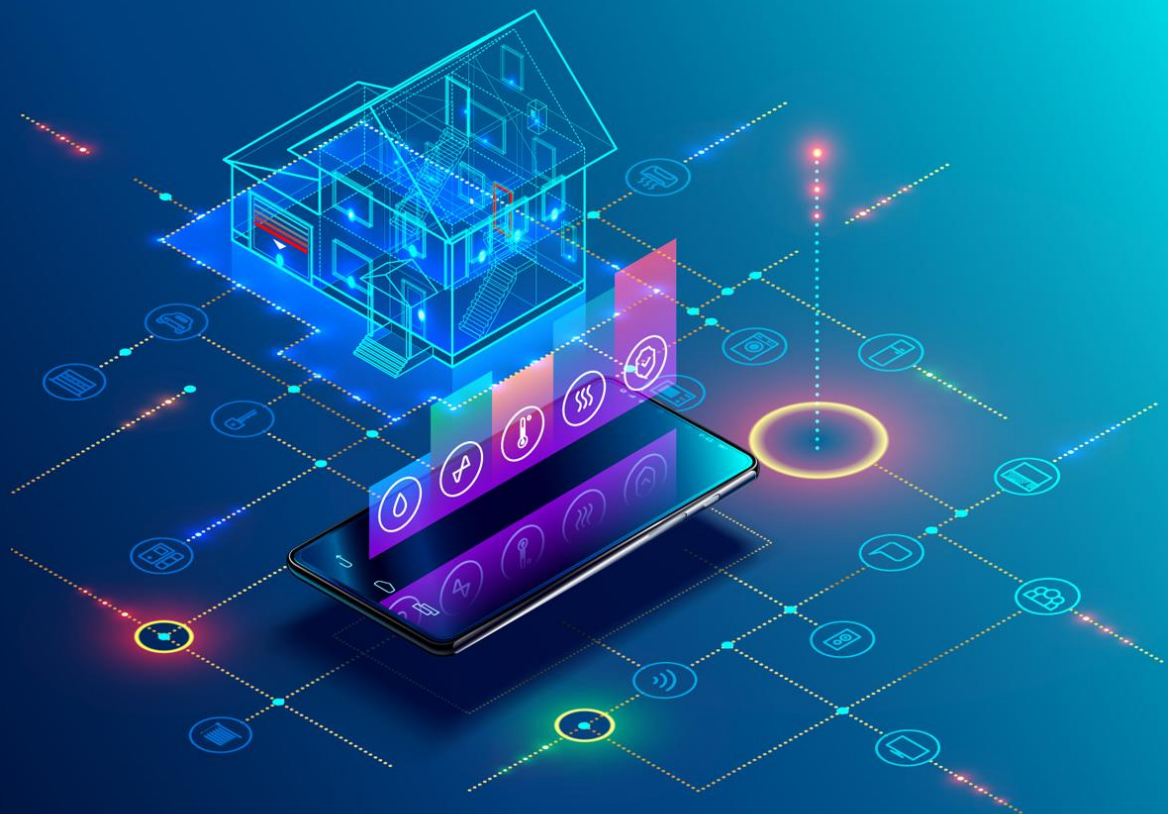# BIM object library and product LCA for renovation projects

Deliverable 2.3

Deliverable 2.3, issue date on 01.12.2021

BIM object library and product LCA for renovation projects

Deliverable 2.3

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Publishable executive summary

Building renovation is one of the current big challenges of the construction sector, which would improve the sustainability of existing structures, in terms of energy and emission savings and, as a consequence, would reduce the overall energy and CO_2 emissions accounting in the building sector. According to the Building Performance Institute of Europe, the building sector accounts for 40% of energy consumption and 36% of CO_2 emissions. Moreover, most of the European existing residential buildings have reached the age for renovation. While new buildings can be realized with high energy and emission saving performances, the existing buildings are mostly characterized by very bad performances and, therefore, their renovation can contribute to the fulfilment of the sustainability goals in the construction sector. The EU funded Research Project BIMSPEED (H2020 GA 820553) aims at providing all stakeholders in the housing renovation market with holistic solutions regarding: an affordable cloud base BIM platform; a set of interoperable BIM tools; validated and standardized procedures for implementing renovation solutions with guaranteed energy performance and inhabitants' comfort.

Within the BIMSPEED Project, a BIM object database has been developed as a support for the renovation design. In fact, a common difficulty encountered by designers during the several analysis of a project is the availability of up-to-date BIM elements, especially with respect to the completeness of their datasets. In this regard, it is quite difficult to find elements that have all the necessary data to perform complete energy or sustainability analysis. On the contrary, it is more frequent to get only geometric data, or at most only some of the most common energy data, such as transmittance, and therefore, in order to obtain the other needed information, users have to contact directly the manufacturers or other connected sources. This represents an obvious additional effort and time commitment, that does not lead to a warranty to acquire all the needed data.

These are some of the motivations behind the development of the BIMSPEED database, which was created with different aims: firstly, it allows general construction building stakeholders to visualize and choose the more appropriate building renovation component, also with the help of specific research filters. The database is organized in renovation categories to which the different objects correspond. Each element is defined by a set of general, energetic, environmental and economic parameters useful to perform energy performance assessment and environmental/economic analyses using ad hoc external tools, as well as a set of documents and files. Finally, in order to guarantee to end users a comprehensive catalogue of objects, the database is also connected to external existing libraries which ensure a constant updating of its population.

Technically, two interfaces have been developed: the first one is dedicated to database administrators, who can use different tools for dataset management; the second one is dedicated to general users who, through a website connected to the database, can access to all the information they need, after a registration process. In addition, ad hoc functionalities have been developed for the management of IFC files.

Indeed, new elements can be created and modified thanks to a specific procedure of reading/writing of the IFC format that facilitates the insertion of data related to new and existing objects.

List of acronyms and abbreviations

API: Application Programming Interface

BEM: Building Energy Model

BIM: Building Information Modeling

BS: BIM-SPEED

COP: Coefficient Of Performance

DHW: Domestic Hot Water

EEB: Energy Efficient Buildings

EER: Energy Efficiency Ratio

EPBD: Energy Performance Buildings Directive

HVAC: Heating Ventilation Air Conditioning

LCA: Life Cycle Assessment

LCC: Life Cycle Costing

RSL: Reference Service Life

SCOP: Seasonal Coefficient Of Performance

TRL: Technology Readiness Level

VRF: Variable Refrigerant Flow

Definitions

Not applicable.

Contents

1. Introduction

The present document represents the supporting report to the BIMSPEED database, dedicated to management by administrators, and the corresponding web platform designed for use by general users.

The EU funded Research Project BIMSPEED (H2020 GA 820553) aims at providing all stakeholders in the housing renovation market with holistic solutions regarding: an affordable cloud base BIM platform; a set of inter operable BIM tools; validated and standardized procedures for implementing renovation solutions with guaranteed energy performance and inhabitants' comfort. Within the BIMSPEED Project, a BIM object database has been developed as a support for the renovation design.

In the first part of the document, an overview about the main features of the database is provided. The main scopes of the database are presented, with a schematic representation of its main functions and the workflow of its concept design. Then a description of its elements is presented, with an eye to how their characteristic are organized, the different categories, the several typologies of objects and the specific datasets useful to perform energy and sustainability analyses. To this regard, the document details the relevant parameters associated with each element which are divided into main packages, i.e. the *info package* with general data, the *energy package* collecting data useful for energy analysis and the *sustainability package* which collects data regarding the environmental and economic impacts of the building components.

Then the document presents the architecture of the database, formally divided into an administrative structure and a web interface. The first is a dashboard that authorized partners can access to, in order to manage the database, equipped with specific tools for the creation and modification of the various elements. The last one represents the front office part dedicated to general users who can simply browse the web portal or, after a registration process, can perform more specific operations such as creation of new items, modification of existing ones and download of the available documentation (technical sheets, IFC files, etc).

Finally, a section of the document is dedicated to the connection of the database with external services, i.e. existing online libraries, which are linked with the database in order to automatically enrich its population according specific categories. Moreover, the database can communicate with external tools and, at this regard, a detailed description of the developed APIs is provided as well as a description of the functions of the specific tools that are currently connected to the database.

2. BIM SPEED Object Database

2.1 Aim of the DB

The BIMSPEED database contains materials and components used for deep renovation of buildings. Building renovation components are defined as the building elements that can provide a contribution to the reduction of the overall energy consumption and/or to an enhanced environmental and economic sustainability. The database collects a set of parameters, which can be divided into two packages: the "info package" and the "software package". In particular, the info package includes the general information, such as the component category, the typology, the application area, and others; whilst the "software package" includes more specific information, i.e. the data needed as support for energy performance assessment, Life Cycle Assessment (LCA) and Life Cycle Costing (LCC). Data collected for the energy performance assessment vary considering different components categories. All the components and the related parameters will be discussed in the following subsections.

The database has several aims: it offers general construction building stakeholders an updated catalogue of building renovation components where they can choose, with the help of research filters, the more appropriate element for their purpose; then, it also provide specific datasets useful to perform energy assessment and environmental/economic analyses using ad hoc external tools and/or software.
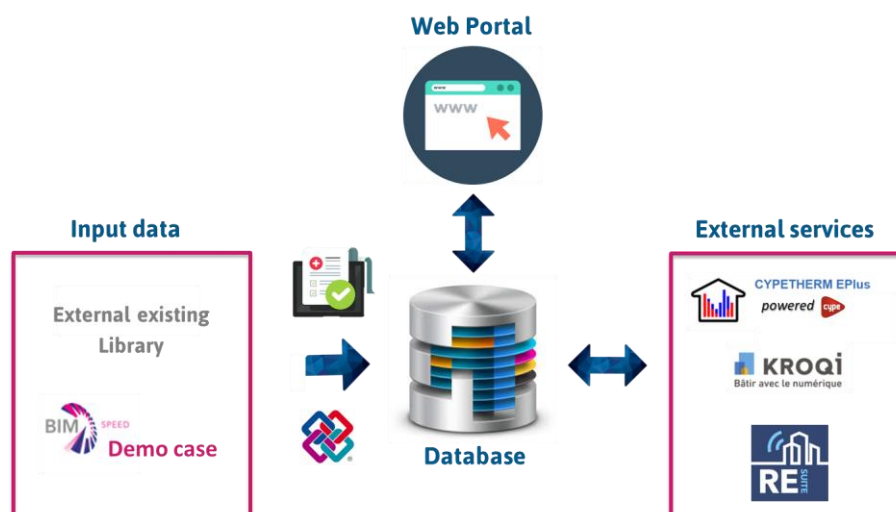

Figure 1: The BIMSPEED database workflow

Figure 1 shows the database workflow which interacts with several input data, external services and a web portal. The database represents the back office platform for partners to manage the different renovation elements, which are in parallel published on a public web portal designed for general users who can simply navigate the website or download and modify the elements upon online registration process. The database can be enriched by different types of input files coming from: external libraries, the project demo cases, the partners who can easily create new elements or edit existing ones. The latter aspect can

be done either through manually entering data or through an automatic procedure that involves loading, reading and editing of existing IFC files. Finally, specific APIs have been developed to allow the connection with external services aiming to use the renovations elements present in the BIMSPEED database for their analysis purposes.

2.2 Definition of the renovation objects

Building renovation components are defined as the building elements that can provide a contribution to the reduction of the overall energy consumption and/or to enhance its environmental and economic sustainability performances. Within the database, the building components have been grouped depending if they are applied on the envelope of the building, if they concern the Heating, Ventilation and Air Conditioning system (HVAC), or if they concern to Domestic Hot Water (DHW). Belonging to the first group are the components that are applied to the building envelope which contribute to energy efficiency, i.e. external walls, roof, ground-floor, insulation materials and panels, facades, ventilated facades, windows, external doors. The HVAC system components, which can be installed inside or outside the building, contribute to the mechanical heating, cooling, and ventilation of the building. These are the components for the water heating system, air/water conditioning system, small Variable Refrigerant Flow (VRF), multisplit and ventilation. Finally, the third renovation component group includes Domestic Hot Water (DHW) systems components. Table 1 schematizes the listed components.

Group	Building Component - Category
Envelope	Material Panel/Roll Facade Ventilated facade Ventilated roof Window/Door
HVAC	Water Heating System Air/Water Conditioning System Small VRF Multisplit Ventilation
DHW	Domestic Hot Water

Table 1 - List of components included in the BIMSPEED database

The types of elements depend on the component category; some of them are reported in Table 2 for an easier exposition.

Category	Type
Material	Thermal insulation
	Acoustic insulation
	Thermo-acoustic insulation
Panel/Roll	Thermal insulation
	Acoustic insulation
	Thermo-acoustic insulation
Facade	Thermal insulation
	Thermo-acoustic insulation
Ventilated facade	Thermal insulation
	Thermo-acoustic insulation
Ventilated roof	Thermal insulation
	Thermo-acoustic insulation
Windows/Doors	Side hung (1 door)
	Side hung (2 doors)
	Side hung (n doors)
	Sliding (1 door)
	Sliding (2 doors)
	Sliding (n doors)
	Top hung
	Tilt and turn
	Pivot vertical
	Pivot horizontal
Water Heating System	Gas boiler
	Electric boiler
	Biomass stove

Table 2 - List of Types for all the building components categories

2.3 Definition of relevant parameters

The database collects, for each element, a set of parameters which can be divided into two distinct packages: the "info package" and the "software package". The Info Package includes the general information related to an element, such as the component category, the typology, the application area, and others; whilst the "software package" includes more specific information, i.e. the data needed as support for energy performance assessment, Life Cycle Assessment (LCA) and Life Cycle Costing (LCC). Data collected for the energy performance assessment vary considering different components categories.

2.3.1 The Info Package

In the Info Package, general data are provided, which aim at the identification of the component and also at guiding the user to choose the building component which better suits his/her renovation design. In particular, Info Package data can be grouped into five sub-packages, being: General Package, Dimension, Fire Package, Durability package and Energy Classification.

- General Package, which gathers the following data: Group; Category; Type; Application area; Name; Description; Brand; Producer Web Site; Main Material; Source BIM Object. Group,

category and type are the information described in the previous paragraph. The application areas represent the physical place to which the component is applied, being the external wall, the internal wall, the floor, the roof, the ground and/or the ceiling. Then, the name, the description of the components, the producer and its website are collected. Finally, the main material of the component and the website where the BIM file can be downloaded are reported;

- Dimensions, which includes length, width and depth. Particularly important for the components included in the envelope group, whilst is not collected for the HVAC and DHW systems, since they can be composed of more than one element;
- Fire package, which collects the information on the Euroclass Fire (A1, A2, B, C, D, E, F according to the EN 13501 1) and, also in this case, it is needed only for the components of the envelope group;
- Durability package, which collects the component's Reference Service Life (RSL), reported in years. RSL can be particularly important for helping the database user to identify his/her best choice.
- Energy classification, which is collected only for the HVAC and the DHW systems components.

2.3.2 Energy performance package

The Energy performance package collects all the data necessary for running the energy performance assessment of the building. The package has been divided into the following sub-sections: Materials, Panels/Rolls, Windows, HVAC Water Heating System, HVAC Aerothermal System, HVAC Small VRF/Multi split, HVAC Ventilation and DHW. For an easier exposition, the energy parameters collected for each components categories and their relative unit of measures are schematized in Table 3. It can be noticed that for the water heating system and the air/ water conditioning system, the component can be used not only for heating/cooling, but also for the production of DHW, which can have or not a storage system. This means that relative additional data need to be collected.

Category	Energy Performance parameters
Material **Panel/Roll** **Façade** **Ventilated façade** **Ventilated roof**	Vapour resistance (μ) Conductivity of materials [W/(mK)] Thermal resistance of unit area of materials [(m^2 K)/W] Thermal transmittance of unit area of materials [W/(m^2 K)] Thickness [m] Density of materials [kg/m^3] Specific Heat of materials [J/(kgK)]
Windows/Doors	Heat transfer of transparent elements [W/(m^2 K)] Air permeability of transparent elements [m^3/(hm^2)] Percentage of opaque elements [%/100] Heat transfer of opaque elements [W/(m^2 K)] Solar absorptivity opaque elements [%/100] Transmittance of solar energy [-]

	Window Thermal transmittance (W/m²K)
Water Heating System	Boiler type Nominal Power [kW]
	Fuel type
	Rated Efficiency at 75°C [%]
	Operating temperature [°C]
	Design delta temperature [°C]
	Terminal unit type

Table 3 - List of energy parameters for all the building components categories

2.3.3 Sustainability package

The sustainability package collects the environmental and economic impacts of the building components considering the stages of their life cycle. In particular, the life cycle stages are related to the EN 15804, which classifies the building product lifetime into four main modules:

- Modules A1-A3 (Production stage), i.e. the extraction and production of the raw materials, the transport to the manufacturing site and the product manufacturing;
- Modules A4-A5 (Construction stage), i.e. the transport to the installation/construction site and the product installation;
- Modules B1-B7 (Use stage), i.e. all the operations that can happen during the product use, such as maintenance, replacement, repair;
- Modules C1-C4 (End of Life stage), i.e. all the operation related to the product End of Life, such as deconstruction, waste processing,

In the LCA package, the information related to the environmental impacts generated during the A1-A3 stage are considered, with reference to a fixed unit of measures, called "Functional Unit". In the LCC package, the information related to the economic impacts generated during the Production, Construction, Use stages are considered. For the LCA and the LCC, the data included in the database are reported in Table 4. It can be noted that the LCA parameters are equal for all the categories, whilst the LCC parameters differ for the envelope and HVAC/DHW categories, because an additional cost info is collected, i.e. the energy cost.

Category	LCA parameters	LCC parameters
Material **Panel/Roll** **Façade** **Ventilated façade** **Ventilated roof**	Functional Unit Global Warming (kg $CO_{2,eq}$) Acidification (kg $SO_{2,eq}$) Eutrophication (kg $PO_{4,eq}$) Ozone Layer Depletion (kg CFC 11 eq) Photochemical Oxidation (kg)	Functional Unit Price Construction/ Installation Costs Maintenance Costs in RSL
Water Heating System **Air/Water Conditioning System**		Functional Unit Price Construction/ Installation Costs

Small VRF **Multisplit** **Ventilation** **Domestic Hot Water**	Abiotic Depletion, elements (kg Sb $_{eq}$) Abiotic Depletion, fossil fuels (MJ)	Maintenance Costs in RSL Operational Energy Costs

Table 4 - List of LCA and LCC parameters for all the building components categories

3. BIM SPEED Library Architecture

3.1 Administrative structure

The database is managed by an administrative dashboard, showed in Figure 2, that only authorized partners can access to visualize the actual datasets, to modify existing elements or to upload new components.

The lateral menu on the left is composed by several sections: the *Registry Management* where the User List and their corresponding personal API keys are provided, the *Catalog* where the details for all the elements are listed and the *Configuration* where each material present in the database is defined.

In the central part of the dashboard, there are some information boxes that allow the user a quick overview of some crucial aspects of database management. In particular, it is possible to recognize two different sections. The first one regarding the population of the database, i.e. the total number of elements, the number of published elements and the elements in review/draft status. Below this section there is an area named "Data Checker" dedicated to a quick overview of the data present in the database: a table summarizes the number of database elements for each category, information about the quantity of data concerning the different packages (Energy, LCA, LCC, IFC file) is reported using markers (green for almost complete, yellow for partially complete, red for almost incomplete) and finally there is an index of requests from users to unlock elements that have been published or are under review (for which no changes can be done).
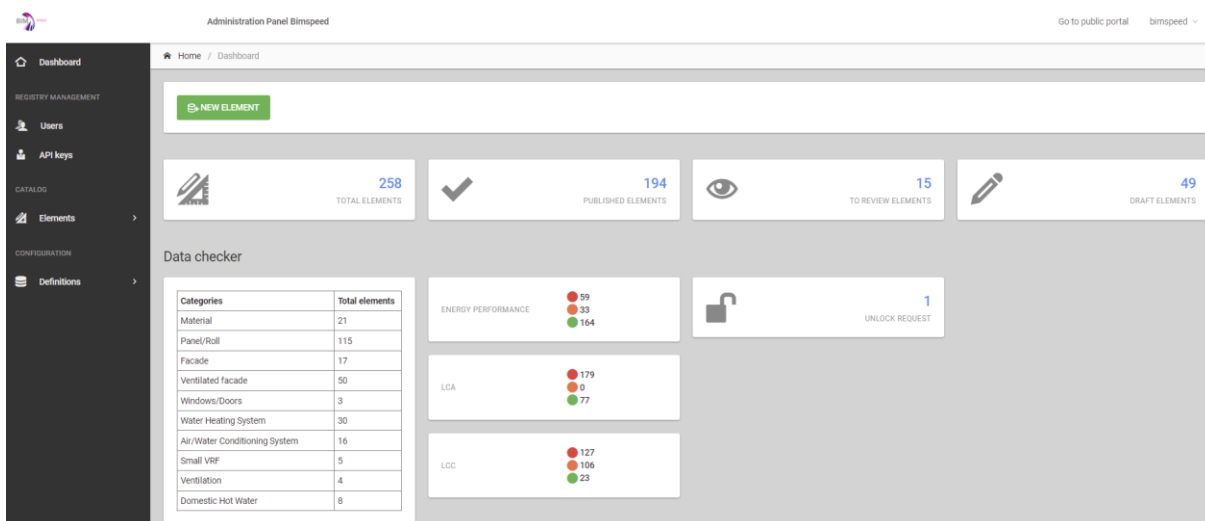

Figure 2 - BIMSPEED database – Administrative Dashboard

Figure 3 shows the section for creating a new element included, for example, in the "Façade" category. Once the user who has introduced the data related to info package, ensuring to enter at least the obligatory ones, he can save the new item. At this point it will be possible to insert also the data related to the other packages. The just-created element will be classified in the status of *draft*, i.e., an element created

by a user but which can still be edited by the author. If the data entered is sufficient, user can send the element for *review* to the administrator. At this point the author will no longer be able to make changes to the element. Once a check has been made on the element, the administrator can decide, also at the request of the author, to set the element as draft again (in order to allow the author to make changes) or, if there is no need to modify the data, to publish it on the portal. After publication, the element will be available to other users.
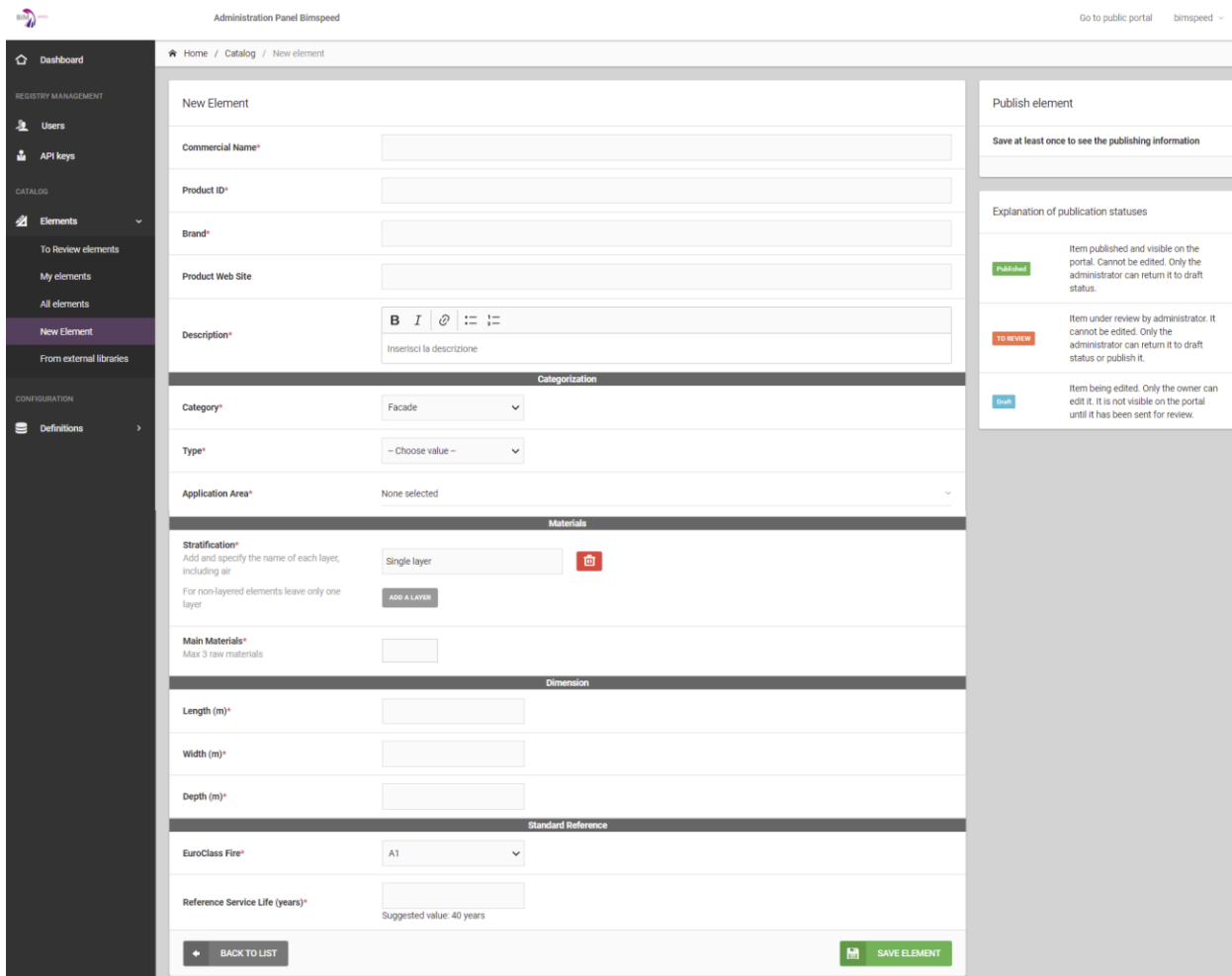
Figure 3 - Administrative Dashboard: data uploading function for the "Facade" category

The catalog of all elements is shown in Figure 4. In order to help users identifying the different status that can characterize an element, a legend has been inserted at the top of the page:

- Draft: every new element edited by user is firstly in the draft status. Only the user can edit it. It is not visible on the web portal until it is sent to review.
- To review: item under review by administrator. It cannot be edited by user. Administrator can return it to draft status or decide to publish it.
- Published: item published and visible on the web portal. It cannot be edited by user. Administrator can return it to draft status for further modifications.

Below the legend there is the list of all the elements populating the database, classified with a picture and product name, the brand, the category and type, the status and some marker used to quantify the completeness of Energy/LCA/LCC packages data (green for almost 80%, yellow for almost 50% and red for less than 20%).
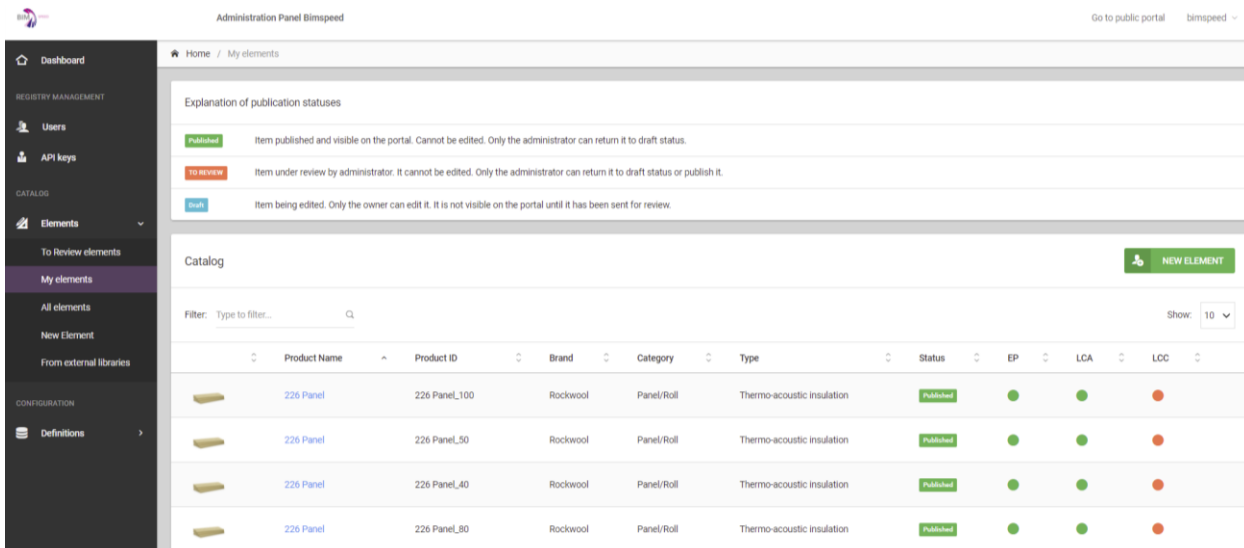

Figure 4 - Administrative Dashboard: the catalog of all elements

Clicking on the name of a product the relative element profile opens with the various information reported in the different packages. Figure 5 shows an example for a "Rockwool thermo-acoustic insulation panel", named "226 Panel". Following the energy and sustainability data packages there is a box, named "File & Download" in which the user can find, if present, the files related to the specific element, such as the picture, other documents, the .ifc and the .rvt file .
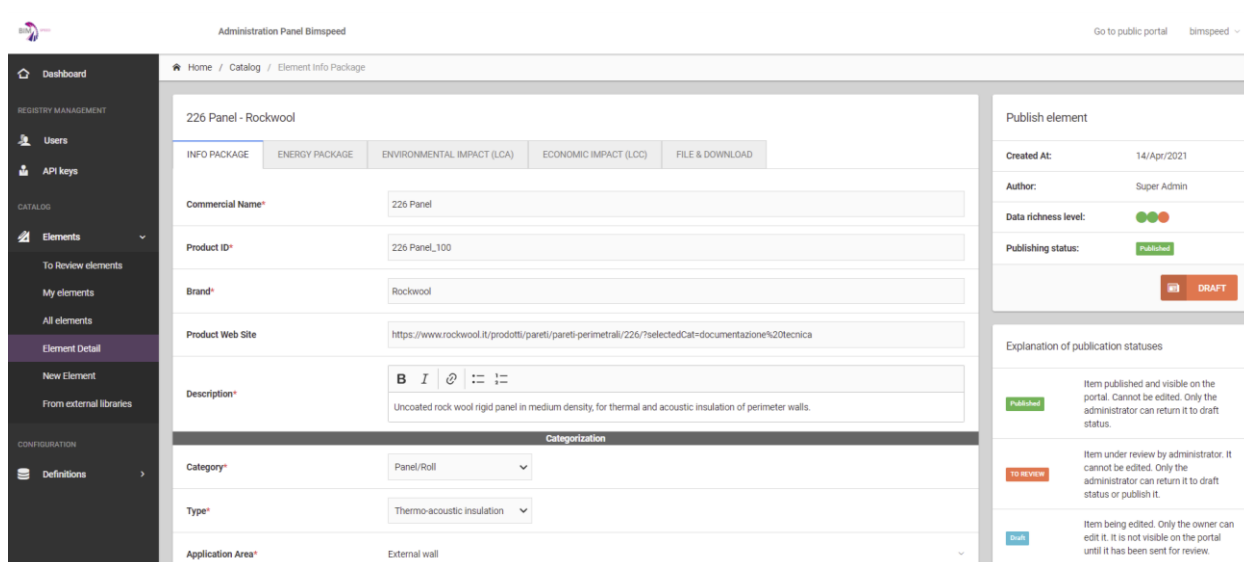
Figure 5 - Administrative Dashboard: detail of the 226 Panel, "Panel/Roll" category

Another useful functionality, showed in Figure 6, is the possibility to enhance an existing IFC file. Indeed, when a user creates an element, he can also upload its IFC file, based on the data firstly inserted in the several packages. If the user later modifies or inserts additional information, then he can also generate a new IFC file containing the updated data, which will appear in the list of available files without removing the previous one.

IFC, or "Industry Foundation Classes", is a standardized, digital description of the built environment, including buildings and civil infrastructure. It is an open, international standard (ISO 16739-1:2018), meant to be vendor-neutral, or agnostic, and usable across a wide range of hardware devices, software platforms, and interfaces for many different use cases. The IFC schema specification is the primary technical deliverable of buildingSMART International to fulfil its goal to promote openBIM® .

BuildingSMART International published a document that contains the specification of the IFC standard. The specification consists of the data schema, represented as an EXPRESS schema specification and alternatively as an XML Schema specification, and reference data, represented as XML definitions of property and quantity definitions.

The IFC specification includes terms, concepts and data specification items that originate from use within disciplines, trades, and professions of the construction and facility management industry sector.

- the data item names for types, entities, rules and functions start with the prefix "Ifc" and continue with the English words in CamelCase naming convention (no underscore, first letter in word in upper case);
- the attribute names within an entity follow the CamelCase naming convention with no prefix;
- the property set definitions that are part of this standard start with the prefix "Pset_" and continue with the English words in CamelCase naming convention;
- the quantity set definitions that are part of this standard start with the prefix "Qto_" and continue with the English words in CamelCase naming convention.

For example, as shown in Figure 6, considering the element "Wall", the defined property set are:

Figure 6 – Standard Property Set Definition Reference for Wall Element

A simple example of how the developed IFC updating procedure works is given below, considering a "Rockwool thermo-acoustic insulation panel". Figure 7 shows the data of the IFC (provided by the manufacturer), visible using an online viewer. It can be noticed that only the standardised data according to the reference of the IFC specification of BuildingSMART International are present.

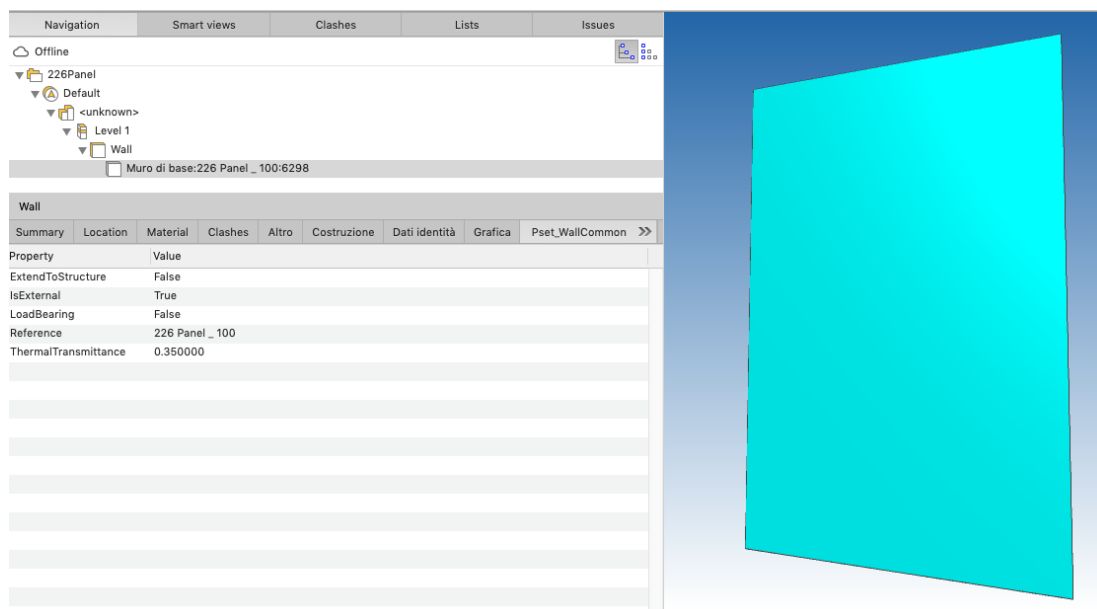Figure 7 - Rockwool thermo-acoustic insulation panel IFC file, standard property set defined by BuildingSMART International

The Figure 8, Figure 9 and Figure 10 show the procedure of entering the missing data into the database, with the compilation of the energy and sustainability data packages (LCA and LCC) respectively.

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Figure 8 – Energy Performance data filling

Figure 9 - LCA data filling

Figure 10 – LCC data filling

As shown in Figure 11, once the additional data has been introduced in the several packages, the "Reload Enhanced IFC" function appears in blue in the "File & Download" section, which allows to update the original IFC file adding the data entered in the property set. The IFC file thus generated is added to the list of documents available for download, with a reference to the date and time of last modification.
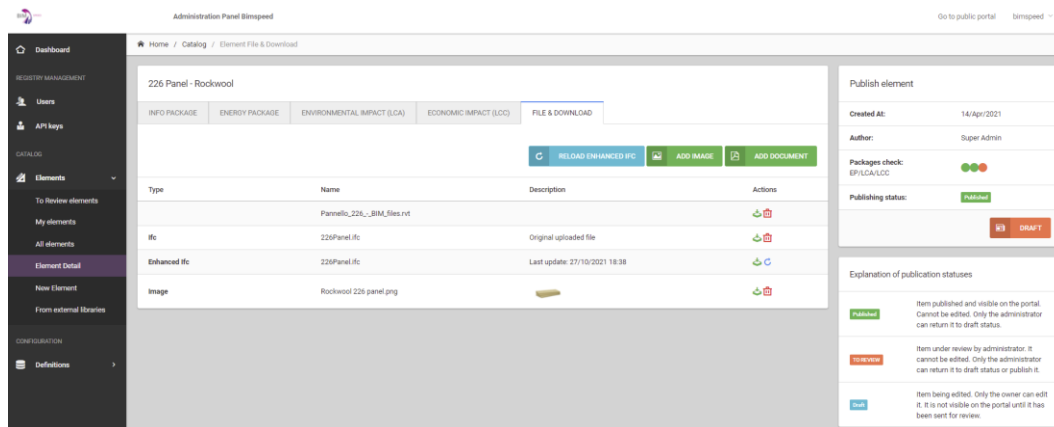
Figure 11 – Enhanced IFC file generation

As shown in Figure 12, Figure 13 and Figure 14, by using an online viewer to open the enhanced file, it is easy to appreciate how the data added to the packages are now present also in the property set of the new IFC.
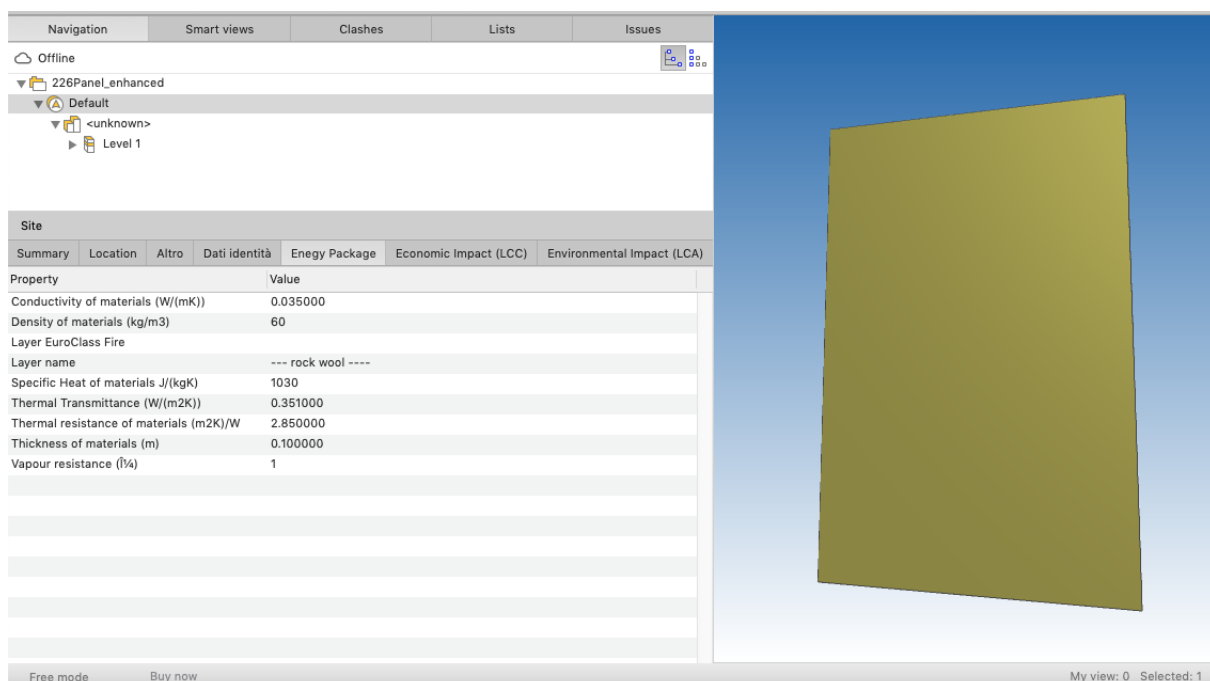
Figure 12 – Visualization of the enhanced IFC file, Energy Performance data
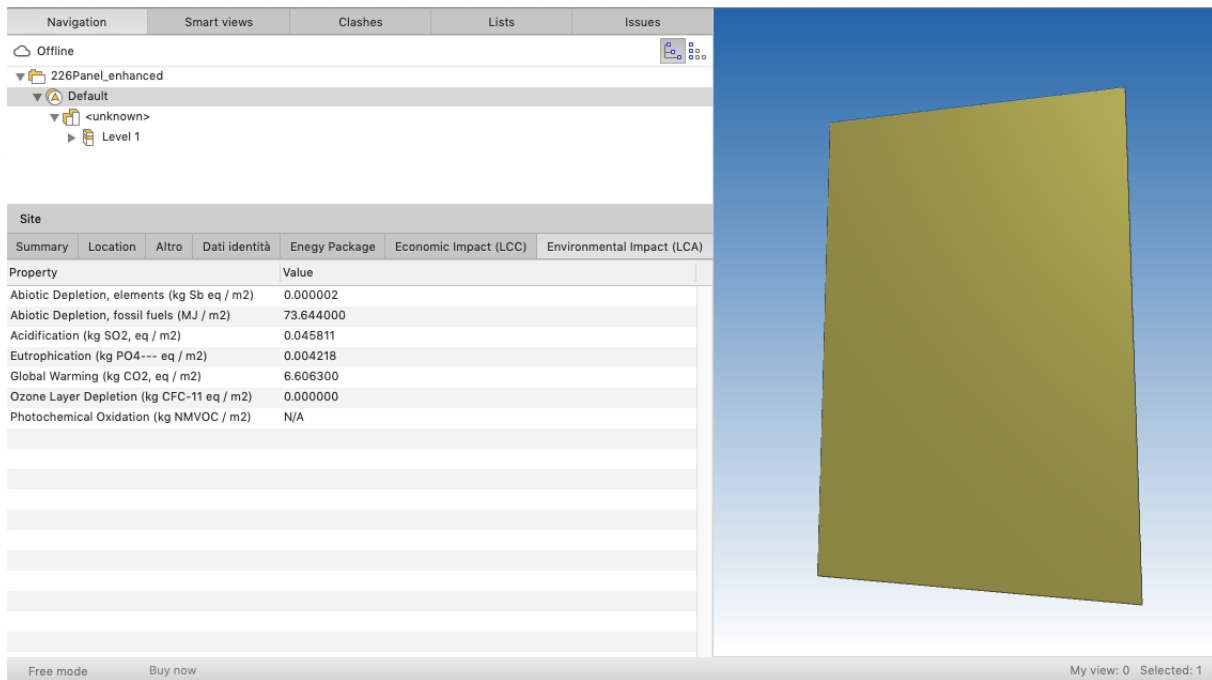
Figure 13 – Visualization of the enhanced IFC file, LCA data
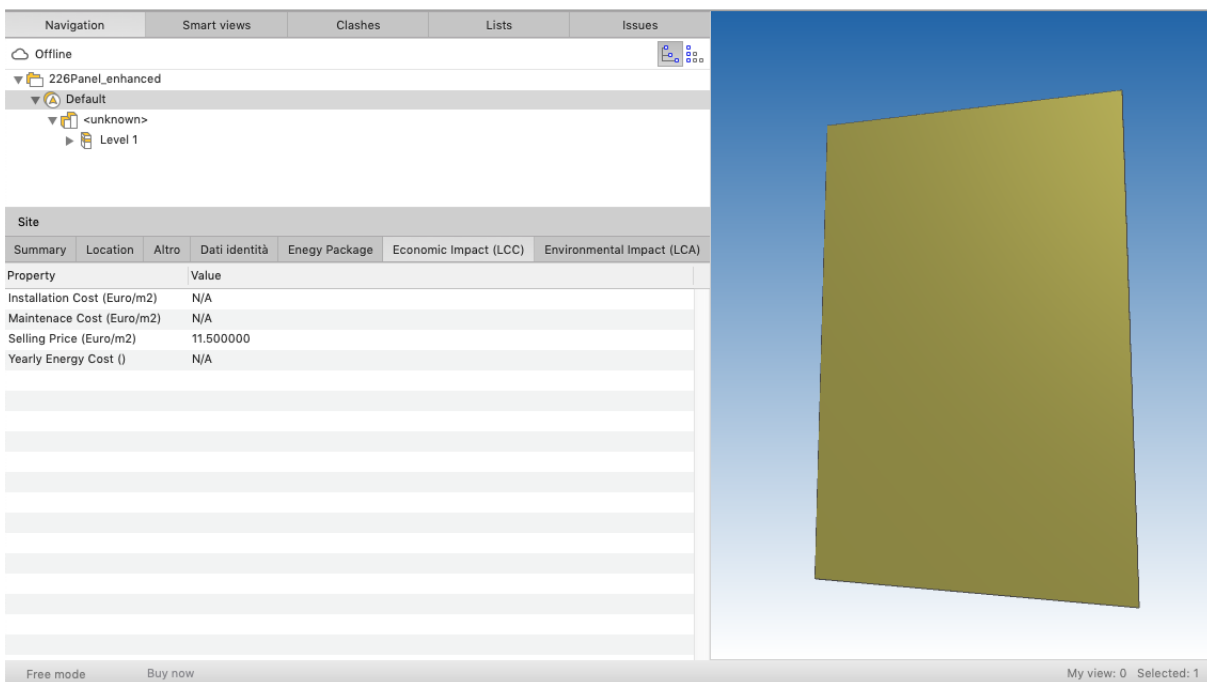
Figure 14 – Visualization of the enhanced IFC file, LCC data

3.2 Public Web Interface

The database communicates with a web portal website providing a graphical interface, helpful for generic users who want to search and visualize renovation BIM objects. To use all the functions of the web portal, users must be registered, allowing them not only to search and view BIM objects, but also to download them and, possibly, to upload new ones. The possibility to upload new renovation objects is strictly bound to a data quality check. Indeed, in order to be included in the BIMSPEED library, the datasets need to include the required parameters, which must be consistent with the other library objects in terms of parameter typologies and related unit of measures. In this regards, each new element created by external users or by partners, will undergo a review phase which allows the element to be published if it meets the fixed requirements. The basic requirement for publication is the compilation of at least the energy data. The details of this process are presented in the following, in the paragraph "User Web Interface" dedicated to the actions that a registered and logged in user can perform. Figure 15a and Figure 15b illustrates the first part of the website's homepage, where a synthetic description of the project's purpose and the different functionality that user can find is provided.
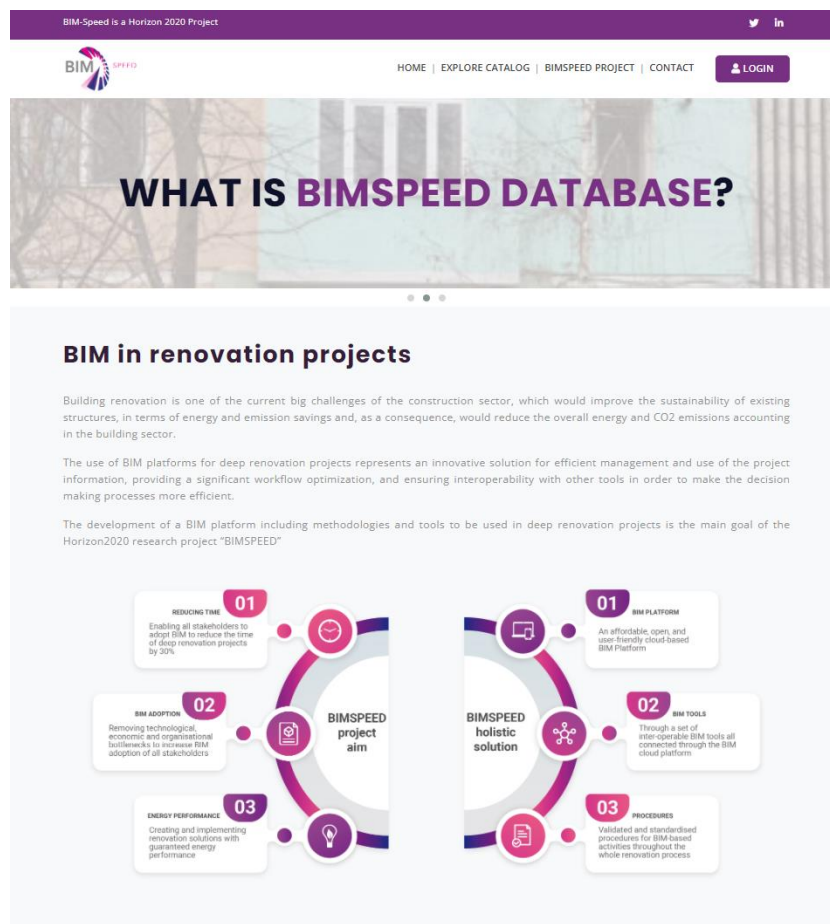
Figure 15a – Homepage of the web interface

The BIMSPEED database

Within the EU-Funded Research Project BIMSPEED (H2020-GA 820553), a BIM Object Database has been developed as a support for the renovation design. The database lists the components mostly used in renovation projects, enclosing a set of general and specific properties, which can be used in a BIM environment for running energy performance and sustainability assessments.

The BIMSPEED database is composed of a number of materials and components used for deep renovation of buildings. Building renovation components are defined as the building elements that can provide a contribution to the reduction of the overall energy consumption and/or to an enhanced environmental and economic sustainability.

The database collects a set of parameters, which can be divided into two packages: the "info package" and the "software package". In particular, the info package includes the general information, such as the component category, the typology, the application area, and others; whilst the "software package" includes more specific information, i.e. the data needed as support for Energy Performance Assessment, Life-Cycle Assessment (LCA) and Life-Cycle Costing (LCC). Data collected for the Energy Performance Assessment vary considering different components categories.

Figure 15b - Homepage of the web interface

All the elements of the database are present on the website, organized by category, as shown in Figure 16. The list of all the categories is the following: materials, panel/roll, façade, ventilated façade, ventilated roof, windows/doors, water heating system, air/water conditioning system, small VRF, multisplit, ventilation, DHW. The generic user has the possibility to explore the catalogue of elements by selecting a specific category and, at the same time, to be informed about the latest published elements by a carousel inserted at the end of the web page, as shown in Figure 17.
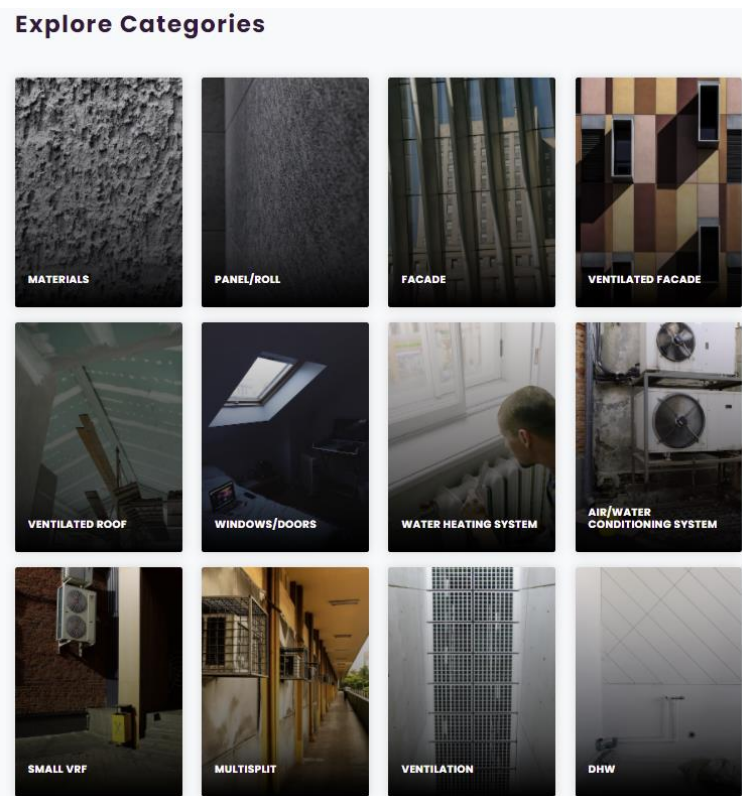
Figure 16 – Web interface: elements categories
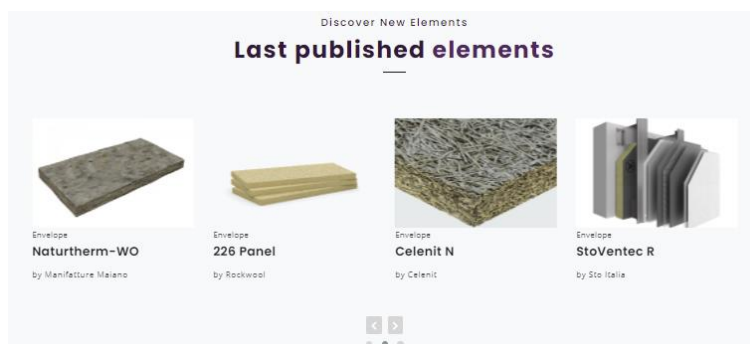
Figure 17 – Web interface: last published elements

As shown in Figure 18, users can also search specific elements thanks to the filter functionalities. By clicking on "explore catalog" in the top bar, the user is redirected to a search page where he/she can use specific filter tools differentiated by Name/Brand/Description, Category, Type and Application Area.
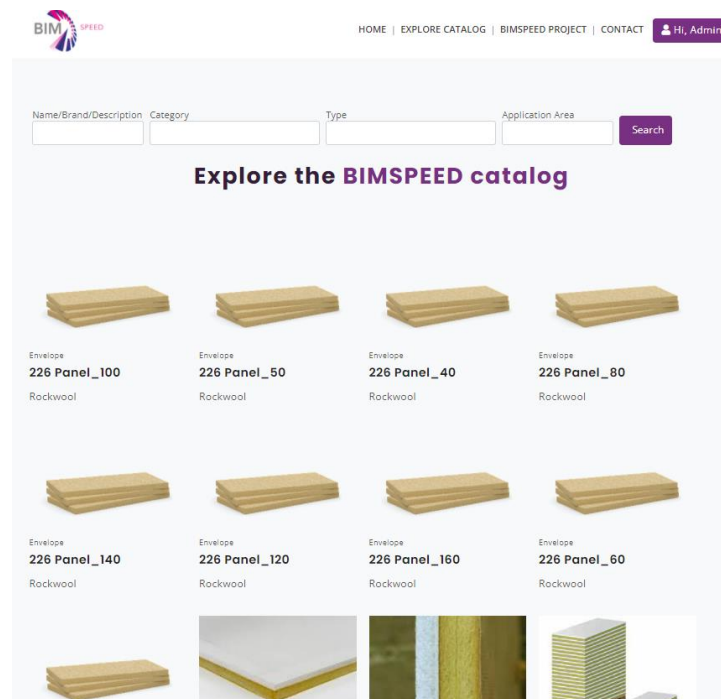
Figure 18 – Explore catalog and searching elements with filters

By selecting a specific product, the user is then addressed to the corresponding sheet, as shown in the Figure 19, where the thermal and acoustic insulation panel "Celenit N" has been selected. All the element sheets are organized as follows. The product name is highlighted, followed by the category, type, application area and a briefly description of the product. Product data reflects the arrangement in packages of the database: the first section contains general info, followed by the energy performance (EPP) and sustainability (LCA/LCC) packages. The website also has a green marker to indicate the degree of completeness of the single packages.

Finally, the dataset is completed with a picture of the product and a section dedicated to the download of the IFC file, accessible only by registered users.

Figure 19 – Detail of the thermal and acoustic insulation panel "Celenit N"

3.3 User Web Interface

A user who does not want to limit his experience to just browsing the website, but would also have the possibility of downloading the documents available for the various elements or enriching the database with new elements, must be registered. The registration process is standard and involves entering some personal data (first name, last name, email and password) and accepting the privacy and marketing policy. After entering these data, the user receives a confirmation email with a verification link; the user is then redirected to the portal to log in, as shown in Figure 20.
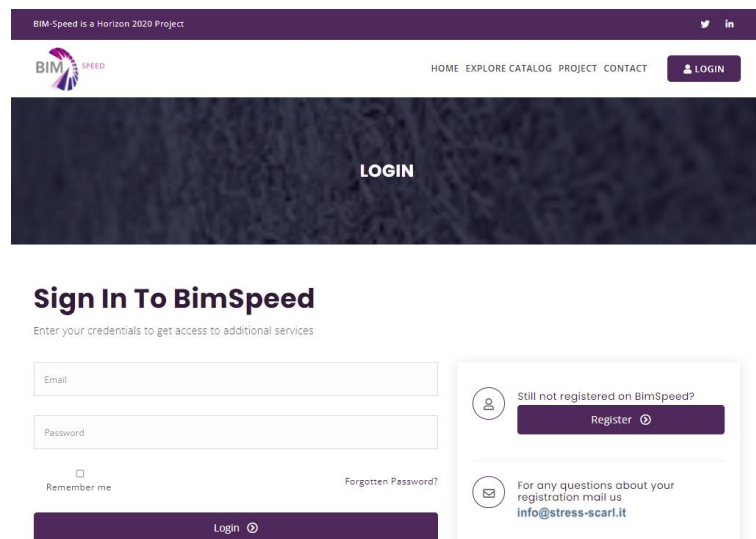
Figure 20 – BIMSPEED Database registration and login page

After logging in, the user enters his personal home page shown in Figure 21, where the possible actions are highlighted: add a new element, view and manage the elements he/she created, explore the general catalogue.
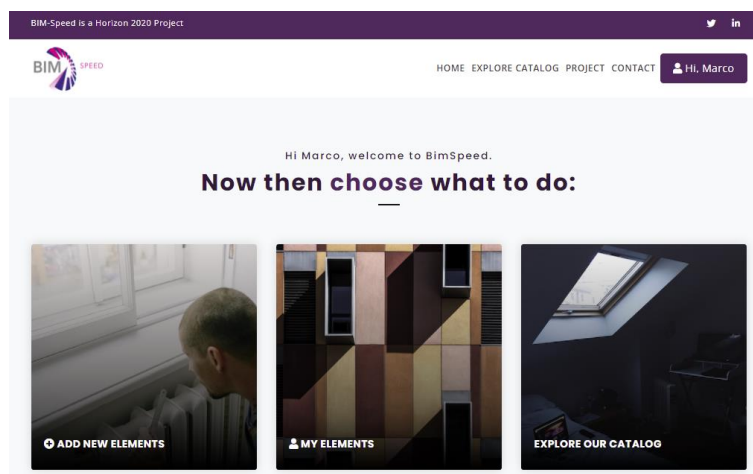
Figure 21 – Personal home page for logged user

The Figure 22 shows the two procedures available for creating a new element: (i) manual, through which the user enters the data required to fill the different packages and (ii) automatic, where the item data is entered automatically by uploading an IFC file (the data entered are those present in the IFC file).
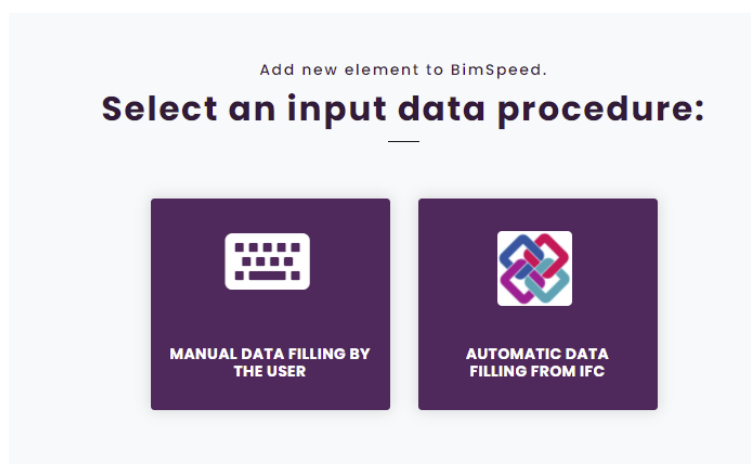
Figure 22 – Manual and automatic procedures to create a new element

Both approaches of creating a new element allow, by means of a wizard procedure shown in Figure 23, to fill in the various sections corresponding to the different packages (Info, Energy Performance, LCA, LCC, File & Download). The only difference is that choosing the automatic procedure, the first point of the wizard corresponds to loading the IFC file, followed by an automatic entering of its data. The procedure then asks the user to integrate the missing data manually, if necessary.
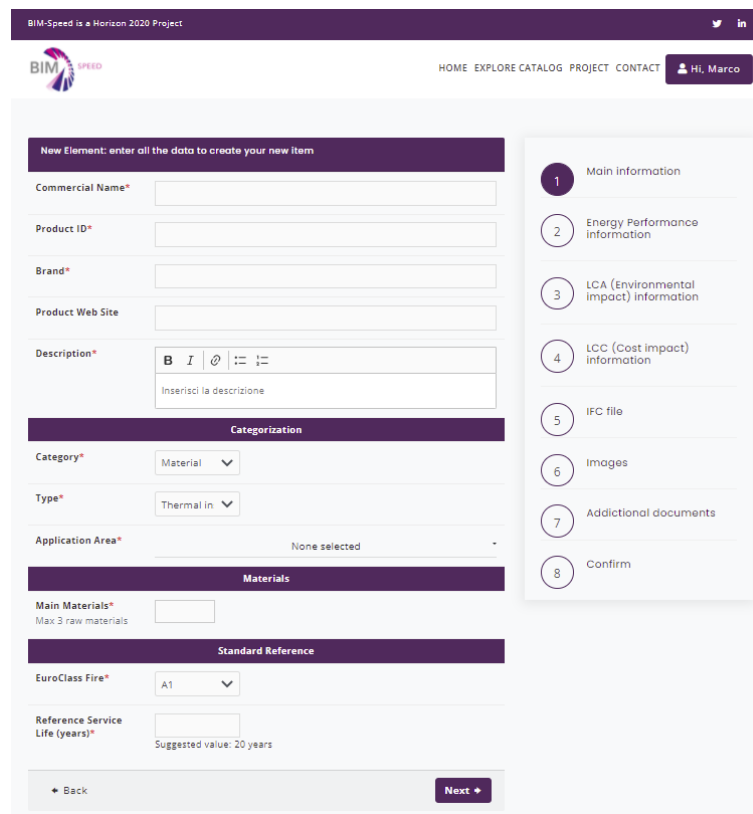
Figure 23 – The wizard procedure to create a new element

At the end of the compilation, the user can save the element which is automatically inserted as a draft in the "My Elements" section. At this point the user can, if necessary, either edit the created element or, if already complete, send it to the administrators for the review phase. At this point the created element can no longer be edited. The administrators, after checking the completeness of the data entered, can decide whether to publish the element or, if the data entered are not sufficient, to return the element in the "draft" status to allow changes to be made by the user. Moreover, if the user needs to edit an element that has already been published or is still under review status, he/she can request its "unblocking" by using the specific request function. Once the request has been send, it will be visible to administrators in the dashboard of the administrative structure.
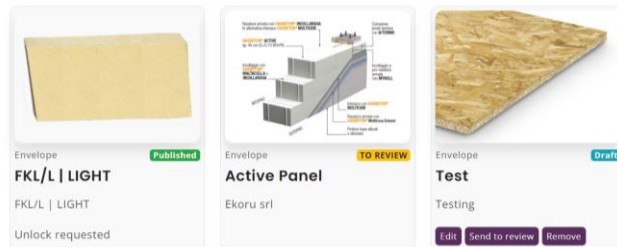
Figure 24 – "My Elements" section: draft, in review and published personal elements

4. Connection with external services

4.1 Communication system with existing libraries

The boundaries of the described database can be enlarged in order to add new inputs and outputs. Several BIM object libraries are available online. Some of the most important ones are BIMObject®, MEP Content, BIM Store, National BIM Library, BIMReL, and others. Such existing libraries collect a big amount of data and BIM files. Nevertheless, the data are not homogeneous and can be used for different aims, according to the parameters included in the BIM file. In order to take advantage of these existing libraries and to add some of them in the BIMSPEED library, it is necessary to make them consistent with the database structure, i.e. to include the BIMSpeed library parameters in terms of typology and unit of measure. To this aim, a data quality check is performed, which finally states if the object can or cannot be included in the library and, if not, which data need to be manual added or modified. It is important to underline that in that case, the entry of these data is not made freely, but it must follow the coding of the BIMSPEED database presented in Chapter 2 - "Definition of relevant parameters". The procedure has been successfully tested on the Italian platform BIMReL and meanwhile an agreement with other platforms on issues related to privacy and copyright is being defined.

4.2 Development of API

To connect the database with external services, such as tools or software used by the different partners, ad hoc APIs have been developed. Figure 25 shows the web page where the partner, authorized with a personal key, can find all the available APIs and their documentation. Currently the system allows to:

- download the database elements (individually or in groups);
- download all the elements of a specific category;
- download all the elements of a specific type;
- download all the elements corresponding to specific research fields.
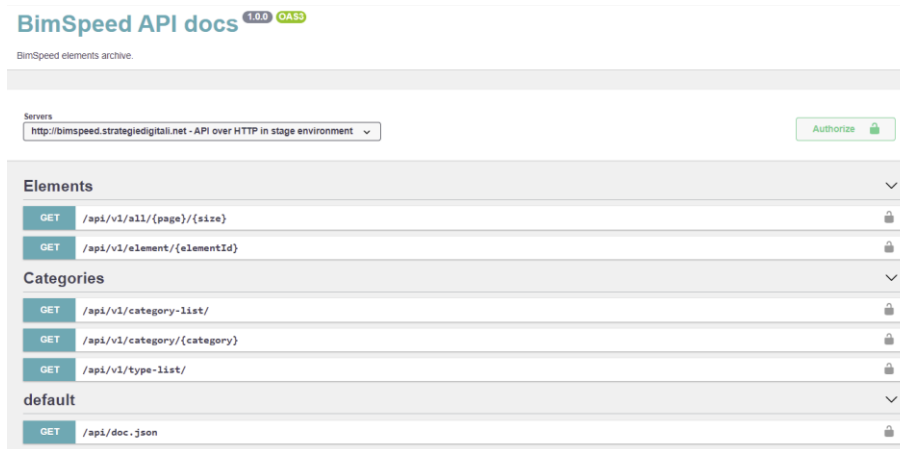
Figure 25 – BIMSPEED APIs

In particular:

- /api/v1/all   --> Returns an array of elements by paging over the entire database
- /api/v1/element   --> Returns the detail of a single element
- /api/v1/category-list   --> Returns the array of the categories surveyed within the database
- /api/v1/type-list   --> Returns the array of the types surveyed inside the database
- /api/v1/category   --> Returns an array of elements belonging to the requested category
- /api/v1/type   --> Returns an array of elements belonging to the requested type
- /api/v1/search   --> Returns an array of elements after a textual search in specific fields

The complete APIs documentation is available in Appendix A of this report.

In addition, APIs able to extrapolate specific elements from the database using a filter criterion based on parameters such as thermal transmittance, fire rating and geometric dimensions have been created. This API will be directly used with an external tool, named "model checker" developed by DEMO that checks all the elements within a BIM model and, if there is a need to replace some of them with better performing elements, can search and select the best element directly from the BIMSPEED database.

4.3 Model Checker DEMO

DEMO Consultants' Model Checker allows specifying a set of rules and conditions with which a model should comply. Upon evaluating a BIM-model with the ruleset a compliant/non-compliant evaluation result is provided for the model. This is then subdivided into similar conclusions on an element-level. This means that individual elements can be checked for compliance with rules, regulations, comfort, aesthetics or other criteria.
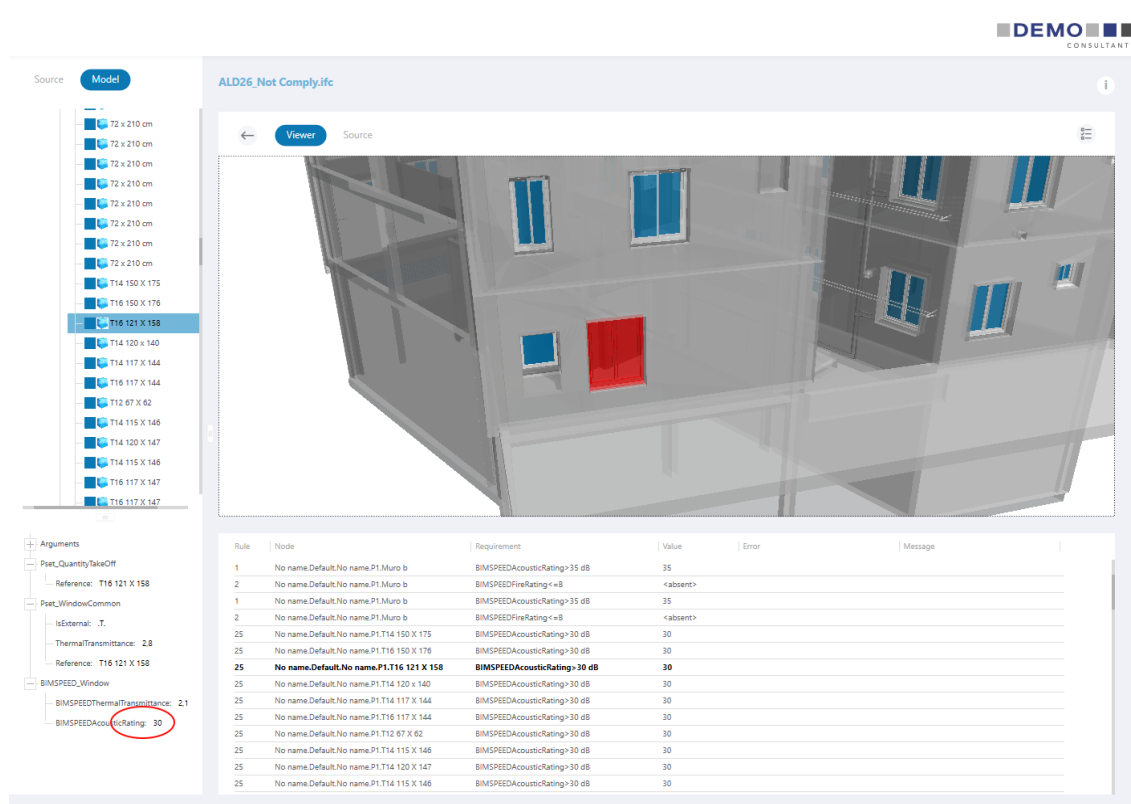
Upon finding elements that do not comply with one of more rules the intent is to offer alternatives for components to replace them with. For this purpose a connection is made to the BIM-Speed

database using the REST API. A targeted search of its population is performed using the endpoints provided. If the API supports the specific search criteria required to find a matching element (for example an acoustic rating larger than 30dB) this search function is used. Otherwise the Model Checker falls back on a more generic endpoint which downloads a large part of the population to perform a local search to find the best matches.

Finally, the list of remaining matches is sorted by ascending cost and/or other sorting criteria. The top result is offered to the user as a sufficiently compliant alternative for the current non-compliant element. An example of non-compliant acoustic rating in the Model Checker is shown in Figure 26.

Figure 26 – A window with a non-compliant acoustic rating in the Model Checker

5. Conclusions

This document presents the main features of the developed BIMSPEED database. It represents the back office management platform for project partners, who can easily administer a continuously updated dataset of renovation elements.

In parallel, a public web portal has been developed that represents the front office version of the database, designed to be used by general users interested in building renovation issues. Users can simply browse the website or decide to register in order to access to the download and editing features of the several elements. The database is constantly updated using input from partners, external libraries or registered external users and, through ad hoc developed APIs, it will be accessible by external services, i.e. design tools or software, interested in getting access to its data and objects.

Currently the database is populated by about 250 objects divided into different categories. Of these elements about 200 are published on the web portal, while the others are under revision by the administrators or under editing by the partners.

6. References

M. Economidou, J. Laustsen, P. Ruyssevelt, D. Staniszek, D. Strong, S. Zinetti Europe's Buildings Under the Microscope — A Country-by-country Review of the Energy Performance of Buildings. Buildings Performance Institute Europe (BPIE)

EN 13501-1:2019 Fire classification of construction products and building elements -Part 1:Classification using data from reaction to fire tests

EN 15804:2012+A1:2013, Sustainability of construction works -Environmental product declarations -Core rules for the product category of construction products

BIMObject® Library, available at https://www.bimobject.com

MEP Content Library, available at https://www.mepcontent.com

BIM Store Library, available at https://www.bimstore.co/search

NBS National BIM Library, available at https://www.nationalbimlibrary.com

7. Appendix A - API documentation

Document Purpose

The purpose of this document is to illustrate the methods of communication via API of the BimSpeed system.

Definitions, Acronyms, and Abbreviations

The following acronyms are used in this document:

API	Application Programming Interface
BIM	Building Information Modeling

General Technical Information

To take advantage of the API you should keep in mind the following technical features

Type of API

API calls are Rest-like and implement GET and POST verbs.
The calls are read-only on the data in the database.
The response to the API is in Json format.

Authentication and sessions

The API system is stateless, so each call is independent from the others.

It is necessary, however, that the applicant is identified as an authorized user of the system, for this purpose

is implemented a recognition system through ApiKey passed through the header of the Http request

The header for passing keys is **X-AUTH-TOKEN.**

The personal unique ApiKey is visible inside the BimSpe control panel accessible with your credentials.

Endoint

The current development url is as follows:

```
http://bimspeed.strategiedigitali.net/api/v1
```

API Calls

Below is the detail of how the currently available API calls work.

/api/v1/all

Returns an array of elements by paging over the entire database.

Endpoint: `/api/v1/all/{page}/{size}`

Parameters:
- **{page} :** (integer, default 0) current page number, the first page is indicated by 0
- **{size} :** (integer, default 10) number of items per page

Response: Json object with the following structure

```
{

    "count": "123",

    "data" : [ //array of element]

}
```

The response returns a total count of available db elements and a "date" array of the elements selected from the given pagination. See /api/v1/element structure details.

/api/v1/element

Returns the detail of a single element.

Endpoint: `/api/v1/element/{elementId}`

Parameters:

   {elementId} : (string, Uuid format) Element's id

Response: Json object with the following structure

```
{
  "id":                                        "aa2178cb-9784-4906-9434-2e3507eefe46",
  "status":                                                            "published",
  "categoryId":                                                               "2",
  "category":                                                          "Panel/Roll",
  "categoryGroup":                                                      "Envelope",
  "typeId":                                                                    "3",
```

```json
  "type":                         "Thermo-acoustic                          insulation",
  "applicationArea":                                                                   {
    "1":                          "External                                     wall",
    "2":                          "Internal                                     wall",
    "4":                                                                        "Roof"
  },
  "name":                             "Celenit                                      N",
  "productId":                        "Celenit                                   N_20",
  "description": "Thermal  and  acoustic  insulation  panel,  in  spruce  wood  wool  with
Portland                                                                    cement.",
  "brand":                                                                   "Celenit",
  "website":                    "https://www.celenit.com/it/celenit-n.php",
  "length":                                                                     "0.000",
  "width":                                                                      "0.600",
  "depth":                                                                      "0.020",
  "euroClassFire":                    "B-s1,                                        d0",
  "referenceServiceLife":                                                           "0",
  "energyClass":                                                                  null,
  "standardReference":                                                            null,
  "mainMaterials":                                                                    [
    "Spruce                        wood                                          wool"
  ],
  "eppMaterial":                                                                      {
    "thermalTransmittance":                                                    "3.333",
    "layers":                                                                        [
      {
        "layerName":              "Spruce                wood                   wool",
        "layerPosition":                                                             1,
        "vapourResistance":                                                      "5.0",
        "conductivity":                                                        "0.065",
        "thermalResistance":                                                   "0.300",
        "thickness":                                                           "0.020",
        "density":                                                                 500,
        "specificHeat":                                                           1810,
```

```
        "euroClassFire":                                "B-s1,                      d0"
    }
  ]
},
"lcc":                                                                              {
  "functionalUnit":                                                             "-",
  "sellingPrice":                                                           "14.48",
  "sellingPriceUnit":                                                           "-",
  "constructionInstallationCost":                                              null,
  "constructionInstallationCostUnit":                                           "-",
  "maintenanceCost":                                                           null,
  "maintenanceCostUnit":                                                        "-",
  "yearlyEnergyCost":                                                          null,
  "yearlyEnergyCostUnit":                                                       null
},
"lca":                                                                              {
  "functionalUnit":                                                             "-",
  "globalWarming":                                                         "13.806",
  "acidification":                                                       "0.037238",
  "eutrophication":                                                      "0.007032",
  "ozoneLayerDepletion":                                              "1.15267146E-6",
  "photochemicalOxidation":                                                    null,
  "abioticDepletionElement":                                          "0.0053905131",
  "abioticDepletionFossilFuel":                                               "107"
},
"attachments":                                                                     {}
}
```

The response reports the entire object data structured according to the object category.

The sub-sections LCC and LCA are independent of the object category or type and all have the same structure. There are the following sub-objects for the Energy Package data based on element category, as shown below:

- Category **Material, Panel/Roll, Facade e Roof** have a field named **eppMaterial**
- Category **Windows/Door,** field **eppWindow**
- Category **Water Heating,** field **eppHvacWaterHeatingl**
- Category **SmallVrf e Multisplit,** field **eppHvacSmallVrf**
- Category **Ventilation,** field **eppHvacVentilation**
- Category **DHV,** field **eppHvacD**

/api/v1/category-list

It returns the array of the categories surveyed within the database.

Endpoint: `/api/v1/category-list`

Parameters: none

Response: Array of Json objects with the following structure

```
[
  {
    "id":                                                              1,
    "name":                                                     "Material",
    "group":                                                    "Envelope"
  }
]
```

The object is composed of the following values:
- **id:** Unique category identifier in the system
- **name:** Readable category identification label
- **group:** Category grouping, possible values are: Envelope, HVAC, DHW

/api/v1/type-list

It returns the array of the types surveyed inside the database.

Endpoint: `/api/v1/type-list`

Parameters: none

Risposta: Array of Json objects with the following structure

```
[
  {
    "id":                                                              1,
    "name":                          "Thermal                  insulation"
  }
]
```

L'oggetto è composto dai seguenti valori:
- **id:** Unique category identifier in the system
- **name:** Readable category identification label

/api/v1/category

Returns an array of elements belonging to the requested category.

Endpoint: `/api/v1/category/{category}`

Parameters:

- **{category}:** (string) Both the **id** and the **name** of the category of interest can be used. In case of non-existent category an error is returned

    Response: Json objects with the following structure

```
{
    "data" : [ //array di elementi]
}
```

See /api/v1/element structure details.

/api/v1/type

Returns an array of elements belonging to the requested type.

Endpoint: `/api/v1/type/{type}`

Parameters:

- **{type}:** (string) Both the **id** and the **name** of the type of interest can be used. In case of a non-existing category an error is returned
    Response: Json objects with the following structure

```
{
    "data" : [ //array di elementi]
}
```

See /api/v1/element structure details.

/api/v1/search

Returns an array of elements after a textual search in specific fields.

The search is of partial type, so it returns all elements where the searched word is present even in longer text.

Endpoint: `/api/v1/search/{searchTerm}`

Parameters:

- **{searchTerm} :** (string) String to search in the following fields: ProductId, Name, Description

   Response: Json objects with the following structure

```
{
    "data" : [ //array di elementi]
}
```

See /api/v1/element structure details.