P2ENDURE
PLUG & PLAY BUILDING RENOVATION

Set-up of a database for asset management of deep renovation

Deliverable Report D4.2

Deliverable Report: D4.2, issue date on 31 August 2018

P2ENDURE
Plug-and-Play product and process innovation for Energy-efficient building deep renovation

This research project has received funding from the European Union's Programme H2020-EE-2016-PPP under Grant Agreement no 723391.

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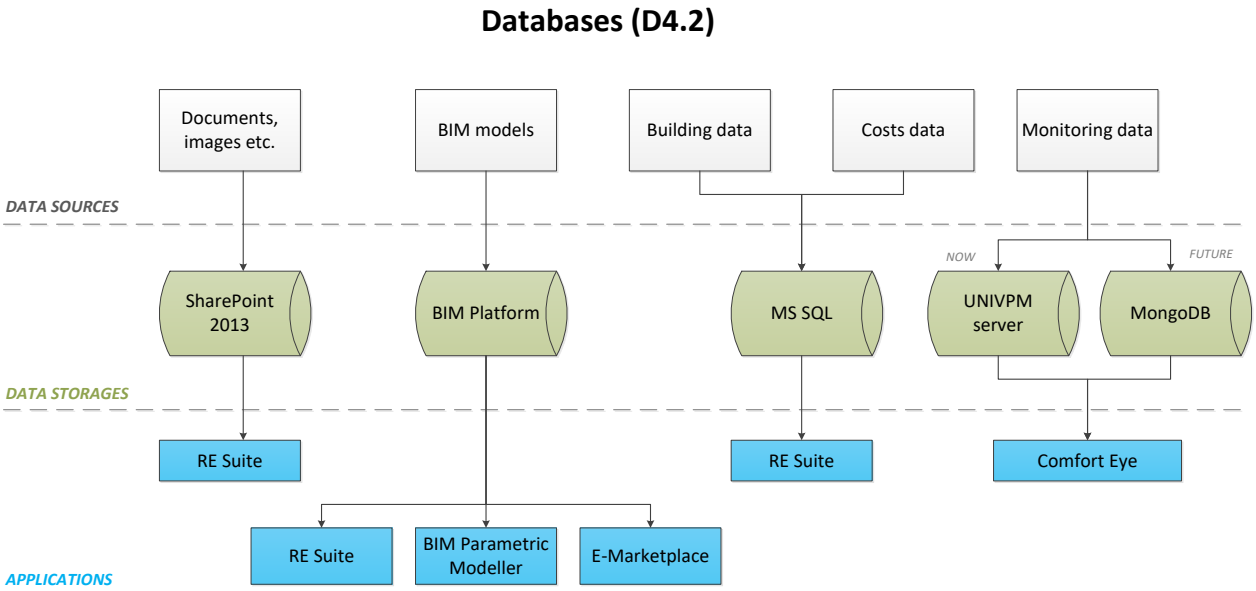
Publishable executive summary

In a project, where a lot of data is gathered, generated, analysed and shared between multiple parties, easily accessible databases are crucial to store and organize all the information.
This deliverable (D4.2) describes the database architecture within P2ENDURE.

In P2ENDURE there are three main categories of data: BIM (Building Information Modelling) data of the P2ENDURE demonstration cases, data on building condition assessment and costs of building performance and renovation, and monitoring data of building energy performance and Indoor Environmental Quality (IEQ).

Three databases have been set up in order to collect and analyse data on technical building condition and costs of building performance as well as to store and access the BIM (Building Information Model) and BEM (Building Energy Model) models of the demonstration cases. In regard to storing, accessing and processing the monitoring data, an example of a method derived from the H2020 MOBISTYLE project is described as possible future solution.



List of acronyms and abbreviations

DoA:	Description of Action
BEM:	Building Energy Model
BIM:	Building Information Model
CAPEX/OPEX:	Capital / Operational Expenditure
DB:	Database
DBMS:	Database Management System
DMP:	Data Management Plan
EeB:	Energy-efficient Building
HVAC:	Heating Ventilation Air Conditioning
IEQ:	Indoor Environment Quality
LCA:	Life Cycle Analysis
LCC:	Life Cycle Costing
MEP:	Mechanical Electrical Plumbing
MRT:	Mean Radiant Temperature
PMV:	Predicted Mean Vote
PnP:	Plug-and-Play
PPP:	Public–Private Partnership
R&D:	Research and Development
RoI:	Return on Investment
SQL:	Structured Query Language
VOC:	Volatile Organic Compounds

Definitions

Database (DB) is a collection of information that is organized so that it can be easily accessed, managed and updated [W3]

Data structure is a specialized format for organizing and storing data. Examples of general data structure types are the array, the file, the record, the table, the tree [W3]

Structured Query Language (SQL) is a standardized programming language used for managing relational databases and stored the data [W3]

Database management system (DBMS) is system software for creating and managing databases [W3]

Contents

1. INTRODUCTION

1.1 Objectives

In a project, where a lot of data is gathered, generated, analysed and shared between multiple parties, easily accessible databases are crucial to store and organize all the information.
This deliverable describes the database architecture within P2ENDURE.

Three databases have been set up in order to collect and analyse data on technical building condition and costs of building performance as well as to store and access the BIM (Building Information Model) and BEM (Building Energy Model) models of the demonstration cases. In regard to storing, accessing and processing the monitoring data, an example of a method derived from the H2020 MOBISTYLE project is described as possible future solution.

The databases provide storage and retrieval of the data necessary to carry out the research and demonstration activities within the project and allow easy access and sharing of the data between several parties.
The goals of developing the databases in P2ENDURE are:

- Providing efficient storage, update and retrieval of data with an easy access for the consortium partners;
- Providing efficient organisation of the specific data depending on the format, source and purpose;
- Providing adaptable and scalable data store to the P2ENDURE requirements, applications and tools;

1.2 Structure of this report

The following chapter of this report (Chapter 2) describes different data and data sources involved in P2ENDURE. There are three main categories of data involved in the project: BIM (Building Information Modelling) data of the P2ENDURE demonstration cases, data on building condition assessment and costs of building performance and renovation, and monitoring data of building energy performance and Indoor Environmental Quality (IEQ). In this chapter the purpose of the data management in P2ENDURE within these three categories is described.

The subsequent chapter (Chapter 3) presents the schematic IT architecture with an explanation on the different data stores and tools used in the project. This chapter describes three databases that are used in P2ENDURE to store and access different data formats: MS SQL, MS SharePoint 2013, BIM Platform and a possible solution to store and process the monitoring data on MongoDB.

Accordingly, Chapter 4 presents the IT development plan with explanation on the design, development, implementation and maintenance of the data stores. The databases are/will be made accessible for other consortium partners, and the access can be obtained by contacting the P2ENDURE Coordinator.

The final chapter (Chapter 5) summarises the outcomes and describes the steps that were conducted in P2ENDURE in order to create the asset management plan. This chapter also explains the relation between the activities regarding software development in Work Package (WP) 2 and the demonstration cases in WP4.

2. Scope

2.1 Data and data sources involved in P2ENDURE

As used in this document, the term "data" refers to raw data, processed data, published data, demonstrations and observations and supporting documents. It includes data generated by technological development, models, simulations, demonstrations and by observations at specific times and locations as well as any custom code or applications that were developed to aid in data analysis or transformation and are necessary to understand the data.

In P2ENDURE there are three main categories of data: BIM (Building Information Modelling) data of the P2ENDURE demonstration cases, data on building condition assessment and costs of building performance and renovation, and monitoring data of building energy performance and Indoor Environmental Quality (IEQ). The purpose of the data management in P2ENDURE within these three categories is described in the next chapter 2.2.

The table below shows an overview of the input and output data of different tools that are used in P2ENDURE. In the D7.1 report - Data Management Plan (DMP), data management life cycle for all data sets that are collected, processed or generated by the research project are described in more details.

P2ENDURE tool & technologies	Input data		Output data	
	Type	Formats	Type	Formats
Comfort Eye - IEQ control systems for real-time monitoring of indoor thermal comfort	Building Geometry, end-use, location. Measurements (air temperature, relative humidity, mean radiant temperature, air velocity, CO2 indoor, CO2 outdoor, indoor sound pressure level, outdoor sound pressure level)	XLSX, DWG, DOCX, CSV, TXT	Report with IEQ assessment (KPIs)	PDF, DOCX, JPG
Thermal scanning technologies and tools integration	List of building components to inspect. Characteristics of building components: Size Stratigraphy Drawings Location Details on Junctions 3D model	XLSX, DWG, Image (standard formats)	Thermal Transmittance (U Value Map) Thermal Bridges (Thermal Resistance Map) Air Leakage (Ultrasound Intensity Map) Sound Insulation (Sound Intensity Vector Map) Sound Insulation (Transmission Loss Value) 3D geometrics scanning Integration of the thermal and acoustic measured data with the points cloud obtained from a 3D laser scanner investigation	Image (standard formats) ASCII, MAT, PDF PTX (ASCII based interchange format for point cloud data.) Point Cloud Exporting Formats (OBJ, PLY, XYZ)

3D scanning (geomatics) – laser and photogrammetry	Scan position (based on number of scans and define shadow cones) Target location (minimum 3 target) Geo-location (GPS location) Positioning sensors Thermal data (wawe emission material) Wi-Fi (internet connection)	DXF, JPG, DOC,ASCII, XYZ	Point Cloud Reflectivity image Thermal imaging Assessment of material Report (holistic information of the project)	**3D vector data** (Spatial coordinates) PTS, PTX, U3D, PLY, XYZ, ASCII, PDF **Radiometric data** PTX, PLY, ASCII **Raster data** JPG, PNG, TIFF **Radiometric data** JPG radiometric Temperature value (colour code) **Report data** TXT, PDF **Report data** Paradata & metadata TXT, PDF, ASCII
3D printing and robotics controlled by on-site scanning and coordination system	CAD drawings, BIM models	DWG, IFC	3D printed façade	
BIM and BEM models and parametric modeller for prefab components	Building information for conducting energy simulations Historical usage data	IFC IDF JSON	Different configuration options with projected energy savings, life-cycle cost savings, first installation costs, and long term maintenance costs	PDF
Mobile inspection tool for condition assessment	List of buildings, GPS location, Cadastre, Information about building condition (e.g. technical problems)	XLSX, IFC, JPG	Report about building condition assessment, multi-year maintenance plan	DOC, DOCX, PDF, XLSX
Software for energy calculation	PRELIMINARY PHASE usually: i) geometrical data (e.g. building dimension, orientation) ii) technological data (e.g. plants typology and efficiency) iii) management (e.g. usage patterns)	DWG, XLS etc.	- mandatory: over all energy demand in terms of primary energy - recommended: single end uses requirements (i.e. electricity, heating, sanitary water, cooling demands), All the calculations must be compliant to the European Directive ED 2010/31/EU	XLS, DOC, etc.
	SECOND PHASE BIM Model from Revit / ArchiCAD data related to occupancy, activities, temperature set points	IFC, gbXML, XLS	Temperature, Heat gain, and thermal diagnostic (envelope, windows, ventilation) Primary energy consumption	XLS, CSV

Software for cost calculation: LCC, asset management	Technical condition on a building stock Maintenance, exploitation and renovation costs	IFC	Report with cost analysis	DOC, DOCX, PDF, XLSX

Table 1: Data types and formats used by P2ENDURE tools (source: D7.1 DMP)

2.2 Purpose of information management in P2ENDURE

The data listed in the previous chapter 2.1 plays a crucial role in completing the tasks within P2ENDURE. The following activities are performed in the project using the specific listed information.

BIM (Building Information Modelling) data

BIM data used for:

- Creating As-built BIM models of the demonstration buildings, urban situation and renovation designs based on existing drawings, areal imagery and/or laser scans;
- Creating integrated solution packages of the chosen P2ENDURE components;
- Communication between different stakeholders from architectural, engineering, and construction industries to convey the project scope, steps, and outcome. The model contains information relevant for different specialists, allowing each discipline to annotate and connect its intelligence to the project.
- Simulating and visualising different design strategies. The increasing number of simulation tools allows designers to visualize and analyse, e.g. the sunlight during different seasons (what was performed in case of analysing design proposal for implementation of BGTEC smart windows) or to quantify the calculation of building energy performance. In P2ENDURE the BIM models are enriched with energy data to create BEM (Building Energy Model) for energy analysis and simulations in order to check possible building energy performance of different renovation scenarios. The results of the energy simulations are shown by the BIM-based Parametric Modeller on e-Marketplace (check the D2.2 and D2.5 reports for more information).
- Cross-learning between different projects through a digital workflow by sharing and collaborating information within BIM models. Much of added project-management functionality is now being delivered in the cloud where there are tools for different disciplines to share their complex project models and to coordinate integration with their peers;
- 3D printing where BIM models are used to pre-programme the robots and on-site processes. More information on the 3D printing technology will be described in an upcoming deliverable report D1.6 due in August 2019.

Building and cost data

Building and cost data are collected regarding the demonstration cases for:

- Creating BIM and BEM models as described in the previous point;
- Building condition assessment before the renovation of the demonstration cases in order to gather data on building condition, using the same coherent methodology that is implemented in the software tool, for comparison between the condition before and after renovation in order to provide tangible and measureable evidence of the improvements through implementation of the P2ENDURE Plug-and-Play solutions for deep renovation (for more information check the D2.3 report);
- Performing LCC (Life Cycle Cost) analysis in order to determine the most cost-effective design alternative comparing three strategies: maintenance costs of a building without renovation, renovation with traditional technologies and renovation with innovative P2ENDURE technologies (for more information check the D3.3 report);
- Managing time planning of the renovation process and estimating reduction of time in comparison to the traditional renovation methods (for more information check the D3.3 report);
- Estimating reduction of disturbance on-site during renovation works (for more information check the D3.5 report)

Monitoring data

Monitoring data is collected for comparison of the building performance before and after the renovation and thus, for validation of the P2ENDURE approach on building deep renovation. The detailed description of the IEQ (Indoor Environmental Quality) monitoring with the Comfort Eye tool will be described in the D3.6 report due in February 2020. Monitoring of actual energy consumption is also performed before and after renovation. So far, this has been done manually based on energy bills and user surveys. In the future, energy data collection through smart meters can be implemented. The results of the monitoring and calculations are presented in the D3.3 report.

These different data formats used in P2ENDURE are stored on the dedicated databases described in the following chapter 3 and are accessible to other consortium partners upon their request.
Scheme 1 of the data sources and databases architecture in the next chapter 3.1 illustrates how the different kinds of information are stored and by which applications they are used.

3. Schematic architecture

3.1 Conceptual scheme

The scheme below shows different sets of data that are stored on the designated databases depending on their formats and applications.

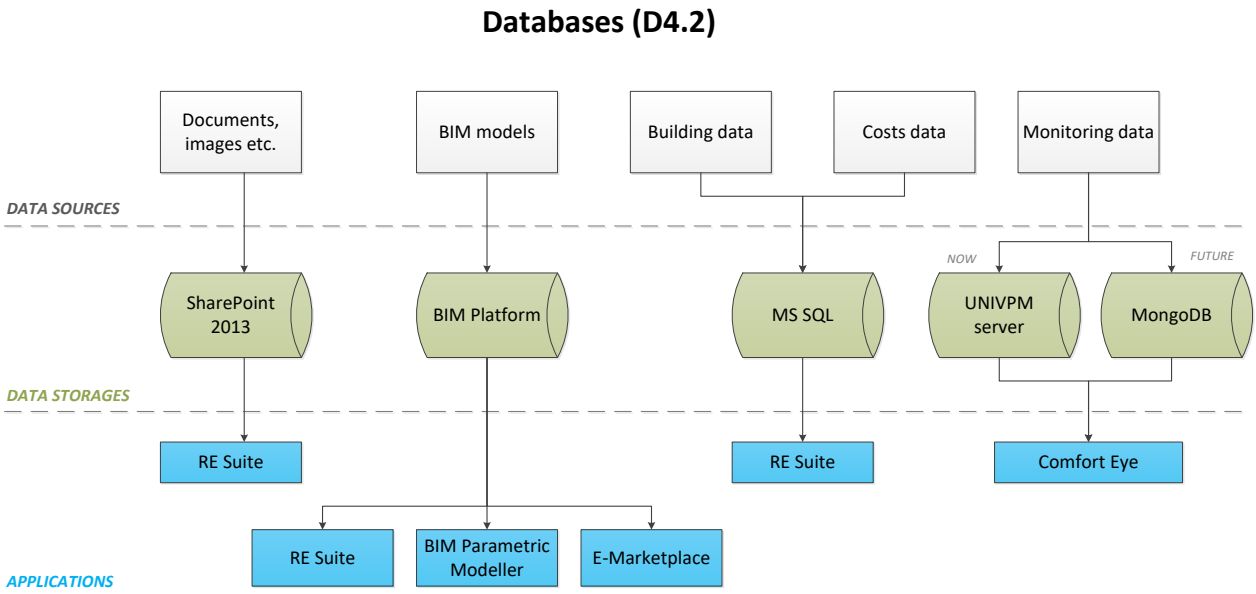


Figure 1: Data sources and databases in P2ENDURE

3.2 Description of data stores and tools

A **database** is a collection of information that is organized so that it can be easily accessed, managed and updated. A database has an underlying methodology for structuring and storing the information it contains. This information can be created, read, updated and deleted (the so-called CRUD-operations). Databases process workloads to create and update themselves, querying the data they contain and running applications against it [W3]. For specific use-cases and/or types of data, a specific type of database, and therefore a specific underlying methodology for structuring and storing the data, is most suited.

It is against this background that, as Figure 1 visualizes, different databases were set-up in P2ENDURE to collect specific types of data for usage by specific tools and applications.

With regards to the data stores, we have adopted the pragmatic concept of identifying the needs of the applications within P2ENDURE and making sure the data stores facilitate these needs, while also identifying potential additional use-cases in the future. Where this is the case, these will be addressed in the in-depth description of each data store.

3.2.1 Data stores

This chapter describes the set-up and configuration of all databases used in P2ENDURE to collect and share different data formats described in the previous chapter 2.

A **relational database** is a set of formally described tables from which data can be accessed or reassembled in many different ways without having to reorganize the database tables, like MS SQL and SharePoint. The standard user and application programming interface (API) of a relational database is the Structured Query Language (SQL). SQL statements are used both for interactive queries for information from a relational database and for gathering data for reports [W2].

MS SQL

The MS SQL database was set up to store the building and cost data used by the RE Suite tool for condition assessment (D2.3 report), LCC and asset management (D2.4 report) within P2ENDURE. This data contains information gathered on-site by the mobile inspection tool on the building technical condition and the cost data of the maintenance and renovation of the demonstration cases.

MS SQL is a **relational database**, characterized by a set of formally defined data structures called tables. These table definitions can be seen as capturing and describing phenomena in data form. This means that data entities of a certain type all have the same structure which can be depended upon, but also that this structure cannot be deviated from. For the storage of data that can effectively be described in such a structure, such as building and cost data, a relational database is the most suited solution.

Interaction (CRUD-operations) with the MS SQL database is performed through the Structured Query Language (SQL). SQL statements are used both for interactive queries for information from a relational database and for gathering data for reports [W2].

In order to manage the interaction with the MS SQL database a data manager has been created. This data manager is part of the Data Access Layer (DAL) built on top of the database and provides programmers with a systematic way to create, retrieve, update and manage data. The data

manager essentially serves as an interface between the database and end users or application programs, ensuring that data is consistently organized and remains easily accessible [W3].

While the building and cost data (among others) is currently only used by the RE Suite end-user application, the data contained within the MS SQL database can also be made available to other applications through this same data manager.

MS SharePoint 2013

Microsoft SharePoint is a highly customizable collaboration platform [W3]. SharePoint – a file server with added functionalities for workflows and version management has been set up to store and share drawings, images, photos etc. This data is used by the RE Suite tool to import drawings, photos and other available files needed for the building condition assessment and overview of the building stock as well as to take and save photos directly by the RE Suite mobile app on-site while, e.g. performing condition assessment.

However, the platform's content can be disseminated to a much broader audience, whether it is to a user through the web interface or to applications through the programmatic interfaces (API's), and therefore can become the central file server within P2ENDURE.

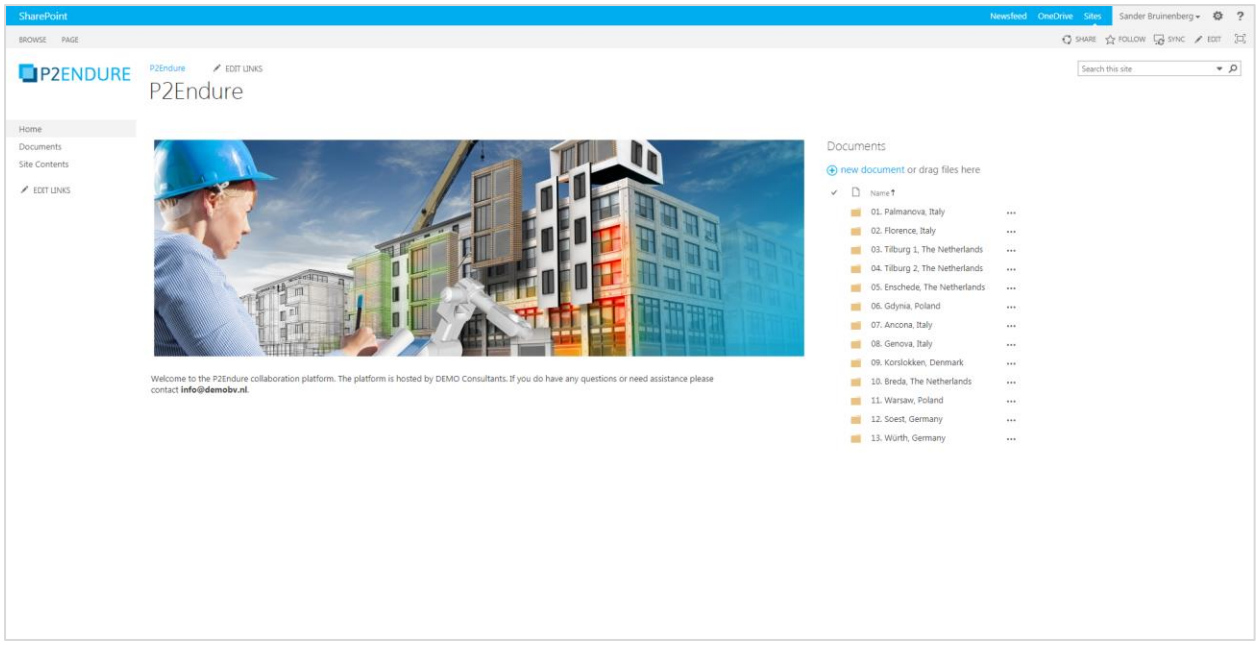


Figure 2: The web interface of the SharePoint 2013 P2ENDURE collaboration platform

BIM Platform

The open-standard IFC BIM platform was set up in order to collect and access the BIM models of the demonstration cases but also to enable monitoring, controlling and managing the retrofitting solutions. The platform is composed of tools to respectively perform the monitoring and control tasks, the energy management tasks, and the BIM for design, manufacturing, assembly and 3D printing. The BIM platform does only enhance information management, but also enable data interaction between buildings and other systems in the district energy grid. The integration of BIM and parametric modeller within the BIM platform enables a participation design process involving the whole value-chain. Various design options can be configured, showing the implications of user requirements and design preferences both on energy performance as well as costs (investment and lifecycle costs).

Description and purpose of the BIM platform:

- Storing BIM files
- Processing BIM files: checking the accuracy, formats

Nowadays the BIM models are stored on the BIM server of the Technical University of Berlin.
The TU Berlin uses the so called "tubCloud". "tubCloud" is distribution of the enterprise edition from the Lexington (USA) based server provider "ownCloud". "ownCloud" is an open source solution for secure file sync and share that can be used in your own data center, on your own servers, with your own storage systems. With the help of open source based file sync and share software, users retain full control over their own data in accordance with German data protection regulations. OwnCloud guarantees access via all common operating systems like Windows, Mac and Linux. Data can also be synchronized with Smartphone or Tablet via Apps for Android and iOS. The included editor supports programming through syntax highlighting and allows editing texts with other users.

The following print screen shows available BIM models of the demonstration case in Enschede, the Netherlands on the BIM server provided by the TU Berlin.

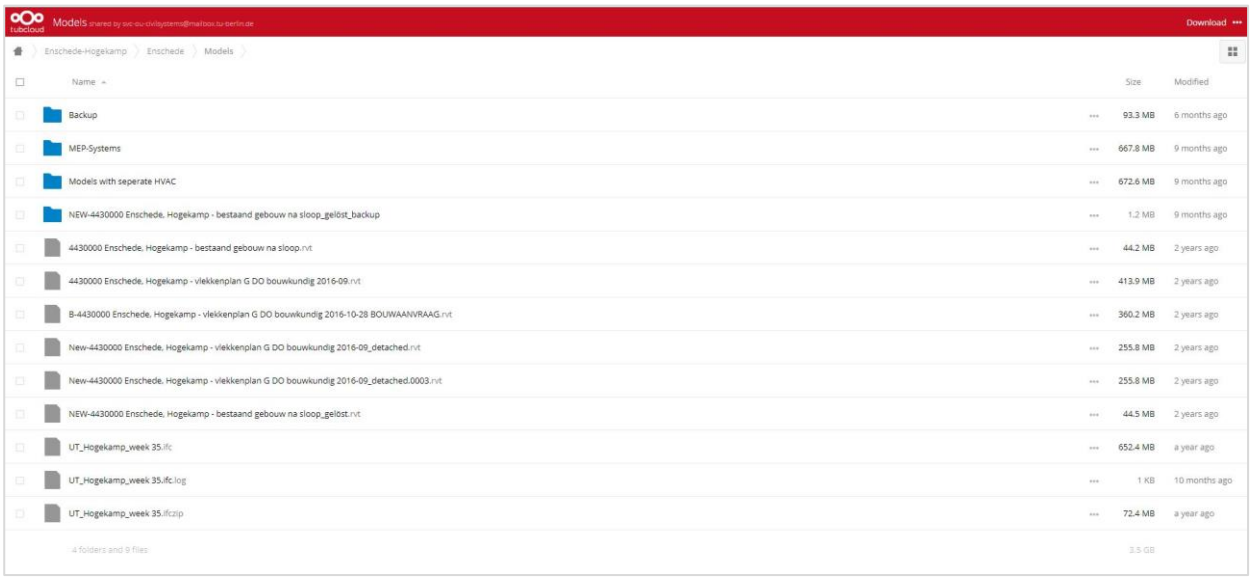


Figure 3: The BIM server of the TU Berlin

MongoDB

Nowadays the monitoring data derived from the Comfort Eye tool (described in the following chapter 3.2.2) is stored on a server hosted by UNIVPM and partially accessible by third parties. The raw data coming from the field is currently organized as list of files and includes:

- thermal map of each room's surface;
- air temperature and humidity;
- volatile organic compounds (VOC);
- CO2 concentration

A custom data processing algorithm is periodically run on the same server, applying all the calculations on the surfaces' temperature to derive PMV and MRT of multiple positions in the considered indoor environment. The user can now interact with the system through webservices, so as to get a non-realtime value of the raw data or processed one.

Currently, the volume of the monitoring data is relatively small and it is only used by the Comfort Eye tool. If either of these aspects change, it is possible that the current database used to store the monitoring data will no longer be suitable. For this scenario, an alternative solution has been formulated: a centralized non-relational monitoring data store; a MongoDB.

MongoDB is an open source **non-relational** database that uses a document-oriented data model; instead of using tables and rows as in relational databases, MongoDB is built on architecture of collections and documents. Documents consist of a key, an identifier, and (a) value(s), one or more field of data.

Such a database is suitable for monitoring data due to:

- Monitoring data from sensors can differ in structure and content between case, manufacturers or type of sensor and therefore require a less rigid data structure.
- Due to its 'free' data structure, a non-relational database can effectively deal with large data streams; a high and continuous volume of data.

The possibilities to store, process and share large amount of monitoring data through MongoDB server were addressed by the Horizon 2020 MOBISTYLE project (https://www.mobistyle-project.eu).
In the project different parties (demonstration cases) are delivering raw sensor data in different formats and with differing frequencies. The data is collected, pre-processed and stored in one central place, the MOBISTYLE database. After that, a mechanism is set up in order to guarantee data transfer to third parties in the consortium which will disclose the information to the different end-users targeted in the project.
Once the database is set up, two main parts are implemented in order to guarantee data collection (data coming in to the database) and data transfer (data going out to other parties):

- Data Collection Service– software responsible for collecting data. It is scheduled for certain frequency, e.g. every 15 minutes, to run and collect all the available last data for all the cases
- Webservice - RESTful web service responsible for making monitoring data available to end-user applications. This web service provides a programmatic interface between the end-user applications and the database, and as such is the data manager for the MongoDB.

The following scheme shows the monitoring data flow from the sensors, through MongoDB to webservice(s).

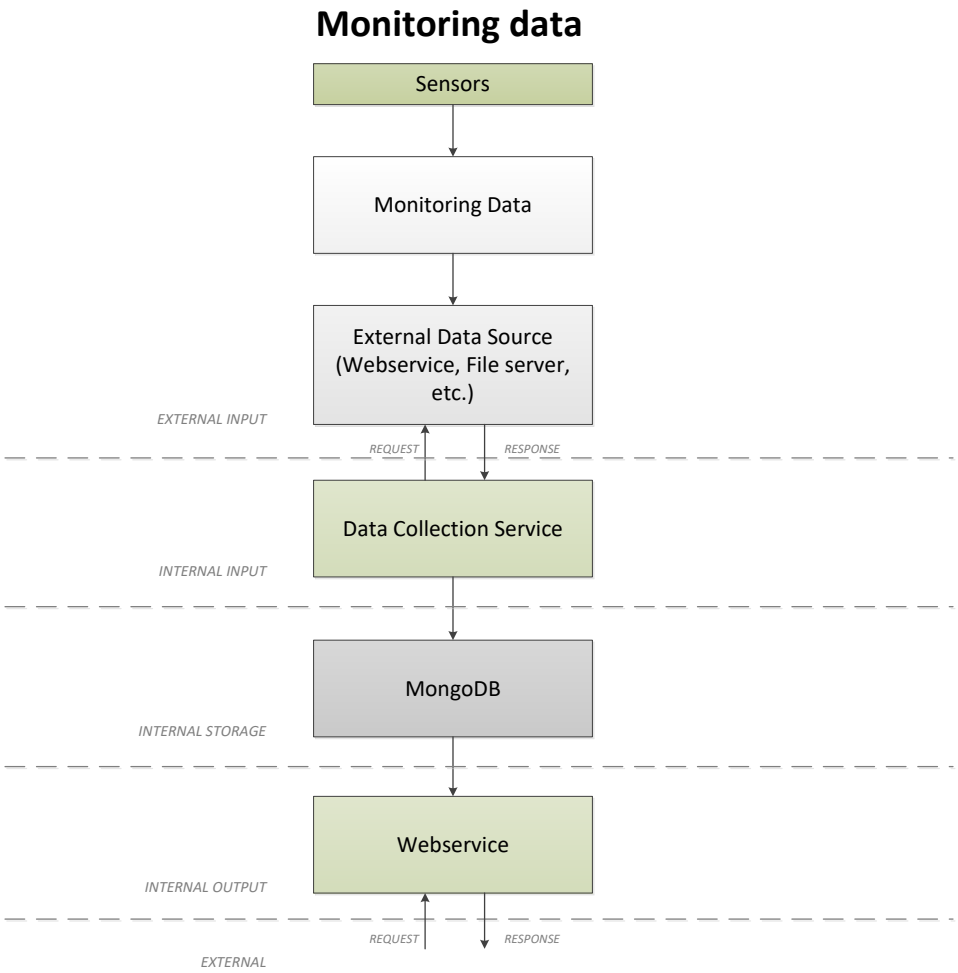


Figure 4: Storing and accessing the monitoring data through MongoDB database

3.2.2 Tools

The following tools are used in P2ENDURE for data gathering and processing as shown in the Figure 1 in chapter 3.1:

RE Suite

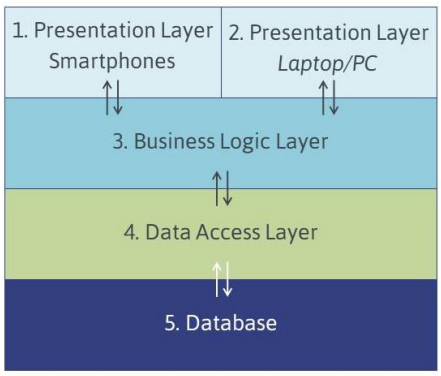
The RE Suite, developed by DEMO Consultants, is a tool that supports collecting, structuring, analysing and disseminating information of buildings and civil infrastructure. It is a comprehensive software solution, which allows various parts to be automated. The software has a modular design and can be implemented in a modular system.

RE Suite supports the entire cycle of real estate development and information management. The tool provides continuous insight into real estate information; and therefore, puts the asset manager better in control of the real estate portfolio.

Figure 5: The main IT Architecture of RE Suite

The RE Foundation Server consists of the data model, links to other external sources, ERP (Enterprise Resource Planning) and administrative systems. From the RE Foundation the data is managed, e.g. the objects, components or encoding. In P2ENDURE the data model of RE Foundation links to the MS SQL and SharePoint databases to retrieve the data on the demonstration cases necessary for creating multi-year maintenance plan, performing LCC analysis and providing technical and financial overview for asset management.

The following scheme shows the multi-layer structure of the source code:



Data Access Layer consists of algorithms and codes allowing communication with the database in order to add new data and delete existing data if needed. In the Business Logic Layer there are algorithms related to specific applications of RE Suite, e.g. formulas for creating multi-year maintenance plans. Presentation layer shows the specific data and results of data analysis both on a mobile device, like smartphone or tablet, and on a desktop computer or laptop.

In P2ENDURE two applications of RE Suite are being further developed:

- The mobile inspection tool for building condition assessment (D2.3) is developed to collect evidence of the building condition before deep renovation. The software can be operated on a mobile device (a tablet) and desktop (laptop / computer).
- The tool for LCC and asset management (D2.4) for a building stock portfolio forecasting model to generate most advantageous asset management strategies. The model calculates the financial flows of capital expenditures (CAPEX) and operational expenditures (OPEX).

Detailed description of the mobile inspection tool for building condition assessment is available in the D2.3 report and a description of the RE Suite tool for LCC and asset management is available in the D2.4 report.

BIM Parametric Modeller

In P2ENDURE BIM models of the existing buildings and deep renovation designs with energetic properties will be created in order to develop the deep renovation design ready for execution. Using the generalized use case BIM, P2ENDURE allows customizing renovation options through a parametric design modeller. The tight integration of BIM and the parametric modeller will enable a participatory design process involving the whole value-chain: clients, end-users, and all suppliers.

The parametric modeller is an essential element of the e-Marketplace providing the user with an overview of the possible thermal, energetic and the resulting cost savings based on the chosen renovation strategies / technical solutions.

Detailed description of the BIM-based Parametric Modeller is available in the D2.2 report.

e-Marketplace

In this task an e-Marketplace will be set-up to be deployed on the existing e-Marketplace platforms operational within the EeB PPP programme and the research projects therein. The P2ENDURE e-Marketplace will support the "Making process" in the 4M P2ENDURE process for implementing Plug-and-Play (PnP) prefab solutions by stimulating market expansion and supply chain integration. The P2ENDURE e-Marketplace will facilitate the establishment of local factories for district-scale deep renovations by providing the local construction players with guidelines and franchise business models. The P2ENDURE e-Marketplace will provide construction players and potential clients with information to quickly understand how to implement / replicate a similar 4M based process on their projects. The core of this information is documentation from the live demonstration projects and the virtual demonstrators, e.g. 3D BIM models, interactive websites and videos.

The results of this task are/will be presented in the D2.5 (submitted in M12 / August 2017) and D2.6 (due in M36 / August 2019) deliverable reports.

The image below shows the e-Marketplace platform with results of costs and energy analysis of the P2ENDURE demonstration case in Genoa, Italy visualised by the Parametric Modeller.

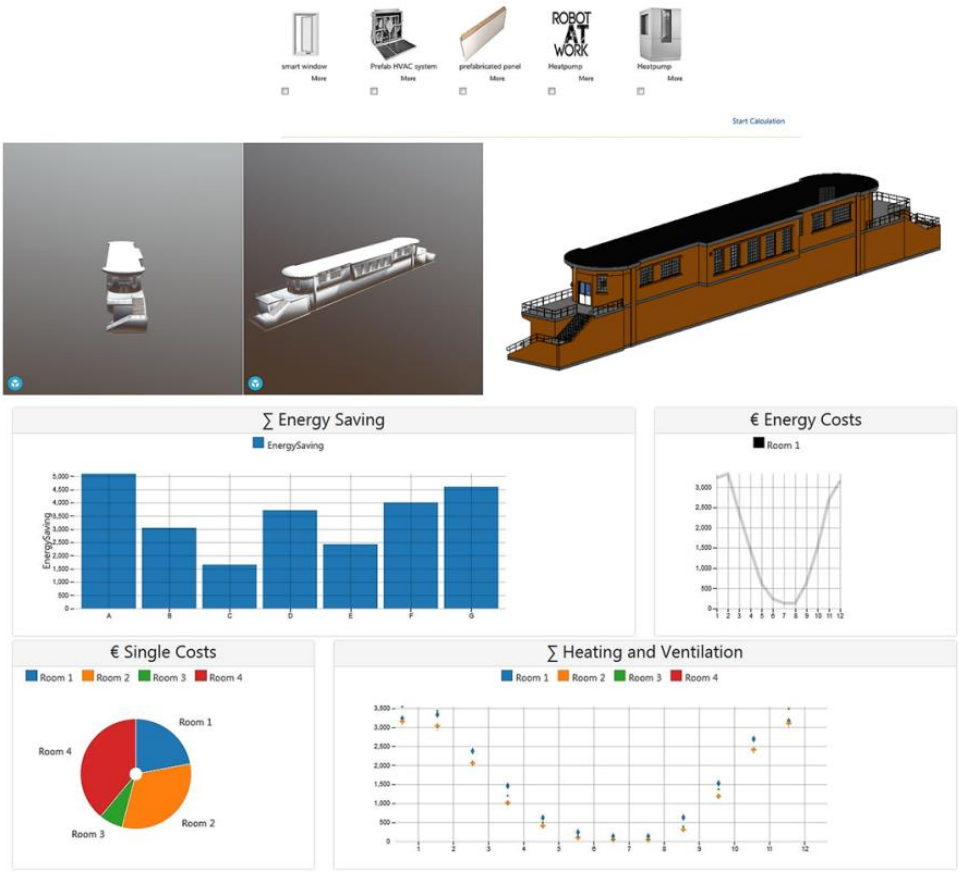


Figure 6: The e-Marketplace platform developed by TU Berlin

Comfort Eye

Comfort Eye is a low-cost sensing device for the real-time monitoring of Indoor Environmental Quality (IEQ), focusing on indoor thermal comfort and indoor air quality. It relies on a microcontroller and a set of sensors with embedded algorithms to derive the Predicted Mean Vote (PMV) index for multiple subjects, together with other parameters such as the air temperature and humidity, CO2, VOC and surface temperatures. In P2ENDURE, the empirical data is collected before and after renovation in both summer and winter periods in order to allow for evidence-based analysis of the comfort improvement through deep renovation. In addition to IEQ information, the Comfort Eye can provide further information about the building envelope performance. In fact, thermal maps of indoor surfaces are acquired continuously and they are used to investigate the temperature variations that are correlated with the insulation properties of the wall.

The first image below shows the Comfort Eye sensor installed in the P2ENDURE demonstration case in Warsaw, Poland and the second image presents thermal map of the wall exposed to the exterior.

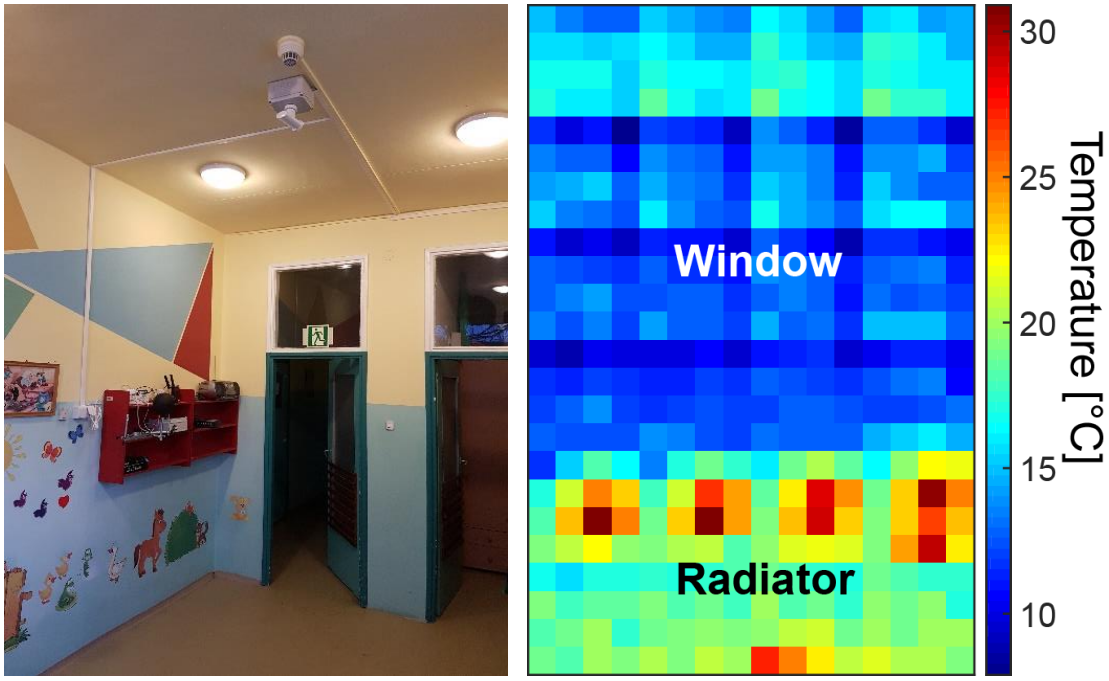


Figure 7: Left: The Comfort Eye sensor installed in Warsaw demo case (PL); Right: Thermal map of the wall

Detailed description of the monitoring procedure of the IEQ performed by the Comfort Eye sensor will be published in February 2020 in the D3.6 report when the results of monitoring of the P2ENDURE demonstration cases are available.

4. IT development plan

In chapter 3, the different types of databases used within P2ENDURE have been outlined and characterized with regards to their type, structure and usage. A large portion of these databases are already operational (as depicted in green in the scheme below).

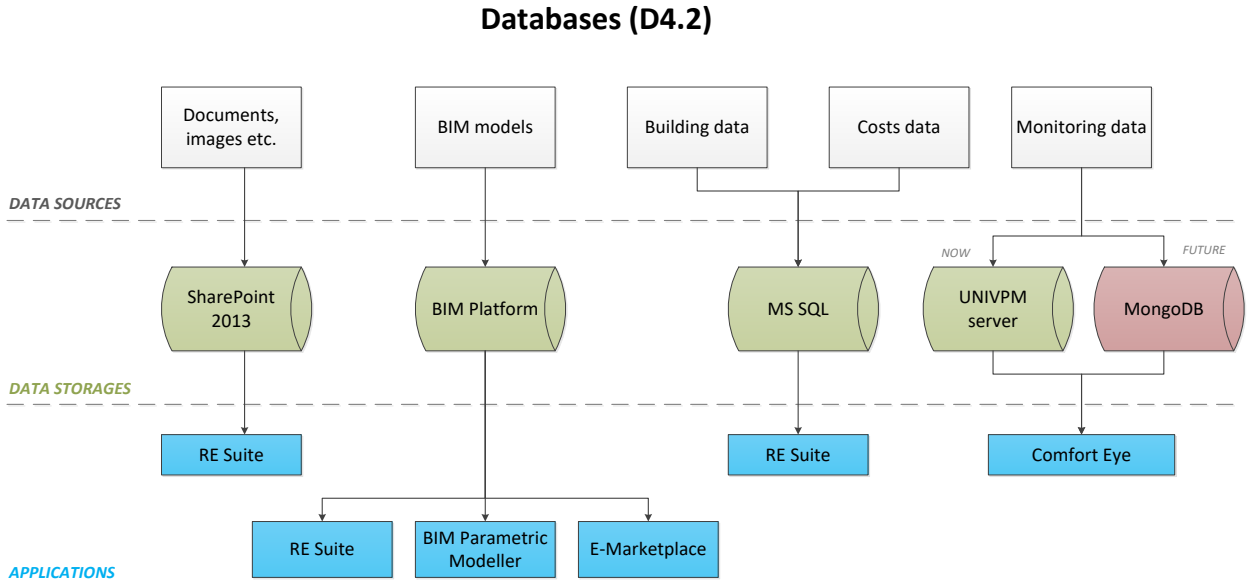


Figure 8: Operational data sources and data bases

As can also be seen in Figure 8, one database is currently depicted in red; not operational. As outlined at the outset of chapter 3.2, the needs of the current end-user applications have been leading in identifying the necessary databases/data stores. Nevertheless, possible future use-cases have already been considered. With regards to monitoring data, as outlined in chapter 3.2, it could be the case that a robust, central, monitoring data store is needed over the course of the project; a MongoDB. The characteristics and the conceptual implementation of such a data store have been described in chapter 3.2, and are therefore in effect 'waiting in the wings'.

5. Conclusions

This report described setting-up of databases for asset management of deep renovation. Therefore, the main purpose of the databases is to support management of individual buildings and building stock. In the result three databases have been set up to store, process, analyse and share different data formats: data on technical condition of buildings, costs of renovation and maintenance, energy monitoring data of building performance, and BIM (Building Information Modelling) data.

Efficient organisation of all the available data on the building performance and technical condition is crucial for monitoring and maintaining good quality and validity of received information and helps to provide a detailed overview of the building stock. Based on this information an asset management plan can be created providing a roadmap to understand the possible long-term strategies, e.g. scope and planning of building maintenance, renovation or possible transformation of the building's function.
In order to create an asset management plan the following steps were conducted in P2ENDURE:

- Building inventory - gathering and organising available information on the demonstration buildings. This data is stored on the MS SQL and SharePoint databases.
- Creating BIM models of the demonstration buildings, which are stored on the BIM platform.
- Performing life-cycle costs (LCC) calculations taking into account costs of maintenance, capital, operational, condition and performance modelling and even the costs of disposal. The cost data is stored on the MS SQL database and used by RE Suite tool to perform the LCC analysis.
- Setting levels of desired service on the basis of the gathered information and performed analysis to outline the overall quality, capacity, function and safety of the building stock.
- Creating long-term financial / maintenance plan to determine which of the goals are feasible, which are important and necessary and which can maintain the priority assets over the long term.

The content related to the deep renovation activities of the demonstration cases in P2ENDURE will be continuously added to the databases when new information becomes available in the course of the project.

The data on the asset management developed within the P2ENDURE project needs to be easily accessible for different parties. Upon request the access can be granted and log-in credentials provided.

The activities regarding software development in Work Package (WP) 2 and the demonstration cases in WP4 are directly related. The information on the demonstration cases is stored on the databases described in this report and used in the software tools to perform analysis and create an overview of the available information. The 'As-renovated' BIM datasets for lifecycle management will be elaborated in the D4.8 report due in August 2020.

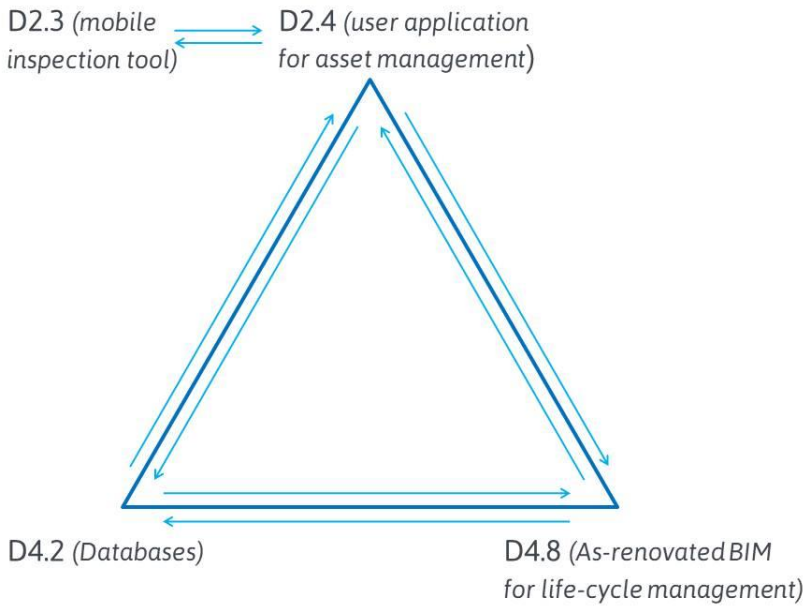


Figure 9: Relation between the D2.3 and D2/4deliverables in WP2 and D4.2 and D4.8 deliverables WP4

References

P2ENDURE Deliverable report D2.2 “BIM Parametric Modeller”; 2017
P2ENDURE Deliverable report D2.3 “Mobile inspection tool for building condition assessment”; 2017
P2ENDURE Deliverable report D2.5 “Set-up of an e-Marketplace [in synergy with existing e-Marketplaces in E2B PPP]”, 2017
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