# UNLOCKING THE EU RENOVATION WAVE

An INClUsive toolBox for accElerating and smartening deep renovation

InCUBE envisions to unlock the EU renovation wave through cutting-edge standardised and integrated processes based on industrialisation, innovative renewable energy technologies, digitalisation, and new market entrants. All while accounting for social inclusion, upskilling, and enhancement of women's role in the construction industry. The InCUBE solutions will be demonstrated in 3 large-scale demo sites: Zaragoza (ES), Trento (IT) and Groningen (NL).

ABOUT

InCUBE brings together **23 high-profile partners** and two affiliated entities from **7 European countries**.
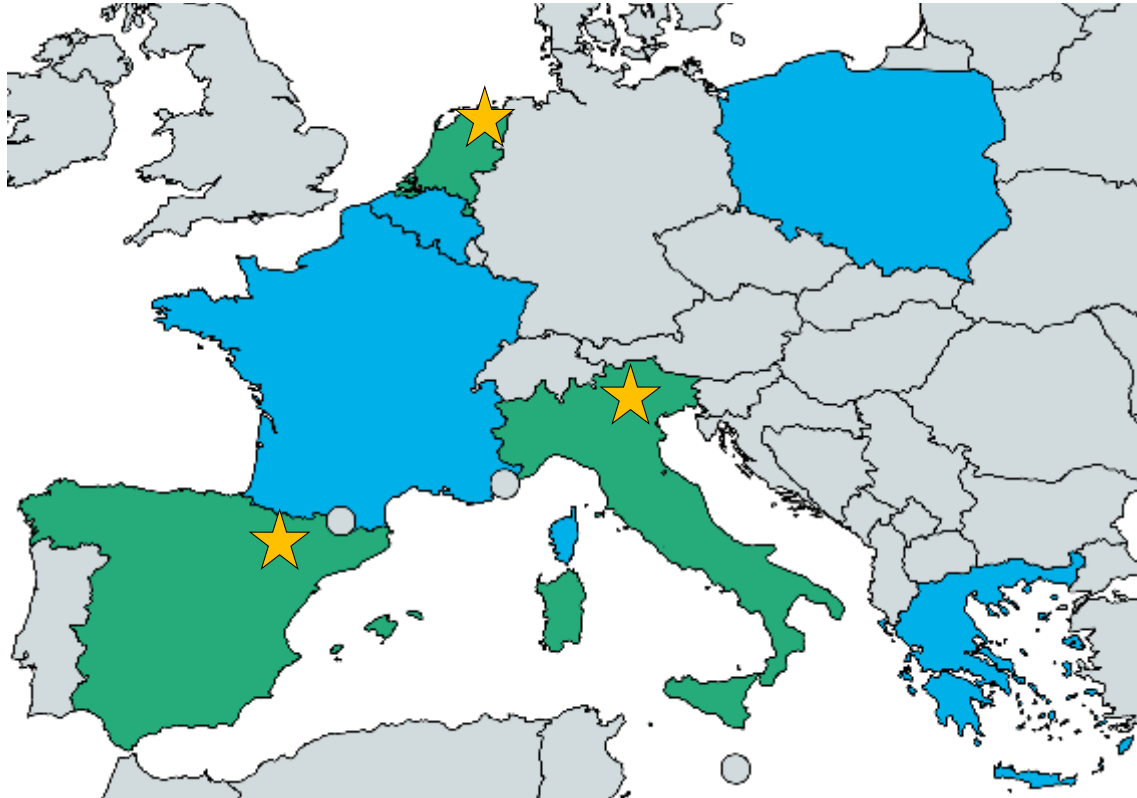
Funded by   European Union
Programme   Horizon Europe Research & Innovation programme
Start project   July 2022
End project   July 2026
Budget   €10 million
EU Funding   €8 million

Key expected outcomes:
- Reduction of waste streams and time needed on-site by >35%
- Reduction in renovation costs by >30%
- Reduction of working time with hazardous activities by >50%
- Energy savings >78% year
- GHG reductions >1,980 tCO2eq/y,
- Achieving an energy performance gap between as-built and as-designed <20%
- Creation of 2 Renewable Energy Communities >2,000 users

INNOVATIONS

InCUBE envisions to unlock the EU renovation wave through cutting-edge standardised and lean integrated processes based on **4 key pillars of innovation.**

INDUSTRIALISATION

NEW TECHNOLOGIES AND MATERIALS

DIGITALISATION

NEW MARKET ENTRANTS

#1 INDUSTRIALISATION

Industrialisation refers to the automation and mechanisation of construction. Currently, this is mainly realised with robot-assisted offsite construction, "prefabrication" of large building elements and onsite assembly of these prefab elements.

InCUBE's process innovations support the industrialisation of renovation through solutions for:

❑ Off-site manufacture
- BIM-based Design of Prefab Modules

❑ On-site installation and automation
- BIM-connected Robotic Systems (Demolition, Construction and Drilling)
- Personal Protective Equipment (PPE) Monitoring System

❑ Circular construction
- Construction Waste Sorting Robot
- Waste Tracking and Management

The introduction of new technologies and materials is a growing trend. New multifunctional solutions are emerging that focus on the operation of the entire building envelope.

InCUBE's product innovations support the utilisation of new technologies and materials such as:

❑ Envelope material solutions
- Prefab & Modular Facades
- Bio-Based PIR Insulation Foam

❑ Renewable energy generation solutions
- BIPV pre-installed on Prefab Facades
- Tegosolar® BIPV Shingles

❑ Solutions for renewable energy storage
- Smart Borehole Thermal Energy Storage

❑ Advanced Heating, Ventilation and Air Conditioning Solutions
- Low temperature Ground Source Heat Pump connected to District Heating & Cooling

❑ Cross-Cutting Solutions
- Low Temperature 100% RES District Heating & Cooling

#3 DIGITALISATION

The use of digital tools in renovation projects, such as design, structural and energy analysis software as well as planning management software, is the norm in certain processes of the planning and design stage of a project.

InCUBE's software innovations support the digitalisation of products and processes such as:

❑ Supporting for 3D building modelling & Digital Twins
❑ Enhanced energy assessment and integrated energy management
❑ Dynamic life cycle evaluations & Decision-Making Tool optimising renovation planning
❑ Ensuring enhanced workers safety and increased efficiency
❑ Offering augmented next-generation training and assistance
❑ Smart Building Energy Management Systems focussed on energy communities
❑ Enhancing the optimal management of distributed renewable energy sources
❑ Optimising workflow and construction & retrofitting works

Today's construction/renovation ecosystem
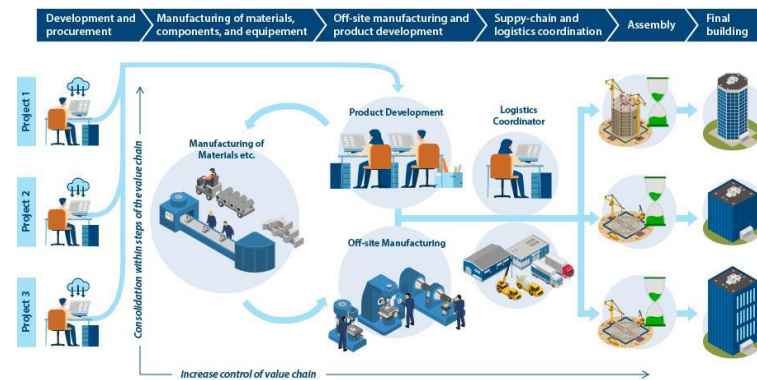
*The construction ecosystem of the future*

#4 NEW MARKET ENTRANTS

New market players, and new funding from venture capital and private equity are transforming current business models. Innovation advancements will lead to the introduction of new entrants and novel business models that will allow for increased levels of collaboration and productivity.

InCUBE's business innovations support new entrants through:
- ❑ Renovation Marketplace for sharing information, knowledge and experiences
- ❑ Novel Business Models including the formation of Renewable Energy Communities
- ❑ Improve the gender mainstreaming in the construction and energy sectors to smarten and accelerate systems, products and operations
- ❑ Training Modules with best practices for upskilling the current and potential workforce
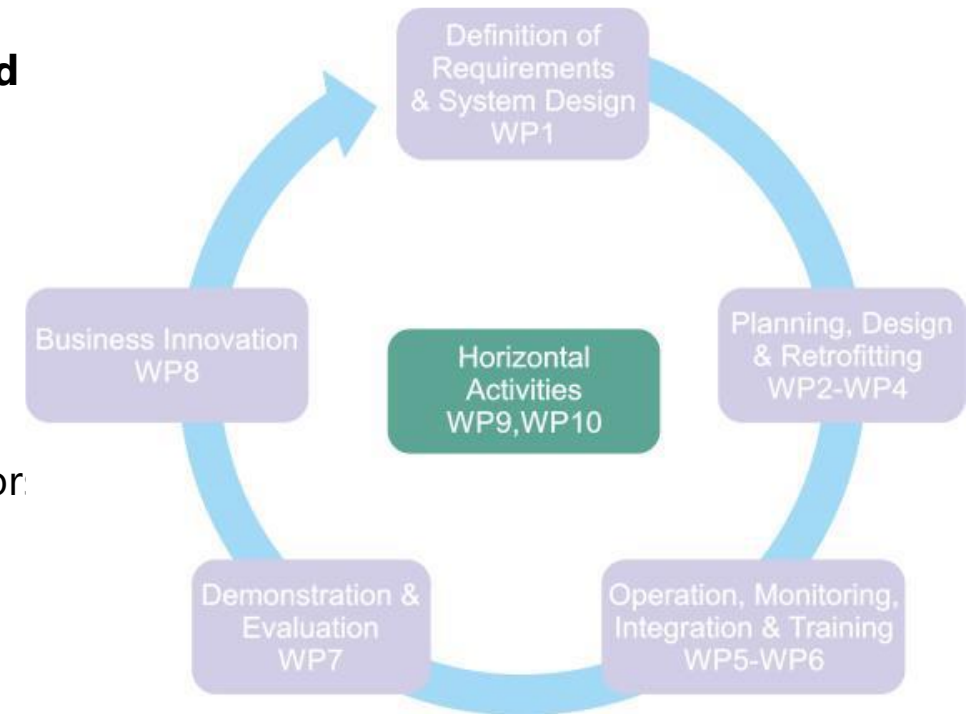
DEEP RENOVATION FRAMEWORK

To this end, InCUBE gathers and demonstrates a set of Hardware-driven (Processes and Products), Software-driven (Digital Tools) and Business-driven (One-Stop-Shop and BMs) innovative solutions.
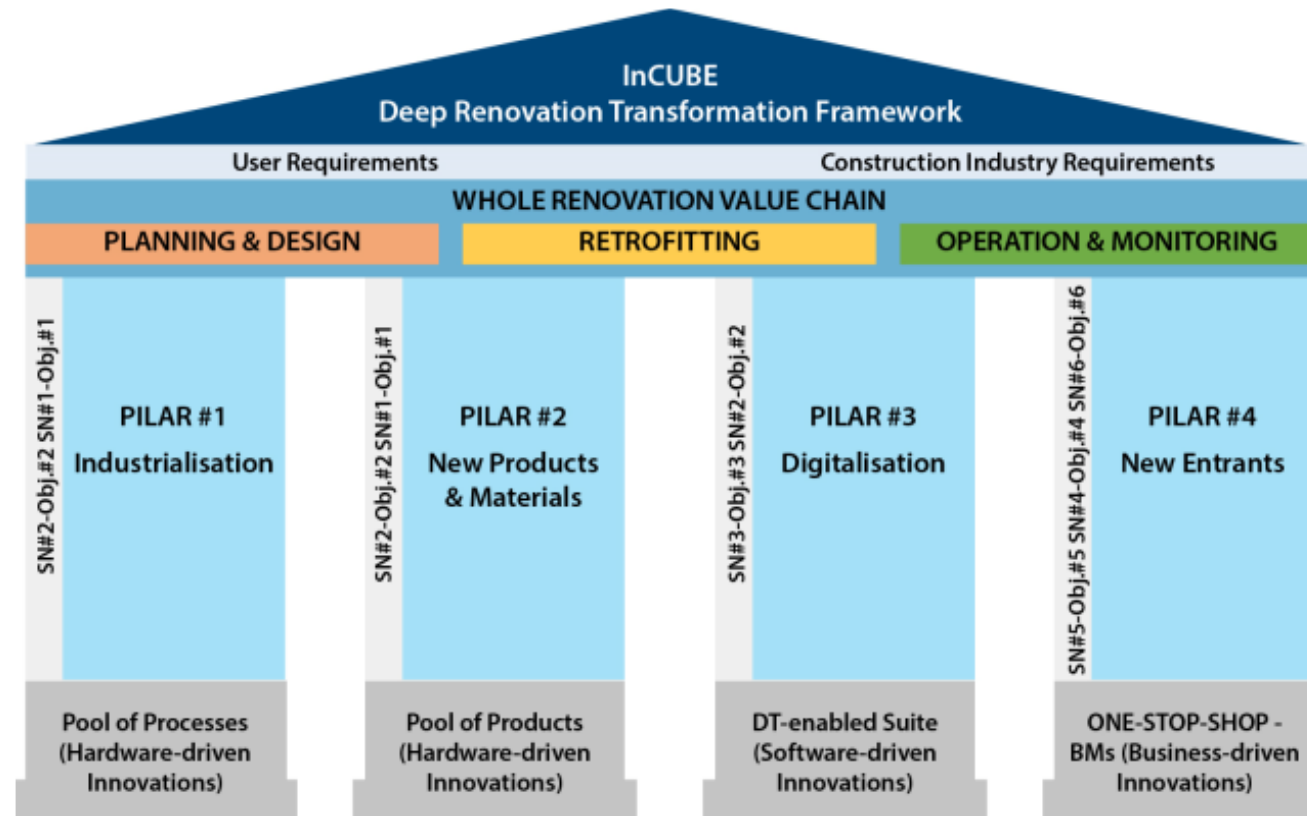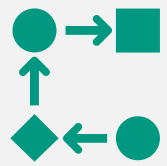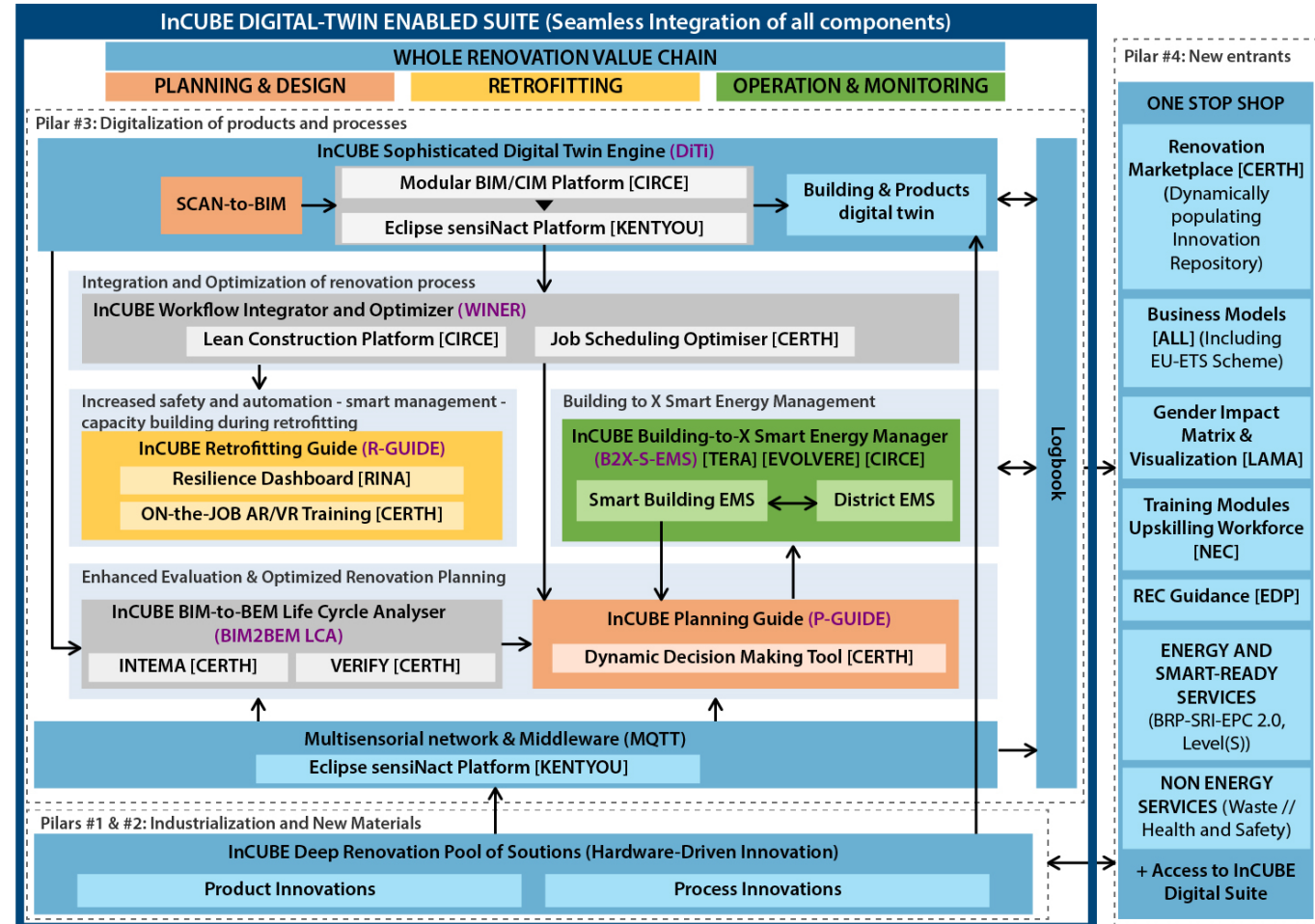
InCUBE's architecture links the different stages of deep renovation

1. Design and Planning (considering change of use when needed)
2. Retrofitting (including manufacturing-installation and demolition where appropriate)
3. Operation and Monitoring (including maintenance) under a holistic value chain approach and will be built as a unified AI-driven, digital-twin enabled suite, the **InCUBE Suite** which integrates and orchestrates the different innovations introduced by InCUBE in all four pillars
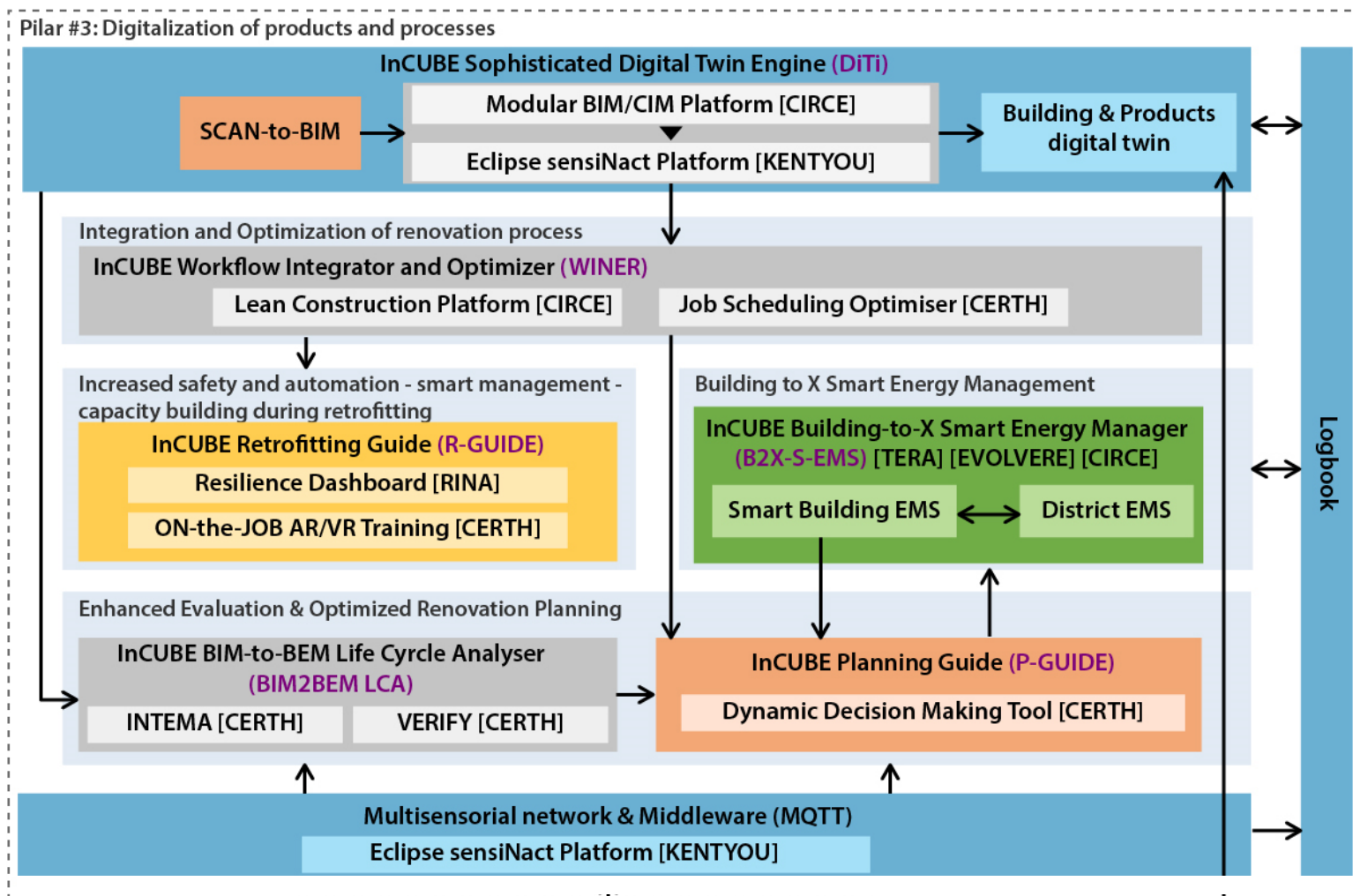
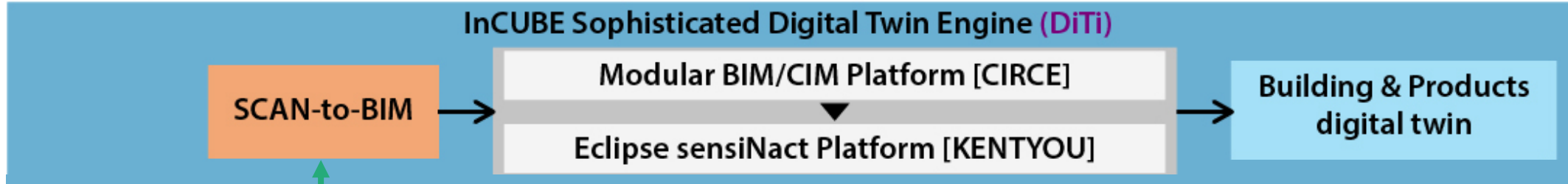Digitalization is a key pillar affecting the future dynamics of construction industry.

❑ InCUBE introduces tools that enable data-driven decision making and enhance the stepwise renovation workflow. These tools are part of the **InCUBE Suite.**

❑ Information gathered from the multisensor network, building data, and processes generated by InCUBE's digital tools are documented and cataloged in the **InCUBE Logbook.** The logbook serves as a dynamic data lake, providing valuable insights into the building's lifecycle, design, operation, and performance over time.

Pilar #3: Digitalization of products and processes

InCUBE Sophisticated Digital Twin Engine (DiTi)

SCAN-to-BIM → **Modular BIM/CIM Platform [CIRCE]** / **Eclipse sensiNact Platform [KENTYOU]** → **Building & Products digital twin**

Integration and Optimization of renovation process
InCUBE Workflow Integrator and Optimizer (WINER)
Lean Construction Platform [CIRCE] | **Job Scheduling Optimiser [CERTH]**

Increased safety and automation - smart management - capacity building during retrofitting
InCUBE Retrofitting Guide (R-GUIDE)
Resilience Dashboard [RINA]
ON-the-JOB AR/VR Training [CERTH]

Building to X Smart Energy Management
InCUBE Building-to-X Smart Energy Manager (B2X-S-EMS) [TERA] [EVOLVERE] [CIRCE]
Smart Building EMS ↔ **District EMS**

Enhanced Evaluation & Optimized Renovation Planning
InCUBE BIM-to-BEM Life Cycle Analyser (BIM2BEM LCA)
INTEMA [CERTH] | **VERIFY [CERTH]**

InCUBE Planning Guide (P-GUIDE)
Dynamic Decision Making Tool [CERTH]

Multisensorial network & Middleware (MQTT)
Eclipse sensiNact Platform [KENTYOU]

Logbook

InCUBE Sophisticated Digital Twin Engine (DiTi)

SCAN-to-BIM → Modular BIM/CIM Platform [CIRCE] ▼ Eclipse sensiNact Platform [KENTYOU] → Building & Products digital twin
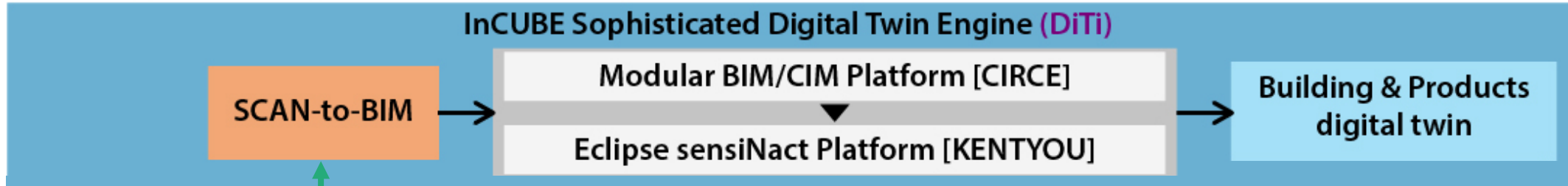
[VW] Drone-enabled Scan-to-BIM 3D modelling

❑ Point Clouds: Created by drone technology (e.g., Lidar) for accurate 3D modeling.

❑ Drone-based scanning offers a faster and highly accurate alternative to conventional surveying methods.

❑ Is particularly suitable for cultural heritage buildings, addressing challenges in identifying deviations from existing plans.
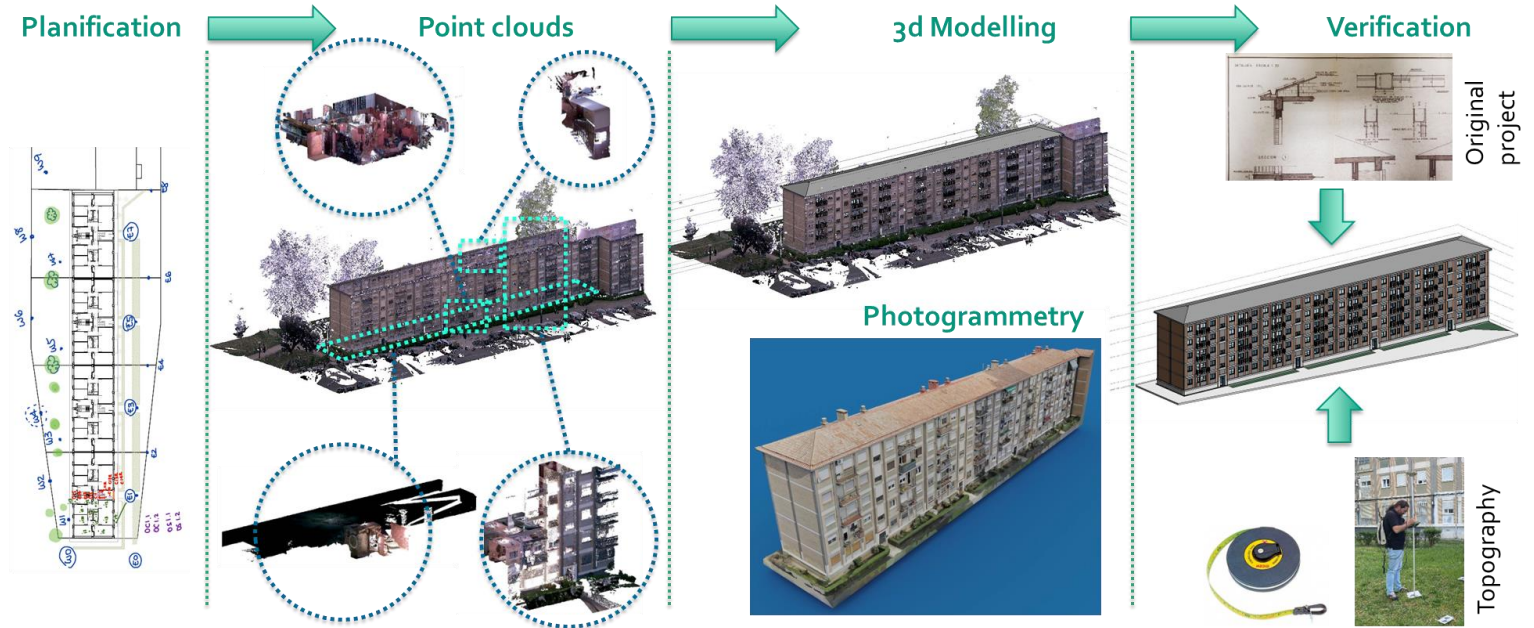
InCUBE Sophisticated Digital Twin Engine (DiTi)

SCAN-to-BIM → Modular BIM/CIM Platform [CIRCE] ▼ Eclipse sensiNact Platform [KENTYOU] → Building & Products digital twin
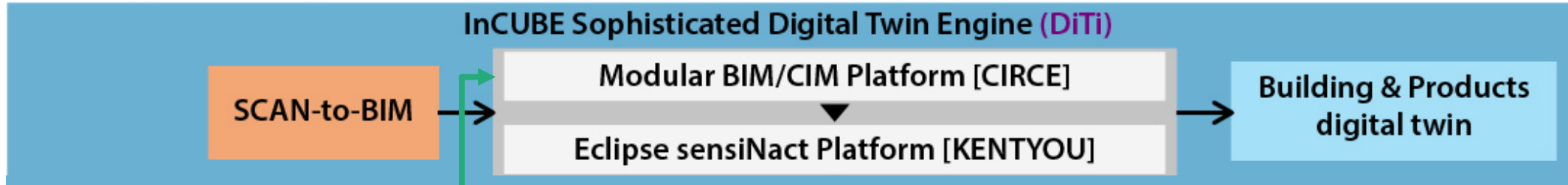
[METRO7] Laser 3D Scanning

- ❑ Laser Scanner: Enables accurate measurements and faster data capture.
- ❑ BIM Tools: Improve communication, workflows, and design processes.
- ❑ IFC and gbXML Formats: Standardized and interoperable formats for BIM data exchange.

Planification → Point clouds → 3d Modelling → Verification

Photogrammetry

Original project

Topography

1. DESIGN AND PLANNING

InCUBE Sophisticated Digital Twin Engine (DiTi)

SCAN-to-BIM → Modular BIM/CIM Platform [CIRCE] → Eclipse sensiNact Platform [KENTYOU] → Building & Products digital twin
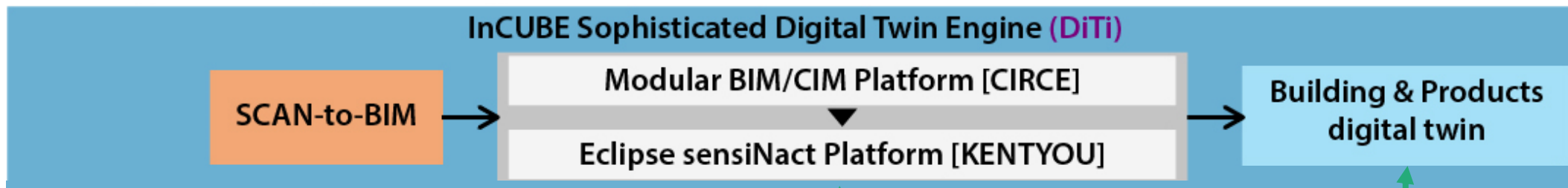
[CIRCE] Modular BIM/CIM Platform
- ❑ Modular and Interoperable Repository: A web-based repository of BIM objects that is modular and interoperable.
- ❑ Time Savings: Reduces modeling time by at least 20% compared to conventional methods without a standardized library.

Parameter Name	Description	Units / Options	Example	Source
Model	The name, or unique series code, of the product	Text		Default
Type / Configuration	The name of the product configuration described by the values contained in the parameters in the same column	Text		Default
B: LEGAL IDENTITY (GENERAL)				
C: CLASSIFICATIONS (GENERAL)				
D: QTY SET(GENERAL)				
E: SPECIFICATION (GENERAL)				
G: TENDERING (GENERAL)				
M: CE MARK (GENERAL)				
H: LOGISTICS (GENERAL)				
J: MAINTENANCE (GENERAL)				
K: HEALTH & SAFETY (GENERAL)				
I: SUSTAINABILITY & LCA (GENERAL)				

1. DESIGN AND PLANNING

InCUBE Sophisticated Digital Twin Engine (DiTi)

SCAN-to-BIM → Modular BIM/CIM Platform [CIRCE] ▼ Eclipse sensiNact Platform [KENTYOU] → Building & Products digital twin
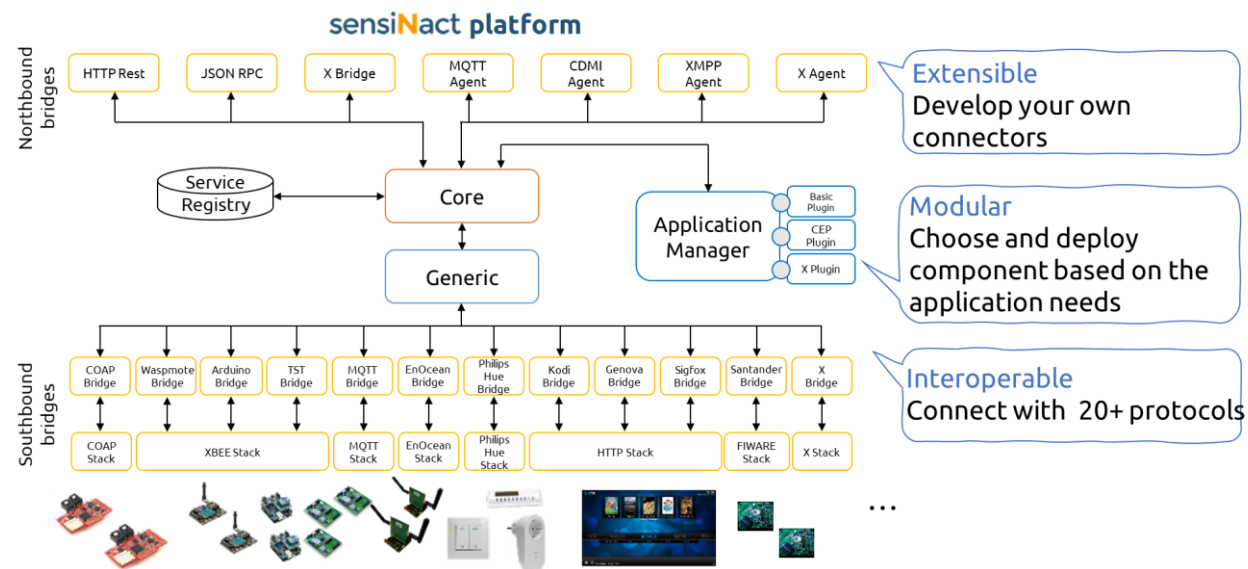
[KENTYOU] Eclipse sensiNact Platform

❑ Modular and open-source digital twin platform for integrating heterogeneous infrastructures.

❑ Data Integration: Collects and processes data from various sources, applying AI and predictive analysis.

❑ Actionable Information: Redistributes actionable information and tracks sensor status with associated details.

Integration and Optimization of renovation process

InCUBE Workflow Integrator and Optimizer (WINER)

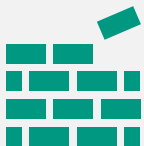| Lean Construction Platform [CIRCE] | Job Scheduling Optimiser [CERTH] |

[CIRCE] Lean Construction Platform

- ❑ A collaborative platform built on the concept of Integrated Project Delivery (IPD) for information exchange and organization among multiple stakeholders in the renovation value chain.
- ❑ The solution is capable of compiling and managing various types of data, including:
  - BIM Information
  - Digital Twins
  - Manufacturer Monitoring Data.
  - Demolition/Retrofitting Data.

INPUTS → OUTPUTS

Manufacturing processes derived from orders with restrictions inherent to the processes (machinery, temperature) and machine maintenance (overheating, wear and tear, etc.).

Personnel calendars

Estimation of raw material demand

Automatic process planning considering constraints and pre-established schedules — PUNCH LIST

Analysis to evaluate improvements and provide process feedback — KPIs

Improve delivery margins — JUST IN TIME

- •Estimation of optimal production times
- •Allocation of resources and personnel per machine
- •Optimisation algorithms to improve efficiency

Integration and Optimization of renovation process

**InCUBE Workflow Integrator and Optimizer (WINER)**

Lean Construction Platform [CIRCE]   Job Scheduling Optimiser [CERTH]

[CERTH] Job Scheduling Optimiser

❑ Optimal Construction/Renovation Sequence: An online tool that generates the best sequence of actions based on time and cost efficiency, considering constraints and preferences.

❑ Multiple Optimizing Methods: Utilizes three optimizing methods and a custom hybrid method for solving complex problems.

❑ Interactive User Interface: Includes an interactive interface for user input and visual review of schedules.

❑ Reduces construction time and costs significantly compared to random work allocation for specific renovation scenarios.
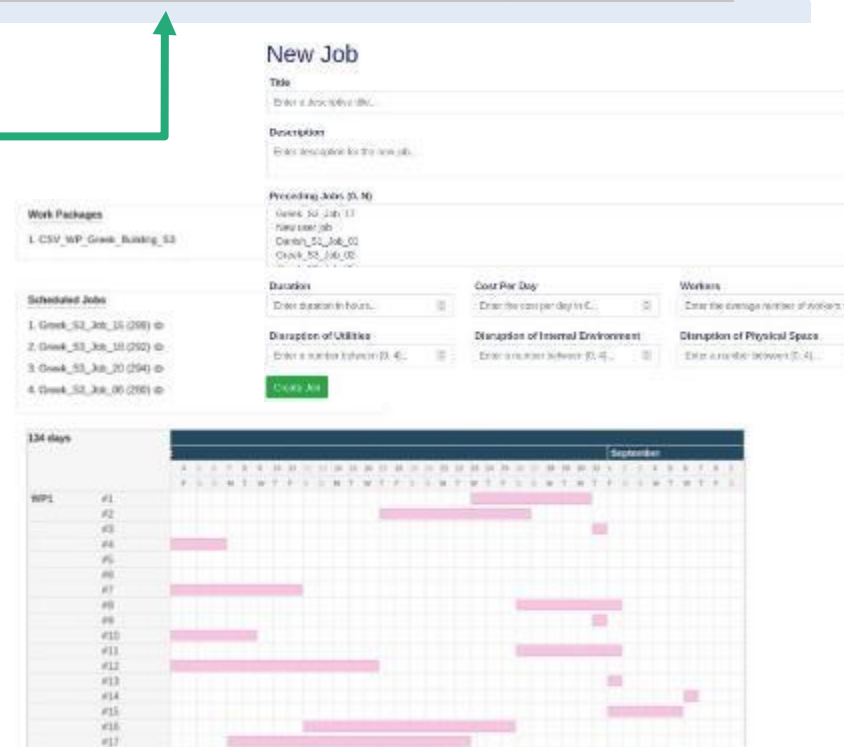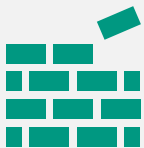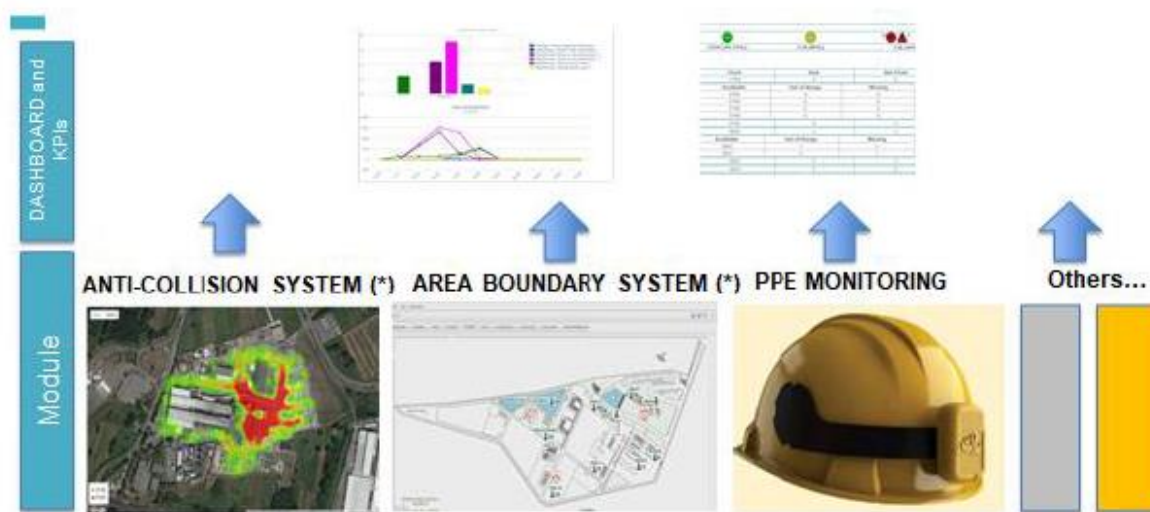
[RINA-C] Resilience Dashboard

❏ Single management platform that enables the communication and coordinated use of various technological tools for achieving a Resilient Construction Site.

❏ Integrated Tools: RD integrates on-site process innovations categorized into three sections:
   - Safety at Work
   - Environmental and Waste Management
   - Vehicle and Equipment Management.

❏ Implementing RCS through RD can lead to increased process efficiency (20%), reduced accidents (20%), and decreased litigation costs or site delays (10%).

Increased safety and automation - smart management - capacity building during retrofitting
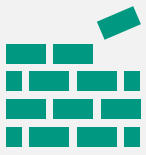
InCUBE Retrofitting Guide (R-GUIDE)

Resilience Dashboard [RINA]

ON-the-JOB AR/VR Training [CERTH]

DASHBOARD and KPIs

Module

ANTI-COLLISION SYSTEM (*)   AREA BOUNDARY SYSTEM (*)   PPE MONITORING   Others...

(*) module interface provided by RINA's service provider

[CERTH] ON-the-JOB AR/VR Training

❑ AR/VR-Enabled Training Toolkit: A toolkit that utilizes augmented reality (AR) and virtual reality (VR) for on-the-job training of workers. It offers both offline training with predefined scenarios and on-site training using AR techniques.

❑ Time and Training Efficiency: reduces construction time by up to 20% and shortens the training time for novice workers.

❑ Error Reduction and On-the-Job Assistance: By utilizing the toolkit, errors and faults during renovation processes are decreased. The on-the-job assistance provided by the toolkit helps minimize delays, resulting in cost savings of up to 20% and reduced duplicated tasks.

Increased safety and automation - smart management - capacity building during retrofitting

InCUBE Retrofitting Guide (R-GUIDE)

Resilience Dashboard [RINA]

ON-the-JOB AR/VR Training [CERTH]

[TERA/EVOLVERE] Smart Building EMS (S-BEMS)

❑ Improved Forecasting: Machine Learning and deep neural network algorithms are applied to enhance energy consumption and renewable energy production forecasting. The focus is on maximizing self-consumption and establishing an Energy Community.

❑ Interoperability: The solution ensures compatibility with various third-party hardware systems through support for key IoT protocols (MQTT, REST) and Building Automation protocols (BACnet, Modbus, KnX, ZigBee, ZWave, M-Bus, LoRa). It also integrates with third-party software applications to expand the range of services and functionalities.
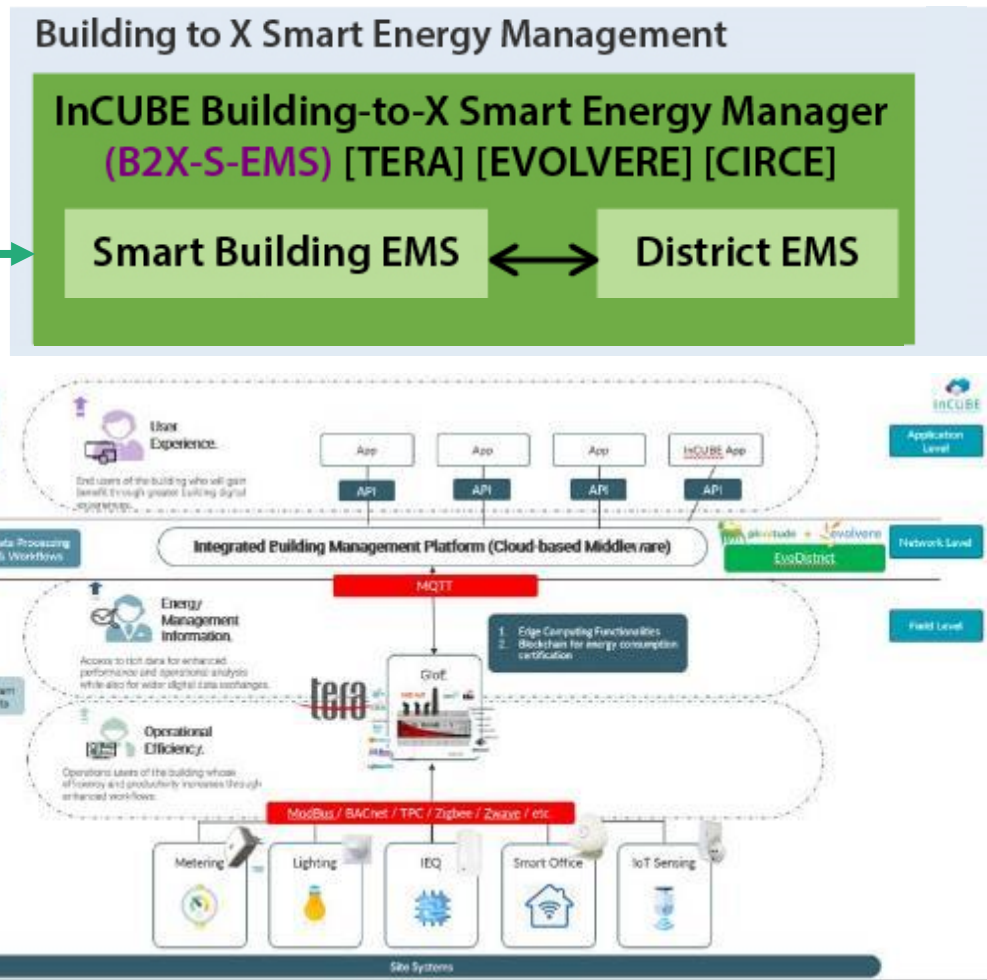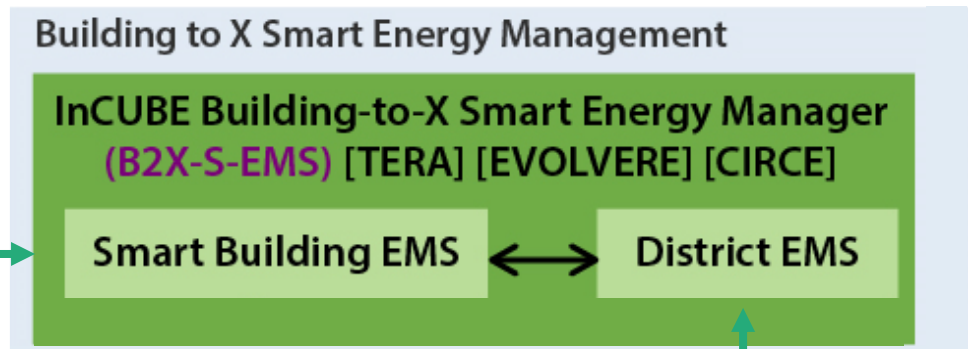
[CIRCE] Energy Cloud EMS

❏ SCADA-Based Building Energy Management: The solution applies an industrial SCADA system to building energy management.

❏ Energy Data Collection: It can collect energy data from various hardware devices, enabling comprehensive monitoring.

❏ Intuitive Visualization: The solution provides an intuitive and simple visualization of energy consumption in the building through a 3D BIM model

Building to X Smart Energy Management

InCUBE Building-to-X Smart Energy Manager (B2X-S-EMS) [TERA] [EVOLVERE] [CIRCE]

Smart Building EMS ⟷ District EMS

[EVOLVERE] EVODISTRICT

❏ EVODISTRICT is a cloud platform for the integration and optimal management of distributed generation, storage and consumption units.

❏ Innovative characteristics: Improving optimization problems in aggregation management and improving processes for collecting data from a variety of devices.

Enhanced Evaluation & Optimized Renovation Planning

InCUBE BIM-to-BEM Life Cyrcle Analyser
(BIM2BEM LCA)

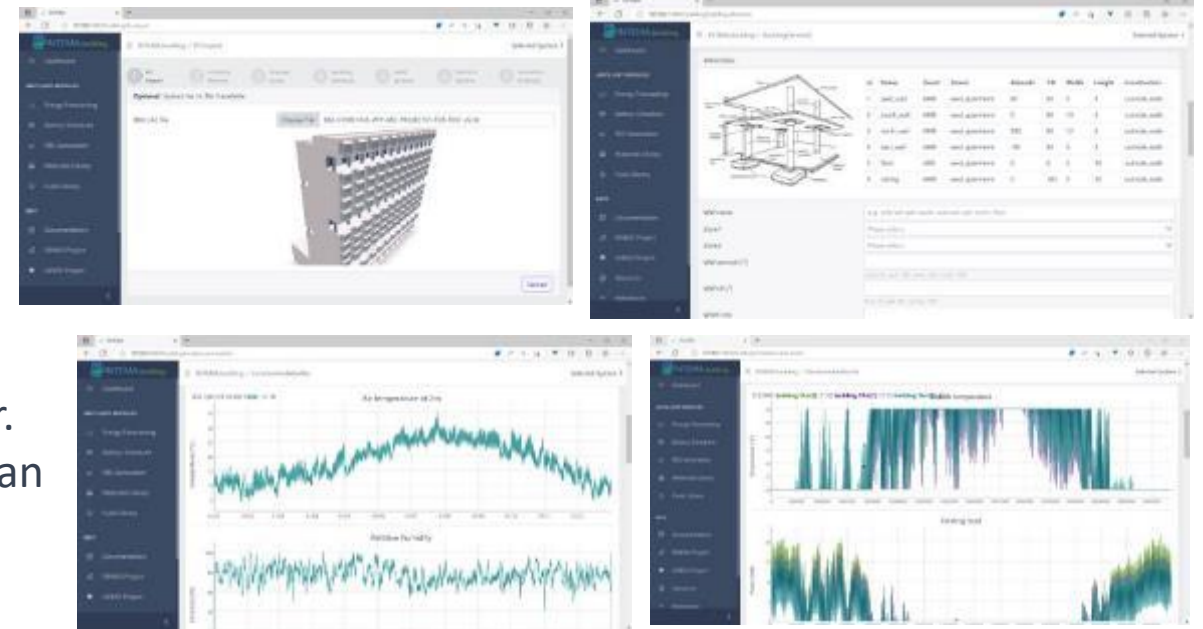INTEMA [CERTH]   VERIFY [CERTH]

InCUBE Planning Guide (P-GUIDE)

Dynamic Decision Making Tool [CERTH]

[CERTH] INTEMA

- ❑ Intelligent Energy Forecasting: This solution uses machine learning and real-time sensor data to accurately forecast energy parameters, enabling automated optimization actions.
- ❑ Open-source Libraries: Built on AixLib, Building Systems, and custom components, the solution provides a validated toolkit for the building sector.
- ❑ Energy Savings and Controllable Loads: INTEMA can achieve energy savings of 10-15% and increase controllable loads by over 30%.

4. OPTIMIZATION

Enhanced Evaluation & Optimized Renovation Planning

InCUBE BIM-to-BEM Life Cyrcle Analyser (BIM2BEM LCA)

INTEMA [CERTH] VERIFY [CERTH]

InCUBE Planning Guide (P-GUIDE)

Dynamic Decision Making Tool [CERTH]

[CERTH] VERIFY

❑ User-friendly web tool for evaluating building renovations based on environmental and cost criteria.

❑ Data Integration: Supports manual upload, retrieval from simulation tools, and real-time analysis with MQTT connected sensors.

❑ Secure Database: Utilizes PostgreSQL for storing and updating project information securely.

❑ Innovative Features: Combines life cycle assessment and costing analysis, real-time analysis with IoT sensor data, and interoperability with big data using SAREF4ENER ontology.

Enhanced Evaluation & Optimized Renovation Planning

InCUBE BIM-to-BEM Life Cyrcle Analyser (BIM2BEM LCA)

INTEMA [CERTH]   VERIFY [CERTH]

InCUBE Planning Guide (P-GUIDE)

Dynamic Decision Making Tool [CERTH]

[CERTH] P-GUIDE

- ❑ Customizable Renovation Assessment: Evaluates various renovation scenarios based on different elements, RES, storage, and hybrid systems, selecting the optimal option according to predefined KPIs.
- ❑ Integration with Building Models and Tools: Easily communicates with BIM/CIM models, LCA-LCC tools, and digital twins, enabling seamless integration and data exchange.
- ❑ User-Friendly Roadmap: Provides a dynamic and user-friendly roadmap for deep renovation planning, offering time and cost savings during the design stage through scenario optimization (up to 30%).

Best Scenario:
Scenario 2
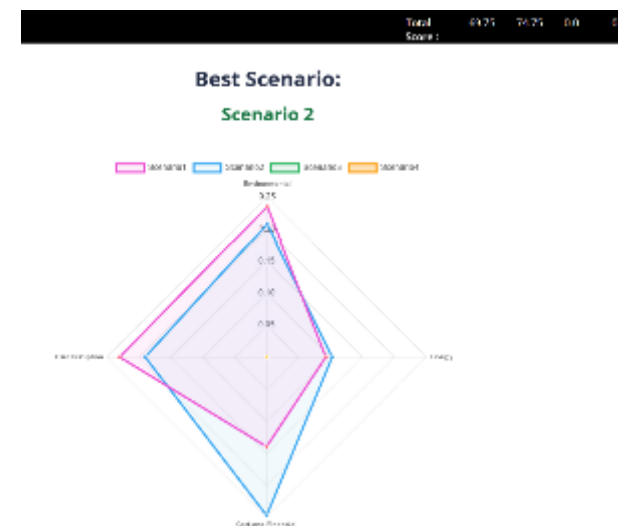
DEMOSTRATORS

TRENTO, ITALY

ZARAGOZA, SPAIN

GRONINGEN, NETHERLANDS

DEMOSTRATORS

TRENTO, ITALY

Name: Santa Chiara district (B1, B2, B3, B4, B5, B6) – Total floor area: 24368 m2 including gym e auditorium
Location: South-east of the historic centre of Trento
B6-Floor area: historical part 5400 m2 and Palabocchi gym and Auditorium that are respectively 1080 m2 and 1458 m2.
B6-Construction date: 1235 (1980)
B6 -Occupants/users: more than 1500 people
B6 -Energy Needs: 490 kWh/m²/y → 250 kWh/m²/y
B6 -Current RES production: 0 MWh/y → 690 MWh/y
B6 -EPC Class: G → C
B6 -Current SRI: 6.6% →71.2 %

ZARAGOZA, SPAIN

Name: Balsas de Ebro Viejo District
Location: North of Zaragoza
Floor area: 3248 m2. Indoor useful and conditioned surface of dwellings: 2562 m2.
Construction date: 1971
Occupants/users: Occupants/users: 79 inhabitants (some dwellings unoccupied, others have not given feedback.)
Energy Needs: 365,7 kWh/m²/y → 57,8 kWh/m²/y
Current RES production: 0 MWh/y → 145 MWh/y
EPC Class: E → A
Current SRI: 0% →60-63 %

GRONINGEN, NETHERLANDS

Name: Van Heemskerckflat
Location: Zeeheldenbuurt District
Floor area: 9800 m2
Construction date: 1966
Occupants/users: 265
Energy Needs: 190 kWh/m²/y y (of which 75% is heating and 25% is electricity) → 40 kWh/m²/y
Current RES production: 0 MWh/y → 267 MWh/y
EPC Class: C → A+
Current SRI: ...% →... % (Still being re-calculated)

Thank you!

Daniel Galera (CIRCE)
Email: dgalera@fcirce.es

UNLOCKING THE EU RENOVATION WAVE