InCUBE
sustainable building innovations

WP7 – D7.1

Pilot Planning and Setup

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FBK

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0.1	16/06/2023	FBK	First version submitted to reviewers
0.2	30/06/2023	FBK	Final version with reviewer implementation
0.3	14/07/2023	FBK	Final version with reviewer implementation and CERTH comments
1.0	21/07/2023	FBK	Final version

Executive Summary

Successful renovation Use Cases with tangible results can act as an exemplar for local communities to be inspired and motivated by. Especially for Europe, where preserved historical buildings and districts (characterized by strong territorial particularities) can be found in many city-centres with recently rebuilt surrounding areas, this comes as an add on challenge for the energy transition plan towards low – to zero carbon cities. InCUBE will demonstrate, monitor and assess the proposed solutions in three different large-scale renovation projects. These demonstrations will take place in three locations in the EU (Trento-IT, Zaragoza-ES, Groningen-NL), fully complementary, to achieve maximum representation of climate, cultural, socio economic and regulatory conditions.

A holistic evaluation framework will be applied to the three-demo utilizing well-defined metrics, that enables the efficient monitoring of the project's success and sustainability performance. To maximize the scalability and replicability (SRA) of the solutions, InCUBE will define an outreach strategy for sharing knowledge and promoting results and will also connect to other projects and initiatives with the ambition to sustain an innovative and inclusive European stakeholders' community.

In this deliverable a global vision of each innovation intervention is offered. A view of the time planning for every intervention is priority described. This purpose was in part fulfilled by the milestone MS12 where a specific Gantt chart was developed to track every step and sub step of each intervention with the related time planning; with the deliverable D7.1 the goal is to explore in more discursive way those steps. One of the aims was to identify and highlight every possible criticizes in operation that involved the renovation of the demo. One scope of the deliverable was to finalize the required licensing that is a major cause of delay. Another important part in the D7.1 is to track the progress done so far to underline the effort of each partner in the achievement of the prefixed targets.

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List of Acronyms and Abbreviations

Term	Description
BIM	Building information model
UAV	Unmanned Aerial Vehicle
IPD	Integrated Project Delivery
LPS	Last Planner System
PPE	Personal Protective Equipment
ACS	Anti-collision System
AB	Area Boundary
RES	Renewable Energy System
BIPV	Building Integrated Photovoltaics
BTES	Borehole Thermal Energy Storage
GWP	Global Warming Potential
DHC	District Health Centre
GSHP	Ground Source Heat Pump
SRI	Smart readiness Indicator
EPC	Energy performance certification
TRL	Technology Readiness Level
PNRR	Piano nazionale di ripresa e resilienza - National recovery and resilience plan
CDW	Construction and Demolition Waste

RD	Resilience Dashboard
RCS	Resilient Construction Site
JSO	Job Scheduling Optimizer
LCP	Lean Construction Platform

1 Introduction

The main object of the WP7 package is to demonstrate and validate the following approaches. More specifically, WP7 will:

a) prepare pilot sites for installation and deployment of solutions and train stakeholders for using the InCUBE Suite and its components (T7.1)

b) deploy the InCUBE Suite under real conditions as well as execute the renovation and construction activities, including renewables and maximizing the use of this kind of energy by creating Energy Communities (T7.2-T7.4)

c) holistically evaluate the InCUBE offered solutions and their impact (T7.5)

d) Prepare a replicability analysis based on the evaluation findings (T7.6).

1.1 Aim of the deliverable

T7.1 aims to ensure the smooth and timely implementation of demonstrations. T7.1 will guide the activities to be performed within T7.2-T7.4 and a dedicated site manager at each demo site will be responsible for the preparatory activities and the execution of works.

1.2 Dependencies with other tasks

Building upon the results of T1.3 and initial results from InCUBE P-GUIDE (prototype) the renovation scenarios and interventions will be defined and finalized. An implementation roadmap time plan (unique to the specific requirements of each country) will be developed early in the project to identify all the external actors involved and the most critical steps (e.g., definition of authorizations, licensing for light/heavy works, contact relevant authorities, preparation of tenders) that need to be integrated in the project implementation to obtain all necessary clearances required on-time. The InCUBE Gantt will be further updated and made specific for each demo site, embracing roles and responsibilities of related InCUBE partners and important 3rd parties , outside this consortium, (e.g. external contractors assigned by the self-tenders of the demo site owners, accountable for own investments), to develop the aforementioned roadmap, where clear roles and responsibilities in implementing tasks, will be assigned, based on the country-specific requirements of each demo site. InCUBE R-GUIDE and WINER (prototypes) will be capitalized for scheduling the retrofitting scenarios. During T7.1, the stakeholders involved will also be trained for the implementation of the InCUBE Suite, capitalizing on the dedicated training modules developed within T6.4.

1.3 Structure of the deliverable

This deliverable will be divided into three main chapters; each chapter will focus on the three-demo site and solutions of each partner involved in the renovation actions. The main focus is to track every step required to apply solutions to the demo case. In this report there is also the exploitation of achievements, changes, and critical steps or other constraints.

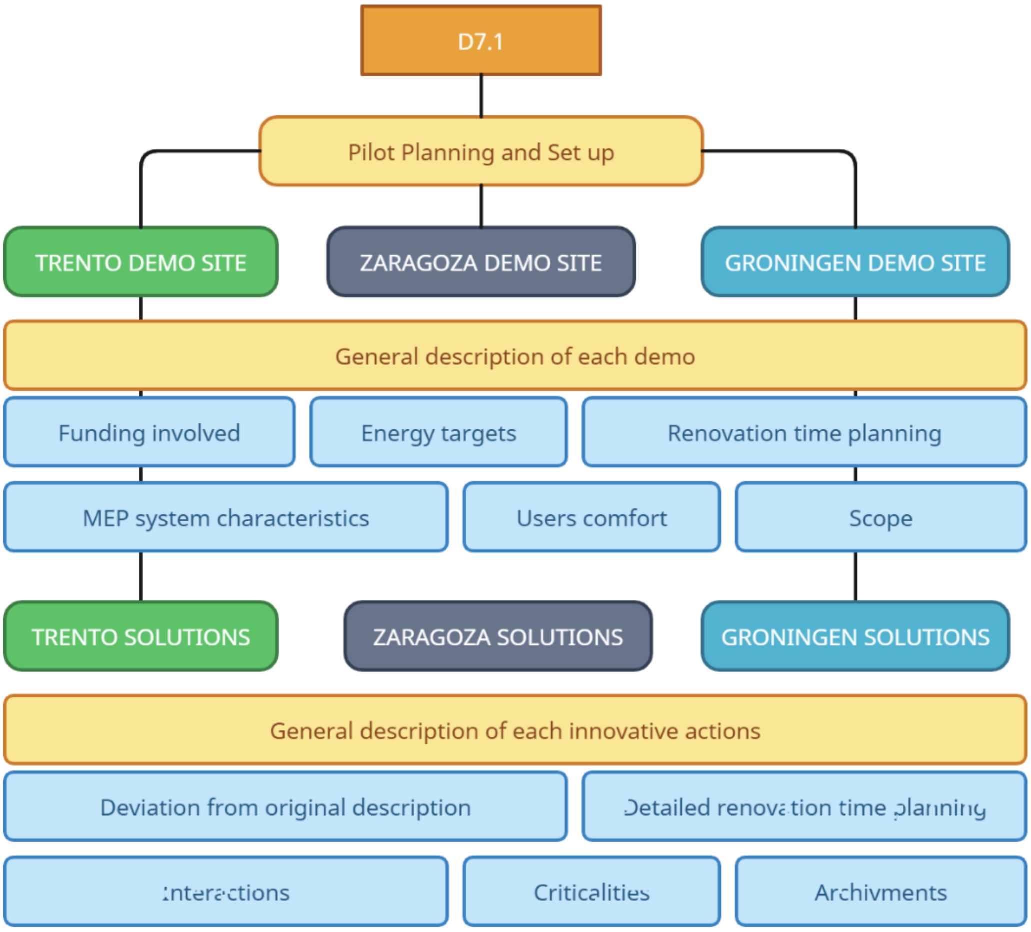

Figure 1 Scheme of contents in D7.1

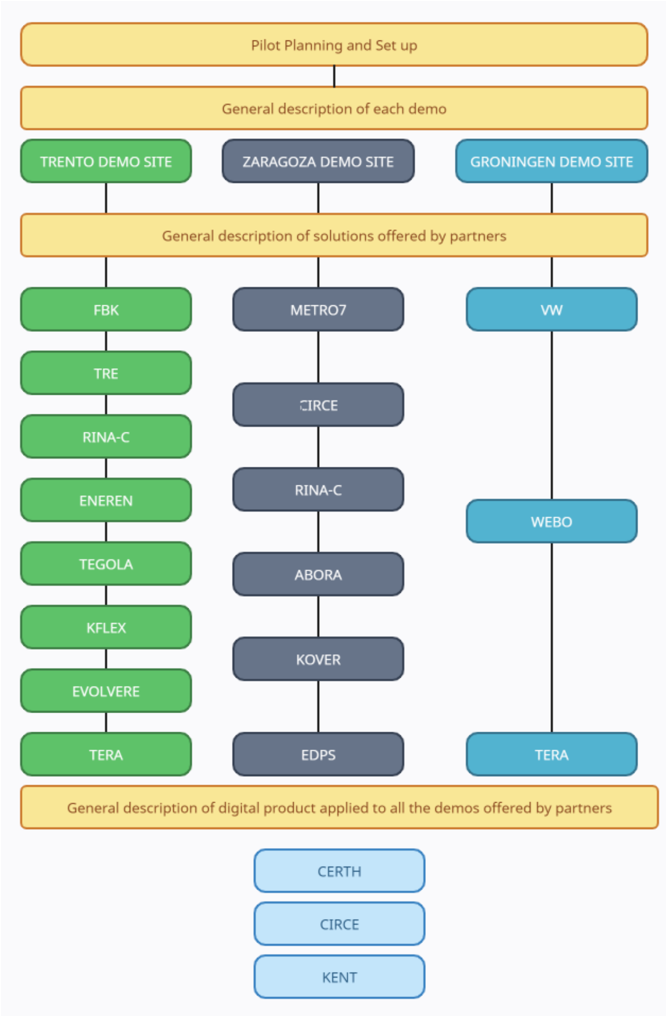

Figure 2 Scheme of structure of D7.1

In the following report all the solutions and digitalization of product and process, Pillars 1, 2 and 3 are shown in detail by each technology's leader. Pillar 4 was not explored in this deliverable.

	Leader	**Demo**
PILLAR#1: InCUBE PROCESS Innovations supporting INDUSTRIALIZATION of renovation		
Solutions supporting Off-Site Manufacture		
BIM-based Design of Prefab Modules	VW	G
Solutions supporting On-Site Installation and Automation		

BIM-connected Robotic Systems: a) Demolition Robot Automating Demolition of Facades // b) Telescopic Crane Enabling Scaffold-less Construction // c) BIM-to-Field Drilling Robot	VW	G
3D reality-based surveying and 3D modelling	FBK	I
IPD, A3 and LPS – driven Rehabilitation	METRO7	Z
Personal Protective Equipment (PPE) Monitoring System	RINA-C	I,Z
Anti-Collision System (ACS)	RINA-C	I
Area Boundary (AB) System	RINA-C	I,Z
Solutions supporting Circular Construction		
Construction Waste Sorting Robot	VW	G
Waste Tracking and Management	RINA-C	I
Environmental Monitoring System	RINA-C	I
PILLAR#2: InCUBE PRODUCT Innovations supporting utilization of new MATERIALS		
Envelope – Material Solutions		
Prefab Facades “Expanding” Available Space	WEBO/VW	G
Modular Facades with Integrated Building Elements	KOVER	Z
ROCK CNX Insulation to reduce thermal bridge	K-FLEX	I
RES Generation Solutions		
BIPV pre-installed on Prefab Facades	WEBO/VW	G
Hybrid Thermal Solar Panels (BI-SHE)	ABORA	Z
Tegosolar® BIPV Shingles	TEGOLA	I
Energy Storage Solutions		
Smart Borehole Thermal Energy Storage BTES (District-level solution)	ENEREN/TRE/FBK	I
Advanced HVAC Solutions		

Low GWP DHC connected GSHP	ENEREN	I
Cross-Cutting Solutions		
Low Temperature 100% RES DHC (District-level solution)	ENEREN/TRE/FBK	I
PILLAR#3: InCUBE SOFTWARE Innovations supporting DIGITALIZATION of products and processes		
Drone-enabled Scan-to-BIM 3D modelling	VW	G
Laser 3D Scanning	METRO7	Z
Modular BIM/CIM Platform – A multi-object BIM library facilitating BIM development	CIRCE	A
Eclipse sensiNact Platform – Developing holistic and interoperable Digital – Twins (DT)	KENT	A
INTEMA – Enhanced energy assessment and integrated energy management	CERTH	A
VERIFY – Dynamic life cycle evaluations	CERTH	A
Planning Guide (P-GUIDE) – Optimizing renovation planning and supporting BRP	CERTH	A
Resilience Dashboard (RD) – Ensuring enhanced workers safety and increased efficiency	RINA-C	I
AR/VR Training Suite – Offering augmented next-generation training and assistance	CERTH	A
ENERGY CLOUD EMS	CIRCE	A
Smart Building EMS (S-BEMS) – An energy community-oriented AI-enabled BEMS	TERA	I,G
District EMS (EvoDistrict) – Enhancing the optimal management of DRES	EVOLVERE/FBK	I
Lean Construction Platform (LCP) – IPD-based workflow optimization	CIRCE	A

Job Scheduling Optimizer (JSO) – Optimization of construction/retrofitting works	CERTH	A
PILLAR#4: InCUBE BUSINESS Innovations supporting NEW ENTRANTS		
Renovation Marketplace	CERTH	A
Novel Business Models including the formation of RECs	RINA-C	A
Gender Impact Matrix	LAMA	A
Training Modules	NEC	A

Table 1 Overview of solutions and digitalization products

Legend

I: Italian demo site

Z: Zaragoza demo site

G: Groningen demosite

A: All demo

2 Trento demo site

2.1 General description of the demo

The Santa Chiara district is a district located at the South-east of the historic center of Trento. This was relevant for the proposal because it was in a progressive abandonment since the end of the 1990, social marginality and building decay, lack of space protection, crime episodes (theft, mugging, harassment). The neighborhood was made up of 5 publicly owned buildings (B1, B2, B3, B4, B6, to be deeply renovated) for tertiary uses and residential spaces, a mixed-uses, residential-tertiary, private complex consisting of two buildings (B5 to be built) and a large green space.

Funding involved in the district (except InCUBE funds):

B1: Total amount for conventional interventions – Presidency of the council of ministers, municipality fund - 3.770.000 euro

B2: Total amount for conventional interventions – Presidency of the council of minister fund – 1.200.000 euro

B3: Total amount for conventional interventions – Presidency of council of minister fund - 12.500.000 euro

B4: Total amount for conventional interventions - Presidency of council of minister fund - 400.000

B5: Total amount for the construction of the entire buildings – Private fund – 23.000.00 euro

B6: Total amount for conventional interventions – PNRR, Province of Trentino and municipality fund- 9.350.000 euro

Renovation time plan:

For buildings B2 and B4 the work is done. For buildings B1, B3, B5 the executive design is being completed and the construction site is started. The construction site will last for the period 2022-2024. For building B6 the executive design will be carried out during the first half of 2023 and the construction site is scheduled for the end of 2023-2024.

General Scope of Renovation:

The building will be transformed to serve several purposes including municipal archives, reception, info-points, an exhibition space, administrative spaces, promotion space for incubation and start-up activities, spaces for the Trento Film festival offices, improved access to the "Cuminetti" experimental theatre, guesthouse areas, common areas for socializing and recreation.

MEP system characteristics (Building B6):

Future Heating system: The two condensing boilers will remain. In the actual heating system will be added a new geothermal heat pump of 300 kW. Another geothermal heat pump of 28 kW will supply heat and cooling to building B1.

Future Cooling system: The actual cooling system will remain. The new geothermal heat pump will supply also additional cooling.

Future Ventilation: no change

Future Lighting: parts of the lighting system will be substituted with LED lamps.

The occupancy sensors for lighting control will remain. Environmental sensors (temperature, relative humidity, CO2, lux) and energy meter (smart plugs) identified by [TERA] will be installed in the most significant – in terms of usage - areas of Building B6. To track Building B6 energy use (both consumption and production) on a 15-minute frequency a dedicated an innovative device capable to read the electrical fiscal open meter “2G” as for ARERA (National Italian Energy Authority) directive will be provided by EVOLVERE and installed at the facility. The monitoring platform, based on TERA IoT edge computing gateway for the hardware perspective and built in alignment to the district monitoring platform provided by [EVOLVERE] implementing the algorithms developed by [FBK] for the software side, will be made available by partner [TERA].

Additionally, to the district monitoring platform, partner EVOLVERE will install several energy meters to track both energy consumption and production for the whole district.

Users comfort (Building B6):

Looking at the results from the questionaries, it can be stated that the current thermal comfort perceived by the users is quite poor. Indeed, both in summer and winter conditions, even if considered acceptable, the conditions are far below the desired comfort levels.

For what concerns the visual comfort, the performances seem to be much better. Anyway, the artificial lighting does not satisfy completely the comfort requirements of the users.

The overall results of this questionnaire suggest that some improvements are needed in the thermal management of the building, but also in the shading devices and the lighting.

Energy transformation (Building B6) Status and Targeted status:

Energy Needs: 250 kWh/m²/y → 188 kWh/m²/y

Current RES production: 0 MWh/y → 700 MWh/y

EPC Class: G → B+

Current SRI: 14.2% →85.7 %

Figure 3 Italian demo and Santa Chiara district overview

2.2 Overview of foreseen interventions and progress

In this chapter a general overview of innovation and conventional intervention on the demo are listed. For conventional interventions, progress is highlighted in this section. In the following chapter every innovative solution will be detailed explore.

Product Solutions:
Innovative
I. [K-FLEX] K-ROCK CNX Insulation to reduce thermal bridge.
II. [TEGOLA] Tegosolar BIPV Shingles (20 kW installed and in general 24 MWh/y).
III. [ENEREN] Low GWP-DHC connected GSHP (supplying building B1 and B6 side 450 MWh/y of heating and 250 MWh/y of cooling). For the two buildings there will be two different geothermal plants: one for B6 of heating capacity of 322,9 kW and another for B1 of heating capacity of 28,9 kW.
Conventional
I. [TRE]Insulation of the roof (new transmittance = 0.20 W/m2K) and replacement of the external windows with thermal break windows (new transmittance = 1.30 W/m2K).

Progress so far: Designer phase in progress the interventions should start in June 2024. Director of works was nominated.
II. [TRE]Small tank for daily thermal energy storage
Progress so far: No progress.
III. [TRE]LED lighting
Progress so far: No progress.
Process Solutions:
Innovative
I. [FBK-3DOM] 3D reality-based surveying and 3D modelling
II. [RINA-C] PPE Monitoring System // AC // AB System //Waste Tracking and Management // Site Environmental Monitoring System
Neighborhood Level Solutions
Innovative
I. [ENEREN] Low-Temperature DHC (450 MWh/y of heating and 250 MWh/y of cooling) in building B1 and B6 which will be fed by (I) geothermal energy, (II) recovery of waste heat from solar thermal and cooling in the summer season. The new LT DHC will also have a seasonal thermal storage (with BTES)
Conventional
I. [TRE] 5 Charging stations by Municipality of Trento
II. [HABITAT] 6 Charging stations by Habitat s.p.a.
Progress so far: The company habitat was working to finishing the entire residential and tertiary complex. They have not installed the charging station yet, but they will do for the end of the year. The same for the municipality of Trento.

Table 2 Solutions of Trento demo site and progress of conventional interventions

2.3 [FBK] 3D reality-based surveying and 3D modelling

2.3.1 General description

Leader partner: **FBK-3DOM**

Changed during the project: **YES**

Main reasons why changed during the project:

Current regulations impose some flight restrictions in urban areas for safety reasons. Only drones with a low payload and limited resolution cameras could be admitted, with the risk of compromising the quality of the final BIM product. Moreover, the historic city center and pilot location of Trento are now within the restricted flight zone imposed by the Italian

Civil Aviation. In view of some planned modifications to the internal partitioning, a broader accurate 3D data acquisition of the entire structure (indoor) is requested. Therefore, TLS would prefer to reach a complete and detailed building representation of all the accessible parts.

Description in the 1 st GA:

A framework to derive 3D information of buildings in urban areas by means of UAV/drone platforms and on-board sensors (cameras or LiDAR instruments). The framework offers data acquisition and 3D processing over urban areas (from single buildings to neighborhoods). UAV-based inspection and 3D modelling can also be used for structural analyses, monitoring of solar panels, thermographic studies, etc.

Advancements within the project and TRL positioning: Currently, the proposed framework is not completely automated in the data processing phase, in particular the derivation of as-build BIM products. During InCUBE the goals are to i) extend the processing pipeline (include RTK / PPP solutions for automated georeferencing and model-based fitting procedures to generate LOD2 building models), ii) make it user-friendly and demonstrate that in real environment. The high-resolution 3D geometric information will be coupled to other available data (e.g., energy-audit, thermal losses), to produce an as-build BIM. The process will be integrated into InCUBE's DiTi.

TRL6 → TRL8

Description updates at month 12

A framework to derive 3D information of buildings in urban areas by means of integrated reality-based data. The framework offers 3D data acquisition, processing and integration, and BIM modelling.

The new technology selected for the 3D data acquisition, the terrestrial laser scanning in place of the UAV flight, complies with the more recently defined interventions planned for the demo site. In particular, high-resolution data were acquired for the facades and indoor spaces where the main building changes are planned. An optimized processing pipeline is developed to manage different resolutions produced 3D data easily. The pipeline includes the use of data fusion techniques for aerial and terrestrial point clouds, data cleaning and points reduction and optimization before modelling in a BIM environment.

TRL6 → TRL8

2.3.2 Main Achievement at month 12

The first 3D model of the demo site was realized starting from existing plans and drawings and completed in December 2022 Figure 4.

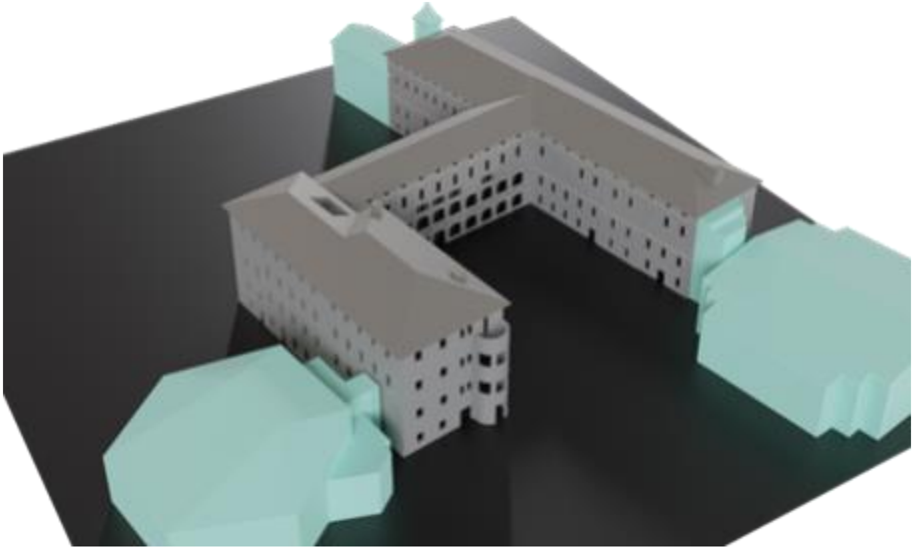

Figure 4 Preliminary geometrical model

In February, after a first building inspection to evaluate the complexity of the building and plan the 3D data acquisition, all accessible indoor and outdoor spaces were scanned with a terrestrial laser scanner Figure 5.

After integrating the laser scanning model with the aerial point cloud realized with available data, the BIM modelling phase started in March. The first BIM model of the actual state will be delivered in May.

Figure 5 Laser scanner survey

Building applied: Building B6

Licensing required: The municipality of Trento authorized the survey inspection with minimum efforts.

Principal role: No role needs to be defined. The FBK-3DOM was in charge of acquiring 3D reality-based data through laser scanning solutions and the municipality of Trento supported the inspection.

Critical step: The planned UAV flight was not possible due to some flight restrictions in the pilot site area, and new technology was selected for the reality-based data acquisition. After receiving authorization from the Municipality of Trento, all accessible indoor and outdoor spaces were scanned.

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart

a) First 3D model based on existing plans and 2D drawings Figure 4.

b) First inspection to evaluate the building size and complexity

c) 3D data acquisition with the terrestrial laser scanner

d) First two BIM versions of the actual state of the B6 building uploaded in the Team folder

e) /

f) /

		YEAR 1												YEAR 2					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
UAV-based surveying, inspection and 3D modelling	FBK-3DOM																		
Preliminary geometrical 3D model																			
First survey (generic inspection to familiarize with the building)																			
Second survey (planned inspection with laser scanner)																			
First Object for current status model BIM version (actual state)												**Final BIM model (actual state)**							
Object for renovation models version BIM (planned renovation)													**First BIM intervantions model**						
Introduction of values in the defined parameters														**Provisional Bim model of project status**					

Table 3 UAV-based surveying, inspection and 3D modelling time planning

2.4 [TEGOLA] Tegosolar® BIPV Shingles

2.4.1 General description

Leader partner: **TEGOLA**

Changed during the project: **YES**

Main reasons why changed during the project:

The detailed specifications developed during the design phase indicated that the roof of the IT B6 demo-building needs extra support for the BIPVs to be installed, which significantly increases the costs; whereas the costs initially foreseen for the BIPVs have already been increased significantly during the last one year (Ukraine crisis). These reasons reduce the potential capacity of the BIPV system to be installed. The Palabocchi is part of the same cadastral parcel, and it is under landscape protection as the B6 part of the GA. It is better to install the Tegosolar BIPV Shingles on the roof of Palabocchi, for a better aesthetic value of the whole B6 and for safety reasons. In fact, the initially foreseen (included in GA) part of the B6 (B6-Ex Lettere) does not have the inspection hatch that for recent buildings is mandatory for the periodical inspection of PV panels (regular maintenance). The regular maintenance ensures a more constant efficiency of the PV panels (cleaning). Another safety reason is linked to the fact that B6-Ex Lettere has the original beams of the 1200 century; those beams are really delicate, and Trento Municipality pushed us to not weigh on those original beams.

Description in the 1 st GA:

These are bituminous-based PV shingles used for complicated building roof geometries where traditional PVs are difficult to install. The shingles' slim design, flexibility, high temperature endurance, class1 fire certification and, most importantly, light weight (12 kg/m^2, 20% less in comparison with traditional PVs), can accommodate many roof types. Cells are made of triple-junction thin-film amorphous silicon absorbing blue, green, and red light through 3 separate layers. PV cells thus produce energy with direct light as well as in diffuse light conditions. Bypass diodes between cells allow the module to produce energy even when it is partially in the shade.

The BIPV shingles will be applied in the context of cultural heritage buildings. This aspect represents further progress of application for this technology; furthermore, different mounting systems will be considered to optimize the interaction with an existing roof. The solution does not utilize metallic frames, thus providing a very low visual impact, is not subject to wind load, is not composed of reflective materials and can easily be installed by a trained asphalt shingle roofer.

TRL 6 → **TRL 8**

Description updates at month 12

There are some variations from the original product: in part for a development of energy production character due to the evolution of product but also to solve application problems experienced in the Trento jobsite.

TRL 6 → **TRL 8**

2.4.2 Main achievement at month 12

1. Increase of electrical efficiency for singular panel: 8 more watts or 5,9% better than original

2. Reduction or surface needed to install the panels from 2,12289 m^2 to 1,97538 m^2 (-6,95%) so the combination of two improvements is about 14% on original material

3. Furthermore it has been developed a special roofing technology to allow the watertightness of the roof with the application of a new wood deck in the jobsite and lamination of PV panel (Tegosolare EX 144 Wp) over a bituminous compound membrane.

During those months, TEGOLA interacted with TRE to clarify every aspect of the executive design phase of the PV installation. A possible configuration is shown in the Figure 6.

Figure 6 Possible configuration of PV panels on part of B6

Building applied: Palabocchi part of B6 in demo site of Trento

Licensing required: Need for authorization from the municipality and from "Superintendence of fine arts of the Province of Trento to install the Photovoltaic in the heritage area of Santa Chiara.

Principal role: For these interventions the main role is cover by the director of works assigned by the municipality of Trento:

- Construction manager external employed
- Site manager employed of partner

Critical step: Timing of definition of authorizations, preparation of tenders, supplying of accessories such as cables

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart: /

		YEAR 1												YEAR 2												YEAR 3					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Tegosolar® BIPV Shingles	TEGOLA																														
Main decision on the design phase																															
Assignment of projects to other technicians (Safety coordinator, DL…)																															
Authorization (Superintendence of fine arts of the Province of Trento)																															
Authorization (Building permission)																															
Assignment to partner and Subcontracting																															
Works (2 months)																															
Test certificate / reporting / payments																															

Table 4 Tegosolar BIPV time planning

2.5 [RINA-C] Personal Protective Equipment (PPE) Monitoring System

2.5.1 General description

Leader partner: **RINA-C Consulting spa**

Changed during the project: **NO**

Description in the 1 st GA:

PPE system monitors correct use of PPE devices by operators. It is based on android Apps installed on smartphones, enabling verification of proper use of PPE (helmet, harness, shoes, etc.) through continuous monitoring of Bluetooth Low Energy tags installed on the PPE. It also monitors man down and dynamic shock detection, indoor and outdoor geo-localization of workers, and monitoring of operating status (battery level, etc.).

The system has already been tested in industrial environments (plants). During InCUBE the system will be configured to serve the needs of constructions sites and will be demonstrated for the first time in real-life renovation projects. More specifically: a) PPE functionalities will be aligned with the requirements of the site owner and the construction companies undertaking the renovation works in InCUBE pilots; b) the system will be customized to communicate (bi-directionally) with the R-GUIDE.

TRL6 → **TRL8**

Description updates at month 12

No changes.

2.6 [RINA-C] Anti-Collision System (ACS)

2.6.1 General description

Leader partner: **RINA-C Consulting spa**

Changed during the project: **NO**

Description in the 1 st GA:

ACS prevents the risk of collision between workers and machines, notifying the driver in real time with a visual and acoustic alarm in the presence and position of pedestrians. Among other functionalities, ACS can display the operator’s position around the vehicle, historizes and analyses detections, enables alarm threshold warning and pre-warning and supports geofencing functionalities. The system has already been tested in industrial environment (plants) whereas during InCUBE the following advancements will take place: a) customization of the system to fit the dynamics of renovation projects (e.g., in terms of activities, number of persons on site, equipment on site for which identification codes such as RFID and/or QR Code are needed) in a cost-efficient way; b) integrate the system into the R-GUIDE. ACS will be demonstrated in real-life renovation projects.

TRL 6/7 → **TRL 8**

Description updates at month 12

No changes.

2.7 [RINA-C] Area Boundary (AB) System

2.7.1 General description

Leader partner: **RINA-C Consulting spa**

Changed during the project: **NO**

Description in the 1st GA:

AB system monitors the presence of personnel in one or more operating dangerous areas. The system has a multi-reading capability, in addition to a great detection range. AB can be linked with a control room that provides an overview of the situation in real time and the position and identity of each operator. During InCUBE AB it will be configured to serve the needs of constructions sites by a) defining the construction dangerous areas per different renovation phase; b) setting application case specifications according to construction companies' needs. AB will be customized to communicate with the R-GUIDE and will be validated for the first time in real-life renovation projects.

TRL 6/7 → **TRL 8**

Description updates at month 12

No changes.

2.8 [RINA-C] Waste Tracking and Management

2.8.1 General description

Leader partner: **RINA-C Consulting spa**

Changed during the project: **NO**

This solution comprises an open waste management system for managing logistics and traceability of different types of waste. Waste traceability is implemented through a blockchain-encryption system in which all flows are certified. The system enables the management of both CDW (Construction and Demolition Waste) and non-CDW (e.g., hazardous domestic waste and bulky waste); for CDW a dedicated platform can estimate the CDW waste quantities that can arise from a demolition project by providing possible utilization options and related logistic references: automatically, by using BIM models, or by inputting design data through a wizard.

System prototype has been tested in industrial environment, requiring customization and configuration for InCUBE construction sites. The platform API will be advanced considering the micro-services architecture and by using the Spring-Cloud ecosystem. The georeferenced information will be upgraded to make use of GeoServer. The front end of the platform will be built using a modern web framework like Angular or React and will be linked with the R-GUIDE. Specific identification codes (e.g., through RFID and/or QR Code) will be installed in selected materials used in InCUBE renovation sites.

TRL 6 → TRL 8

Description updates at month 12

No changes.

2.9 [RINA-C] Environmental Monitoring System

2.9.1 General description

Leader partner: **RINA-C Consulting spa**

Changed during the project: **NO**

Description in the 1 st GA:

This system collects environmental data on emissions from field sensors.

It integrates the following streams: i) Energy Monitoring ii) Fuel consumption Monitoring iii) Environmental Management and Waste Management consumption and treatment, and iv) Stationary emission monitoring. AI algorithms and ML techniques are used to compare the monitoring results to a baseline, considering also meteorological conditions, and others. The RINA-C environmental monitoring system builds upon solutions already available in the market. The advancement in the TRL lies in the development of "logics" that correlate the environmental monitoring on site with open data available (such as weather forecasts) therefore supporting operational windows. The system will be integrated within R-GUIDE and make all necessary configurations to support the monitoring of parameters to be indicated by involved construction companies

TRL 7 → TRL 8

Description updates at month 12

No changes

2.10 [RINA-C] Resilience Dashboard (RD) – Ensuring enhanced workers safety and increased efficiency

2.10.1 General description

Leader partner: **RINA-C Consulting spa**

Changed during the project: **NO**

Description in the 1 st GA

RD is a single management platform that enables the communication and orchestrated use of different technological tools that lead to a "Resilient Construction Site" (RCS). RD integrates several tools (on-site process innovations) that respond to the needs of the site, organized in 3 sections: a) Safety at Work, b) Environmental and Waste Management and c) Vehicle and Equipment Management. The implementation of RCS can lead to increased process efficiency (20%), decrease in accidents (20%), decrease in litigation costs or site steps (10%). A system prototype has been tested in an industrial environment whereas during InCUBE the RD will be customized and configured (including the visualization of information) to serve the needs of construction/renovation projects. RD will be advanced to communicate and/or control selected process innovations introduced by InCUBE (e.g., vehicles and equipment tracking, waste tracking, environmental monitoring system) as well other modules of InCUBE digital Suite (AR/VR Suite, LCP) taking full advantage of the DTs created. RD will be demonstrated under real-life renovation projects – InCUBE pilot sites.

TRL 6 → **TRL 8**

Description updates at month 12

No changes.

2.11 [RINA-C] Main Achievement at month 12

Given the specificity of the individual protection device, RINA-C is trying to install removable sensors to avoid that they fall since by Italian safety law it is not possible to take back the helmet after handing it to the worker.

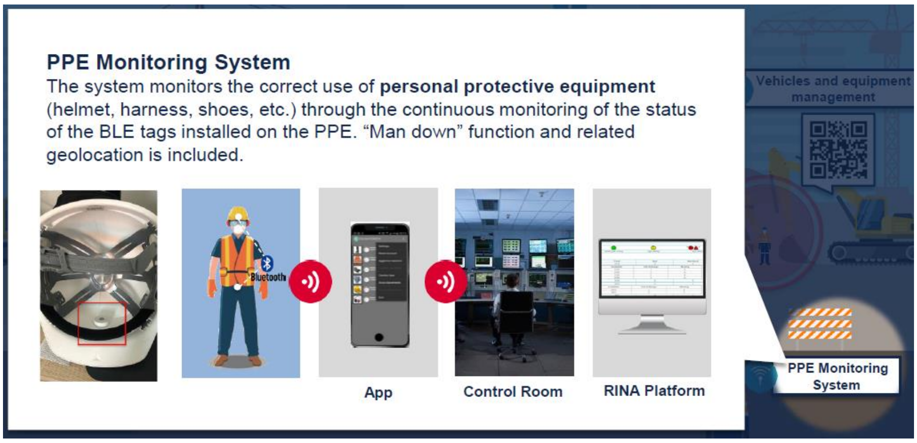

Figure 7 PPE monitoring system

The preliminary design of AC system has been done in relation to the specific application. Therefore, the numbers and typologies of sensors are under final evaluation. A site visit on the 22nd of June will allow to complete this task.

Figure 8 Anti-collision

AR is in the design phase of the test. An area will be identified for testing where in case of the presence of unauthorized peoples will be reported to the system.

For the waste management part, a geographical framework analysis has been done to identify best practices and technologies for the countries involved in INCUBE. Then, rules/algorithms have been identified on CDW management to be implemented in the resilient dashboard and validated in WP7.

For the waste tracking part an identification of potential recyclers close to the construction site in Trento has been done. A navigable map will be included in the dashboard where recyclers could be added and consulted, allowing waste tracking (e.g., which CDW is available and where).

The RD is in the development stage; it is needed to identify vendors to integrate sensor communications with the platform and management system.

Figure 9 Resilient dashboard

Building applied: Building B6

Licensing required: It will be defined in a formal contract the use of the system, considering that solution will be applied only for the testing campaign during a specific period of operation of the construction site. On-site training will be done in order to properly prepare the final users. Workers who will use it by giving consent to the test will be informed and trained.

Principal role: For these interventions the main role is cover by the director of works assigned by the municipality of Trento:

- Construction manager (external/ employed by the municipality/employed of partner)
- Site manager (external/ employed by the municipality/employed of partner)
- Resilience Manager

Critical step: Timeline agreement with TRE municipality (already done, with the risk of possible delays on their side). Work scheduled for autumn 2023 has now been postponed to summer 2024.

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart:/

		YEAR 1												YEAR 2												YEAR 3												YEAR 4											
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Personal Protective Equipment (PPE) Monitoring System, Anti-Collision System (ACS), Area Boundary (AB) System, Waste Tracking and Management, Environmental Monitoring System	RINA-C																																																
Anti collision system																										start of the test																							
Definition of the intervention																										start of the test																							
Design of intervention																										start of the test																							
Implementation																										start of the test																							
Waste Track and management												Site inspection and characterization of sensors																																					
Definition of the intervention																										start of the test																							
optimization of rules and algorithm with respect to specific case and interaction with the resilience Dashboard																										start of the test																							
Implementation																										start of the test																							

Environmental monitoring system												**Site inspection and characterization of sensors**																																					
Definition of the intervention																									start of the test																								
Design of intervention																									start of the test																								
Implementation																									start of the test																								
Resilience Dashboard (RD) – Ensuring enhanced workers safety and increased efficiency																			**start of activities, V1 of dashboard**						**final version of dashboard**																								
Data collection																									start of the test																								
Data elaboration																									start of the test																								
Data visualisation																									start of the test																								

Table 5 Rina-C time planning - Italian demo site

2.12 [KFLEX] ROCK CNX Insulation to reduce thermal bridge

2.12.1 General description

Leader partner: **K-FLEX**

Changed during the project: **YES**

Main reasons why changed during the project:

This is due to safety reasons (very strict fire resistance level is required), which were identified during the design phase for the B6.

Description in the 1 st GA:

A biobased PIR insulation foam with improved fire class (B-s2-d0 classification EN 13501 part 3), capable of increasing building envelope efficiency by more than 50%). Its biobased content is >15% (plus a 10% of PIR production scrap). Boards and material are specifically produced on the need of the building design allowing a decrease in cutting waste by 20%. The solution has a payback time of 3-4 years. In the Trento demo site, the legislation does not allow the application of external coats on a protected building – thus this solution enables to apply internal. The foam's TRL will advance from 5 to 8. During the project its demonstration will be done in real-life conditions, contributing to the marketability of environmentally friendlier relevant products. Properties of the foam will be technically advanced for the benchmark with a lambda of 0,025 W/m*K aged and a density of 30 Kg/m3. The PIR foam will be easily removed and recycled. Its manufacturing process will allow production of tailor-made solutions directly from CAD.

TRL 5 → **TRL 8**

Description updates at month 12

K-FLEX's innovative and circular one mineral wool (MW) insulation material offers the advantage that it can be cut in pre-defined custom designed shapes (even complex of irregular shapes ones), reducing that way the formulation of thermal bridges on the joint areas of the MW and pre-existing standard insulations. Compared also to standard materials, it can be cut in every dimension needed, in the range of 10-2400 mm for the width; thus, significantly reducing the material quantity, which is not used and is a waste. K-FLEX offers the availability as well that CNC machines are used for the cutting of the material according to available 3D models of the building, while at the manufacturer site, every scrap will be processed (grounded into fine granules) as insulation for blowing into spaces between ceilings or between walls in places with difficult access. This material is fire-proof according to A1 fire standards and sound proofing according to ISO 11654:1997 and ISO 717-1:2013 Acoustics.

2.12.2 Main achievement at month 12

Developing a new range of insulation materials.
Starting certification process with Forschungsinstitut für Wärmeschutz e.V. München https://fiw-muenchen.de/en

Figure 10 Technical sheet of k-flex product

Audit in the production plant 20.03.2023 performed by FIW auditor regarding production of Mineral wool Boards
Samples preparation for test needed for CE MARK.a

Building applied: Building B6

Licensing required: CE mark needed for building products. Certification process in progress.

Principal role: None

Critical step: None

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart: None

		YEAR 1												YEAR 2												YEAR 3								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
ROCK CNX Insulation to reduce thermal bridge	KFLEX																																	
Preliminary assumption on the quantity, total surface and thickness																																		
Official quantity, surface and thickness - Shipping																																		
Product ready for the installation																																		**End of roof insulation**
Supervision for																																		

the correct installation																																		

Table 6 Bio-based pir insulation time planning

2.13 [ENEREN/TRE/FBK] Smart Borehole Thermal Energy Storage BTES (District-level solution)

2.13.1 General description

Leader partner: **ENEREN**
Contribution from TRE and FBK

Changed during the project: **YES**

Main reasons why changed during the project:

Buildings B2 and B3 were already in the construction phase at the start of the InCUBE project and had already integrated air source heat pumps, powered by a renewable energy source (no need to connect to a new geothermal DHC). B5 was already in the construction phase at the start of the InCUBE project and had already integrated geothermal heat pumps, powered by renewable energy sources (no need to connect to a new geothermal DHC). B4 was already in the construction phase at the start of the InCUBE project and was not possible to integrate heat pumps and other renewable energy sources because it was protected as a church, however its energy needs are extremely low (20 MWh/year compared to the total of the Santa Chiara District equal to 3164 MWh/year).

Description in the 1st GA:

A central geothermal resource providing heating (965 MWh/year) and cooling (804 MWh/year) through borehole heat exchangers (BHEs) and acting as a seasonal storage (borehole thermal energy storage - BTES) for the residual heat from building cooling and for the excess solar heat production. This solution incorporates a set of innovative components: advanced drilling techniques based on combined rotation-percussion-vibration and use of radio controls (-30% work time, -25% cost, enhanced safety), pipes pre-assembly and automated installation (-40% work time, -30% cost, enhanced safety), PCM grouting, seasonal recovery of waste heat from space cooling and solar thermal. These components have been demonstrated in individual or partially integrated way, mainly in relevant environment (TRL6), but the full integration of all these components in the context of a “low temperature 100% RES DHC”, part of a REC, is innovative and will be brought to TRL8. This implies a new integrated approach in the innovative DHC modelling and planning, maximizing local resources and synergies between technologies, in an urban context.

TRL 6 → **TRL 8**

Description updates at month 12

A central geothermal resource providing around 450 MWh/y of heating and 250 MWh/y of cooling for B1 and B6 buildings through borehole heat exchangers (BHEs) and acting as a seasonal storage (borehole thermal energy storage - BTES) for the residual heat from building cooling. This solution incorporates a set of innovative components: advanced drilling techniques based on combined rotation-percussion and use of radio controls (-30% work time, -25% cost, enhanced safety), pipes pre-assembly and automated installation (-40% work time, -30% cost, enhanced safety), PCM grouting, seasonal recovery of waste heat from space cooling. These components have been demonstrated in individual or partially integrated ways, mainly in relevant environments (TRL6), but the full integration of all these components in the context of a "low temperature 100% RES DHC", part of a REC, is innovative and will be brought to TRL8. This implies a new integrated approach in the innovative DHC modeling and planning, maximizing local resources and synergies between technologies, in an urban context.

2.14 [ENEREN] Low GWP DHC connected GSHP

2.14.1 General description

Leader partner: **ENEREN**

Changed during the project: **NO**

Main reasons why changed during the project:

Description in the 1 st GA:

A prototype will be developed for both heating and cooling (reversible unit) using refrigerant R744 or R1234ze. CO2 (ASHRAE designation R744) has a very low environmental impact (ODP = 0; GWP = 1), it's non-flammable and non-toxic (A1 safety class) and its price is low. R1234ze, has a low GWP=6, ODP=0, mild flammability (A2L) and low density. The final selection of refrigerant will be made during dimensioning of DHCN.

The PBT of a geothermal heat pump is usually 8-10 years compared to a conventional solution with a gas boiler. At the moment, the cost of high and low GWP refrigerants is similar but soon, due to the more restrictive phase down of high GWP refrigerants, their cost (incl. maintenance) is set to increase and so, also the components cost. The purpose of this development is to improve the efficiency of the heat pump application with internal regeneration and to increase the performance of the heat-transfer for the new refrigerant without increasing the internal volume of the refrigerant cycle. Moreover, low GWP refrigerant will be used to reduce the environmental impact and the lifecycle global warming potential. TRL8 will be justified though demonstration. This technology will be demonstrated in the Trento demo site, where the use of GSHPs will allow to avoid the negative visual impact of the outdoor units of fossil fuel boilers (chimneys) or of the air solutions (ASHP), as well as to avoid the high acoustic impact and the summer heat island effect in urban centers.

TRL 6 → **TRL 8**

Description updates at month 12

No changes.

2.15 [ENEREN/TRE/FBK] Low Temperature 100% RES DHC (District-level solution)

2.15.1 General description

Leader partner: **ENEREN**
Contribution from TRE and FBK

Changed during the project: **YES**

Main reasons why changed during the project:

Buildings B2 and B3 were already in the construction phase at the start of the InCUBE project and had already integrated air source heat pumps, powered by a renewable energy source (no need to connect to a new geothermal DHC). B5 was already in the construction phase at the start of the InCUBE project and had already integrated geothermal heat pumps, powered by renewable energy sources (no need to connect to a new geothermal DHC). B4 was already in the construction phase at the start of the InCUBE project and was not possible to integrate heat pumps and other renewable energy sources because it was protected as a church, however its energy needs are extremely low (20 MWh/year compared to the total of the Santa Chiara District equal to 3164 MWh/year).

Description in the 1st GA:

Six buildings will be supplied with a low temperature DHC system based on a “geosolar heat and cool supply & storage” concept. The system consists of:

1. A central geothermal resource providing heating and cooling through borehole heat exchangers and acting as a seasonal storage (BTES),
2. A low temperature DHC network (T<50°C) connecting geothermal resources to buildings.
3. Low-GWP electric heat pumps at building level,
4. Distributed PV feeding electric heat pumps.
5. Distributed solar thermal collectors for domestic hot water and space heating
6. Distributed small building storage for domestic hot water and space heating/cooling inertia. Compared to a conventional solution based on a methane gas boiler, operating costs are 50% lower, due to the high efficiency of the geothermal HPs (SPF = 5 expected), and seasonal heat recovery, resulting in a PBT of 10 years. The outcomes of the project include detailed dimensioning of all components and their adjustment to each other for best overall system performance, development of operation strategies, evaluation of possible tariff models, identification and proof of sensitive parameters (e.g., geothermal characteristics, solar production profiles, individual building thermal demand profiles). The

technologies that make up the proposed system have been individually demonstrated in a relevant environment; the integration of technologies in the context of a 100% RES DHC, part of a REC, is innovative and will be brought to TRL8

TRL 6 → **TRL 8**

Description updates at month 12

Two buildings (B6 and B1) will be supplied with a low-temperature DHC system based on a "geosolar heat and cool supply&storage" concept.

The system consists of:

i) A central geothermal resource providing heating and cooling through borehole heat exchangers and acting as seasonal storage (BTES),

ii) A low temperature DHC network (T<50˚C) connecting geothermal resources to buildings.

iii) Low-GWP electric heat pumps at the building level,

iv) Distributed PV feeding electric heat pumps.

v) Distributed small building storage for domestic hot water and space heating/cooling inertia. Compared to a conventional solution based on a methane gas boiler, operating costs are 50% lower, due to the high efficiency of the geothermal HPs, and seasonal heat recovery, resulting in a PBT of 10 years.

TRL 6 → **TRL 8**

2.16 [ENEREN] Main achievement at month 12

No achievement

Building applied: Building B1 and B6

Licensing required: The municipality need to approve the intervention and deal with the authorization iter**.**

Principal role: None

Critical step: None

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart: None

		YEAR 1												YEAR 2												YEAR 3											
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Smart Borehole Thermal Energy Storage BTES (District-level solution), Low GWP DHC connected GSHP, Low Temperature 100% RES DHC (District-level solution)																																					
Preliminary project form TRE Technician with eneren support	**ENEREN**																																				
Heat Pump Design Project																		**Final Heat pump configuration**																			
Site preparation																																					
Heat Pump Production																								**the Heat pump can be installed**													
TRE project on the heat pump																																					

in the B6 power plant and how to connect it to the B1																																					
Test certificate																																					

Table 7 Geothermal plant installation time planning

2.17 [TERA] Smart Building Energy Monitoring System (S-BEMS) – Open, agnostic, and AI-powered BEMS

2.17.1 General description

Leader partner: **TERA**

Changes during the project: **No**

Description in the 1 st GA:

S-BEMS is an integrated BMS that moves beyond business-as-usual BEMS by: a) applying Machine Learning (ML) and deep neural network algorithms to significantly improve forecasting of energy consumption and RES production, with special emphasis given on the maximization of self-consumption; b) ensuring interoperability with a multitude of systems through the support of most key IoT protocols (e.g. MQTT, REST) and Building Automation protocols (e.g. BACnet, Modbus, KnX, ZigBee, ZWave, M-Bus, LoRa). The S-BEMS is highly cost-efficient (PBT=1-2 years). Considering a 7-storey building with 640 m2 per floor, compared to BEM solutions with traditional electronic systems a capital investment up to 40% lower is achieved. Advancements within the project and TRL positioning: The current version of S-BEMS will be tested during 2021 in 150 residential units in the Lombardy Region whereas during InCUBE this solution will be advanced to better serve the needs of energy communities and real time DR. More specifically, BEETA™ MoCo – the edge computer capable to monitor and manage bi-directional energy flows of battery storage inverters and other electrical equipment and loads, will be upgraded and integrated in the S-BEMS aiming at enhancing the electric energy flow management systems in smart grids and energy communities. The S-BEMS will be adapted to interact with the energy management at the district level developed by EVOLVERE through the development of relevant energy rules and logic. Advancements will comply with Directive 2014/53/EU (RED, Radio Equipment Directive) and ROHS.

TRL 6 → **TRL 8**

Description updates at month 12

S-BEMS is an integrated Building Monitoring System BEMS that moves beyond business-as-usual BEMS by: a) applying Machine Learning (ML) and deep neural network algorithms to significantly improve forecasting of energy consumption and RES production, with special emphasis given on the maximization of self-consumption; b) ensuring interoperability with a multitude of systems through the support of most key IoT protocols (e.g., MQTT, REST) and Building Automation protocols (e.g., BACnet, Modbus, KnX, ZigBee, ZWave, M-Bus, LoRa). The S-BEMS is highly cost-efficient (PBT=1-2 years). The current version of S-BEMS also adopted to support energy diagnosis for industrial buildings, residential and commercial where during InCUBE it will be advanced with the aim to serve the needs of renewable energy communities and real time energy flexibility services better also. More specifically, BEETA™ MoCo and/or GioE IoT edge computer will be upgraded to enhance the S-BEMS aiming at enhancing the electric energy flow management systems in smart grids and energy communities. The S-BEMS – powered by [FBK] algorithms - will be adapted to interact with the district energy management or aggregation platforms developed by partner [EVOLVERE] through the development of relevant energy rules and logic. Advancements will comply with Directive 2014/53/EU (RED, Radio Equipment Directive) and ROHS.

2.17.2 Main Achievement at month 12

No achievement

Building applied: Building B6

Licensing required: Need of authorization from the tenants of Building B6 from the Italian demo to access to the available LAN and access to internet.

Need of authorization from the tenants of the Dutch demo to install multiparameter sensors (temperature, relative humidity, CO2, lux) and energy meter inside the candidate residential units. Need to access to the formal accreditation process from SET Distribuzione, DSO for the Italian pilot, to their platform with regards to read electrical fiscal open meter "2G" that will be installed at the demo site.

Principal role: Italian demo site the main role is covered by the director of works or appointed manager or who may concern assigned by partner [Comune di Trento].

Critical step: Worldwide well know hardware/chip/semiconductor supply chain crisis that affects hardware manufacturing in (i) extended procurement time, (ii) production time, and (iii) increase in the overall costs for prime material and end product

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart: To be defined and detailed during the upcoming T5.1 kick-off meeting.

		YEAR 1												YEAR 2												YEAR 3												YEAR 4											
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Smart Building EMS (S-BEMS) – An energy community-oriented AI-enabled BEMS	**TERA**																																																
Preliminary phase for the estab-lishment of the energy community																																																	
Gateways, smart me-ters, Sen-sor's pro-curement, installation, calibration and com-missioning																																																	
Data collec-tion on evolvere platform																																																	
Elaboration of Data																																																	
Monitoring system																																																	

Table 8 S-BEMS time planning

2.18 [EVOLVERE] District EMS (EvoDistrict) – Enhancing the optimal management of DRES

2.18.1 General description

Leader partner: **EVOLVERE**

Changes during the project: **NO**

Description in the 1 st GA:

EvoDistrict is a cloud-based platform for the integration and optimal management of distributed energy (generation, storage and consumption) within a district; combining Blockchain and Cloud-Computing technologies. EvoDistrict unlocks services such as generation and load forecasting, creation of baselines, internal flexibility optimization (day head and real time) and the calculation of bids for participating to the ancillary service markets. It effectively allows remote control of the charge/discharge of residential battery storages, while ensuring the maximization of self-consumption for the individual user. EvoDistrict has been updated during the last years under the framework of Italian national projects (ComESto, UVAM) and has been field-tested in its current form. During InCUBE it will: a) improve the current optimization models of a virtual aggregate of energy users, as well as the development of new, more effective models; b) improve the collection process of data sent by a wide variety of monitoring and controlling devices, supporting and implementing almost all open communication protocols, non-open or proprietary protocols; c) ensure interconnectivity with the TERA S-BEMS. Advancements will comply with standards relevant to Infrastructure as a service (IaaS); VMware virtualization technology; System Development Life Cycle (SDLC); BackOffice Web interface; HTTP, WebSocket, MQTT, JSON.

TRL 7 → **TRL 8**

Description updates at month 12

No changes.

2.18.2 Main achievement at month 12

By participating in the coordination meetings of task 7.1, EVOLVERE contributed to the better identification and definition of the distributed generation and consumption resources that make up the "Santa Chiara district" pilot. In collaboration with the partner TERA, EVOLVERE worked with the distribution system operator (namely SET Distribuzione SpA) to activate the local smart metering service (applying the open meter Chain 2 protocol) for all points of delivery connected to the low voltage electricity grid. As for the points of delivery connected to the medium voltage electricity grid, the local smart metering service cannot be activated therefore, in collaboration with its partner TERA, EVOLVERE has designed an alternative solution which is under discussion for final approval. Finally, EVOLVERE drafted two key documents, required to realize a renewable energy community within the “Santa Chiara district" pilot, i.e., the constitutive act and the statute of the community. These documents are under review; now, the review is carried out by the legal and administrative office of the Municipality of Trento which will be the legal entity that “owns” the renewable energy community.

Building applied: The entire Santa Chiara district will be involved in the EVOLVERE operations:

B1

B2

B3

B4

B5

B6 – Main building

Licensing required: None

Principal role: None

Critical step: None

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart: None

		YEAR 1												YEAR 2												YEAR 3												YEAR 4											
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
District EMS (EvoDistrict) – Enhancing the optimal management of DRES	**EVOLVERE**																																																
a) Articles of Incorporation Bylaws/ ERC																																																	
b) Regulations																				**Energy community formed**																													
c) SMART METER Installation (1G)																																																	
B6 – EX LETTERE																																																	
B2 – CENTRO ANZIANI																																																	
d) GATEWAY Installation for 1G																																																	
B6 – EX LETTERE																																																	
B2 – CENTRO ANZIANI																																																	
e) SMART METER Installation (2G)																																																	

B4 – CHIESETTA	
B1 -EX MENSA	
B3 – UFFICI COMUNALI	
B5 – HABITAT	
f) GATEWAY Installation for 2G	
B4 – CHIESETTA	
B1 -EX MENSA	
B3 – UFFICI COMUNALI	
B5 – HABITAT	
g) Creation of the data visualization, processing and collection platform. Accessible to all partners. Protocols to be defined.	
h) End of the project - disposal of the platform	

Table 9 district EMS time planning

3 Zaragoza demo site

3.1 General description

The Balsas de Ebro Viejo is in North of Zaragoza. This neighborhood is chosen for this project for his relevance as Working-class neighborhood constructed in 1971 with several plans for the rehabilitation as part of the "Balsas Positivo" project, focused also on achieving an energy positive district. The building is a privately owned residential building made up of 4 blocks of 10 dwellings each, two per floor. The constructed floor area is3248 m2. Indoor useful and conditioned surface of dwellings: 2562 m2. Construction date: 1970. Occupants/users: 79 inhabitants. The neighborhood is made up of two adjacent, identical residential buildings (B1, B2), each one consisting of two blocks of 725m2. Building B1 and B2 are privately owned residential buildings outside Zaragoza (2 blocks of 10 dwellings each, two per floor).

Funding involved in the district (except InCUBE funds):

Foreseen investment for renovation activities on a district level until 2026: Best-case funding scenario, where energy savings of at least 60% will be achieved, the investment will be covered as follows:

i) Investment required per dwelling: 35,000€-40,000€;

ii) NEXT Generation contribution: 21,400 € (61%).; PENDING ON COMPATIBILITIES

iii) Municipal funds contribution: 3,000€ (depending on loans limits;

iv) Private owners' investment: € 10.600 (22%). A bank loan has already been evaluated (5% interest rate) with a monthly cost of less than 70€ per dwelling.

Least favorable funding scenario, without Next generation funds:

i) Investment required per dwelling: 35,000€- 40,000€;

ii) Municipal funds contribution: 14,000€ (40%).

iii) Private owners' investment: 21,000 € (60%).

Last update (as of 31/10/2022: Ministry and regional government contacted to confirm compatibilities.) Construction budget is still being studied for the different scenario. 35.000-40.000€ considered per dwelling in addition to 10.000€-17.000€ approx. coming from InCUBE innovations. Total expected 50.000€ (architectural project and taxes included)

Renovation time plan:

Start Date: Between July and Dec 2024 (design and licenses will start in early 2023)

Date of completion: 06/2025

General Scope of Renovation:

Specific problems identified include poor insulation, thermal bridges, 90% of the homes have a mixed gas boiler (for DHW and heating), while the remaining 10% operate with electric systems. Renovation interventions are expected to improve building energy efficiency and accessibility, especially for elderly residents.

Envelope characteristics after renovation:

The actual walls will be covered by modular Facades improving insulation and reducing thermal bridges. The actual windows will be doubled with high performance windows (also maintaining the original ones) and the roof and ground floor are going to be insulated following current standards.

MEP system characteristics:

Future heating system: Individual systems will not be modified

Future DHW: Hybrid thermal-solar panels + BIPVs panels. Common storage deposit by building leveraging the Hybrid PV panels for Domestic Hoy Water

Future cooling system: No relevant modifications expected. Current exterior units will be relocated and/or substituted if necessary while works on façades

Future ventilation: No intervention expected

Future lighting: Lighting in common areas will be LED and automated.

Future Energy manager system: There will be a monitoring system related to renewable energy production.

Energy production: Hybrid thermal-solar panels + BIPVs

Users comfort (Building B6):

The results reported show the bad performances in terms of comfort, both in summer and winter conditions regarding temperature. On the other hand, quite good results for what concerns the visual comfort have been reported. Indeed, the large majority of the users replied with satisfactory answers to the survey submitted.

Energy transformation Status and Targeted status:

Energy Needs: 273.4 kWh/m²/y → 49.6 kWh/m²/y

Current RES production: 0 MWh/y → 145.5 MWh/y

EPC Class: E → A

Current SRI: 0% → 70%

Figure 11 Zaragoza demo site

3.2 Overview of foreseen interventions and progress

In this chapter a general overview of innovation and conventional intervention on the demo are listed. For conventional interventions, progress is highlighted in this section. In the following chapter every innovative solution will be explored in detail.

Product Solutions:
Innovative
I. [ABORA] Hybrid thermal-solar panels (BI-SHE) (thermal energy production: 19 kWh/m2/y, PV energy production 38 kWh/m2/y, 10 SHE PVT + 28 BIPVs-450kW per block (4x) – 40 SHE PVT and 112 BIPVs-450W in total). Common storage deposit by building leveraging the Hybrid PV panels for Domestic Hot Water.
II. [KOVER] Modular Facades (2.090 m2 of façade units and 188 m2 of lateral façades
Conventional
I. [KOVER] High performance window glass (Incorporated in modular façades)
Progress so far: Option evaluation
II. KOVER, METRO7, ABORA] Façade, ground floor and roof thermal insulation (Incorporated in modular façades and PV panels)
Progress so far: Option evaluation

III.	[KOVER] High performance aluminum-based joinery (Incorporated in modular façades)
Progress so far: Design phase	
Process Solutions:	
Innovative	
I.	[METRO7] IPD, A3 and LPS – driven Rehabilitation
II.	[METRO7, ESTUDIO] Laser 3D Scanning
III.	[RINA-C] PPE Monitoring System // Anti-Collision System (ACS)
Neighborhood Level Solutions	
Innovative	
I.	[EDPS] Renewable Energy Community based on PV installations on tertiary floor
Conventional	

Additional Neighborhood/ district buildings (forming REC):

During InCUBE, EDPS will develop a solar district in Balsas that will be operated as a REC to maximize self-consumption and independence from the grid. This solar district will be built deploying two solar installations of 50 KWp each or one solar installation of 100 kWp. The initial estimation is that it will be composed of 110 PV panels of 455Wp. However, this power could vary depending on the number of members of the solar community. Batteries will not be considered due to technical infeasibility, as surpluses are not going to be big enough to consider storage. T. In addition, the batteries are not suitable for installation outside the building and must be in a cool and ventilated place. This hinders the possibility of storage in this project. The location is in the process of negotiation with the city council. The location is pending due to political property reasons, other roofs are being considered: public sports pavilion, nursing home, etc. nearby (to be finalized by the end of the year-early 2023). The estimated cost of each installation will be 81.396€ and will trigger saves of at least 30% to each Neighbour aggregated of the community. The initial estimations from EDPS are that at least 200 dwellings will join the REC during the first months, being the potential scope of 3.604 dwellings and 26 business.

The installation process will start after the customer acquisition.

The installation and registration process are regulated by law and the main players involved are Local administration and Electrical distribution company.

The management of the building license is a process that depends on the town hall, so it would be necessary to request it in conjunction with the rest of the rehabilitation project.

For the sharing agreement between the dwellings, it is necessary to inform the cadastral reference and the UTM coordinates of each participant. Under current law, the maximum distance between the solar installation and the participant is 500m (new regulation extends it up to 1km), in orthogonal projection.

The access and connection contract has a regulated term of 30 days to be signed, but it can take up to 6 months. EDP requirements: - Agreement signed with the owner of the roof to carry out the installation. - Definition of participation criteria. - The number of participants will define the final power installed. EDP proposes the creation of informative sessions that allow the adhesion and recruitment of participants. Customer Business Case - Grid Consumption: 2.200 kWh/year o 688 €/year = 57 €/month o Grid tariff: 312 €/MWh - Solar Power for Each participant: 0.5 kWp o Investment: 815€ o Self-consumption: 700 kWh/year □ savings 32% o Grid consumption: 1.1500 kWh/year o Savings 32%: Electrical Bill= 468 €/year = 39 €/year

Table 10 Solutions of Zaragoza demo site and progress of conventional interventions

3.3 [METRO7] Laser 3D Scanning

3.3.1 General description

Leader partner:	**METRO7**
Changes during the project:	**NO**

Description in the 1 st GA:

The solution improves the architectural project development and drafting process. On the one hand, data collection using Laser Scanner allows accuracy improvement and time reduction. On the other modelling with BIM tools improves communication and connection, workflows and design. The solution com with IFC (ISO 16739-1:2018) and gbXML formats which are interoperable and standardized BIM formats.

Advancements within the project and TRL positioning: The objective is to standardize, adapt and integrate the BIM methodology to the renovation processes, also incorporating and rendering interoperable 3D scanning and AR/VR tools (R-GUIDE), to improve communication and data exchange. The specific vectorization of the constructed map, as produced by the Laser Scanning software, will facilitate easy integration with other state of art and commercial software, which can be easily imported to any custom developed Digital Twin (in this case DiTi).

TRL 6	→	**TRL 8**

Description updates at month 12

The new technology added for the 3D data acquisition, photogrammetry through UAV flight, provides more information for the interventions planned for the demo site. In particular, high-resolution data were acquired for the facades and mostly from the roof where 3D information was not feasible using Laser Scanner. Optimized data management is developed to combine the different 3D information generated by both technologies to develop 3D data easily. The process includes the use of data fusion techniques for Drone (aerial) and Scanner (terrestrial) point clouds, points reduction, joining and optimization before modelling in BIM.

TRL 6 → **TRL 8**

3.3.2 Main achievement at month 12

i) In March, 3D scanning started outdoors.

ii) In April, 3D scanning continued with staircases, two dwellings, the pitched roof and under the ground floor.

iii) In April, after receiving the license de UAV fight was done. At the same moment the topographic survey was done - Figure 12

Figure 12 BLK Scanner

Figure 13 Topographic device

Figure 14 Drone

In total 107 terrestrial 3D scans were performed. They were combined in 6 different point clouds. One of them was used to combine with the aerial 3D scanners. Point clouds were optimized and cleaned. All of them are organized and joined following an internal naming criterion according to the date, location, raw file, resolution, day and point cloud where it is included - Figure 13, Figure 14

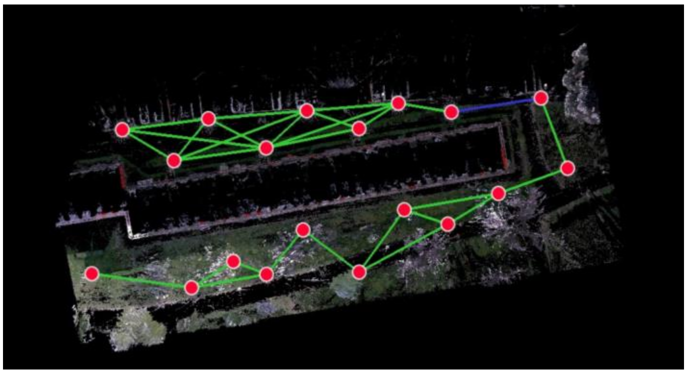

Figure 15 Outdoors point cloud

SCAN SURVEY OVERVIEW						
CODE	RAW FILE	LOCATION	DATE	DAY	RESOLUTION	POINT CLOUD
E0	P07_K02_042	EAST	24/03/2023	1	HIGH	OUTDOORS
E1	P07_K02_043	EAST	24/03/2023	1	HIGH	OUTDOORS
E2	P07_K02_044	EAST	24/03/2023	1	HIGH	OUTDOORS
E3	P07_K02_045	EAST	24/03/2023	1	HIGH	OUTDOORS
E4	P07_K02_046	EAST	24/03/2023	1	HIGH	OUTDOORS
E5	P07_K02_047	EAST	24/03/2023	1	HIGH	OUTDOORS
E6	P07_K02_048	EAST	24/03/2023	1	HIGH	OUTDOORS

Figure 16 Scan survey Template

iv) After integrating the terrestrial laser scanning point cloud with the aerial point cloud, the BIM modelling phase started in April - Figure 17

At the moment, the first BIM model of the current status based on 3d scanning is available with high definition - Figure 18

Figure 17 Combined point cloud

Figure 18 BIM model

Building applied: Zaragoza Demo site

Licensing required: Authorization from the Municipality, from Zaragoza's Police and from Zaragoza's Military Academy for the UAV flight was necessary.

The agreement of Valle de Oza 1,3,5,7 owners for scanning indoors and staircases was necessary.

Principal role: For terrestrial scanning and BIM modelling the main role is covered by Metro7 and Estudio. For UAV flight and topographic survey an external company was subcontracted.

Critical step: After receiving license from the Municipality of Zaragoza, from Zaragoza's Police and from de Zaragoza's Military Academy all outdoor spaces were documented. After receiving the agreement of the dwellings all common spaces and some indoor spaces were scanned.

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart:

a) From M1 to M6 preliminary architectural project was developed to present to the neighborhood during a general meeting.

b) Compatibilities were analyzed at neighborhood level and individual interest was shown.

c) In M8 the interest was classified, and 4 communities were selected with technical criteria and signed a pre-agreement.

d) In M9 and M10 first inspection, topographic, Laser scanner and drone fight surveys were done in order to obtain 3d data information.

e) In M10 data management is developed to combine the different 3D information generated.

f) From M10 to the present BIM 3d current state is being developed in order to get BIM's ready on month 13

		YEAR 1												
		1	2	3	4	5	6	7	8	9	10	11	12	13
		jul-22	ago-22	sep-22	oct-22	nov-22	dic-22	ene-23	feb -23	mar-23	abr -23	may-23	jun -23	jul-23
Large Scale Demonstration of InCUBE framework-Zaragoza	**METRO7**													
Architectural project development incorporating innovative solutions conjugation and settle owners' commitment	**METRO7-ZAVI**													
Previous architectural project development	METRO7													
Initial budget and fundings compatibilities. Meetings with Ministry and project coordinators	METRO7-ZAVI													
Neighborhood level general meeting to present project	METRO7-ZAVI													
Individual interest letters classification and advance works with interested communities (more specific information and doubts clarification)	ZAVI													
Manifestation of interest at community level signed by building owners	ZAVI													
Classification of manifestations of interest received and procedure of selection of the 4 communities with technical criteria.	ZAVI													
Official communication to all the communities about the final selection, and pre-agreement signed with selected communities	ZAVI													

Previous Neighbour coordination document license (if necessary)	METRO7-ZAVI														
Location of solar district: meetings with owners (municipality or private tertiary buildings)	EDP-ZAVI														
Location of solar district agreement	EDP-ZAVI														
Buildings scan survey	METRO7														
Topographic (and UAV optional) survey	METRO7														
BIM 3d model current estate and point cloud management + BIM objects and repository	CIRCE-METRO7														BIM's ready
BIM 3d model renovation proposal	CIRCE-METRO7														BIM's ready

Table 11 Laser 3D Scanning time planning

3.4 [METRO7] IPD, A3 and LPS-driven Rehabilitation

3.4.1 General description

Leader partner:	**METRO7**
Changes during the project:	**No**

Description in the 1 st GA:

The specific solution refers to the application of Lean methodology for the rehabilitation process. It combines Integrated Project Delivery (IPD) work processes, development of A3 report models based on PDCA to reflect problems and solutions for future actions, and continuous improvement and application of Last Planner System (LPS) for the work planning. A3 reports collect background, current situation, cause analysis, improvement actions, action plans and results monitoring. LPS is a planification methodology that promotes detailed communication between all stakeholders preventing issues becoming critical. Advancements within the project and TRL positioning: During InCUBE, the aim is to incorporate A3 analysis reports for continuous improvement into the system, which can be worked on collaboratively through LPS. In this way, a transformation towards a collaborative IPD model, during which all stakeholders are integrated and exchange information with each other continuously is achieved. The time of the entire process can be reduced by 10-20%. Waiting times and slack are eliminated, optimizing material and personnel resources. The whole methodology will be demonstrated for the first time in a residential deep renovation project.

TRL 6	→	**TRL 8**

Description updates at month 12

No changes.

3.4.2 Main achievement at month 12

I. Initial meeting with Circe to share ideas, current internal procedures and scope in order to adapt InCUBE suite tools related to Lean methodology to be developed in WP5

II. Initial IPD approach: creation of FOLLOW-UP commission and open book approach review for initial presentations and budget estimations

Figure 19 Internal organization in the Zaragosa demo site

Figure 20 Scheduled meeting with owners

III. Collaborative architectural project development

IV. Development of D2.4 preliminary ideas about innovation description and initial research

Building applied: Zaragoza Demo site

Licensing required: None

Principal role: METRO7 AND ESTUDIO: implementation, coordination and management of renovation works under Lean construction criteria.

ALL DEMO SITE PARTNERS: work in a collaborative way following Lean construction methodology and participate in meetings and other necessary activities or actions.

OWNERS: participate actively

Critical step: Detailed definition of digital and physical tools available to ease Lean construction methodology implementation

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart:

I. In line with T2.4, the preliminary methodology assessment has already started, although it was expected to start in M15.
II. Initial coordination meetings have started with Circe, sharing information of expected results from T5.2 and Lean construction implementation requirements.
III. -
IV. -
V. Although IPD, A3 and LPS- driven rehabilitation is expected to be fully implemented during renovation works. The way the selection of the building has been conducted and the design for renovation works is being developed, IPD methodology implementation has already started. A Follow-up commission has been created by 4 owners, real estate managers of the building, ZAVI and METRO7/ESTUDIO, together with occasional collaboration of KOVER, ABORA and CIRCE. Regular meetings are being organized to share updates and work in a collaborative way with an initial open book approach.

		YEAR 1						YEAR 2												YEAR 3											
		7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
		ene-23	feb-23	mar-23	abr-23	may-23	jun-23	jul-23	ago-23	sep-23	oct-23	nov-23	dic-23	ene-24	feb-24	mar-24	abr-24	may-24	jun-24	jul-24	ago-24	sep-24	oct-24	nov-24	dic-24	ene-25	feb-25	mar-25	abr-25	may-25	jun-25
Lean methodology assessment and digitization. IPD and LPS implementation																															
Methodology preliminary assessment	METRO 7																														
Coordination with Circe and Certh for Lean platform T5,2	METRO 7-CIRCE-CERTH															T5.2															
Templates preparation	METRO 7																														
Resources needed definition	METRO 7																														

Table 12 IPD, A3 and LPS-driven Rehabilitation time planning

3.5 [RINA-C] Personal Protective Equipment (PPE) Monitoring System

3.5.1 General description

Leader partner: **RINA-C Consulting spa**

Changed during the project: **NO**

Description in the 1 st GA:

PPE system monitors correct use of PPE devices by operators. It is based on android Apps installed on smartphones, enabling verification of proper use of PPE (helmet, harness, shoes, etc.) through continuous monitoring of Bluetooth Low Energy tags installed on the PPE. It also monitors man down and dynamic shock detection, indoor and outdoor geo-localization of workers, and monitoring of operating status (battery level, etc.).

The system has already been tested in industrial environments (plants). During InCUBE the system will be configured to serve the needs of constructions sites and will be demonstrated for the first time in real-life renovation projects. More specifically: a) PPE functionalities will be aligned with the requirements of the site owner and the construction companies undertaking the renovation works in InCUBE pilots; b) the system will be customized to communicate (bi-directionally) with the R-GUIDE.

TRL6 → **TRL8**

Description updates at month 12

No changes.

3.6 [RINA-C] Anti-Collision System (ACS)

3.6.1 General description

Leader partner: **RINA-C Consulting spa**

Changed during the project: **NO**

Description in the 1 st GA:

ACS prevents the risk of collision between workers and machines, notifying the driver in real time with a visual and acoustic alarm in the presence and position of pedestrians. Among other functionalities, ACS can display the operator’s position around the vehicle, historizes and analyses detections, enables alarm threshold warning and pre-warning and supports geofencing functionalities. The system has already been tested in industrial environment (plants) whereas during InCUBE the following advancements will take place: a) customization of the system to fit the dynamics of renovation projects (e.g., in terms of activities, number of persons on site, equipment on site for which identification codes such as RFID and/or QR Code are needed) in a cost-efficient way; b) integrate the system into the R-GUIDE. ACS will be demonstrated in real-life renovation projects.

TRL 6/7 → **TRL 8**

Description updates at month 12:

No changes.

3.7 [RINA-C] Main achievement at month 12

Given the specificity of the individual protection device, we are trying to install a removable sensor to avoid losing the sensor since by Italian safety law it is not possible to take back the helmet after handing it to the worker.

The preliminary design of the system has been done in relation to the specific application. Therefore, the numbers and typologies of sensors are under final evaluation. A site visit on the 22nd of June will allow to complete this task.

Building applied: Zaragoza demo site

Licensing required: It will be defined in a formal contract the use of the system, considering that solution will be applied only for the testing campaign during a specific period of operation of the construction site. On-site training will be done in order to properly prepare the final users. Workers who will use it by giving consent to the test will be informed and trained.

The use of the system will be defined in a formal contract, considering that the sensors will be installed only for the testing campaign and then will be uninstalled once the monitoring campaign is completed.

On-site training will be done to properly prepare the final users.

Principal role: For these interventions the main role is cover by the director of works assigned by the municipality of Trento:

Construction manager (external/ employed by the municipality/employed of partner)

Site manager (external/ employed by the municipality/employed of partner)

Resilience Manager

Critical step: None

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart: None

		YEAR 1												YEAR 2												YEAR 3												YEAR 4											
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
AB and PPE monitoring system	RINA-C																																		Site in-spec-tions		**Test case with RINA tech-nolo-gies**												
Use of PPE																																					start of the test												
Area Boun-dary																																					start of the test												
Resilience Dashboard																																					start of the test												

Table 13 RINA-C time planning - Zaragoza demo site

3.8 [KOVER] Modular Facades with Integrated Building Elements

3.8.1 General description

Leader partner:	**KOVER**
Changed during the project:	**NO**

Description in the 1 st GA:

Lightweight (30% lighter in comparison with other similar solutions), modular (different building elements such as external lifts, balconies and windows can be integrated) construction system for the rehabilitation of residential buildings with the aim of improving their energy performance. The system allows the use of any material to adapt the facades finish to the will of the designers and urban planning requirements, which makes it potentially applicable to protected buildings. The solution is standardized under technical building code RD 3142006. Advancements within the project and TRL positioning: During InCUBE the necessary profiles (supporting structures) of the module construction will be designed, manufactured and demonstrated, making all necessary configurations to limit the weight of the modules and use sustainable materials, achieving total industrialization of the process and guaranteeing minimum maintenance during its useful life. In addition, the new profiling system will allow the installation of “transparent” elements of the façade (joinery and glass) and the facilitation of the installation of any façade finish, allowing the improvement of the external buildings appearance.

TRL 6 → **TRL 8**

Description updates at month 12:

No changes.

3.8.2 Main achievement at month 12

The second prototype has been developed with improvements regarding the first one. The wall thickness is reduced through the optimized structure to the specific application. 3D data acquisition through laser scanning has allowed us to define all the types of modules.

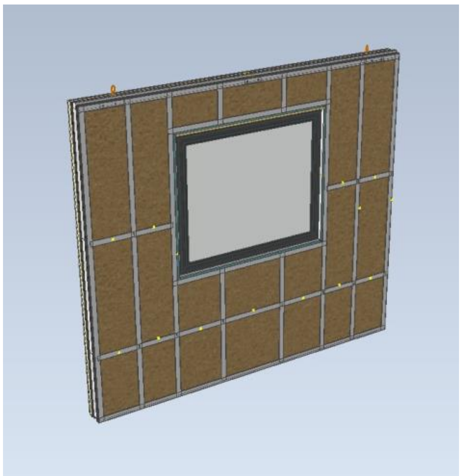

Figure 21 Prototype design

Figure 22 Prototype

Figure 23 Prototype

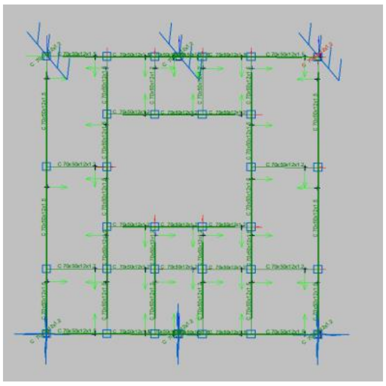

Figure 24 Scheme of the prototype

Figure 25 Configuration of the prototype on the building

Building applied: Zaragoza demo site

Licensing required: The municipality of Zaragoza authorized the use of this product.

Principal role: None

Critical step: None

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart: None

Planning and setup of	YEAR 2											
	January	February	March	April	May	June	July	August	September	October	November	December
Modular Facades with Integrated Building Elements	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18
Preliminary 3D model												
Building inspection												
1st mockup												
3D data acquisition/laser scanning												
First object for current status model BIM version												
2nd mockup												
Object for renovation models version BIM												

Table 14 Modular Facades with Integrated Building Elements time planning

3.9 [ABORA] Hybrid Thermal Solar Panels (BI-SHE)

3.9.1 General description

Leader partner:	**ABORA**
Changes during the project:	**NO**
Description in the 1 st GA:	

SHE (Solar Heat and Electricity) is currently the solar panel with one of the highest performances on the market (88%). The system includes monitoring capacities that enable users to know cost savings originating from use. Panels leave the factory with quality tests (pressure, electrical tests, etc.) already verified. Grouping of panels is achieved with greater precision in their dimensional tolerances, higher quality (watertightness, connections, etc.), lower product cost (16%), 67% lower installation cost and lower roof work accident risk. The BI-SHE panel will emerge as an evolution of the SHE panel developed under Horizon 2020 project (SHE). The BI-SHE panel will be based on a prefabricated design that simplifies site installation and solves the connections complexity through a) diodes incorporation inside the panel; b) plug and play photovoltaic inter-panel connection; c) quick inter-panel pipe connection, and d) a single bench grouping structure for panels to be installed on the building envelope. This allows for higher quality factory single structure panel preassembly, with group geometries adaptable to the building envelope

TRL 7	→	**TRL 8**

Description updates at month 12

No changes.

3.9.2 Main achievement at month 12

In order to know the number of solar panels that are required in Demo syte #2 (ES) and its distribution depending on the possible shadows of the roof, different distribution studies have been carried out. Using specific software tools, panels distribution has been set - Figure 26.

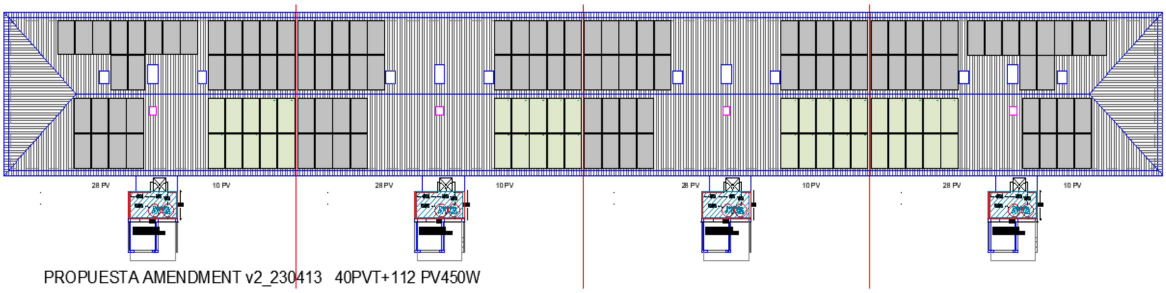

Figure 26 Solar panels distribution PV (grey) and PVT (green)

With the help of abora software and other tools such as PVsyst shadow simulation Figure 27 has been carried out.

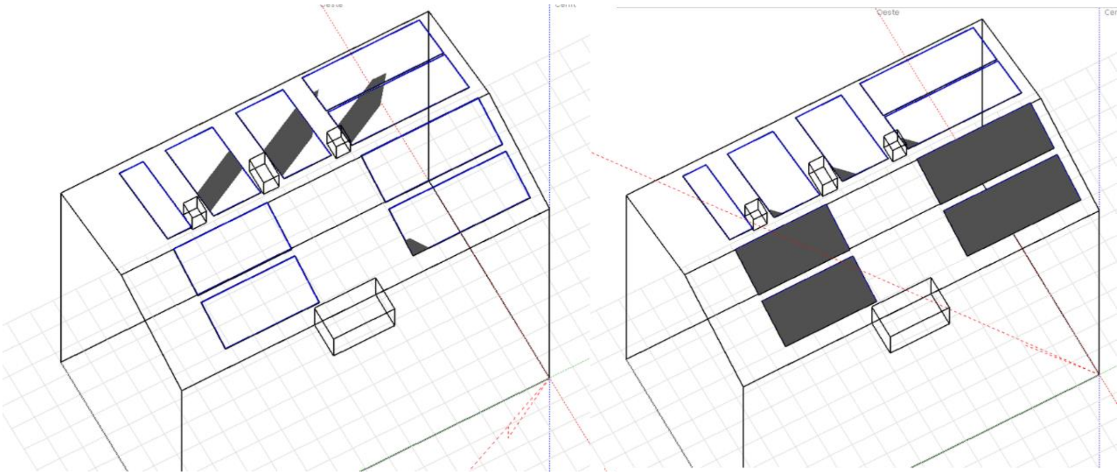
Figure 27 Shading model

Building applied: Zaragoza demo site

Licensing required: Need of authorization from the municipality to install the panels

Principal role: No role needs to be defined.

Critical step: The next step is to work on the detailed engineering and manufacturing of solution that will be performed the procurement of materials and manufacture of the assembly as well.

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart: /

3.10 [CIRCE] ENERGY CLOUD EMS

3.10.1 General description

Leader partner:	**CIRCE**
Changes during the project:	**NO**

Description in the 1 st GA: This solution applies the performance of an industrial SCADA system to the Building Energy Management, being able to collect Energy Data from many different hardware devices and enabling to visualize the Energy consumption the building in an intuitive and simple way via a 3D BIM model.

Advancements within the project and TRL positioning: CIRCE ENERGY CLOUD will show in a multiplatform and comprehensive way the energy consumption of the shareholders, providing in a 3D environment energy information for every user. Through InCUBE an innovative approach to the BEMs will become available, empowering the non-technically trained citizens via 3D BIM intuitive platforms, and providing real energy estimations of their day-by-day appliances, just with one electricity meter.

TRL 6 → **TRL 8**

Description updates at month 12

No changes.

3.10.2 Main Achievement at month 12

- Definition of system
    - Sensors
    - Gateway
    - Communication protocol
- Definition of visualization interface requisites

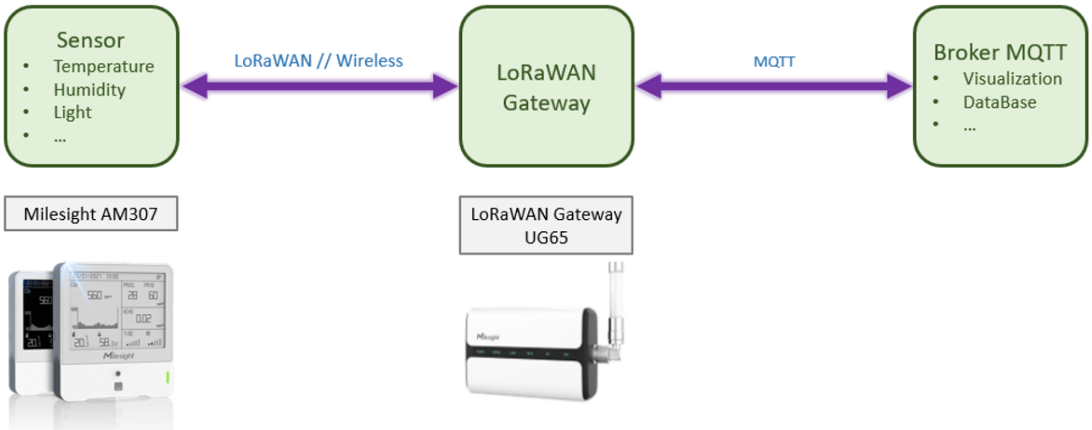

Figure 28 Definition of sensors system

Building applied: Zaragoza demo site

Licensing required: The material is ready to be installed and doesn't need authorization from anyone. Need for permissions from Neighbors to access their electricity consumption.

Principal role: No role needs to be defined yet.

Critical step: Risk: Relevant configurations could indicate the need for more field sensors than expected, which could lead to unforeseen costs.

Mitigation: Confront the costs

Risk: Possible delay in the delivery date of the equipment

Mitigation: Looking for new supplier

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart: None

Action	Main outcome	Internal deadline	Expected delivery
Reception of hardware components	-----	M9-M13	on time
Configuration the system	-----	M12-M15	on time
Installation and commissioning of devices	-----	M13-M15	on time
Deployment of the user interface	-----	M15-M16	on time

			8	9	10	11	12	13	14	15	16
			feb-23	mar-23	abr-23	may-23	jun-23	jul-23	ago-23	sep-23	oct-23
ST7.3.3	**Monitoring system**	CIRCE									
	Definition of visualisation interface requisites										
	Purchase order of sensors, gateways and software licenses										
	Reception of hardware components										
	Configuration of the hardware sytems										
	Deployment on site and start of data capture										
	Deployment of the users interface										

Table 15 Monitoring system by Circe time planning

4 Groningen demo site

4.1 General description of the demo

The Van Heemskerckflat is in Zeeheldenbuurt District. This district is in Van Heemskerckstraat 1, Groningen, Netherlands. The Van Heemskerckflat represents a broader European challenge. In the 1960's and 70's a very large amount of affordable family housing was built throughout Europe. Fifty years onwards, most of them are at the end of their economic and technological lifetime. Dismantling the building entirely is uneconomical, time consuming and unsustainable option. Therefore, building owners of 1960-1970 apartment flats are facing the challenge of finding a cost-effective way for the deep renovation of these buildings, in a way that the renovated building is future proof and compliant with current demands.

The neighborhood is composed of seven (7) similar apartment buildings owned by LEFIER due to their proximity there are plans for deep renovation and replicating solutions.

Funding involved:

VW funding secured for renovating the demo-building: 13.4M€ (10.4M€ for energy-oriented interventions)

Renovation time plan:

The Preliminary Design for the Van Heemskerckflat will be concluded at the end of May. From there on it will take approx. 3 months to come to a Final Design. Around September 2023 procurement will start. Also, further elaboration of the design into Work- and Shop Drawings will take place. The construction works on site will start April 2024 and take approx. 14 months. Meaning renovation works will end mid-2025.

General Scope of Renovation:

The Heemskerckflat was specifically designed for students. In the building students have their own room, connected to a common hallway. They share facilities such as bathrooms, kitchens, and dining areas. This way of living is outdated and there is a surplus in shared spaces. In the new design the rooms will be extended. Each room will have its own bathroom. On each floor the rooms will be divided into four groups of seven rooms – communities - with a shared kitchen for each community. Public facilities for all the residents in the building, such as a library, living room and washing machines will be located on the ground floor. The upper level of the building will be expanded and improved as current fire safety measures do not meet the current requirements.

MEP system characteristics

Future heating system: heat is centrally produced by a Natural Gas boiler with a size of 475 kW, while two indirect heated DHW cylinders are installed for Domestic Hot Water production (2x 100 kW). The boiler has been recently replaced (2019). Radiators are used as terminals for the heating system.

Future Cooling system: No cooling system is currently present in the building

Future Ventilation: Mech ventilation is present in the building using five AHUs of a capacity of about 1300 m3/h each. The associated consumption is about 300 W/(m3/s). These systems are equipped with an inverter that regulates the fan speed depending on the required air flow. The system is currently operating properly, but no energy reducing measure is currently applied (no heat recovery as well).

Future lighting system: The lamps installed in the building are mainly fluorescent and standard light bulbs, both indoor and outdoor. No LED lamps have been detected, therefore there is huge potential for improvement on this side.

Energy management system: No occupancy sensors or similar are currently installed in the building. The regulation of the heating system is performed by thermostatic valves installed on the radiators in the different rooms. For what concerns the lighting system in common areas, temporized switches are used, while the outdoor lighting is controlled by crepuscular sensors.

Users comfort (Building B6): No data gathered.

Energy transformation Status and Targeted status:

Energy Needs: 190 kWh/m²/y → 40 kWh/m²/y

Current RES production: 0 MWh/y → 267 MWh/y

EPC Class: C → A+

Current SRI: 10.5% → 84.2%

Figure 29 Groningen demo site

4.2 Overview of foreseen interventions and progress

In this chapter a general overview of innovation and conventional intervention on the demo are listed. For conventional interventions, progress is highlighted in this section. In the following chapter every innovative solution will be detailed explore.

Product Solutions:
Innovative
I. [WEBO/VW] BIPV pre-installed on Prefab Facades
Conventional
I. [VW] Full contemporary building insulation (e.g., windows U-value 0,7-1,2[W/m2K], facades Rc-value 1,3-3,5 m2K/W)
Progress so far: Preliminary design finished. Final design started with Architect and Client.
II. [VW/LEFIER] 11 Water-water heat pumps (1/ floor)

Progress so far: First research done on possible options. Consulting company hired to prepare some heating scenarios for the Van Heemskerckflat. Lefier to choose the best feasible option.	
Process Solutions:	
Innovative	
I.	[WEBO/VW] Improved design of prefab modules/facades that allows building expansion through attachment of modules to the longitudinal side of the building
II.	[WEBO/VW] BIM-based Design of Prefab Modules [METRO7, ESTUDIO] Laser 3D Scanning
III.	(VW) Drilling Robot // Demolition Robot
IV.	(WEBO/VW) Facades installation through scaffolders telescopic crane
Conventional	
I.	(WEBO/VW) Prefabricated facades
Progress so far: Starting final/detail design with WEBO.	
Neighborhood Level Solutions	
Conventional	
I.	[VW/LEFIER] The possibility to connect to the municipal district heating project 'Warmtestad' will be explored. Suppliers of the residual heat are the data centers Bytesnet and QTS (formerly TCN), both located on Zernike Campus. This heat network can increase CO_2 savings by >55%. If it is not possible to connect to 'Warmtestad', other renewable energy sources will be selected for the heating of the building. In that case we are looking for example at using groundwater heat and cold. The PV panels integrated in the prefab facades will contribute some extent of the energy required. The usage of natural gas is not an option in any scenario.
Progress so far: First research done on possible options. Consulting company hired to prepare some heating scenarios for the Van Heemskerckflat. Lefier to choose the best feasible option.	

Table 16 Solutions of Groningen demo site and progress of conventional interventions

4.3 [VW] BIM-based Design of Prefab Modules

4.3.1 General description

Leader partner: **VW**

Changes during the project: **NO**

Description in the 1 st GA:

Re-designing the construction process of prefab modules by producing modules that require no further work at the building site other than assembly – these are fitted with windows, electrical wiring, plumbing and carpentry throughout the assembly line. The modules' assembling lines are digital by design – offering products, which are designed and generated according to the client's preferences, through interactive platforms.

Advancements within the project and TRL positioning: VW is currently re-designing its construction process with a view to maximize off-site manufacturing and automatization; thus, creating the required speed (decreasing assembly time by up to 80%, in 2-3 weeks instead of a few months) to decrease manufacturing costs (by 25%).

During InCUBE, the goal is to make all necessary adjustments in the design and manufacturing process, building upon real-life experiences, to integrate and take maximum advantage of BIM (through DiTi) as the key system to ensure the building's performance. The end-goal is a BIM-led design and manufacturing process.

TRL 5 → **TRL 8**

Description updates at month 12

No changes.

4.3.2 Main Achievement at month 12

Preliminary design of the building is finished. Further elaboration of the preliminary design into a final design is needed. In this phase also co-makers will join.

Figure 30 Preliminary design

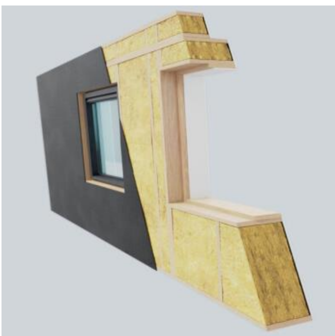

Figure 31 Preliminary design

Building applied: Groningen demo site

Licensing required: No licensing required.

Principal role: No role needs to be defined. VW is in charge of the detail design process.

Critical step: Timely procurement of subcontractors and co-makers is required to incorporate their knowledge into the process.

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart: None

4.4 [VW] BIM-connected Robotic Systems: a) Demolition Robot Automating Demolition of Facades // b) Telescopic Crane Enabling Scaffold-less Construction // c) BIM-to-Field Drilling Robot

4.4.1 General description

Leader partner:	**VW**
Changes during the project:	**NO**

Description in the 1st GA:

BIM-connected demolition robot to automate the demolition process (e.g., facades) and attain a higher process speed; b) BIM-connected telescopic crane, for installing facades so as to avoid scaffolding (constructing safe scaffolding is highly time consuming and most building-related accidents take place on scaffolding); c) BIM-connected drilling robot optimizing drilling for renovation purposes (e.g. cable wiring and pipelines), which enables savings of up to 30% of execution time and up to 40% of raw material requirements. The robot can drill up to 800 holes a day without any physical effort. All these robots are fully equipped with warning sensors to minimize any unexpected damage to the surroundings (e.g., due to human error), which makes them an excellent choice for potentially renovating cultural heritage buildings.

Advancements within the project and TRL positioning: The robots themselves are already commercially available but require significant configuration, to operate based on the BIM models to be developed and communicate with InCUBE Suite (e.g., DiTi). During InCUBE the following advancements will be performed by VW in close collaboration with HILTI (sub-contractor): a) enable the integration of SCAN-to-BIM data (e.g., 3D models) to control in an automatic way the robotic systems; b) enable the communication and orchestrate the combined operation of the different robotic systems; c) improve the individual performance of every robot. These robots will be demonstrated for the first time combined in a residential renovation project.

TRL 6	→	**TRL 8**

Description updates at month 12

No change.

4.4.2 Main Achievement at month 12

Preliminary design of the building is finished. Further elaboration of the preliminary design into a final design is needed. In this phase also subcontractors will join.

Figure 32 Preliminary robotic system

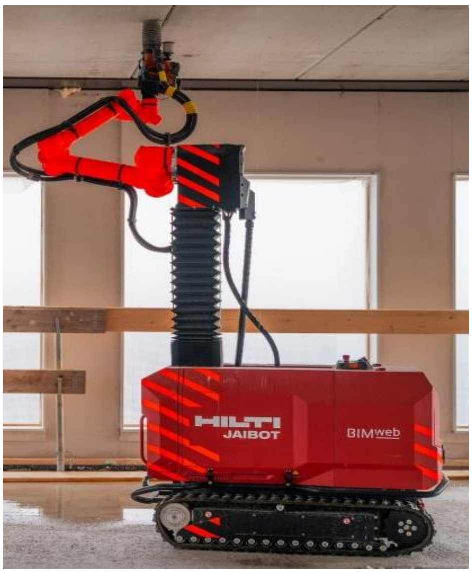

Figure 33 Preliminary robotic system

Building applied: Groningen demo site

Licensing required: No licensing required.

Principal role: No role needs to be defined. VW is in charge of the procurement process.
Critical step: Timely procurement of subcontractors and co-makers is required to incorporate their knowledge and requirements into the process.

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart: None

4.5 [VW]Construction Waste Sorting Robot

4.5.1 General description

Leader partner:	**VW**
Changes during the project:	**NO**

Description in the 1 st GA:

A robot for scanning and separating waste facilitating recycling and reducing material disposal located in the construction site. This solution is part of VW's BIM-connected Robotic Systems described above. The sorting robot is stationed outside the renovated building so it can be applied to any building typology. Advancements within the project and TRL positioning: The robot itself is already commercially available but require significant configuration in order to operate (execute the renovation) and being controlled by the BIM models to be developed and being seamlessly connected and communicate with other InCUBE Suite components (e.g., DiTi, R-GUIDE) (see Solutions Supporting On-Site Installation - BIM-connected Robotic Systems for more details).

TRL 5	**→**	**TRL 8**

Description updates at month 12

No changes.

4.5.2 Main Achievement at month 12

Preliminary design of the building is finished. Further elaboration of the preliminary design into a final design is needed. In this phase also subcontractors will join.

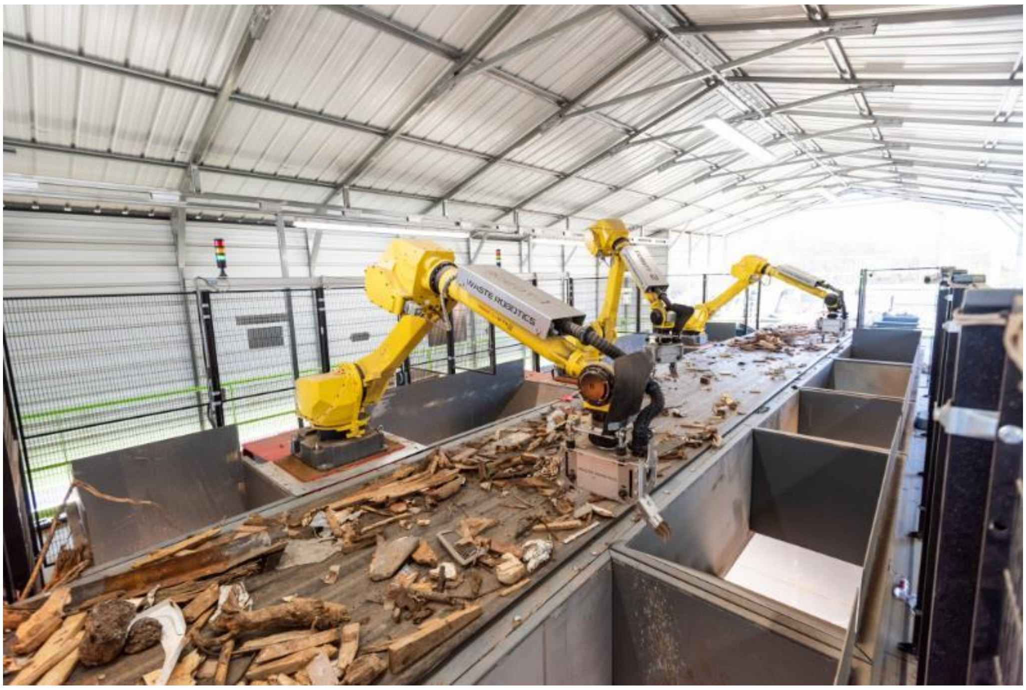

Figure 34 Construction waste sorting robot

Building applied: Groningen demo site

Licensing required: No licensing required.

Principal role: No role needs to be defined. VW is in charge of procurement process

Critical step: Timely procurement of subcontractors and co-makers is required to incorporate their knowledge and requirements into the process.

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart: None

4.6 [VW]Drone-enabled Scan-to-BIM 3D modelling

4.6.1 General description

Leader partner:	**VW**
Changes during the project:	**NO**

Description in the 1 st GA:

Point clouds are created by drone technology (such as Lidar) equipped with 3D scanners. The specific process is much quicker than conventional surveying methods and results in a very high accuracy of the developed 3D model. The solution is compliant with NEN-&-ISO

19650 and is highly suitable for cultural heritage buildings, where a major challenge is coping with deviations that cannot be identified in existing building plans.

Advancements within the project and TRL positioning: The main advancement lies in the integration of Scan-toBIM 3D modelling tool to InCUBE's DiTi and the overall project's suite, enabling the link-cooperation with the functionalities of all renovation phases on site (e.g., scaffolding, demolishing, drilling). Works to be undertaken during InCUBE will lead to a more reliable BIM model, which enables the preparation of work more efficiently, cutting time up to 50% and, as a result, significantly reduces failure costs up to 16% and margin of error by 20%.

TRL 7 → **TRL 8**

Description updates at month 12

No change.

4.6.2 Main Achievement at month 12

The first 3D-scanning took place in May 2023. The outside and some of the public spaces inside the building were scanned. This was done with the use of a stationary scanner.

Figure 35 3D scanning

Figure 36 Indoor scanning

Coming months further scanning will take place to acquire a complete point cloud of the building. The tenants that remain in the building will be informed. After 3D scanning a Revit model will be created based on the point cloud. The building will also be scanned with the help of a drone. This will create photometric data.

Building applied: Groningen demo site

Licensing required: Tenants have to give their permission to scan inside their rooms. Permit is needed to fly the drone.

Principal role: Lefier, as landlord, shall support the communication with the tenants.

Critical step: Communication with tenants should take place as soon as possible. Point cloud to be converted to Revit 3D-model

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart: None

			YEAR 1												YEAR 2											
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
			jul-22	aug-22	sep-22	okt-22	nov-22	dec-22	jan-23	feb-23	mrt-23	apr-23	mei-23	jun-23	jul-23	aug-23	sep-23	okt-23	nov-23	dec-23	jan-24	feb-24	mrt-24	apr-24	mei-24	jun-24
T7.4	**Large Scale Demonstration of InCUBE framework-Groningen**	**VW**																								
ST7.4.1	Deep Renovation of building following interventions as defined in 1.2.4.																									
	Preliminary Design																									
	Site Visit																									
	Defining Employer Requirements																									
	Procurement of relevant consultants																									
	Preparing architectural design																									
	Preparing structural design																									
	Consult municipality of Groningen																									
	Finalizing preliminary design																									
	Apply for building permit																									
	Apply for other required permits																									
	Permit granted																									
	Financial closure																									
	Final Design (3D/BIM)																									
	Aquire 3D-data building																									
	Prepare 3D-Models Architectural																									
	Prepare 3D-Models Structural																									
	Prepare 3D-Models Mechanical																									
	Detail Design																									
	Elaborate 3D-Models Architectural with co-makers																									
	Elaborate 3D-Models Structural with co-makers																									
	Elaborate 3D-Models Mechanical with co-makers																									
	Procurement																									
	Shop Drawings																									
	Finalizing 3D-Models > 2D-Drawings Steel Structures																									
	Finalizing 3D-Models > 2D-Drawings Bathrooms																									
	Finalizing 3D-Models > 2D-Drawings Window Frames																									
	Finalizing 3D-Models > 2D-Drawings Stairs																									
	Finalizing 3D-Models > 2D-Drawings Wall Elements																									
	Production																									
	Production Steel Structures																									
	Production Bathrooms																									
	Production Window Frames																									
	Production Stairs																									
	Production Wall Elements																									
	Renovation Works																									

Table 17 VW time planning

4.7 [WEBO]Prefab Facades "Expanding" Available Space

4.7.1 General description

Leader partner: **WEBO**

Contributing VW

Changes during the project: NO

Description in the 1 st GA:

Prefabricated facades that are fixed directly onto the building's core structure. The facades ensure state-of-the-art requirements in terms of insulation, energy-efficiency and noise reduction. In the case of InCUBE (NL demo site), their application will also expand the building by attaching modules to the longitudinal side of the building. Doing so, will add 7m² to the living area of each apartment. The facades themselves will be own-funded but due to their innovative characteristics and their relevance to the project's objectives, they were included in the innovations portfolio and were briefly presented. Advancements linked with this solution are described in BIM-based Design of Prefab Modules (PILLAR#1) and BIPV pre-installed on Prefab Facades (PILLAR#2 - RES Generation Solutions).

TRL - → **TRL -**

Description updates at month 12:

No changes

4.7.2 Main Achievement at month 12

Design a prefab façade with integrated IBPV-Panels to generate electric power for the Van Heemskerckflat.

Building applied: Groningen demo site

Licensing required: No licensing need

Principal role: No role needs to be defined. WEBO is in charge of procurement process of the prefab facades

Critical step: Timely procurement of subcontractors and co-makers is required to incorporate their knowledge and requirements into the process.

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart: None

4.8 [WEBO] BIPV pre-installed on Prefab Facades

4.8.1 General description

Leader partner: **WEBO**

Contributing VW

Changes during the project: No

Description in the 1 st GA:

Prefabricated façade system with integrated solutions for energy production purposed for renovation of high-rise dwellings/apartment buildings. Standards NEN-EN 14915:2013, NEN-EN 13501, BRL 1001 are considered. Advantages include: 1) Usage of vertical space on facades to generate solar energy (150 Wp/m2), 2) Prefabrication of integrated solutions reduces CO2 impact by incorporating a circular demountable connection design. 3) Save up to 20% of PV façade installation costs. The system's demount ability was tested as a prototype TRL6. The PV integration on vertical surface area is currently on TRL5. During the project the demount connector and PV integration will be optimized to enhance the seamless integration in the renovation process of high-rise dwellings, allowing for 50% reduction of assembly time on site. The solution will be demonstrated in real life environment (high-rise residential building) achieving a TRL8. The demounting ability of the system eases maintenance and provides predesigned return logistics after product life end, to re-use or repurpose the façade system.

TRL 5/6 → **TRL 8**

Description updates at month 12

No changes.

4.8.2 Main Achievement at month 12

<u>More detailed information was not available at the time of writing this document and will be provided in the next updated version of the Deliverable.</u>

Building applied: Groningen demo site

Licensing required: None

Principal role: None

Critical step: None

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart: None

4.9 [TERA] Smart Building Energy Monitoring System (S-BEMS) – Open, agnostic, and AI-powered BEMS

4.9.1 General description

Leader partner:	**TERA**
Changes during the project:	**No**

Description in the 1 st GA:

S-BEMS is an integrated BMS that moves beyond business-as-usual BEMS by: a) applying Machine Learning (ML) and deep neural network algorithms to significantly improve forecasting of energy consumption and RES production, with special emphasis given on the maximization of self-consumption; b) ensuring interoperability with a multitude of systems through the support of most key IoT protocols (e.g. MQTT, REST) and Building Automation protocols (e.g. BACnet, Modbus, KnX, ZigBee, ZWave, M-Bus, LoRa). The S-BEMS is highly cost-efficient (PBT=1-2 years). Considering a 7-storey building with 640 m^2 per floor, compared to BEM solutions with traditional electronic systems a capital investment up to 40% lower is achieved. Advancements within the project and TRL positioning: The current version of S-BEMS will be tested during 2021 in 150 residential units in the Lombardy Region whereas during InCUBE this solution will be advanced to better serve the needs of energy communities and real time DR. More specifically, BEETA™ MoCo – the edge computer capable to monitor and manage bi-directional energy flows of battery storage inverters and other electrical equipment and loads, will be upgraded and integrated in the S-BEMS aiming at enhancing the electric energy flow management systems in smart grids and energy communities. The S-BEMS will be adapted to interact with the energy management at the district level developed by EVOLVERE through the development of relevant energy rules and logic. Advancements will comply with Directive 2014/53/EU (RED, Radio Equipment Directive) and ROHS.

TRL 6 → **TRL 8**

Description updates at month 12

S-BEMS is an integrated Building Monitoring System BEMS that moves beyond business-as-usual BEMS by: a) applying Machine Learning (ML) and deep neural network algorithms to significantly improve forecasting of energy consumption and RES production, with special emphasis given on the maximization of self-consumption; b) ensuring interoperability with a multitude of systems through the support of most key IoT protocols (e.g., MQTT, REST) and Building Automation protocols (e.g., BACnet, Modbus, KnX, ZigBee, ZWave, M-Bus, LoRa). The S-BEMS is highly cost-efficient (PBT=1-2 years). The current version of S-BEMS also adopted to support energy diagnosis for industrial buildings, residential and commercial where during InCUBE it will be advanced with the aim to serve the needs of renewable energy communities and real time energy flexibility services better also. More specifically, BEETA™ MoCo and/or GioE IoT edge computer will be upgraded to enhance the S-BEMS aiming at enhancing the electric energy flow management systems in smart grids and energy communities. The S-BEMS – powered by [FBK] algorithms - will be adapted to interact with the district energy management or aggregation platforms developed by partner [EVOLVERE] through the development of relevant energy rules and logic. Advancements will comply with Directive 2014/53/EU (RED, Radio Equipment Directive) and ROHS.

4.9.2 Main Achievement at month 12

No progress.

Building applied: Groningen demo site

Licensing required: Need of authorization from the tenants of the Dutch demo to install multiparameter sensors (temperature, relative humidity, CO2, lux) and energy meter inside the candidate residential units.

Principal role: In Dutch demo site the main role is covered by whom may concern assigned by partner [VW]

Critical step: Worldwide well know hardware/chip/semiconductor supply chain crisis that affects hardware manufacturing in (i) extended procurement time, (ii) production time, and (iii) increase in the overall costs for prime material and product.

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart: To be defined and detailed during the upcoming T5.1 kick-off meeting

5 Software innovations applied to all demo sites

5.1 [CERTH] INTEMA – Enhanced energy assessment and integrated energy management

5.1.1 General description

Leader partner:	**CERTH**
Changes during the project:	**NO**

Description in the 1 st GA:

INTEMA combines machine learning and novel algorithms setting up an intelligent system, which, based on raw data fed by almost real-time input data from sensors (as well BIM if available), is able to accurately forecast key operational parameters (e.g., power load, PV production), enabling energy system's automated actions and suggestions to the user. It is based on the open-source AixLib and Building Systems libraries. The tool combines a) the power related modules of the Modelica Standard Library, b) the well-validated open-source libraries for the building sector Buildings, AixLib, Building Systems, along with c) custom-made in-house components. INTEMA can lead to primary energy savings of 10-15%, increase total controllable loads (>30%) and has a PBT of around 3-4 years.

Description updates at month 12

No changes.

5.1.2 Main Achievement at month 12

So far, the following actions have been completed: a) web user interface; b) experimentation for data-driven models development based on open-access datasets; c) dynamic modelling for the novel InCUBE products and materials and d) integration with VERIFY through Restful API.

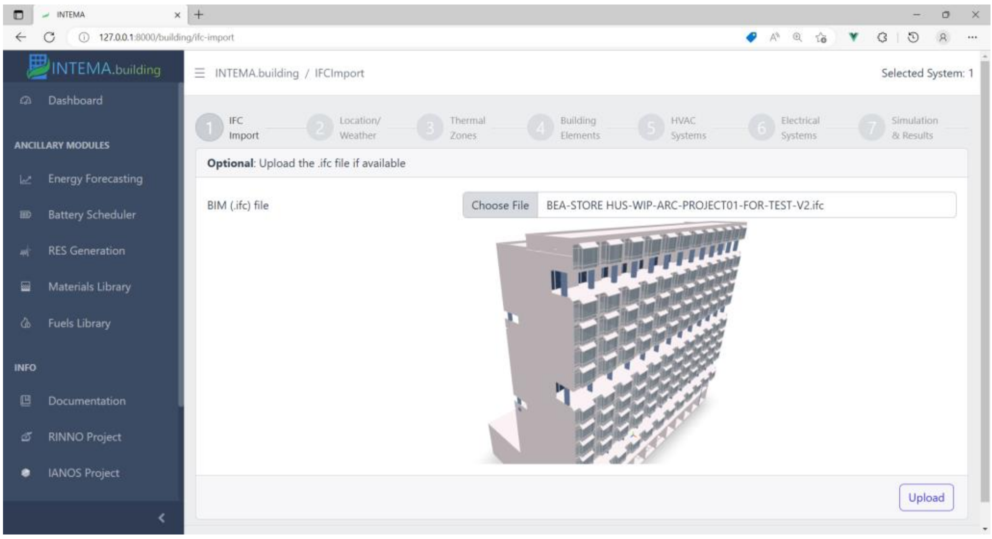

Figure 37 Capture of ITEMA platform

Figure 38 Capture of ITEMA results

During the next period CERTH will complete the following: a) Integration with the rest of InCUBE Suite; b) programmatically editing, saving, and export of BIM data in Python; c) testing (unit, E2E) and deployment and d) support for popular data models.

Building applied: All demo sites

Licensing required: No licensing is required to use the software since it is developed and run by CERTH.

Collection of necessary data from pilot leaders and solution providers is required to run the simulations.

Principal role: The technical team of CERTH (CPERI) is responsible for the development and operation of the INTEMA tool in order to produce the desired simulation results, based on the received pilot/product data.

Critical step:

- **Seamless integration with other modules** could pose significant challenges in terms of e.g., communication protocols to be applied, adopted formats etc., and require continuous communication with the developers of respective modules. Significant bottlenecks could arise if the development of one of these modules is delayed for any reason.
- **Implementation of data-driven** (machine learning) models requires operation data for the particular energy systems under consideration. Such data can be obtained from testing procedures by the manufacturer (performance, standardization etc.) or from historical operation data in the field by metering equipment. The lack of such data prohibits the development of such models.

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart: Subtasks of T4.1 as described in the Gantt chart below are on time. No delays are expected currently.

5.2 [CERTH] VERIFY – Dynamic life cycle evaluations

5.2.1 General description

Leader partner:	**CERTH**
Changes during the project:	**NO**

Description in the 1 st GA:

VERIFY is an online web-based platform, performing environmental and cost oriented analysis and computations. A PostgreSQL database is responsible for keeping all the important information secure and updated. VERIFY main advantages, over similar available commercial tools, lie on the web server installation, the variety of computations it can perform and the use of open-source programming libraries. Communication with remote sensors is achieved through MQTT messaging transport protocol.

Description updates at month 12

No changes.

5.2.2 Main Achievement at month 12

So far, the following actions have been completed: a) web platform implementation; b) implemented KPIs considering the whole life-cycle staging of technologies (embodied primary energy, embodied CO2 emissions etc.); c) implemented subset of KPIs imposed by

LEVEL(S) (Primary energy demand, lifecycle global warming potential, life cycle costs) and d) achieved communication with INTEMA.building through Restful API.

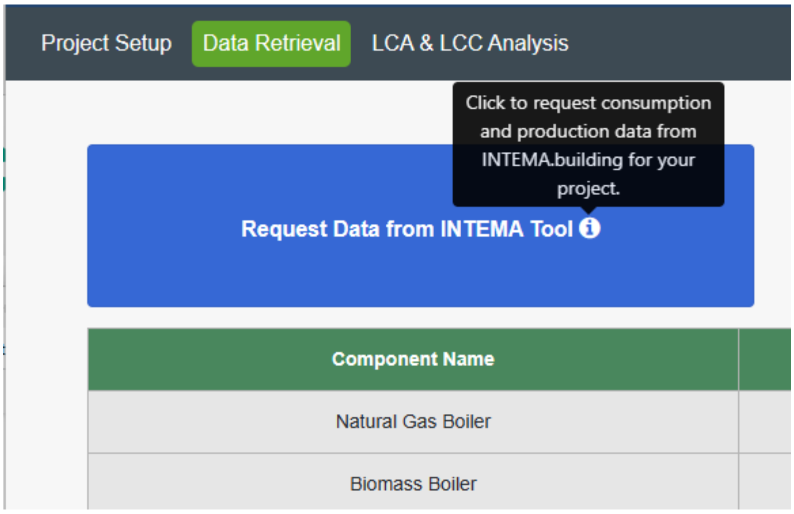

Figure 39 Web platform implementation - VERIFY

	Primary Energy (kWh)	CO2 Emissions (kg)
Annual (functional)	166,650	11,731
Initial Embodied	1,961,053	122,523
Lifetime	6,312,031	427,317

View details per component

Figure 40 Implemented KPI - VERIFY

Investment Costs	
Initial Investment (€)	159,491.6
Lifespan Capital Costs (€)	177,465.2

Infrastructure Costs		
	O&M (€)	Fuels (€)
Annual	815.1	10,655.9
Lifespan	20,245.8	270,143.0

Figure 41 Subset of KPI - VERIFY

During the next period CERTH will complete the following: a) implementation of relevant construction related KPIs; b) implementation of other relevant KPIs imposed by LEVEL(S); c) extend the methodology for wider scales (district); d) implement Restful API to provide data to external tools on demand.

Building applied: All demo sites

Licensing required: No licensing is required to use the software since it is developed and run by CERTH.

Collection of necessary data from pilot leaders and solution providers is required to run the simulations.

Principal role: The technical team of CERTH (CPERI) is responsible for the development and operation of the VERIFY tool in order to produce the desired simulation results, based on the received pilot/product data.

Critical step: Seamless integration with other modules could pose significant challenges in terms of e.g., communication protocols to be applied, adopted formats etc., and require continuous communication with the developers of respective modules. Significant bottlenecks could arise if the development of one of these modules is delayed for any reason.

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart: Subtasks of T4.1 as described in the Gantt chart below are on time. No delays are expected at this time.

5.3 [CERTH] Planning Guide (P-GUIDE) – Optimizing renovation planning and supporting BRP

5.3.1 General description

Leader partner:	**CERTH**
Changes during the project:	**NO**

Description in the 1st GA:

The tool is able to assess different renovation scenarios (e.g., diverse elements, with/without RES, storage, hybrid systems) and select the optimum one based on pre-defined KPIs, offering a customized roadmap towards deep renovation. The key advantage over similar solutions is that it can be easily customized to communicate with BIM/CIM models, LCA-LCC tools and DTs. The result is a user-friendly dynamic roadmap the owners can use to plan deep renovation, as well leading to time and cost savings during the design stage (30%) through the optimization of the renovation scenarios.

Description updates at month 12

No changes.

5.3.2 Main Achievement at month 12

Functional and non-functional requirements for the P-GUIDE have been defined.
The different KPIs that will be considered for the evaluation of the different renovation scenarios have been defined. Moreover, relevant indicators for each KPI were specified, as shown below.

- Cost
  - Total Cost
- SRI index impact
  - Total SRI score
- Retrofitting time
  - Duration in days or hours
- Disturbance level
  - Physical / Accessibility
  - Ambient noise
- Environmental impact
  - Overall waste
  - CO2 emission savings
- Energy impact
  - Yearly RES production
  - Decrease in total energy consumption
  - Heating / Cooling efficiency
  - Heating demand reduction

Figure 42 Definition of KPIs

The workflow for the user through the web-based UI has been defined as follows:

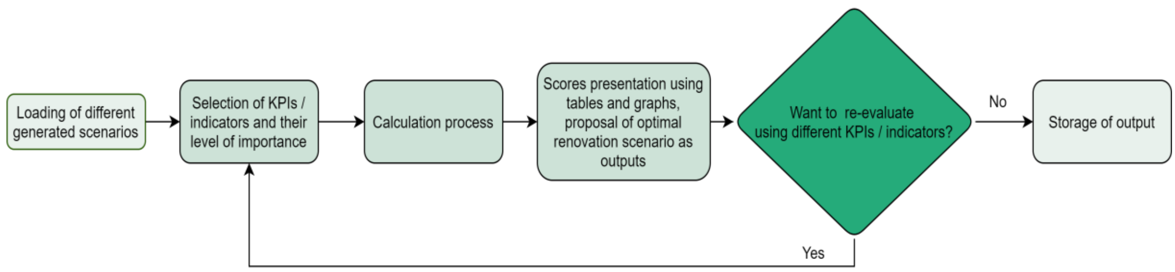

Figure 43 Workflow of P-GUIDE

As a next step, the renovation scenarios at each demo site will be formulated in order to be used as inputs.

Building applied: All demo

Licensing required: No licensing is required to use the software in the context of InCUBE project.

Principal role: The technical team of CERTH is responsible for the development of the P-GUIDE.

Construction managers and demo site/building managers are the end-users for P-GUIDE.

Critical step: Definition of the candidate renovation scenarios to be considered, based on the foreseen interventions at each demo site.

The accuracy and relevance of the output result presented to the user depends on the configuration, such as the (priority) weight of each KPI. The weights have to be easily configurable.

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart: Subtasks are on time and no delays are expected at this point.

5.4 [CIRCE] Modular BIM/CIM Platform – A multi-object BIM library facilitating BIM development

5.4.1 General description

Leader partner:	**CIRCE**
Changes during the project:	**NO**

Description in the 1st GA:

CIRCE's BIM platform is a modular (able to swap BIM object categories) and interoperable web-based repository of BIM objects (incl. conventional and novel building solutions) – reducing modelling time by at least 20% in comparison with conventional modelling process without the use of a standardized library. Advancements within the project and TRL positioning: During InCUBE the BIM platform will be adapted to a standardized common format, e.g., IFC data structure format, to facilitate collaborative work among all BIM developers. The platform will be extended to integrate City Information Modelling (CIM) data from demo sites at city level supported with Geographic Information Systems (GIS). From the data gathered at BIM/CIM level, key building variables, such as envelope type, will be revised, identified, and selected as a first step to the generation of building database at district/city level under the CityGML standard. These variables will be incorporated into existent cadastral databases that will be enhanced with the calculation of complementary attributes.

TRL 6	→	**TRL 8**

Description updates at month 12

No changes.

5.4.2 Main Achievement at month 12

A basic BIM objects data collection has been developed including the information requested from the demo sites - Figure 44

BIM REPOSITORY ELEMENTS					
	Do you need a specific component to be included in the BIM repository? *Select it from the list below*	*Name or main material*	*Brief description of the object such as main components, function, models, etc*	*Current status / Renovation status*	*Select it from Uniclass Table EF (level 3)*
STRUCTURE	- Beam	Reinforced contrete	Variable dimensions. Not very detailed	Both	EF_20_10_80
STRUCTURE	- Beam	Reinforced contrete	Variable dimensions. Not very detailed	Both	EF_20_10_80
STRUCTURE	- Beam	Steel. Balconies and elevator	#120.60, IPE 160, IPE140, IPE 120 + accesories, anchor plates and connectors	Renovation Status	EF_20_10_80
STRUCTURE	- Beam	Steel. Facades extention	HEA 140, 180, 240, HEB 180, UNP 180		EF_20_10_80
STRUCTURE	- Wall	Reinforced concrete walls	Reinforced concrete walls	Renovation Status	EF_20
STRUCTURE	- Wall	Ground floor wall	Concrete wall	Both	EF_20
STRUCTURE	- Wall	Level walls	Reinforced concrete walls	Both	EF_20
STRUCTURE	- Wall	Ground floor wall	Reinforced concrete	Both	EF_20
STRUCTURE	- Wall	Bricks	Brick bearing walls	Current status	EF_20
STRUCTURE	- Column	Reinforced concrete. General building structure	250x250. Not very detailed geometrical definition a priori needed for architectural project, perhaps data for LCA	Both	EF_20_10_80
STRUCTURE	- Column	Elevator structure	#120.60, IPE 160, IPE140, IPE 120 + accesories, anchor plates and connectors	Renovation Status	EF_20_10_80
STRUCTURE	- Column	Reinforced concrete	Variable dimensions. Not very detailed	Both	EF_20_10_80
STRUCTURE	- Column	Steel. Facades extention	HEA 140 - 160	Renovation Status	EF_20_10_80
STRUCTURE	- Structural floor	Slabs	precast concrete joists + ceramic vault. Not very detailed geometrical definition a priori needed for architectural project, perhaps data for LCA	Both	EF_30_20
STRUCTURE	- Structural floor	Existing balconies	Reinforced concrete	Both	EF_30_20
STRUCTURE	- Structural floor	Balconies expansion and lifs' landings	#120.60, IPE 160, IPE140, IPE 120 + accesories, anchor plates and connectors	Renovation Status	EF_30_20
STRUCTURE	- Structural floor	Slabs	Reinforced concrete	Both	EF_30_20
STRUCTURE	- Isolated footing	Concrete	Variable dimensions according to their possition: stairs, façade, indoors	Both	EF_20_05_30
STRUCTURE	- Strip footing	Concrete	Variable dimensions according to their possition: stairs, façade, indoors	Both	EF_20_05_30

Figure 44 Extract of the BIM objects data collection

From this data collection, a BIM element classification has been done. In accordance with this, a set of parameters and data structure for the BIM objects has been included in coordination with task T3.3 - Figure 45. It includes different information depending on the type of element Figure 46.

		Parameter name Identifier [bim element]	Description	Type of Data	Example
		Identifier [bim element]			
1	A.1	Model	Product name or code	Text	Generix
2	A.2	Type	Product configuration name	Text	850 x 1200 mm - Wall fixation
		Legal identity			
3	B.1	Author	Author of the BIM object. Who has created it. It can be a company or organization (legal person) or a	Text	Incube
4	B.2	Headline	It is the person or organization that can make a use and exploitation of the BIM object. It can be a	Text	Partners Incube
5	B.3	License number	Serial number of the legitimate/legal license of the software in which the BIM object has been created,	Text	XXX-XXXX9536 / BIMETA PARAMETRIC DESIGN
6	B.4	Version	The field represents the software version which is currently developed by the object. The field must be	Text	RVT2017-LT
7	B.5	BIM element issuance date	Date on which the creation of the BIM element for professional use has been valid	Text	2/2/2018
8	B.6	Expiration date of the BIM element	Deadline which is considered valid the object information	Text	4/2019
9	B.7	Record	Text summarizes the modifications of data made in the object. The data must be represented with an	Text	RVT2020-V01) Element creation. (RVT2021-V02)
		IfcElement_QtySet (in addition, the parameters assigned to QtySet for each category of element will be included))			
23	D.1	Quantity / count	Amount of elements used in project. Also available in PSET prescription	Automatic No.	23
24	D.2	Length	Distance X of the element	mm	1800 mm
25	D.3	Width	Distance and the element	mm	600 mm
26	D.4	Height	Z Distance from the element	mm	600 mm
27	D.5	Area	The area that covers an element	m2	25.00 m2
28	D.6	Perimeter	The perimeter that covers an element	m	10.00 m
29	D.7	Weight	The weight of the element	Kg	8.20 kg
		Specification (generic objects)			
30	E.1	Description	Element description	Text	Generic sofa of 3 seats
31	E.2	State	The situation in which the BIM object is. Options: New, existing, demolished	Listed value	New
32	E.3	URL	Example web link to the product manufacturer as a reference	URL	www.xyz.com
33	E.4	Level	Level (plant) in which the element is found in the project	-Automatic-	Level 2
34	E.5	It is exterior	Indicates whether the product is placed outside / weathering	But	No
35	E.6	Space	Enclosure that defines the program and function establishing the architectural finishes	Text	Office
36	E.7	Zone	Enclosure, group of spaces, which defines the main variables for the purposes of MEP calculations,	Text	Public Office
37	E.8	System	Applicable only to MEP elements only	Text	Plumbing
38	E.9	Responsible for prescription	It is the professional' (natural person), company or organization (legal person) who decides on which	Text	Christopher Wayne, ACME TNT CO.
39	E.10	Case Material	Material that compounds the case of the product	Text	Stainless steel
40	E.11	Finish	Type of finish or product color	Text	Green lacquered
		Prescription (brand objects)			
41	G.1	Reference	Element type identifier	Text	R20354
42	G.2	Manufacturer	Name (corporate name) of the company that provides the product	Listed value	MANUFACTORX S.L.
43	G.1	ManufacturerAdress	MANUFACTURING COMPANY LOCATION DIRECTORATE	Text	Fernando Católico Street, 2
44	G.2	ManufacturerCity	CITY OF LOCATION OF THE MANUFACTURER COMPANY	Listed value	Madrid
45	G.3	Manufacturer Postal Code	Postal Code of Location of the Company Manufacturer	Text/number	28010

Figure 45 Extract of the proposed data structure for the BIM objects

	B	D	G
1	**Parameter Name**		**ConcreteSlab**
2	**Model**	Text	Concrete T-16 Slab
3	**Configuration / Type**	Text	(14+6)*70 / Ceramic curved board
13	**Modelado**		
17	**Pset_Legal Identity**	7	5
25	**Pset_Classification**	13	13
26	IfcExportAs	Text	IfcSlab
27	IfcExportType	Text	Concrete Joist Floor
28	CobieCateogry	Text	IfcSlab
29	OmniclassCategory	Text	23-13 31 15
30	OmniclassDescription	Text	Precast Structural Concrete
31	MasterformatCode	Text	03 41 16
32	MasterformatDescription	Text	Precast Concrete Slabs
33	Uniclass2015Code	Text	20-85-14-15
34	Uniclass2015Description	Text	Concrete solid slabs
35	UNSPSCCode	Text	30121704
36	UNSPSCDescription	Text	Concrete slab
37	GuBIMClassCode	Text	20.20.20.10
38	GuBIMClassDescription	Text	Forjados
39	**Pset_Specification**	6	4
51	**Pset_SlabCommon**	6	6
61	**Pset_ConcreteElementGeneral**	6	13
74	**7.8.4.4 Pset_ConcreteElementFabrication**	6	4
82	**7.8.4.5 Pset_PrecastConcreteElementGene**	6	7
103	**7.8.4.12 Pset_ReinforcementBarPitchOfWal**	6	14
110	**Pset_Prescription**	28	16
140	**Pset_Logistics**	5	0
153	**Pset_Management & Maintenance**	10	3
170	**Pset_Safety & Health**	4	0
178	**Pset_Sustainability & LCA**	40	0
219	**Qto_IfcSlab**	6	6
231	**Slab Configuration**		

Figure 46 Detailed example for an object type

Since May, a recurring development and updating of the BIM objects has been organized. It consists of weekly partners review of the BIM objects available in the common platform - Figure 47.

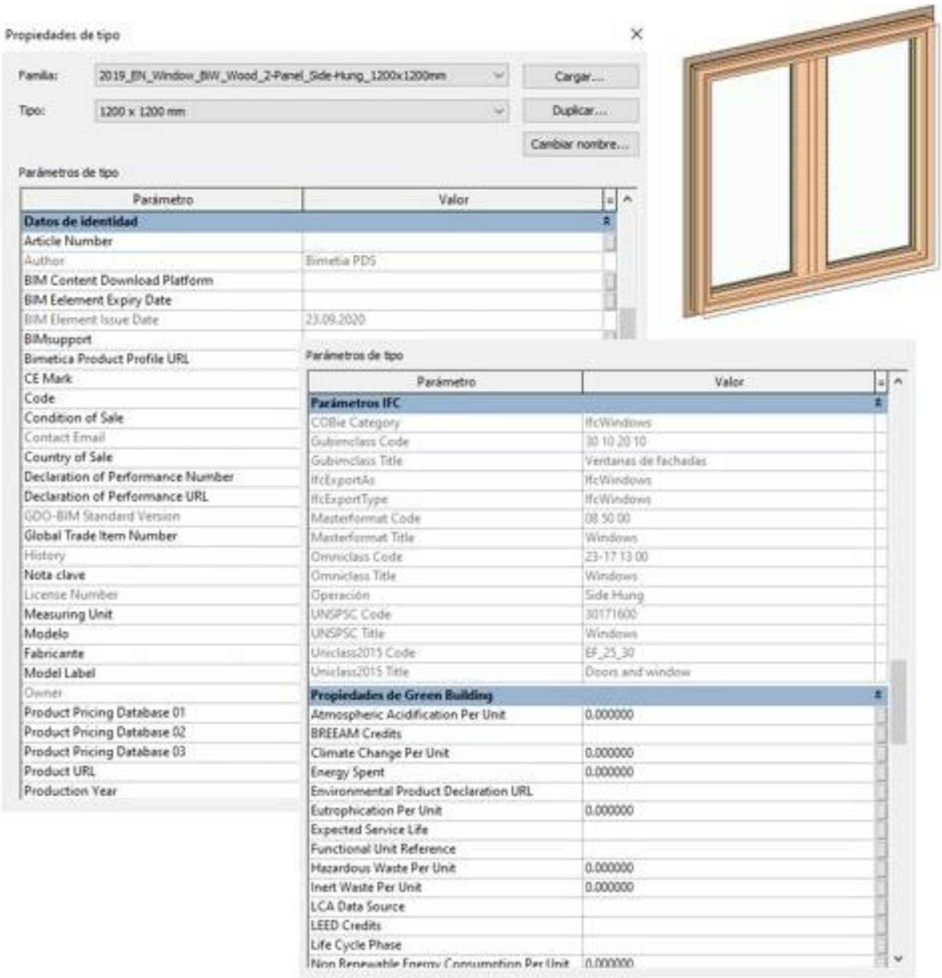

Figure 47 Example of a preliminary design of a BIM object

Building applied: All the buildings from the ES, IT, NL demo-sites will include in their digital model the BIM objects from the Modular BIM/CIM platform.

Licensing required: No need of requirements to install/ track/use the platform.

Principal role: No role needs to be defined yet.

Critical step:

Risk: Vague definition of BIM objects characteristics needed for the development of the BIM models for the demos.

Mitigation: Development of generic objects: Create easily customizable family types with structured information and attributes that can be adapted to provide the necessary information to InCUBE tools. This approach will allow for flexibility and accommodate evolving requirements.

Risk: Delay in contracting the development of InCUBE-specific BIM objects (Revit families).

Mitigation: Agree on partial delivery milestones: Prioritize the elements required for the current phase of the project, followed by the renovation phase, and finally introduce values in the defined information parameters. This approach ensures that progress can be made despite any delays in contracting the BIM object development.

Risk: Possibility of not having 3D information of the pilot cities obtained from public sources to complete the CIM repository.
Mitigation: Model simple volumetry of city buildings from cadastral information. If the complete 3D information is unavailable from public sources, create a basic representation of the city buildings using cadastral information such as building perimeter and heights. This approach provides a reasonable approximation of the buildings' 3D characteristics.

By implementing these mitigation plans, the project can minimize the impact of these risks and ensure progress in developing the BIM models for the demos. The planned UAV flight was not possible due to some flight restrictions in the pilot site area, and new technology was selected for the reality-based data acquisition. After receiving authorization from the Municipality of Trento, all accessible indoor and outdoor spaces were scanned.

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart: None

5.5 [CERTH] AR/VR Training Suite – Offering augmented next-generation training and assistance

5.5.1 General description

Leader partner:	**CERTH**
Changes during the project:	**NO**

Description in the 1 st GA:

CERTH has developed an AR/VR-enabled toolkit for the "on-the-job" training of workers being able to train the workers either "off-line" with predefined scenarios, or on-site ("on-the-job" training) based on AR techniques. The AR/VR toolkit decreases the construction time (up to 20%), as well as the training time of novice workers. Furthermore, it can decrease the errors and faults during the renovation processes, while the "on-the-job" assistance can decrease any delays resulting in cost savings (20%) and duplicated tasks.

Description updates at month 12:

No changes.

5.5.2 Main Achievement at month 12

So far, supported functionalities relevant to InCUBE have been identified. These are categorized into 'Training' and 'Assistance':

Training:
- "on-the-job" training, e.g., showing installation or assembly processes step by step, for the safe and accurate execution of construction works
- "off-line" training of workers with predefined scenarios

Assistance:

- Real-time communication of workers with the engineers/supervisors upon request
- Provide current information in AR environment, based on location (E.g., values from critical sensors, notifications related to safety & information about forbidden zones)
- "on-the-job" assistance for specific step/work

The next steps are the following:

- Determine the functionalities to be tested at each demo site in specific use case scenarios.
- Collect the material to be used for installation/assembly processes (text, images, videos) per demo site.
- Implement the integration with the Resilience Dashboard.

Building applied: All demo

Licensing required: No licensing is required to use the software in the context of InCUBE project, as it is developed by CERTH.

Principal role: The technical team of CERTH is responsible for the development of the AR/VR Training Suite and for providing usage instructions Demo site manager (employed of partner) is expected to assist in organizing the demonstrations InCUBE technology partners / Construction manager is expected to assist in the provision of the required training material Experienced workers / Novice workers will use the solution and provide their feedback

Critical step:

- Seamless integration with other modules, such as the Resilience Dashboard and the Digital Building Logbook for sending and retrieving data. In most cases, the data has to be exchanged in real-time, and tests will be necessary prior to the actual demonstrations.
- Creation of high-quality material for training, which is easy to understand by novice workers.

Interaction with P-guide: None in month 12

Interaction with R-guide: None by month M12 (AR/VR Training Suite is part of the R-Guide)
Interaction with InCUBE suite: None in month 12
Comment on Gantt chart: None

5.6 [CERTH] Job Scheduling Optimizer (JSO) – Optimization of construction/retrofitting works

5.6.1 General description

Leader partner: **CERTH**
Changes during the project: **NO**
Description in the 1 st GA:
JSO is an online tool, generating the optimal construction/renovation actions sequence, in terms of time and cost efficiency, according to the selected constraints and preferences (e.g., energy consumption, cost reductions, available workers, precedence relations between activities). JSO is accompanied by an interactive user interface, which allows users to provide their preferences. JSO can reduce construction time and costs by 6-20% in comparison with random work allocation for a specific renovation scenario.
Description updates at month 12
No changes

5.6.2 Main Achievement at month 12

So far, the following actions have been completed: a) web platform implementation; b) extendable jobs list: users can add customized jobs in the tool's database; c) extendable scheduling algorithms: constraints can be added/removed; d) tenant's disruption constraint: the tool minimizes the total tenant's disruption during renovation (considering that disruption is modelled in a measurable way).

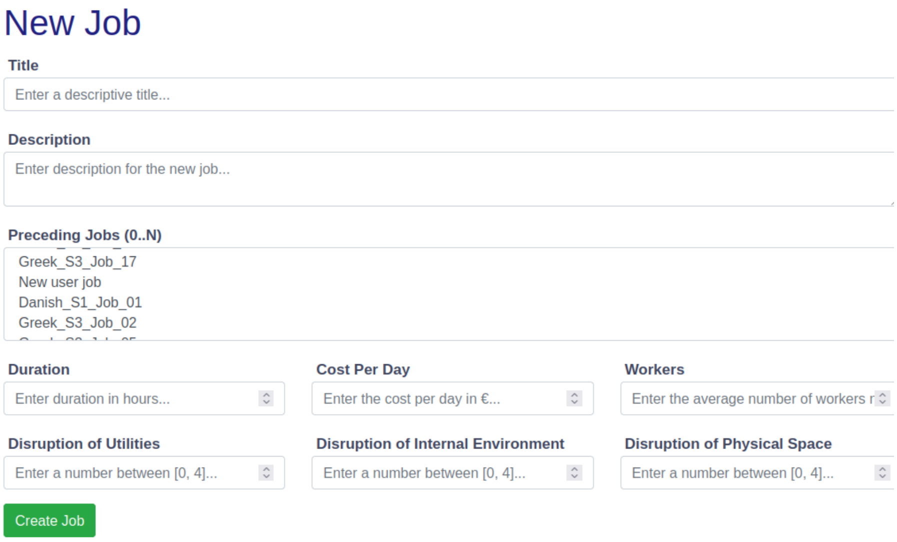

Figure 48 Web platform implementation - JSO

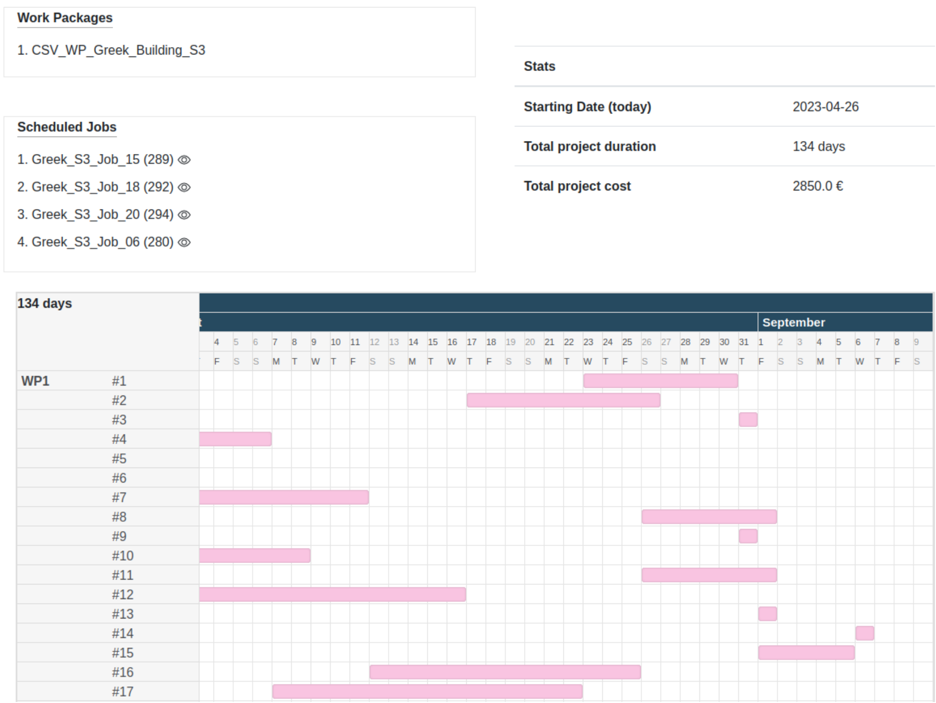

Figure 49 Extendable scheduling algorithms - JSO

During the next period the following actions will be completed: a) collect information about social constraints according to residents' welfare, add constraints to algorithms; b) Create RESTful API to provide data to external tools on demand and c) improve User Interface to be aligned with InCUBE's needs.

Building applied: All demo

Licensing required: No licensing is required to use the software since it is developed and run by CERTH.

Collection of necessary data from pilot leaders and solution providers is required to run the simulations.

Principal role: The technical team of CERTH (CPERI) is responsible for the development and operation of the JSO tool in order to produce the desired simulation results and integrate it into the WINER module in collaboration with CIRCE (under T5.2).

Critical step:

Identification of the optimal integration path with the LCP to form the WINER module of InCUBE.
Seamless integration in the InCUBE Suite and collaboration with the P-Guide and R-Guide.

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart: The subtasks of T5.2, where the JSO tool will be developed and integrated to the WINER module, are described in the Gantt chart below. No delays are expected at this time. ST5.2.2 is expected to start being active after the first trilateral meeting among CIRCE-CERTH-KENT on 12/5.

5.7 [KENT] Eclipse sensiNact Platform – Developing holistic and interoperable Digital – Twins (DT)

5.7.1 General description

Leader partner: **KENT**

Changes during the project: **NO**

Description in the 1st GA:

Eclipse sensiNact Platform - Developing holistic and interoperable Digital - Twins (DT): Eclipse SensiNact is a modular, open-source edge to cloud, digital twin platform that was created to rapidly integrate heterogeneous infrastructures, thus being compatible with a variety of smart connected devices and environments at the building and district level. It collects, via APIs, and processes data from heterogeneous sources; applies AI for decision making, carries out predictive analysis; and redistributes actionable information.

Building upon Eclipse sensiNact, InCUBE's DT will provide real-time awareness of the buildings processes and analyze data using new AI algorithms for decision making (e.g., use of ventilation), exploit forecasting models (e.g., energy consumption, comfort level) and link IoT data to WoT. To achieve the latter innovation, IoT data will be semantically enriched (e.g., using well-known ontologies, SAREF) enabling DTs to reuse, share or interact with other WoT entities. Another key advancement is the development of new connectivity bridges for building standards, that will be used in the pilots, helping increase the interoperability level of the sensiNact's interoperability level. Seamless communication with other InCUBE's modules (e.g., BIM/CIM platform) will be ensured and relevant visualizations (e.g., 3D models) will be developed.

TRL 6 → **TRL 8**

Description updates at month 12

No changes.

5.7.2 Main Achievement at month 12

sensiNact is a software component for collecting and aggregating data. Initial positioning work contributing to the definition of the architecture of the InCUBE digital platform. Eclipse sensiNact is part of the Digital Twin functional component within the architecture.

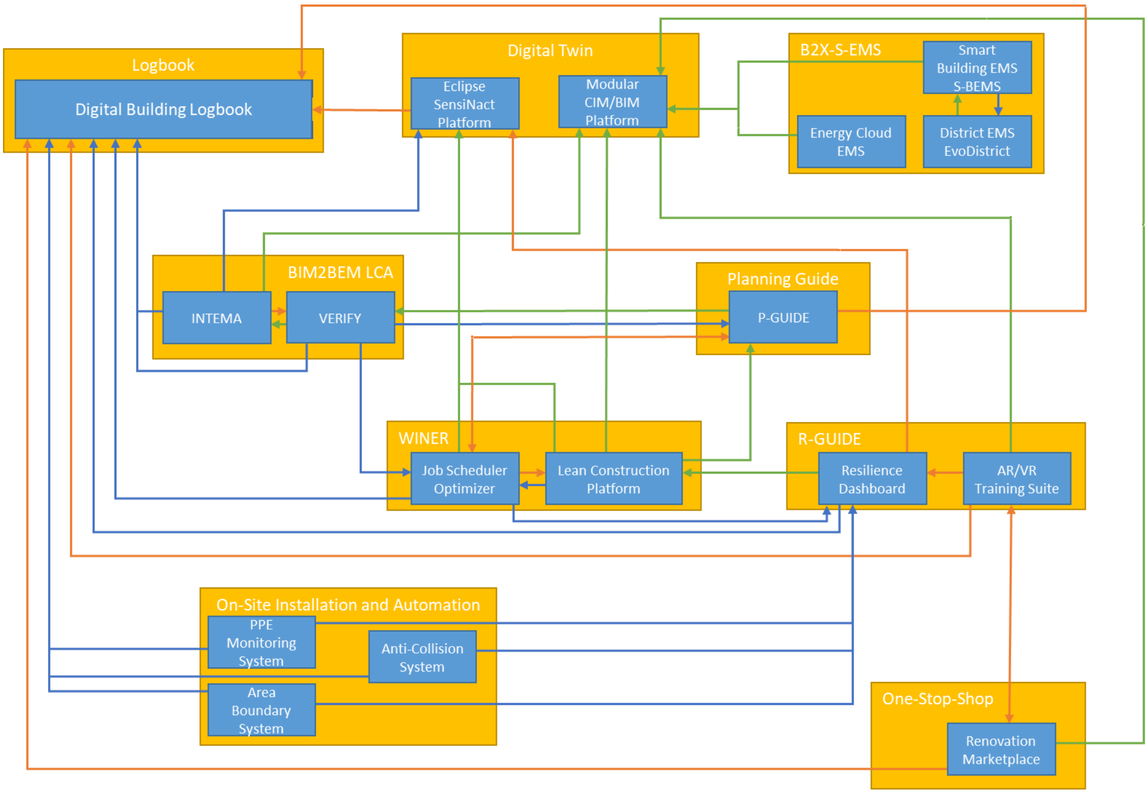

Figure 50 SensiNact architecture

Building applied: All demo

Licensing required: Possibly need local authorization by demo owner for local deployment of the software.

Software can also be deployed in Cloud infrastructure and accessed remotely.

Principal role: Ideally a single local point of contact should be designed for each of the demo site interactions with the InCUBE digital platform / digital twin. This person should have an overview of all digital component deployment at the local level.

Critical step: Definition of the architecture of the InCUBE digital platform

Identification of locally deployed equipment / data sources to be connected to the platform and communication protocols to be used

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: Part of the InCUBE suite, contribution to the architecture initial definition. sensiNact will take inputs from Sensors, INTEMA and the Digital Logbook it will then propagates events from IoT sensors and Smart Devices to the Digital Building Logbook

Comment on Gantt chart:

No demo related Gantt chart at this stage for this component.
Indicative Gantt of the digital platform

5.8 [CIRCE]Lean Construction Platform (LCP) – IPD-based workflow optimization

5.8.1 General description

Leader partner:	**CIRCE**
Changes during the project:	**NO**

Description in the 1 st GA:

LCP is a web-based collaborative platform, built upon the concept of Integrated Project Delivery (IPD), allowing information exchange and organization among multiple stakeholders of the renovation value chain. CIRCE's LCP is able to compile and manage a) BIM information; b) information from products' digital twins; c) monitoring data from product manufacturers; d) monitoring data from demolition/retrofitting.

Advancements within the project and TRL positioning: CIRCE has exploited the capabilities of IPD in several EU projects (NEED4B, RINNO, POCITYF, RESPONSE) whereas a lite version of LCP (non-dynamic with less information sources supported) will be demonstrated in RINNO project. Building upon these experiences, CIRCE will advance LCP to: a) allow the automatic reading and virtual representation of manufacturing process data of the product through the connection with the corresponding tables in SCADA or ERP systems of the demo site (by product reference or ID), including information of quantities and properties of its components, status (obtained by sensors), associated environmental impacts, and information related to transport and installation requirements, which enables its traceability; b) centralize data from several resources using the BIM format and monitoring data from manufacturers for visual communication, installation scenarios, efficient design, etc. c) support communication with other InCUBE's tools such as the BIM/CIM modular platform and Job Scheduling Optimizer.

TRL 5	→	**TRL 8**

Description updates at month 12

Redefinition of the tool: KPIs (medium-term, during renovation process) of the project to optimize: (based on d1.4)

- Working time with hazardous activities on-site during the construction phase,
- Number of accidents during renovation,
- Waste generated on-site during renovation,
- Number of workers/stakeholders trained.

Our Lean Platform will optimize these KPIs to reduce environmental impacts and improve security, applying Lean philosophy.

5.8.2 Main Achievement at month 12

Meetings with demos: guide the tool

Building applied: All demo

Licensing required: None: we wouldn't need municipality approvals

Principal role: No interventions in our tool.
Principal role at the moment: CIRCE (owner of the tool).

Critical step: Definition of the WINER tool at the moment. In the future, communications between modules.

Interaction with P-guide: None in month 12

Interaction with R-guide: None in month 12

Interaction with InCUBE suite: None in month 12

Comment on Gantt chart: None

6 Conclusion

During the preliminary phase of the process, it is possible for every partner to track a common path; every partner spends several months in the definition and in the feasibility study of their interventions. In Trento demo site the main issues were to adapt the planned intervention on an historical building and following the process of the local municipality. In Zaragoza the main issues were to convince owners to accept the innovation solution and to participate in a small amount financing the interventions. For Groningen the main issues were the time and the local authorization which led to the definition of a new building.

The main difference during this first phase is the approach and time planning of each partner. This is mainly due to the process that every solution follows before the installation. One of the aims in WP7 of the InCUBE project is to deploy the InCUBE Suite under real conditions as well as execute the renovation and construction activities. The aim of D7.1 is to understand the process and the execution in three different European countries. Due to the experiences that derived from the planning and the setup of construction sites, it will be possible to offer a holistically evaluation of the InCUBE solutions and their impact; nevertheless, a potential replicability analysis based on the evaluation findings.

At month 12 (June 2023) the main outcome of this first report is how every partner intends to prepare pilot sites for installation and deployment of solutions; not secondary how they are planning the timely implementation of each intervention to match the expecting deadline.
Except certain solutions that experience delay, all the other solutions are in a design phase and seem to meet the deadline of the end of June 2025, the last month available for interventions before starting the monitoring phase.

7 Annex - Template form submitted to demo leader

	Site and state of art proposed in 1st GA document at the start of the project	Site changes and progress archived from M1-M12 In GREEN additional parts added to the original propose
Name of the demo site		
Location of the demo site		
Relevance:		
Neighborhood/ district building(s) of the demo site		
Own funding of the demo site		
Renovation time plan		
General Scope of Renovation		
Main Building type (Building B6)		
Envelope characteristics (Building B6)		

MEP system characteristics (Building B6)	•	
Usage and characteristics (Building B6)		
Users comfort (Building B6)		
Energy transformation (Building B6) **Status → Targeted status**	•	•
Foreseen interventions - Overall Renovation overview (Including innovation and conventional interventions) (Building B6)	**I.**	I.
Foreseen interventions - Overall progress. Innovative interventions will be described in detail for each partner that owns the technology. (Building B6)		

8 Annex - Template form submitted to each demo partners

Pillar	
Solutions supporting On-Site Installation and Automation	
Description use in the GA in the 1st GA:	
New description at M12 for solution that change something during the project:	
Main achievements at the month M12 – month of the deliverable:	
Applied to which building:	
Licensing required:	
Principal role:	
Highlights of the critical steps:	
Interaction with P-guide	
Interaction with R- guide	

Interaction with InCUBE Suite	
Comment on Gantt chart	a) b) c) d)