cellars are lit by fluorescent portholes controlled by push-buttons on timers, and the lighting in the service rooms and other communal areas is provided by portholes and strip lights with fluorescent lamps. These lights are outdated, consume a lot of energy.	
Equipment installation	
Fridge/freezer, ceramic hob, microwave, television, computer, iron. All homes are equipped with fluorescent bulbs equivalent to a power of 2 W/m².	
Type of equipment present using renewable energy	
None	

2.2.5 BIM Modelling

Thermal simulation software	Pleiades 6.23.9.3 and Sketchup

	The 3D model is created using Sketchup and then imported into the Pleiades data processing software. All information regarding the walls, joinery, lighting, heating, cooling, ventilation, domestic hot water systems, and thermal bridges is directly entered into Pleiades and assigned to the corresponding element of the model. The goal is to accurately represent the building in order to propose representative energy optimizations in a future phase of the project.
Screenshot	    

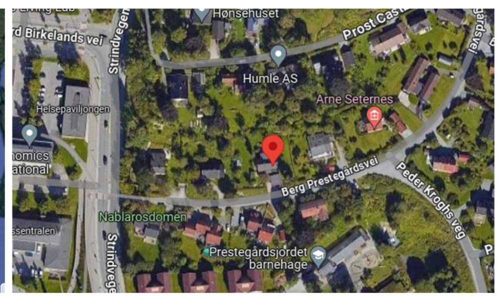
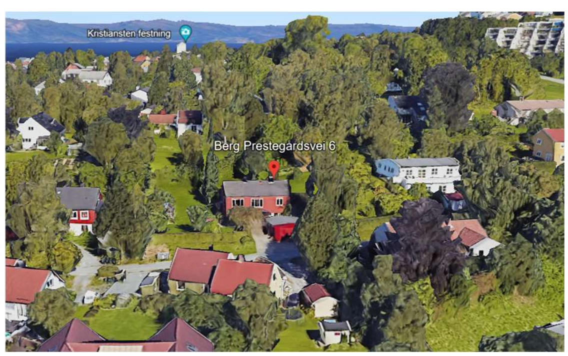
	  

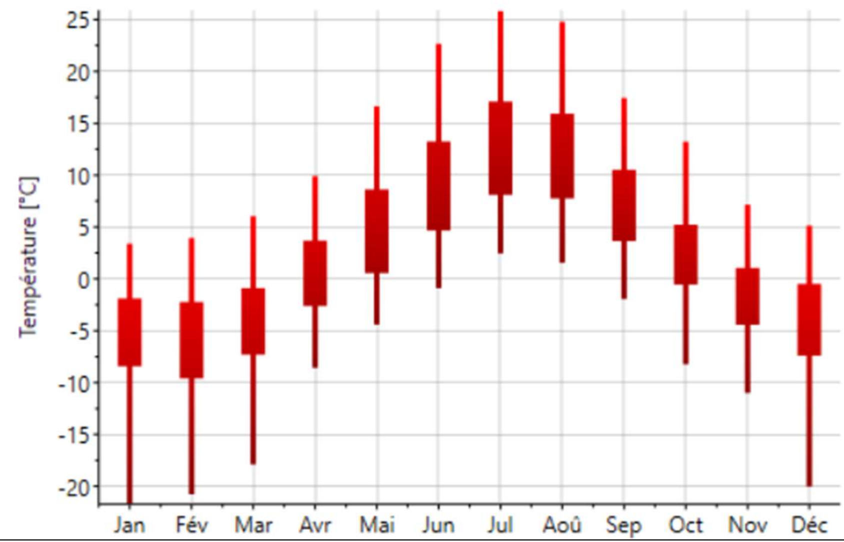
2.3 *Use case n°3: Trondheim (NO)*

2.3.1 General information

Location	Trondheim, Norway 
Year of construction	1960s
Uses	Family house
Total heated area [m²]	150
Number of floors	Ground floor + 1 storey
Specification	Partially renovated building

2.3.2 Geographic and climate data

Satellite view	 
Aerial view	
Weather Station:	Storlien-Visjovalen
Altitude [m] :	56

Average temperatures from 2000 to 2019 from the Meteonorm database used in Pleiades software	

2.3.3 Building envelope characteristics

Opaque envelope	Slab on ground floor: concrete with little insulation (around 50 mm) Exterior walls on ground floor: concrete with approximately 150 mm of insulation added in early 2000. One wall is underground. Exterior walls on first floor: timber frame construction with original insulation from 1960s (around 50-70 mm). Additional insulations were added in early 2000. Roof (lost attic space): timber frame without insulation.
Exterior joinery	Double glazing from early 2000. Interior solar protection; Insulated steel entrance door;

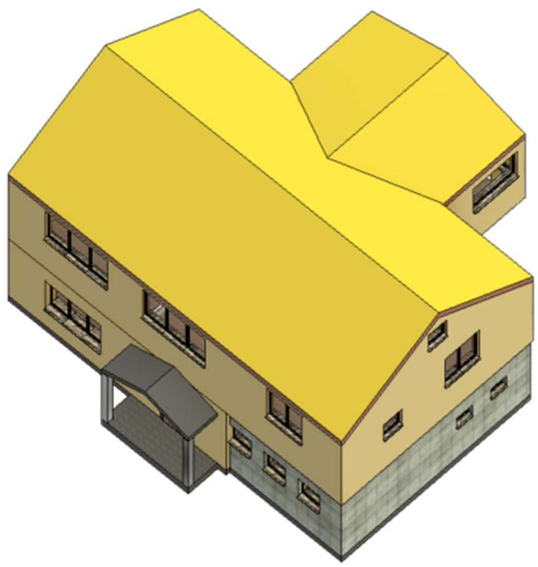
2.3.4 Building system characteristics

Heating	
Production	Wooden stove and electric heating.
Emission	Wooden stove. Wall electric panels and electric floor heating in bathrooms.
Air conditioning	
Production	No air-conditioning system
Emission	No air-conditioning system
Ventilation	
NA	
DHW production	
Wooden stove / electric	
Lighting Type	
Various	
Equipment installation	
Fridge/freezer, ceramic hob, microwave, television, computer, iron. Fluorescent bulbs equivalent to a power of 2 W/m².	
Type of equipment present using renewable energy	

The owners would like to install an heat pump during this winter (but not decided yet)

2.3.5 BIM Modelling

Thermal simulation software	Autodesk Revit The 3D model is created using Autodesk Revit. All information regarding the walls, joinery, lighting, heating, cooling, ventilation, domestic hot water systems, and thermal bridges is directly entered into Revit and assigned to the corresponding element of the model. The goal is to accurately represent the building in order to propose representative energy optimizations in a future phase of the project.
Screenshot	 

3. Monitoring plan

The building in Germany (use case 1) is not currently occupied. Renovation works are already in progress on the building; therefore it will be impossible to monitor consumption in this building. So the monitoring plan only concerns use case n°2 and n°3.

For a full year, the buildings (use cases n°2 and n°3) will be instrumented, enabling consumption to be monitored with regular measurements. The data collected will be used to adjust the assumptions used in the thermal studies.

The monitoring plan is as follows :

1- Detailed requirements definition
2- Quotations of monitoring sensor specifications
3- Validation of the monitoring sensor specifications
4- Installation of monitoring systems for each building from April 2024
5- Testing of monitoring systems
6- Real-time data monitoring for each building by April 2025
7- Data analysis

Notes:

- It is not necessary to measure the outside temperature because the outside temperature data used in the thermodynamic simulations will be the UDDs (unified day degree) from the weather stations at each site.

	Equipment	Offices Measure	Units	Housing Measure	Units
Occupancy	-	Number of occupants, occupancy density	m^2/workstation	Number of inhabitants	-
		Occupancy rate per hour, per day, per year.	%	Occupancy rate (%) per hour, per day, per year.	%
Lighting	Solarimeter	Installed power of lighting			W/m^2
One-time measurement	-	Air permeability of the building Thickness of glass and gas slats of joinery Sunscreen opening/closing scenario per hour, per day, per year			m3/h/m^2 mm -
Heating & cooling	Temperature probe	Indoor Temperature Setpoint,			°C
		Temperature Reductions			°C
		Indoor Temperature scenario per hour, per day, per year.			°C

<table>
<tr><td>Outdoor Temperature</td><td>Temperature probe</td><td colspan="3">Minimum and maximum temperature per day, Indoor Temperature per hour, per day, per year</td><td>°C</td></tr>
<tr><td rowspan="4">Ventilation</td><td rowspan="4">Flow meter</td><td colspan="3">Power</td><td>W</td></tr>
<tr><td colspan="3">Flow Rate</td><td>m3/h</td></tr>
<tr><td colspan="3">Location of ventilation outlet</td><td>-</td></tr>
<tr><td colspan="3">Ventilation Flow Scenario by Day Month, Year</td><td>m3/h</td></tr>
<tr><td>DHW</td><td>-</td><td colspan="3">DHW consumption requirement at 60°C per hour, per day, per year</td><td>Liters</td></tr>
<tr><td>Dissipated power</td><td>-</td><td>Scenarios for the use of equipment (computers, etc.) per hour, per day, per year</td><td>W or W/m²</td><td>Equipment use scenarios (computer, plates, oven, etc.) per hour, per day, per year</td><td>W or W/m²</td></tr>
</table>

Table 1: definitions of parameters for the monitoring plan

3.1 *Use case n°2: Gennevilliers (FR)*

3.1.1 Meters specification

The use case number 2, as described in previous sections, has a ground floor and 15 upper floors, with 2 basements. It comprises 96 flats, including 32 T2, 32 T3 and 32 T4, with a caretaker's room on the ground floor.

Electricity consumption provide to lighting each apartment, and in general provide energy to the electro domestics, like ceramic hob, televisions, microwave, etc. The main heating system count on the district heating network substation, that provides heat to the rooms through water radiators. The district heating network also supplies the domestic hot water needs.

As first attempt it has been decided to monitor the main parameters for the energy consumption, and indoor comfort assessment, like temperature and CO2 concentration.

Electric Energy Consumption. The electricity will be monitored in a sample of apartments, providing the total consumption. Data will be gathered from the Linky meter. The specific electric energy use will be estimated, based on data collected and dwellers habits. A questionnaire will be provided to the inhabitants, in order to define a typical occupation rate, during week and weekends, as well as space occupation and general habits, that would affect energy consumption.

Heat consumption. The total heating consumption will be based on data provided by the owner-lessor of the building. Contact temperature sensors will also be installed on flat radiators.

Domestic Hot Water (DHW). As for the heat, to measure domestic hot water consumption, it will be installed a monitoring system to measure the actual water consumption and its temperature.

Indoor parameters. In order to calibrate the energy simulation models, actual thermal behaviour of the building has to be monitored. Indoor temperature and relative humidity (RH) of some apartments will be measured, in the sleeping rooms and living rooms.

Outdoor conditions. Climatic data will be provided by the nearest weather station to the site. However, if it is technically possible to install a weather station on the tower, the measured climatic data will be used. Actually, to correctly calibrate the energy demand and the thermal behaviour of the house, it is always preferable to directly measure the actual outdoor conditions, especially in terms of temperature and relative humidity, rather than refer to public meteorological stations, to minimize possible errors, and deviation, caused by differences in parameters measured in two different points, even if located in the same region.

Data gathering and communication. Data from sensor, will be registered in local datalogger, that will communicate through a gateway, with a remote platform that will store data communicated in a ordinated database.

A summary of the equipment needed is provided in the following **Table 1**. We are going to measure consumption using the flat sampling method. To do this, the consumption of 9 flats will be monitored (the three types on the ground floor, three types on one floor and three types on the top floor).

The installation scheme, based on the previous considerations, is reported in the drawings, in the following **Figure 1**.

Parameter	Equipment	Units	Meters quantity
Occupancy rate, week and weekends days, and general habits	Questionnaire	None	None
Total Electric Energy Consumption	Two solutions: measuring device installed directly on the electricity meter or collection of consumption data from electricity provider (ENEDIS)	kWh	9
Heat consumption	Thermal sensors installed on water radiators	kWh	54
Indoor Temperature, RH	Temperature, RH sensor	ºC, %	9
DHW temperature	Contact temperature sensor (to be installed on the DHW piping)	ºC	1
DHW water consumption	Flow meter	m^3/s	1
Outdoor conditions, T, RH, wind speed, solar radiation	Weather station (installed on the roof if possible)	ºC, %, m/s, W/m2	1
Data acquisition	Datalogger	-	?
Data communication	Gateway (internet connection provided by the host)	-	1

Table 2: Equipment and associated sensors description

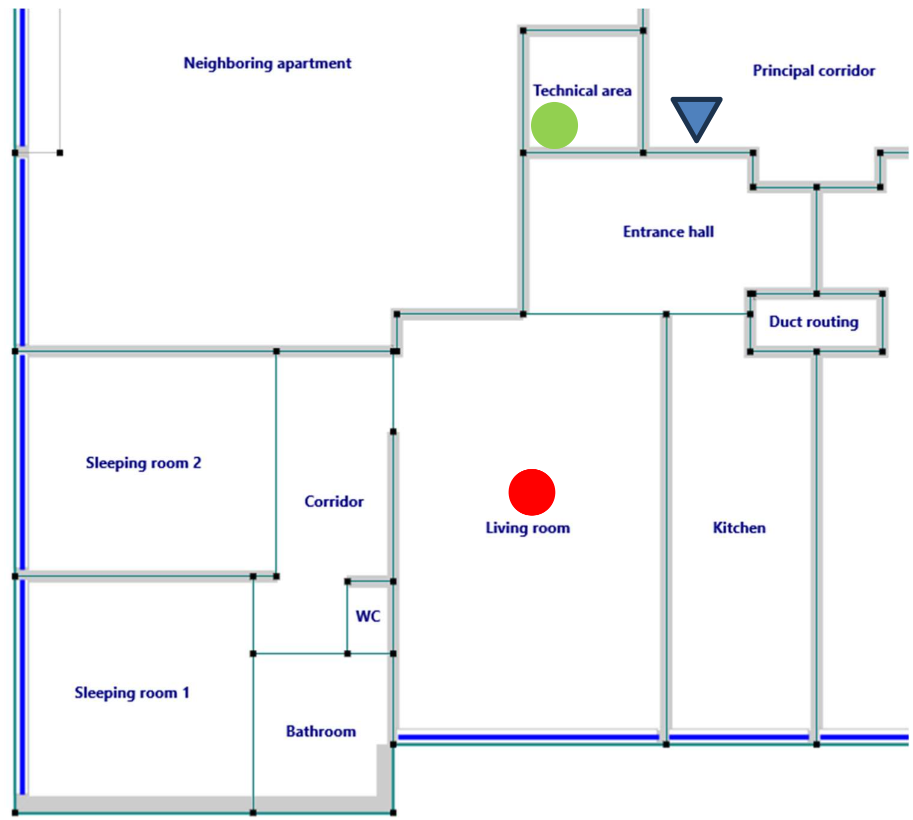
Key	**An example of a flat from the use case n°2**
Electric Energy meter Temperature, RH sensor Gateaway	

Figure 1: Monitoring Scheme. Use Case nº2

3.1.2 Expected accuracy

Parameter	Meter characteristics	Estimated Accuracy
Electric energy meter	Class 1 conforming to IEC 62053-21 and IEC 61557-12	+/- 1%
Indoor Temperature	Range -40 ºC to 60 ºC	+/- 0.3 ºC
RH	0% to 100%	1%
Water flow meter	0,6 to 2,5 m3/h	+/- 2%
Contact temperature	Pt sensing elements: B class according to EN 60751. Range 15ºC to 90ºC	± (0.3 + 0.005|t|) in °C
Outdoor conditions, T,	Range -40 ºC to 60 ºC	+/- 0.3 ºC
Outdoor conditions, RH	0% to 100%	1%
Outdoor conditions, Wind speed	Range 0 m/s to 40 m/s	+/- 1m/s or 5%
Outdoor conditions, Radiation	Range 0 W/m2 to 1.300 W/m2	+/- 120 W/m2 or 10%

Table 3 : measured parameters and accuracy

3.2 *Use case n°3: Trondheim (NO)*

3.2.1 Meters specification

The use case number 3, as described in previous sections, has 3 floors, ground, first floor and attic. The attic is empty, while the main rooms and the kitchen are on the ground floor.
Electricity consumption provide heating through the walls and floors radiators, and in general provide energy to the electro domestics, like ceramic hob, televisions, microwave, etc.
The main heating system count on a wooden stove, that provides heat to the rooms through radiators. The stove also supplies the domestic hot water needs.
As first attempt it has been decided to monitor the main parameters for the energy consumption, and indoor comfort assessment, like temperature and CO_2 concentration.
Electric Energy Consumption. The electricity will be monitored at global level, providing the total consumption. Data will be gathered from the fiscal meter (if existing), otherwise a submeter should

be installed. The specific electric energy use will be estimated, based on data collected and dwellers habits. A questionnaire will be provided to the inhabitants, in order to define a typical occupation rate, during week and weekends, as well as space occupation and general habits, that would affect energy consumption.

Heat consumption. The total heating consumption will be based on data provided by invoices and bills of purchased wood. Also, two temperature sensors will be installed on the supply and return ducts, as well as a water flow meter, in order to account the actual energy provided to the house at a more detailed scale.

Domestic Hot Water (DHW). As for the heat, to measure domestic hot water consumption, it will be installed a monitoring system to measure the actual water consumption and its temperature. Main points of measurement will be in the bathrooms.

Indoor parameters. In order to calibrate the energy simulation models, actual thermal behaviour of the building has to be monitored. Indoor temperature and relative humidity (RH) will be measured, in the sleeping rooms and living rooms. CO2 concentration will be monitored too, to evaluate actual indoor air quality.

Outdoor conditions. To correctly calibrate the energy demand and the thermal behaviour of the house, it is always preferable to directly measure the actual outdoor conditions, especially in terms of temperature and relative humidity, rather than refer to public meteorological stations, to minimize possible errors, and deviation, caused by differences in parameters measured in two different points, even if located in the same region.

Data gathering and communication. Data from sensor, will be registered in local datalogger (estimated one per floor), that will communicate through a gateway, with a remote platform that will store data communicated in a ordinated database.

A summary of the equipment needed is provided in the following Table 4.
The installation scheme, based on the previous considerations, is reported in the drawings, in the following Figure 2.

Parameter	Equipment	Units	Meters quantity
Occupancy rate, week and weekends days, and general habits	Questionnaire.	None	None
Total Electric Energy Consumption	Smart meter (fiscal meter, if available, otherwise the installation of a dedicated instrument has to be provided)	kWh	1
Wood consumption	Manual register, or invoices, bills	Kg/ton	None
Indoor Temperature, RH	Temperature, RH sensor	ºC, %	9

Parameter	Equipment	Units	Meters quantity
Indoor CO2 concentration	CO2 sensor	ppm	8
DHW temperature	Contact temperature sensor (to be installed on the DHW piping)	ºC	2
DHW water consumption	Flow meter	m^3/s	2
Heat consumption. Temperature	Contact temperature sensor (to be installed on the DHW piping)	ºC	1
Heat consumption. Water flow	Flow meter	m^3/s	1
Outdoor conditions, T, RH, wind speed, solar radiation	Weather station	ºC, %, m/s, W/m2	1
Data acquisition	datalogger	-	3
Data communication	Gateway (internet connection provided by the host)	-	1

Table 4: Equipment for monitoring plan of use case n°3

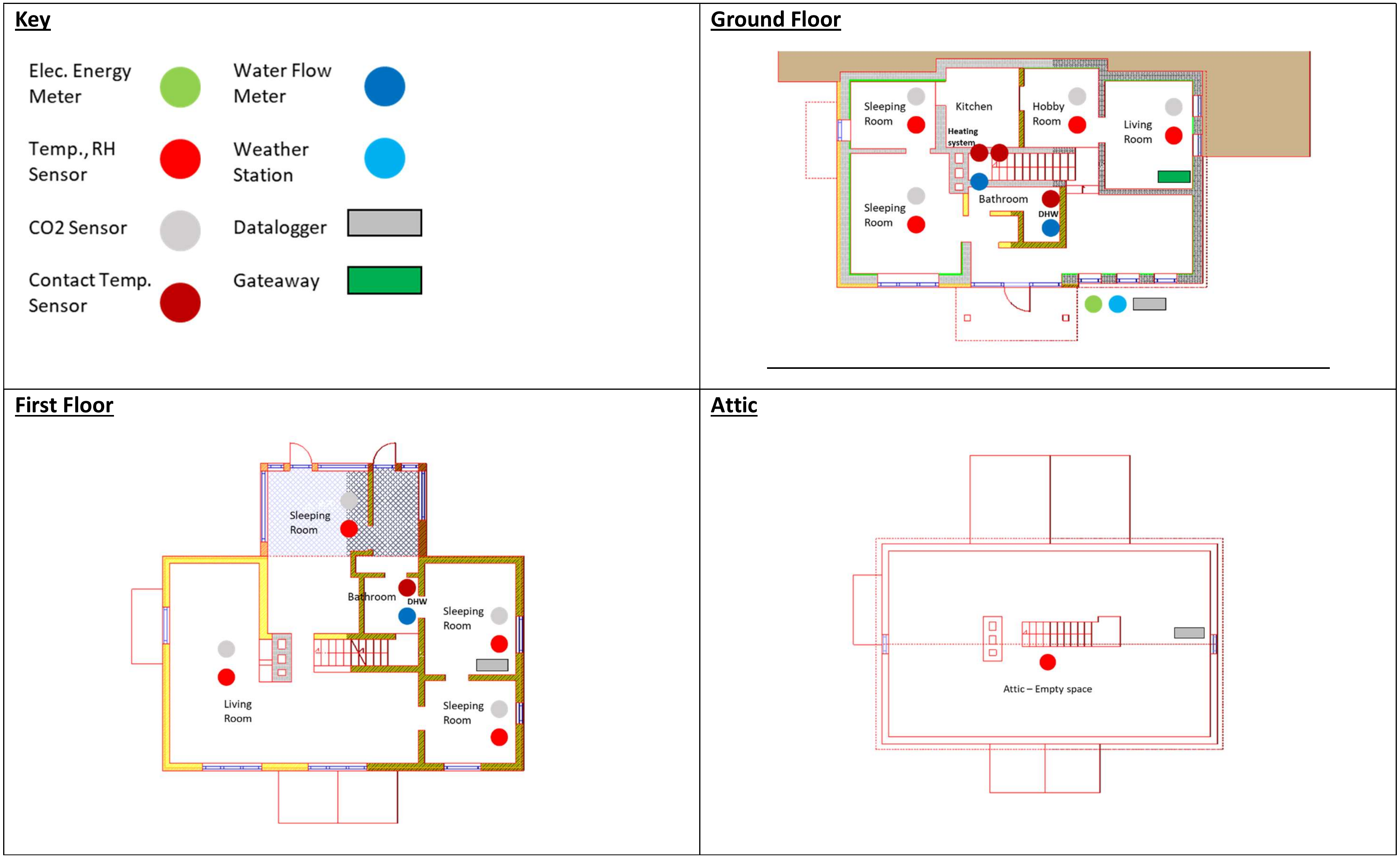


Figure 2: Monitoring Scheme. Use Case nº3

3.2.2 Expected accuracy

Parameter	Meter characteristics	Estimated Accuracy
Electric energy meter	Class 1 conforming to IEC 62053-21 and IEC 61557-12	+/- 1%
Indoor Temperature	Range -40 ºC to 60 ºC	+/- 0.3 ºC
RH	0% to 100%	1%
Indoor CO2 concentration	0 to 10.000 ppm	100 ppm + 5%
Water flow meter	0,6 to 2,5 m3/h	+/- 2%
Contact temperature	Pt sensing elements: B class according to EN 60751. Range 15ºC to 90ºC	± (0.3 + 0.005|t|) in °C
Outdoor conditions, T,	Range -40 ºC to 60 ºC	+/- 0.3 ºC
Outdoor conditions, RH	0% to 100%	1%
Outdoor conditions, Wind speed	Range 0 m/s to 40 m/s	+/- 1m/s or 5%
Outdoor conditions, Radiation	Range 0 W/m2 to 1.300 W/m2	+/- 120 W/m2 or 10%

Table 5: expected accuracy in use case n°3