RINNO PROJECT

Report

Transforming energy efficiency in European building stock through technology-enabled deep energy renovation

Deliverable 5.1: RINNO IoT Middleware – List and Specifications of the RINNO Multi-Sensorial Network

Work Package 5: **RINNO Operational Platform with**

MOTIVIAN

May 2022

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 892071

Document Information

Title	List and Specifications of the RINNO Multi-Sensorial Network
Author(s)	Motivian
Editor(s)	Certh
Reviewed by	UNN, CERTH
Document Nature	Report
Date	
Dissemination Level	Public
Status	
Copyright	
Grant Agreement Number	892071
Lead Beneficiary	

Revision History

Version	Editor(s)	Date	Change Log
1.0	CERTH	03/11/2022	Integrate list with the specifications of the sensors installed in all pilots
1.1	UNN	28/11/2022	Internal Review
2.0	CERTH	29/11/2022	Second version of deliverable with integrated all comments from internal review
3.1	CERTH	30/11/2022	Final version drafted
3.2	CERTH	30/11/2002	Final refinements, updated final version – Ready for submission

Executive Summary

Deliverable 5.1 "RINNO IoT Middleware - List and Specifications of the RINNO Multi-Sensorial Network" covers the list of devices that are installed in the four demo sites. It presents the various IoT devices, their specifications and the Middleware infrastructure system which ensures interoperability and seamless system deployment in order to support different types of devices and communication protocols.

Table of Contents

TABLE OF FIGURES

LIST OF TABLES

Abbreviations List

API	Application Programming Interface
BRP	Building Renovation Passports
DHW	Domestic Hot Water
EI	Expected Impacts
IoT	Internet of Things
KPIs	Key Performance Indicators
LED	Light-emitting diode
PES	Primary Energy Savings
RR	Renovation Roadmap
TVOC	Total Volatile Organic Compounds

1. Introduction

The present report is a public deliverable (Deliverable D5.1 “List and Specifications of the RINNO Multi-Sensorial Network) of the RINNO H2020 funded European project (GA 892071). The work presented in the deliverable describes the selection of sensors and devices to be installed in each pilot, along with the different communication protocols that had to be defined. The due date was on M24 however, there was a delay regarding the selection of devices because requirements needed to be adapted during installation. Additionally, the Danish pilot selection had to be finalized before deciding on the list of devices and their specifications.

1.1 Scope and Objectives of Deliverable 5.1

The main aim of this deliverable is to present the work performed in Task 5.1 regarding the use of the IoT Sensorial Network and Control System. In this task a variety of devices have been discussed for choosing those that, at last, have been installed in the demo sites of RINNO project. The devices are specified as plug-n-play, cognitive, control and optimization ones. During the execution of this task, the devices to be installed in each demo site were decided in order to server the multimedia monitoring operation needs of the buildings. In all buildings, the devices contain sensors that measure variables for lighting and heating, temperature, humidity, electricity, production and consumption for real-time profiling and IoT device managers.

According to the needs of each building, the IoT infrastructure is selected so that the interoperability and deployment of the system will be seamless and easy to support different sensors and communication protocols. For this purpose, the “Middleware Infrastructure” has been implemented to support the Multi-Sensorial Network.

1.2 Relation with other Tasks and Deliverables

The work described in this deliverable is directly correlated with the objectives of Task 5.5 which has to deliver Renovation Passports (BRPs) for each demo site and Logbooks all of which lead to the development of the Renovation Roadmap (RR). Additionally, the Middleware Infrastructure will contribute to the evaluation of the data collection that will be performed in Task 6.4. Finally, this deliverable describes the IoT infrastructure which is part of the Multi-Purpose IoT-Enabled Building Monitoring system described in Deliverable 5.3.

1.3 Structure of the Deliverable

The structure of the Deliverable is as follows:

In **Section 2** detailed description of the decision-making process of the devices installed in all demo sites of RINNO Project and the details of these devices. This section is separated into four sub-sections, one for each demo-site, thus in 2.1 we present the Greek infrastructure, in 2.2 the French one, in 2.3 the Polish one and in 2.4 the Danish one.
In **Section 3** the deployment view of the IoT System is presented which describes the technical details of the architecture of the IoT infrastructure.
In **Section 4** the conclusions of this report are presented along with next steps that will be implemented and presented in the final version of this deliverable.

2. RINNO Multi-Sensorial Network

The selection of the devices for the multi-sensorial network was based on the KPI's that will be used to evaluate the project's success as well as the various ICT tools that will make use of monitored data.

Key performance indicators

To determine the KPIs and the subsequent monitored data required for their calculation, a set of expected impacts were defined (summarized in Table 1 of the proposal). In order to determine the required building monitoring equipment that needs to be installed on the demo buildings, the respective KPIs and expected impacts (EI) related to the building performance were identified. These are:

- KPI 1.1: PES triggered by the project during its implementation: 0.98 GWh/year
- KPI 1.3: Reduction of cost of electricity: >30%
- KPI 2.2: Payback period: <4 years on average
- KPI 3.1: Energy efficiency/decrease in energy consumption: >65%
- KPI 3.2: Electric energy harvesting of RINNO technologies: >125 Wp/m2
- KPI 3.4: RES penetration on a building level: >30%
- KPI 7.1: Reduction of GHG emissions 241 tons CO2-eq/year during the project implementation
- EI 3.1: Thermal energy harvesting

Furthermore, in Deliverable 'D1.6 – Report on RINNO KPIs' additional KPIs relevant to the performance of the buildings have been identified:

- Del KPI 1 – Primary Energy Savings (PES)
- Del KPI 4 – Degree of energy self-supply (DE)
- Del KPI 6 – Return on Investment (ROI)
- Del KPI 7 – Payback period (EPP)
- Del KPI 21 – Time outside Indoor air quality range (IAQ)
- Del KPI 22 – Time outside thermal comfort range

Finally, the following improvement targets have been set for the demo buildings (Table 1 of the proposal):

- Energy Consumption (total)
- Heating consumption
- DHW consumption
- Cooling consumption
- Consumption for ventilation
- Other consumption
- RES based electricity production
- RES based heating production

Software monitoring requirements

In addition to the calculation of KPIs and expected impacts of the project, the monitoring equipment that will be installed in the demo buildings will be also used for feeding with near real-time data the various RINNO ICT tools in WP3 and WP5.

WP3 tools will be used (at the first stage of the analysis) to simulate the energy, environmental and lifecycle performance of the renovation scenarios as well as to assess the well-being of the occupants. Some of these tools consider the use of monitored data retrieved from the building monitoring system of the demo buildings (T5.2, T5.3 and T5.5, WP6) for either i) improving the accuracy of the results (Digital Twin – T3.2), ii) validating/informing the simulations (VERIFY – T3.3), iii) as a basis of the analysis conducted, or iv) to compare the simulation results to the actual performance of the buildings (Optimiser and Planner – T3.4)

Digital Twin tool (T3.2)
The Digital Twin tool (VTT) is a tool used for the energy simulation of the buildings. The tool uses machine learning modelling approach and the model may be trained from measured data on an hourly basis, either of single consumption points or building consumption points, IoT sensors, automation data as well as the building specifications.
Data required from sensors:

- Internal temperature
- External temperature
- Energy consumption for heating at flat/building level
- Total Electrical consumption
- Electrical consumption for cooling at flat/building level (if applicable)
- Electrical consumption for ventilation at flat/building level (if applicable)
- RES electricity production (if applicable)
- RES heating production (if applicable)

INTEMA.building (Energy analysis) (T3.3.1)
The INTEMA.building platform will be used for the detailed energy analysis of the renovation scenarios. There are no specific requirements for monitored data.

VERIFY (LCA/LCC analysis) (T3.3.2)
The VERIFY platform will be used for the environmental and lifecycle cost assessment of the renovation scenarios. The tool is able to conduct the analysis with the use of simulation data for the use-phase of the building. However, it is also able to receive monitored data from the building monitoring system in order to improve the accuracy of the LCA analysis and/or validate the assessment of a building.
Data required from sensors:

- Internal temperature
- External temperature
- RES electricity production
- RES thermal production
- Total electrical consumption
- Electrical consumption for cooling at flat/building level (e.g air-condition),
- Electrical consumption for ventilation at flat/building level (if applicable)
- Energy/fuel consumption of relevant equipment for heating at flat/building level

Social-LCA (social impact assessment) (T3.3.3)
The social-LCA tool considers a methodology to quantify the well-being of the occupants. The tool requires two sets of inputs: i) manual input from the occupants regarding the internal conditions of the building, and ii) monitored data from the sensors installed in the demos. Regarding the monitored data, the following are required:

- Indoor temperature
- Relative Humidity
- CO2

The monitoring is one of the most important phases to evaluate the success of the project. Based on the above analysis, a variety of sensors was decided to be installed in the demo

cases and a monitoring campaign was started in order to collect data about the building before the deep renovation.
At this moment, various sensors are installed in a Greek Pilot, Polish Pilot, French Pilot and the Danish pilot in order to be able to determine KPIs and expected impacts (EI) of the RINNO project and demonstrate the building performance improvement targets from the renovation. A more detailed description of the Pilots will be given in the following sections.

The IoT devices include: a) sensors (e.g. temperature, humidity) for the tenants' indoor comfort, b) energy monitoring devices (e.g., smart meters measuring energy (electricity, heating and/or cooling) production and consumption real-time profiles) and IoT device managers (e.g. gateways and devices with embedded intelligence).
By creating the IoT Platform, we connect these devices remotely for ease of operation. Essentially, it helps in communication with the sensors of devices and ensure the connectivity. The IoT platform is a set of components that provides an insight into the sensor measurements. It helps in the collection of data and information from any kind of devices under any kind of protocol (e.g. TCP/IP, Bluetooth, ZigBee, Z-Wave), continuously.

Based on this Multi-Sensorial Network we plan to be able and calculate the optimal results for the KPIs thus, have the targets for which we are performing renovation to all four demo sites. Moreover, since the devices send values continuously, it is possible to monitor the evolution of renovation towards the expected impacts. Additionally, some information regarding the calculation of the expected impacts per demo site can be found in deliverable D6.7.

2.1 List and Specifications of sensors installed in Greek pilot

In order to be able to showcase the achievement of KPIs and expected impacts of the RINNO project and demonstrate the building performance improvement targets from the renovation, relevant monitoring equipment was installed in the Greek Pilot. This equipment is used in order to monitor:

- Total Electricity Consumption -> DIN-RAIL
- Electrical Consumption of AC/units -> NGAS: DIN-RAIL, OIL: DIN-RAIL
- Natural gas/heating oil boiler electrical consumption -> NGAS: DIN-RAIL, OIL: DIN-RAIL

Moreover, regarding the environmental parameters, the multisensorial network that is installed in Greek pilot is able to monitor the following environmental parameters:

- Internal Temperature
- Relative Humidity
- Motion
- Illuminance

The Greek Pilot is composed by eight flats out of which the six are monitored (1A, 1B, 2A, 2B, 3A, 3B,) as displayed in the table below. Each flat has its equipment with a unique ID.
For example, in flat 1A, there is a gateway, type *Janus GW* with ID 124B0011EEE95D.

Table 1. Flats of Greek Pilot with the equipment inside each of them and the unique IDs.

Flat	Equipment (unit)	ID	TYPE
1A	DinRail 1-ph	124B0002CC3B31	Dinrail 1Phase
	DinRail 3-ph	124B0018D71ECD	Dinrail 3Phase 63A
	Smart plug	124B0002CBACA3	Bizy Plug
	Presence sensor	15BC001A018B5A	Motion Sensor
	Air-quality sensor	15BC0036000227	Air Quality Sensor
	Gateway	124B0011EEE95D	Janus GW
1B	DinRail 3-ph	124B0018D6F61A	Dinrail 3Phase 63A
	Smart plug	124B0002CC9045	Bizy Plug
	Presence sensor	15BC001A018C7F	Motion Sensor
	Air-quality sensor	15BC00360002BB	Air Quality Sensor
	Gateway	124B0011EEE8BE	Janus GW
2A	DinRail 3-ph	124B0018D6F985	Dinrail 3Phase 63A
	Presence sensor	15BC001A018C7D	Motion Sensor
	Air-quality - sensor	15BC00360002DA	Air Quality Sensor
	Smart plug	124B0002CBAF58	Bizy Plug
	Smart plug	00124B0002CBAE3F	Bizy Plug
	Gateway	124B0011EEE8B8	Janus GW
2B	DinRail 3-ph	124B0018D6F76E	Dinrail 3Phase 63A
	Smart plug	124B0002CBAC89	Bizy Plug
	Smart plug	124B0002CBAEFB	Bizy Plug
	Smart plug	124B0002CBAE39	Bizy Plug
	Presence sensor	15BC001A018B54	Motion Sensor
	Air-quality sensor	15BC003600032C	Air Quality Sensor
	Gateway	124B0011EEE9F5	Janus GW
3A	DinRail 1-ph	124B0002CC3A0C	Dinrail 1Phase
	DinRail 3-ph	124B0018D6FAE5	Dinrail 3Phase 63A
	Presence sensor	15BC001A018D18	Motion Sensor
	Air-quality sensor	15BC0036000222	Air Quality Sensor
	Smart plug	124B0002CC7A7F	Bizy Plug
	Gateway	124B0011EEEA25	Janus GW
3B	3-ph DinRail	124B0018D6F9C1	Dinrail 3Phase 63A

Presence sensor	15BC001A018AF3	Motion Sensor
Air-quality sensor	15BC00360001D4	Air Quality Sensor
Gateway	124B0011EEE992	Janus GW
	EXTRA DEVICES	
	124B0018D6F655	Dinrail 3Phase 63A
	124B0002CBAF58	Bizy Plug

Information about the devices:

Each device has different features that characterize it. Below are the specifications for each device.

- *Dinrail 3-Phase*

Table 2. Specifications for Dinrail 3-Phase device.

Descriptor	Unit	Multiplier	Long Description
cnrgA	kWh	0.001	Energy Consumed, Phase A
cnrgB	kWh	0.001	Energy Consumed, Phase B
cnrgC	kWh	0.001	Energy Consumed, Phase C
cosA	-	0.01	Power Factor-L1
cosB	-	0.01	Power Factor-L2
cosC	-	0.01	Power Factor-L3
curA	A	1.0	Current, Phase A
curB	A	1.0	Current, Phase B
curC	A	1.0	Current, Phase C
pwrA	W	1.0	Power, Phase A
pwrB	W	1.0	Power, Phase B
pwrC	W	1.0	Power, Phase C
rpwrA	var	1.0	Reactive Power, Phase A
rpwrB	var	1.0	Reactive Power, Phase B
rpwrC	var	1.0	Reactive Power, Phase C
vltA	V	1.0	Voltage, Phase A
vltB	V	1.0	Voltage, Phase B
vltC	V	1.0	Voltage, Phase C
pnrgA	kWh	0.001	Energy Produced, Phase A
pnrgB	kWh	0.001	Energy Produced, Phase B
pnrgC	kWh	0.001	Energy Produced, Phase C
rsumA	kvarh	0.001	Reactive Energy Summation, Phase A
rsumB	kvarh	0.001	Reactive Energy Summation, Phase B
rsumC	kvarh	0.001	Reactive Energy Summation, Phase C

Global Note: The application of a multiplier to the received value results in the measure, expressed in the given unit. This serves the purpose of preserving the desired precision, while limiting the size of transmitted packet Report

Interval: 5 minutes

- *Dinrail 1-Phase*

Table 3. Specifications for Dinrail 1-Phase device.

Attribute	Unit	Multiplier	Long Description
cnrgA	kWh	0.001	Energy Consumed, Phase A
curA	A	1.0	Current, Phase A
frq	Hz	0.01	Frequency
pwrA	W	1.0	Power, Phase A
rpwrA	var	1.0	Reactive Power, Phase A
vltA	V	1.0	Voltage, Phase A
vminA	V	0.1	Voltage MIN, Phase A
vmaxA	V	0.1	Voltage MAX, Phase A
pnrgA	kWh	0.001	Energy Produced, Phase A
rsumA	kvarh	0.001	Reactive Energy Summation, Phase A

Report Interval: 5 minutes

- *Smart plug*

Table 4.Specifications for Smart plug.

Attribute	Unit	Multiplier	Long Description
cnrgA	kWh	0.001	Energy Consumed, Phase A
curA	A	1.0	Current, Phase A
frq	Hz	0.01	Frequency
pwrA	W	1.0	Power, Phase A
rpwrA	var	1.0	Reactive Power, Phase A
vltA	V	1.0	Voltage, Phase A
vminA	V	0.1	Voltage MIN, Phase A
vmaxA	V	0.1	Voltage MAX, Phase A
pnrgA	kWh	0.001	Energy Produced, Phase A
rsumA	kvarh	0.001	Reactive Energy Summation, Phase A

Report Interval: 5 minutes

- *Presence sensor*

Table 5. Specifications for Presence sensor.

Attribute	Unit	Multiplier	Long Description
batvlt	V	0.1	Battery Voltage
hmd	%	0.01	Relative Humidity
tmp	C	0.01	Temperature
izbat	-	1	Battery Alarm
bindc	-	1.0	Binary Input
illu	Lux	1.0	Illuminance

Report Interval: 10 minutes

Note 1 – The descriptor «bindc» determines whether a move with values of 0 (no detection) or 1 (move detected), was detected.

Note 2 – The basic report interval of the meter is to send measurements every 10 minutes but in the case of "Presense Sensor" there is a process to send certain values onChange., this means that when detecting a movement, you should see the descriptor "bindc" coming more often than 10 minutes.

Note 3 – The "Presense Sensor" is likely to send 3 additional attributes (izmov, iztam, izs) but these are for different modes of operation which we do not use in our system.

- Air Quality Sensor

Table 6. Specifications for Air Quality sensor.

Descriptor	Unit	Multiplier	Long Description
batvlt	V	0.1	Battery Voltage
hmd	%	0.01	Relative Humidity
ppb	-	1.0	Parts per billion
tmp	C	0.01	Temperature

Report Interval: 10 minutes

- <u>JSON packet</u>

Regarding the implementation, devices will send data to the MQTT Broker where it is possible to subscribe to the topic “/rinno/iot/Athens”.

The data format will be in JSON.

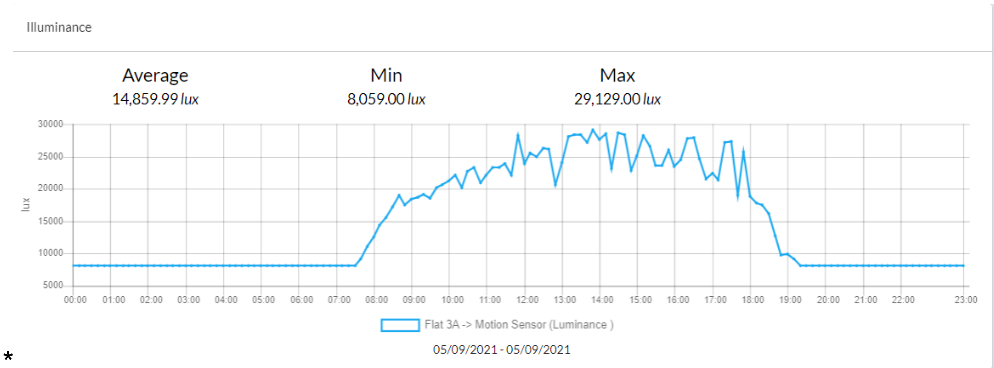
The JSON format will be as follows:
{"device": "<Device MAC>", "values": {"<desc1>":<value1>,…."<descN>": <valueN> }, "ep":<Endpoint>, "ts": <UTC milliseconds since 1970/1/1>, "seq_num": <Sequence Number>}

For example:

{"device": "124B0002CC9205", "values": {"pwrA": 10.332, "curA": 0.224, "rpwrA": -43.4, "vltA": 224.618}, "ep": 10, "ts": 1625585762000, "seq_num": 29799}

- <u>Illuminance</u>

The illuminance curve indicates when the values received are out of Lux. In indoor environments. As addressed in “Levels, R.L. Recommended Light Levels (Illuminance) for Outdoor and Indoor Venues, 2020”, 10.000 lux are outdoor with sunlight. Moreover, the indoor illuminance level near a window is almost 1000 lux. As a result, there must be an equation described in the sensors manual to convert this reported value to Lux.



*

Figure 1.Example from Flat 3A- lux values during a specific day.

- <u>*Consumption*</u>

Energy consumption is the aggregated value for a specific flat.

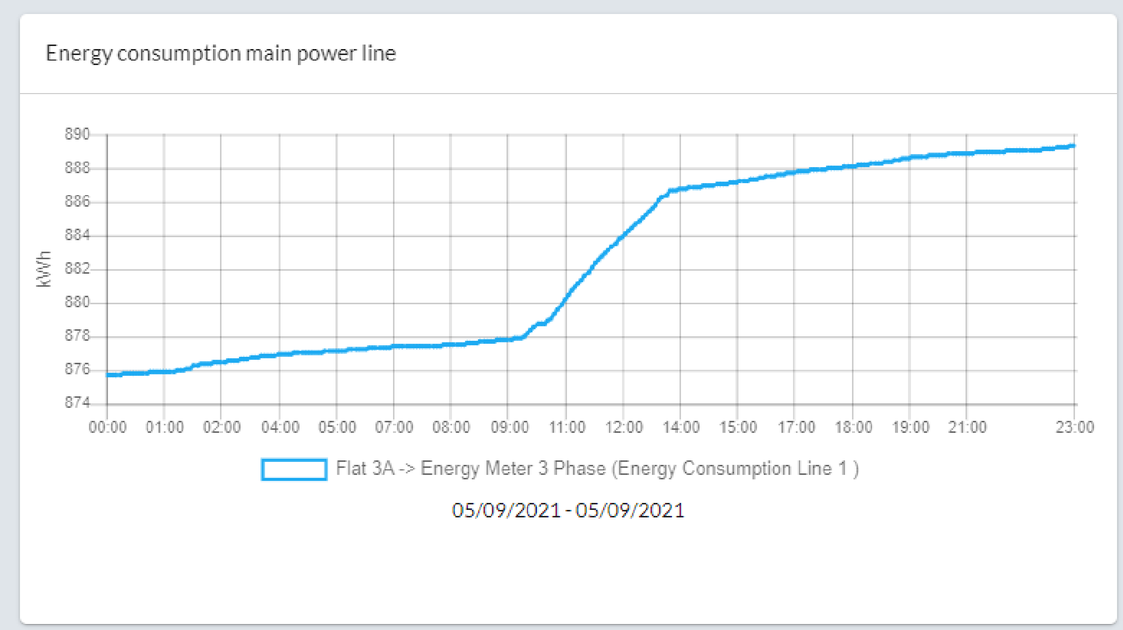


Figure 2. Example from Flat 3A- Energy consumption values during a specific day.

- Energy consumption is cumulative value (constantly increasing), so if it is required to calculate the consumption between 2 time points, subtract the 2 values and the difference gives the energy.
- Also an important piece worth mentioning. The meters continuously measure the cumulative energy regardless of the state of the network.

For example:

If Janus Gateway is down for a few days and data are not received from the server, in network reset, the meter will bring in total "cnrg" values all the energy it has measured on days when data are not received. So it is possible to see a sharp increase that is in fact nothing more than the cumulative energy consumption difference between the two points in time when data communication was lost and re-established.

- *TVOC (ppb)*

Table 7 The table with the prices that the descriptor ppb gets.

	LEVEL	HYGIENIC RATING	RECOMMENDATION	TVOC [µg/m³]	TVOC [ppb]
5	Unhealthy	Situation not acceptable	Intense ventilation necessary	10'000 - 25'000	2200 - 5500
4	Poor	Major objections	Intensified ventilation / airing necessary	3'000 - 10'000	660 - 2200
3	Moderate	Some objections	Intensified ventilation recommended	1'000 - 3'000	220 - 660
2	Good	No relevant objections	Ventilation/airing recommended	300 -1'000	65 - 220
1	Excellent	No objections	Target value	< 300	0 - 65

The above table of the manufacturer helps to have an image to explain the prices that the descriptor "ppb" gets.

Limitations in monitoring system for Greek Pilot

HPHI has proceeded with the installation of several monitoring sensors in the building for the monitoring of the internal environmental parameters. However, several difficulties have been observed. These refer to i) difficulties with continuous monitoring in some of the apartments due to bad WiFi and internet conditions, ii) the difficulty in finding suitable CO2 sensors working with the Zigbee protocol (which is what is currently installed by the contractor) and iii) the installation of a heat meter that will monitor the thermal energy produced by the solar thermal collector. HPHI along with the relevant contractor are currently working to resolve these issues to ensure continuous monitoring of all related parameters during the project

2.2 List and Specifications of sensors installed in French pilot

- In order to be able to showcase the achievement of KPIs and expected impacts of the RINNO project and demonstrate the building performance improvement targets from the renovation, relevant monitoring equipment was installed in the French Pilot.,

The French demo site is a four-story building with a total area of 1120m², located in Wazemmes, Lille, France.

Figure 3. The French demo site in Wazemmes, Lille, France.

The building comprises 30 flats:

- 29 flats T1 with a 36 m² floor area
- 1 flat T3 with 72 m² floor area

As part of RINNO, eight T1 flats will be renovated. In summary, the main parameters of each flat are presented below:

Table 8. The main parameters of each flat in French pilot.

Parameter	Specification
Heating system	Central gas boiler with hot water storage tank
Cooling system	-
Mechanical ventilation	Central mechanical ventilation system
Domestic Hot Water	Electrical Heater

In the following sections, equipment to monitor the systems in each flat as well as main environmental parameters inside the properties are presented.

Equipment for monitoring

a) <u>Environmental parameters</u>

In each flat the following parameters will be required to be monitored:

- Temperature (internal and external)
- Relative Humidity (internal and external)
- Air quality (CO2 and/or other pollutants)
- Illuminance/Brightness
- Noise levels

Several multi-sensors have been identified that can monitor all the above parameters but the chosen one is the MCOHOME 9 in 1 sensor, measuring the Temperature, Relative Humidity, CO2 levels, Illuminance, Noise levels, VOCs, PM2.5, smoke, PIR (motion). The sensor is compatible with the z-wave protocol (http://mcohome.com/ProductDetail/3897793.html).

Figure 4. MCOHOME 9-in-1 sensor.

b) *<u>Building systems monitoring</u>*

The total energy consumption in all flats is due to space heating consumption, electricity consumption, domestic hot water, and mechanical ventilation.

Monitoring final equipment

To summarize, the monitoring equipment that is used is described in the following table:

Table 9. Sensors and their measurements, French Pilot. (1)

Sensor	Wireless Protocol	Measurements
MCOHOME 9-in-1 sensor (A8-9) 	Z-WAVE	- CO2 LEVEL - HUMIDITY - LOUDNESS - LUMINANCE - SMOKE DENSITY - TEMPERATURE - VOC* QUANTITY

Table 10.Sensors and their measurements, French Pilot. (2)

Sensor	Wireless Protocol	Measurements
ZIPATO - Micromodule Energy meter - 2 counts 	Z-WAVE PLUS	- ECS CUMULATIVE_CONSUMPTION CURRENT_AMPS CURRENT_CONSUMPTION CURRENT_POWER_FACTOR CURRENT_VOLTAGE - Total CUMULATIVE_CONSUMPTION CURRENT_AMPS CURRENT_CONSUMPTION CURRENT_POWER_FACTOR CURRENT_VOLTAGE

Table 11. Sensors and their measurements, French Pilot. (3)

Sensor		Measurements
Ultraflow Non-Intrusive Thermal Energy Meter 	Modbus communication: Modbus RTU slave, serial link and RS485 interface.	It allows the flow and temperature of the fluid to be measured without intervening in the pipework.
EWATCH - Impulse 3EQM - 1 **TIC + 2 Pulse** 	EnOcean	Electric meter - CUMULATIVE_CONSUMPTION - CURRENT_CONSUMPTION - TARIFF

2.3 List and Specifications of sensors installed in Polish pilot

In order to be able to showcase the achievement of KPIs and expected impacts of the RINNO project and demonstrate the building performance improvement targets from the renovation, relevant monitoring equipment was installed in the Polish Pilot.,

The Polish Pilot is composed of 5 flats and common areas (Flat 1 Polish, Flat 2 Polish, Flat 3 Polish, Flat 4 Polish, Flat 5 Polish, Staircase, Common Parts, measuring station, weather station and external environment). Each flat has its equipment with a unique ID.

Table 12.Specifications in every flat, Polish Pilot.

Attribute	**Mandatory / Optional**	**Specification**
External temperature and relative humidity	Mandatory	Yes
Outdoor air quality parameters PM2,5	Mandatory	Yes
Internal temperature and relative humidity	Mandatory	Yes, in flat 1, flat 2, flat 3, flat 4, flat 5
Internal temperature	Mandatory	Staircase
Human presence sensors	Mandatory	Yes, in flat 1, flat 2, flat 3, flat 4 and flat 5 and staircase
Carbon dioxide (CO2)	Optional	Yes, in flat 1, flat 2, flat 3, flat 4 and flat 5
Indoor air quality parameters PM2,5	Optional	Yes, in flat 1, flat 2, flat 3, flat 4 and flat 5
Indoor air quality parameters VOCs	Optional	Yes, in flat 1, flat 2, flat 3, flat 4 and flat 5
Luminance	Optional	Yes, in flat 1, flat 2, flat 3, flat 4 and flat 5 and staircase
Central electricity consumption meters	Mandatory	Yes, in flat 1, flat 2, flat 3, flat 4 and flat 5 and common parts
Heating consumption	Mandatory	Survey among residents - how much coal and wood were purchased in the heating season 2020/2021.
Cooling	Mandatory	Nor applicable
Mechanical Ventilation	Mandatory	Nor applicable
Power and storage units (e.g. PVs, PVTs, batteries)	Mandatory	Nor applicable
Domestic Hot Water	Mandatory	Nor applicable

Equipment for monitoring

Table 13.Sensors and information about them.

Wireless sensors	Parameters monitored	Additional information
MCOHOME A8-9 (5 pcs) 	**Temperature sensor** **Humidity sensor** VOC sensor **Noise sensor** **Light intensity sensor** **Motion sensor** Smoke sensor **CO_2 sensor** **PM2.5 sensor** *Periodic reports:* *5-minute*	TECHNICAL SPECIFICATIONS: **Z-Wave Plus** **compatible Power** **Supply：DC12V Self-** **dissipation: <3W** Temperature range: -20~100℃ Humidity range: 0%RH~99%RH PM2.5 range: 0~500ug/m^3 CO2 range: 0~2000ppm VOC: 1~5 level PIR angle detection: up to 120° Illumination range: 0~40000Lux Noise range: 30dB~100dB
Fibaro FGMS-001 (6 pcs) 	**Temperature sensor** **Light intensity sensor** **Motion sensor** *Periodic reports:* *5-minute*	
Looko2v3 + Looko2 Extender (1 set) 	**Outdoor sensor of PM2.5 and PM10** **Outdoor temperature sensor** **Outdoor humidity sensor** *Periodic reports:* *5-minute*	TECHNICAL SPECIFICATIONS: Compatible with FIBARO (Wifi) Power Supply：DC12V PM2.5 range: 0~500ug/m3 +/-10% PM10 range: 0~500ug/m3 +/- 10% https://looko2web.nazwa.pl/en/

Table 14. Sensors and information about them.

Wireless sensors	Parameters monitored	Additional information
OneMeter Home (6 pcs) 	**OneMeter enables communication with an electric energy meter through an optical connector.** *Periodic reports: 30-minute*	https://onemeter.com/

Monitoring system for flats

- MCOHOME A8-9
- Fibaro FGMS-001

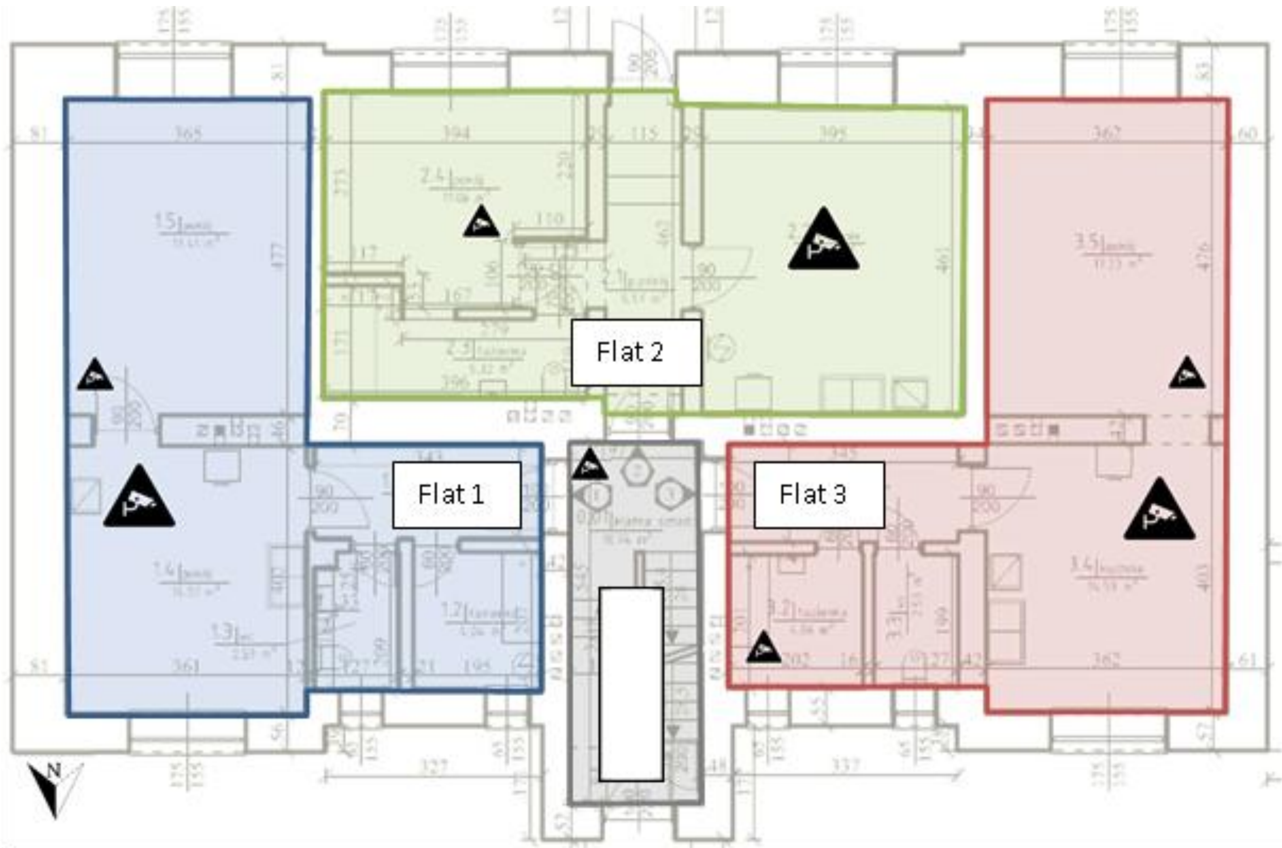


Figure 5. Flats on ground floor (plan of flats 1,2 and 3)

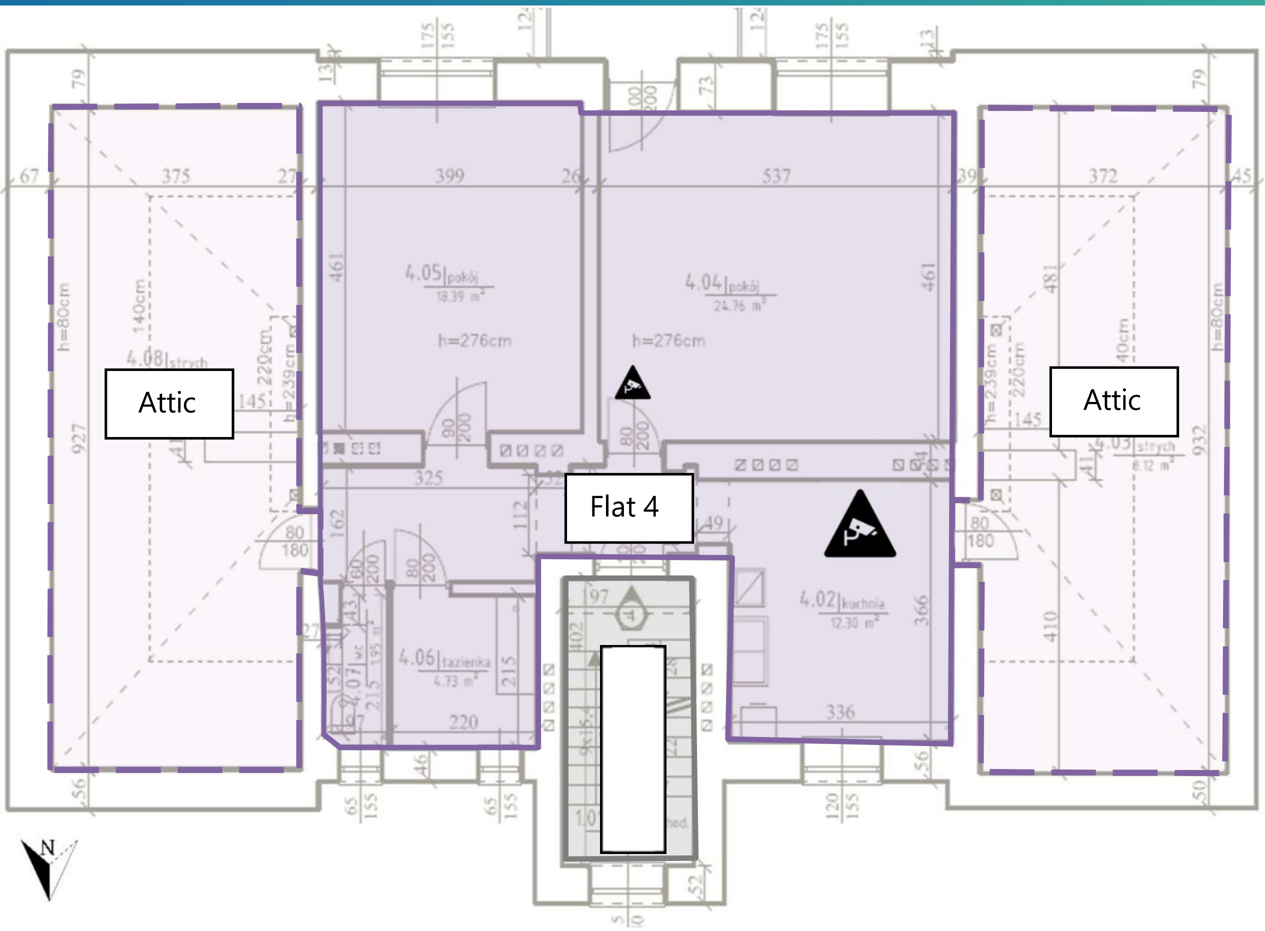


Figure 6. Flat on first floor (plan of flat 4)

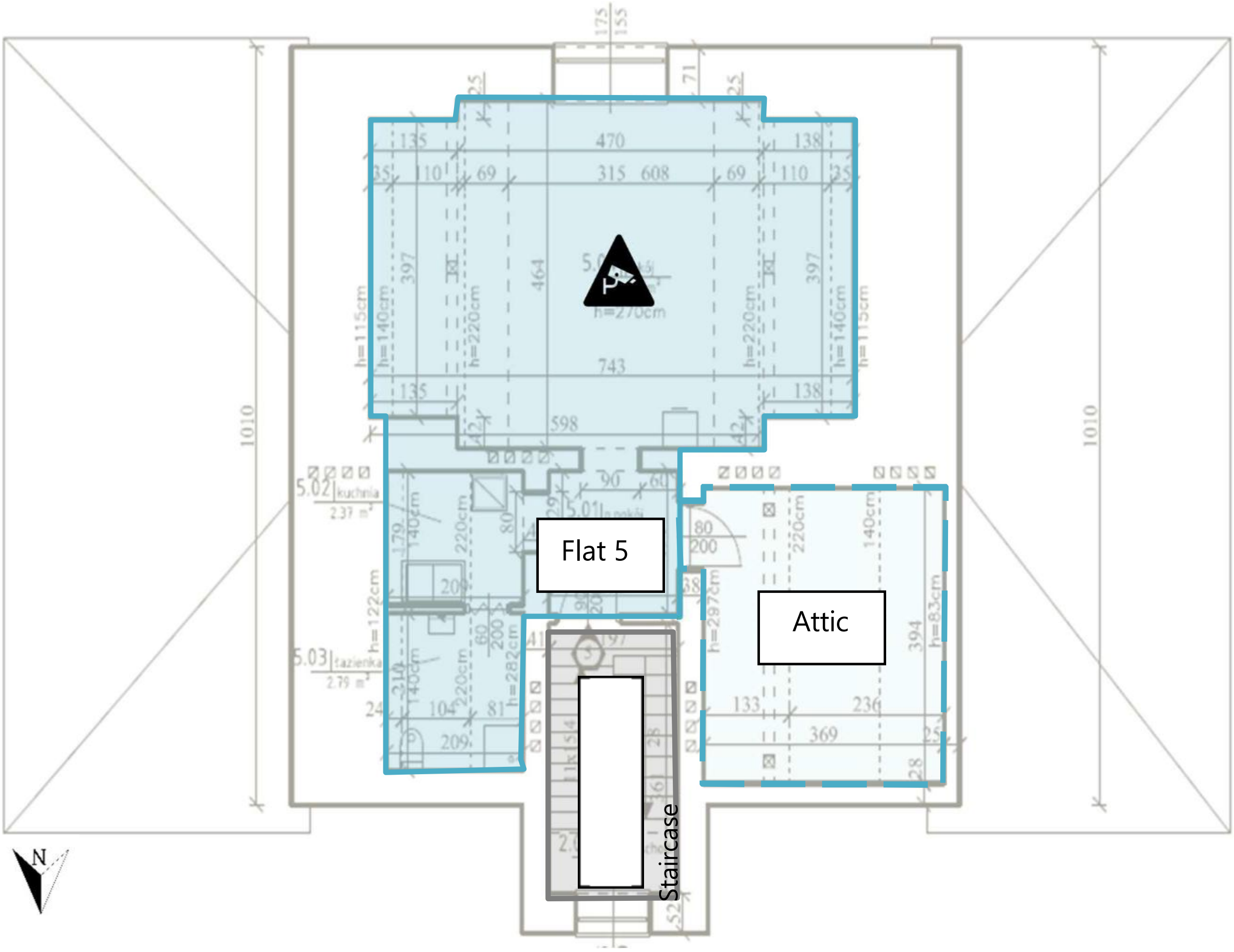


Figure 7. Flat on second floor (plan of flat 5)

Staircase monitoring

In staircase, the following parameters will be monitored:

- Temperature
- Relative Humidity
- Motion Sensor

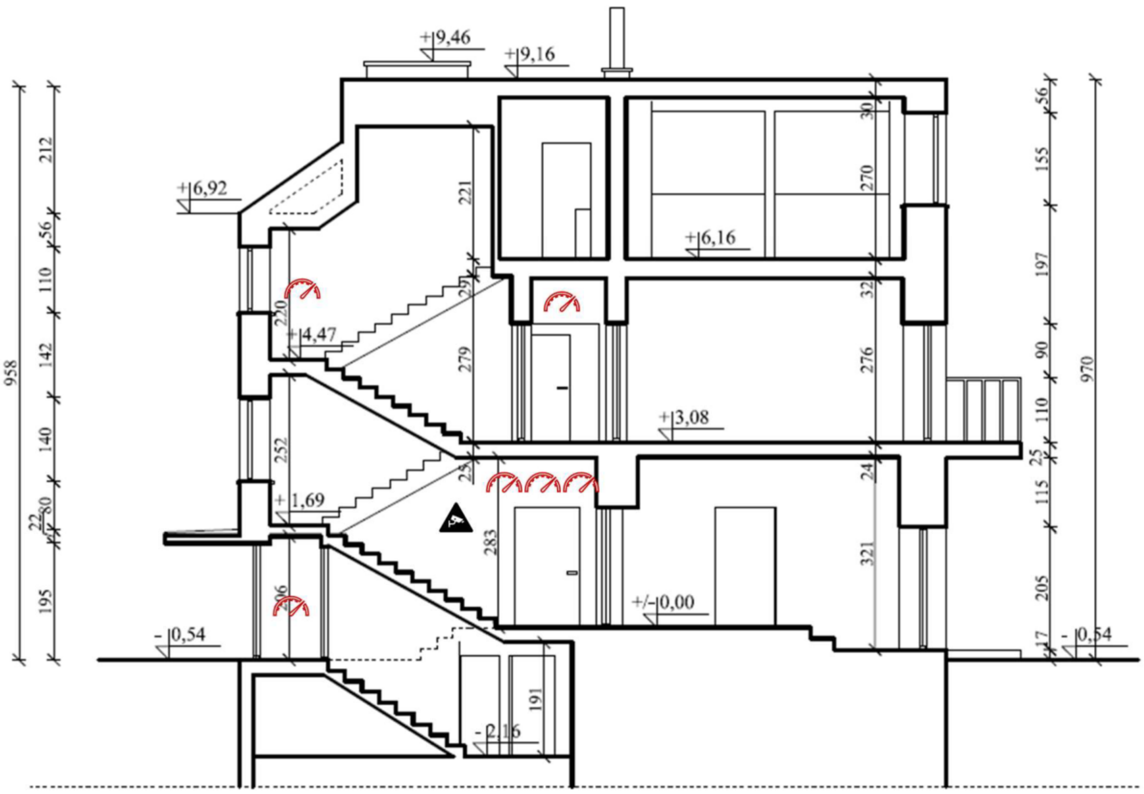


Figure 8. Location of installation of electricity meters in the staircase (cross-section of the staircase)

Parameters of the external environment

The following outside air parameters will be monitored:

- Temperature
- Relative Humidity
- PM2.5 and PM10 concentration

Additional data from nearby air quality and meteorological stations are available for the Demo Site #4. High-quality data from these measuring stations can be downloaded and placed on the RINNO server (for example, once a month).

The measuring station of Provincial Environmental Protection Inspectorate in Warsaw located at Zegrzyńska street 38 in Legionowo (powietrze.gios.gov.pl,, ID: PL0129A). The station is approximately 6,600 m (in a straight line) from the demonstration building and automatically records the pollutant concentrations at a resolution of 1 hour:

- PM10 [μg/m^3]
- PM2,5 [μg/m^3]
- NO2 [μg/m^3]

- O3 [μg/m³]
- NOx [μg/m³]

Access to the data: https://powietrze.gios.gov.pl/pjp/current/station_details/chart/471

Figure 9. Weather station "The Palace and park complex in Jabłonna".

The weather station "The Palace and park complex in Jabłonna" (www.wunderground.com, ID: IJABON4). The station is approximately 3,300 m (in a straight line) from the demonstration building and records the following parameters of the outdoor environment in a resolution of "every 5 min":

- Temperature [°C]
- Dewpoint [°C]
- Humidity [%]
- Wind speed and direction [km/h]
- Pressure [Pa]
- Precipitation [mm]
- UV [-]
- Solar radiation [W/m²]

Access to the data: https://www.wunderground.com/dashboard/pws/IJABON4

2.4 List and Specifications of sensors installed in Danish pilot

- In order to be able to showcase the achievement of KPIs and expected impacts of the RINNO project and demonstrate the building performance improvement targets from the renovation, relevant monitoring equipment was installed in the Danish Pilot.,

Table 15.Specifications in each flat, Danish Pilot.

Parameter type	Mandatory / optional	Specification
External temperature	Mandatory	www.yr.no/nb/detaljer/tabell/2-2613460/Denmark/Zealand/Slagelse/Slagelse
Outdoor air quality PM	Optional	www.yr.no/nb/detaljer/tabell/2-2613460/Denmark/Zealand/Slagelse/Slagelse
Internal temperature and relative humidity	Mandatory	Yes, so far in flat 1, 3 and 11
Internal temperature	Mandatory	Yes, so far in flat 1, 3 and 11
Human presence sensors	Mandatory	No, IC-meter, the system gets this from the other data (computer intelligence)
CO2	Mandatory	Yes, so far in flat 1, 3 and 11
Indoor air quality parameters PM	Optional	No
Indoor air quality parameters VOCs	Optional	No
Luminance	Optional	No (maybe)
Heating consumption	Mandatory	Heat meter 80248104 is the total consumption for all the apartments under this property. Location where the property is connected to central heating which is usually in the basement.
Cooling	Mandatory	Nor applicable
Mechanical ventilation	Mandatory	No meter for the old ventilation is installed. It is only measured once for the baseline. It is not planned to measure the new ventilation
Power and storage units	Mandatory	Nor applicable
Domestic hot water	Mandatory	Yes (and no), the m3 use of cold water is measured (meter 68847124). But the district heating use is not measured (which includes losses)
Heating consumption	Mandatory	Yes
Cooling	Mandatory	No cooling
Mechanical ventilation	Optional	Yes
Power and storage units (e.g. batteries, PVs, PVTs)	Mandatory	PV
Domestic hot water	Mandatory	Included in the heating consumption
Domestic water	Mandatory	Yes

Equipment for monitoring

Table 16. Sensors and additional information, Danish pilot.

Wireless sensors	Parameters monitored	Additional information
Exhausto VEX 3/EVR 67 VF	Ventilation	See enclosed reports and drawings below
ICMeter 	Indooor temperature Humidity CO2 Noise sensor	Is installed p.t. 2 in two flats – Olufsgade 5, ground floor to the left and Olufsgade 7, ground floor to the left. Planned to be installed in 6-8 flats. See placement and functionality below
	Heating and hot water	
	Electricity	
	PV	

- *Exhausto*

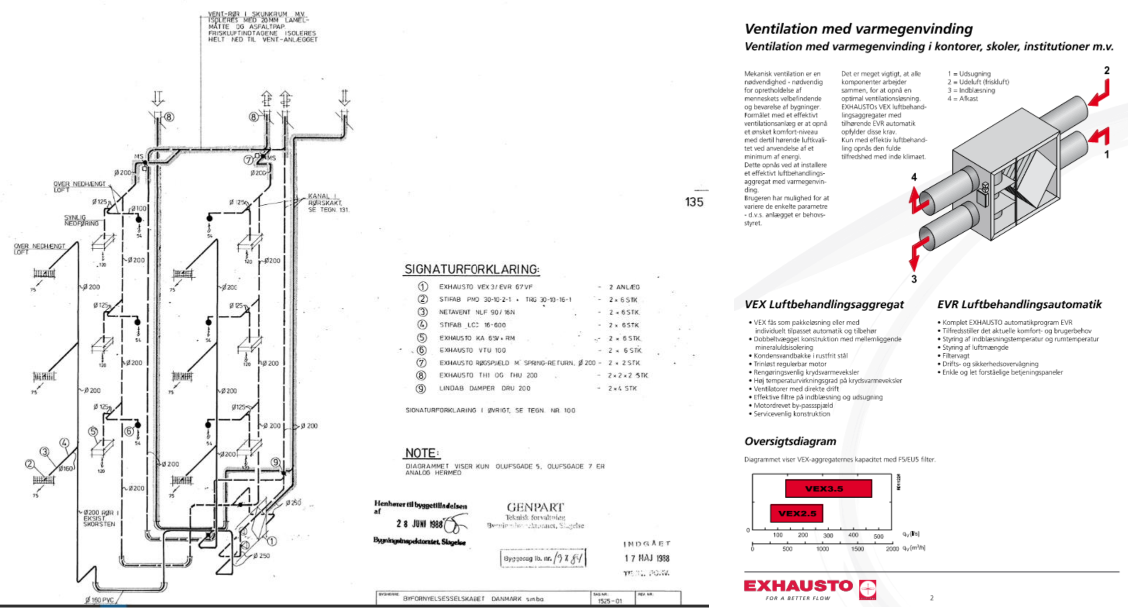


Figure 10.Exhausto sensor and additional information

- *ICMeter - functions*

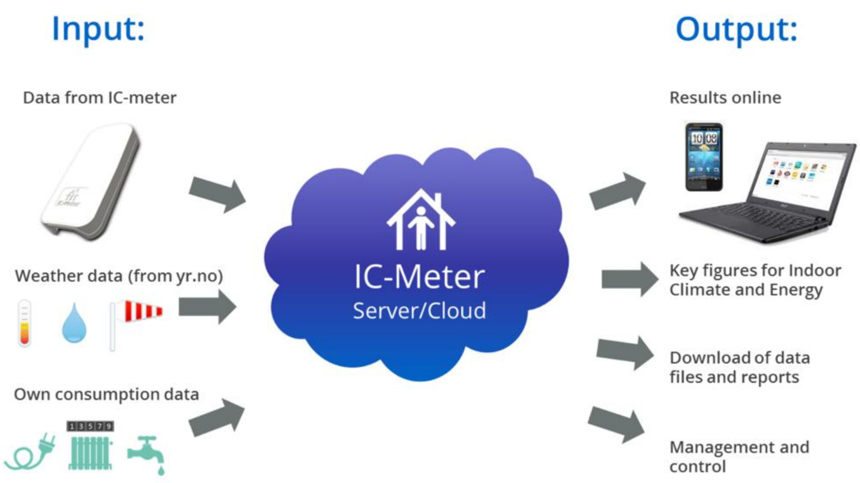


Figure 11.ICMeter sensor and functions.

Parameters of the external environment

The weather in Slagelse – from the Danish Meteorological Institute (DMI) shows the following parameters of the outdoor per hour. It is possible to have an API access for free. Information on:

- Temperature [oC]
- Dewpoint [oC]
- Humidity [%]
- Wind speed and direction [km/h]
- Pressure [Pa]
- Precipitation [mm]
- UV[-]

Access to the data: https://www.dmi.dk/lokation/show/DK/2613460/Slagelse/

3. Deployment view

Deployment view describes how and where the system is deployed, which physical requirements are essential for the system to go live. Another important factor is the dependencies of the various components, modules, and sub-modules, their hardware requirements, and their physical constraints. In this view the physical environment where the system will run is defined, including:

- Hardware and Technical requirements.
- Mapping of software elements to the runtime environment.
- Third-party software requirements.
- Network requirements.

In this chapter it is analysed the deployment environment of the RINNO Building Monitoring System.

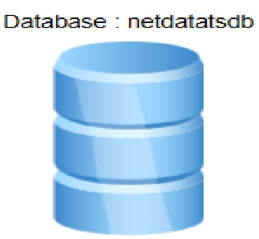
The IoT-Platform is written with angular-js at the front-end and node-js at the back-end.
The connection of the platform with the remote sensors in the sites is done through the MQTT broker, that ensuring an uninterrupted flow of communication between the devices and sensors. MQTT-S is an extension of the open publish/subscribe protocol Message Queuing Telemetry Transport (MQTT). The entity, which ensures that the data gets from the publishers to the subscribers, is the *broker.*
The *MQTT broker* is an intermediary entity that enables MQTT clients to communicate. Specifically, the MQTT broker received messages sent by the publishers (sensors) and distributes them to the subscribers (the IoT Platform).

Data storage is based on the SiteWhere.
One of the data storage strategies supported by SiteWhere is a hybrid arrangement where device management data is stored in MongoDB while device event data is stored in InfluxDB. This division of labor allows each storage technology to focus on its strengths, with MongoDB being well-suited for the document-oriented nature of the device data and InfluxDB being well-suited for the time-series nature of the event data. Since InfluxDB takes care of common data-tier concerns such as clustering and retention policies, this arrangement is very scalable.
In the database are stored all the components that have been created in the IoT-platform.

Details for the database

In MongoDB are stored all the data for the buildings, users, devices and rules for IoT-Platform. The table “assets” contains a unique Id- the assetID (created when creating the asset within the platform's management section), the name of the asset and the image for each device.
The table “devices” contains the hardware ID (the incoming sensor ID), the site Token (a unique ID for each apartment) and the specification token (the device ID as it has been auto generated in IoT-Platform).
The “specifications” table contains the auto-generated specification token, the asset name, that the specification is connecting with and the assetID.
The “sites” table contains all the apartments (name of the apartment and token ID)
In the ‘’assignment’’ table, are the data of the device Hardware-ID, the assetID, the assignment token and site token.
The device Hardware-ID in the site, is connected to the assignment token of the device, created on the platform, for the corresponding site, using the site token from the 'sites' table.
The InfluxDB is for storage and retrieval of time series data in fields such as operations monitoring, metrics, sensor data, and real-time analytics.

An example of the InfuxDB and how the data are stored is presented in the following figure.



Measurement : netdata.users.mem.root

time	host	value
1580940044000000000	vpsfrsqlpac2	45.833595
1580940054000000000	vpsfrsqlpac1	34.718747
1580940054000000000	vpsfrsqlpac2	45.229299
1580940064000000000	vpsfrsqlpac1	34.113279
1580940064000000000	vpsfrsqlpac2	45.417577

Measurement : netdata.users.cpu.root

time	host	value
1580940044000000000	vpsfrsqlpac2	0.85109
1580940054000000000	vpsfrsqlpac1	1.59948
1580940054000000000	vpsfrsqlpac2	1.17322
1580940064000000000	vpsfrsqlpac1	5.4392
1580940064000000000	vpsfrsqlpac2	1.18461

Figure 12. Format of devices values stored in InfluxDB.

4. Conclusions

The work regarding the development of the RINNO Middleware infrastructure, implemented for Task 5.1 from M6 to M27 is presented in this Deliverable D5.1 - “RINNO IoT Middleware – List and Specifications of the RINNO Multi-Sensorial Network”. The Middleware is the component used in the RINNO Suite system to gather the values of the variety of IoT devices and ensure the seamless interoperability amongst them. The list of the required devices along with their specifications have been reported as well per demo site. The devices have been chosen based on the attributes that have to be monitored in order to calculate the KPIs that are defined to evaluate the success of the RINNO project. Based on these devices and the variables that each one of them measures, the Building Monitoring System will be implemented and Building Renovation Passports will be created. It should be noted that since renovation has not started yet at any of the demo buildings, this information refers to the IoT Multi-sensorial network for the existing condition of the buildings. In case of installing further or supplementary HVAC or RES systems during renovation, the required additional monitoring sensors/actuators will be reported in Deliverable 5.4.

ABOUT RINNO

RINNO is a four-year EU-funded research project that aspires to deliver greener, bio-based, less energy-intensive from a life cycle perspective and easily applicable building renovation elements and energy systems that will reduce the time and cost required for deep energy renovation, while improving the building energy performance. Its ultimate goal is to develop, validate and demonstrate an operational interface with augmented intelligence and an occupant-centered approach that will streamline and facilitate the whole lifecycle of building renovation.

For more information, please visit **https://rinno-h2020.eu/**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 892071

REFERENCES