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PLUG-AND-USE RENOVATION WITH ADAPTABLE LIGHTWEIGHT SYSTEMS

D5.1 Modules for DST

Information requirements for BIM components and databases

Version: 1.0

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Terms, definitions and abbreviated terms

GA	Grant agreement
EU	European Union
EC	European Commission
FP7	Seventh Framework Programme
H2020	Horizon 2020 Project
PLURAL	Plug-and-Use Renovation with Adaptable Lightweight systems
CZ	Czech Republic
ES	Espana
GR	Greece
PnU	Plug and Use
MODEST	Multi-objective Decision Support Tool
AMScope	AMS Control Panel
WP	Work Package
D	Deliverable

DST	Decision Support Tool
3D	Three-Dimension
BIM	Building Information Modelling
LOG	Level of Geometry
LOI	Level of Information

1. Publishable summary

2. Executive summary

This document, D5.1 of the PLURAL project, summarizes the information requirements for the creation of BIM components and database with integrated environmental information to perform the assessment of the PLURAL solutions. The deliverable allows to create the BIM library for T5.1, provide information to Lysis platform for T5.3, the Decision Support Tool for T5.4, the PLURAL prototypes for T4.4 and produce the PLURAL kits for T6.4.

The present document is based on the outcome of WP2 (D2.1, D2.2 and D2.6), WP4 (D4.1, 4.2 and D4.3) and WP7 (D7.1) of the PLURAL Project.

D5.1 summarizes the work done under T5.1 by ITeC and contributing partners (INTRA, IREC, DEN, RDR).

The main aim of T5.1 is to collect and classify the information required to feed the BIM based big data management platform (LYSIS platform based on StreamHandler) and the MODEST Decision Support Tool (DST) developed under T5.2, T5.2 and T5.4 of WP5. Hence, the title of D5.1 "Modules for DST" signifies the above requirement, namely BIM is the central module that will be linked to LYSIS, which subsequently feed information to the MODEST DST.

3. Introduction

3.1 Relation with other WPs

The present document is based on the outcome of WP2 (D2.1, D2.2 and D2.6), WP4 (D4.1, 4.2 and D4.3) and WP7 (D7.1) of the PLURAL Project.

This deliverable D5.1 allows to create the BIM library for T5.1, provide information to Lysis platform for T5.3, the Decision Support Tool for T5.4, the PLURAL prototypes for T4.4 and produce the PLURAL kits for T6.4.

3.2 Objectives

The main purpose of the deliverable is to identify and gather the information required to feed the BIM based big data management platform (StreamHandler) and Decision Support Tool (DST) that will enable to select the optimal components, integration, speed, low-cost manufacturing, and installation for obtaining the most suitable PnU kit for different European climates and residential building typologies.

The BIM based big data management (StreamHandler) will rely on applications for environmental simulations and assessment in the Lysis Platform and related modules such as BIM Parser (T5.2 & T5.3 in WP5) together with the Decision Support Tool (T5.4) or the BIM-LCA&LCC assessment (T5.5). The present document defines a set of technical specifications which are the basis for the creation of the BIM library (D5.3 in M22) containing:

- Inventory of BIM objects from the existing building envelopes and renovation solutions
- BIM objects from the PnU kits
- Parametric BIM models of the new construction solutions for all demo cases (the PNU kits applied on the buildings).

The document refers to the modular BIM requirements regarding the different end uses envisaged for the BIM objects and models.

3.3 Document structure

The document is divided in the following parts: an (3) Introduction and description of the PnU kits and Demo buildings, a section with (4) Definitions of basic BIM concepts, the successive sections (5 to 9) of Requirements for BIM objects according to the information needs in:

- The BIM parser and StreamHandler tool
- The Decision Support Tool
- The Inventory Library
- The PNU kits
- The Parametric modelling of new construction solutions

(10) Conclusions, (11) Reference documents and (12) D5.1 Annex.

3.4 Description of the PnU kits

The PLURAL concept proposes a set of core systems as Plug and Use kits (PNU) to adapt construction processes in renovation projects to industrial protocols based on the LEAN management approach (with high quality products, elimination of defects, waste, production time and cost reduction and improvement in the workers protection and safety). Three separate core technologies have been defined for real and virtual demo on the assumption that some commercial products like the developed components will be able to be used in the PNU kits without significant modifications in the assembly lines of the manufacturers.

TABLE 1: INFORMATION ABOUT THE PNU KITS.

Core Systems	Core System 1	Core System 2	Core System 3
Name of PLURAL solutions	Smart Wall	eWHC	eAHC kit
Concept	Easy adjustable to almost every façade and to any dimension. Can be recovered with all kinds of finishing material. Ideal for warm climates.	Integrated low temperature hydronic exterior wall heating and cooling system between the existing wall and new applied envelope. To be implemented in timber frame structures that will integrate solar energy converters. Proved to be efficient in cold climates.	Air handling unit integrated into the building envelope, combining a passive and active heat exchanger, with building integrated PVs and providing the capability of temperature control of supplied air and equipped with thermoelectric elements. Appropriate for moderate heat-cold climates.
Components / Products	• Innovative windows • Fan coil • PV panels • Solar panels • Heat pumps • Control Toolbox • Multifunctional coatings.	• Gas boiler heat source replaced by Heat Pump • Facade panels with air handling and heating/cooling system/installation • Windows • New control system, monitoring • Integration of BIPV system and/or solar thermal for DHW	• Insulation • PV panels • Ventilation units • Innovative windows • Folding blinds

3.5 Demo buildings to test the PnU kits

The PLURAL concept is being implemented at two levels: in Real scale demonstrations and in Virtual demo sites already renovated towards NZEB to fully validate the concept in terms of cost savings besides the energy performance.

The **Real scale demonstrations** are three different types of residential buildings and urban locations: two dwelling blocks and one retirement home placed in urban or natural locations and diverse climate conditions (Mediterranean mild/hot summer and Continental warm humid). The buildings were selected to have high heating requirements (Kasava demo site) or moderate heating and cooling demands (Terrassa and Voula demo sites).

The **Virtual demo sites** were renovated buildings selected to address mainly Nordic countries heating/cooling requirements (Bern, Berlin and Väsvy), taking into account economic factors to prove not only the energy performance but also the time and cost savings resulting for the PNU kits in the PLURAL concept.

The combination of building typologies and climatic zones is intended to maximize the coverage of residential building deep renovation options all most European cities. Throughout the project, all six demo buildings will be modeled with the PNU kits and will feed the applications for the environmental simulations and assessment in the Lysis Platform, the Decision Support Tool and the BIM-LCA&LCC assessment.

TABLE 2: INFORMATION ABOUT 6 DEMO BUILDINGS.

Building Name	**Demo 1 Real Demo Kaçava**	**Demo 2 Real Demo Terrassa**	**Demo 3 Real Demo Voula**	**Demo 4 Virtual Bern**	**Demo 5 Virtual Berlin**	**Demo 6 Virtual Väsby**
Country	Czech Republic	Spain	Greece	Switzerland	Germany	Sweden
Building Location	Kasava	Terrassa	Voula	Bern	Berlin	Väsby
Building Description	Retirement home	Block of residential dwellings	Block of residential dwellings	Multi apartment building	Single family housing	Multi-residential building
Building Owner	Kasava Town	Catalan Agency of Housing (AHC)	Voula Municipality	To be defined	To be defined	To be defined
Construction Year	2000	2008	1971	1964	1965	1960
PLURAL solutions	eWHC	eAHC kit	Smart Walls	eWHC	Smart Walls	eWHC

The models for the preliminary design of the Demo buildings were developed by PA – ZRS under "T7.1 Building's survey and preliminary design". At that stage, a PLURAL BIM Guideline was proposed as a BIM working tool to define a way of modelling useful for the intended use of the models in the BIM based big data management platform and the Decision Support Tool (framework for the environmental simulations and assessment in T5.2 & T5.3, T5.4 and T5.5). The PLURAL BIM Guideline is an internal document being updated over the project's progress, and its main key issues have been integrated in the present delverable.

3.6 General goals

This deliverable is fully committed to identify and define the necessary requirements to accomplish "Task 5.1 Creation of BIM components and databases" which consists of the following activities:

1. Creation of an Inventory library of BIM objects related to the existing building and renovation solutions, including environmental information which is useful for environmental assessment.
2. Creation of BIM objects for PnU kits with integrated environmental information to perform an assessment of the new building.
3. Parametric BIM modelling of the new construction solutions for all demo cases.

The Inventory library, the PnU kits and the Parametric BIM modelling of the new construction solutions will contain BIM objects which will be used for the environmental simulations and assessment in the Lysis Platform (and related connections such as BIM Parser and StreamHandler, T5.2 & T5.3 in WP5), the Decision Support Tool (T5.4) and the BIM-LCA&LCC assessment (T5.5). The main goal is to gather the requirements to create the BIM objects based on the existing specification standards (IFC and eCOB) complemented by the information needs to perform Tasks 5.2, 5.3 and 5.5 as expressed in the following figure.

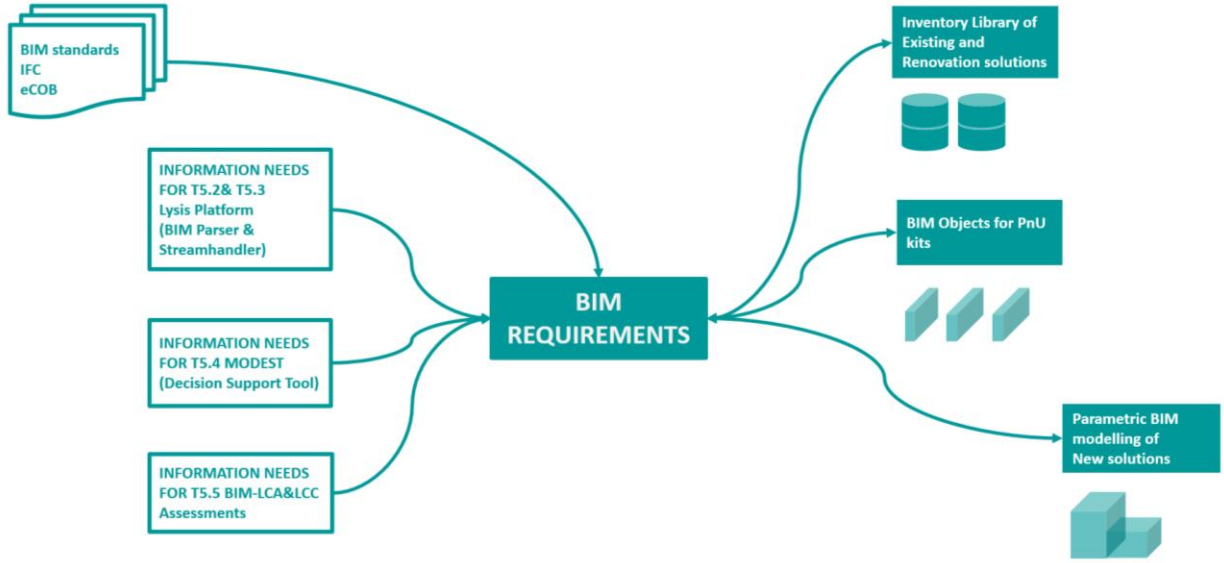

FIGURE 1: BIM REQUIREMENTS FOR PLURAL BIM COMPONENTS AND DATABASES.

The first goal is to get BIM objects that ease the collaboration between partners and express the complexity of the PnU kits. These kits will be formed by components and building products that belong to different domains such as Architecture (façades and roofs), Structure (frames and subframes) and Services (heating, cooling, plumbing and electricity generation) and they should be managed in an easy way from all parts perspective.

Another goal is to get parametric BIM objects from the PnU kits. This means that every component of the kit which is being modelled as a digital item, besides its geometry, material definition and associated data should contain rules that define its digital behaviour, how interacts with other objects, adapts to the existing building envelope or responds to changes in the parameters.

The ultimate goal is that the properties and values included in the BIM objects and models feed the BIM based big data management platform and the Decision Support Tool to allow their managing, calculating and display in the web environment. This achievement assumes that the information in the BIM items shall be readable by means of the IFC open interoperable format and the data stated in the objects (geometry, materials, properties, and values) at different levels (building, level, space and building elements) will be integrated in the Lysis platform and DST.

4. Definitions

4.1 Basic BIM definitions

BIM Objects: Units of information in a BIM model with geometric representation in 2 and 3 dimensions that contain properties and values for their definition. BIM objects can be spaces, elements, materials, or modeling aids.

BIM Use: Expected purpose for generating a BIM model out from a physical building, system, element, component, or construction product.

BIM Spaces: Digital representation of the project, area, zones, or volumes in which the BIM elements are located. They hierarchize the spatial structure of the project and divide it by grouping the objects into subsets so that any element can be included in one of the space classes (>IfcSite, IfcBuilding, IfcStorey, IfcSpace).

BIM Elements: Digital representation of parts of a construction following the standard of>Building Elements of the>Industry Foundation Classes (Fundamental Classes of the Industry defined in the EN ISO 16739 standard).

BIM Materials: Digital representation of the constituent matter (amorphous physical materials) of the construction element, layers or components as they are incorporated into the work (ceramic factory, steel, reinforced concrete, etc.). BIM materials are not always coincident with the products supplied on site, which have defined and finite forms (ceramic pieces, insulation plates, etc.).

IFC Classes: Fundamental classes of the construction industry defined in the EN ISO 16739 standard and whose evolution is gathered in the IFC Specifications Database[1] by BuildingSmart International.

[1] https://technical.buildingsmart.org/standards/ifc/ifc-schema-specifications/

eCOB®: Standard for the creation of BIM Objects[2]. It is a tool for generating generic or industrial BIM objects with consistent and accurate structures, facilitating interoperability between BIM programs throughout the lifecycle of a building or infrastructure. eCOB® is based on the international IFC standard, the European harmonized regulatory framework and National regulations applicable to construction projects in a specific country. At present, it is only adapted to the Building Spanish Regulations.

eCOB® BIM classes: Extension of the IFC classes to adapt them to the current regulatory context and local techno-diversity.

eCOB® BIM Type: Each of the groups of elements of a BIM model that have the same structure, general shape and main properties common to a certain number of individuals. The eCOB® BIM types relate each BIM element to one or more work units so that the quantities extracted from a BIM model are incorporated into the measurements for budget programs, specifications, planning, certification, environmental impacts, etc.

Parametric objects: Objects created using geometric definitions, associated data and rules that define their behaviour, how they interact with other objects or respond to changes in their parameters.

Psets (Property sets): Group of Properties of BIM objects that are grouped to report on the same subject (for example, the properties for each type of element, 5D, 6D, 7D, Classifications, Topology, etc.).

Work unit: Also called work item, it is the unit carried out by the same group of specialists in a construction work and which is the smallest part that can form an estimate, with or without indirect costs. Digital work units in construction databases are an essential part for creating digital construction takeoffs, estimates and budgets for calculating economic, environmental and LCA costs of a building or infrastructure.

4.2 BIM uses intended for PLURAL project

According to the above definition, a BIM Use is the reason for applying BIM during the life cycle of an asset to achieve one or more specific objectives. Depending on the phase of the life cycle in which the BIM item is located, some uses may be applied. The BIM Uses intended for PLURAL BIM Objects and models will meet the BIM uses stated in the following table.

[2] https://ecobject.com/

TABLE 3: INTENDED BIM USES IN PLURAL PROJECT

Use	Responsible parties	Tools
BIM Classification of building Elements	ITeC	Revit 2017
Naming of Materials	ITeC	Revit 2017
Architectural Modelling	PA - ZRS	Revit 2020 Vectorworks 2019 Ifc Export Plug-in
Clash Detection		
Simulating and Quantifying: Quantity take-off from Materials and Elements		
Simulating and Quantifying: Energy Utilisation	IREC, SPF, CVUT	TRNSYS
Simulating and Quantifying: Cost Estimation	ITeC	TCQ
Simulating and Quantifying: Life Cycle Assessment	ITeC	TCQ-GMA
Plural Interoperability Uses	INTRA, ITeC	StreamHandler BIM Parser
Plural Big Data Management uses	INTRA, NTUA, CVUT, ITeC, IREC	Plural LYSIS platform Multi-objective decision tool (MODEST)

Other BIM Uses such as Space programming, 3D Detailing, Construction planning, Acoustic Analysis, etc. are dismissed.

4.3 Levels of development

The BIM elements are made to meet the Levels of Development or LOD of two classes:

Levels of Geometry (LOG): The same object must be generated at least in the Basic and Medium geometry levels, and when convenient in the Detailed level:

- **Basic**: Blocks (boxes or schematic volumes).
- **Medium**: The lightest geometry able to represent in a simple way the actual appearance of an object. It is a conceptualization aimed at creating light files.
- **Detailed**: There is no minimum or maximum detailed level, but it is recommended to make detailed representations without collapsing the digital file system.

Levels of Information (LOI): With four possibilities of information of the objects.

- LOI 1 deliverable for Basic Projects
- LOI 2 deliverable for Detailed Projects
- LOI 3 delivered at the end of the Construction stage (*As built* and Building Logbook)
- LOI 4 deliverable for the Operation and Maintenance model

The levels of development of the BIM objects are combined to respond to the needs of the project agents in the different stages.

The level of development in the objects in PLURAL BIM Models will meet the intended BIM Uses stated in the precedent section. The BIM objects will be developed in LOG Medium and LOI 2 or 3 as defined in the following table:

TABLE 4: LEVELS OF DEVELOPMENT OF PLURAL BIM OBJECTS

Levels of Development	Definitions	PLURAL BIM Objects
Levels of Geometry		
LOG Basic	Blocks, bounding boxes or schematic volumes.	--
LOG Medium	The lightest geometry able to represent the object's visual aspect.	All elements
LOG Detailed	Precise detailing without collapsing the digital system.	PLURAL Solutions
Levels of Information		
LOI 1	Properties, values and information required during Basic and Developed Design stages (generic elements)	--
LOI 2	Properties, values and information required during Technical Design stage (generic elements)	All elements
LOI 3	Properties, values and information required during Construction, Handover and Close out stages (industrial elements from fabrication and assembly as built)	PLURAL Solutions
LOI 4	Properties, values and information required during Operation and In Use Stages.	--

5. BIM requirements for BIM Parser and StreamHandler

According to the BIM Parser architecture being defined in T5.3, the BIM parameters that will run into the tool will be obtained from IFC files and will be stored in StreamHandler in an object-oriented database. JSON is the chosen format to represent the information.

The team working in the BIM Parser and StreamHandler tool identified a set of properties taken from the IFC standard desirable to be found in the BIM Objects of the PnU kits and Demo models. These properties will be assigned at the different categories of objects considered by the IFC4 scheme (see the figure below).

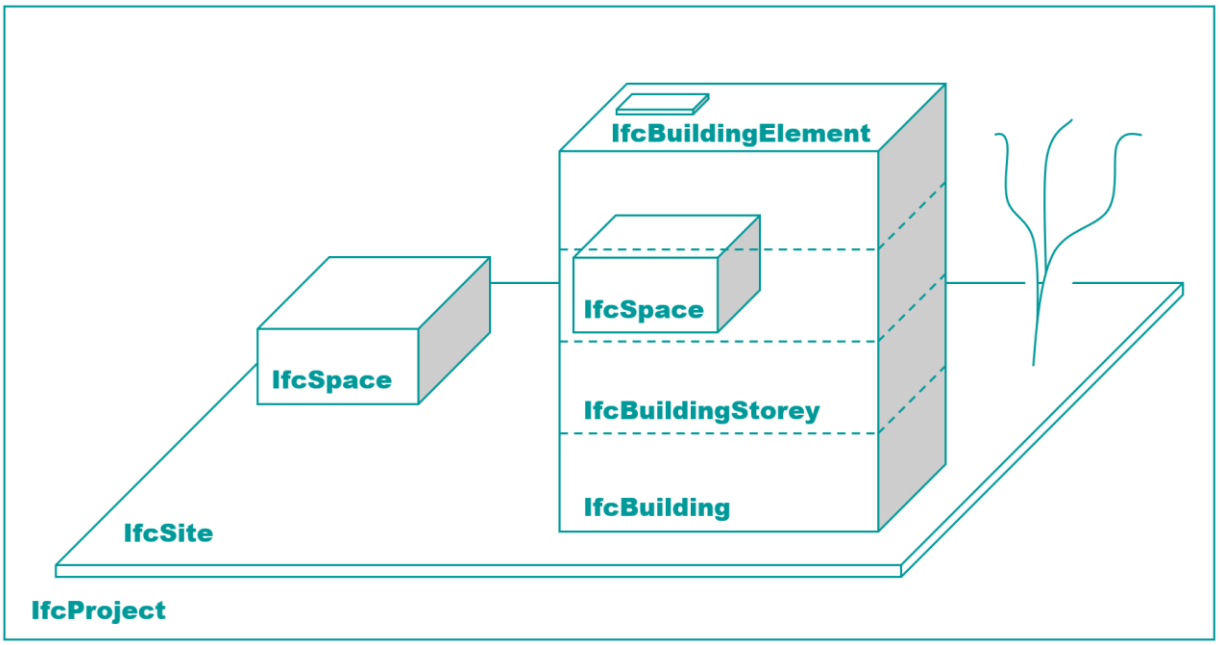

FIGURE 2: LEVELS TO ASSIGN BIM PROPERTIES TO BIM OBJECTS ACCORDING TO THE IFC SCHEME.

5.1 Building Storey Property Sets

The practical experience with models exported from the available modelling tools confirms that no information is allocated at the level of building storeys. Thus, **no properties at the level of Building Storey** will be expected in the PLURAL BIM models.

5.2 Building Space Property Sets

The BIM Parser and StreamHandler tools are being designed to manage information about the building spaces and a series of KPI related to the heated spaces: Non-renewable primary energy balance, Renewable Energy Ratio, Carbon Dioxide (CO2), Illuminance and daylight factor, Primary energy demand / consumption, Thermal Energy demand per area, Electric consumption of mechanical ventilation, Energy consumption for lights and the Total Investments in Greenhouse Gas emissions.

The BIM Parser and StreamHandler tools count on extracting from the BIM models the area and volume of every heated floor to run calculations for the mentioned KPI. These direct data will be combined with other data values loaded into the StreamHandler from sources different than BIM models.

For the KPI calculations it is required then that the heated spaces of the PLURAL buildings BIM models are shaped as IfcSpaces: **One single IfcSpace per floor of the Demo buildings should be modelled and their corresponding area and volume exported into the IFC file according to the IFC4 scheme**.

If required for other purposes, new properties to come should be defined according to the ifc Property Sets and the eCOB standard.

5.3 Building Element Property Sets

BIM Parser and StreamHandler are also being designed to deal with:

- The building elements that envelope the heated spaces, such as walls, windows, doors, slabs and roofs.
- Other building elements that compose the PnU kits and belong to the Electrical, HVAC, Plumbing, Structural or Building controls domains.

In D5.1 Annex of the present document there is a list of all the IFC classes of the building items which will be readable by the BIM Parser and the StreamHandler together with their respective set of properties whose values are expected for every class of enclosure element and PnU component. These properties were defined according to the latest version of Ifc Property Sets[3]. If new properties are required further on and they do not exist in the IFC standard, they will be defined and customised according to section 2.5 in eCOB standard[4] rules.

5.4 BIM Parser Use Case

A BIM Use Case has been modelled containing all the identified classes of BIM objects that may take part in the PLURAL envelopes and PnU kits. The Use Case is made of a simple building made out of building envelopes, spaces and independent components. It was developed as a prototype to run into the BIM Parser and StreamHandler tools in order to confirm the "readability" of items and properties for all the envisaged types of BIM objects in the PLURAL project (the figure below shows a general view of the BIM Parser Use Case). Section 4.1 in D3.2b contains the interaction sequence between the BIM Parser and StreamHandler tested with the Ifc file of the BIM Parser Use Case.

[3] http://ifc43-docs.standards.buildingsmart.org/
[4] https://ecobject.com/estandar-ecob/parte-2-creacion-de-objetos-con-ecob/#25

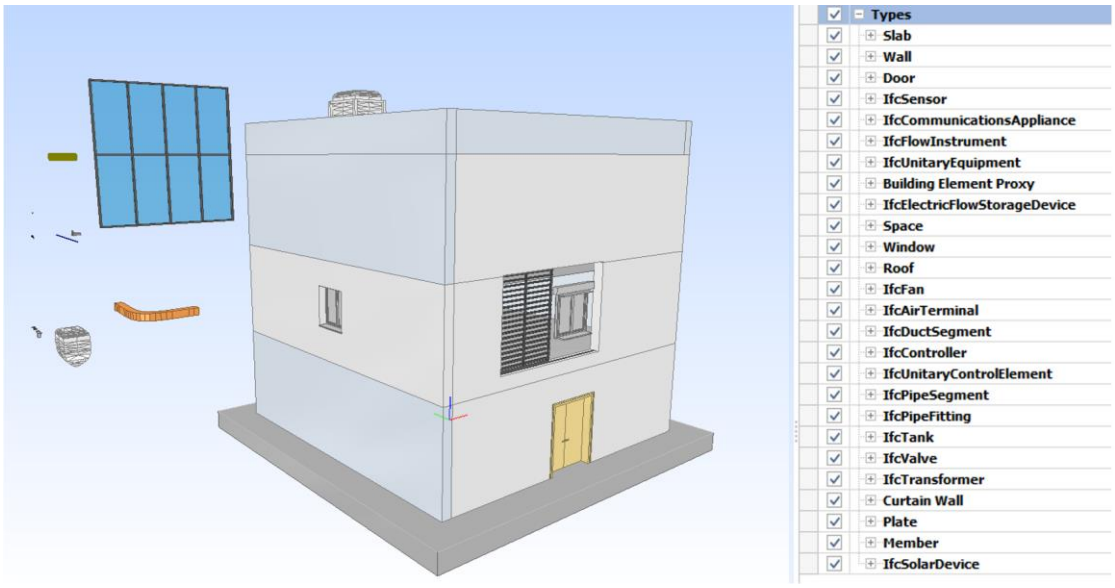

FIGURE 3: BIM USE CASE DEVELOPED AS A PROTOTYPE FOR BIM PARSER AND STREAMHANDLER.

6. BIM requirements for the Decision Support Tool

6.1 MODEST Decision Support System requirements

According to the MODEST Decision Support System Requirements Specification document, the following statements regarding BIM objects have been identified:

- There will be a sorted set of alternative configurations for every PNU kits in Modest. Modest is a tool to aid users and decide which PNU kits are more suitable for a particular project.
- Modest platform will allow to calculate:
  - Total building energy consumption
  - Total renovation cost
  - Perceived comfort for the users
- Modest should enable to calculate the total weight of materials needed for a renovation project from the number of units and type of PNU kits, as well as to calculate the total energy consumption and the costs of the project (economic and environmental).
- The Plural Lysis platform (based on StreamHandler) will store values from de PNU kits and the buildings/projects.

The properties in D5.1 Annex are a first proposal of answer to these requirements. The properties have been applied on the same BIM Use Case tested for BIM Parser and StreamHandler tools (see following figures).

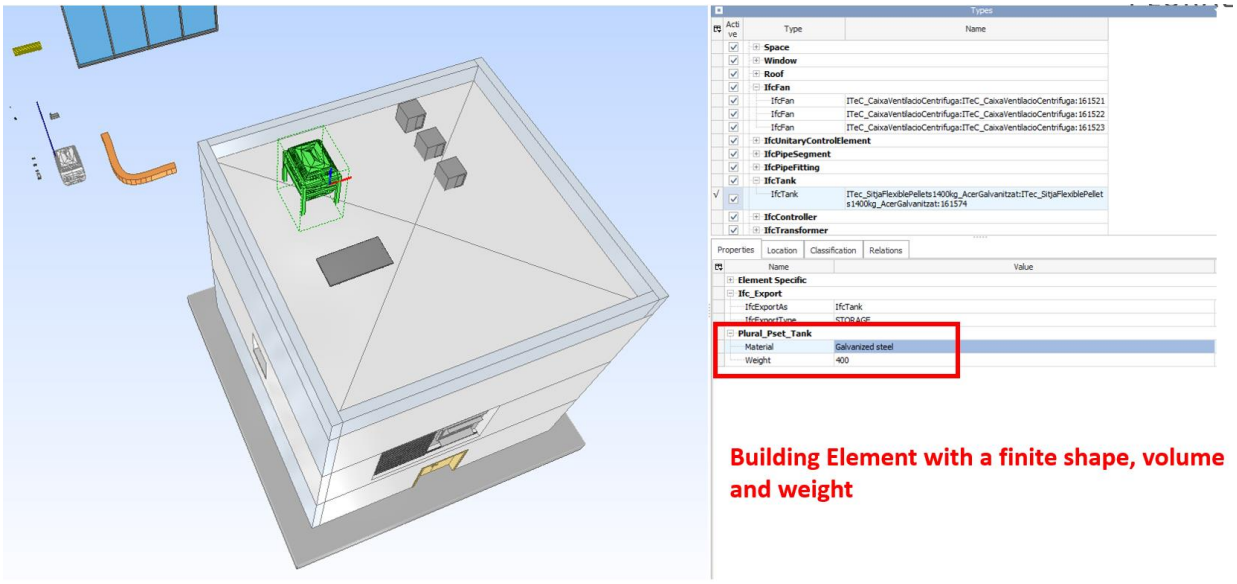

FIGURE 4: PLURAL PROPERTIES DEFINED FOR BUILDING ELEMENTS WITH FINITE SHAPE, VOLUME AND WEIGHT.

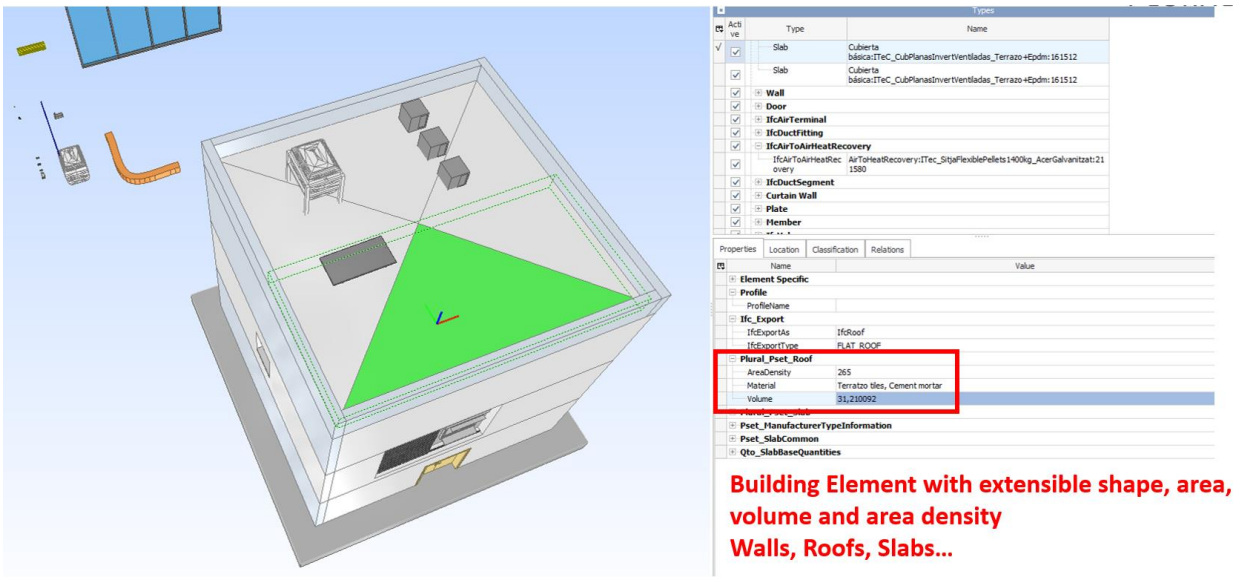

FIGURE 5: PLURAL PROPERTIES DEFINED FOR BUILDING ELEMENTS WITH EXTENSIBLE SHAPE, AREA, VOLUME AND AREA DENSITY.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958218

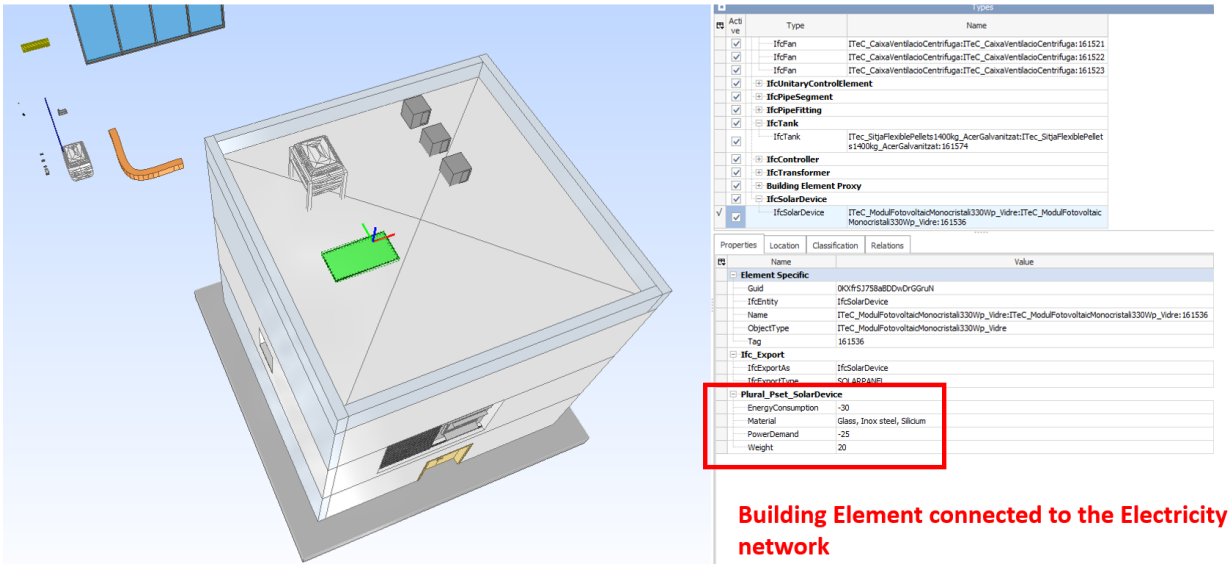

FIGURE 6: PLURAL PROPERTIES DEFINED FOR BUILDING ELEMENTS CONNECTED TO THE ELECTRICITY NETWORK.

6.2 Energy Simulations requirements

For the Energy simulations, some complementary properties for the BIM objects in the PLURAL project are required:

- Window frame: thermal resistance (R), thermal emissivity (e), thermal absorptivity (a)
- Window glass: thermal resistance (R), thermal emissivity (e), thermal absorptivity (a), solar transmissivity (g) (data defined by the manufacturer)
- Cladding tiles (Plates): thermal resistance (R), thermal emissivity (e), thermal absorptivity (a) (data defined by the manufacturer and standard data for materials will be used).
- Insulation layer: thermal resistance (R)
- PV. Properties to be determined.
- Shading elements: Properties to be determined.

These properties and their respective values have been included in D5.1 Annex to the level of the building elements (window, door, wall, cladding and shading elements).

6.3 LCA&LCC assessment requirements

The LCA&LCC assessments will estimate the economic and environmental costs of the PnU kits and new solutions. This assessment will be carried out with TCQ software according to ITeC methodology. This software allows to develop a project's estimate out from BIM models in IFC by linking every type of BIM object with one or several work units whose costs are defined in BEDEC's database[5].

For the LCA&LCC assessments, the BIM objects in the PLURAL new solutions will be required to contain:

- The base quantities exported out from the modelling programs according to their corresponding IFC class.
- Properties that link the objects to its corresponding work units.

7. BIM requirements for the Inventory Library

7.1 The Inventory Library

The library will be formed by a set of BIM objects to model the building envelopes of the existing and renovation projects with information necessary for the environmental assessment of the buildings. The Inventory Library will be composed by objects of the following BIM classes: Walls, Windows, Doors, Roofs and Floors.

7.2 Requirements for the Inventory Library

The Inventory Library can be used for modelling the renovation solutions of the 6 demo buildings (Czech, German, Greek, Spanish, Swedish and Switzerland demos) and the corresponding PNU kits. The objects in the Inventory Library should allow to perform an assessment of the new building and an easy communication/sharing of information between applications.

The objects will be created in native BIM modelling applications and will be exported into IFC interoperable format. The files are to be exported under IFC4 Reference View scheme and contain objects with:

- IFC Entity entered correctly in the property IfcExportAs (to prevent from using Building Element Proxies)
- OmniClass Construction Classification System Table 21
- Qto_*BuildingElement*BaseQuantities (according to the building element class)
- One single space per floor representing the heated floor area and volume.
- Material of building elements (one or several separated by commas) entered in the Material property

[5] https://itec.es/servicios/bedec/

- Construction stage (Existing – New)
- Properties and Psets specific for each building element class according to spreadsheet in D5.1 Annex.
- The units of the project will be defined in the International System of Units metric system (SI).
- When exporting to IFC, it will be required to include IfcSite elevation in the site local placement origin according to the IFC4 definition[6]
- All projects, related or linked files (CAD files), IFC, numbers of points or any other format of graphical representation) and all the possible ones generated from these models, must share the coordinate system (x, y, z reals) and use the reference of the UTM system with the corresponding Datum[7] and Fuse (e.g. in Terrassa Demo: Datum ETRS89 and Fuse 31 T)
- The models must be situated at the real Z coordinate.

8. BIM requirements for PnU Kits

The PnU kits will be formed by a set of components defined by the design teams of each PNU kit in D2.1 and D2.2. The PnU kits will be composed by BIM objects of the BIM classes identified in the D5.1 Annex. After several meetings, their requirements were defined in the following sections.

8.1 eWHC kit

The integrated panel should contain all the layers that compose the panel and the related information for describing them such as thickness, material type and physical properties.

It is desirable that the cooling/heating layer that contains the pipelines is modelled with the precise geometry and disposal of the piping system, with the same method used for radiant floor systems. It can be done according to the CAD files that are being developed for the manufacturing of the panels. If the modelled geometry is not precise and according to real installing conditions, then it is not convenient to model the pipelines because the BIM model may lead to misunderstandings and errors in the production of the radiant walls. A prototype of one demo case of integrated panel can be modelled according to these requirements to confirm the feasibility and usefulness of modelling the pipelines.

It is desirable that the wall framing of the integrated panels is modelled with the precise geometry and disposal (with studs, plates, sills, lintels, and head trimmers made of timber). The usefulness and feasibility of this modelling can be tested in the same demo prototype.

6 https://standards.buildingsmart.org/IFC/RELEASE/IFC4/FINAL/HTML/schema/ifcproductextension/lexical/ifcsite.htm

7 https://epsg.io/

Regarding the windows, it is desirable that the internal blinds come integrated in the same element to simplify the usability of windows to design teams. Further requirements related to the usability of the window BIM objects will be defined in "D4.4 PnU kit prototypes addressing the 3 Demo building requirements".

8.2 SmartWall

The smart wall panel should contain all the layers that compose the panel and the related information for describing them such as thickness, material type and physical properties.

It is desirable that the wall framing of the integrated panels is modelled with the precise geometry and disposal (with studs, plates, sills, lintels, and head trimmers made of steel hollow sections). The usefulness and feasibility of this modelling can be tested in the same demo prototype. The size of the framing elements is still being defined according to new seismic calculations and testing campaign. The frame elements may change their section and this change in the BIM elements should be made easily.

It is desirable that the blinds and the heat recovery come integrated with the window in the same element to simplify the usability of windows to design teams. Further requirements related to the usability of the window BIM objects will be defined in "D4.4 PnU kit prototypes addressing the 3 Demo building requirements".

8.3 eAHC kit

The idea is to have a parametric curtain wall system (or a parametric façade component) with the following characteristics:

The curtain wall should adapt to the height and width of the curtain wall drawing (or it is an independent façade panel with parameters of height and width, to be attached to existing façade, whatever is easier). The rules for modulation of the façade/roof panels are defined in section 5.1.2 of D2.1.

The eAHC kit objects should fulfil the following conditions:

Denvelops substructure

- Respects the limitations of the Denvelops solution
- Is arranged automatically according to the selected width and height
- Material is fixed, also the definition of the lines and connectors can be fixed, just their distribution and dimensions in terms of width and height change
- Can be divided automatically into Sequences.
- Distance (D) between lines is chosen. Fix a criteria of how to distribute D at the extremes of Sequences. (ex: we can use 20cm between lines but if we have more or less than 20 cm at the

extremes of the sequence, the curtain wall has to decide if doing smaller or bigger pieces at these extremes). Fix the criteria of Distance "Edge of a Sequence – Line"

Denvelops cladding

- Is related to the distribution rules of the Denvelops structure (or opposite)
- Material can be chosen freely
- It could be interesting and useful to mark the cladding pieces that will be retired in situ for the installation of UV systems. For example, by including a parameter that can be checked whenever.

Insulation:

- It would be desirable that the insulation layer is related somehow to the cladding system so they can be managed as a single element for enlarging/shortening, opening windows, etc.
- Thickness can be chosen
- Material can be chosen

The façade should have the possibility to include:

Windows:

- As a curtain window, it replaces part of the façade by means of an opening element in the curtain wall.
- It should work with any window of the library.
- It should come with the possibility to include the solar shading.
- The solar shading should adapt to the width and height of the window, according to its limitations (f.e. the maximum width of the shading element), ideally it follows the cladding distribution.
- It is desirable that the blinds come integrated with the window with the option of having/not having blinds depending on the specific position of window.
- The metal sheet frame should adapt to the window measures, and isolation + Denvelops thickness.
- Further requirements related to the usability of the window BIM objects will be defined in "D4.4 PnU kit prototypes addressing the 3 Demo building requirements".

Ventilation units:

- It should be included within the insulation layer
- Its position should be able to be defined: Next to the window, in a height that allows for maintenance.
- It would be desirable that the ventilation channels connect to the interior.

PV panels

- Possibility to replace cladding with PV panels (this would be easy in the curtain wall setting).
- The PV panels to be used in the PnU kits are well defined, and there are no options, just to choose how many modules are used in the vertical sense (the width is fixed, the height can be a multiple of a module height).
- Possibility to always have a count of Area of solar collection.
- Automatic collocation of microinverters and batteries.

Further requirements related to the usability of the BIM objects for the ventilation units and PV panels will be defined in "D4.4 PnU kit prototypes addressing the 3 Demo building requirements".

9. BIM requirements for the parametric modelling of the new construction solutions

The parametric modelling rules will be applied in the native modelling programs where the BIM models are constructed because up today, the BIM objects in the IFC files have limited parametric properties.

Regarding parametric properties, the BIM objects and models of the new construction solutions will meet the following requirements:

- Visualization of the model in 3D to resemble the attributes of the real behavior of the components and products.
- Automation for composing the solutions with the defined components and products for the PnU kits.
- Ability to change the shape of model geometry as soon as the dimension values of the element are modified.
- Ability to change the materials of model items according to the available components and products defined for the PnU kits.
- Ability to change the values in properties according to the declared values in the components and products defined for the PnU kits.

10. Conclusion

D5.1 Annex of the present document distils the requirements for the building items which will compose the PLURAL BIM models together with the BIM properties which have been defined by the different intended uses of the BIM models.

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The BIM classes of building elements and their respective properties have been defined according to the latest version of Ifc Property Sets[8]. If new elements and properties are required further on and they do not exist in the IFC standard, they will be defined and customised according to section 2.5 in eCOB standard[9] rules.

All the previous requirements will be considered to carry out the creation of the BIM components and database for PLURAL as far as possible. The requirements may also be considered to complete tasks 5.3, 5.4 and 5.5 of PLURAL.

11. Reference documents

Industry Foundation Classes 4.0.2.1 Reference View 1.2

OmniClass™ Construction Classification System

BIMeInitiative – Model Uses Table

eCOB Standard for creating BIM objects

BEDEC database

12. Annex

PLURAL D5.1 Annex: BIM Objects Database of Plural Technologies for BIM Modelling and LCA calculations

[8] http://ifc43-docs.standards.buildingsmart.org/
[9] https://ecobject.com/estandar-ecob/parte-2-creacion-de-objetos-con-ecob/#25