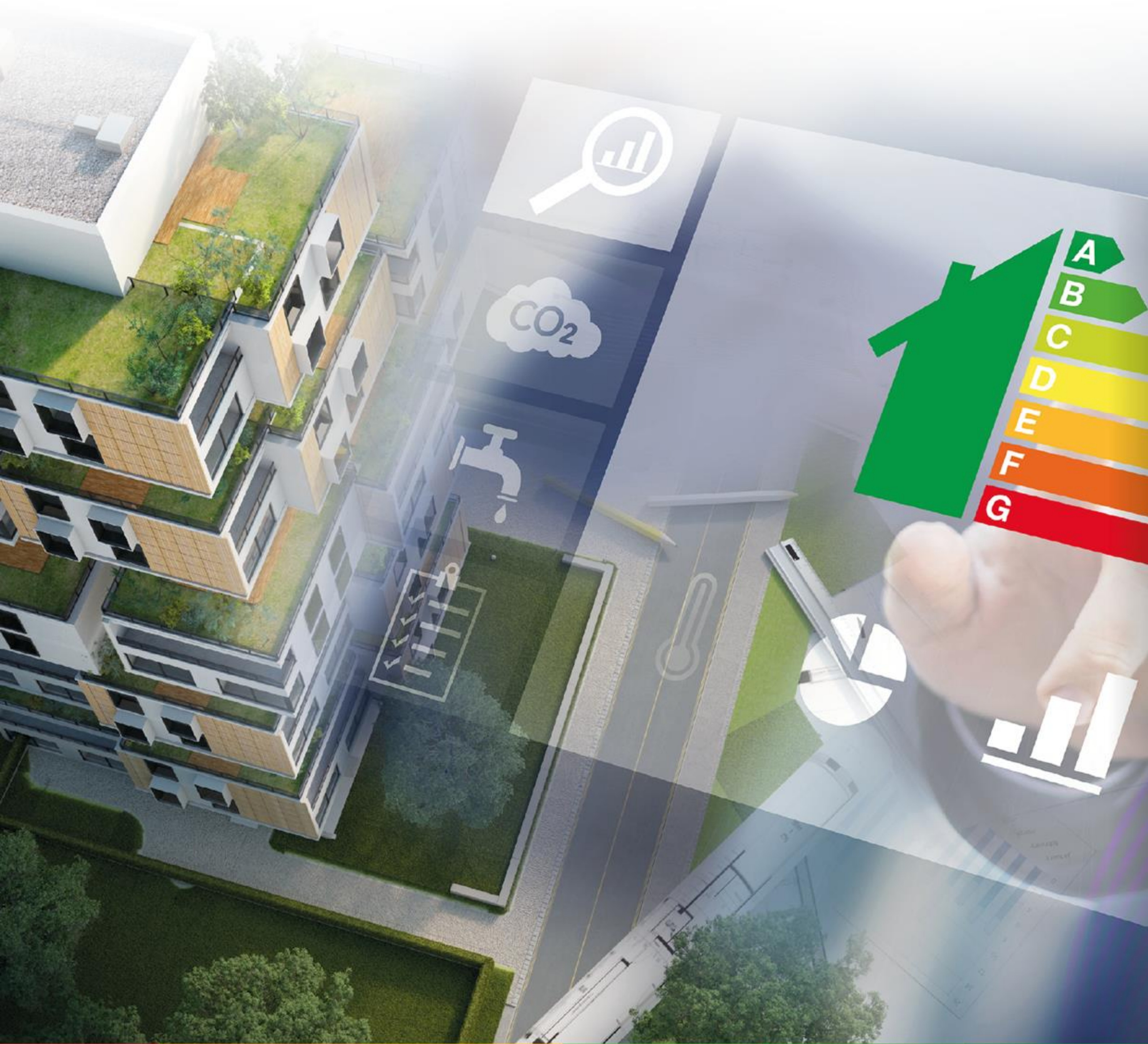
D6.2 SmartLivingEPC Pilot Planning and Setup



This project has received funding from the European Union's Horizon Europe research and innovation programme under the grant agreement number 101069639. The European Union is not liable for any use that may be made of the information contained in this document, which is merely representing the authors' view.

Project Acronym:	SmartLivingEPC
Project Full Title:	Advanced Energy Performance Assessment towards Smart Living in Building and District Level
Grant Agreement:	101069639
Project Duration:	36 months (01/07/2022 – 30/06/2025)

Deliverable 6.2
SmartLivingEPC Pilot Planning and Setup

Work Package:	WP6 – Demonstration and Impact Assessment
Task:	T6.2 Pilot planning and preparation
Document Status:	v1.0
File Name:	SmartLivingEPC_D6.2_SmartLivingEPC Pilot Planning and Setup
Due Date:	29.02.2024
Submission Date:	01.03.2024
Lead Beneficiary:	Taltech

Dissemination Level	
Public	☒
Confidential, only for members of the Consortium (including the Commission Services)	☐

Authors List

Leading Author				
First Name		Last Name	Beneficiary	Contact e-mail
Helena		Kuivjõgi	TalTech	helena.kuivjogi@taltech.ee
Co-Author(s)				
#	First Name	Last Name	Beneficiary	Contact e-mail
1	Jarek	Kurnitski	TalTech	jarek.kurnitski@taltech.ee
2	Andrea	Ferrantelli	TalTech	andrea.ferrantelli@taltech.ee
3	Karl-Villem	Võsa	TalTech	karl-villem.vosa@taltech.ee

Reviewers List

Reviewers			
First Name	Last Name	Beneficiary	Contact e-mail
Leandro	Ferron	UDEUSTO	l.ferron@deusto.es
Samy	Iousef	QUE	s.iousef@que-tech.com

Version History

v	Author	Date	Brief Description
v0.1	Helena Kuivjõgi	20/02/2024	First draft
v0.2	Leandro Ferron (UDEUSTO)	20/20/2024	Comments on complex level aspects in Leitza buildings
v0.3	Samy Iousef (QUE)	21/02/2024	Suggestions for elaboration and clarification
v1.0	Helena Kuivjõgi	29/02/2024	Final draft

Copyright

Table of Contents

1 Introduction 9
1.1 Scope and objectives of the deliverable 9
1.2 Structure of the deliverable 9
1.3 Relation to Other Tasks and Deliverables 9
2 Overview of SmartLivingEPC Case Studies 10
3 Demo Site #1: nZEB Smart House DIH 11
3.1 Metering equipment for operational rating 11
3.2 Communication readiness to CIEM 13
3.3 Actions 13
4 Demo Site #2 Limassol Main Building - Frederick University 14
4.1 Metering equipment for operational rating 14
4.2 Communication readiness to CIEM 18
4.3 Actions 18
5 Demo site #3 University building, Tallinn, Estonia 19
5.1 Metering equipment for operational rating 19
5.2 Communication readiness to CIEM 22
5.3 Actions 22
6 Demo Sites #4-9 – Leitza Complex Buildings 23
6.1 Metering equipment for operational rating 23
6.1.1 DS 4. Single family housing 23
6.1.2 DS 5. Apartment building 25
6.1.3 DS 6. Commercial and apartment building 26
6.1.4 DS 7. City Hall 28
6.1.5 DS 8. School building 29
6.1.6 DS9. Sports centre 31
6.2 Communication readiness to CIEM 33
6.3 Actions 33
7 Case Studies Summary 34
7.1 Pilot risks and Mitigation Actions 34
8 Conclusions 36

List of Figures

Figure 1. Northeast side of the Smart House 11
Figure 2. Frederick University, Limassol 14
Figure 3. The view of IoT platform (Library – 3rd floor) 18
Figure 4. Demo Site 3 building outdoor view 19
Figure 5. The Building Automatics overview of Demo Site 3 22
Figure 6. LORA protocol explanation 23
Figure 7. Exterior view of the building DS4 24
Figure 8. Exterior view of the building DS5 25
Figure 9. Exterior view of the building DS6 27
Figure 10. Exterior view of the building DS7 28
Figure 11. DS8 - school building 30
Figure 12. Exterior view of the building DS9 31

List of Tables

Table 1. IEQ sensors needed for operational rating calculation and the description of DS1 equipment 11
Table 2. IEQ sensors to be installed in DS1 for operational rating calculation 12
Table 3. Description of DS1 electricity energy meters 13
Table 4. Pilot’s activities and milestones for DS1 13
Table 5. IEQ sensors needed for operational rating calculation and the description of DS2 equipment 17
Table 6. IEQ sensors to be installed in DS2 for operational rating calculation 17
Table 7. Description of DS2 electricity energy meters 18
Table 8. Pilot’s activities and milestones for DS2 18

Table 9. IEQ sensors needed for operational rating calculation and the description of DS3 equipment 20

Table 10. IEQ sensors to be installed in DS3 for operational rating calculation 20

Table 11. Description of DS3 electricity, heating and cooling energy meters 21

Table 12. Pilot's activities and milestones for DS3 22

Table 13. IEQ sensors to be installed in DS4 for operational rating calculation 24

Table 14. Energy meters to be installed in DS4 for operational rating calculation 24

Table 15. IEQ sensors to be installed in DS5 for operational rating calculation 25

Table 16. Energy meters to be installed in DS5 for operational rating calculation 26

Table 17. IEQ sensors to be installed in DS6 for operational rating calculation 27

Table 18. Energy meters to be installed in DS6 for operational rating calculation 27

Table 19. IEQ sensors to be installed in DS7 for operational rating calculation 28

Table 20. Energy meters to be installed in DS7 for operational rating calculation 29

Table 21. IEQ sensors to be installed in DS8 for operational rating calculation 30

Table 22. Energy meters to be installed in DS8 for operational rating calculation 30

Table 23. IEQ sensors to be installed in DS9 for operational rating calculation 31

Table 24. Energy meters to be installed in DS7 for operational rating calculation 33

Table 25. Pilot's activities and milestones for DS4-9 33

Table 26: Risks and mitigation actions 34

List of Acronyms and Abbreviations

Term	Description
API	Application Programming Interface
BEMS	Building Energy Management System
CIEM	Common Information Exchange Model
D	Deliverable
DCV	Demand Controlled Ventilation
DS	Demo Site
EPC	Energy Performance Certificate
HTTP	Hypertext Transfer Protocol Secure
HVAC	Heating, Ventilation and Air-Conditioning
IoT	Internet of Things
IEQ	Indoor Environmental Quality
PM2.5	Particulate Matter – particles less than 2.5 micrometres in diameter
RES	Renewable Energy Sources
REST	Representational State
T	Task
WP	Work Package

1 Introduction

1.1 Scope and objectives of the deliverable

The deliverable's scope is to give an overview of the planning and setup activities related to the pilot buildings. The main objective is to compile the concise tables outlining each pilot metering equipment and the planning for future installations. Furthermore, the objective is to give an overview of the status of the communication methods and data exchange with SmartLivingEPC's Common Information Exchange Model (CIEM).

In the following text, a short description of each pilot is included, addressing the metering equipment, the connection readiness to CIEM, and what needs to be installed in the future.

A general, main objective is performing activities that are related to the pilots, for defining the scope of the demonstrations, together with the appropriate stakeholders.

More into detail, the task consists of preparing a detailed plan with a set of actions to guide and prepare the installation of the various types of devices (energy meters, carbon dioxide sensors etc.) that will be installed in the 9 pilots. The installation plan is based on the integrated solution that is delivered in D5.1.

A detailed schedule for the establishment and operation of the pilots is here defined, together with a methodology for data collection for evaluation and validation. Activities for each individual pilot are here documented via a detailed list of milestones, together with a list of possible issues that are related to the pilots' implementation.

Finally, hardware requirements (smart devices, Internet of Things (IoT) sensors, Building Energy Management System (BEMS), Heating, Ventilation and Air-Conditioning (HVAC) equipment, etc.) and a detailed plan for installation are here listed, according to the SmartLivingEPC methodology that is defined in Work Package (WP) 3.

1.2 Structure of the deliverable

The deliverable's Section 2 provides an overview of the general status of pilot building planning. Section 3, 4, 5, 6 provide an overview of each building metering equipment, specifications about the communication interface with CIEM, and an action plan. Section 7 then contains a summary of risks and mitigation actions for all pilots, while general conclusions on pilot planning and setup are drawn in Section 8.

1.3 Relation to Other Tasks and Deliverables

This deliverable is part of WP6 and includes T6.2. The WP6 "Demonstration and impact assessment" here uses the content of Deliverable (D) 1.2 from WP1 and D3.1 from WP3 as a guidance, for selecting and installing the meters and sensors in the pilots and offer input on its iterative processes in order to create the final and comprehensive system architecture in Month (M) 21, according to the CIEM framework that is developed in WP4. The installation plan instead is prepared according to the integrated solution that is delivered in Task (T) 5.4.

2 Overview of SmartLivingEPC Case Studies

The pilot buildings in SmartLivingEPC project are useful for testing the methodologies that different tasks are developed. The pilots have different location and purpose of use:

- Pilot #1: CERTHs nZEB Smart House DIH in Greece
- Pilot #2: Frederick's University Main Building in Cyprus
- Pilot #3: TalTech's University of Technology in Estonia
- Pilot #6: Building Complex in Spain. Specifically, in Leitza town are 6 demo sites considered also as neighbourhood:
    - Demo Site (DS) 4. Single family housing
    - DS 5. Apartment building
    - DS 6. Commercial and apartment building
    - DS 7. City Hall
    - DS 8. School building
    - DS 9. Sports centre

Data collection

Each representative partner, developing SmartLivingEPC calculation methodologies, collected historical data for method testing. In following months, the Pilot Buildings IoT platforms integration with CIEM will take place and the data collection will be done through the SmartLivingEPC platform. The communication methodology are covered by T4.1 and D4.1.

Following sections will give the description of each pilot building, the metering equipment, the communication readiness to CIEM, the equipment that needs to be installed in the future, and the action list with milestones. The detailed description of all 9 DS are covered under Task 1.3 Pilot Surveys and Use Case Scenarios definition.

3 Demo Site #1: nZEB Smart House DIH

The nZEB Smart House is a residential and office/laboratory building, located in Thessaloniki, Greece (N 40.56, E 22.99). It was completed in 2016, as part of a project, with the goal of a near zero emission building that can be further experimented on. The building is equipped with cutting-edge envelope insulation materials, fenestration, and energy production.

Figure 1. Northeast side of the Smart House

3.1 Metering equipment for operational rating

The current list of metering equipment of Demo Site 1 is presented in Table 1-Table 3. The building is well equipped with indoor environmental quality (IEQ) sensors as shown in Table 1. The table includes also the equipment network protocols and additional information like the equipped rooms, comments about why data is missing and default values from standard etc. Furthermore, DS1 is the only building for now where PM2.5 concentration sensor is installed. The equipment network protocols Z-Wave and Zigbee are wireless communication protocols commonly used in smart home devices and IoT. The outdoor data comes from third-party service through a provided Hypertext Transfer Protocol Secure (HTTP) Representational State (REST) Application Programming Interface (API).

However, not all required equipment is completely installed in the pilot site. Outdoor air ventilation flow rate to the room is not measured, because the building has natural ventilation. There are two additional sensors to be installed in Demo Site 1 (

Table 2). Considering the energy metering equipment, there are only main electricity meters and two sub-meters for heat pump electricity listed is in Table 3. The additional installation will be detailed by WP3 Deliverable.

Table 1. IEQ sensors needed for operational rating calculation and the description of DS1 equipment

Value Name	Unit	Timestep	Information	Equipment Network protocols and integration to system
IEQ sensors				

Room air temperature sensor	°C	15 min	Double bedroom, single bedroom, Corridor, Back-corridor, Playroom, Bathroom, Stairs, Hall, Living Room, Kitchen, Guest room, WC	Z-Wave, Zigbee. A dedicated gateway for each communication protocol is installed in the building
Room CO_2 volumetric concentration	ppm	15 min	Playroom, Living Room	
Room PM2.5 volumetric concentration	µg/m^3	15 min	Living Room	
Outdoor air ventilation flow rate to the room*	L/s	N/A	natural ventilation	N/A
Room occupancy (Presence sensor)	-	15 min	[0, 1] motion detection in Double bedroom, single bedroom, Corridor, Back-corridor, Playroom, Bathroom, Stairs, Hall, Living Room, Kitchen, Guest room, WC	Z-Wave, Zigbee. A dedicated gateway for each communication protocol is installed in the building
Outdoor air temperature	°C	10 min	local weather station	LTE. Communication with a third-party service through a provided HTTP REST API
Outdoor CO_2 volumetric concentration	ppm	N/A	default 400 ppm	N/A
Room air relative humidity	%	15 min	Double bedroom, single bedroom, Corridor, Back-corridor, Playroom, Bathroom, Stairs, Hall, Living Room, Kitchen, Guest room, WC	Z-Wave, Zigbee. A dedicated gateway for each communication protocol is installed in the building
Outdoor PM2.5 volumetric concentration	µg/m^3	N/A	-	N/A
Outdoor air relative humidity	%	10 min	local weather station	LTE. Communication with a third-party service through a provided HTTP REST API
***if measured, no need to measure the number of occupants. In CAV system, design air flow rate may be used instead. System status to be monitored or inferred from CO2 level readings.**				

Table 2. IEQ sensors to be installed in DS1 for operational rating calculation

Value Name	Unit	Timestep	Information	Equipment Network protocols and integration to system
IEQ or outdoor sensors to be installed				
Outdoor CO_2 volumetric concentration	ppm	daily	daily average is min step	Building weather station connected to IoT platform - TBD
Outdoor PM2.5 volumetric concentration	µg/m^3	15 min	-	

Table 3. Description of DS1 electricity energy meters

Value Name	Unit	Timestep	Information	Equipment Network protocols and integration to system
Energy meters existing				
Total electricity - building	kWh	15 min		Modbus TCP. A dedicated software script collects data frequently.
Total electricity - per floor	kWh	15 min	Currently out of service	
Heat pump 1 electricity	kWh	15 min		
Heat pump 2 electricity	kWh	15 min		

3.2 Communication readiness to CIEM

The Smart House has a dedicated IoT platform which is used to collect measurements from all the equipment that is installed within. The information is then available through an HTTP REST API for retrieval of historical data of the preferred time. Access to the API can be provided accordingly (so data retrieval can be established right away.). In the following months, it will be decided if there is a need for an additional interface to be provided (e.g. AMQP-based, as QUE partners have proposed).

The communication with CIEM will be further detailed within the framework of T4.1.

3.3 Actions

As there are still some equipment to be installed to Demo Site 1, the activities and milestones of following months are outlined in

Table 4. In final months, there is need for feedback, how works the communication with CIEM.

Table 4. Pilot's activities and milestones for DS1

No.	Milestone name	Due date	Means of verification
MS1	IoT platform integration with CIEM	**M21**	The IoT platform is integrated with CIEM
MS2	Installation of additional IEQ sensors	**M22**	The sensors are installed to the external environment of the building.
MS3	The feedback of the communication with CIEM	**M28**	Real-time and historical data exchange with CIEM works in pilot side.

4 Demo Site #2 Limassol Main Building - Frederick University

Frederick University's building comprises classrooms, computer and engineering laboratories, art and craft studios, workshops, a library, seminar rooms, administration and faculty offices, and a large cafeteria. The building was constructed in 1996, and an additional floor was constructed in 2021. New classrooms, a library, study areas, and a seminar room have been added to the newly renovated building's floor.

Figure 2. Frederick University, Limassol

4.1 Metering equipment for operational rating

The current list of metering equipment of Demo Site 2 is in

Table 5-Table 7. The building is equipped with IEQ sensors in

Table 5. The equipment network protocol used in DS2 is LoRaWAN that is a long-range, low-power wireless communication technology specifically designed for efficient data exchange in IoT applications.

However, not all required equipment is completely installed in the pilot site. Outdoor air ventilation flow rate to the room is not measured, because the building has natural ventilation. There are four additional sensors to be installed in Demo Site 2 (Table 6). Besides to DS1, the Demo Site 2 have in addition the lighting and application electricity sub-meters. The full list of energy metering equipment is in Table 7. The additional installation will be detailed by WP3 Deliverable.

Table 5. IEQ sensors needed for operational rating calculation and the description of DS2 equipment

Value Name	Unit	Timestep	Information	Equipment Network protocols and integration to system
IEQ sensors				
Room air temperature sensor	°C	10 min	Cafeteria, Library, Classroom, Office	LoRaWAN® protocol
Room CO_2 volumetric concentration	ppm	10 min	Cafeteria, Library, Classroom, Office	LoRaWAN® protocol
Room PM2.5 volumetric concentration	µg/m^3	N/A	not measured	N/A
Outdoor air ventilation flow rate to the room*	L/s	N/A	natural ventilation	N/A
Room occupancy	persons or m^2/person	10 min	Presence sensor in Cafeteria, Library, Classroom, Office	LoRaWAN® protocol
Outdoor air temperature	°C	Daily average	Region weather station	LoRaWAN® protocol
Outdoor CO_2 volumetric concentration	ppm	N/A	default 400 ppm	N/A
Room air relative humidity	%	10 min	Cafeteria, Library, Classroom, Office	LoRaWAN® protocol
Outdoor PM2.5 volumetric concentration	µg/m^3	N/A	not measured	N/A
Outdoor air relative humidity	%	N/A	not measured	N/A

Table 6. IEQ sensors to be installed in DS2 for operational rating calculation

Value Name	Unit	Timestep	Information	Equipment Network protocols and integration to system
IEQ or outdoor sensors to be installed				
Outdoor air temperature	°C	daily	daily average is min step	Building weather station connected to IoT platform - TBD
Outdoor CO_2 volumetric concentration	ppm	daily	daily average is min step	
***Suggested*: Outdoor PM2.5 volumetric concentration**	µg/m^3	15 min	-	
***Suggested*: Room PM2.5 volumetric concentration**	µg/m^3	15 min	15 min is min step	Modbus RTU (Bacnet MS/TP) integration into BMS

Table 7. Description of DS2 electricity energy meters

Value Name	Unit	Timestep	Information	Equipment Network protocols and integration to system
Energy meters existing				
Total electricity - building	kWh	daily		LoRaWAN® protocol
Total electricity - per floor	kWh	daily		
Lighting electricity - per floor	kWh	daily		
Appliances electricity - per floor	kWh	daily		
Heating and cooling electricity - building	kWh	daily	Heat pump electricity	
Heating and cooling electricity - per floor	kWh	daily	Heat pump electricity	

4.2 Communication readiness to CIEM

The Pilot building IoT platform (view shown in Figure 3) is ready to exchange the data using APIs. The data can be pushed via POST HTTP in JSON format. Energy Consumption will be sent around midnight when all daily values are calculated. Indoor Air Quality data will be sent every 10 minutes upon data transmission by the sensors.

The communication with CIEM will be further detailed within the framework of T4.1.

Figure 3. The view of IoT platform (Library – 3rd floor)

4.3 Actions

There will be need for additional installation of IEQ sensors and energy meters in Demo Site 2. Therefore, the activities and milestones outlined in Table 8 indicate the installation during following months. In final months, there is need for feedback, how works the communication with CIEM.

Table 8. Pilot's activities and milestones for DS2

No.	Milestone name	Due date	Means of verification
MS1	IoT platform integration with CIEM	**M21**	The IoT platform is integrated with CIEM
MS2	Installation of additional IEQ sensors	**M22**	The sensors are installed into selected rooms and to the external environment of the building.
MS3	The feedback of the communication with CIEM	**M28**	Real-time and historical data exchange with CIEM works in pilot side.

5 Demo site #3 University building, Tallinn, Estonia

Ehituse Mäemaja is an NZEB office and laboratory building in Tallinn, located on the campus of Tallinn University of Technology (TalTech). The building produces solar energy with the entire roof surface, and wooden structures have been used to reduce the carbon footprint. The construction of the building finished in 2021.

Figure 4. Demo Site 3 building outdoor view

5.1 Metering equipment for operational rating

The current list of metering equipment of Demo Site 3 is in Table 9-

Table 11.The building is well equipped with IEQ sensors outlined in Table 9. As this building has mechanical ventilation and demand controlled ventilation (DCV), there is measured also the outdoor air ventilation flow rate to the room. The used protocol Modbus RTU (Bacnet MS/TP) that is a communication standard commonly employed in building automation systems. Modbus RTU facilitates the exchange of data between diverse devices, while Bacnet MS/TP is specifically tailored for building automation, ensuring interoperability and effective communication among various equipment within the system.

However, not all required equipment are completely installed in pilot site. There are four additional sensors to be installed in Demo Site 3 outlined in Table 10. The Demo Site 3 has many sub-meters beside the main meters. However, there is not energy measured floor based and lighting and appliances are metered as tenant electricity - together with one meter. Energy metering equipment list is in

Table 11 and the additional installation will be detailed by WP3 Deliverable.

Table 9. IEQ sensors needed for operational rating calculation and the description of DS3 equipment

Value Name	Unit	Timestep	Information	Equipment Network protocols and integration to system
IEQ sensors				
Room air temperature sensor	°C	15 min	Schneider Electric Room Controller SE8300; Rooms selected for testing: office, meeting room and two classrooms	Modbus RTU (Bacnet MS/TP) integration into BMS
Room CO_2 volumetric concentration	ppm	15 min		Modbus RTU (Bacnet MS/TP) integration into BMS
Room PM2.5 volumetric concentration	µg/m^3	N/A	Not measured	N/A
Outdoor air ventilation flow rate to the room*	L/s	10 min	VAV in rooms 206, 207, 309 (office, meeting room and classroom)	Modbus RTU (Bacnet MS/TP) integration into BMS
Room occupancy (no of occupants or from presence sensor)	persons or m^2/person	N/A	not measured, could be calculated from CO2 and air flow	N/A
Outdoor air temperature	°C	1 hour	Weather station of the region (Tallinn-Harku)	historical data
Outdoor CO_2 volumetric concentration	ppm	N/A	not measured, default 400 ppm	N/A
Room air relative humidity	%	15 min	Schneider Electric Room Controller SE8300; Rooms selected for testing: office, meeting room and two classrooms	Modbus RTU (Bacnet MS/TP) integration into BMS
Outdoor PM2.5 volumetric concentration	µg/m^3	N/A	not measured	N/A
Outdoor air relative humidity	%	1 hour	Weather station of the region (Tallinn-Harku)	historical data
* if measured, no need to measure the number of occupants. In CAV system, design air flow rate may be used instead. System status to be monitored or inferred from CO2 level readings.				

Table 10. IEQ sensors to be installed in DS3 for operational rating calculation

Value Name	Unit	Timestep	Information	Equipment Network protocols and integration to system
IEQ or outdoor sensors to be installed				
Outdoor air temperature	°C	daily	daily average is min step	Building weather station connected to IoT platform - TBD
Outdoor CO_2 volumetric concentration	ppm	daily	daily average is min step	
Outdoor PM2.5 volumetric concentration	µg/m^3	15 min	-	
Room PM2.5 volumetric concentration	µg/m^3	15 min	15 min is min step	Modbus RTU (Bacnet MS/TP) integration into BMS

Table 11. Description of DS3 electricity, heating and cooling energy meters

Value Name	Unit	Timestep	Information	Equipment Network protocols and integration to system
Energy meters existing				
Total electricity - building	kWh	daily		Modbus TCP
Plugs and lights electricity - per floor	kWh	daily		Modbus TCP
Tenant 1 electricity submeter	kWh	daily	test hall AC, plugs, lights and different work benches	Modbus TCP
Tenant 2 electricity submeter	kWh	daily	test hall plugs, lights and different work benches	Modbus TCP
Tenant 3 electricity submeter	kWh	daily	test hall plugs, lights and different work benches	Modbus TCP
Tenant 4 electricity submeter	kWh	daily	test hall plugs, lights	Modbus TCP
Tenant 5 Test Hall submeter	kWh	daily	test hall lighting and different work benches	Modbus TCP
Climate chamber submeter	kWh	daily		Modbus TCP
Pumps, service room lights and plugs submeter	kWh	daily		Modbus TCP
Elevator submeter	kWh	daily		Modbus TCP
Server room and controllers submeter	kWh	daily		Modbus TCP
Devices for air conditioning submeter	kWh	daily	dryer, humidifier, also some lighting	Modbus TCP
Fancoils, plugs and lights, work devices submeter	kWh	daily		Modbus TCP
Chiller submeter	kWh	daily		Modbus TCP
AHU 2 submeter	kWh	daily		Modbus TCP
AHU 1 submeter	kWh	daily		Modbus TCP
AHU 9 submeter	kWh	daily		Modbus TCP
AHU 4 submeter	kWh	daily		Modbus TCP
AHU 3 submeter	kWh	daily		Modbus TCP
nZEB test facility submeter	kWh	daily		Modbus TCP
PV production	kWh	daily		Modbus TCP
Heating main meter	kWh	1 hour		Modbus TCP
|-> Radiators submeter	kWh	1 hour		Modbus TCP
|-> Test hall heating submeter	kWh	1 hour		Modbus TCP
|-> AHU heating + Air curtains heating + Underfloor heating submeter	kWh	1 hour		Modbus TCP
|-> Test hall AHU heating submeter	kWh	1 hour		Modbus TCP
Cooling main meter	kWh	1 hour		Modbus TCP
|-> Test hall AHU cooling submeter	kWh	1 hour		Modbus TCP

5.2 Communication readiness to CIEM

The existing IoT platform is the building automatics web server EcoStructure Building operation WebStation (HTTP: Non-binary, port configurable, default 80; HTTPS: Encrypted supporting TLS 1.2, 1.1, and 1.0, port configurable default 443), where the sensors and meters data are collected. The detailed description is in Figure 5. The Gateway will be set up to communicate with CIEM.

The communication with CIEM will be detailed in T4.1.

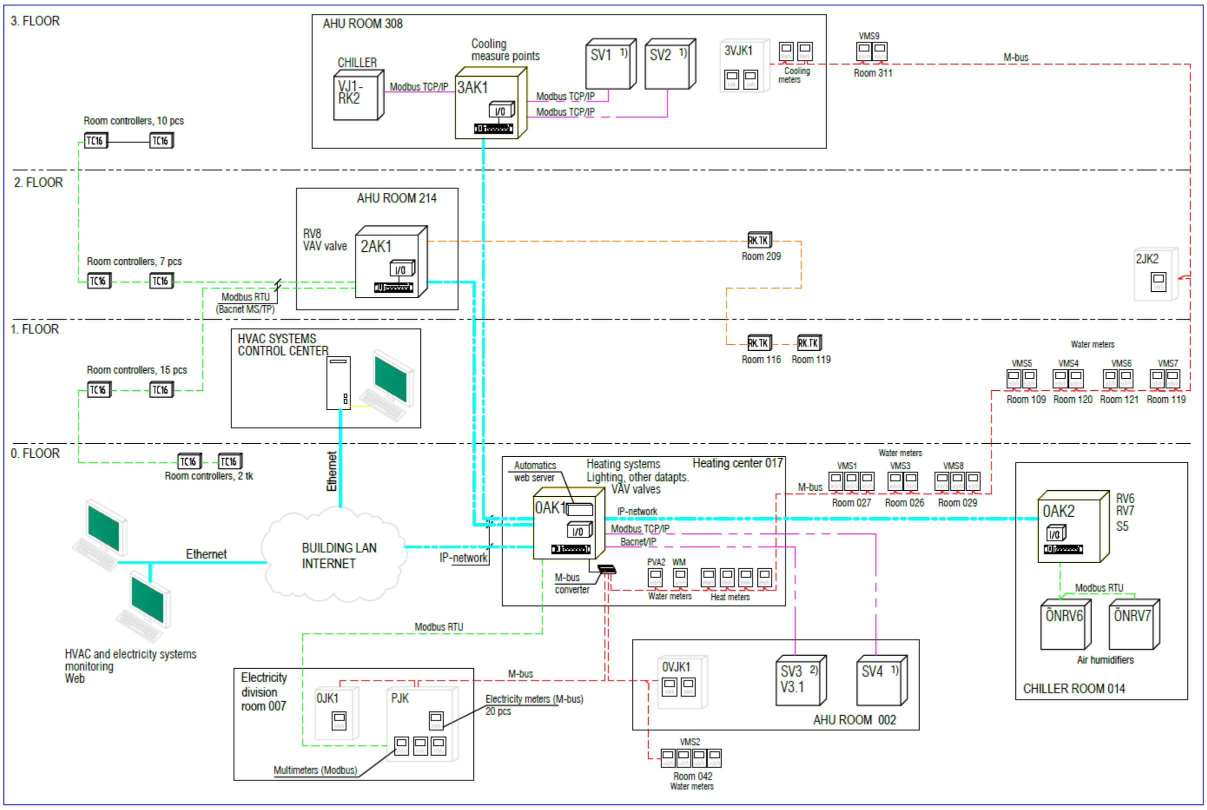


Figure 5. The Building Automatics overview of Demo Site 3

5.3 Actions

In Demo Site 3 the additional IEQ sensors will be installed. The activities and milestones of following months are in Table 12. As for all buildings, in final months, there is need for feedback, how works the communication with CIEM.

Table 12. Pilot's activities and milestones for DS3

No.	Milestone name	Due date	Means of verification
MS1	IoT platform integration with CIEM	M21	The IoT platform is integrated with CIEM
MS2	Installation of additional IEQ sensors	M22	The sensors are installed into 2 rooms and to the external environment of the building.
MS3	The feedback of the communication with CIEM	M28	Real-time and historical data exchange with CIEM works in pilot side.

6 Demo Sites #4-9 – Leitza Complex Buildings

The installed equipment list of Leitza's buildings is short. There are installed Renewable Energy Sources (RES) generation meter for all area, self-consumed electricity meter of collective photovoltaic system, total electricity consumption of the assessed area, (metered separately per each pilot building) including the street light consumption. All energy meters will log in 60 min timestep and in kWh. There is planned installation of IEQ sensors, weather station and required energy meters. These are described in the following sections for all buildings. Outdoor air ventilation flow rate to the room is not planned to measure, because the building has natural ventilation, and it is hard to measure the air flow in this case. The equipment network protocol is planned to be LORA (Figure 6). The weather station could be a single station, since the neighbourhood is small.

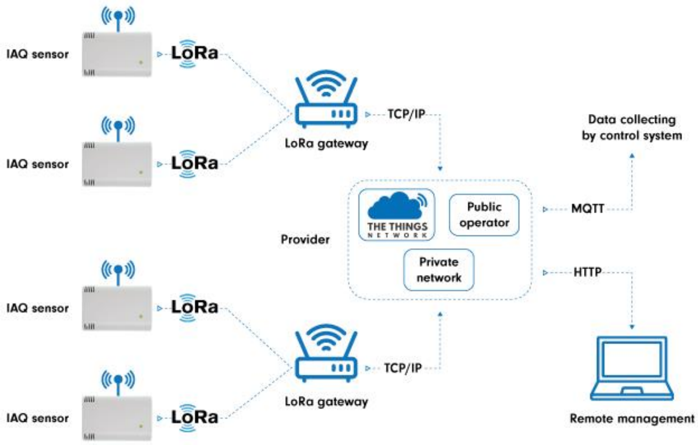


Figure 6. LORA protocol explanation[1]

6.1 Metering equipment for operational rating

6.1.1 DS 4. Single family housing

It is a detached single-family house located in Leitza where 4 people currently live. The property consists of 4 bedrooms, kitchen, living room, garage, and auxiliary space in the semi-basement. It is a building constructed in 2001, so it was built according to the Spanish building regulations NBE-79 with very little insulation. The IEQ sensors to be installed to DS4 are in Table 13. The energy meters to be installed to DS4 are in Table 14Table 13.

[1] https://www.unipi.technology/reference/integration-of-an-iot-indoor-air-quality-sensor-with-lora-communication-364

Figure 7. Exterior view of the building DS4

Table 13. IEQ sensors to be installed in DS4 for operational rating calculation

Value Name	Unit	Timestep	Information	Equipment Network protocols and integration to system
IEQ or outdoor sensors to be installed				
Room air temperature sensor	°C	15 min	Living Room; Bedroom 02	Comfort sensor (Temp/Hum/CO2) RAY LORA TH
Room CO2 volumetric concentration	ppm	15 min	Living Room; Bedroom 02	Comfort sensor (Temp/Hum/CO2) RAY LORA TH
Room air relative humidity	%	15 min	Living Room; Bedroom 02	Comfort sensor (Temp/Hum/CO2) RAY LORA TH
Room PM2.5 volumetric concentration	$\mu g/m^3$	15 min	Living Room; Bedroom 02	
Outdoor PM2.5 volumetric concentration	$\mu g/m^3$	15 min	-	
Outdoor air temperature	°C	daily	daily average is min step	
Outdoor CO_2 volumetric concentration	ppm	daily	daily average is min step	

Table 14. Energy meters to be installed in DS4 for operational rating calculation

Value Name	Unit	Timestep	Information	Equipment Network protocols and integration to system
Energy meters existing				
Gas meter	m^3	daily	natural gas boiler	model: Pulse converter + transmitter LORA; communication protocol: LORA
Heating & DHW Thermal energy (heating from boiler to radiators)	kWh	daily	natural gas boiler with wood-burning fireplace support	model: Thermal energy meter with pulse output (DN15) + transmitter LORA; communication protocol: LORA; requires hydraulic installation

Heating thermal energy (wood fireplace heat exchanger)	kWh	daily	natural gas boiler with wood-burning fireplace support	model: Thermal energy meter with pulse output (DN15) + transmitter LORA; communication protocol: LORA; requires hydraulic installation
Lighting electricity	kWh	60 min		sensor with 15A ammeter clamp; communication protocol: LORA

6.1.2 DS 5. Apartment building

Demo site 5 is a flat located on the ground floor of a residential block of 3 flats (1 flat per floor). A family of 4 people currently lives there. The property consists of 3 bedrooms, kitchen, living room, 2 bathrooms and a storage room and has a surface area of 92.5 m^2.

Access to the dwelling is via a general entrance to the building (north-east façade), 34 Elgoien Street. The dwelling is also adjacent to the boiler room located at the bottom of the terrace on floor 1. The rest of the dwelling faces the north-east, south-east and south-west façades.

The building is old, originally it did not house any living quarters on the ground floor, but the object dwelling was formed in 1985.

The IEQ sensors to be installed to DS5 are listed in Table 15. The energy meters to be installed are iTable 13n

Table 16.

Figure 8. Exterior view of the building DS5

Table 15. IEQ sensors to be installed in DS5 for operational rating calculation

Value Name	Unit	Timestep	Information	Equipment Network protocols and integration to system
IEQ or outdoor sensors to be installed				
Room air temperature sensor	°C	15 min	Bedroom 01	Comfort sensor (Temp/Hum/CO2) RAY LORA TH

Room CO2 volumetric concentration	ppm	15 min	Bedroom 01	Comfort sensor (Temp/Hum/CO2) RAY LORA TH
Room air relative humidity	%	15 min	Bedroom 01	Comfort sensor (Temp/Hum/CO2) RAY LORA TH
Room PM2.5 volumetric concentration	$\mu g/m^3$	15 min	Bedroom 01	
Outdoor PM2.5 volumetric concentration	$\mu g/m^3$	15 min	-	
Outdoor air temperature	°C	daily	daily average is min step	
Outdoor CO_2 volumetric concentration	ppm	daily	daily average is min step	

Table 16. Energy meters to be installed in DS5 for operational rating calculation

Value Name	Unit	Timestep	Information	Equipment Network protocols and integration to system
Energy meters existing				
Gas meter	m^3	daily	natural gas boiler	model: Pulse converter + transmitter LORA; communication protocol: LORA
Heating & DHW Thermal energy (heating from boiler to radiators)	kWh	daily	natural gas boiler	model: Thermal energy meter with pulse output (DN15) + transmitter LORA; communication protocol: LORA; requires hydraulic installation
Lighting electricity	kWh	60 min		sensor with 15A ammeter clamp; communication protocol: LORA

6.1.3 DS 6. Commercial and apartment building

Demo site 6 is a mixed-use building, as the ground floor houses a chocolate shop and an auxiliary space, and floors 1 and 2 house two flats. The building was built in 1860.

The first floor consists of 4 bedrooms, kitchen, living room and two bathrooms. The second floor consists of 3 bedrooms, kitchen, living room and two bathrooms. On the same floor there is also a storage space.

The main entrance to the building is from calle Elgoyen no. 32. The access to the chocolate shop is from the opposite façade.
The IEQ sensors to be installed to DS6 are in

Table 17. The energy meters to be installed are iTable 13n Table 18.

Figure 9. Exterior view of the building DS6

Table 17. IEQ sensors to be installed in DS6 for operational rating calculation

Value Name	Unit	Timestep	Information	Equipment Network protocols and integration to system
IEQ or outdoor sensors to be installed				
Room air temperature sensor	°C	15 min	Shop; Living Room Flat 01; Bedroom Flat 02	Comfort sensor (Temp/Hum/CO2) RAY LORA TH
Room CO2 volumetric concentration	ppm	15 min	Shop; Living Room Flat 01; Bedroom Flat 02	Comfort sensor (Temp/Hum/CO2) RAY LORA TH
Room air relative humidity	%	15 min	Shop; Living Room Flat 01; Bedroom Flat 02	Comfort sensor (Temp/Hum/CO2) RAY LORA TH
Room PM2.5 volumetric concentration	$\mu g/m^3$	15 min	Shop; Living Room Flat 01; Bedroom Flat 02	
Outdoor PM2.5 volumetric concentration	$\mu g/m^3$	15 min	-	
Outdoor air temperature	°C	daily	daily average is min step	
Outdoor CO_2 volumetric concentration	ppm	daily	daily average is min step	

Table 18. Energy meters to be installed in DS6 for operational rating calculation

Value Name	Unit	Timestep	Information	Equipment Network protocols and integration to system
Energy meters existing				
Heating energy - per flat	kWh	daily	two thermal energy meters - from biomass	Model: Thermal energy meter with pulse output (DN15) + transmitter LORA;

			boiler to flat 01 and to flat 02	communication protocol: LORA; requires hydraulic installation
Heat pump electricity	kWh	15 min	-	model: sensor with 15A ammeter clamp; communication protocol: LORA
DHW heating gas meter - for all apartments	m^3	daily	one gas meter for Flat 01 and Flat 02 consumption in total	model: Pulse converter + transmitter LORA; communication protocol: LORA
DHW electric meter - shop	kWh	15 min	Electric water boiler for shop	model: sensor with 15A ammeter clamp; communication protocol: LORA
Lighting electricity	kWh	60 min	-	

6.1.4 DS 7. City Hall

Demo site 7 is the City Hall, which is located in Elbarren street No.1 of Leitza. It was constructed in 1917, so it has a wooden structure and mansory walls. The roof was renovated totally in 2018.

There are 22 daily employees working and it receives approximately 30 daily visitors. This building contains multiple uses: offices, the court of justice, municipal archives, a multipurpose room, a storage space, a radio station, social services, Basque language school and so on.

The main entrance is from the main façade overlooking the town square, in the portico of the building. Once inside the building, the main core connecting all the floors is located in the central part of the building. The boiler room has its independent access at the back of the building on the ground floor.

The IEQ sensors to be installed to DS7 are in Table 19Table 15. The energy meters to be installed are iTable 13n Table 20.

Figure 10. Exterior view of the building DS7

Table 19. IEQ sensors to be installed in DS7 for operational rating calculation

Value Name	Unit	Timestep	Information	Equipment Network protocols and integration to system
IEQ or outdoor sensors to be installed				
Room air temperature sensor	°C	15 min	Main Officies; Plenary Hall	Comfort sensor (Temp/Hum/CO2) RAY LORA TH

Room CO2 volumetric concentration	ppm	15 min	Main Officies; Plenary Hall	Comfort sensor (Temp/Hum/CO2) RAY LORA TH
Room air relative humidity	%	15 min	Main Officies; Plenary Hall	Comfort sensor (Temp/Hum/CO2) RAY LORA TH
Room PM2.5 volumetric concentration	$\mu g/m^3$	15 min	Main Officies; Plenary Hall	
Outdoor PM2.5 volumetric concentration	$\mu g/m^3$	15 min	-	
Outdoor air temperature	°C	daily	daily average is min step	
Outdoor CO_2 volumetric concentration	ppm	daily	daily average is min step	

Table 20. Energy meters to be installed in DS7 for operational rating calculation

Value Name	Unit	Timestep	Information	Equipment Network protocols and integration to system
Energy meters existing				
Heating gas meter - building	m^3	daily		model: Pulse converter + transmitter LORA; communication protocol: LORA
DHW electric meter - building	kWh	15 min	Electric water boiler	model: sensor with 15A ammeter clamp; communication protocol: LORA
Lighting electricity	kWh	60 min		
RES generation	kWh	60 min		

6.1.5 DS 8. School building

Demo site 8 is the Erleta School where today 314 children between 3- and 12-years old study and has 36 teachers. The building has two parts: a main block built in 1968 and the annex building built in 1979.

The main building consists of classrooms, offices, small storeroom, photocopy room, toilets, kitchen and canteen. The annex building has a gymnasium and its storage spaces, changing rooms, laboratories, another small storage space, classrooms, offices, toilets and boiler room.

Both parts of the school have their own access. The main building is accessed from the central part of the building from the courtyard. And on the same façade, slightly recessed, is the access to the annex building. In any case, both parts are connected with a door on each floor that connects the vertical communication core of the annex building with the main corridor of the main building. The canteen, although integrated in the main building and with access from the interior, also has its own independent access from the exterior.

The IEQ sensors to be installed to DS8 are in Table 21. The energy meters to be installed are iTable 13n

Table 22.

Figure 11. DS8 - school building

Table 21. IEQ sensors to be installed in DS8 for operational rating calculation

Value Name	Unit	Timestep	Information	Equipment Network protocols and integration to system
IEQ or outdoor sensors to be installed				
Room air temperature sensor	°C	15 min	Classroom 01- Floor 01; Classroom 01- Floor 02; Staff room	Comfort sensor (Temp/Hum/CO2) RAY LORA TH
Room CO2 volumetric concentration	ppm	15 min	Classroom 01- Floor 01; Classroom 01- Floor 02; Staff room	Comfort sensor (Temp/Hum/CO2) RAY LORA TH
Room air relative humidity	%	15 min	Classroom 01- Floor 01; Classroom 01- Floor 02; Staff room	Comfort sensor (Temp/Hum/CO2) RAY LORA TH
Room PM2.5 volumetric concentration	μg/m^3	15 min	Classroom 01- Floor 01; Classroom 01- Floor 02; Staff room	
Outdoor PM2.5 volumetric concentration	μg/m^3	15 min	-	
Outdoor air temperature	°C	daily	daily average is min step	
Outdoor CO_2 volumetric concentration	ppm	daily	daily average is min step	

Table 22. Energy meters to be installed in DS8 for operational rating calculation

Value Name	Unit	Timestep	Information	Equipment Network protocols and integration to system
Energy meters existing				
Heating - gas meter	m^3	daily	-	model: Pulse converter + transmitter LORA; communication protocol: LORA
Kitchen gas burner	m^3	daily	-	

Lighting electricity	kWh	60 min	-	sensor with 15A ammeter clamp; communication protocol: LORA

6.1.6 DS9. Sports centre

Demo site 9 is the Amazabal sports centre. It is located in Amazabal street No.39 at the rear of the demosite8 building. It was built in 2001 and the envelope was refurbished in 2016. A ventilated façade with insulation was built and the exterior carpentry was replaced by others with better thermal performance. It is a multi-sports pavilion with a 44.70x22m and 7m high court where all kinds of sports activities such as soccer, handball, basketball, etc. can be carried out. Likewise, the facility has 3 gymnastics rooms, squash and sauna. It also has bleachers for 400 spectators, dressing rooms and facility rooms. The access from the outside space is through the main façade on the ground floor, with a secondary access on the rear façade, and there are two external evacuation staircases leading to the upper floor.

The IEQ sensors to be installed to DS9 are in

Table 23. The energy meters to be installed are iTable 13n Table 24.

Figure 12. Exterior view of the building DS9

Table 23. IEQ sensors to be installed in DS9 for operational rating calculation

Value Name	Unit	Timestep	Information	Equipment Network protocols and integration to system
IEQ or outdoor sensors to be installed				
Room air temperature sensor	°C	15 min	Gym; Court-Bleachers	Comfort sensor (Temp/Hum/CO2) RAY LORA TH
Room CO2 volumetric concentration	ppm	15 min	Gym; Court-Bleachers	Comfort sensor (Temp/Hum/CO2) RAY LORA TH

Room air relative humidity	%	15 min	Gym; Court-Bleachers	Comfort sensor (Temp/Hum/CO2) RAY LORA TH
Room PM2.5 volumetric concentration	µg/m^3	15 min	Gym; Court-Bleachers	
Outdoor PM2.5 volumetric concentration	µg/m^3	15 min	-	
Outdoor air temperature	°C	daily	daily average is min step	
Outdoor CO_2 volumetric concentration	ppm	daily	daily average is min step	

Table 24. Energy meters to be installed in DS7 for operational rating calculation

Value Name	Unit	Timestep	Information	Equipment Network protocols and integration to system
Energy meters existing				
Heating gas meter - building	m^3	daily	oil-fired boiler and a storage tank	model: Pulse converter + transmitter LORA; communication protocol: LORA
Heat pump electricity	kWh	15 min	for heating; multi-split (2x1)-heat pump installation for the main gym	model: sensor with 15A ammeter clamp; communication protocol: LORA
Air conditioner for heating - fuel	m^3	daily	hot air heater with oil burner (diesel); Model: GER WIND W-250	model: Pulse converter + transmitter LORA; communication protocol: LORA
Air conditioner for heating - electricity	kWh	15 min	hot air heater with oil burner; Electrical power supply motors: 2 motors of 2.2kW each one	model: sensor with 15A ammeter clamp; communication protocol: LORA
Lighting electricity	kWh	60 min		model: sensor with 15A ammeter clamp; communication protocol: LORA

6.2 Communication readiness to CIEM

The IoT platform and communication is to be detailed in next months.

6.3 Actions

Demo Sites 4-9 in Leitza's area are poorly equipped. Therefore, there should be started with installation of the devices as soon as possible. It was estimated that the installation will be finished by M22. Further activities are outlined in Table 25.

Table 25. Pilot's activities and milestones for DS4-9

No.	Milestone name	Due date	Means of verification
MS1	Close the IoT devices installation planning	**M20**	The installation list of the sensors and meters is completed, and the installation can be started.
MS2	IoT devices installation	**M22**	The IoT devices are installed to the buildings.
MS3	The communication with CIEM	**M22**	The communication plan is defined and ready to integrate the IoT platform with CIEM.
MS4	IoT platform integration with CIEM	**M23**	The IoT platform is integrated with CIEM
MS5	The feedback of the communication with CIEM	**M28**	Real-time and historical data exchange with CIEM works in pilot side.

7 Case Studies Summary

7.1 Pilot risks and Mitigation Actions

The possible risks and mitigation actions are in Table 26. In general, there are three categories of risk: risk on IoT security (e.g. software issues), risks on technology (e.g. hardware and connectivity) and risks related to end-users.

Table 26: Risks and mitigation actions

Risk	Description	Mitigation measures
Risks on IoT security (software issues)		
Software vulnerabilities	Vulnerabilities that affect the functionality of devices or IoT platform.	Regular update for protection against vulnerability. Immediate notification and action in case of vulnerability.
Leak of privacy data	Privacy data protection is insufficient	Encrypt commands and sensitive user data collected by IoT devices. Ensure encryption is complete and correct configured.
Insecure data transfer and storage	Risk for example due to the lack of encryption and access controls.	Implement secure authentication. Specify access rights. Use encrypts in data transfer.
Server maintenance	Hardware will break, system will be overload, cyber attacks	Dedicated person should conduct routine preventive maintenance and data backups. Server should be updated regularly.
Risks on technology (hardware, connectivity)		
Measurement equipment error	Equipment do not work correctly	There should be communication so IoT platform will discover the error and sends notification.
Connection problems	The connection is off	Regular check or monitoring the connectivity.
Equipment installation problems	The installer does not have technical guidance and instructions.	Prepare the technical guidance.
Delay of equipment installation	Delays can be triggered to different aspects and force majeure.	Preparing the installation plan in advance.
Not enough or sufficient data for the project	In case of data holes, wrong timestep etc.	The method dealing with data holes should be agreed within the project. The timestep and other data related aspects should be discussed and communicated to installation/pilot site teams.

Risk	Description	Mitigation measures
Risks related to end-users		
Lack of agreement or stability of end-users	There is no permission of installation from end-user due to misunderstanding or some other reason	Prepare simple and clear information about the project and installation aspects.
End-users do not feel comfortable with the collection of information	People are not willing to participate in surveys, don't want to share information	Prepare a relatively short and clear questionnaire. Share information about the project and show the results of survey. Explain how the anonymity is guaranteed, if so.
End-users do not want to install IoT devices	Users don't want to install the device in their room, because they do not feel themselves comfortable with that.	Explain in detail what kind of devices will be installed, what is the purpose and what it measures. What they will get from this measurement results or why it is important.

8 Conclusions

This document is a deliverable that provides an overview of the planning and setup activities in relation to the 9 SmartLivingEPC pilot buildings. The various tables outline the existing equipment and the planning for future installations in each pilot. An overview of the status of the communication methods and data exchange with CIEM, the Common Information Exchange Model, is also given.

Demo Sites #1 to #3 are smart buildings; they are thus already well equipped with IEQ sensors and energy meters, including also non-standard sensors such as presence sensors for room occupancy.

However, additional outdoor CO_2 and PM2.5 detection sensors shall be installed; three smart buildings (buildings #1-#3) are otherwise already delivering operational data to their own dedicated IoT platform. Such measurements are stored within an API that could be accessed and interfaced with the CIEM. In the next months it will be discussed whether an additional interface will be necessary for Pilot #1.

The general communication with the CIEM will be detailed in T4.1.

The Leitza pilot complex building (which includes buildings #4 to #9) currently has only RES generation meters for all areas, self-consumed electricity from collective photovoltaic systems, total electricity use per building, and energy used by the public lighting. The planned installation features IEQ sensors (RH, indoor and outdoor CO_2 and PM2.5), a weather station and additional energy meters. The equipment network protocol is planned to be LORA, and the installation plan regards IoT devices as well as the IoT platform integration with CIEM, which will be implemented from the start.

Furthermore, the demand of additional installation of energy meters will be detailed by WP3.

HE Grant Agreement Number: 101069639
Document ID:
WP<n.>/D/IR

Advanced Energy Performance Assessment towards Smart Living in Building and District Level

https://www.smartlivingepc.eu/en/

https://www.linkedin.com/company/smartlivingepc/

https://twitter.com/SmartLivingEPC

https://www.youtube.com/channel/UC0SKa-20tiSabuwjtYDqRrQ

This project has received funding from the European Union's Horizon Europe research and innovation programme under the grant agreement number 101069639. The European Union is not liable for any use that may be made of the information contained in this document, which is merely representing the authors' view.