BIMERR
RENOVATION 4.0

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DELIVERABLE D7.7
Urban Planning Module 1

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FER	Ferrovial Agroman S.A	Spain

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AUTHORS LIST

Leading Author (Editor)			
Surname	**First Name**	**Beneficiary**	**Contact email**
Bergmayr	Julia	Xylem	bergmayr@xylem.tech
Co-authors (in alphabetic order)			
#	**Surname**	**First Name**	**Beneficiary**	**Contact email**
1	Fenz	Stefan	Xylem	fenz@xylem.tech
2	Giannakis	Giorgos	Hypertech	g.giannakis@hypertech.gr
3	Heurix	Johannes	Xylem	heurix@xylem.tech
4	Manesis	Fotis	CONKAT	fmanesis@konkat.gr
5	Neubauer	Thomas	Xylem	neubauer@xylem.tech
6	Papapolyzos	Thomas	Hypertech	thomas@hypertech.gr
7	Wachter	Christoph	Xylem	wachter@xylem.tech
8	Wellner	Florian	Xylem	wellner@xylem.tech

REVIEWERS LIST

List of Reviewers (in alphabetic order)			
#	**Surname**	**First Name**	**Beneficiary**	**Contact email**
1	Bosché	Frédéric	UEDIN	f.bosche@ed.ac.uk
2	Vafeiadis	George	UBI	gvafeiadis@ubitech.eu

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ACRONYMS

Acronym	Meaning
BEP	Building Energy Performance
BIF	BIMERR Interoperability Framework
BIMERR	BIM-based holistic tools for Energy-driven Renovation of existing Residences
IFC	Industry Foundation Classes
KPI	Key Performance Indicator
RenoDSS	BIMERR Renovation Decision Support System

EXECUTIVE SUMMARY

This document describes the BIMERR Deliverable D7.7 "Urban Planning Module 1" demonstrator and concludes the first iteration of the development activities in T7.4 "Urban Planning module". This first release of the BIMERR Urban Planning module provides the geographical perspective of the building under renovation and its surrounding buildings, detailed information about energy production/consumption patterns and how the building interacts with utility networks in its vicinity.

The BIMERR Urban Planning module is based on state-of-the-art technologies and three layers: (i) the Presentation Layer which visualizes the energy flows and allows users to set their preferred data sources for energy production/consumption profiles of surrounding buildings. The user interface is built upon Angular, Typescript, and NGRX Entity/Store and uses Leaflet for visualizing the map view, (ii) the Business Logic Layer which calculates the KPIs and energy flows based on the stored production/consumption profiles of the renovation project and the surrounding buildings. This layer is based on Spring Boot and OpenJDK, and (iii) the Data Layer utilizes PostgreSQL to store consumption/production profile data of the renovation project and surrounding buildings for faster access at later usage.

In the second release of the BIMERR Urban Planning module we will (i) integrate energy networks data and visualize energy networks based on sample data, (ii) convert sample network data from pre-validation and validation sites to CityGML network representation, (iii) implement CityGML export functionality to ensure that available network, energy mix and energy consumption/production data can be exported to a standardized data format, (iv) visualize energy flows between renovation project and surrounding buildings, and (v) visualize excess energy on the district level.

1. INTRODUCTION

The BIMERR Urban Planning provides the geographical perspective of the building under renovation (renovation project) and its surrounding buildings based on the geolocation extracted from the building's IFC[1] file. The map view allows to set energy production and consumption profiles of surrounding buildings (see Section 2.6). Based on these profiles the Urban Planning module calculates electrical energy excess profiles of the surrounding buildings to estimate how much electrical energy excess is available to the building (see KPI EN18 in Section 2.8). Based on the BIMERR BEP (Building energy performance) module (D7.5) output the Urban Planning module estimates how much of the energy generated in the building can be exported to the district (see KPI EN19 in Section 2.8).

1.1 SCOPE AND OBJECTIVES OF THE DELIVERABLE

D7.7 "Urban Planning Module 1" reports the development activities in the context of Task T7.4 "Urban Planning module" of WP7 "Renovation Decision Support System". It documents the first version of the BIMERR Urban Planning module.

The objective of this document is to give an overview and documentation of the first stable release of the BIMERR Urban Planning module and describe:

- Functionalities of the BIMERR Urban Planning module
- Technology stack
- Communication with the BIMERR data management module
- Assumptions and restrictions of the first and initial release
- Installation instructions
- Usage walkthroughs
- Licensing

The BIMERR Urban Planning module will be delivered in two releases, in M20 and M30. The second release of the BIMERR Urban Planning module will be built on the outcome of this deliverable and will contain all planned functionalities and enhancements based on the feedback of the pre-validation and validation activities (WP8).

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[1] https://standards.buildingsmart.org/IFC/RELEASE/IFC4/ADD2_TC1/HTML/, last access: 24.08.2020

1.2 RELATION TO OTHER TASKS/DELIVERABLES

T7.4 "Urban Planning module" and therefore D7.7 "Urban Planning Module 1" are related to the following BIMERR deliverables:

- D3.1 "Stakeholder requirements for the BIMERR system": the business scenarios, use cases, and system requirements described in D3.1 are the basis for the development of the BIMERR Urban Planning module.
- D3.3 "BIMERR evaluation methodology": energy KPIs related to Urban Planning described in D3.3 are calculated by the Urban Planning module.
- D3.5 "BIMERR system architecture first version": the first version of the BIMERR architecture provided an overview on the BIMERR components, how they communicate to each other and how the BIMERR Urban Planning module is embedded in the BIMERR Renovation Support Tools.
- Functionalities that are introduced in this deliverable will be integrated into the Renovation Decision Support System (RenoDSS) developed in T7.5.
- T8.1 "External Information Availability and Sourcing": ensures that energy network and surrounding building data relevant for pre-validation and validation sites are available.

1.3 STRUCTURE OF THE DOCUMENT

Section 1 describes the scope/objectives of the deliverable and its relations to other tasks and deliverables.

Section 2 gives an overview of the BIMERR Urban Planning module, its architecture, functionality, calculated KPIs, technology stack, assumptions, restrictions, installation instructions and licensing.

Section 3 provides an end-to-end walkthrough to show the functionalities on an example building.

Section 4 outlines the research and development plans for the second iteration of the BIMERR Urban Planning module due in M30.

2. BIMERR Urban Planning module

2.1 Overview

The BIMERR Urban Planning module provides the geographical perspective of the building under renovation and its surrounding buildings, detailed information about energy production/consumption patterns and how the building interacts with utility networks in its vicinity.

The first version of the BIMERR Urban Planning module is embedded in BIMERR RenoDSS and available at: https://renodss.xylem-technologies.com/ [2]

2.2 Architecture

Based on the BIMERR architecture (D3.5), Figure 1 shows the architecture of RenoDSS and its modules.

The main aim of RenoDSS is to put forward an intuitive and easy-to-use interface that illustrates the renovation options, evaluates their impact on the building performance and guides the user through various alternatives towards the optimal choice for given boundary constraints (such as size of intervention, budget, target energy savings, etc.). RenoDSS will offer to the user a renovation configurator that will allow her to explore alternative renovation interventions.

RenoDSS communicates via the RenoDSS Data Management Module with the BIMERR Urban Planning module. The Data Management Module sends the IFC file and the BEP module's output to the Urban Planning module, which returns the district energy flow KPIs, visualizes the building and its surrounding on a map, provides tools to enter energy production/consumption patterns of surrounding buildings and generates the CityGML export containing relevant building and energy network data.

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[2] For security reasons the access to RenoDSS is restricted to authorized IP addresses. Please send an email to support@xylem-technologies.com to request access to RenoDSS.
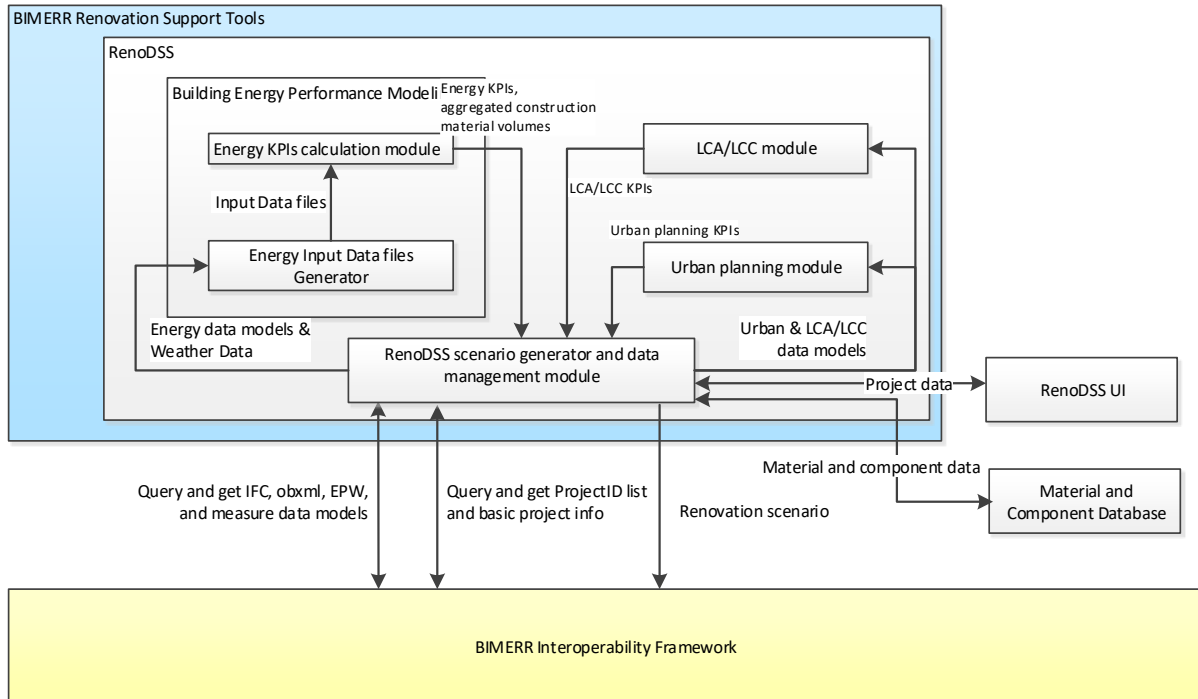
Figure 1: Architecture of the BIMERR Renovation Support Tools

2.3 PROVISION OF DATA VIA AN INTEGRATION FRAMEWORK

RenoDSS and the Urban Planning module are intended to be integrated with the BIMERR Interoperability Framework (BIF) by its second release that is expected on M30. The RenoDSS Data Management module will be responsible for querying the IFC file from the BIF and provide it together with the BEP module's output to the Urban Planning module. The calculated KPIs of the final renovation scenarios are provided by the RenoDSS Data Management module back to the BIF.

2.4 DATA MODEL

The main goal of the urban planning module is to calculate and visualize energy data in the district of the renovation project building. Therefore, the data model (see Figure 2) builds around 3 core entities that represent the renovation building, its surrounding buildings and the load profiles associated to buildings in the district.

The renovation project building itself is persisted in table *glb_renovation_project* which holds basic data about the project such as geographic location, floor area, name and region of the site as well as additional data needed for the urban planning module including annual energy consumption and

production as well as excess production of the project (EN19 – see Chapter 2.8) and excess production of the district surrounding the project (EN18 – see Chapter 2.8).

The surrounding buildings are stored in table *prj_building* in association to the renovation project building, holding the same values for each surrounding building (geographical location, name, region, annual energy production/consumption).

Usage type shares associated to buildings are persisted in table *prj_usage_type*, with reference to the usage type provided by the admin and the percentage of this usage type in the building as well as the reference to the building.
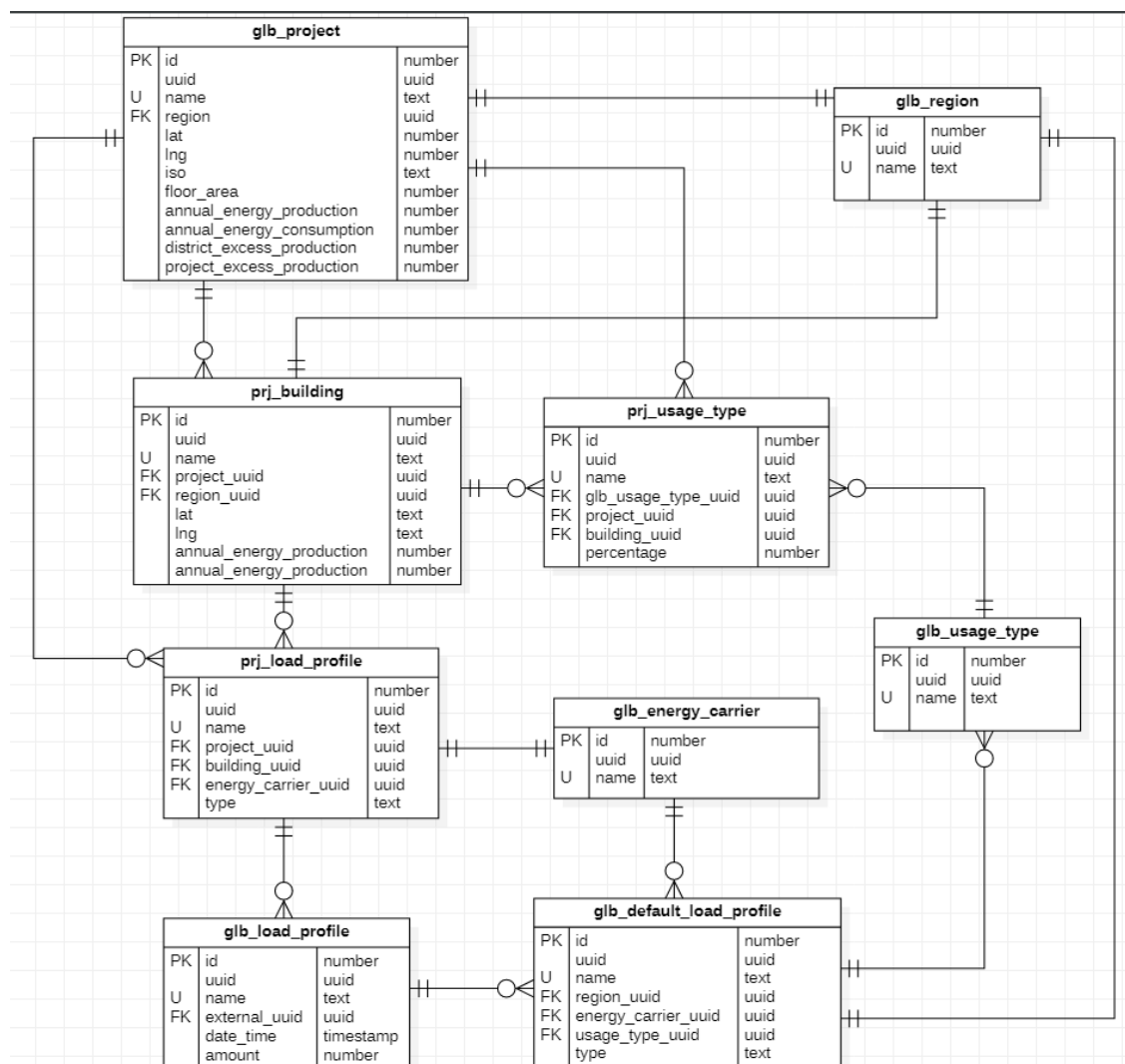

Figure 2: data model for Urban Planning module

The third main entity is the load profile which is provided by the user and stored in 3 different tables according to their associated entity. The table *glb_default_load_profile* holds information about

default load profiles for a specific energy carrier, usage type and region provided by users associated to the admin role. The table *prj_load_profile* holds values about profiles created for a specific building and with values for energy carrier and type (consumption/production) as well as a reference to the building it is associated to. The third table (*glb_load_profile*) is where the actual values of the uploaded profiles are stored. It consists of 3 columns for storing timestamp and value as well as the external id of the profile these values belong to.

Other entities persisted include the usage types and regions provided by the admin which are persisted in tables *glb_usage_type* and *glb_region* as well as a list of energy carriers (*glb_energy_carrier*).

2.5   VISUALIZE RENOVATION PROJECT AND SURROUNDING BUILDINGS

The Urban Planning module uses the LeafletJS[3] framework for map visualization and interaction. This open source framework supports all major browsers and is always used in the latest version available. It offers a variety of features for map interaction and can be extended easily using plugins.

For the building under renovation (renovation project) to be displayed on the map, its coordinates are extracted from the IFC file. To achieve this, the Urban Planning module requests the RenoDSS data management module to send the IFC file to the xbim Toolkit[4] service (runs on the same server as RenoDSS) that is used to load and parse the IFC file. The calculated and extracted data is returned in a JSON[5] structure and the coordinates of the renovation project are stored in the database for further reference. The representation of coordinates in the IFC-File:

IFCSITE('0Ptjw2Nvj20PFzUGaJ5RYG',#42,'Surface:255272',$,$,#22332,#22327,$,.ELEMENT.,(42,21,30, 344238),(-71,-3,-35,-194702),0.0,$,$);

JSON-Output of renovation project site parameters:

{"lat":42.358333333333334, "lng":-71.05972222222222,}

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[3] https://leafletjs.com/, last access: 10.08.2020

[4] https://docs.xbim.net, last access: 10.08.2020

[5] https://www.json.org/, last access: 10.08.2020

By moving the mouse pointer over a pin on the map, general information about the corresponding building such as usage type and annual energy consumption/production are shown (see Figure 3). The next sections describe how this data is entered by the user into the RenoDSS system.

Figure 3: map view of renovation project and surrounding buildings

2.6 SETTING CONSUMPTION AND PRODUCTION PROFILES OF SURROUNDING BUILDINGS VIA GUI

To enter information about buildings surrounding the renovation project the user needs to perform the following steps:

1. By double-clicking a point on the map, the user can set the location of a surrounding building.

2. A form opens in which the user can enter the address of the building and choose which load profile data are available for the building (see Figure 4).
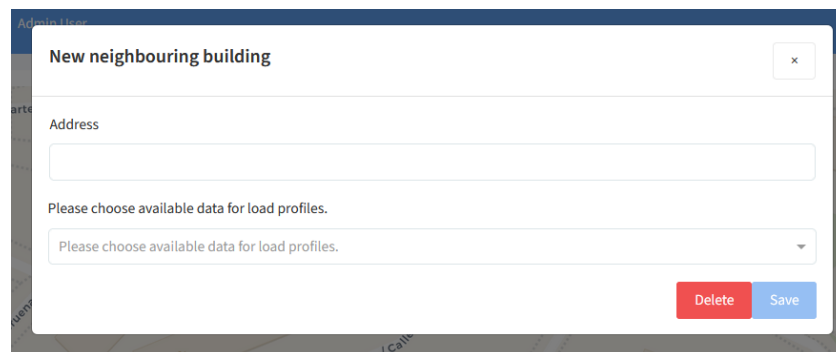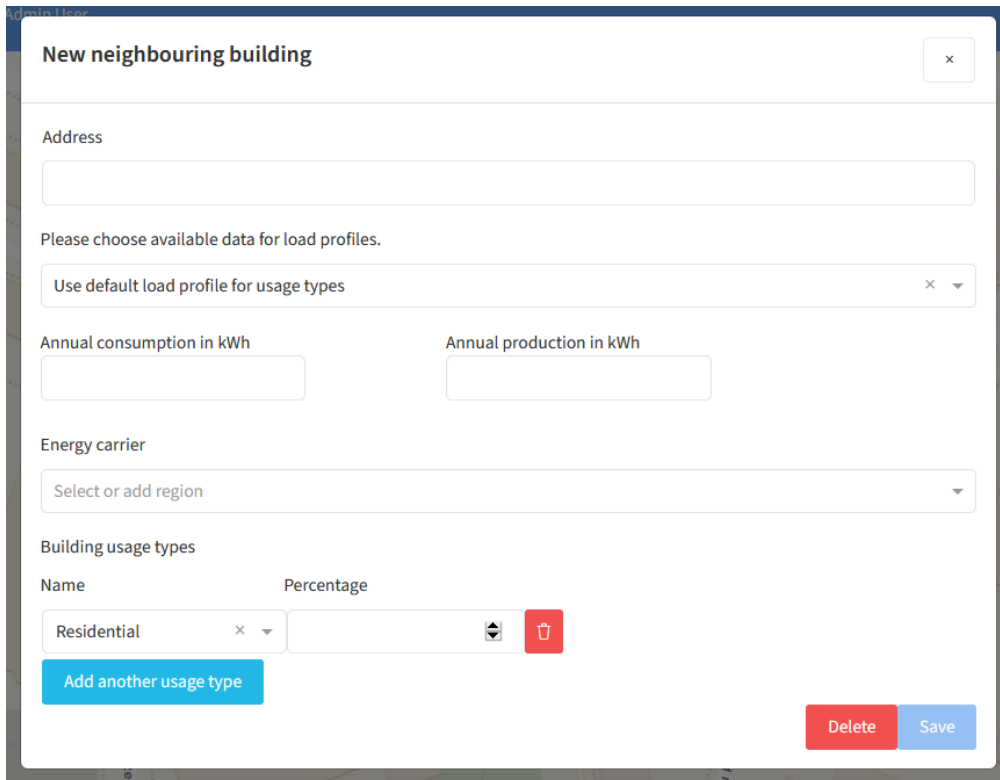

Figure 4: form for entering data of surrounding building

3. If the user chooses to use default load profiles based on the building's usage type, annual consumption/production figures and usage types of the building need to be provided (see Figure 5). Multiple usage type shares, which must sum up to 100%, can be assigned to a single building (e.g., 80% residential, 20% office).

Figure 5: information needed for default load profile usage

In the first version of the Urban Planning module the following usage types are provided[6]:

- residential
- office
- wholesale and retail trade
- hotels and restaurants
- health care
- educational buildings
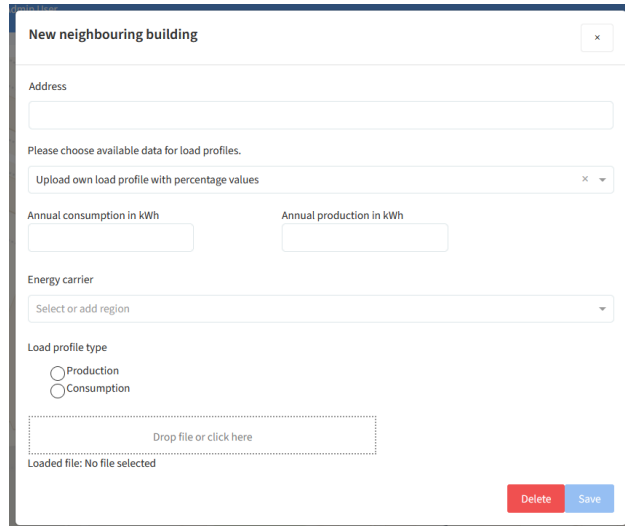
This list can be modified by users associated to the admin role --- see Section "Admin tools for Urban Planning module" for further elaborations about the admin tools for the Urban Planning module.

4. The user can also choose to provide a specific profile if more accurate or real-world data (e.g., smart meter data) is available containing absolute (kWh values for each 15min time interval

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[6] Based on building types used in the EU buildings database: https://ec.europa.eu/energy/eu-buildings-database_en, last access: 10.08.2020

of a year) or relative load profile values (percentage values for each 15min time interval of a year). If relative load profile values are provided, the user must also provide values for annual consumption/production figures. Load profile values can be added by using the upload button or dragging/dropping a CSV formatted file into the provided area (see Figure 6). The profiles must be provided in 15-minute resolution as shown in the sample in Section 2.7.

Figure 6: load profile upload on building creation

5. On saving the building information a new pin is added to the map on the location specified in Step 1.

6. To change or complete the data of a surrounding building the user can always open the modal by clicking the pin on the map.
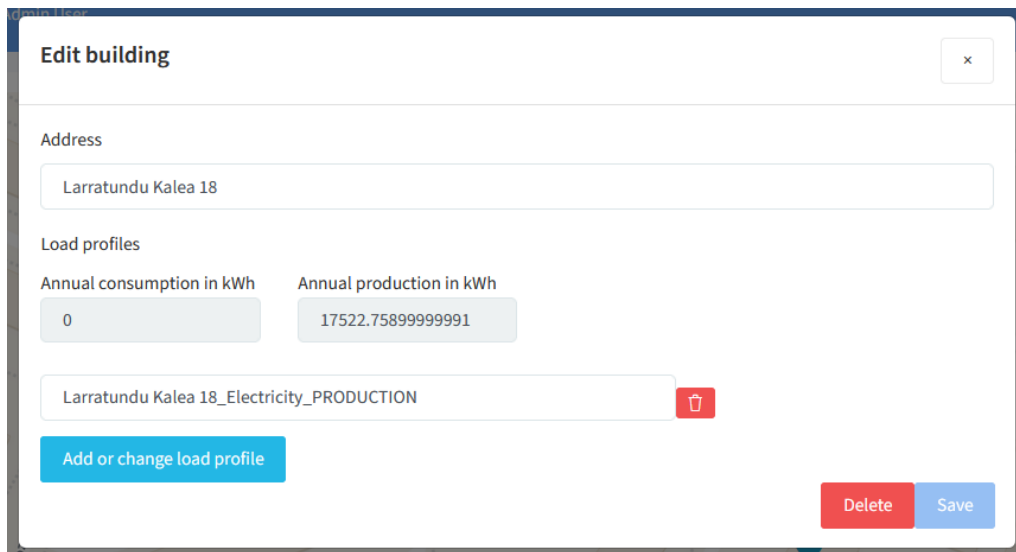
Figure 7: view for altering building data

2.7 ADMIN TOOLS FOR URBAN PLANNING MODULE

The admin tools are used to provide necessary default values for the Urban Planning module as well as for the rest of the application. These values, which can be modified, added, and deleted by users associated to the admin role, include usage types, regions as well as default load profiles. Those new admin tools can be found in the RenoDSS admin view by choosing menu item "General".
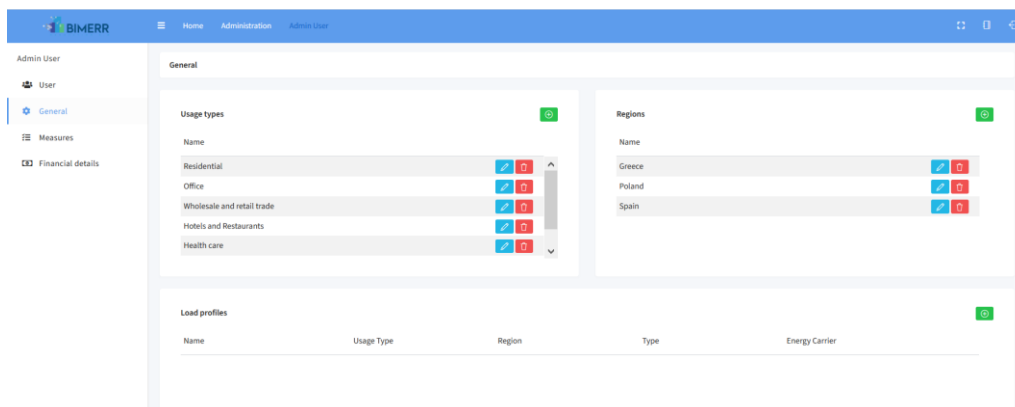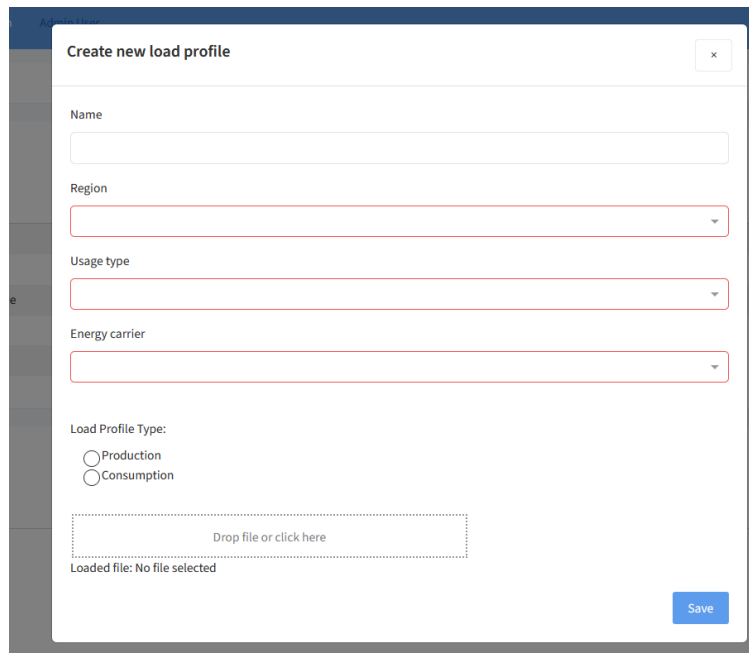
Figure 8: admin view for adding/editing usage types, regions, and load profiles

A new default load profile can be added for a specific region and usage type. The admin user needs to specify a unique name as well as the energy carrier and the type of the profile

(production/consumption). These profiles will then be available when a new surrounding building is created using the form described in Section 2.6.

Figure 9: functionality for uploading a default load profile

CSV files must provide data in a 15-minute resolution with the first column defining the time and the second column defining the load in kWh as shown in the following sample:

2020-01-01T02:45:00	0
2020-01-01T03:00:00	0
2020-01-01T03:15:00	0
2020-01-01T03:30:00	0
2020-01-01T03:45:00	0
2020-01-01T04:00:00	0
2020-01-01T04:15:00	0
2020-01-01T04:30:00	0
2020-01-01T04:45:00	0
2020-01-01T05:00:00	0
2020-01-01T05:15:00	0,00001
2020-01-01T05:30:00	0,00004
2020-01-01T05:45:00	0,00015
2020-01-01T06:00:00	0,00039
2020-01-01T06:15:00	0,00086
2020-01-01T06:30:00	0,00165
2020-01-01T06:45:00	0,00285
2020-01-01T07:00:00	0,00459

Figure 10: CSV sample for load profile upload [7]

2.8 KEY PERFORMANCE INDICATORS

This section describes how each Urban Planning KPI is calculated and which data sources are used.

2.8.1 EN18 – Electrical energy generated in the district and used onsite

In the first version of the Urban Planning module, the energy generated in the district and available for consumption on site is calculated by subtracting the sum of all available consumption profiles from the sum of all available production profiles in the area of the renovation project. This leads to a detailed production profile in 15-minute resolution that can be used for further calculations. Production and consumption profiles of surrounding buildings are provided by the user (based on usage types and estimated yearly consumption and production figures) or actual meter data provided by third parties such as building owners or utility providers.

In the second version of the Urban Planning module, we will consider in the calculation the distance between buildings and the renovation project. As excess power should be consumed by the consumer which is closest to the production site, this will give us a clearer view on the energy flows within the district and a more accurate estimation of the energy which is produced in the district and can be used at the renovation project.

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[7] https://ebutilities.at/utilities/konsultationen/detail.php?ConsultationID=9, last access: 10.08.2020

2.8.2 EN19 - Energy generated on site and exported to the district

This KPI expresses the energy which is produced by renovation measures (e.g., PV) but not fully used onsite, so that the excess of it can be exported via the grid to surrounding buildings. The following data sources are considered:

- Renovation project energy consumption profile
  - Simulated by Energy Plus or actual meter data
- Renovation project energy production profile
  - Simulated by Energy Plus in the context of specific renovation measures (e.g. PV)

Excess energy production is calculated by subtracting the consumption profile from the production profile. This excess production profile can then be used for further calculations and visualisation of energy flows to the surrounding buildings (see Section 4). This calculation is done for the renovation project each time a new production/consumption profile is available.

2.9 TECHNOLOGY STACK AND IMPLEMENTATION TOOLS

The BIMERR Urban Planning module is based on state-of-the-art technologies and three layers:

- The Presentation Layer which visualizes the energy flows and allows users to set their preferred data sources for energy production/consumption profiles of surrounding buildings. The user interface is built upon Angular, Typescript, and NGRX Entity/Store and uses Leaflet for visualizing the map view.
- The Business Logic Layer which calculates the KPIs and energy flows based on the stored production/consumption profiles of the renovation project and the surrounding buildings. This layer is based on Spring Boot and OpenJDK.
- The Data Layer utilizes PostgreSQL to store consumption/production profile data of the renovation project and surrounding buildings for faster access at later usage.
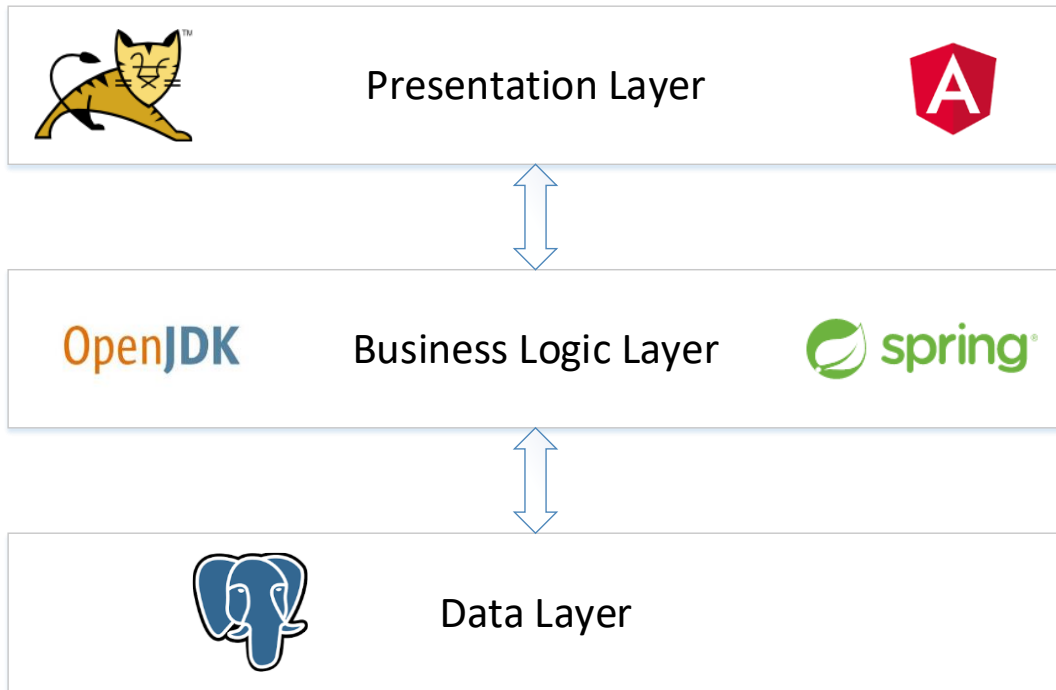
Figure 11: Architecture of the BIMERR Urban Planning module

In more detail, the BIMERR Urban Planning module utilizes open source technologies and libraries as defined in the following table.

Table 1: Technologies and libraries used in BIMERR Urban Planning module

Name of the technology/library	Version	License
Apache Tomcat	9	Apache License 2.0 license
Angular	8	MIT License
Typescript	3.5.3	Apache License 2.0 license
NGRX Entity/Store	8.5.2	MIT-style License
LeafletJS	1.6.0	BSD-2-Clause
Java OpenJDK	11	GPLv2
Spring Boot	2.2.1	Apache License 2.0 license
Hibernate	5.4.8	LGPL 2.1
PostgreSQL	9.5	PostgreSQL License (similar to BSD/MIT)

2.10 API DOCUMENTATION

The communication between the front end (RenoDSS UI) and the back end (Urban Planning module) is typically through internal APIs. As they serve inter-subcomponent integration purposes, they are not documented at this point in detail.

2.11 ASSUMPTIONS AND RESTRICTIONS

As the development of BIMERR applications is still ongoing and validation activities have not started yet, the first release of the BIMERR Urban Planning module is based on the following assumptions/restrictions:

- The current implementation assumes that calculation of excess energy production is restricted to electricity.
- The current implementation assumes that all default load profiles provided by the admin for a certain usage type and geographical location contain values in a 15-minute-resolution.
- The current implementation assumes that load profiles provided by the user for a certain building contain absolute values in kilowatt-hours in a 15-minute-resolution.

2.12 INSTALLATION INSTRUCTIONS

The BIMERR Urban Planning module is part of BIMERR RenoDSS, which is accessible via a web-based GUI, and therefore does not require installation or downloading of any component to use it.

2.13 LICENSING

The KPI calculation schema is public. As parts of the BIMERR Urban Planning module are based on and integrated into the Xylem business intelligence platform it is a closed source component.

3. END-TO-END USAGE WALKTHROUGH TO THE BIMERR URBAN PLANNING MODULE

After selecting a renovation project in the project list on the dashboard, the user can navigate to the Urban Planning Module by selecting the button "Open Urban Planning Module" on the bottom of the page.
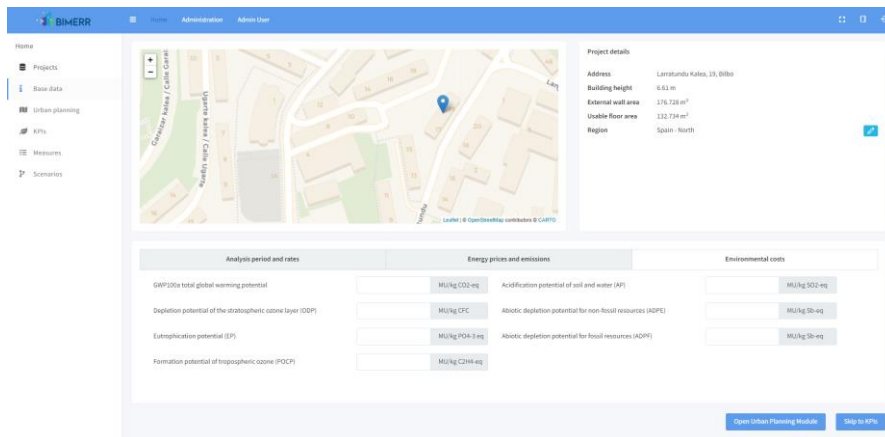

Figure 12: RenoDSS base data view

The Urban Planning view consists of a map showing the renovation project and surrounding buildings that were already created.
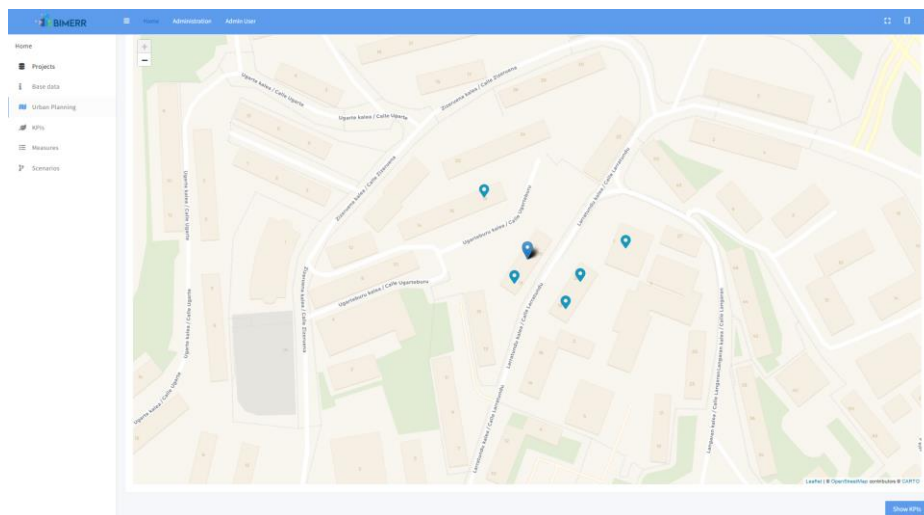

Figure 13: Urban Planning view

To create a new building the user can double-click the map on the location of the building to be created. On double-click a modal form opens, where data about the building can be entered. The region is automatically abstracted from the renovation project. Other data that is required include the address and usage type shares summing up to 100%. The user can choose either to use default load profiles provided by the admin or to upload a building-specific load profile. For detailed information about the modal form please refer to Section 2.6.

After the user clicks the Save button all building information is persisted and the new building is shown on the map in form of a pin at the selected location.

To show detailed information about a building or to edit the building's data the user can click this pin again and a similar modal opens where all available data is shown and can be edited.

The KPIs calculated by the Urban Planning module are shown in the RenoDSS KPI view which can be opened by button "Show KPIs".

4. CONCLUSIONS AND PLAN FOR SECOND ITERATION

In its first version, the BIMERR Urban Planning module (i) provides the geographical perspective of the building under renovation and its surrounding buildings based on the geolocation extracted from the building's IFC file, (ii) allows to set energy production and consumption profiles of surrounding buildings via a map view, and (iii) calculates the urban planning KPIs "EN18 – Electrical energy generated in the district and used onsite" and "EN19 - Energy generated on site and exported to the district". The following extensions are planned for the second release of the BIMERR Urban Planning module:

- Energy networks integration and visualization based on sample data
    - Convert sample network data from pre-validation and validation sites to CityGML network representation
    - CityGML export functionality ensures that available network, energy mix and energy consumption/production data can be exported to a standardized data format.
- Visualization of energy flows between renovation project and surrounding buildings assuming that energy always takes the shortest path. The paths show the direction of energy flows and are labelled with the annual energy exchange. By clicking on the path, the detailed production and consumption profiles of the two buildings are shown. To calculate the energy distribution to the surrounding buildings the hill climbing algorithm is used.
- Visualization of excess energy on the district level: if there are no surrounding buildings to which excess energy can be exported an arrow to/from the neighbourhood is used to visualize a non-point source/target.