Design and Implementation of the D^2EPC GIS Tool

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DELIVERABLE D3.2

Design and Implementation of the D^2EPC GIS Tool

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Executive Summary

This report presents the results of T3.2 – Development of a GIS scheme for EPC documentation describing the developed WebGIS application for the D^2EPC project. The overall goal of this report is to provide a holistic overview on the D^2EPC WebGIS tool, its scope, design, sub-components, functionalities, requirements and use cases that drove the implementation steps.

The first chapter of this report describes the overall content covered in this deliverable, its structure and its relation and dependencies with other tasks within the D^2EPC project. Chapter 2 presents the scope of D^2EPC WebGIS tool, starting form a brief introduction to the EU policies on Energy Performance of Buildings as well as the current market situation regarding the EPC documentation.

Moving towards the designing of the application, the Business Scenario and technical use cases covered from this implementation are described (chapter 3). The aforementioned aspects are of high importance as they drive the designing of the software and consequently, the final implementation. Furthermore, the functional and non-functional requirements of the application are presented, continuing the works done during the user and stakeholders' definition and the system's conceptual architecture. Lastly, the final architectural design of the application is given by providing functional, deployment and sequence diagrams which describe in depth the tool's mechanisms.

The implementation of the application is discussed in chapter 4. This section depicts the technologies and tools used for each sub-component as well as the software libraries and frameworks utilized for the development of the code.

Chapter 5 presents a demonstration assessment of the implemented solution. This section narrates the full functionalities of the application, by providing plenty of illustrations from the application. In addition, it serves as an informal user manual for the application as it provides some insights concerning tool's interface.

Lastly, a conclusion of the work undergone within this task is given. Task T3.2 concludes by delivering this report and the actual implementation (code) with the final version of the application. However, as the project progresses, some revisions of this tool's implementation may be required either for integration purposes or improvements and added functionalities. Such activities will be considered as part of T4.4 dEPC Interfaces, visualisation, and platform integration.

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List of Acronyms and Abbreviations

Term	Description
API	Application Programming Interface
BIM	Building Information Model
CRS	Coordinate Reference System
CSS	Cascade Style Sheets
DB	Data Base
RDBMS	Relational Data Base Management System
dEPCs	Dynamic Energy Performance Certificates
EGD	European Green Deal
EPC	Energy Performance Certificate
ESCOs	Energy Service Companies
EU	European Union
GDPR	General Data Protection Regulation
GHG	Greenhouse Gas
GIS	Geographic Information Systems
HTML	HyperText Markup Language
IFC	Industry Foundation Classes
MSs	Member States
NZEB	Nearly Zero Energy Buildings
NUTS	Nomenclature of territorial units for statistics
OGC	Open Geospatial Consortium
OS	Operating System
SPA	Single Page Application
SQL	Structure Query Language

WFS	**Web Feature Service**
WKT	**Well Known Text**
WMS	**Web Map Service**
WMTS	**Web Map Tile Service**
WP	**Work Package**
WSGI	**Web Server Gateway Interface**
UI	**User Interface**
UML	**Unified Modelling Language**
URL	**Uniform Resource Locator**

1 Introduction

1.1 Scope and objectives of the deliverable

The goal of this deliverable is to provide a full description of the D^2EPC GIS (Geographic Information System) tool, the methodology followed as well as the technologies, frameworks and tools utilized in the development process. Furthermore, this deliverable addresses the technical uses cases, business scenarios and functional/non-functional requirements that drove the designing phase. In addition, the architecture, functionalities and the implementation of the WebGIS application is described.

The D^2EPC WebGIS scheme mainly aims to be a generalised, across all EU member states (MSs) but not exclusively (UK, Turkey etc. are also considered), EPC documentation and visualisation tool of the generated EPC statistics. The dynamic Energy Performance Certificates concern both Asset and Operational Ratings, are issued by the D^2EPC platform and stored in D^2EPC's main repository. The WebGIS offers the functionality of visualising this information in a uniform manner and on a map, while enabling the extraction of meaningful statistics that can help third party users in policy making, market analysis and useful insights extraction.

1.2 Structure of the deliverable

The second chapter of this report, briefly discusses the role of EPCs and the current EPC schemes available on the market. A business scenario and technical use cases applied to the WebGIS (according to D1.4 - "*D^2EPC Framework Architecture and specifications v1*") are introduced. The functional and non-functional requirements are also described in this chapter.

Chapter No. 3 describes the WebGIS tool architectural design, starting from the deployment of business scenarios. In addition, the updated technical use cases for the application are described followed by the functional & non-functional requirements that shape the tool's design. Lastly, a series of diagrams and architectural views are presented, describing the functional capabilities and the internal processes of the application.

Chapter No.4 concerns the actual implementation phase. In this chapter, the technologies used for the development are described. The characteristics of each component are briefly discussed, the reasoning of choosing them as well as their integration within the whole application.

Chapter No.5 depicts the various functionalities that the D^2EPC WebGIS offers to end-users. It includes a number of pictures and screenshots coming from the application itself. This chapter can be very useful for later stages of the project as it acts as a basis for the user manual for the WebGIS.

Chapter No.6 is the summary of this deliverable. It describes the work done during T3.2 and proposes new steps that can be taken to explore new functionalities for the application and/or improve them.

1.3 Relation to Other Tasks and Deliverables

Task 3.2 deals with the development of the D^2EPC WebGIS tool and it is the second task of Work Package 3 "Building digitalisation and inverse modelling for implementing next generation dEPCs". The task is related to several other tasks. More specifically:

- Task 1.4 - "*System Technical Requirements, Specs & Architecture*". This task defines the overall system architecture as well as the functional and non-functional requirements required by the WebGIS tool.
- Task 3.3 - "*Building digital twin for EPCs issuance*" which delivers the Building Information Models for dwellings imported to the platform. Such BIMs can be visualised using 3D graphics on the GIS application.
- Task 4.4 - "*dEPC Interfaces, visualisation and platform integration*" that deals with the development of the main D^{2}EPC web platform. As mentioned earlier, the WebGIS is part of this platform, thus close collaboration with this task is mandatory to achieve seamless integration of the WebGIS into the overall platform in terms of technologies on both back and front end.

2 D^2EPC WebGIS scope

2.1 EU policy

The European Green Deal (EGD) announced by the European Commission in 2019 provides a roadmap to cope with climate change and reduce the greenhouse gas (GHG) released into the atmosphere. The goal is to achieve a reduction of 55% on carbon emissions (compared to 1990 levels) by 2030 and achieve carbon neutrality by 2050 [1, 2]. The EGD urges actions in all major sectors of economy such as industry, transportation, agriculture, oceans, energy and regional development.

Recently, European Commission proposed to integrate the rules regarding the energy performance of buildings within the EGD. Buildings are the largest energy consumer in Europe as they account of an approximate of 40% in total consumption [3]. As fossil fuels are the primary power source for buildings, the Commission proposes that all new buildings must be zero-emission by 2030. Furthermore, the worst performing 15% of the building stock of each MS must be upgraded from EPC grade G to at least F by 2027 in case of non-residential buildings and 2030 in case of residential.

To accomplish the goals set for the building sector, it is critical for each MS to measure and keep track of the energy performance of buildings. Moreover, studies of buildings sector suggest that today's buildings will make up at least 75% of the 2050 available stock. Consequently, each EU MS should keep track of energy performance of buildings not only for new constructions but for renovated buildings as well. A study prepared for European Commission [4] showed the impact of energy renovations for buildings for years 2012 – 2016. Specifically, an average of 9.5% of energy savings in non-residential and 12.3% in residential buildings was calculated for energy renovations across EU-28.

The Energy Performance of Buildings Directive [5] published in 2010 stated that all new buildings have to be NZEBs by the end of 2018. NZEBs are defined as buildings with nearly zero or very low-amount of energy required should be covered by renewable energy sources which is being produced on-site or nearby. Each MS had to develop definitions for NZEBs taking account the specific climate conditions and a numerical indicator of energy use.

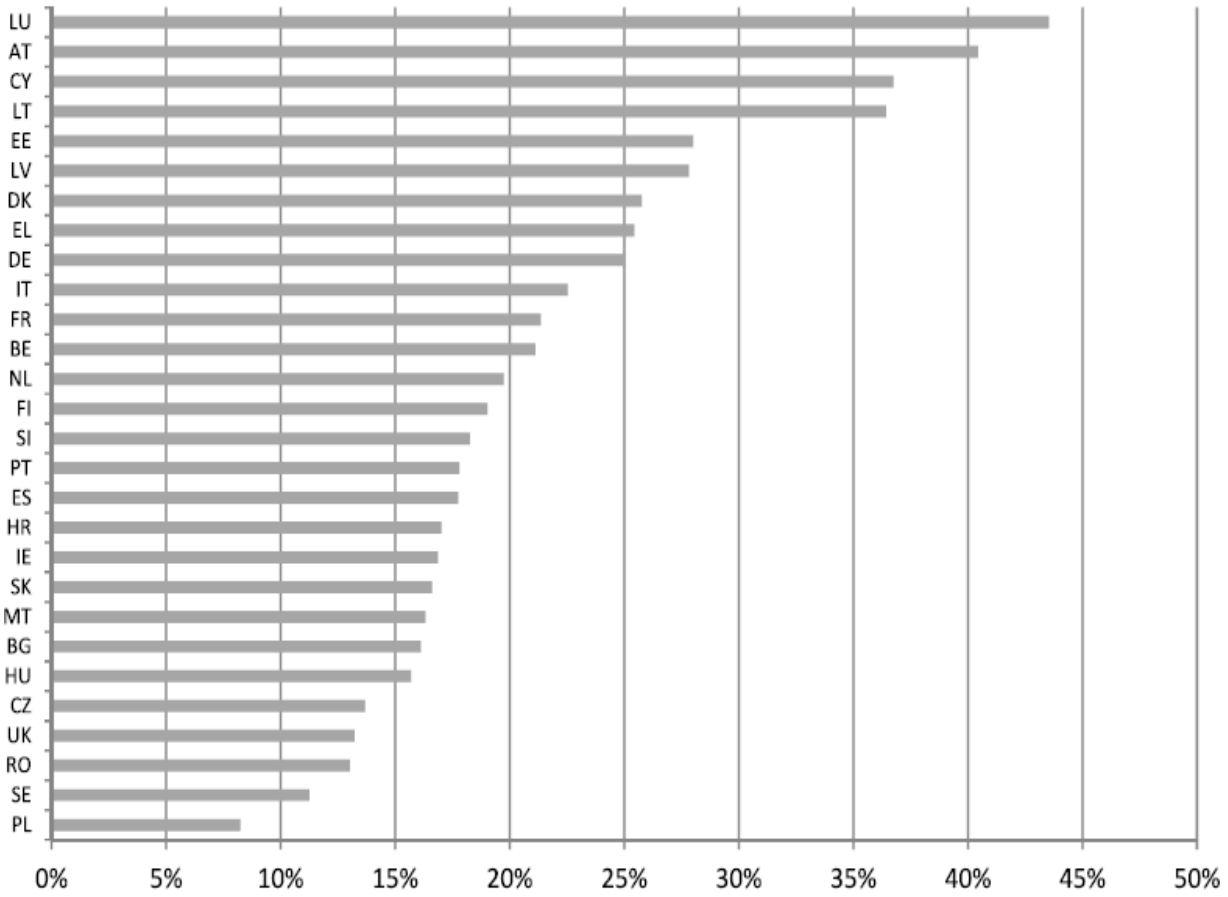

Figure 1. Share of NZEBs in the total construction market of MS (Data Elaborated from: [4] Comprehensive study of buildings)

2.2 Current EPC schemes

One of the main objectives of D^2EPC is to propose and establish dynamic EPCs (dEPCs). The project aims to introduce a common methodology for issuing dEPCs across all EU MSs, which is calculated and issued regularly in a semi-automatic manner. EPC issuing is a mandatory process in all MSs during constructing, selling or renting of buildings. Under T1.1- "*Comparative assessment of current EPC schemes and relevant emerging building performance paradigms*" both a desk and a field research was conducted, in order to gather relevant information about current methodologies followed by EU MSs [6] (Figures 2 & 3).

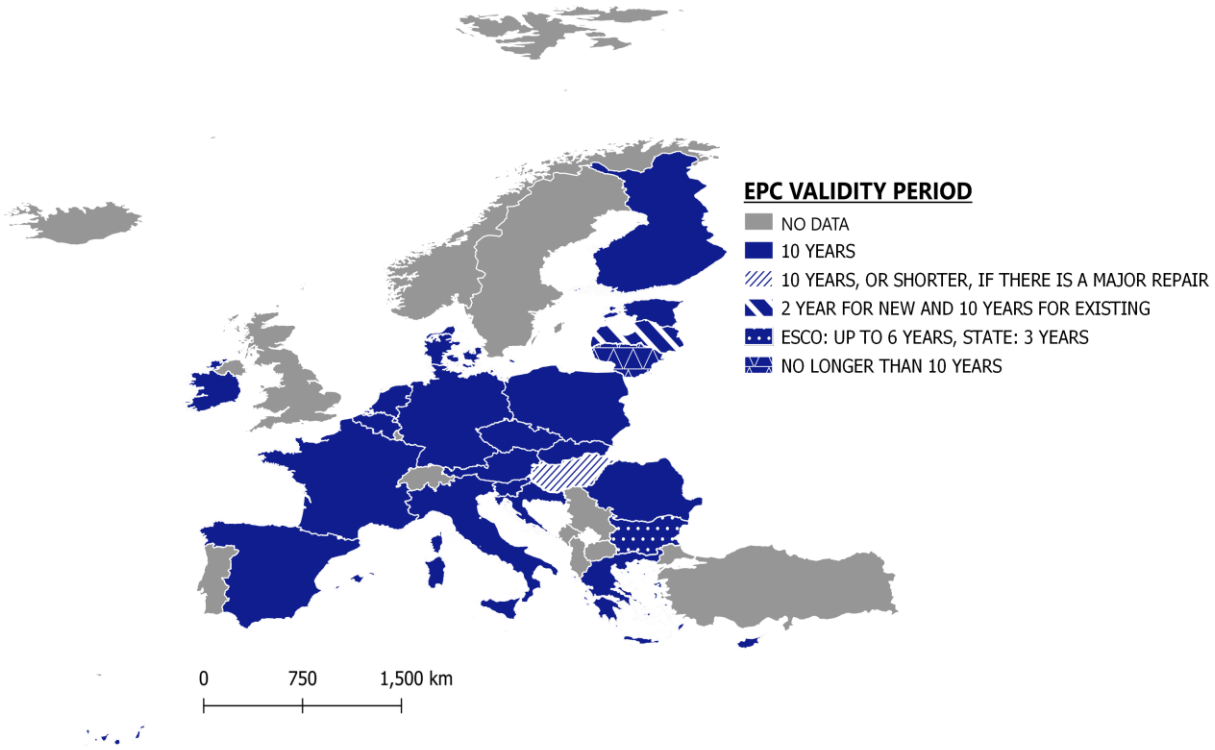

Figure 2. Validity period of current EPC schemes for EU MSs. Data elaborated from the field research [1].

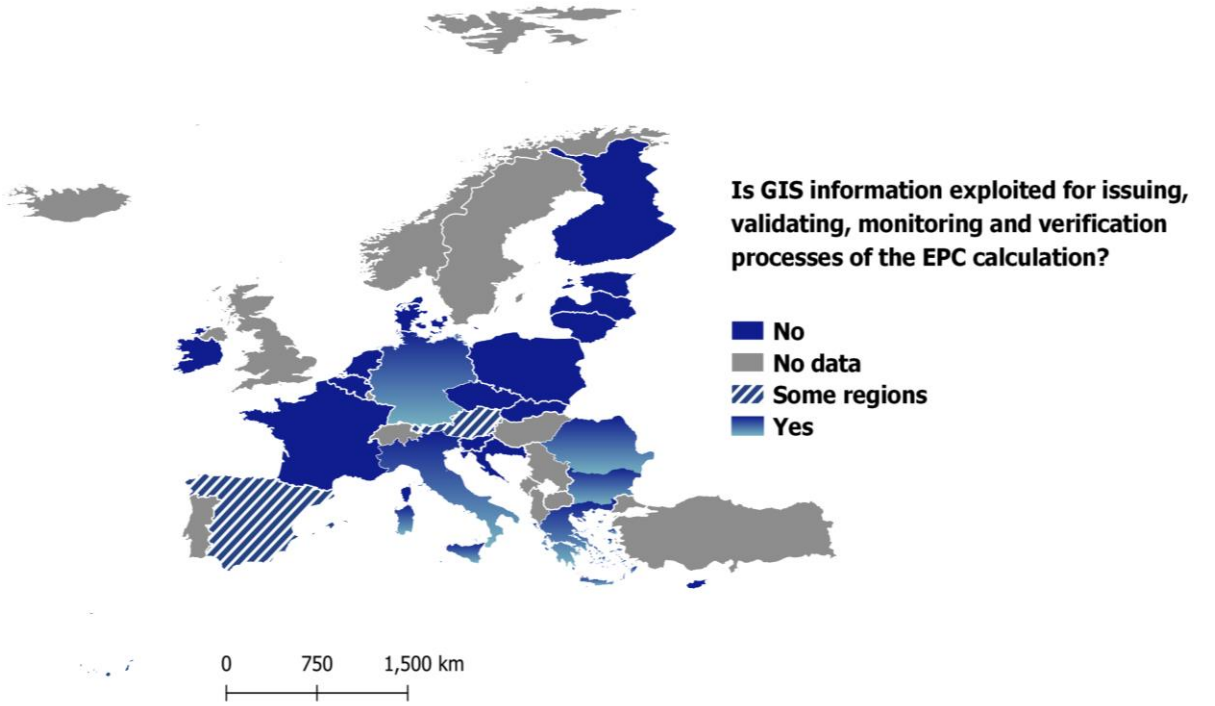

Figure 3. Use of GIS information for issuing, validating, monitoring and verification processes of the EPC calculation. Data elaborated from the field research [1].

2.3 D^2EPC WebGIS scope

Energy performance certificates provide important information about energy consumption and play an important factor in investing, renting, and buying decisions. As proposed by 2025, issued certificates must be based on a common homogenous scale of energy classes ranging from A to G. To this end, the D^2EPC framework mainly focuses on delivering an EU-based platform for issuing EPCs based on a common methodology for buildings across EU MSs. This implementation leads to the construction of a centralized database for storing these dynamic EPCs.

Centralized information of EPCs regarding important information such as the energy class/grade, the type of building/dwelling and an approximate location can be very useful for data interpretation and further analysis. Currently, based on the field and desk research undertaken during the comparative assessment of current EPC schemes (D1.1), it was identified that most MSs don't provide a point of access for (anonymised) EPC statistics[1]. The identification of this as a possible business scenario leads to the introduction of an added value service such as the D^2EPC WebGIS application for constructing and visualising EPC statistics per regions/countries.

Figure 4 displays the proposed D^2EPC architecture (as defined in D1.4 – "*D^2EPC Framework Architecture and specifications v1*). The D^2EPC WebGIS tool is an application of the representation layer and a sub-component of the overall Web Platform. The WebGIS directly connects with the Calculation Engine from where it retrieves the data about dEPC statuses. It creates the dEPC statistics by combining the asset ratings contained in the main D^2EPC repository and the spatial information to create a geospatial database. Then the geospatial data are displayed in a WebGIS application that it is integrated within the main D^2EPC Web Platform.

[1] Example for UK EPC statistics: https://www.gov.uk/housing-local-and-community/energy-efficiency-in-buildings

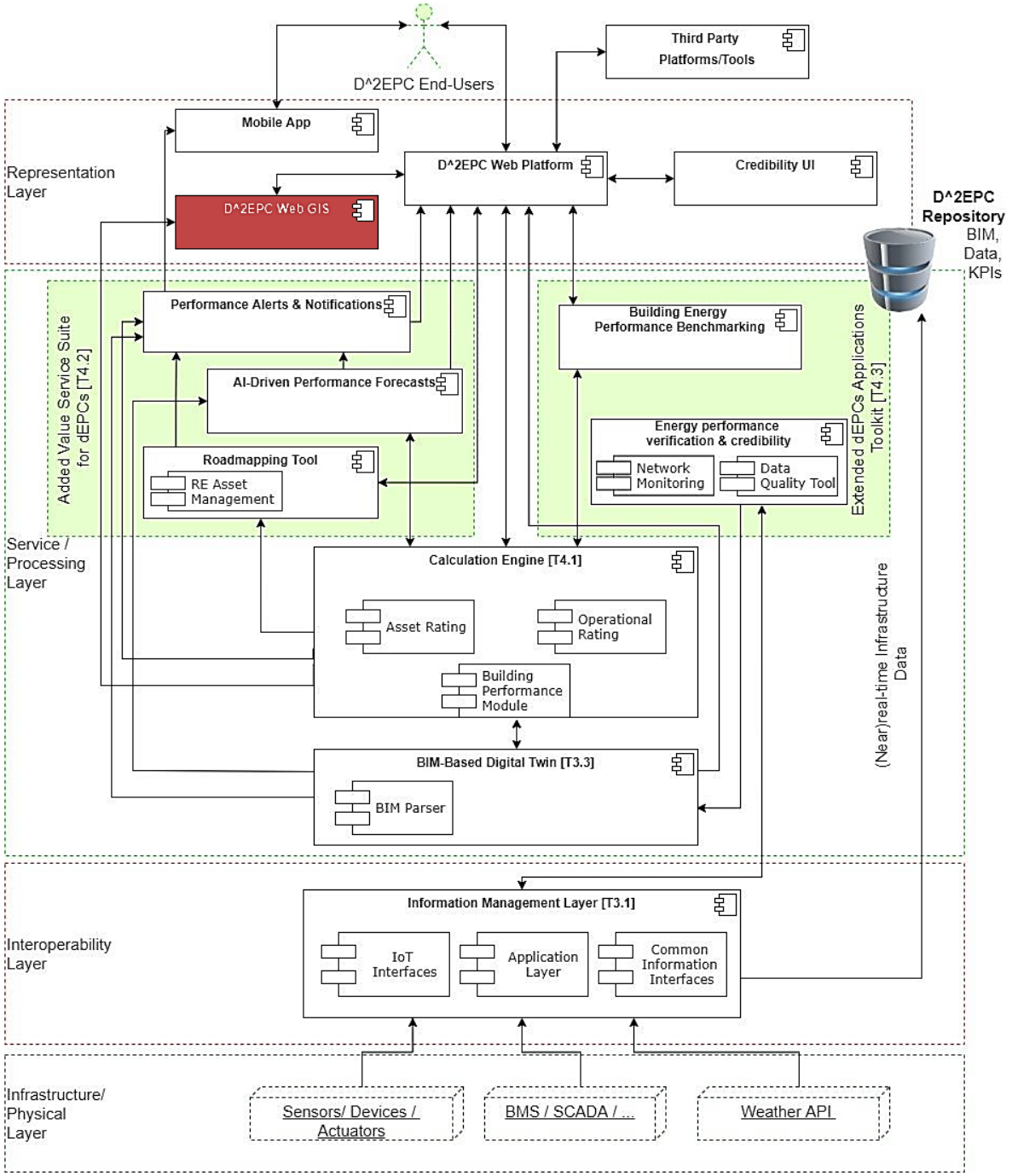

Figure 4. D^2EPC architecture version 1. The WebGIS application is part of the representation layer.

3 WebGIS design

3.1 Business scenario

To better capture the business values that the various D^2EPC framework components and applications offer, several Business Scenarios (BSs) have been deployed. Within these BSs, the Business Group C: "*Evaluation and Benchmarking of more certificates for policy making / marketing / business purposes*" was proposed for implementing added value services.

The D^2EPC WebGIS covers this BS by providing regional level EPC statistics to third party stakeholders. Based on this BS, the tool developed under this task should function as both a generator of EPC statistics –by combining geospatial data with EPCs coming from the dEPC Calculation Tool- and a visualisation platform for disseminating the generated anonymised added value information. The list of interested parties for this Tool contains several D^2EPC stakeholders such as authorities/ registries /public bodies, Energy Service Companies (ESCOs), real estate agencies, the Building services industry, researchers or academia, environmental organisations and standardisation bodies.

3.1.1 Technical use cases

The technical use cases for the WebGIS application were initially proposed during the works of T1.4. Since then and after elaborating this task some aspects of these use cases have been revised (figure 5). More specifically:

- The regional areas for the calculation for the EPC statistics used are the Nomenclature of territorial units for statistics (NUTS) [7]. The purpose of this division is to harmonise the regional statistics. The NUTS classification is provided by EUROSTAT and is a system that divides the economic territories of the EU and the UK into three levels:
    - NUTS level 0: countries
    - NUTS level 1: major socio-economic regions
    - NUTS level 2: basic regions for the application of regional policies
    - NUTS level 3: small regions for specific diagnoses

  Alongside the progress and findings of other D2EPC tasks, the inclusion of Pan-European climatic zones will also be investigated, as additional regional areas.
- The provision of real time energy performance of a building can't be considered as a functionality of the WebGIS as it may raise incompatibility issues with GDPR compliance. Therefore, the data visualisation on the WebGIS concerns only fully anonymised aggregated over regions data for statistics extraction.
- Buildings performance benchmarking is considered only for asset rating regional statistics. Third party stakeholders are able to keep track of the regional EPC grade changes over time as the dynamic EPCs are calculated via the D^2EPC calculation engine and synchronised with the WebGIS (geo-) database. In addition, the functionalities of visualising EPC ratings vs.

benchmarking percentages, regulated by each regions and EU policies, is given along with the ability of comparing EPC statistics between two regions of the same NUTS level.

- Lastly, the provision of the enriched GIS data through open standards and OGC services is provided for further research activities.

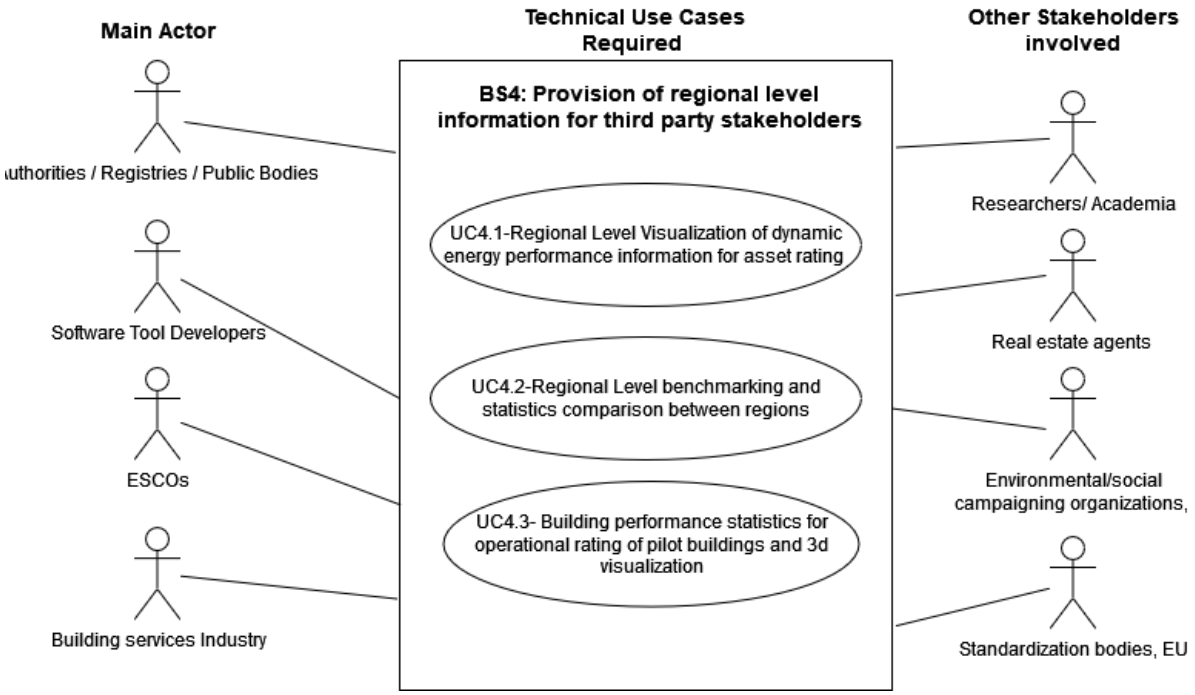

Figure 5. WebGIS technical use cases.

3.2 Functional & Non-functional requirements

The first version of the D^2EPC WebGIS functional and non-functional requirements was based on the results of the tasks T1.2, T1.3 and T1.4 during months M1-M7 of the project's lifetime. Following the Volere Methodology, the Business Scenarios and technical use cases for the WebGIS were defined, as well as four main functional & non-functional requirements.

During the next period of the project and under this task, the aforementioned requirements were slightly redefined. These changes are mainly originating from restrictions concerning GDPR compliance. More specifically:

- The regions for dEPC statistics are the NUTS regions (fixed)
- The exact location of buildings is not depicted on map (except for authenticated user and their own affiliated buildings/dwellings or public buildings)

Table 1. WebGIS functional and non-functional requirements v1.

ID	Description	Rationale	Fit Criterion	CS	CD	Priority
D2EPC-27	Visualisation of generated EPCs in a GIS environment, empowering users to perform various types of spatial and attribute queries	Need to include visualisation of EPC data in a GIS environment for the users which will also allow comparison vs the statistics of the region	Provision of a geospatial database integrated with the updated inputs	1	3	Critical
D2EPC-28	The GIS tool shall be able to make queries and analysis for regions, assisting and providing insight to policy makers	Need to provide valuable insights on buildings energy efficiency to NUTS regions which will allow policy makers to monitor and introduce further energy related policies	Access to additional descriptive data related to the building environment (approximate location, NUTS regions)	-	-	Major
D2EPC-30	The solution shall visualise buildings in a 2D mode, on a unified common coordinate system	Need to include 2D building mode and common coordinate system which will enable visualisation	Check the validity of the visualisation deriving from different sources and CRSs, ensuring minimal distortions	-	-	Nice to have
DEPC-14	The user shall be able to select between different basemaps for the 2D map/3D globe visualisation	Need to offer the possibility to the user to navigate and visualise basemaps in an effective manner	The exact functionality will be provided in the next version of the report	1	4	Medium

3.3 Architectural design

As a sub-component of the representation layer, the WebGIS tool is an application that functions as an endpoint between end users and the D^2EPC system providing data in a form to be shown on a D^2EPC portal. Through the API the application is also designed to operate independently from the D^2EPC Web platform while also being able to connect to the main repository for updating its contents. There are two ways/endpoints to access to the WebGIS:

- Through the D^2EPC Web Platform: Although the two applications mentioned above are to be deployed through separate web servers (or a single web server via virtual hosting), the main platform will provide an endpoint to access WebGIS (e.g. via the menu button/http request). Additionally, the main platform will provide an authentication token if the end user is logged in before logging in to WebGIS.
- Independently: In this way, only unauthenticated access is granted by simply requesting the WebGIS using the appropriate URL on a web browser.

The main functionalities of the WebGIS Tool are the following:

1. Produce EPC statistics per region by correlating EPCs issued by the D^2EPC framework with NUTS regions
2. Visualise the EPC statistics on a WebGIS map
3. Provide attribute and spatial querying tools
4. Provide an endpoint for data dissemination using OGC (Open Geospatial Consortium) services
5. Visualise BIM models of Pilot Cases using 3D graphics for the buildings (public) as demonstration and BIM models of buildings/dwellings provided by users (only to authenticated users) on a map

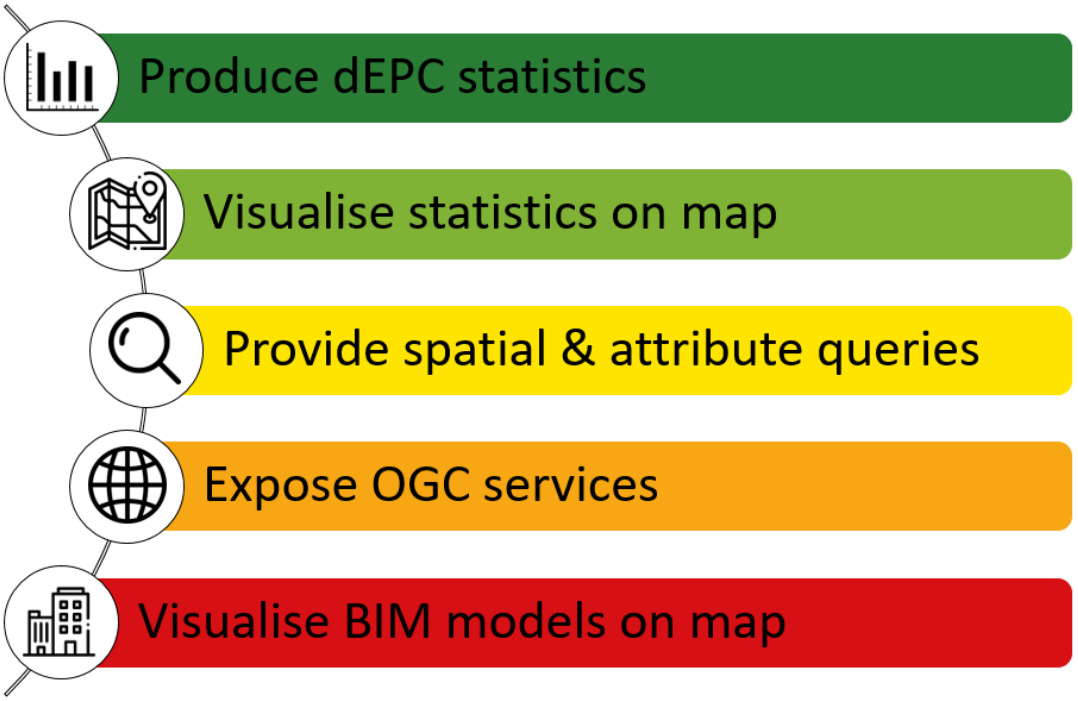

Figure 6. D^2EPC WebGIS tool functionalities.

The WebGIS tool consists of three main sub-components:

1. **Geospatial database server**
   The role of the geospatial database is to both store and handle the dynamically generated data regarding spatial information of issued EPCs as well as to enable the spatial functions required for storing, querying and processing spatial features. This database consists mainly of four tables corresponding to the four NUTS levels used and each one of them holds anonymised EPC statistics (asset rating grades) per region.
2. **OGC web server**
   This server functions as an intermediate channel between the database and the application's main web server. It serves the database tables as OGC services (WFS, WMS) to the WebGIS backend as well as to (authenticated) end users to view and analyse in external GIS applications.
3. **Web server**
   The backend of this server is responsible to update the statistics for each region (various NUTS layers) in the application's geodatabase as soon as a EPC is issued (new building), updated or deleted in the D^2EPC main database. In addition to writing to the database, the backend also retrieves the data from the database and serves them to the frontend via forming proper http requests to the OGC web server. The frontend displays the layers on a map and their corresponding statistics via visualisation tools, the BIM models using 3D graphics and the querying structure for end users to engage with the database.

To better describe the architectural design of the application, the revised functional and deployment views are given here, similar to the corresponding views depicted in D1.4. However, since the WebGIS is a web application, a sequence UML diagram is also provided here that describes the http requests and data transfers between client and server. The diagrams were designed using the online draw.io[2] tool.

3.3.1 Functional View

The Functional View depicts the architectural sub-components that deliver an application's functionalities. The sub-components are represented as functional elements based on their responsibilities and their primary interactions with other elements. Functional models express time-free and sequential execution semantics reflecting in this way the quality properties of the system. Towards describing the WebGIS Tool functional view the component diagram along with the table with the interfaces are provided. Component diagrams present the component by depicting their sub-components and their communication/interactions with other components while the tables of interfaces describe the communication between components or external services.

[2] https://app.diagrams.net/

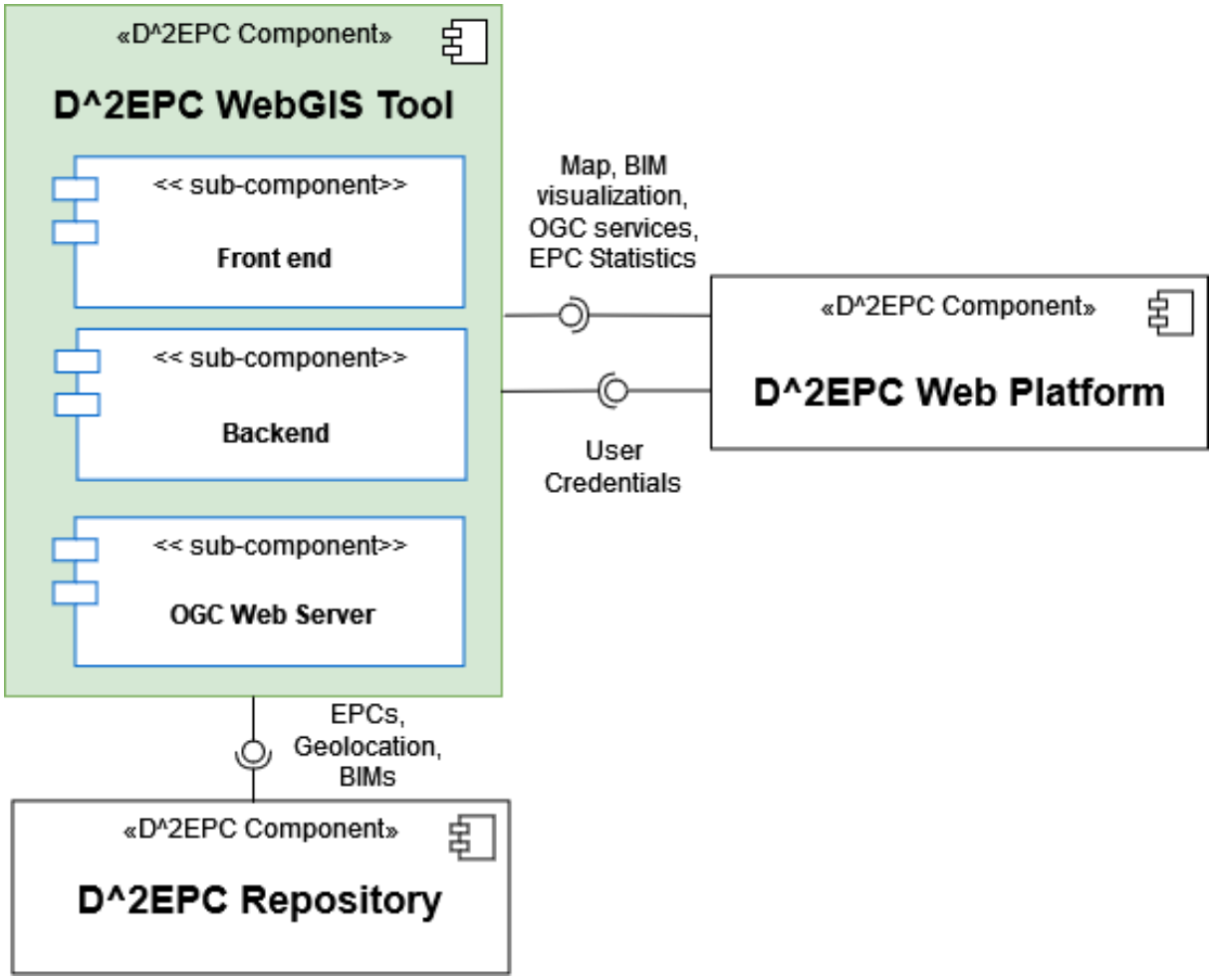

Figure 7. D^2EPC WebGIS Tool functional diagram.

Table 2. D^2EPC WebGIS Tool table of interfaces.

Interface	R/W	Description (including preliminary format and context)
Thermal Building model	R	Asset Rating EPC grade text
	R	IFC BIM Model
	R	JSON (geoJSON) or text for building location or postal code or approximate location
Querying tool	R	Query in PostgreSQL database with PostGIS extension
WebGIS	W	SW tool (web mapping server) with custom JavaScript code
D^2EPC Web Platform	W	Provide results visualisation to be delivered to the end user
	R	Logged in user credentials

3.3.2 Deployment view

Deployment diagrams are UML diagram types that show the execution architecture of a system or application, including nodes of hardware and software execution environments as well as the middleware components connecting them. Deployment diagrams visualise the hardware processors/ nodes/ devices of a system, the links of communication between then and the placement of software files on that hardware.

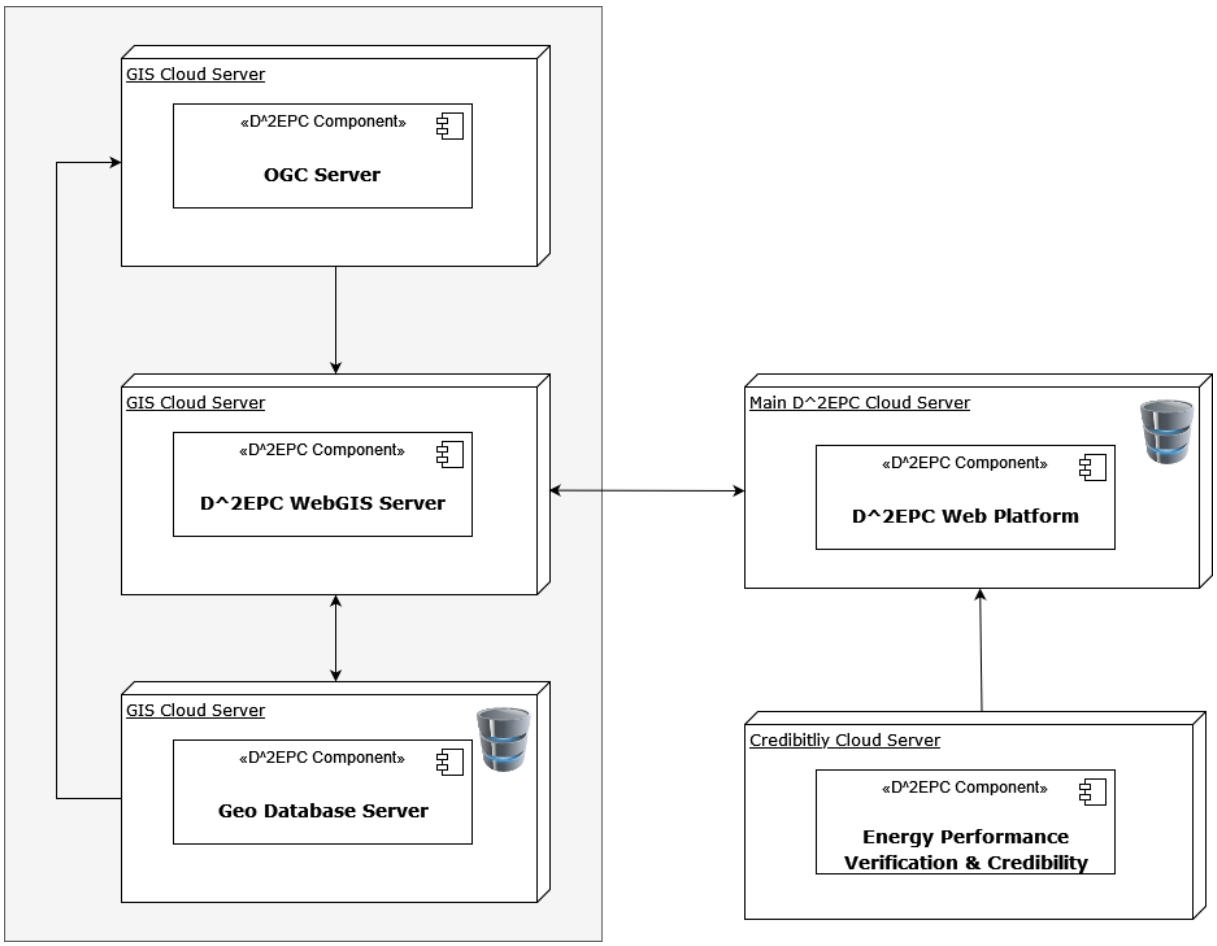

Figure 8. D^2EPC WebGIS Tool deployment diagram.

3.3.3 Sequence diagrams

UML sequence diagrams (also known as event diagrams) are used to depict object interactions arranged in time sequence. Usually, a sequence diagram focuses on a usage scenario and displays the objects involved in this scenario as well as the sequence of messages exchanged between the objects needed to carry out the required from the system functionality. Sequence diagrams show processes or objects that live simultaneously as parallel vertical lines and the messages exchanged between these processes as horizontal arrows.

Towards describing the D^2EPC WebGIS data transferring three event diagrams are provided here based on the equivalent three main interactions between end users and the WebGIS application.

3.3.3.1 Sequence diagram 1: Render Web Map

The most important feature of the application is the view of the calculated statistics in the GIS environment. Firstly, in order to access the tool, end user has to either enter the main D^2EPC Web Platform -insert their credentials for authenticated access- and select choose the WebGIS application or simply access it using the URL (TBD). The WebGIS front end retrieves the WFS vector layers containing regions and their corresponding features from the OGC Server which in turn has formed the WFS from the data contained in the geo DB. This data provision is an asynchronous call to the backend. The WebGIS return the vector layers as well as the rest of the application - WMSs for map base layers and HTML components.

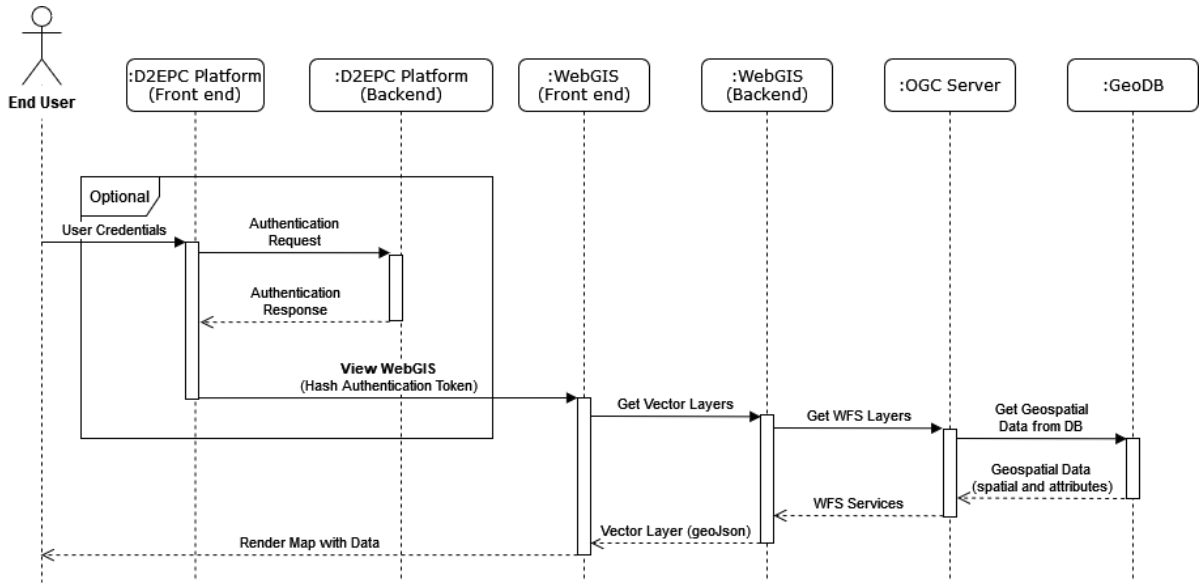

Figure 9. Sequence diagram 1: View of the WebGIS.

3.3.3.2 Sequence diagram 2: EPC statistics visualisation & querying

Following the rendering of the WebGIS map on the client device the services of visualising the EPC statistics and querying are provided. The data are already provided by the sequence of calls to the backend, OGC server and geo DB. This improves the user experience as it minimizes the application's response times for accessing the requested data. Querying requests take place in the front end of the application avoiding in this way further data transmitting between client and server. The visualisation of the EPC statistics is provided by front end functions and libraries that display data using plots. Lastly, the application provides links to the WFSs coming from the OGC server that can be used for viewing and analysing data in external GIS tools (e.g. QGIS) and in http client environments.

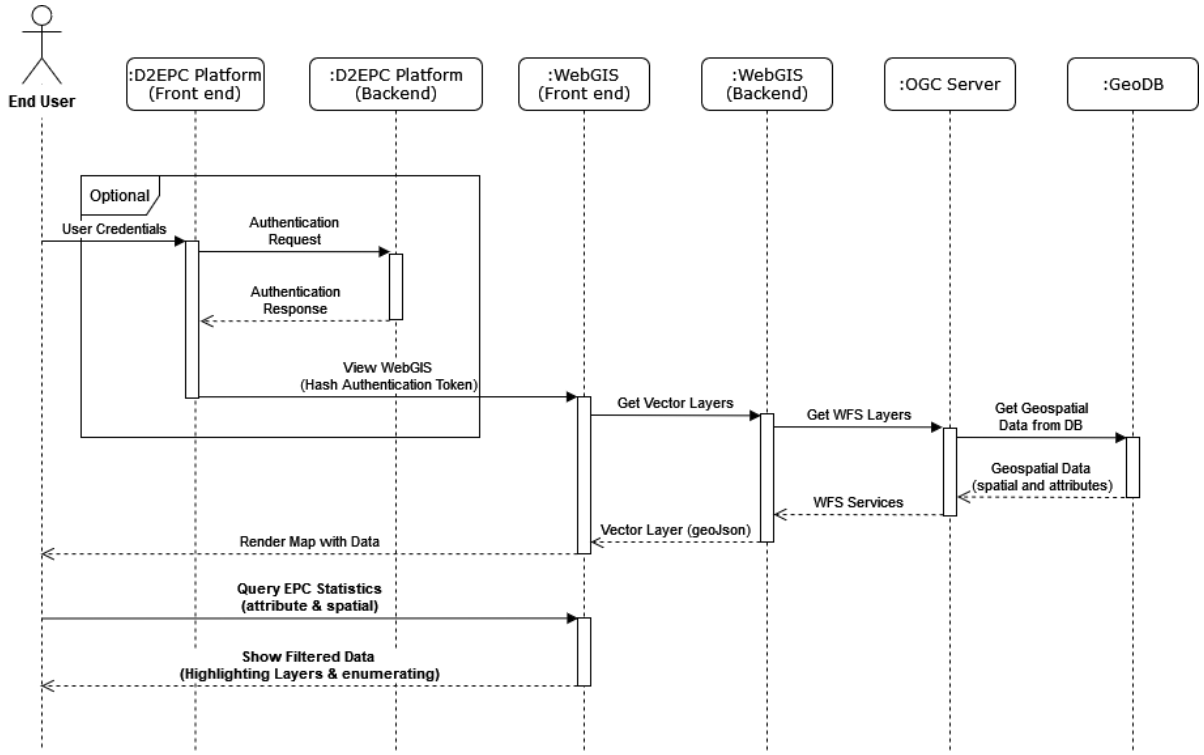

Figure 10. Sequence diagram 2: EPC statistics visualisation and querying.

3.3.3.3 Sequence diagram 3: BIM visualisation

The third use case scenario for end users is the 3D BIM visualisation. Similarly, to the above two use cases, end users enter the application through D^2EPC main platform or via the URL. However, users who haven't logged in using an account are restricted to visualisation of 3D BIM models that are free to access by anyone. These models include at least some of the pilot buildings only (TBD). Authenticated users can visualise proprietary buildings according to the policy that will be decided by the consortium and also see how these compare against other buildings in the same region in terms of energy performance.

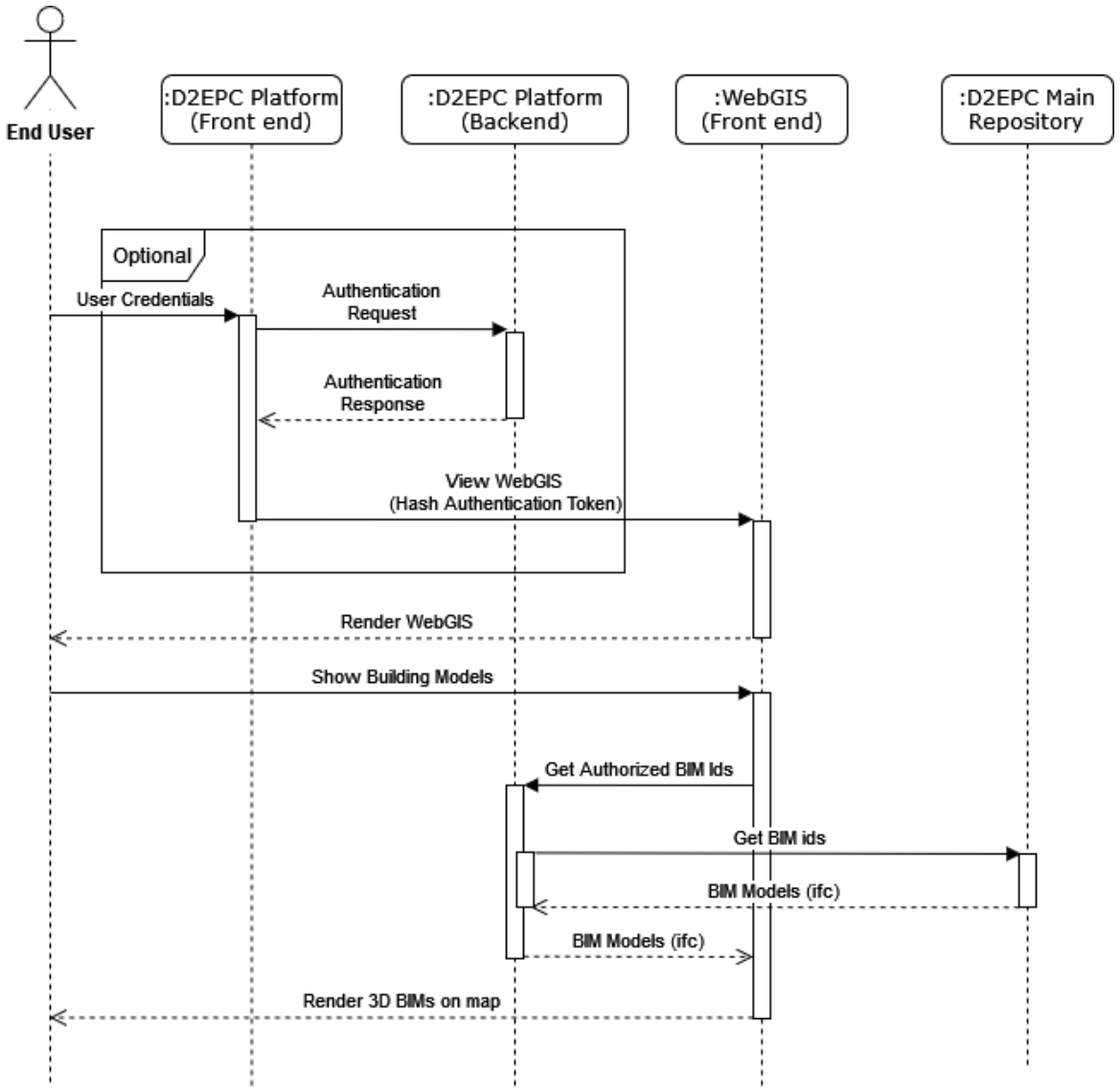

Figure 11. Sequence diagram 3: Visualisation of BIMs.

4 Implementation & technologies

This chapter concerns the implementation and technologies used to implement the architecture thoroughly described in chapter 3. As mentioned earlier, the WebGIS application consists of three main components: 1) A database server, 2) A geospatial web server, 3) The application which is hosted on another web server and can further split up to front and back end.

For the implementation of the WebGIS application only free and open source libraries/tools have been utilised. The following paragraphs narrate which tools are selected, the reasons that led to choose them and briefly discuss how they function. Figure 12 displays the "deployment view" of the application including the most important technologies and libraries utilised for each component.

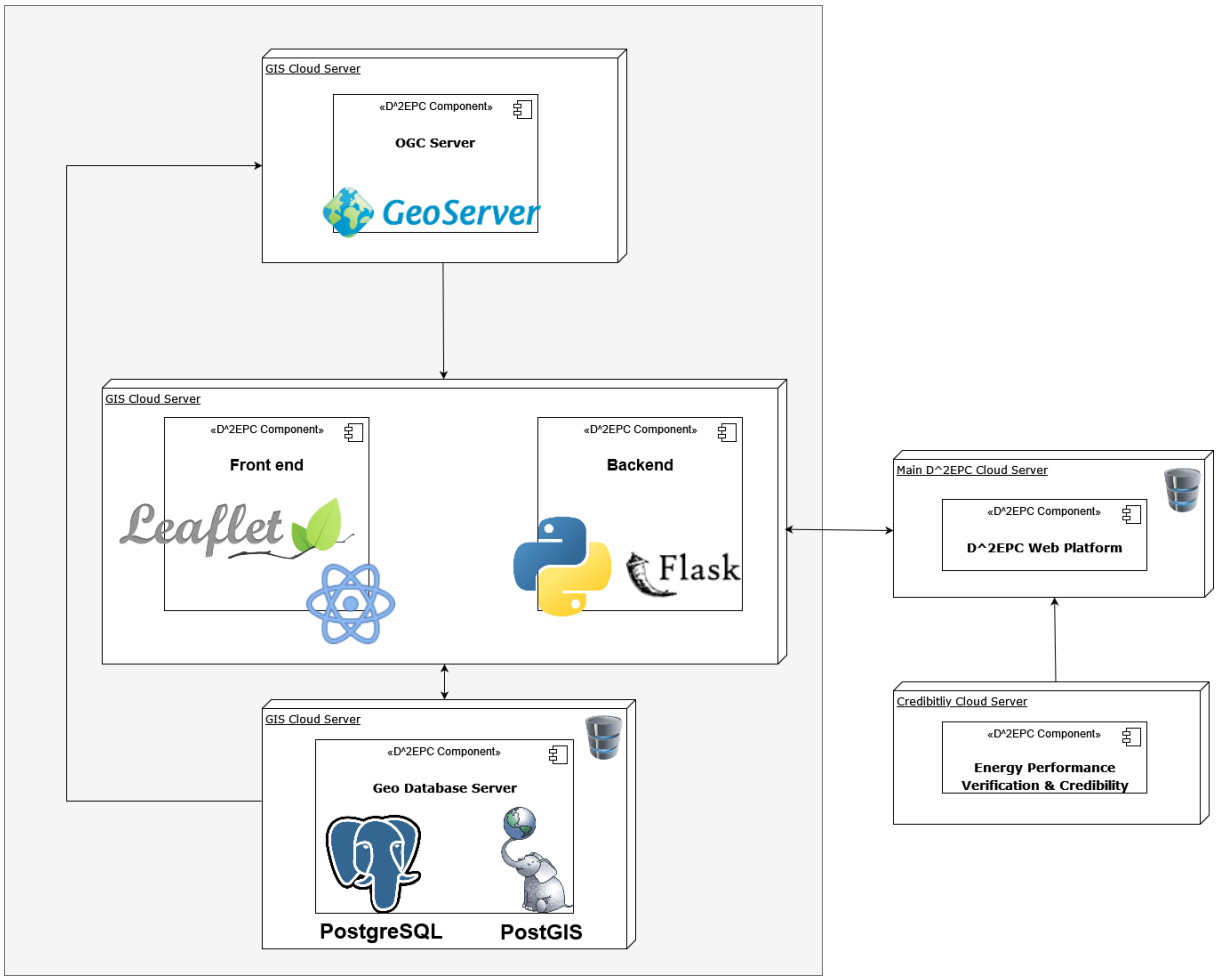

Figure 12. D^2EPC WebGIS Tool's technology stack.

4.1 WebGIS database

The WebGIS application incorporates the open-source RDBMS PostgreSQL[3] for storing and handling data. PostgreSQL (also known as 'Postgres') is a reliable database system with over 30 years of active development release released under the PostgreSQL License, a liberal Open Source license (see Annex A). For handling the geospatial data, the geospatial extension of PostgreSQL, PostGIS[4] is deployed. PostGIS is a spatial database extender that adds support for geographic objects allowing location queries and many other geographic functions to be run in SQL. PostGIS is released under the GNU Public License (GPLv2[5]).

The WebGIS geoDB utilizes a PostGIS extension enabled DB along with four main tables, each one corresponding to the four NUTS regions provided by Eurostat chosen to host the dEPC statistics. The columns of table contain the main features of NUTS (id, country & level code, nuts name and nuts name Latin etc.), the geometry attributes (polygon geometry and centroid) and the total number of EPCs issued per grade (A-F) and region. The geospatial attributes are saved and processed using the PostGIS extension in WKT format and in CRS EPSG:4326[6]. The EPC statistics are produced by accessing the (approximate) location and energy class from D^2EPC Repository's DB and using the PostGIS function ST_Contain to allocate the energy class of a building/dwelling to the corresponding NUTS region. The WebGIS backend automatically updates the PostgreSQL database in case of insertion, deletion or update of an EPC asset rating.

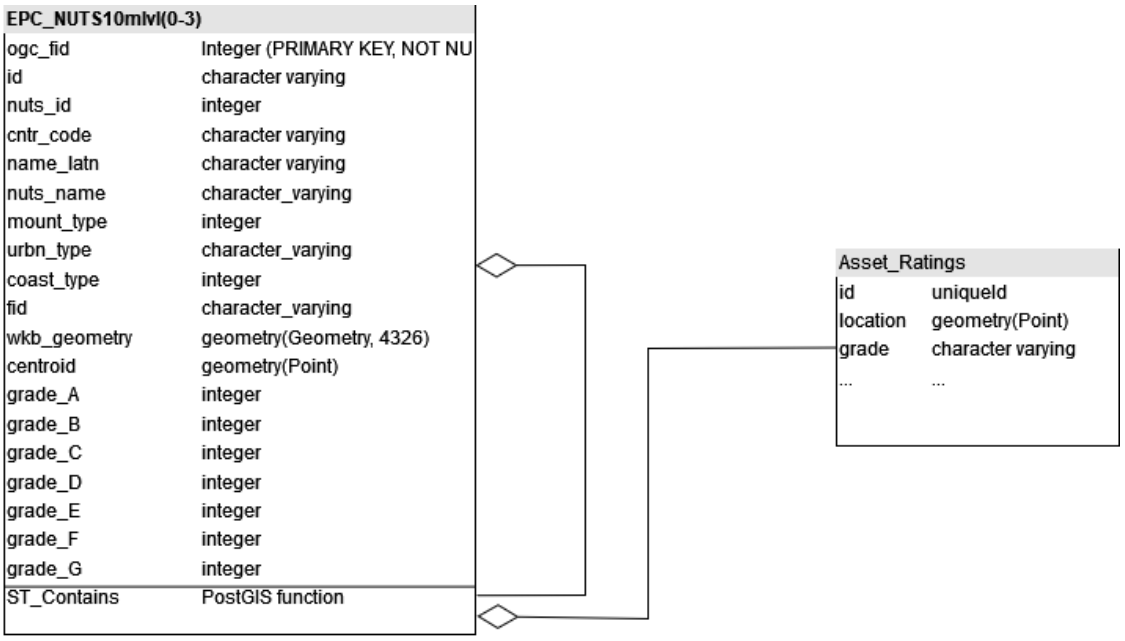

Figure 13. WebGIS DB Table schema for EPC statistics.

[3] https://www.postgresql.org/

[4] https://postgis.net/

[5] https://opensource.org/licenses/gpl-2.0.php

[6] https://epsg.io/4326

4.2 OGC Server

Towards optimizing the dissemination and map creation for the data contained in PostgreSQL the WebGIS tool utilizes Geoserver[7]. Geoserver is a Java-based server that allows users to view and edit geospatial data using open standards set forth by the Open Geospatial Consortium (OGC). The program is released as free software under GNU General Public License Version 2.0 (Annex B).

Within WebGIS application, Geoserver is utilized as a middleware application by connecting the WebGIS back and front end with the geospatial DB. Geoserver creates OGC services namely WFS, WMS and WMTS for displaying data coming from the PostGIS DB. The advantages of using Geoserver over connecting directly the backend with the DBMS are many: use of OGC services, CRS handling, tile caching, security features and of course ease of use. Geoserver offers, among others a GUI for the handling, storing and configuration of geospatial datasets (see example in figure 14). Lastly, Geoserver functions as an OGC service creator for viewing and analysing the data on external GIS tools. Formats supported from Geoserver are:

- WMS: AtomPub, GIF, GeoRSS, GeotTiff, GeoTiff 8-bits, JPEG, JPEG-PNG, JPEG-PNG8, KML (compressed), KML (network link), KML (plain), OpenLayers, OpenLayers 2, OpenLayers 3, PDF, PNG, PNG 8bit, SVG, Tiff, Tiff 8-bits, UTFGrid
- WFS: CSV, GML2, GML3.1, GML 3.2, GeoJSON, KML, Shapefile, text/csv

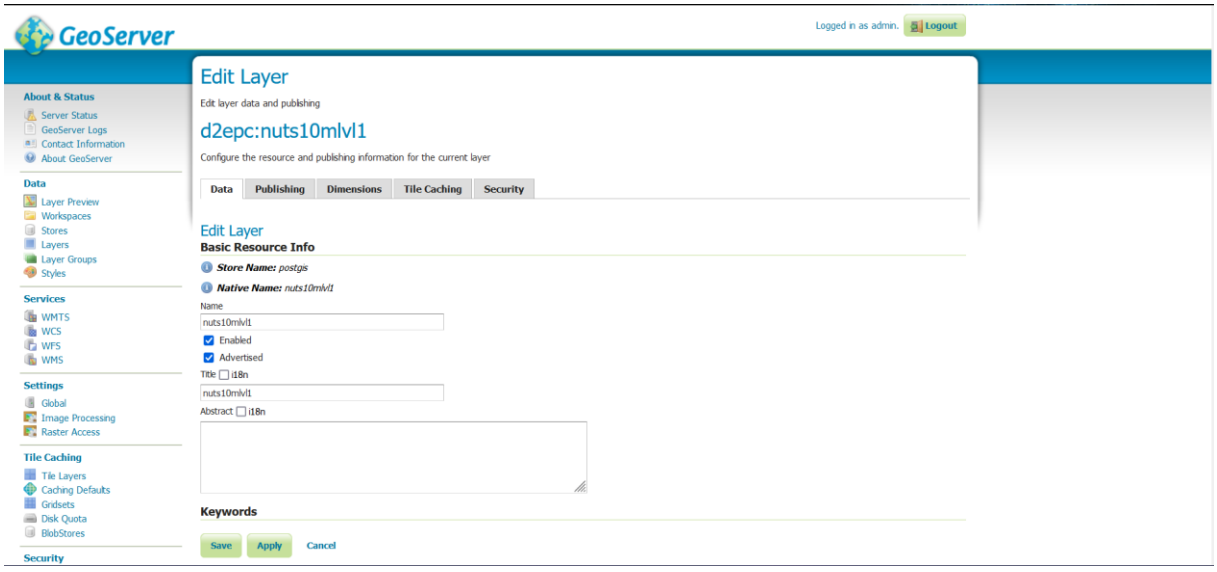

Figure 14. Settings editing for NUTS10mlvl1 of EPC statistics in Geoserver.

[7] http://geoserver.org/

4.3 Backend

The WebGIS tool's backend implements the connection of the front end with the PostgreSQL and the Geoserver. The backend utilises the OGC services forwarded by Geoserver using Python3[8] which is release under the Python Software Foundation License Agreement (ANNEX C) and Flask[9] licensed under the Clause Source License (ANNEX D) as an API service provider. Python is one of the most popular backend programming languages offering highly scalability, an extensive standard library and a wide variety of third-party libraries and frameworks. Flask is a lightweight WSGI web application framework with little to no dependencies to external libraries (micro-framework) and can support the creation of both small and bigger commercial websites.

In addition, for the connection of Python to PostgreSQL and the usage of spatial functions provided by the PostGIS extension the python packages SQLAlchemy[10] and GeoAlchemy2[11] have been used. Both libraries are open-source and released under the MIT License (Annex E, Annex F). SQLAlchemy provides both a SQL toolkit and Object Relational Mapper (ORM) that supports the developers with the full power and flexibility of SQL. GeoAlchemy2 is a library that provides extensions to SQLAlchemy for working with spatial databases and fully supports the PostGIS extension of PostgreSQL.

4.4 Front-end

The application's front-end is developed using HTML5, CSS3 and JavaScript (JS). More specifically the user interface is built using the React[12] JS framework (MIT License, Annex G). React is one of the most popular JS frameworks and it is developed by Facebook. React is declarative meaning it efficiently updates and renders just the right components when data changes and is based on components which when combined accordingly create complex UIs.

The WebGIS map is implemented using one of the most widely used web mapping libraries Leaflet[13]. Leaflet in an open-source JS library released under the BSD 2-Clause "Simplified" License (Annex H). Leaflet is designed with simplicity weighing only 39KB, it has a well-documented API and works efficiently across all major desktop and mobile platforms. In addition, it provides numerous third-party plugins covering most mapping features.

[8] https://www.python.org/

[9] https://flask.palletsprojects.com/en/2.0.x/

[10] https://www.sqlalchemy.org/

[11] https://geoalchemy-2.readthedocs.io/en/latest/

[12] https://reactjs.org/

[13] https://leafletjs.com/

4.5 WebGIS deployment and integration

The core of the WebGIS application, namely the back and front end, are deployed using the Nginx[14] Web Server. Nginx is one of the most widely used Web Servers which is also can be used as a reverse proxy and load balancer and it distributed as open source under the terms of the 2-clause BSD license (Annex H). For the code development, a GitLab[15] instance was installed on the physical server for issue tracking and version control.

Towards deploying the WebGIS application to the main D^2EPC Platform and ensure the interoperability with the host OS the Docker Engine[16] is used. Docker Engine is an open source containerization technology for building and deploying applications that can easily re-installed and run on any platform. Docker Engine is licensed under the Apache License[17]. The WebGIS application is deployed using 3 Docker containers, each for every sub-component, namely the PostgreSQL, the Geoserver and the web application along with the Nginx Web Server.

[14] https://www.nginx.com/

[15] https://about.gitlab.com/

[16] https://docs.docker.com/engine/

[17] https://raw.githubusercontent.com/moby/moby/master/LICENSE

5 WebGIS functionalities and user manual

This chapter narrates the functionalities provided by the D^2EPC WebGIS application based on the use cases described in chapter 3. A full description for the UI of the application is provided which can be also used as a basis for the respective user manual. However, it should be noted that not all front-end components are finalised, and these may change slightly in terms of non-functional aspects and "use & feel" attributes. Furthermore, the whole application may be subject to some mainly minor changes, as the project progresses and in the context of Continuous Integration/ Continuous Development established by the consortium members (T4.4).

5.1 Homepage

The WebGIS tool is a Single Page Application (SPA). SPAs are websites that interact with users by dynamically rewriting the current web page with new data from the server. This feature avoids the need to load entire new pages by the web browser resulting in faster transitions while promoting a native app feel for the website. The homepage of the application displays the initial or home view of the map, zoomed to fit the EU MSs.

The upper part of the homepage features a horizontal bar consisting of the D^2EPC WebGIS logo, an area for displaying data deriving from the map (e.g. region name on hover) and an additional area for showing the time and date of the last issued EPC and the total number of dEPCs issued by the platform. On the footer area, there is the EU funding abbreviation and a link to the main D^2EPC Website.

The main area of the application consists of the navigation tool bar on the left and the map on the right.

Figure 15. D^2EPC WebGIS homepage.

5.2 Change of NUTS levels

The dEPC statistics are provided in four NUTS levels provided by Eurostat. By default, on the home view and initial zoom level the NUTS regions level-0 (countries) are shown on the map. However, the functionality of changing the level displayed on the map according to the current zoom level is provided (Table 3).

Figure 16. View of NUTS level-1 regions over France on zoom level 6.

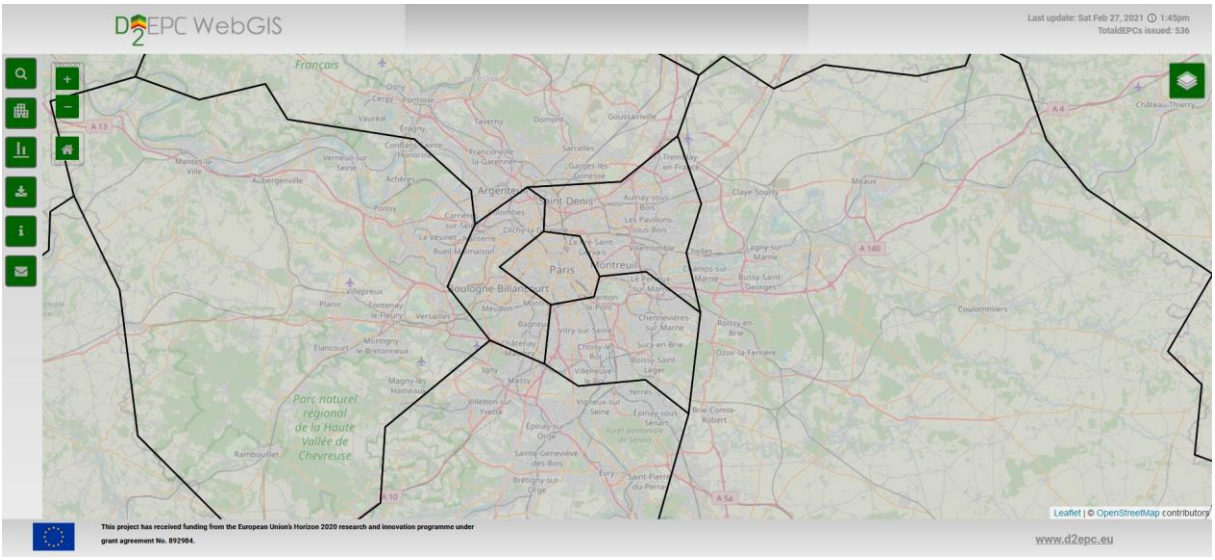

Figure 17. View of NUTS level-3 regions over Paris on zoom level 10.

Table 3. NUTS levels - zoom levels matching.

Layer	Zoom Levels
NUTS level 0	1-4, (4 initial zoom)
NUTS level 1	5-7
NUTS level 2	8-9
NUTS level 3	10-19 (19 max. zoom)

5.3 EPC statistics view

For the dEPC statistics view for a region of interest, the user can select the polygon simply by clicking it on the map. The statistics are displayed on a pop-up box on the right-hand side of the map as a pie chart plot and the selected polygon alternates its colour to notify that it is selected. Hovering over a part of the pie chart also displayed the absolute number of buildings belonging to each EPC grade. Lastly, the pop-up box automatically updates its context as soon as another region gets selected, and the fill colour of the polygons are changing accordingly.

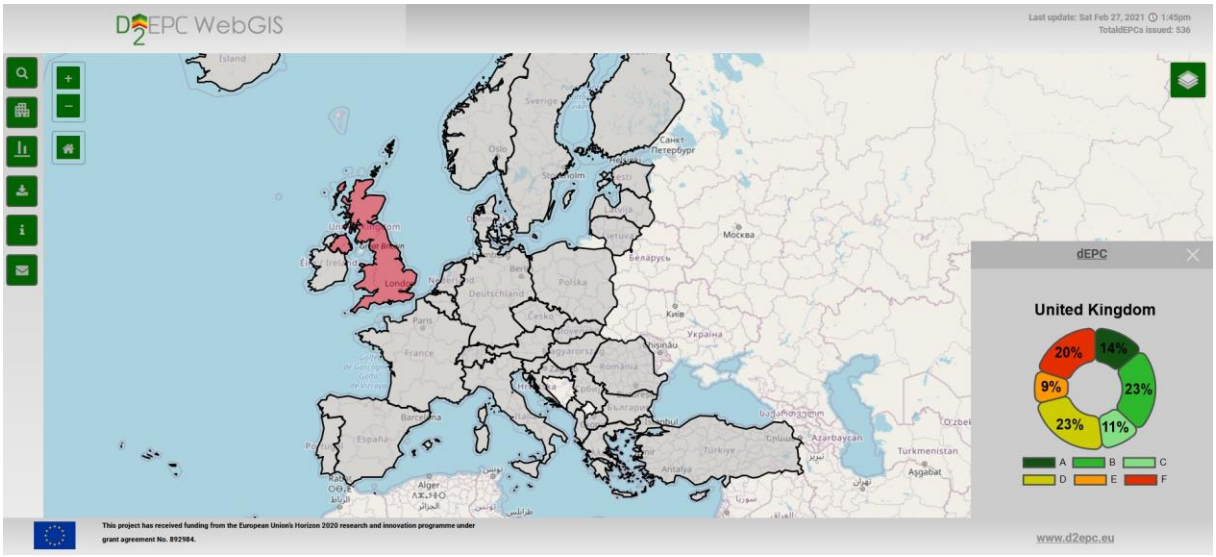

Figure 18. View of dEPC statistics over

5.4 EPC Comparison

By selecting the EPC Comparison button from the button navigation bar located on the left hand side of the website, end users are able to select two regions of the same NUTS level in order to compare them. The result is shown as a bar plot diagram on the right part of the site and above the map. The selection of the first region is the basis for the comparison while the second region can be updated. Similarly, to the pie chart for the statistics of a single region, hovering over the bar plot lines displays the total number of buildings belonging to each energy class.

Figure 19. EPC statistics comparison between two regions of the same NUTS level.

5.5 Queries

Choosing the button for queries from the toolbar results in opening a new window on the left side of the page. The users are able to choose either by a region name (spatial querying) or by EPC statistics conditions (attribute querying). The user must firstly choose the NUTS level for which the region of interest belongs to. In order to provide further help, hovering above the 4 NUTS levels displays the brief description for each as given by Eurostat. The selection of the level also displays the level on the map and disables the automatic change based on the zoom level.

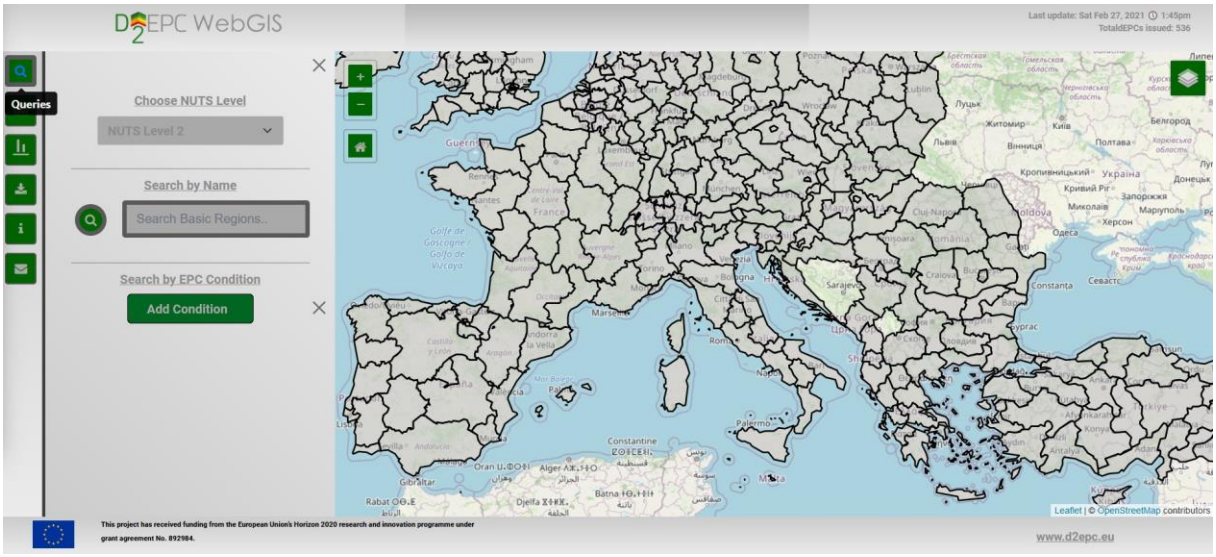

Figure 20. The querying tool box.

5.5.1 Spatial Queries

Writing the name of the region (e.g. Bretagne) on the search box and selecting the search button triggers the "fly-to" event on the leaflet map and opens the pop-up box containing the dEPC statistics for the region.

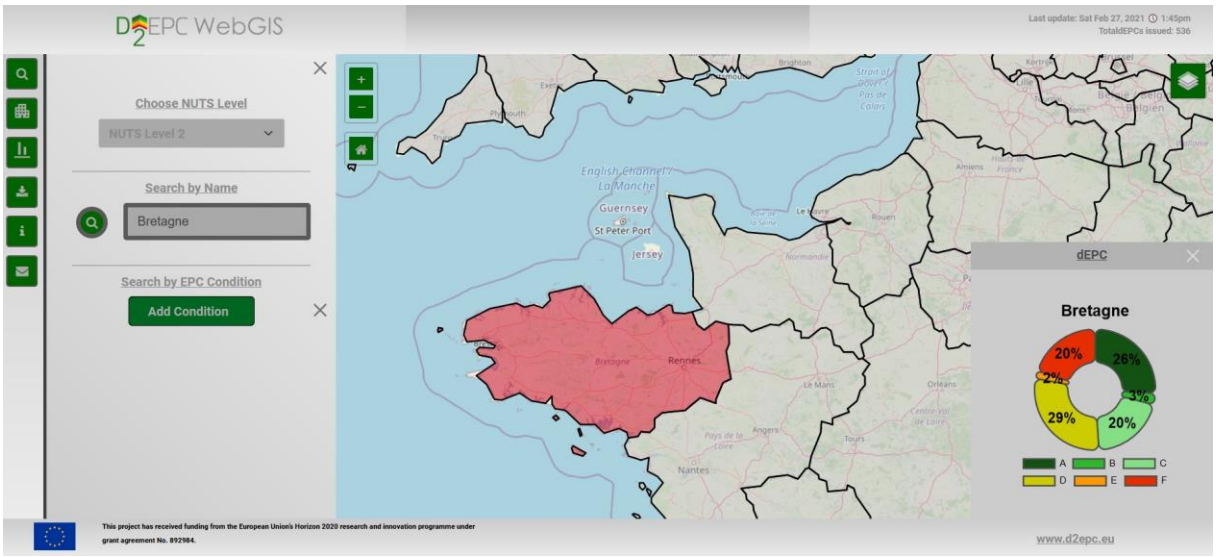

Figure 21. Viewing dEPC statistics for selecting region using spatial querying.

5.5.2 Attribute Queries

In addition to the spatial queries, the users are provided with the functionality of building complex attributes queries and visualise the results on the map. Under the “Search by EPC Condition” area, the button “Add Condition” sets a new condition using a dropdown list (A≥, A<, B≥, B<, …). The percentage for each condition is set through sliding a horizontal bar. The creation of complex mathematical expression is given by combining multiple condition and using the logical operators and/or. The results of the queried areas are also displayed in the bottom part of the querying toolbox in the form of HTML table.

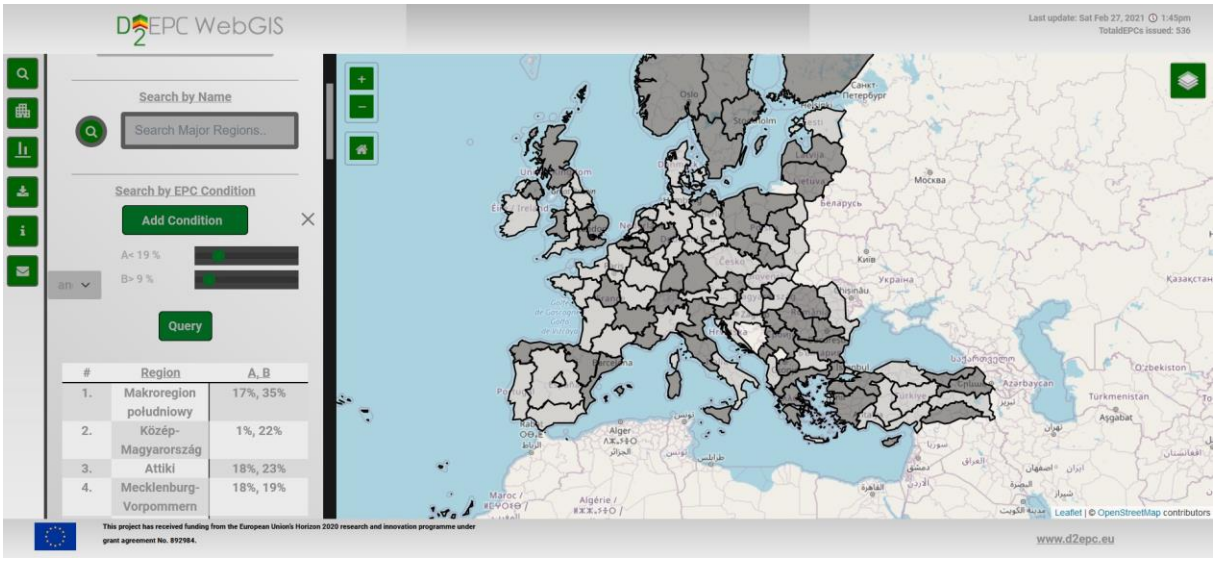

Figure 22. Example of attribute query.

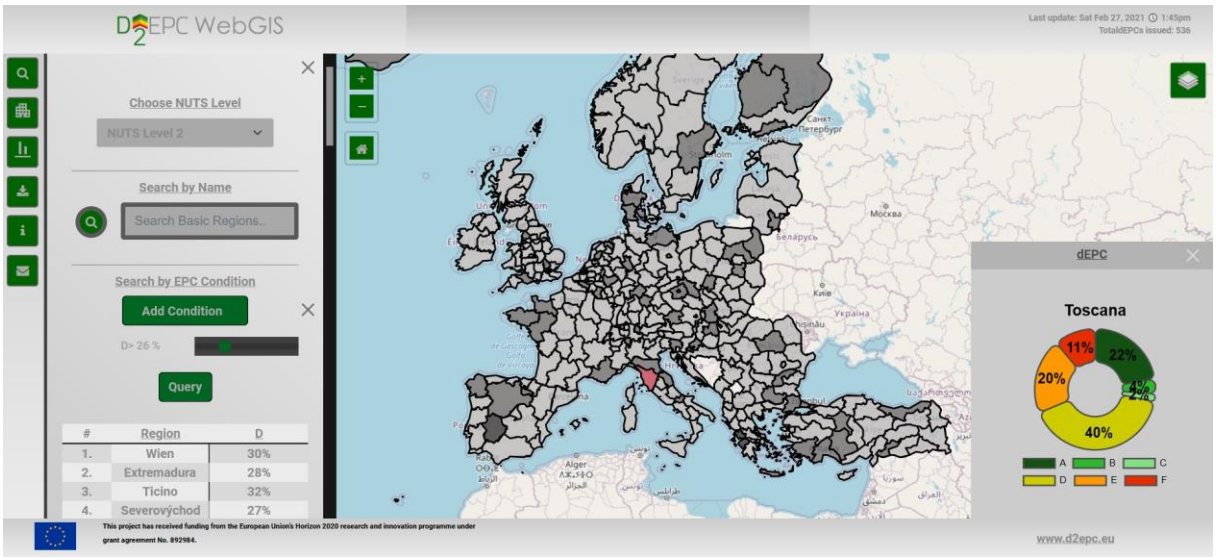

Figure 23. Example of attribute query and selection of region for visualising statistics.

5.6 BIM Visualisation

The BIM visualisation button of the toolbox (figure 23) provides a dropdown list of the available buildings for 3D visualisation. These include the pilot case buildings as well as the end-user's uploaded files. Selecting a building from the dropdown list triggers the "fly-to" feature on leaflet map and selecting the marker starts the 3d rendering of the building (figure 24). The BIM model is fully interactive, providing the users to view various aspects of the building through clicking on them.

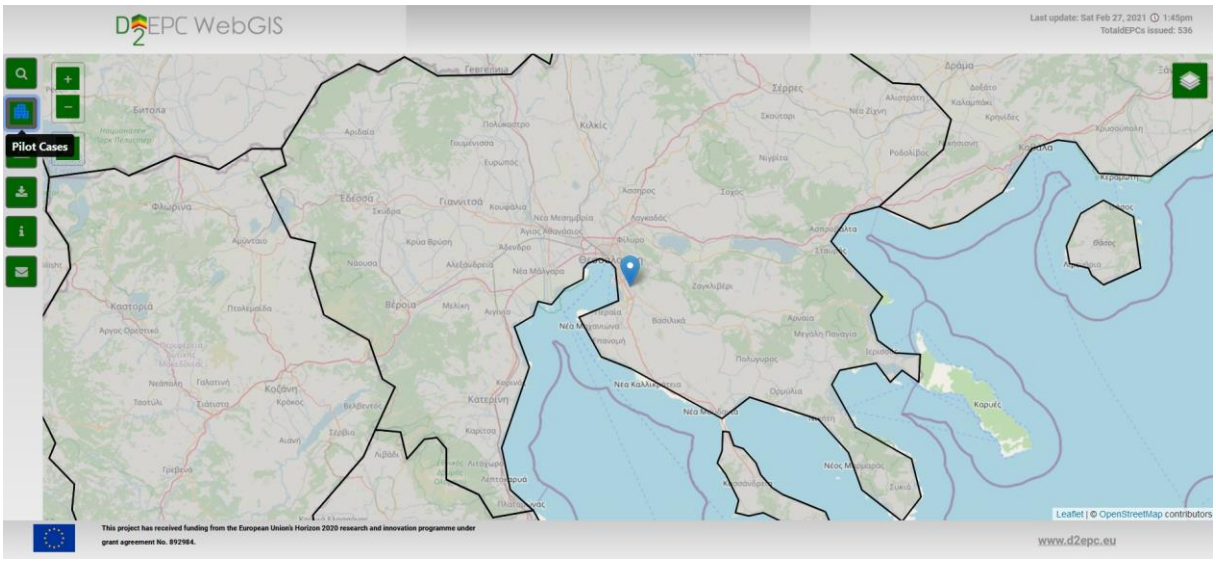

Figure 24. Position on map (2D) of a pilot case building.

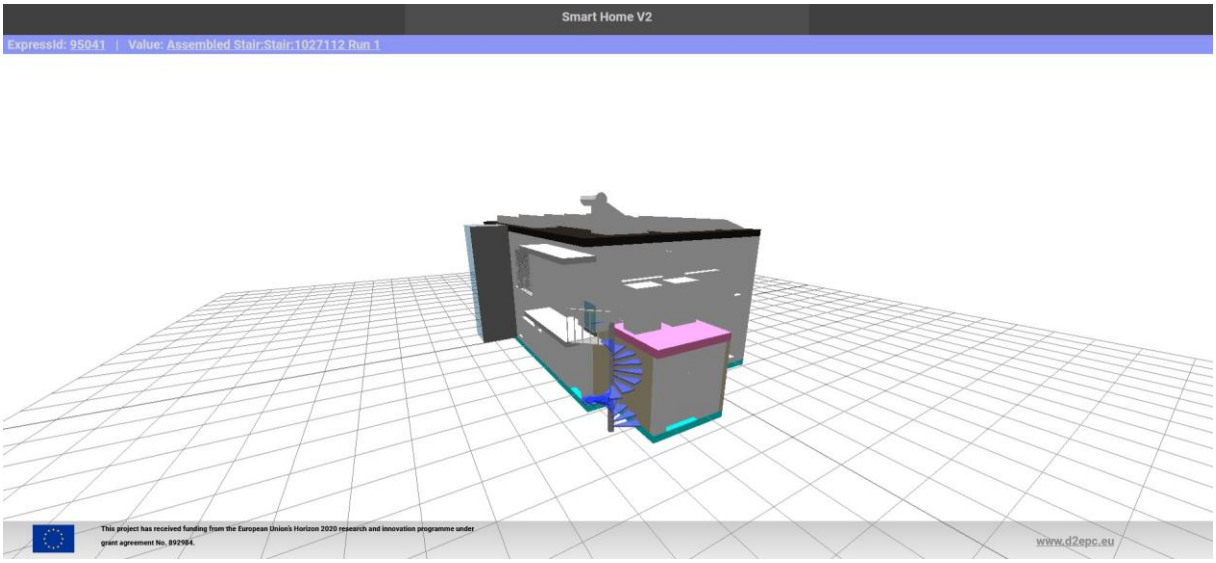

Figure 25. 3D fully interactive visualisation of a pilot case building's BIM.

5.7 OGC Services

The D^2EPC WebGIS provides the service of disseminating OGC services to third party applications. Choosing the appropriate button from the left toolbar, the service links for the vector layers generated by D^2EPC and hosted by the OGC server. Inserting these links on a third party GIS tool (e.g. QGIS), gives the users the ability to view and analyse the data in their tools of choice.

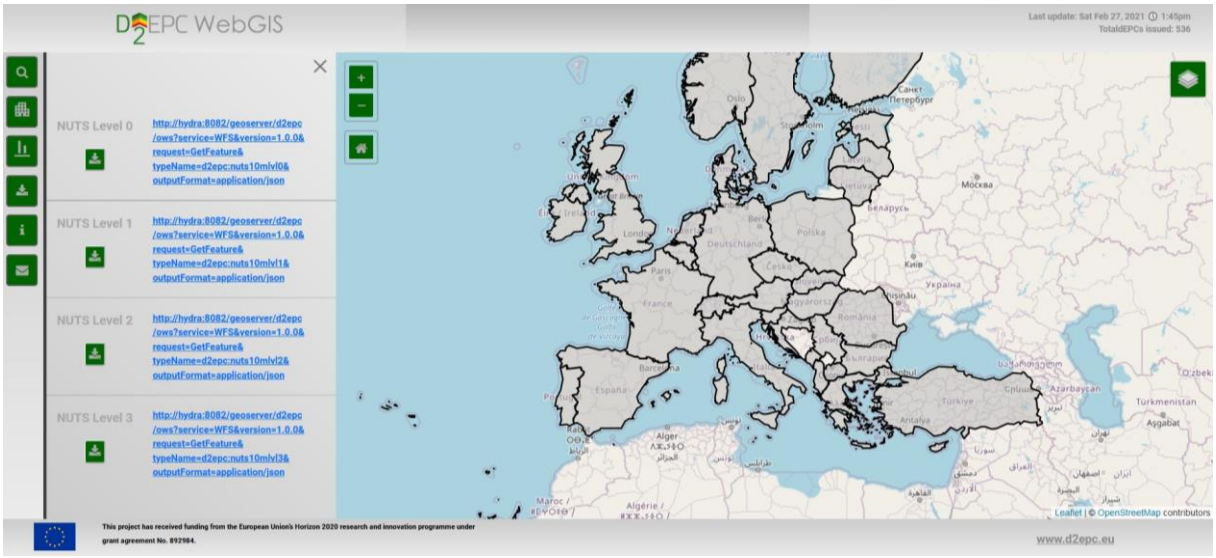

Figure 26. The Web Feature Services provided by D^2EPC WebGIS.

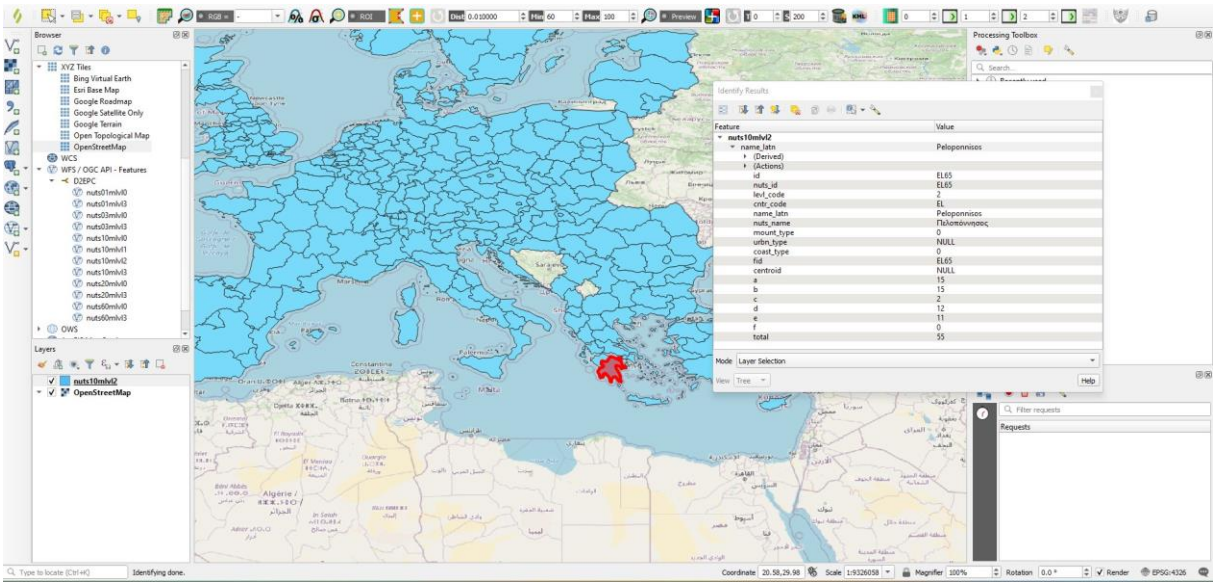

Figure 27. Example of viewing the WFS layers on external GIS application (QGIS).

6 Conclusion

This report is the final deliverable for the D^2EPC WebGIS development. It is a report for describing the application's scope, design, main building blocks and functionalities. It gives a comprehensive overview of the application by defining all sub-components as well as detailed information of each one.

The D3.2 "Design and Implementation of the D^2EPC WebGIS Tool" is a report for describing all the aspects concerning the WebGIS application. More specifically:

- The D^2EPC WebGIS scope and purpose
- The Business Scenario and the technical use cases that drive the WebGIS design
- The functional and non-functional requirements the application must comply with
- The architectural design, including functional, deployment and sequence diagrams
- The actual implementation and the technologies used
- The functionalities provided by the tool as well as short description for each one

The T3.2 "Development of a GIS scheme for EPC documentation" terminates on M19 of the project. As the WebGIS is a sub-component of the general D^2EPC Web Platform, which is delivered on later stages of the project, some modifications may be required for enabling the seamless integration to the D^2EPC Portal. Furthermore, as the project progresses, new business scenarios and/or use cases may be defined that the WebGIS can be used for. In this case, adding more features to the current version of the tool will be possible or adding a whole new version of the tool at the end of the project in case of major revisions. All the above reasons can lead to a continuous development of the WebGIS application and surely to a full support by the task partners throughout the lifetime of the D^2EPC project.

7 References

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[5]. Directive 2010/31/EU, European parliament and of the council of 19 may 2010 on the energy performance of buildings (recast), Official Journal of the European Union, 2010, pp. 13–35.

[6]. Frederick Research Center; 7 Frederickou Str., 1036, Nicosia, Cyprus. Copies of this publication – also of extracts thereof – may only be made with reference to the publisher. Deliverable 1.1

[7]. https://ec.europa.eu/eurostat/web/nuts/background

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