



[www.bim4eeb-project.eu](http://www.bim4eeb-project.eu)

# Digital Twin for energy buildings' renovation based on new ontologies and linked data

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Sustainable Places 2022, Nice (F), 6-9 September 22



**POLITECNICO**  
MILANO 1863



This project has received  
funding from European  
Union's H2020 research and  
innovation programme under  
grant agreement N. 820660

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# BIM4EEB General objectives

An EU-funded project supporting the renovation industry in retrofitting existing residential buildings with a complete

**BIM-based toolkit for Efficient rEnovation in Buildings, in order to :**

- **make the flow of information efficient**
- **decrease intervention working time,**
- **improve building performances, quality and comfort for inhabitants.**

# The BIM4EEB specific objectives

## *O1. Maximise efficiency in building renovation:*

- Renovation working time reduction (20%)
- Renovation costs reduction (15%)
- Building quality control with less than 10% performance gap
- Faster energy audits -50% of time
- Net primary energy use decrease (10%)

## *O2. Accelerate the market uptake across Europe towards a digital built environment:*

- Uptake of BIM-based renovation by construction companies (50%)
- Uptake of BIM-based dynamic energy assessment plus 30%
- Connection of BIM and GIS environments
- Implementation of as-built data collection in logbooks

# The BIM4EEB objectives

## *O3. Speed-up data gathering and processing*

- Fast mapping tools for acquiring data of existing buildings and creating BIM models (30% time reduction)
- Innovative tools for connecting BIM models and BACS
- Improved performance and environmental data monitoring/ analysis to support decision-making on renovation scenarios (30% time reduction)
- Occupant behaviour data monitoring to enhance comfort, performance and building operation
- Enhanced simulation (performance gap of max. 10%)

## *O4. Interoperability of different stakeholders and tools, harmonising data exchange formats*

- Improve the utilisation of increasingly heterogeneous building data by making it more accessible and interconnected
- Central, accessible, reusable platform for storing information
- Harmonised standardisation for data exchange formats
- Standardise data exchange between BACS and BIM



# The project in a nutshell

## CALL/Topic

- INDUSTRIAL SUSTAINABILITY - ENERGY-EFFICIENT BUILDINGS (EEB)
- LC-EEB-02-2018 Building information modelling adapted to efficient renovation (RIA)

## ACTION ID

- BIM4EEB
- BIM based fast toolkit for Efficient rEnovation in Building
- GA No. 820660

## Duration:

- 42 months - 1 January 2019 – 30 June 2022

## Financial

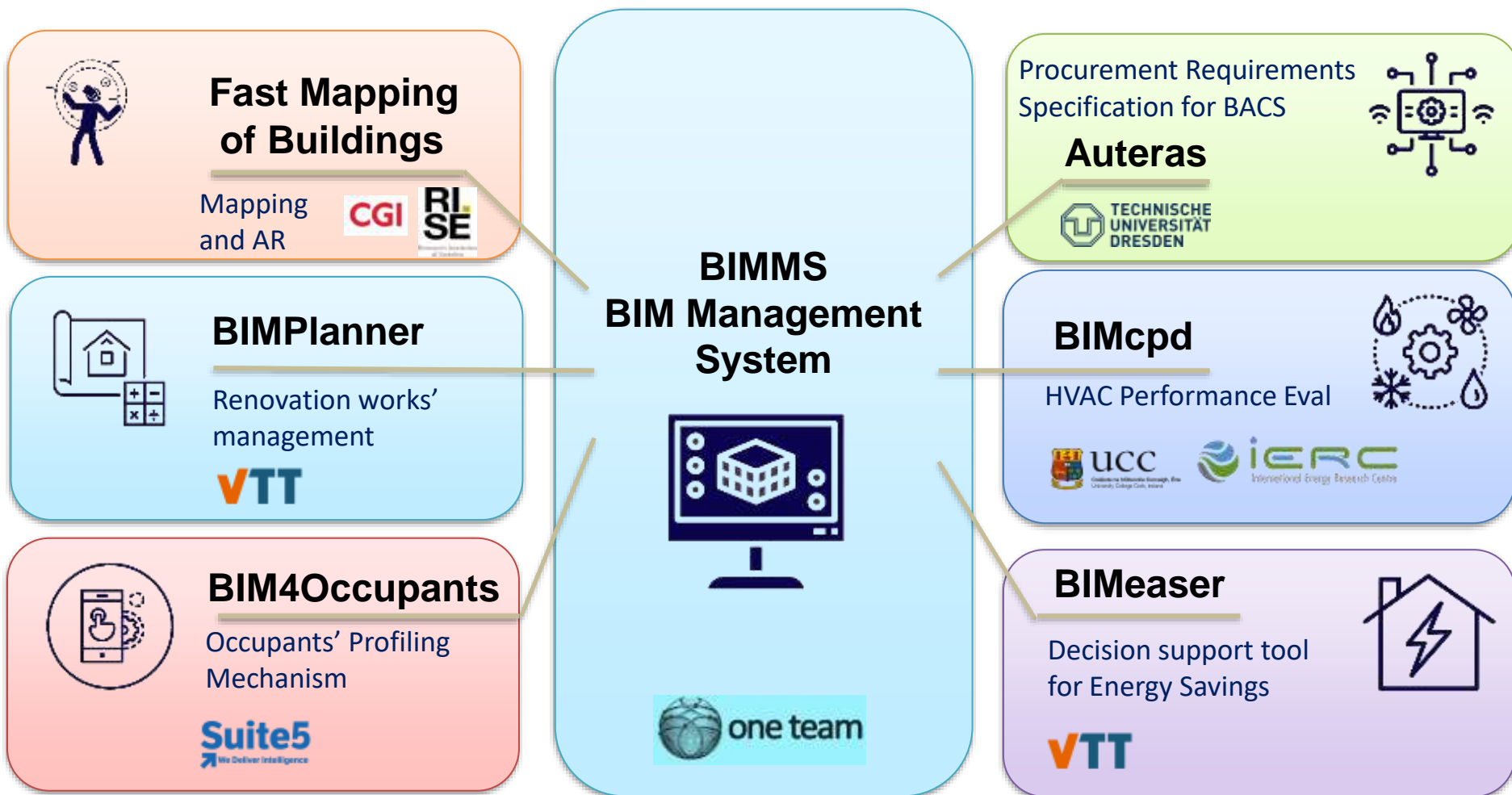
- Costs 6'933'940 EUR
- EC Funding 100%

## 15 partners representing main stakeholders

- 3 Universities: PoliMi, UCC, TUD
- 2 Research Institutes: VTT, RISE,
- 2 Public administrations: Lombardy Region / ALER VCBM
- 4 SMEs/ Start-ups: SOLINTEL, SUITE5, OneTeam, VisualLynk
- 3 Large Enterprises: CAVERION, GCI Sverige, PROCHEM
- 1 Association ACE



# The BIM4EEB toolkit



# From BIM towards Digital Twin

Common elements – 3D model viewer and IoT connection



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# From BIM towards Digital Twin

The screenshot displays the BIM4EEB - IoT Data interface. At the top, the title bar reads "BIM4EEB - IoT Data". The main window features a 3D model of a multi-story building. On the left, a sidebar contains a "Resource manager" with a list of zones: "0001 - IfcProject", "apartment\_40 - IfcZone", "apartment\_02 - IfcZone", "apartment\_38 - IfcZone", "apartment\_13 - IfcZone", "apartment\_46 - IfcZone", "apartment\_47 - IfcZone", "apartment\_30 - IfcZone", "apartment\_59 - IfcZone", "apartment\_32 - IfcZone", "apartment\_01 - IfcZone", "apartment\_00 - IfcZone", and "Outdoors - IfcZone". A red arrow points from "apartment\_13 - IfcZone" to the "Linked Data" window. The "Linked Data" window has tabs for "Occupants", "Sensors", "Plants", "Surveys", and "Others". It displays a table with columns "code" and "type". A red arrow points from the "Sensors" tab to the "Sensor Data" window. The "Sensor Data" window displays a table with columns "date", "value", "UM", and "type".

**Linked Data**

code	type
4559806-59c5-41cc-84ae-a8b625190d	Aeon Home Energy Meter
5016121b-78b4-4318-b5f11-6157625a11b	Aeon Multisensor S
e04c77e5-d5a4-410f-be23-5cbe9d08d2f7	Netatmo Health Coach
1850cbc2-7516-4026-ac08-7fb5f7419ef5	Aeon Home Energy Meter

**Sensor Data**

date	value	UM	type
13/01/2022 17:35:06	721	ppm	carbonDioxide
13/01/2022 17:35:06	26	%	humidity
13/01/2022 17:35:06	50	dB	soundPressureLevel
13/01/2022 17:35:06	22	C	temperature
13/01/2022 17:05:19	709	ppm	carbonDioxide
13/01/2022 17:05:19	26	%	humidity
13/01/2022 17:05:19	44	dB	soundPressureLevel
13/01/2022 17:05:19	21.9	C	temperature
13/01/2022 16:36:27	751	ppm	carbonDioxide
13/01/2022 16:36:27	26	%	humidity
13/01/2022 16:36:27	21.9	C	temperature
13/01/2022 16:36:27	72	dB	soundPressureLevel



# From BIM towards Digital Twin

## Digital Logbook to manage the building and its renovation interventions

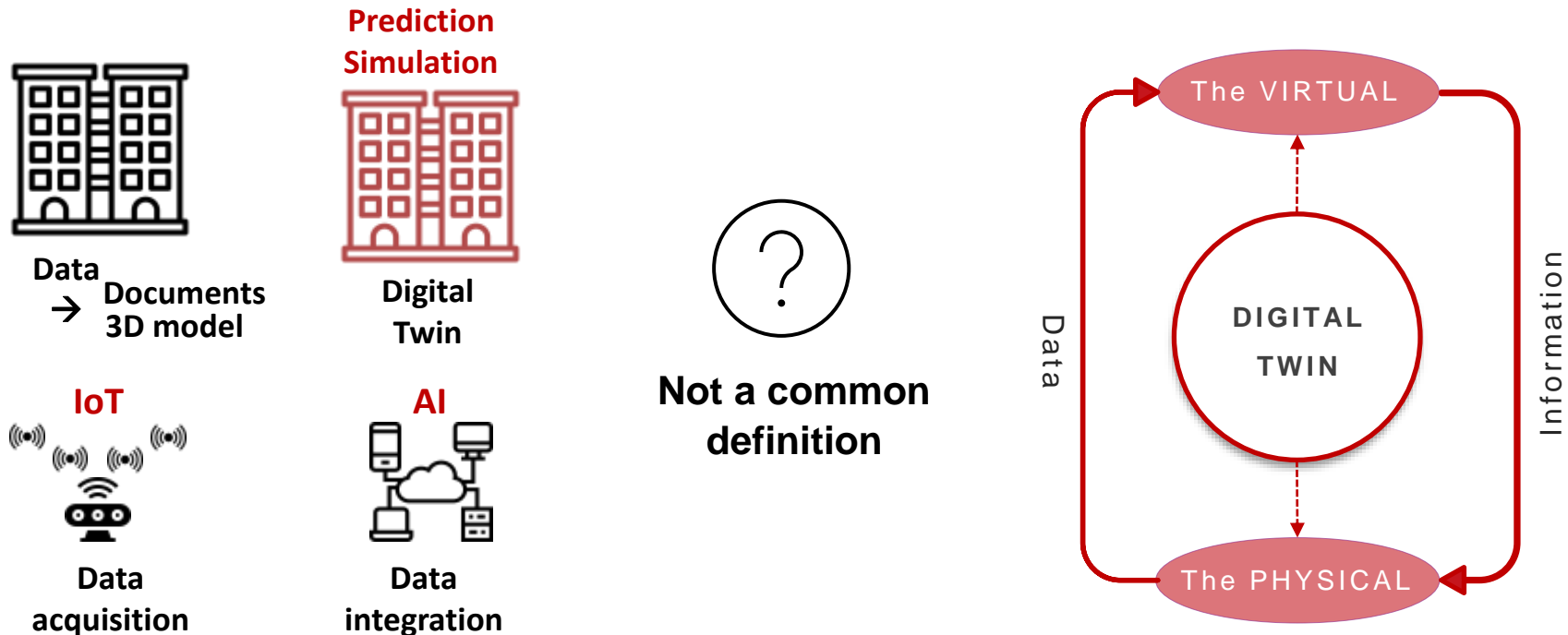
The screenshot displays the BIM4EEB Digital Logbook interface. The top navigation bar includes the BIM4EEB logo, a search bar, and user settings. The left sidebar contains a menu with icons for Home Page, Roles and rules, Resource management, Logbook Data List, and BIM models. The main content area is titled 'Resource Data' and 'Digital Logbook'. It features a tabbed interface with 'Info' selected, showing a list of categories: General and administrative information, Building construction information, Building Energy Performance, Building Operation and Use, and SMART information. A detailed form for 'General and administrative information' is shown, containing fields for Building ID, Name of the building, Main destination, Other destinations, Building permit ID, Construction year, Last renovation year, Energy class, Cadastre ID, Building address, GIS coordinates, and Distance from sea. The form is organized into sections: Building ID, General and administrative information, Registry, Urban and services data, Geotechnical and Geological data, Tender agreement, and Dimensional data.

General and administrative information	
Building ID	
Name of the building	Main destination (Residential, Commercial, Industrial, etc.)
Other destinations (if any)	Building category (Single-family detached, Single-family attached, Large multi-family, Office, Retail, Hotels, Special-purpose, Manufacturing, Warehouse/distribution, etc.)
Building permit ID (Amnesties)	Construction year
Last renovation (partial or general) year	Energy class
Cadastre ID (Cadastral sheet, Cadastral map)	Building address (Nation, Province, Town, Postal code, Street/Road/Square, Nr)
GIS coordinates, Longitude	GIS coordinates, Latitude
DD	DD
Height above the sea level	Distance from sea
m	m
Max number of occupants	

Registry
Urban and services data
Geotechnical and Geological data
Tender agreement
Dimensional data

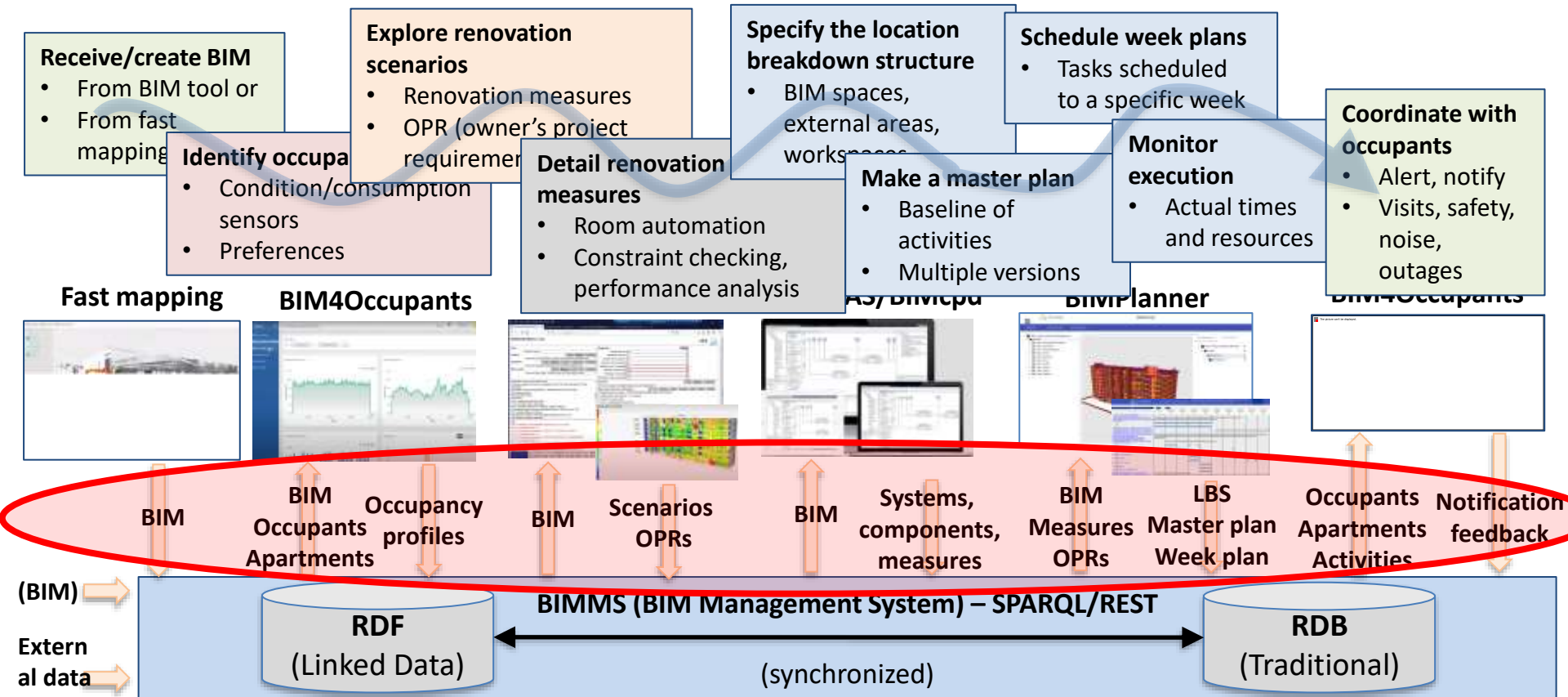
Operational tool

# DIGITAL TWIN definition

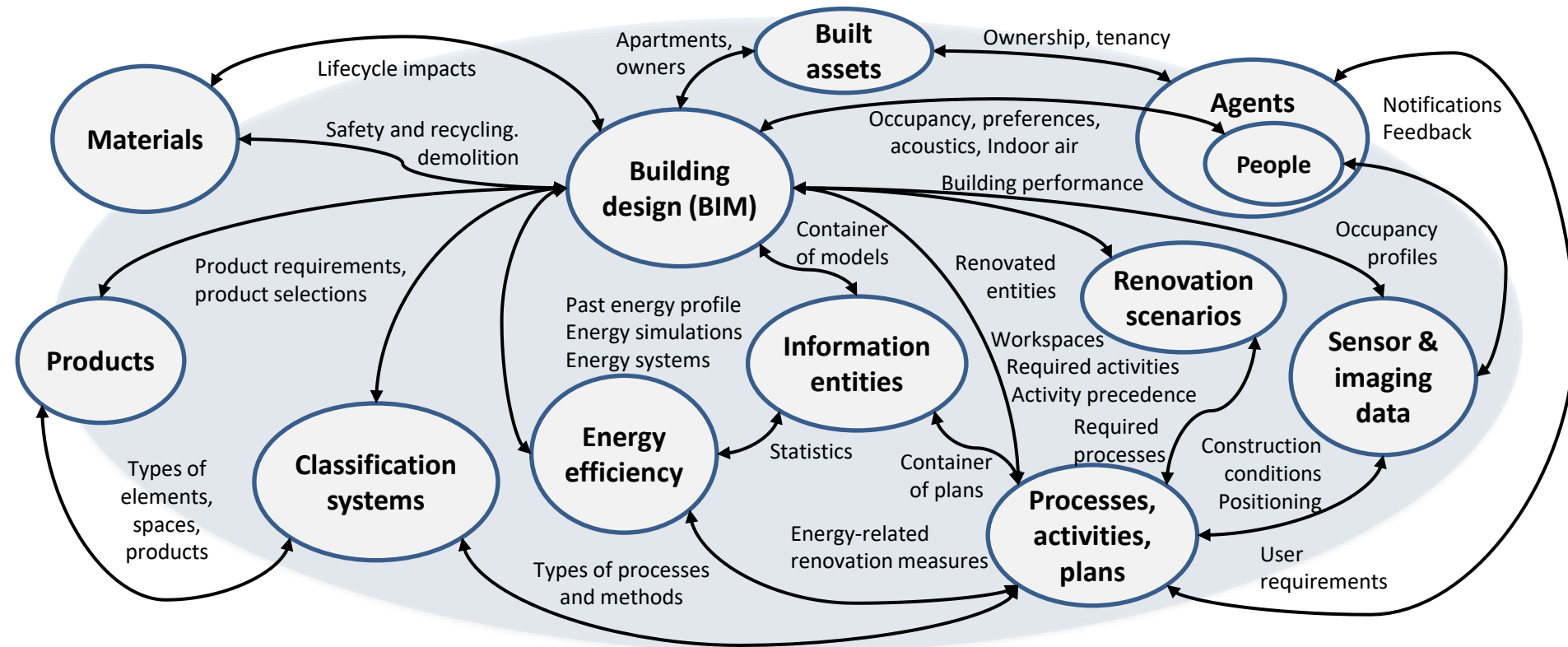


- “a **set of virtual information constructs** that fully describes a potential or actual physical manufactured product from **the micro atomic level to the macro geometrical level**” *Grieves & Vickers*
- “a **digital duplicate of the physical environment, states and processes**. While a BIM model contains as-is and historical data, a DT can be used to assess the current state, and to potentially forecast the future state” *Stojanovic et al.*
- “a **realistic digital representation of assets, processes, or systems** in the built or natural environment” *Bolton et al.*

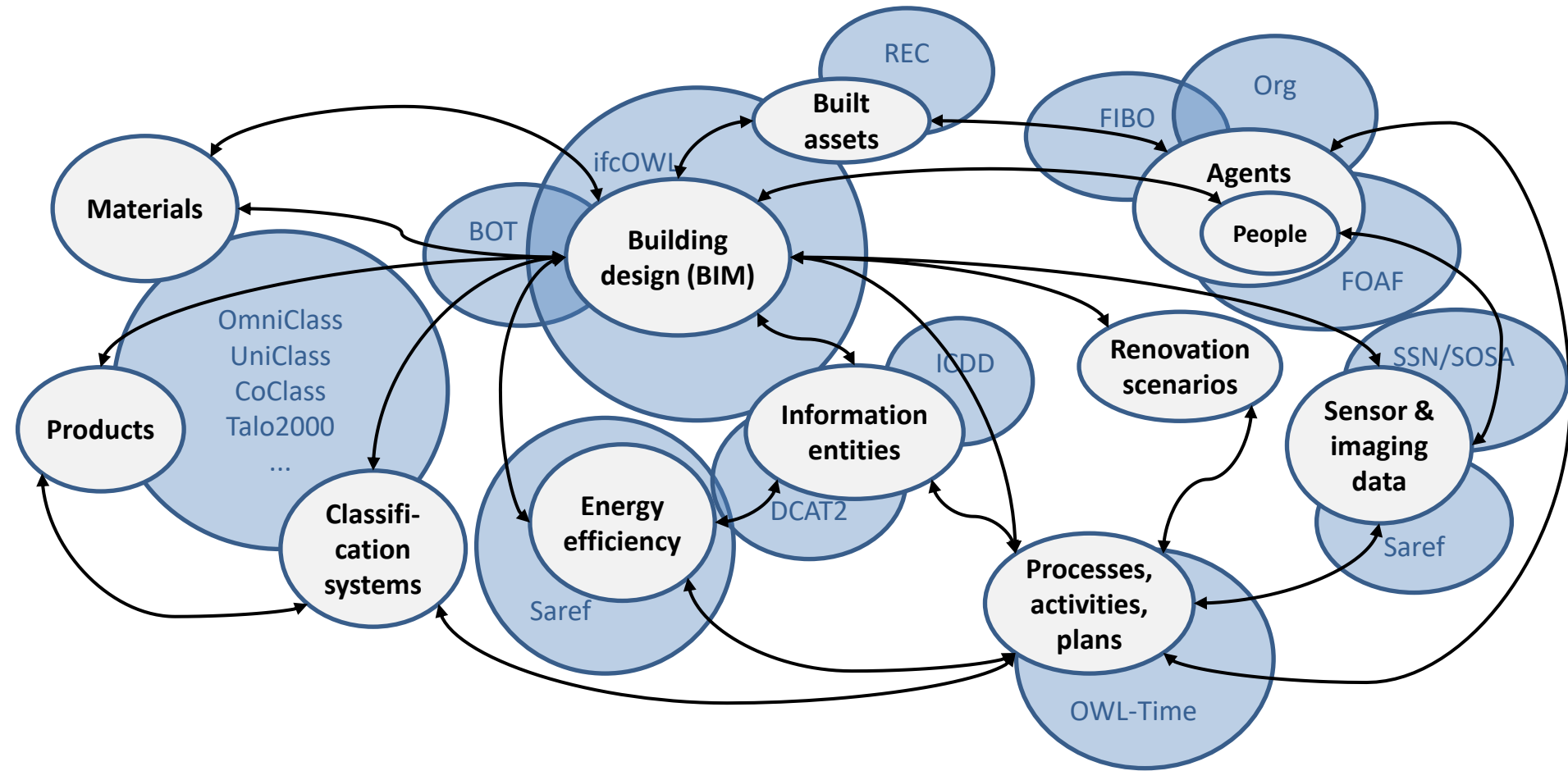
# Role of **ONTOLOGIES** in the BIM4EEB toolkit



# Areas of the renovation terminology

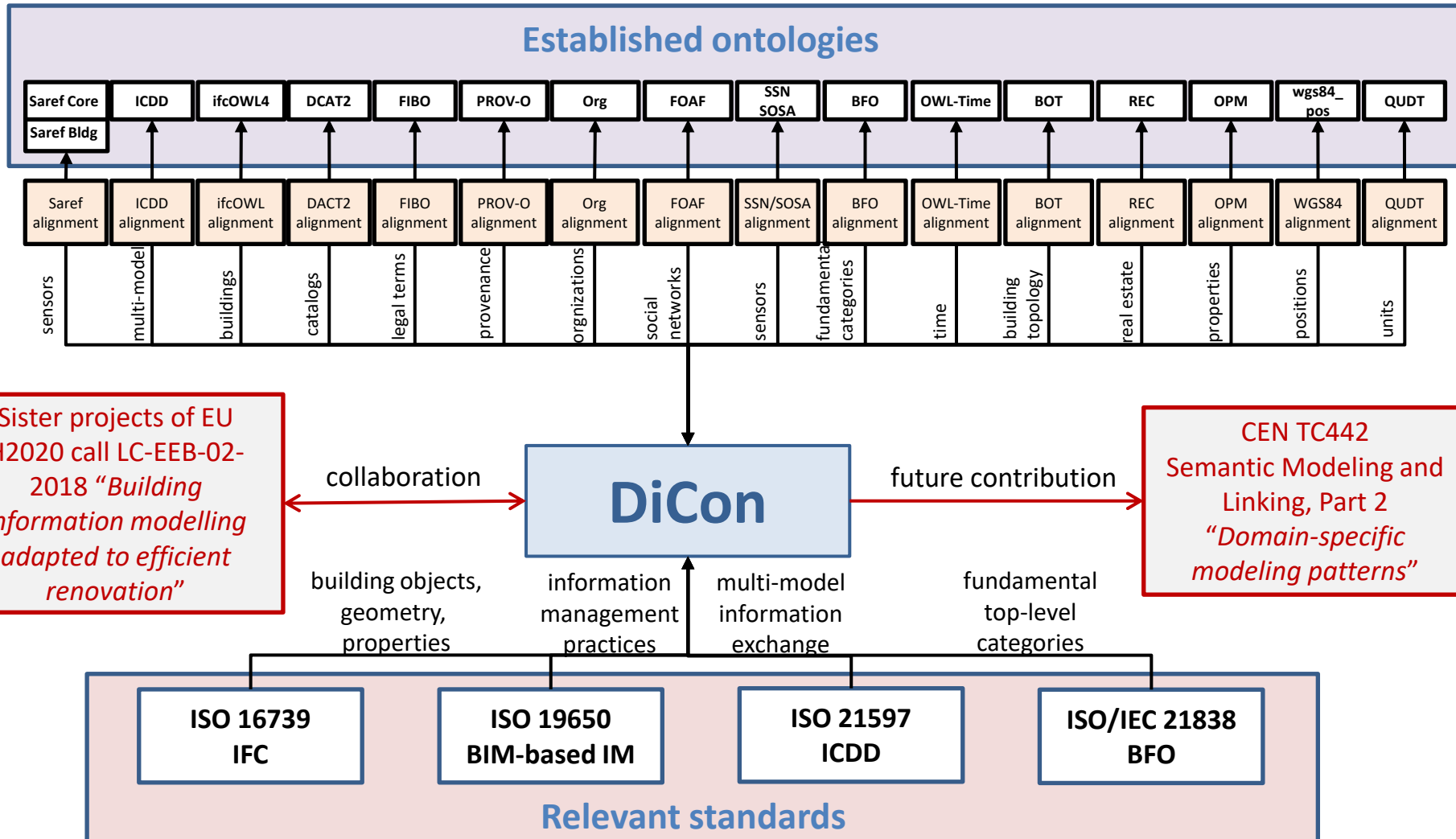


# Existing ontologies or terminologies

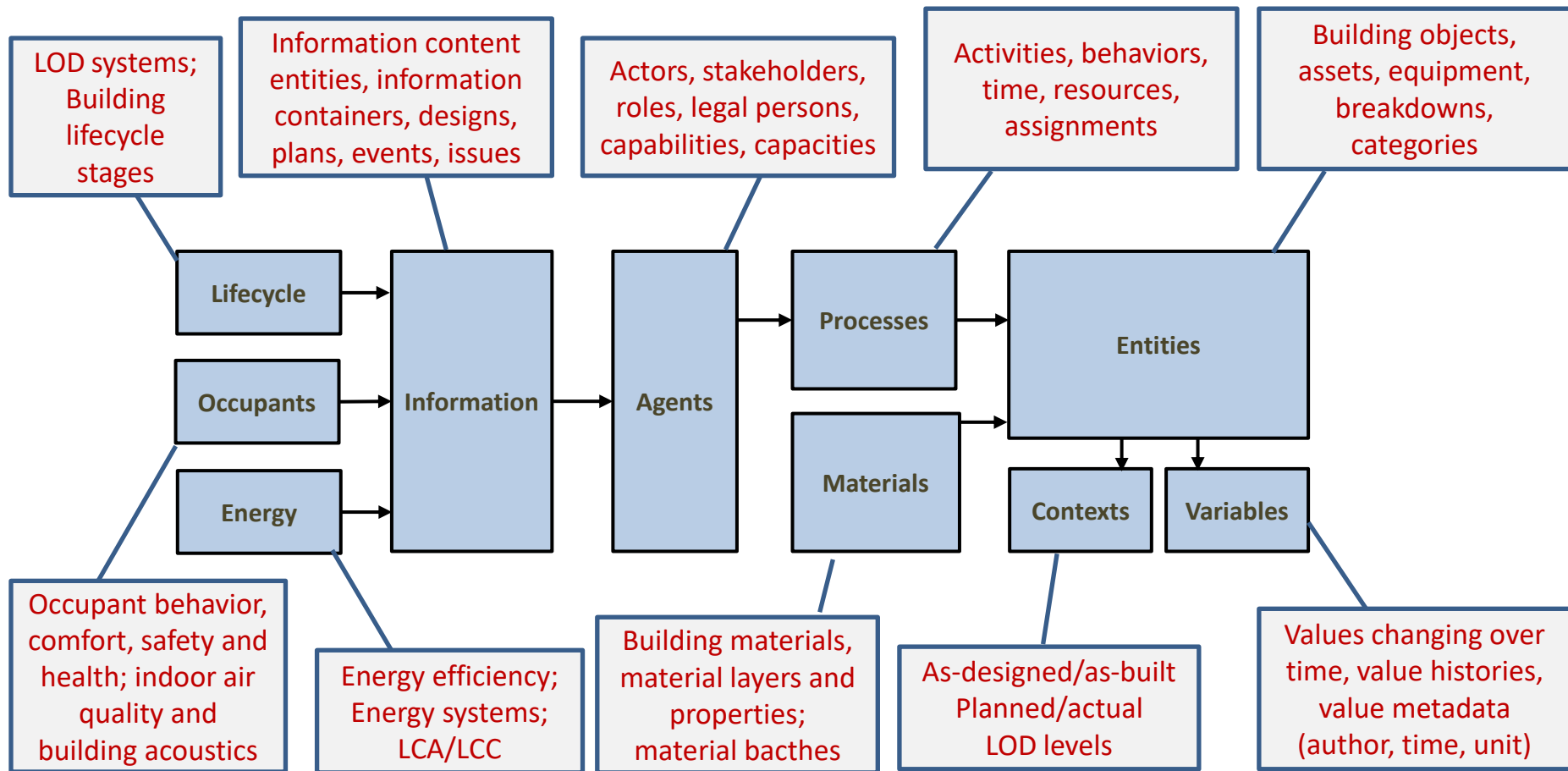




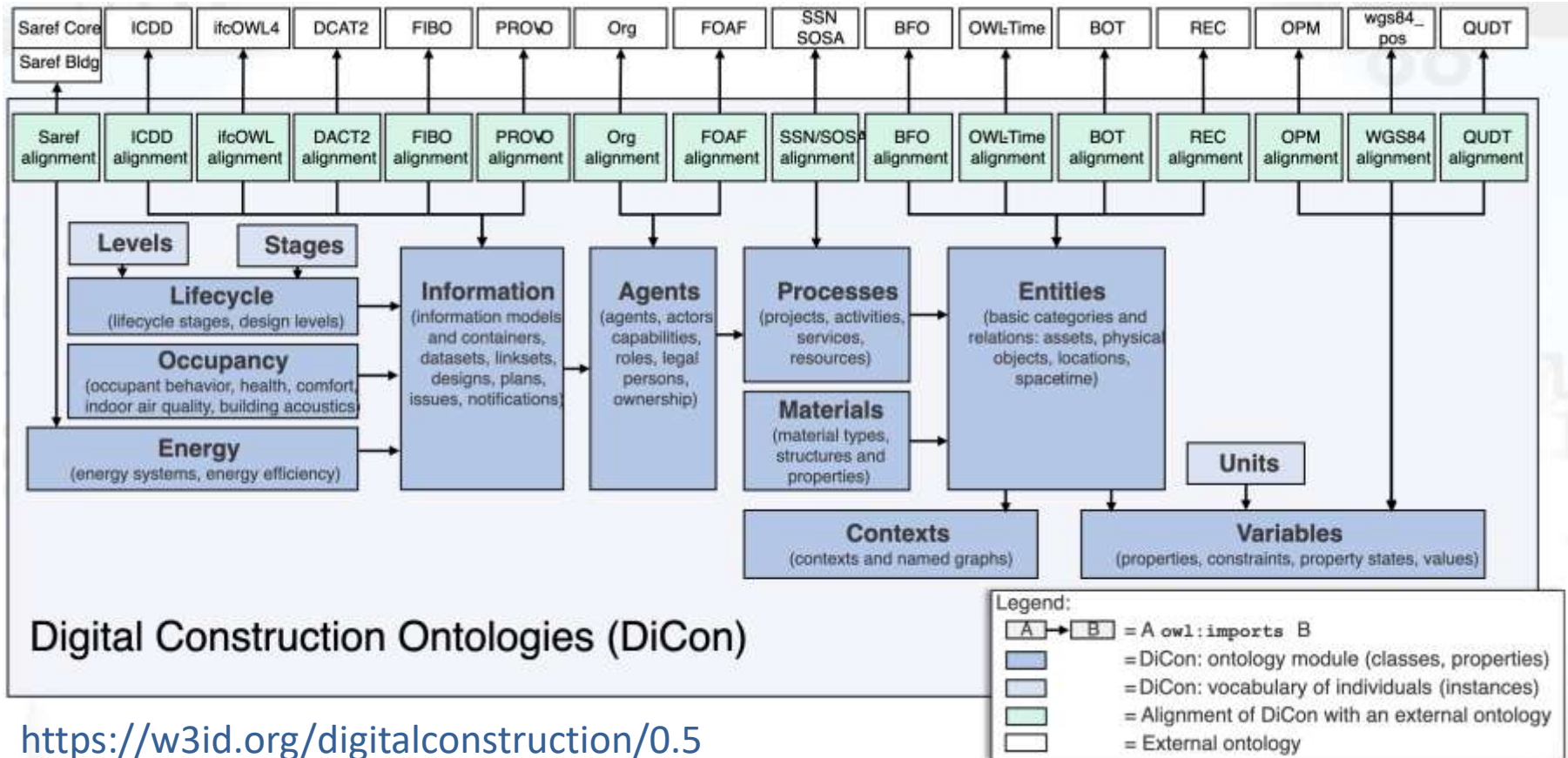
# DiCon relations



# Modules of DiCon



# Digital Construction Ontologies (DiCon)



# Comparison with sister Ontologies

Ontology	Description	Reused ontologies
<b>BIM-SPEED</b>		<b>No direct reuse</b>
<b>Reno-Inst</b>	Installation of windows, ETICS panels, and radiators in renovation projects.	–
<b>LCA-C</b>	LCA/LCC assessments, the assessed building, and the products/materials	–
<b>BEM-Reno</b>	A renovation ontology based on the structure of BOT, albeit not reusing it	Copy, adapt and extend BOT
<b>BIMERR</b>		<b>Reuse by reference</b>
<b>Occupancy Profile</b>	Occupants behavior inside buildings for the BIMERR project	Saref, Saref4Building, OWL-Time, SKOS, FOAF
<b>Sensor Data</b>	Sensors located inside buildings for the BIMERR project	Saref
<b>KPI</b>	Key performance indicators related to building renovation works	Saref, Saref4City, OWL-Time
<b>Weather</b>	Weather data for the BIMERR project	Geo, Saref, SSN, SOSA, Saref4City
<b>Building</b>	Building data for the BIMERR project	BOT
<b>Material Properties</b>	Properties to describe building elements in BIMERR	Saref
<b>Annotations Objects</b>	Annotations and extra information of building elements	–
<b>Information Objects</b>	The files and documents attached to building elements	–
<b>Renovation Process</b>	The construction processes in a building renovation	Saref
<b>Metadata</b>	Annotations for ontology to data model transformation	–
<b>BIM4REN</b>		<b>No direct reuse</b>
<b>buildings</b>	Elements related to a basic description of a building, inspired by BOT	Copy, adapt and extend BOT
<b>buildingcomponents</b>	Components of the building that as walls, windows, ...	–
<b>buildingsystems</b>	HVAC, domestic hot water, lighting and appliances.	–
<b>occupancy</b>	Occupants and their activities within the building	–
<b>energy</b>	Energy modeling of the building.	–
<b>BIM4EEB</b>		<b>Reuse by alignment</b>
<b>Contexts</b>	Multi-contexts data: planned/actual, as-designed/as-built	ifcOWL
<b>Variables</b>	Objectified properties for time varying values, constraints, value metadata	QUDT, Geo, OPM, ifcOWL, PROV-O, SSN/SOSA, Saref
<b>Entities</b>	Basic categories with identifiers, classifications, breakdowns, and groupings	BFO, Geo, ifcOWL, OWL-Time, FOAF, Org, BOT, REC, SSN/SOSA, S4Bldg
<b>Processes</b>	Activities and resources, resource assignments, and objects of activities	ifcOWL, FOAF, PROV-O, REC, Saref
<b>Agents</b>	Actors, stakeholders, roles, legal persons, capabilities, capacities	ifcOWL, Org, FOAF, FIBO, ICDD, REC
<b>Information</b>	Information content entities, containers, designs, plans, events, issues	ifcOWL, PROV-O, FIBO, DCAT2, ICDD, REC
<b>Materials</b>	Material structures, properties and material batches	ifcOWL, BOT
<b>Occupancy</b>	Occupant behavior, comfort, safety, health; air quality; building acoustics	ifcOWL, BOT, SOSA, REC, Saref
<b>Energy</b>	Energy efficiency including energy systems	ifcOWL, Saref
<b>Lifecycle</b>	Information over LOD levels and construction lifecycle	ifcOWL, Org



# BIM4EEB Conclusion1: toolkit validated and available for further developments

## Phase 1



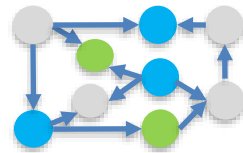
Construction & service companies



HVAC designers



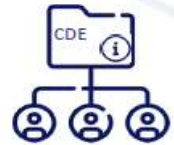
owners & inhabitants



linked data & ontologies

**Requirements,  
linked data & ontologies**

## Phase 2



common data environment



AR for fast mapping & survey



Logbook for fast planning & tracking

BIM-BACS  
data  
exchange



**Tools development**

## Phase 3



Monza demo site (IT)



Chorzow demo site (PL)



Tampere demo site (FI)

**Demonstration in  
relevant environment**



# ***Conclusion2: Digital Twin for energy buildings' renovation based on new ontologies and linked data***

- BIM4EEB toolkit and ontologies are available for sharing, standardization further developments
- Digital Twin developments is ongoing: need for an agreed definition and finalization
- Dynamic Digital Logbook is one priority for existing building
- Need for an International and European Coordination Action to share Sister Projects results and to finalize them for:
  - Standardization (ex. CEN TC 442)
  - Buildingsmart, W3C
  - Building Digital Twin Association
  - DIGIPLACE



BIM based fast toolkit for  
Efficient rEnovation in Buildings

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*Thank you for your attention!....*



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