BIM-based EU -wide Standardized Qualification Framework for achieving Energy Efficiency Training

D4.2 BIMEET Platform Delivery

WP 4	**Leader: LIST**
Task 4.2	**Leader: INES Formation**
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Abbreviations

AEC	Architecture, Engineering and Construction
ALO	Achieved Learning Outcomes
BEM	Building Energy Model
BIM	Building Information Modelling
CA	Consortium Agreement
DoA	Description of the Action
EE	Energy Efficiency
EPBD	Energy Performance Buildings Directive
EPC	Energy Performance Certificate
EQF	European Qualification Framework
GA	Grant Agreement
HOTS	High Level Thinking Skills
ICT	Information and Communication Technologies
ILO	Intended Learning Outcomes
KSC	Knowledge – Skills – Competencies
LAU	Local Administrative Unit
LO	Learning Outcomes
LOTS	Low Level Thinking Skills
Mx	Milestone date designating the start of a given task
My	Milestone date designating the end of a given document delivery deadline
NUTS	Nomenclature for Territorial Units for Statistics
PC	Project Coordinator
PSC	Project Steering Committee
QA	Quality Assurance
RIBA	Royal Institute of British Architects
RTO	Research and Technology Organization
TAM	Technology Acceptance Model
TF-IDF	Term Frequency - Inverse Document Frequency
ToC	Table of Content
TUI	Tangible User Interface
UAS	Universities of Applied Sciences
WP	Work Package
WPL	Work Package Leader

1 Executive Summary

The BIMEET platform is in line with the works previously carried on the ERASMUS+ BIM4VET[1] prototype. This new platform is structured around five major components:

- A database including BIM/EE training data,
- A Map server,
- A recommender engine,
- A tangible tabletop device.

This application is dedicated to institutions which want to design a new training. The BIMEET application is basically an interactive map, relying on a natural user interface to explore data about a.) the potential target audience for a given area and b.) the available trainings in the same region. The general idea is to provide training institutions with information required for identifying market needs and consequently improving the consistency of the training offer.

[1] https://www.bim4vet.eu/

2 Introduction

Based on a first prototype developed in the framework of the Erasmus+ BIM4VET project[2] , the BIMEET platform extends the scope of the functionalities and includes support for BIM training course design.
Described in the deliverable 4.1, the process deployed in order to develop the BIMEET application has been deployed as follow (See Figure 1):

- **Step 1: Data collection**

  In this first step, a questionnaire has been developed in order to collect data about the process of training course design, the profile of the future users as well as the expectations about a software tool.

- **Step 2: Analysis**

  The analysis of data collected in step 1 has allowed detecting useful functionalities for the BIMEET application and the different roles.

- **Step 3: Mock-up**

  During project meetings, the mock-up and first prototype versions of the tangible interface have been used to regularly collect partners' feedback. It enabled to stabilize the concepts of the interface before the development stage.

- **Step 4: Development**

  This step concerns the development of all the components of the application (i.e., the database & forms for data collection, the recommender and the tangible User Interface (TUI)).

- **Step 5: Validation**

  This last step will focus on the user tests based on an experimental protocol. The user's feedback that will be collected will be a source for the BIMEET application improvement.

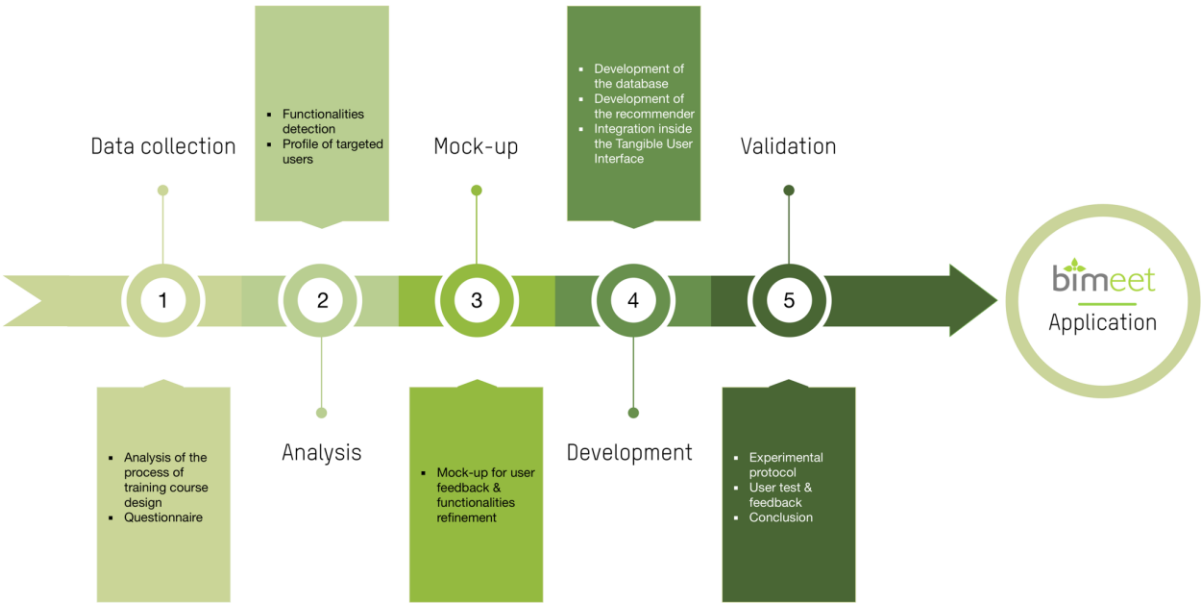


Figure 1. Process for BIMEET application development

[2] https://www.bim4vet.eu/

The following deliverable presents results resulting from step 4 and describes all the technical components that have been developed in the framework the BIMEET application and more specifically, the following components:

- The training repository (see section 3.3.2),
- The map server (see section 3.3.2.3),
- The BIM/EE training data form (see section 3.3.3),
- The recommender engine (see section 3.3.4),
- The tangible user interface a (see section 3.3.5).

3 Architecture for a TUI application

The field of human-computer interactions relies heavily on the use of metaphors. As an example, in the field of Graphical User Interfaces (GUI), the desktop metaphor in combination with the folder and file metaphor of the filesystem mimics a physical office environment. Graphical symbols or Icons represent known objects from that environment thus implying the functionality of the given user interface element. The use of efficient metaphors renders a user interface easy to manipulate and reduces the time and effort required by a user to get accustomed to using the interface[3].

A decade ago, GUIs mainly relied on point-and-click devices (mouse, touchpad) for interaction and keyboards for data capture. With the advent of touch-based devices like smart phones and tablets, those physical devices have slowly become obsolete or have been replaced by virtual counterparts like onscreen keyboards. The introduction of multi-touch interfaces, i.e., touch interfaces which were able to detect more than one finger simultaneously, enabled more natural interactions by allowing gestures such as pinching, swiping and rotating, gestures which have already become second nature to users, even to the least tech-savvy ones.

Tangible User Interfaces (TUI) are an attempt to further lower the accessibility and acceptance hurdle of computer systems, leveraging the fact that human beings are used to manipulate physical objects. Where GUIs rely solely on the users' visual capacities, TUIs are able to convey information on a haptic and topological level as well, mixing both physical and digital elements to interact with the interface. GUIs in general are very structured interfaces, meaning that control and visualisation elements are *rigidly* laid out, following a strict organisation pattern in order for the user to easily find them once he's accustomed with the interface. TUIs on the other hand break this paradigm by giving designers the freedom to *de-structure* the interface either completely or partially, thus requiring a more efficient set of metaphors to imply functionality and guarantee usability.

3.1 Tangible Tables

TUI applications require a specific input output device called a **tangible table-top device** or simply a **tangible table**. Figure 2 shows the working principal of such a device.

[3] E.Tobias, V.Maquil, T.Latour, 'Method for providing data input using a tangible user interface', PT03427EP

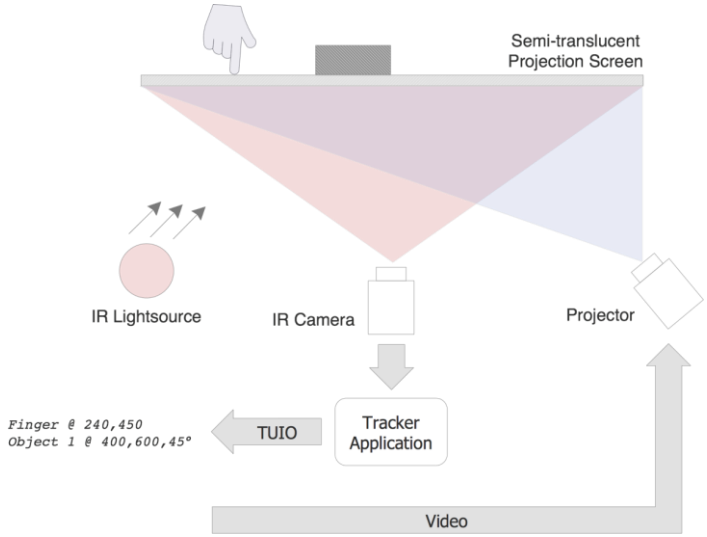


Figure 2. Tangible Table-top Device

All components depicted below the **semi-translucent projection screen** are installed inside an opaque enclosure, the projection screen being the top face of the enclosure. An **Infrared light source** floods the enclosure with infrared light. **Objects** and **fingers** placed on the semi-translucent projection screen reflect some of the light. A **video camera** with an infrared filter matching the wavelength of the emitting light source, captures those reflections and feeds the captured frames to a **tracker application**. The tracker application processes the received frames and extracts the x and y positions of the captured reflections. For the tracker to be able to identify individual objects and their respective orientation on the table, it is important to tag each individual object with a visual black and white marker.

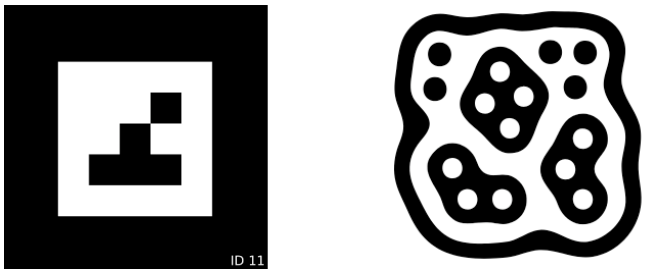


Figure 3. Examples of Markers (left Multitaction – right Reactivision)

The type of marker to affix is governed by the choice of the tracker application. Figure 3 shows two markers representing both the identifier number 11, the one on the left is for the Multitaction proprietary tracker and the one on the right for the ReactiVision open-source tracker. The information extracted by both tracker applications is transmitted as events using a de-facto standard protocol called TUIO.

A connected computer reads the incoming TUIO events, interprets them and acts upon them. In most cases the resulting action consists in drawing information and data at the respective object positions. The video output of the connected computer is fed to a video projector build into the enclosure, projecting the drawn items on the semi-translucent projection screen, reconciling both the physical object and its virtual representation.

3.1.1 The Hardware

The choice of the hardware being used is mostly influenced by the cost factor of the respective solution, but also by criteria such as transportability, ruggedness and reliability. The cheapest solution in terms of costs is the DIY approach. We, that is the ITIS/HDCE[4] research unit of LIST, have built a number of those tables ourselves and helped schools to build their own tables. The price tag of such a table is below 5k€, depending on the chosen components. On the downside, those tables are not easy to transport and require a time-consuming calibration process after moving them in order to realign the camera and the projector. If transportability and ruggedness are key, then a commercial table such as the MT-Cells (https://www.multitaction.com/hardware) from the Finnish manufacturer Multitaction is a possible candidate. They come in the shape of a 1215 x 686 x 200mm Full-HD Display, integrating all the required hardware and software (Tracker Application) in one single unit. They come with a rugged flight-case for easy and safe shipping. All this comes with a price of course, which is approximately 20k€ per unit.

3.2 Background

3.2.1 Tulip Framework

The TUI developed in the scope of work package WP4 by the ITIS/HDCE unit (LIST), is based on our existing TULIP framework, a JAVA software framework for developing tangible applications, progressively developed in house and extended since its gestation in 2014. In order to establish TULIP as a de-facto standard for TUI applications, the framework is available under an LGPL version 3 open-source licence on our GIT server (https://git.list.lu/nui/tulip/wikis/home).

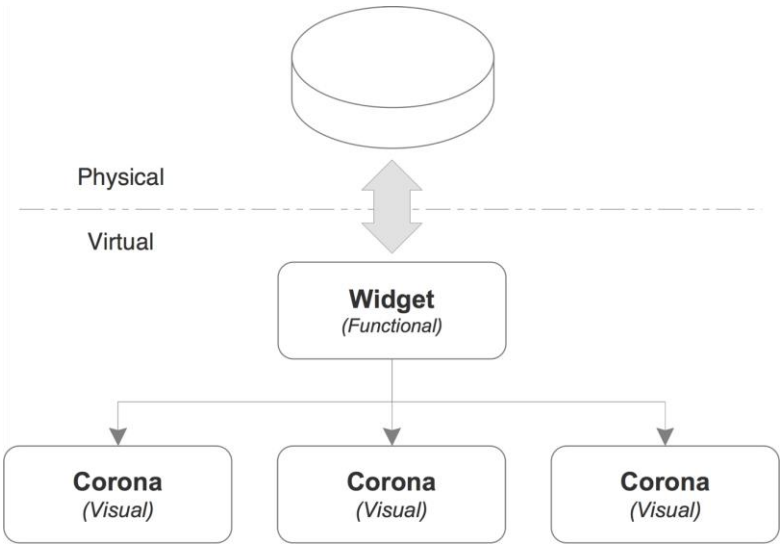


Figure 4. Mapping between Physical and Virtual Objects

[4] https://www.list.lu/en/research/itis/

The TULIP framework is a collection of customizable building blocks, mapping the physical objects on the table to a virtual representation on the screen (See Figure 4). Each physical object, identified by its marker, is mapped to a dedicated software representation, called a **Widget**. Widgets define the **functional** behaviour of the object. Each widget has one or more associated **Coronas**, defining the **visual** representation of the object on the table. The mapping of markers to widgets and subsequently of coronas to widgets is defined in an external XML file called a **Scenario**. The scenario file encapsulates all design related aspects of the application to build, i.e., graphical and functional attributes of coronas, configuration of data sources, chaining of data processing steps.

3.2.2 Tulip Software Architecture

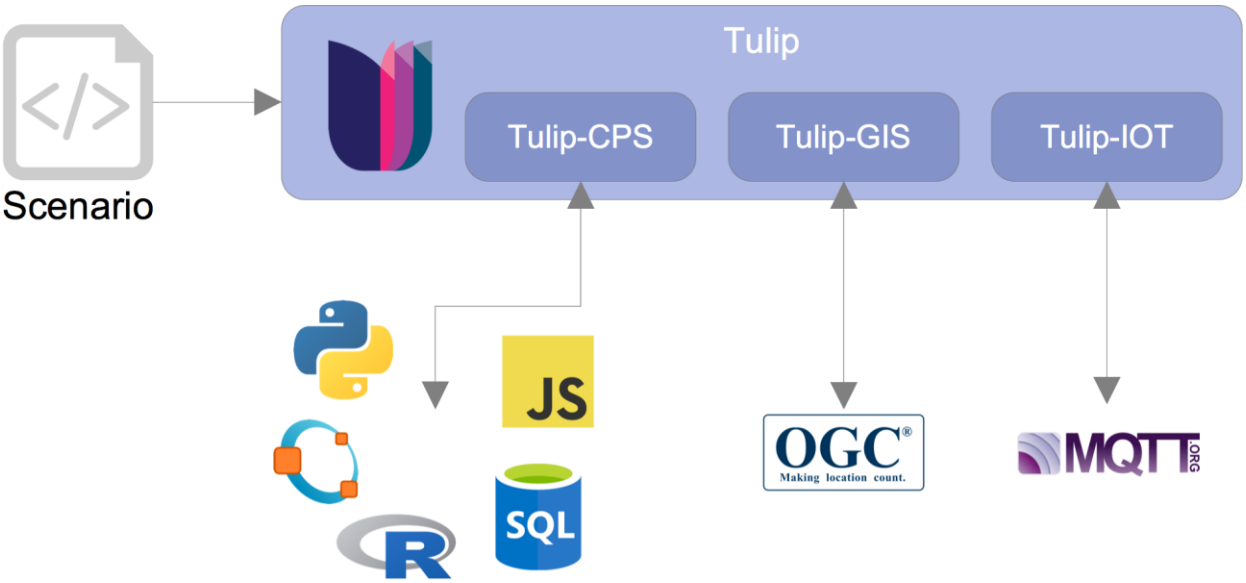


Figure 5. Tulip Architecture

From a software architecture point of view, the TULIP framework consists of the open-source Tulip core package and a number of domain specific extensions. Each extension not only adds domain specific widgets and coronas, but also adds connectivity to external systems and environments (see Figure 5).

3.2.2.1 Tulip-CPS

CPS stands for Complex Problem Solving. The extension adds the concept of **variables** and provides widgets and coronas to manipulate and visualise those variables. On top of that, Tulip-CPS adds the concept of **equation systems** to the scenario, mapping variables either as parameters or results to individual equations. Tulip-CPS provides a number of specific **Executors** for those equations, enabling the author to either externalise the processing body of the equation in third party languages like Python, JavaScript or Octave, R, or to directly query SQL databases.

3.2.2.2 Tulip-GIS

Tulip-GIS adds geographical information to Tulip. The extension adds interfaces for connecting with OGC (Open Geospatial Consortium) compliant GIS systems and brings along widgets and coronas for manipulating geographical maps.

3.2.2.3 Tulip-IOT

Tulip-IOT is the latest addition to the Tulip family, adding IOT (Internet-Of-Things) connectivity to Tulip. This is achieved by adding MQTT messaging, a lightweight messaging protocol for small sensors and mobile devices, to the scenario. By adding the concept of **messaging systems** to the scenario, the author has the possibility, in combination with the Tulip-CPS extension, to retrieve sensor values and to control actuators.

3.3 Foreground

3.3.1 System Architecture

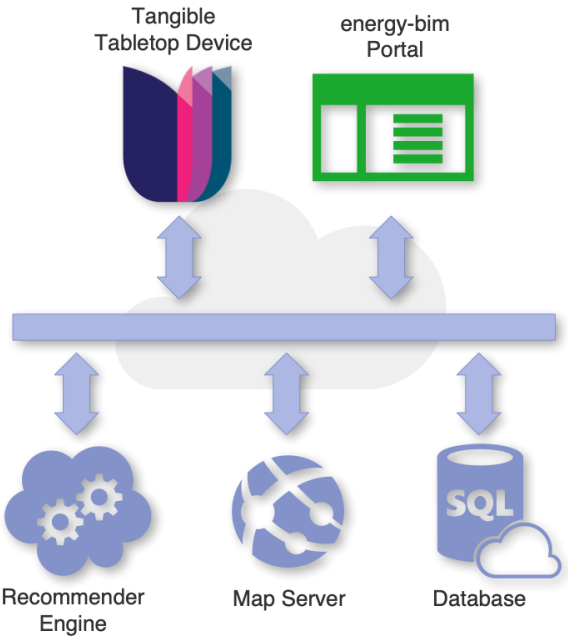


Figure 6. BIMEET Training Platform System Architecture

The architecture of the BIMEET Training Platform (see Figure 6) is both distributed and heterogenous. This design choice was motivated in equal parts by technical and organisational constraints. The frontend components, i.e., the **Tangible Tabletop Device** and the **energy-bim** portal, access a number of backend components, namely the **Recommender Engine**, the **Map Server** and the **Database** hosting the training repository. Most of the components were developed or designed individually by consortium partners involved in the project. With this kind of setup, it becomes clear that a.) the backend components are best located in the cloud and b.) some of the components are not developed from scratch but are developed on top of already existing technology assets.

3.3.2 Training Repository

The BIMEET training platform is articulated around the central training repository (see Table 1). The repository links both the energy-bim portal and the TUI application. The energy-

bim portal was originally built upon a local MySQL database, hence the choice was made to use MySQL as the database engine for the training repository as well.

3.3.2.1 Learning Outcome Matrix

Table 1. Excerpt from the LO Matrix

No	Learning outcome	EQF level		
Architectural design roles				
Architectural design and Architectural BIM Coordinator (ARBCO), Architectural chief designer (ARCD), Architect (ARCH), Architectural assistant designer (ARAD)		ARCD	ARBCO/ARCH	ARAD
ADLO1	**Learner is able to explain the fundamentals of BIM and the underlying principles of uses with respect to building life-cycle.**	**6**	**6**	**3**
AD1.1	Recall essential contents, summarize and give examples of BIM terminologies, definitions and standards.	6	6	3
AD1.2	Recall essential contents, summarize and give examples of overall BIM process for a building's life cycle.	6	6	3
AD1.3	Explain and use standard information exchange processes for different design domains in general and especially in detailed technical design.	5	5	2
AD1.4	Explain the essential issues related to information management, data transfer and sharing.	5	5	2
AD1.5	Explain the added value of using open file formats (i.e. IFC) to ensure interoperability.	5	5	2
AD1.6	Recall, summarize and explain essential contents and relevant parts of national BIM guidelines.	6	6	3
ADLO2	**Learner is able to explain the fundamentals of sustainable and energy-efficient buildings and building performance.**	**4**	**6**	**2**
AD2.1	Explain and give examples of aspects and terminologies of energy and building performance.	6	6	2
AD2.2	Describe the financial and environmental aspects and related indicators, benchmarks and certification systems of energy and building performance.	2	6	2
AD2.3	Explain the issues that affect energy performance of buildings and demonstrate competence in domain specific solutions.	4	6	1
AD2.4	Explain relations between life-cycle costs, energy performance and building performance.	4	6	2
AD2.5	List and explain the core concepts of sustainable building rating and certification systems.	4	4	2
AD2.6	Summarize and give examples about the potentials of renewable energy sources applicable to buildings including district-scale solutions.	4	4	1
AD2.7	Point out legislation and regulations related to energy performance, thermal comfort and air quality.	6	6	3

The Learning Outcome Matrix originating from WP3 contains a total of 272 individual learning outcomes, defined in a hierarchical manner for six major roles, namely, Client & client advisors, Architectural design, Structural design, Building services design, Construction work and Maintenance work.

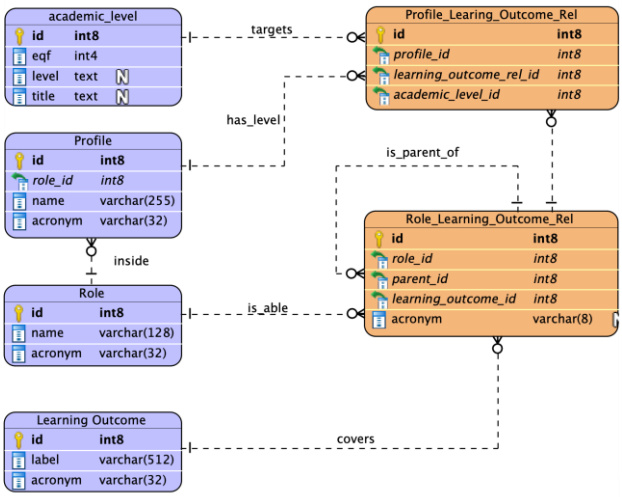


Figure 7. Leaning Outcome Matrix tables

In subsequent figures, blue tables represent seed data, i.e., data which is considered to be static and not subject to change. In Figure 7 for instance, **Academic Level**, **Profile**, **Role** and **Learning Outcome** are such tables. The Academic Level table defines the various qualification levels as defined by the European Qualification Framework. The Role and Profile tables contain the list of the roles and their respective profiles whereas the Learning Outcome table contains the full set of available learning outcomes.

The orange **Role Learning Outcome** relation table maps the individual learning outcomes to their respective roles, as defined in the learning outcome matrix. The table furthermore models the hierarchical relation between high-level learning outcomes (ADLO1, ADLO2, …) and their respective children (AD1.1, AD1.2, ...). With reference to Table 1, the Role Learning Outcome relation table thus defines the individual rows for each role.

The Table 1illustratesthe various profiles defined for the different roles, represent the columns of the matrix. The purpose of the orange **Profile Learning Outcome** relation table is exactly the same. Each entry in this table maps an EQF level and a profile to each individual entry (row) in the Role Learning Outcome table.

3.3.2.2 Trainings

The BIMEET training repository leveraged parts of the model developed in the scope of the BIM4VET project[5]. The original model was revised and extended in order to capture available meta-data with the highest possible level of granularity.

[5] https://www.bim4vet.eu/

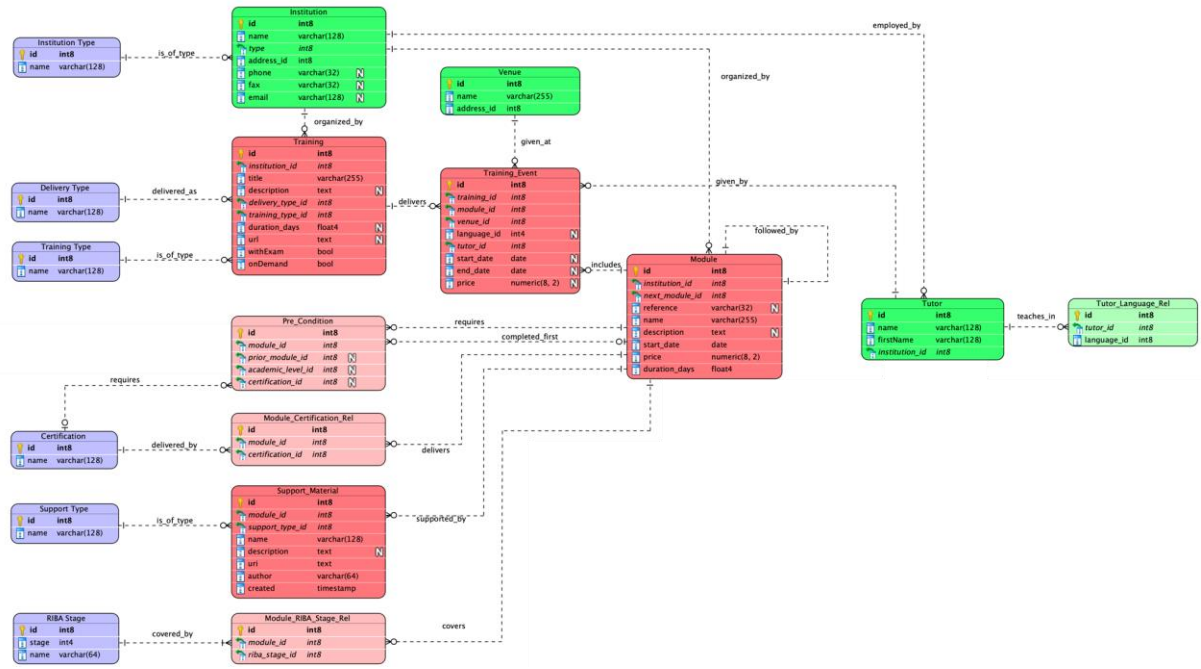


Figure 8. Training database model

Figure 8 depicts the tables central to the training repository. The colours of the various tables have the following meaning. Green tables embody a kind of address book of available training institutions, training venues and tutors. Red tables capture data directly linked to the training itself, i.e., which modules the training is composed of, when and where a training is given, which support material exists for a given training. Lighter colour tables are generally relation tables, i.e., tables which do not contain actual data, but represent links to other entries or available seed data (blue tables). Examples of such tables are the **Precondition** table, **Module Certification** and **Module RIBA Stage** tables.

At the heart of the model lies not the training itself, but the module. A training module is the basic building block that each training is built from. This explains why most, if not all, database relations originate from the module table. One training is composed of one or more modules, which may be followed either sequentially, with optional certification steps, or in random order.

Since most trainings are given recurrently, a dedicated **Training Event** table was introduced in the latest version of the model, thus relieving training institutions from the burden of recreating a given training each time the same training is scheduled in the future. The introduction of this dedicated table further allowed to separate the actual **content** of the module from data pertaining to the **distribution** of the content, i.e., when is the module given and where, who's the tutor and which language is it given in.

Figure 9. Module and Learning Outcome Matrix Relationship

Figure 9 shows the link between the learning outcome matrix and the training repository. The **Module Prerequisite** and **Module Outcome** tables both link the module with entries in the **Profile Learning Outcome** table. As a reminder, the later table represents the columns, i.e. the various profiles, in the matrix. As their respective names imply, the prerequisites table defines which expertise is required to attend the module, the outcome table defines the expertise the attendee gains by attending. The particularity of the Module Prerequisite and Module Outcome tables consists in their link to the **Maturity** table. This table defines maturity levels as defined by the *Dreyfus* scale, ranging from novice to expert in five stages. The rational for this expertise overlay stems from the thought that, even though a certain learning outcome is associated with a given EQF level for a given profile, a basic or introductory training will only provide the attendee with a subset of the knowledge ascribed to the respective learning outcome.

Last but not least, we'd like to introduce the **Tutor Expertise** relation table, which, even though not used yet, would allow to capture and compare the expertise of the various tutors. By doing so, it would be possible in the future to recommend matching trainers for a given module or training profile.

3.3.2.3 Geo-referenced model

As already mentioned earlier, the BIMEET database model evolved from the BIM4VET model. The BIM4VET model captured the address and country of training institutions and training venues. However, it is important to understand that address data down to the street address alone is of no use if the GPS coordinates of the precise location are not available. Google Maps offers a (commercial) API which allows to query their services to obtain GPS coordinates of individual street addresses, but the effort comes with a price tag, both in terms of usage of the service as well as the time spent to do so. It was thus decided to follow a

different approach by using an already available location framework, developed and maintained by Eurostat.

3.3.2.3.1 NUTS (Nomenclature for Territorial Units for Statistics)

The NUTS classification was adopted by the European Commission in 2003 with the aim of producing regional statistics based on a coherent system of territorial division. It is used in order to compare statistics for regions of similar size.

The repository as it exists today already incorporates all levels (NUTS-0 to NUTS-3) of available territorial units as defined by Eurostat (see Figure 10).

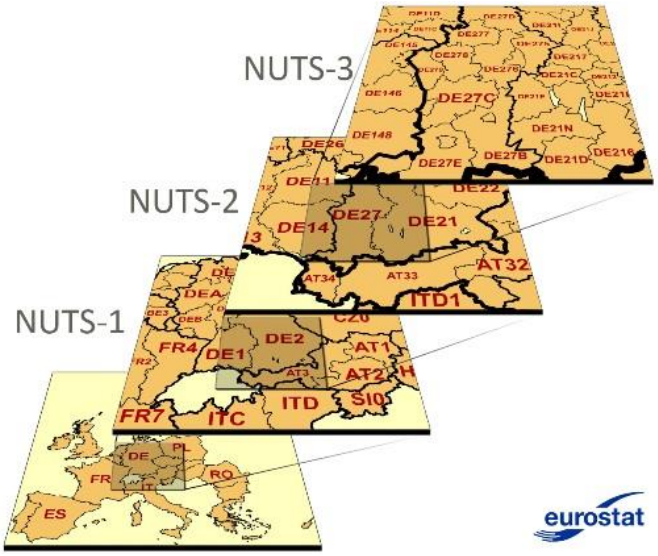


Figure 10. Eurostat NUTS Levels[6]

NUTS level 0 generally represents individual countries whereas higher NUTS level represents administrative divisions of finer granularity. Eurostat defines the different NUTS levels based on population thresholds. For example, a NUTS level 1 has a population between 3.000.000 and 7.000.000 inhabitants (see Table 2):

Table 2. NUTS Population Thresholds

NUTS Level	Lower Population Bound	Upper Population Bound
1	3.000.000	7.000.000
2	800.000	3.000.000
3	150.000	800.000

The NUTS nomenclature favour's national structures, i.e., it mirrors the territorial administrative divisions of each EU Member State (see Table 3).

Table 3. Examples of National Structures (Source Wikipedia)

Country	NUTS-1	NUTS-2	NUTS-3
France	Z.E.A.T	Regions	Prefectures

[6] Picture from https://ec.europa.eu/eurostat/fr/web/nuts/background

	Zone d'études et d'aménagement du territoire		
United Kingdom	Regions	Counties	Districts
Finland	Mainland Finland	Large Areas *Suuralueet / Storområden*	Regions *Maakunnat / Landskap*
Greece	Groups of development regions	Regions	Prefectures

All territorial units come with a unique code and their geographical boundary (Shape) which allows us to determine their respective geographical location, i.e., by computing the centroid of the shape for instance.

3.3.2.3.2 LAU (Local Administrative Units)

The standard nomenclature defines under the three NUTS levels an additional level, labelled LAU (Local Administrative Units), representing for most countries the level of municipalities. As for the territorial units, each LAU comes with a unique code and their respective geographical boundary. Figure 11 shows the boundaries of all LAUs currently available in the repository. For more information regarding the names and codes assigned to the individual LAUs, please consult the official correspondence tables[7] maintained by Eurostat.

[7] Eurostat LAU - https://ec.europa.eu/eurostat/web/nuts/local-administrative-units

Figure 11. Boundaries of LAUs[8]

A granularity at LAU level, or a NUTS3 level at least, should be more than sufficient in general for what we would like to achieve. Special considerations may be required for certain regions in northern Europe with a lower LAU density and where a more precise location may prove to be necessary.

[8] Image generated with https://mapshaper.org/

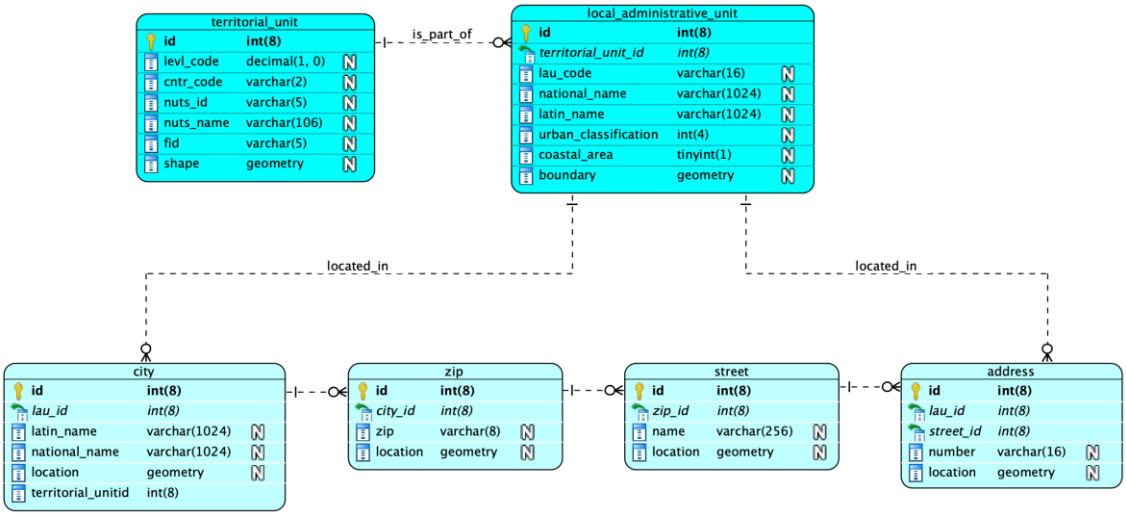


Figure 12. Georeferenced database model

Figure 12 shows the database tables involved in handling physical addresses and the localisation of the same. The schema is hybrid in the sense that it allows to follow both a conventional hierarchical street address model (**city**, **zip**, **street** and **address** tables) with optional GPS location columns, and in parallel to fall back or complement localisation by using available data from the NUTS-LAU (**territorial_unit** and **local_administrative_unit** tables) model. Datasets for the NUTS-LAU model were downloaded from Eurostat's website[9] and imported into the database. The **territorial_unit** table contains **1522** NUTS3 units (units with the highest granularity), further sub-divided into **95870** local administrative units.

3.3.2.4 AEC Professionals Repository

Since the training platform had been repurposed, for lack of available trainings, to help training institutions in designing new trainings, the training repository has been extended to include a repository of AEC professionals. By doing so, training institutions not only know which trainings are currently available in a given area, but also, how their potential target audience in the same area looks like.

3.3.2.4.1 Activity Type

We propose classifying companies in the repository by their respective activity type (see Table 4). A dedicated database table is used for collecting all required activity types. At the time of writing, the following activity types are available:

[9] NUTS-2016 Dataset Scale 1 :1million | https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/administrative-units-statistical-units/nuts#nuts16
LAU-2018 Dataset Scale 1 :1million | https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/administrative-units-statistical-units/lau#lau18

Table 4. Existing Activity Types

Activity Type	NACE code	Linked Role
Architect	71.110	Architectural design (AD)
Consulting Engineer	71.121	Building services design (BS)
Construction Company	41.200	Construction work (CS)
Facility Management	81.100	Maintenance work (MW)
Plumbing, Heating and HVAC	43.220	Building services design (BS)

This list is far from being comprehensive and shall be extended as the repository is populated. It is important to note that we're using the NACE[10] classification to uniquely identify activity types. One **activity type** may be linked to one or more **roles** as defined in the learning outcome matrix (see Figure 13).

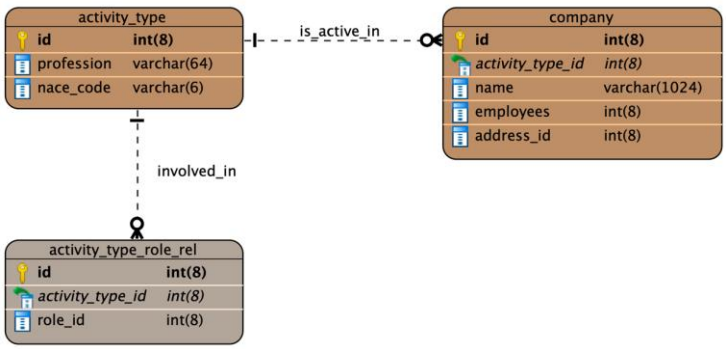


Figure 13. AEC repository database tables

At the time of writing, only data about Luxembourg was available in the repository. The data set was pulled from the open data portal (http://data.public.lu), offering a great number of open data sets created by public sector bodies. The portal was setup in the scope the Luxembourgish government's Digital Luxembourg Initiative.

3.3.3 energy-bim.com platform and Web form for training data collection

3.3.3.1 Introduction to the platform and motivations

We have adapted and re-developed a web-based platform solution that provides integrated access to building information modelling (BIM) resources to support the methodology and create a dynamic community to capture BIM training requirements. The platform (see Figure 14) is an open, scalable and polymorphic context-based solution with modules that enable serendipitous BIM information and knowledge discovery using a symbiosis of technologies such as semantic web, social networking.

This is a web-based platform solution that provides integrated access to BIM resources in the form of interactive, dynamic and user-oriented services that fully exploit the latest advances in computing technology. The platform is an open, scalable and polymorphic context-based solution with modules that enable serendipitous information and knowledge discovery through the use of a symbiosis of technologies such as semantic web and social networking.

[10] EUROSTAT – Statistical classification of economic activities in the European Community (https://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF)

This platform has helped in the process of BIM training requirements for energy efficiency, but also aims to address the key issue of knowledge dissemination and stakeholder engagement with BIM practices and construction. The objective is to identify gaps and requirements as an initial phase, but also to support the implementation phase of the project by providing construction professionals with the necessary training to provide effective BIM expertise in energy-efficient and low-carbon solutions, while also enabling them to use the latest innovative practices and regulations.

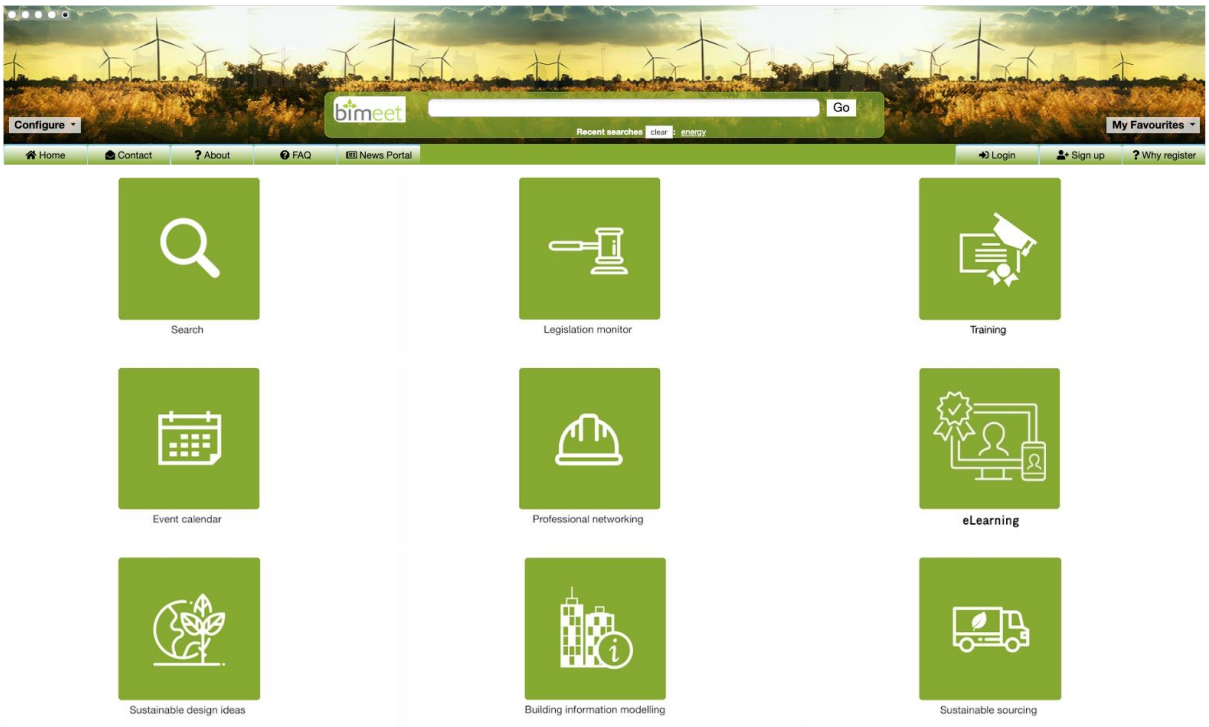


Figure 14. The energy-bim.com platform

The results of our consultations and the exploration of key perceived barriers allowed to identify the need to create impact circles that connect building professionals, energy administrations and people with shared sustainability expertise to address a number of issues, including:

- Lack of sharing, exploitation and re-use of isolated sustainable practices and principles.
- Lack of knowledge and understanding among key building stakeholders and end-users.
- Lack of easy access to organised sustainability information and knowledge.
- An unmistakable connection between sustainability values and existing construction regulations and standards.
- Confusion as to the expense of sustainable solutions / technologies.

Various actors have created different libraries, coordinated activities, etc. in an attempt to better understand the evolving construction environment, but with little to no coordination to knowledge of what each other is doing. We have recognized from the results that a socio-technical 'information approach' will resolve the issues described above. This led to the introduction of a one-stop-shop web-based platform. The key themes that arise can be summarized as the following guidelines for the proposed solution in terms of information specifications and functionality / services:

Information requirements:

- Categorising information: various categories of information and topics need to be discussed, including laws, legislation, analysis and innovation, etc.
- Dedicating and focusing information on best practice: previously to the implementation of the ***energy-bim.com*** platform, much of this information was very 'high-level;'
- Information and knowledge management and sharing: there was a need to translate 'information' into knowledge, therefore requiring advanced content management and contextualisation of new concepts;
- Providing avenues of marketing, or connectors: data and information regarding supply chain, products, etc. are required.

Functionality / Services:

- Smart search facilities: current search methods are unsatisfactory and restricted, processing documents as 'black boxes' and lack of filtering mechanisms.
- Build and enforce sustainable construction ontology: this would be a prerequisite to ensure smart search functionality.
- User profiles: this service would empower users and improve customer loyalty in terms of key professional events, that provide both knowledge exchange and facilitate networking.
- Bi-networks for information exchange and enrichment: incorporation of e- and professional networking capabilities. This will focus on both Ontology and User Profiling.
- Interface for Shared Resources / Services: free to use resources and possible paid tools, include subscriptions that provide users access to premium e-learning courses, training facilities, state-of-the-art conference and events.
- CPD facilities: including educational resources such as live and/or virtual case studies, and specific information on access to professional training programs, training courses and eLearning content.

3.3.3.2 The ontology and search service

Informed by the consultation studies conducted as part of the EU BIMEET project, we have adapted the energy-bim.com platform to be capable of managing, storing and analysing BIM related information. The platform supports BIM knowledge sharing and enrichment with a community of BIM professionals and resources with a view to advance the implementation of BIM for energy efficiency in the construction sector. The ***energy-bim.com*** platform integrates various BIM related data sources based on which a set of TF-IDF (term frequency - inverse document frequency) and Metric Cluster methods are applied to determine relevant roles and skills around BIM.

In the form of interactive, responsive, user-oriented applications, which completely leverage the latest technologies, the ***energy-bim.com*** portal provides access to integrated BIM resources for a community of users and professionals. The framework is an open, scalable, polymorphic context-based solution with modules that allow BIM information and knowledge to be unlocked through a symbiosis of technology.

The platform retrieves and stores a repository of BIM data sources including:

- Documents as scientific publications, standards and regulations in the field of BIM for energy efficiency,
- Twitter data from different organisations working in the field of BIM and energy efficiency.

We have retrieved around 80 key BIM related publications and regulations and a total of 4 million tweets based on which the analysis has been conducted. We have developed a ***Search service*** that searches the BIM Knowledgebase database from several authoritative URIs, as part of the application. The BIM query submitted contains a number of related ontological principles to improve the accuracy and retrieve the returned data. The search service also includes data from a number of reputable BIM-related sources via the web. These sources can be suggested by users and tested in terms of energy efficiency by a group of experts.

The ***Search service*** implemented on the platform also performs semantic searches on the BIM Knowledge Base platform from a set of authoritative URIs. The BIM query submitted contains a set of associated ontological concepts to improve the accuracy and recall of the results returned. The search service also provides an aggregation of BIM-related data from a variety of trusted sources via web-crawling.

The list of web sources the ***energy-bim.com*** platform fetches data from can be found below:

http://www.bim.psu.edu
http://digitalbuilding.lu
http://www.list.lu
http://objectif-bim.com
http://www.batiment-numerique.fr
http://www.accept-project.com
http://construction21.org
http://bimcrunch.com
http://mediaconstruct.org
http://bimblog.house
http://geometrygym.wordpress.com
http://cardiff.ac.uk
http://www.ines-solaire.org
http://eksergia.fi
http://buildingsmart.fi

Other sources can be suggested by users and tested in terms of energy efficiency by a group of experts.

The ***Search service*** on the ***energy-bim.com platform*** is powered by an ontology running in the background, that has facilitated the mining and analysis phases of the BIM knowledge harvesting process. The query and extension methods within the BIMEET framework provide the main use of ontology to drive the search engine. Firstly, the terms in ontology are used when entering search terms (using the query method) to give keyword suggestions. Secondly, the relationships between words are used to help users expand / limit their questions on the basis of ontological suggestions.

The ontology service is built based on semantic vectors to ensure the required level of knowledge for the platform is met. The ontology seeks to enhance and extend the contents and current domain requirements with additional concepts and aspects taken from: (i) engineering-specific knowledge repository, and (ii) information structures which are the basis for calculations, simulations and resources for monitoring compliance. The ontology uses term frequency - inverse document frequency (TF-IDF) and metric cluster algorithms to detect related ontological concepts in and around a knowledge-based repository. We measure the degree of significance (semantic) in more detail for each definition and facet of the text and the entire collected documentary repository. To ensure that the relationships between

concepts are important, a process is implemented that specifies the number of co-occurrences of concepts in the document. This clustering algorithm calculates the difference between two terms in the measurement of its correlation factor. The Profiling Service manages user authentication and controls platform access. Each user has a profile associated, containing collection of common interests and disciplines that are used for other services such as search, professional networking and news feeds as input data.

As illustrated in Figure 15, each user has associated rights and roles defining access to various modules within the platform. A module identifies a service with an associated polymorphic widget (see Figure 14) that can be administered and continuously updated with new data and information related to sustainable practices. More importantly, the user provenience can be diverse, the platform enabling additional compatibility for smartphones and tablets. Whereas a user can outsource to BIMEET various services and applications by using the Kernel layer, the interfacing layer ensures compatibility for smartphones and tablets.

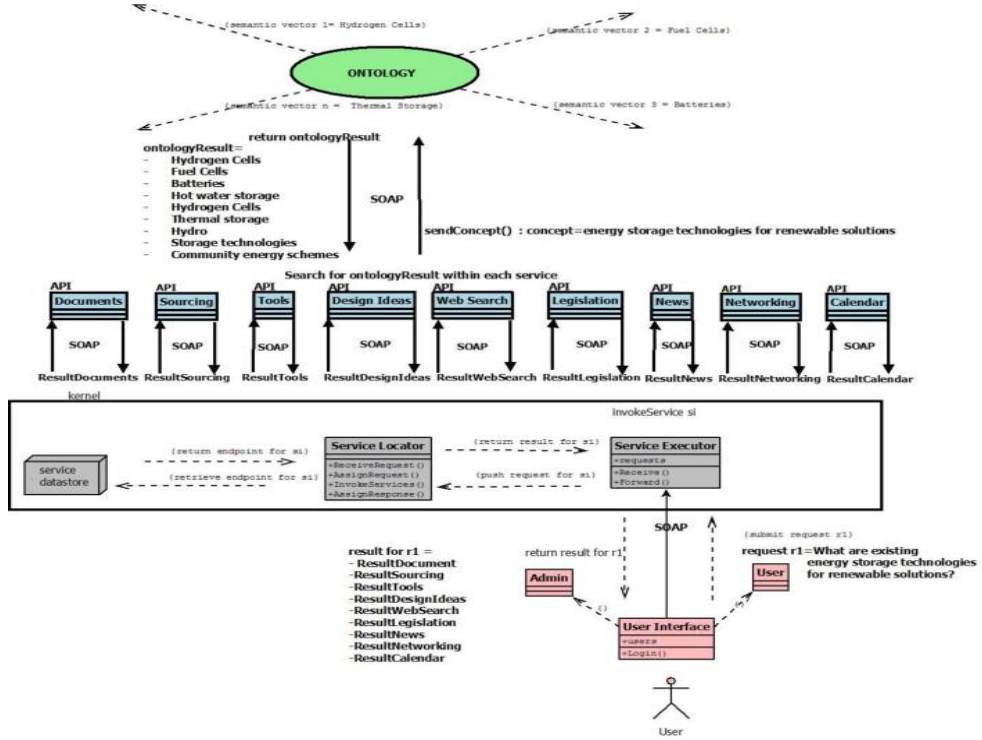


Figure 15. The BIMEET use case diagram

In terms of workflow, Figure 15 illustrates how the services are interacting when requests are submitted. The interaction is triggered when a request is submitted at the client level. The kernel receives the request and calls associated services. Assuming that a request r_1 is received by the kernel, the Service Executor identifies a service s_i associated with r_1. Once the service is identified, a request is sent to the Service Locator for retrieving the endpoint of service s_i. The Service Executor receives the service endpoint from the Service Locator and calls the service. According to the provision type, a service can return results generated with its own mechanism of managing data or it can use the ontology. S_i necessitates an ontological call and consequently a query is submitted to ontology.

For example, users can submit queries such as:

- What are the BIM energy performance requirements for passivhaus design?

- What are the most effective renewable energy BIM technology solutions for the domestic sector?
- What are current BIM energy regulations applicable to new build in office building?
- Cost-effectiveness of solar panels in building BIM energy retrofit
- What are the BIM techniques for integrating ground source heat pump technology into pile foundation construction?
- What are renewable energy generation options for off-gas villages in the EU?
- What is current legislation as to electric vehicles integration and support within buildings?
- What are existing energy storage BIM technologies for renewable solutions?
- What are current feed-in tariffs schemes for renewable energy deployment in the domestic sector in the EU?

The use case identifying the steps performed within the platform for computing a query is illustrated in Figure 15. The query used in the example is "*What are existing energy storage technologies for renewable solutions*" and the associated ontological terms are "*hydrogen cells, fuel cells, batteries, hot water storage, hydrogen cells, thermal storage, hydro storage technologies, community energy schemes*". These ontological terms will be then passed to each individual service for information searching and the aggregated result of these services will be provided to the user via the user interface.

Within the BIMEET platform the query and expand methods are exposed to provide the key use of the ontology, which is to drive the search engine. Firstly, the terms within the ontology are used to provide keyword suggestions when entering search terms (using the query method). Secondly, the relationships between terms are used to help users expand/restrict their queries based on suggestions from the ontology (as observed in Figure 16).

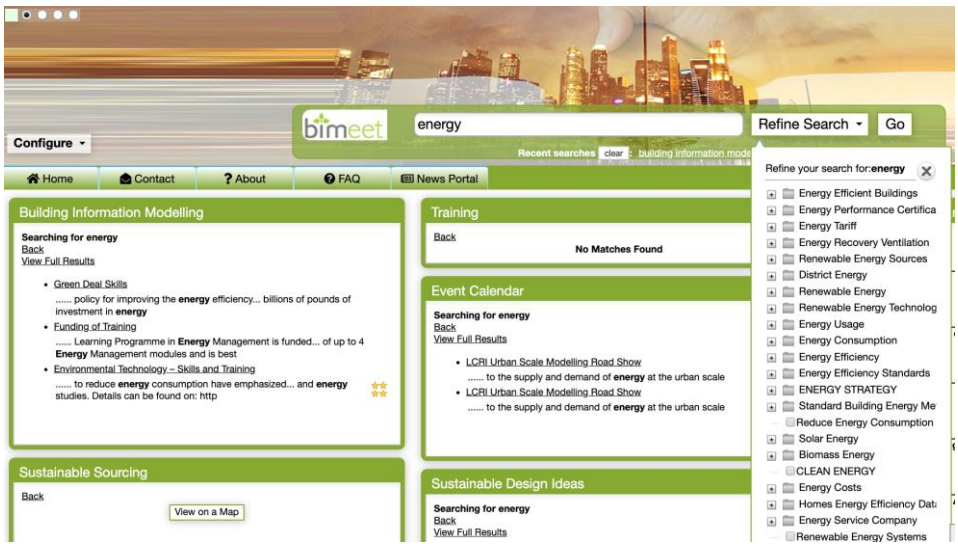


Figure 16. The energy-bim.com platform search system

3.3.3.3 The energy-bim.com platform BIM services (widgets)

We have also implemented a ***Professional Networking Service*** (see Figure 17) that enables users to collaborate using social networks such as LinkedIn and Twitter by aggregating associated data. This service also allows users to search for partners and colleagues and identify the corresponding networking profiles based on a set of BIM interests and disciplines.


Professional Networking
Search for colleagues:
Name:
Select Disciplines
Select Interests
Search
bimeet-partners
A Twitter list by @bimeetEU
VTT Retweeted
Leena Rantasalo
@LRantasalo
”Tavoitteena on luoda niin houkuttelevat tilat, että ihmiset haluavat tulla sinne. Parhaiten teemme työtä yhdessä” @ahavasara #VTTbeyondtheobvious
20m
VTT
@VTTFinland
We are getting new premises to support renewal and innovation. #VTTbeyondtheobvious

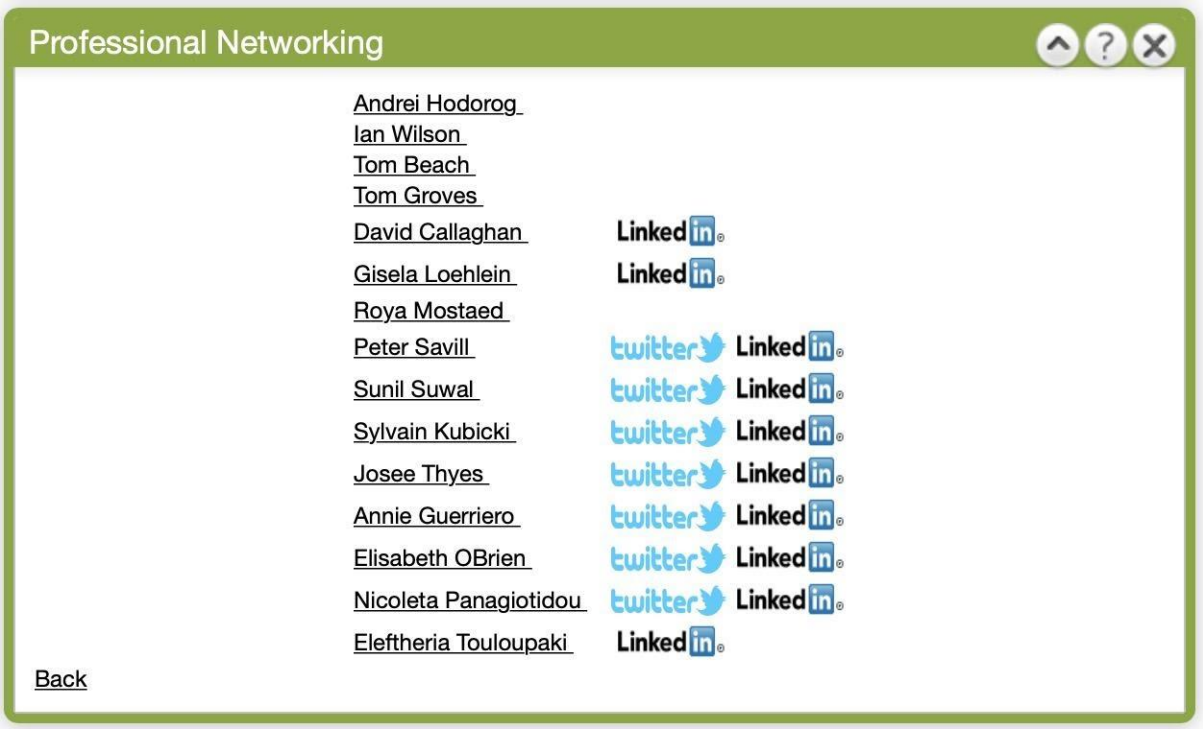


Figure 17. Professional networking widget

An ***Events Calendar Service*** (see Figure 18) is used as a reminder of the important BIM events from the engineering community. Users can subscribe and synchronise these events relating to sustainability with their personal calendar.

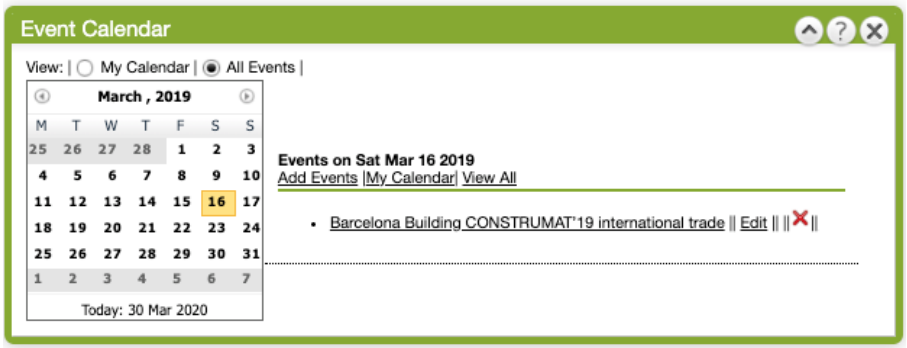


Figure 18. The Event Calendar widget

A ***BIM Tools Service*** (see Figure 19) was implemented to expose a number of BIM tools addressing various aspects of energy such as carbon emissions, energy simulations.

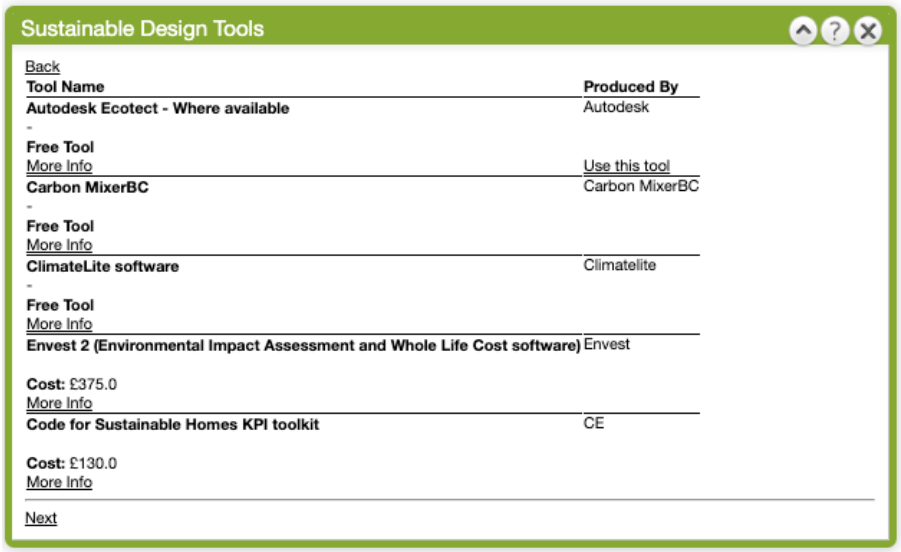


Figure 19. The BIM Sustainable Design Tools widget

A ***BIM service*** (see Figure 20) was implemented to store, retrieve, manage and visualise statistics of use cases related to BIM for energy efficiency.

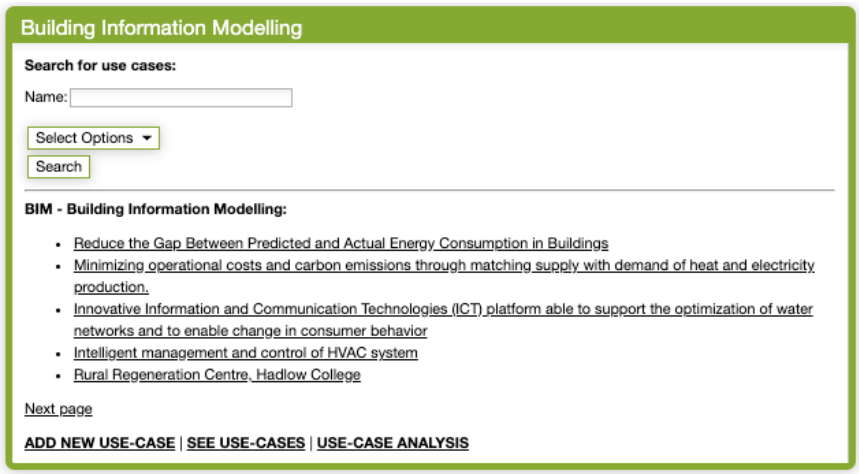


Figure 20. The BIM use cases widget

Figure 21 below illustrates a dashboard centralising the use case statistics that are computed in real time by the ***energy-bim.com*** platform. These are updated automatically every time a use case is added, deleted or changed. The users are able to sort the tables by count and filter the elements of the pie charts according to their interests. The use cases can also be filtered by parent *Type*, *Building type*, *Project type*, *Discipline* and *Lifecycle*.

Type	Count
5 test cases and 1 real-world application	1
BIM guideline	3
BIM tools	1
Project	1
R&D	19
R&D, Real-world application	1
R&D, real-world application	1
R&D; Master Thesis	2
Real world (prototype)	1
Real world application	1
Real world application involving R&D aspect	1
Real world project	1
Real-world application	20
Total	**53**

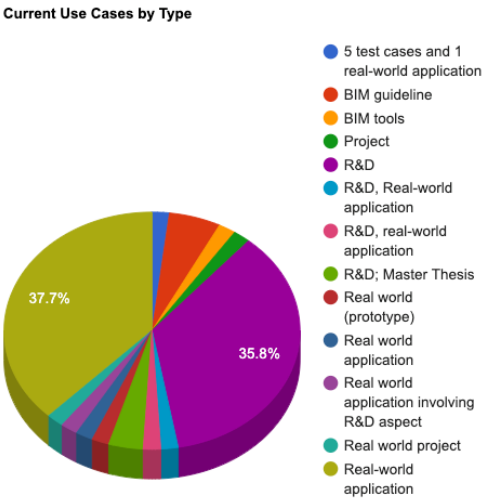


Figure 21. The BIM use cases statistics dashboard

A ***BIM Training Servi**ce* (see Figure 22) was implemented, enabling users to identify courses and lectures related to BIM for energy efficiency in construction from various institutions such as universities, research organisations and governments agencies.

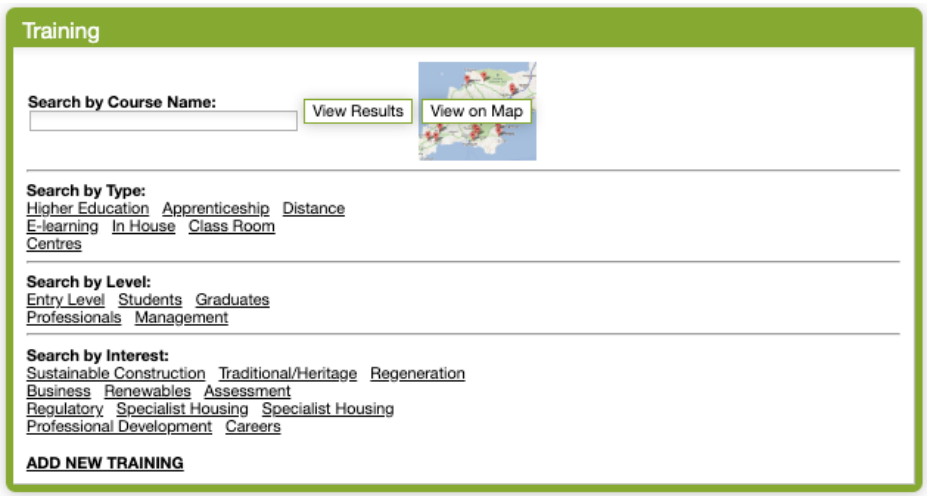


Figure 22. The BIM trainings service

3.3.3.4 Training addition form

A dedicated form for adding trainings into the database was implemented, which is subsequently linked to the tangible table application, a tool linked to the ***energy-bim.com*** platform that is dedicated to supporting training institutions to require the information they need when creating a new training, while enabling them to explore their target audience, explore profile coverage and exploring existing available training offers on the market and associated learning outcomes and their maturity levels.

Figure 23. Steps of the training addition process

The training addition form is totalling a number of 8 steps, as outlined in Figure 23 above.

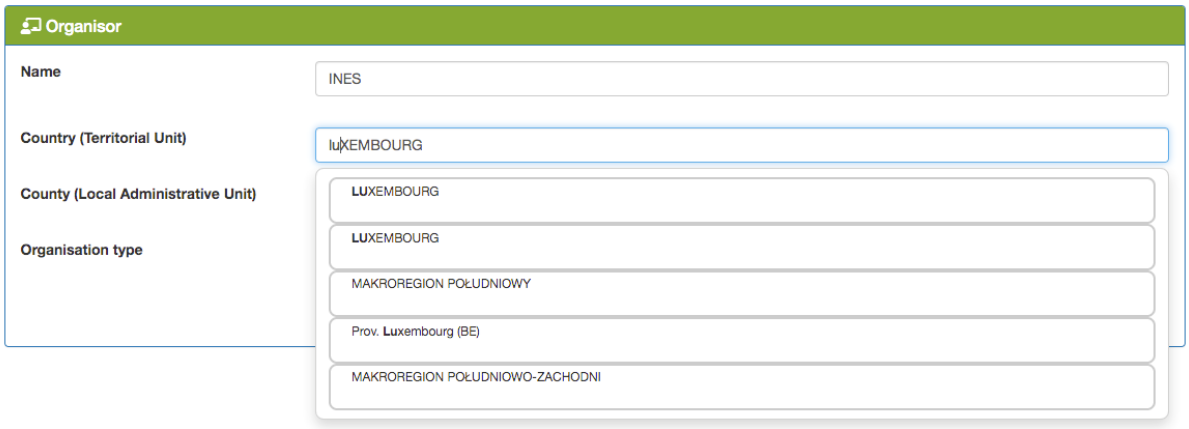


Figure 24. The Organiser step of the Training addition form

1. ***Organiser*** (Figure 24), with the following fields: name, country, local administrative unit and organisation type of the training provider. This step enables users to add a new organiser to the database or select one from a list of existing organisations stored in the database. The fields feature an autocomplete feature that queries the database in real time. Upon selecting an existing organiser, the *Country*, *County* and *Organisation type* fields are populated automatically;

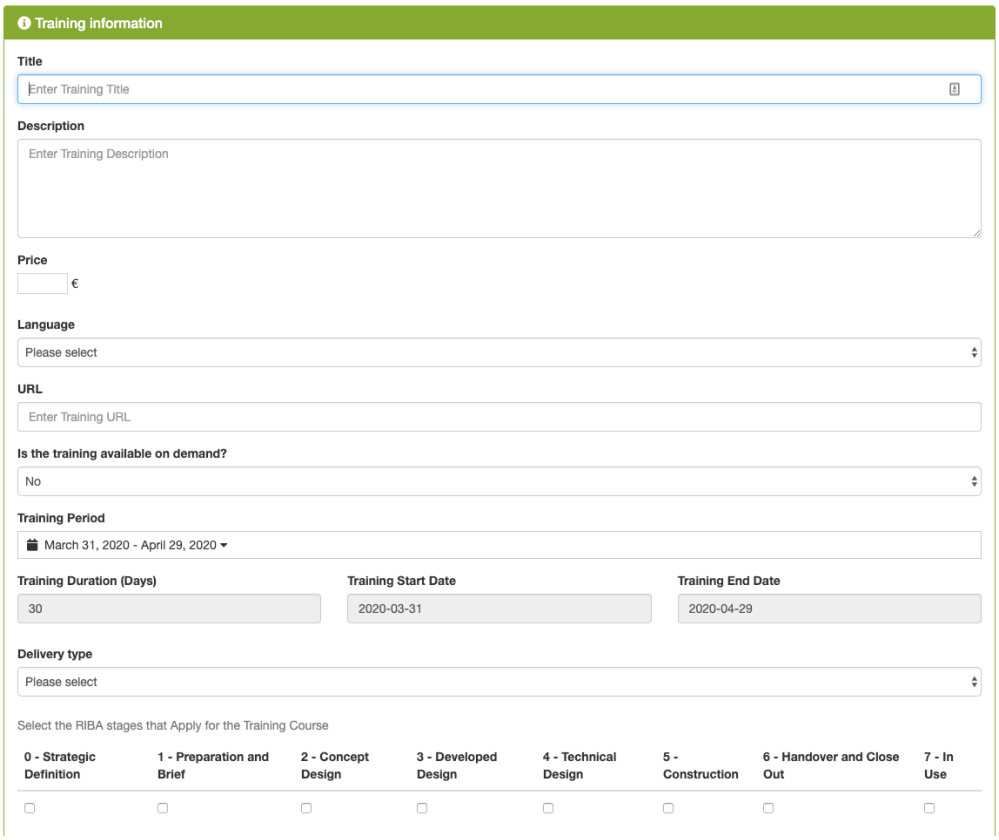


Figure 25. The Training information step of the Training addition form

2. ***Training information*** (Figure 25) enables the user to specify the information related to the specific training to be validated, such as training name, description, price, language, URL, duration, start and end dates (for trainings that are not available on demand). The selection of training period interval automatically updates the *training start date* and the *training end date* are hidden by default if the training is available on demand. Additionally, depending on the RIBA stages selected at this step, different modules and learning outcomes will be displayed at step 6.

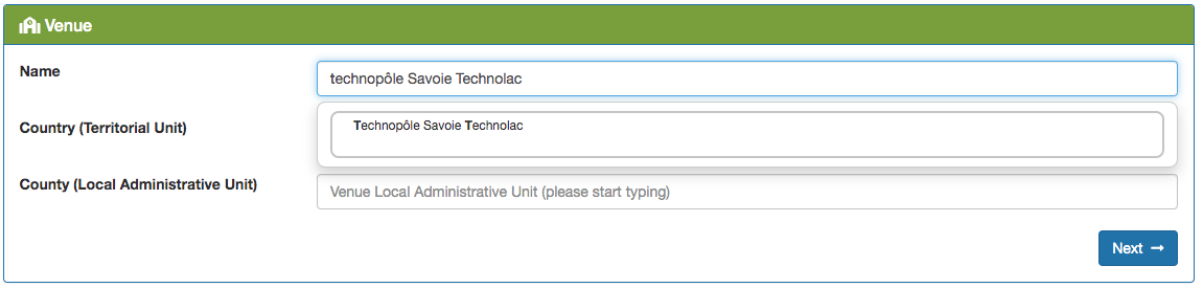


Figure 26. The Venue step of the Training addition form

3. ***Venue*** (Figure 26) is almost identical in terms of functionality with ***Organiser***. Its necessity is given by the fact that there could be an institution or location hosting the Training different to the ***Organiser***.

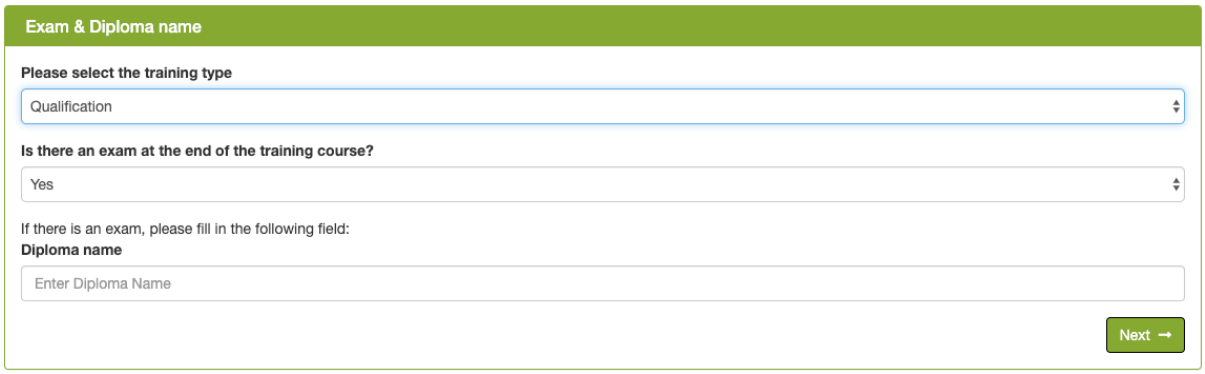


Figure 27. The Exam & Diploma name step of the Training addition form

4. ***Exam & Diploma name*** (Figure 27) enables the selection of the training / diploma type (Certification, Qualification or Graduate Education) and whether an exam needs to be passed for completion. In case of a positive answer, the *Diploma name* field is enabled.

Figure 28. The Targeted public step of the Training addition form

5. ***Targeted public*** (Figure 28) enables the selection of the target audience categories for the training in question. This will further filter the learning outcomes displayed at the next stage.

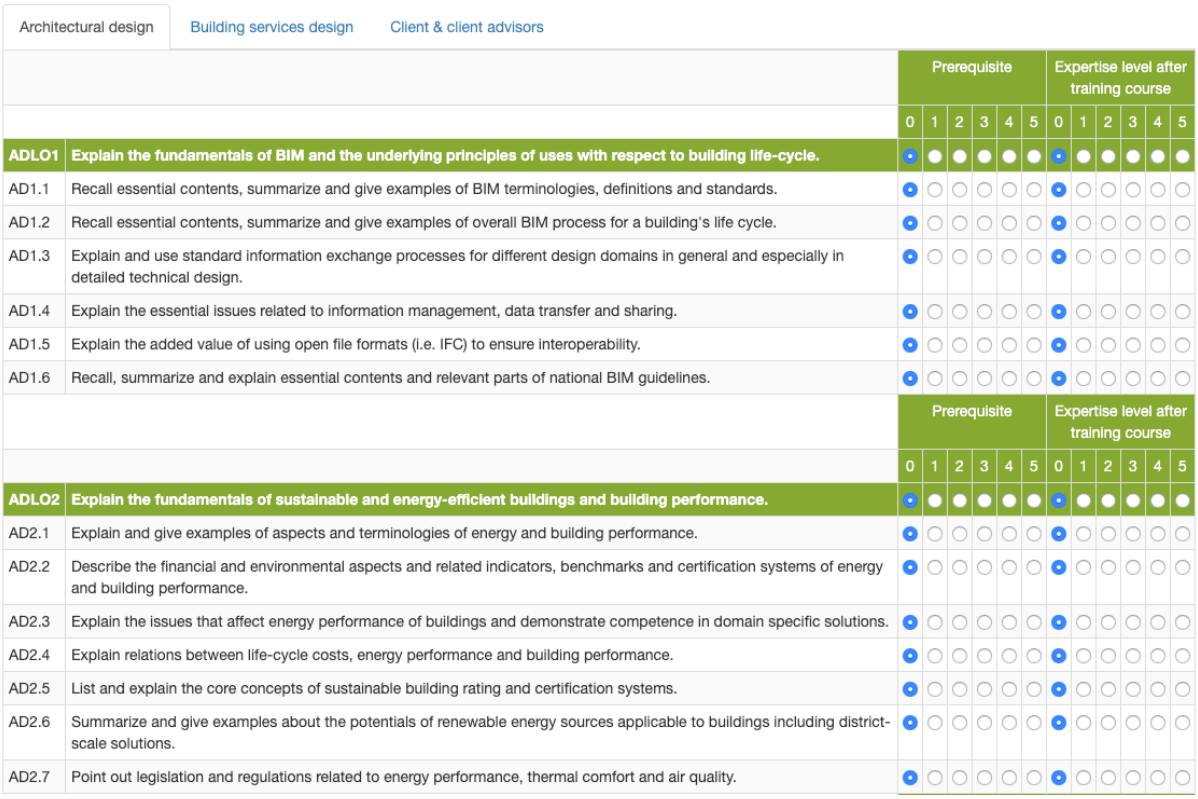


Figure 29. The Learning Outcomes step of the Training addition form

6. ***Learning outcomes*** (Figure 29) enables users to select the relevant Learning Outcomes (specific to the target audiences selected at Step 5 and RIBA Stages selected at Stage 2), in order to associate them and their respective prerequisites and expected maturity levels with the newly added training and associated modules.

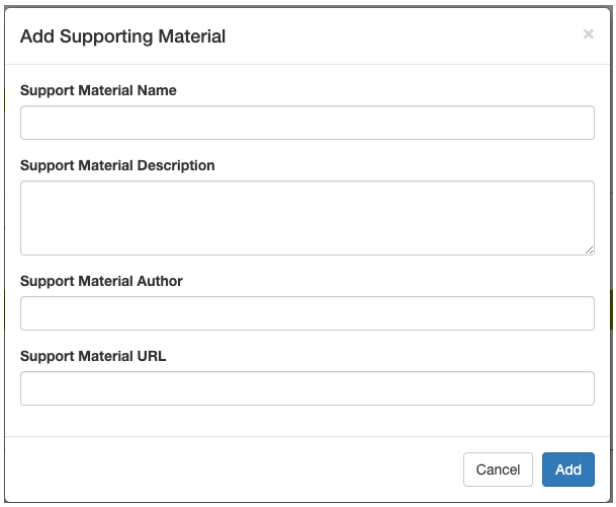


Figure 30. The Supporting Materials step of the Training addition form

7. ***Supporting Materials*** (Figure 30) encourages (although it does not oblige) the user to associate supporting materials with the newly added training.

Figure 31. The Finish step of the Training addition form

8. ***Finish*** (Figure 31) displays the newly added training that is now pending validation by an administrator to be added to the database.

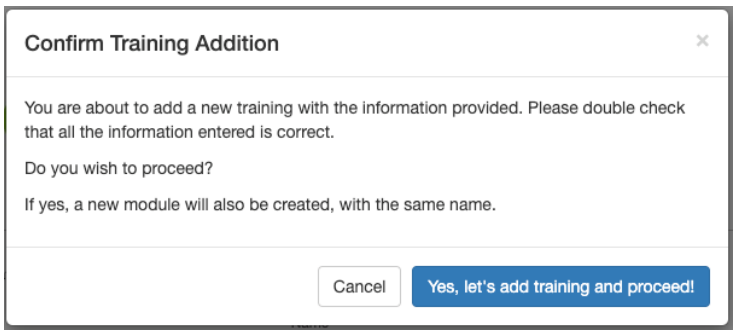


Figure 32. Training addition confirmation message

The training is effectively processed as early as when the user clicks the *Next* button at stage 5, in order for the next steps to function properly through data associations. Before the training is persisted into the database, the user is prompted with a confirmation message (Figure 32).

3.3.4. The *energy-bim.com* platform validity and usage statistics

The innovative dimension of the BIMEET platform lies in its open, scalable and polymorphic context-based widgets that reconfigure and update themselves to respond to changing user context and (BIM related) queries while enabling serendipitous BIM information and knowledge discovery. Each service has a corresponding widget that can be updated and administered remotely by users.

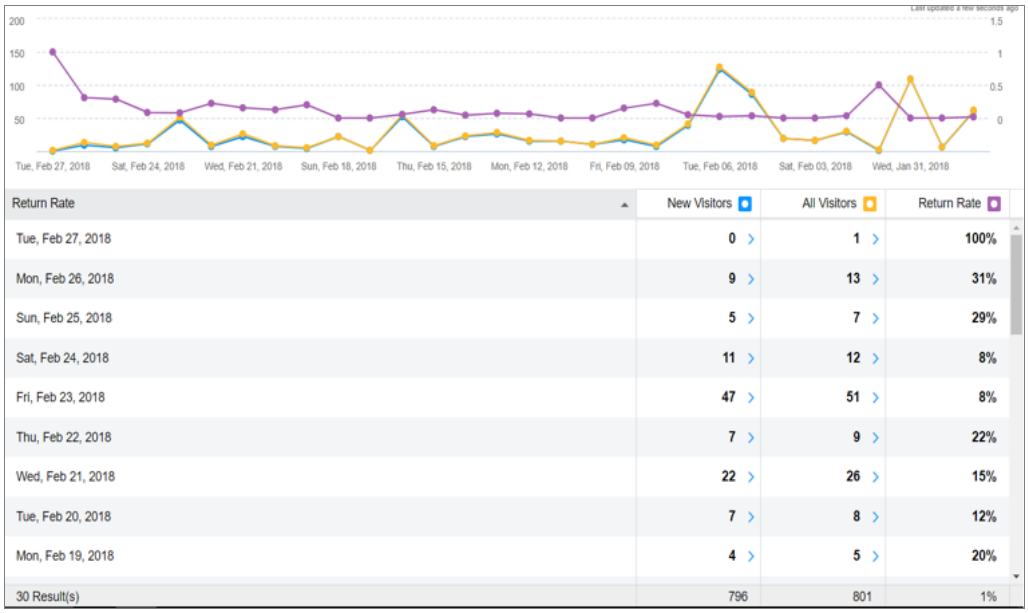
The analysis of users' statistics and comments helped identify some key issues to be addressed in future releases of the platform.

We have exposed the energy-bim.com platform as an online location for creating a community of users in the field of BIM training for energy efficiency. From the monitoring interval between December 2017 - February 2020 we have attracted new users and identified an increase number of visits. Using the Google Analytics dashboard bellow we provide several statistics on the platform web activity. Figure 33 illustrates the total amount of visits of the energy-bim.com platform over a trial period of 3 months. It can be identified that the popular services and the associated accessed content are related to different countries in Europe.

Country	Users	Users
	1,875 % of Total: 100.00% (1,875)	1,875 % of Total: 100.00% (1,875)
1. United States	713	37.91%
2. United Kingdom	224	11.91%
3. Hong Kong	87	4.63%
4. India	68	3.62%
5. Canada	40	2.13%
6. France	36	1.91%
7. Germany	33	1.75%
8. Australia	32	1.70%
9. China	26	1.38%
10. Spain	23	1.22%
11. Brazil	22	1.17%
12. Netherlands	22	1.17%
13. Poland	22	1.17%
14. Egypt	21	1.12%
15. Japan	20	1.06%
16. Italy	19	1.01%
17. Turkey	18	0.96%
18. Switzerland	17	0.90%
19. Norway	17	0.90%
20. Singapore	17	0.90%
21. Belgium	16	0.85%

Figure 33. Statistics for energy-bim.com web activity

Regarding the online activity of access BIM resources, Figure 33 illustrates the fact that a significant percentage of the users conduct web searching for BIM resources. Analysing the visitors' geographical provenience, we have identified that the platform presents interest not only of UK visitors but also for US or other EU countries.



Return Rate	New Visitors	All Visitors	Return Rate
Tue, Feb 27, 2018	0	1	100%
Mon, Feb 26, 2018	9	13	31%
Sun, Feb 25, 2018	5	7	29%
Sat, Feb 24, 2018	11	12	8%
Fri, Feb 23, 2018	47	51	8%
Thu, Feb 22, 2018	7	9	22%
Wed, Feb 21, 2018	22	26	15%
Tue, Feb 20, 2018	7	8	12%
Mon, Feb 19, 2018	4	5	20%
30 Result(s)	796	801	1%

Figure 34. Returning visitors to energy-bim.com

Figure 34 illustrates the fact that a significant proportion of the visitors to the energy-bim.com platform return after their first visit, finding the content and services provided valuable.

From the initial statistics, it can be concluded that the proposed web portal (a) has the potential to engage further practitioners in delivering BIM interventions as inferred through our portal validation work, and (b) contributes to the ongoing debate and BIM integration in the energy efficiency domain. In addition, the diversity of technologies can contribute to the emergence of new business models and contribute to the development of online marketplaces for the construction industry. We will further improve the energy-bim.com platform to refine search capabilities and result display as well as the online support and interface features in order to develop an effective and easy-to-use BIM training dedicated platform for the energy sector.

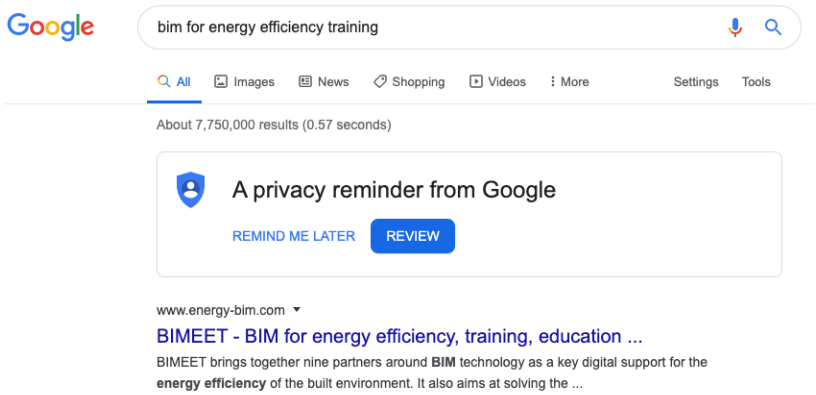


Figure 35. Ranking in Google of energy-bim.com for long-tail keyphrase

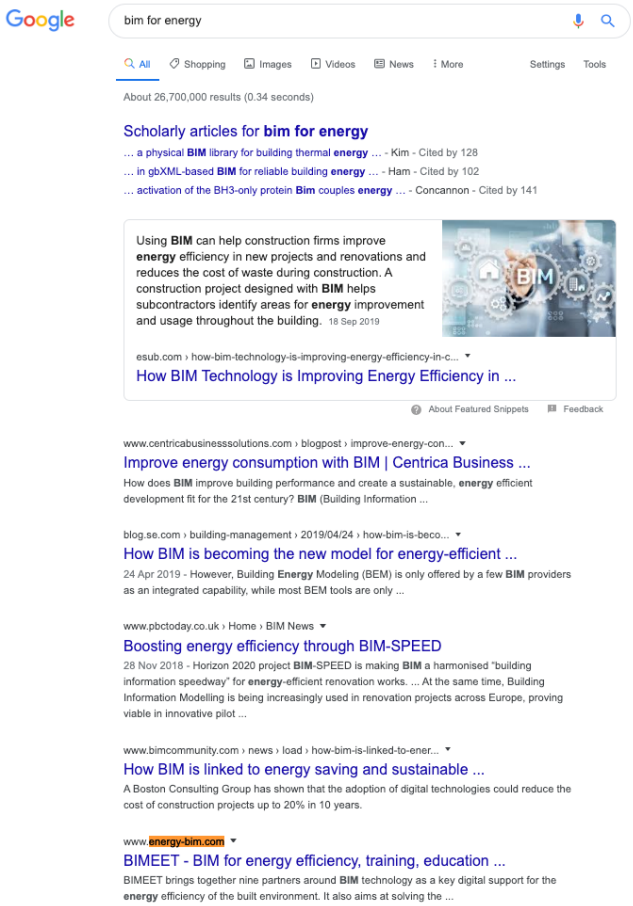


Figure 36. Ranking in Google of energy-bim.com for short-tail keyphrase

We can further validate the quality of our portal and its relevance to the public through the ranking of Google that the energy-bim.com platform achieved, ranking on the first page both for the “BIM for energy efficiency” long-tail keyphrase, that is specific and has a low ranking competition (Figure 35) and the “BIM for energy” short-tail keyphrase, that is more general and has a higher ranking competition (Figure 36).

In addition to the ***energy-bim.com*** portal, we have also developed the BIMEET blog, a child project that can be accessed at https://blog.energy-bim.com (Figure 37). This is an automated content aggregator that automatically fetches news about BIM from the most popular sources on the internet and categorises them in a tag cloud (Figure 38).

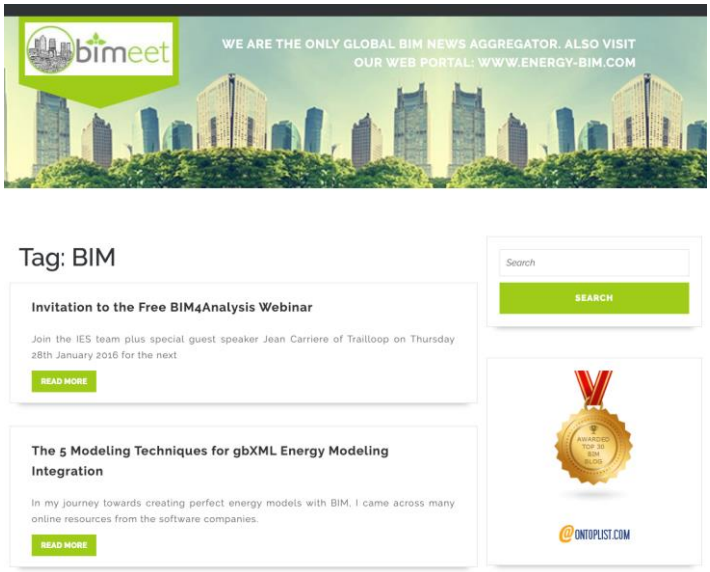


Figure 37. Ranking in Google of Energy-BIM Blog

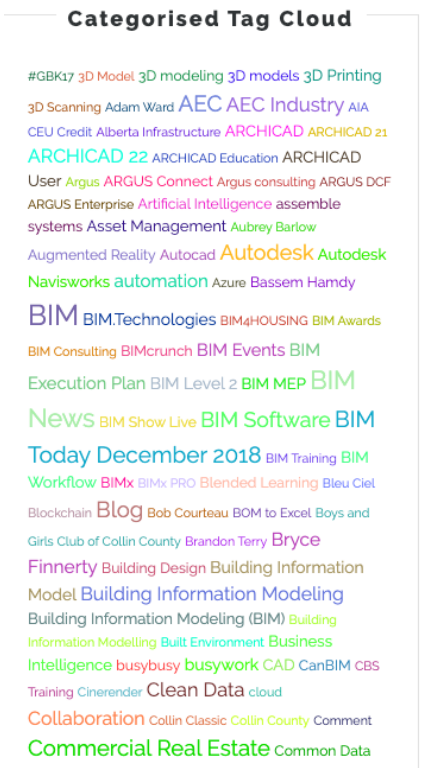


Figure 38. Ranking in Google of Energy-BIM Blog

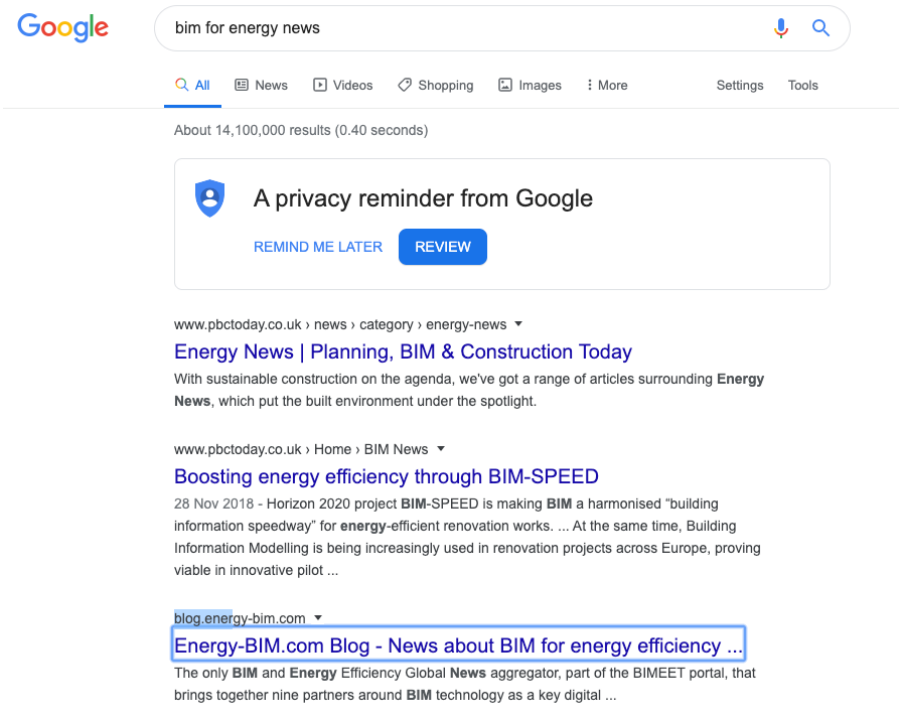


Figure 39. Ranking in Google of Energy-BIM Blog

As we can observe from Figure 39, the BIM news blog has also ranked high in google the medium-tale key phrase (“BIM for energy news”), proving its content to be relevant for the public.

It is important to mention that the BIM news blog was one of the “gateway” traffic generators for the Energy-BIM portal, through its direct link at the top to the main portal.

After conducting a brief online research, it is fairly safe to assume that the BIMEET Blog is the only news aggregator with a dedicated focus on BIM for energy efficiency.

3.3.4 Recommender

A recommender system [1] aims at ranking different items regarding users' preferences. They have been intensively studied for the last decades with the proliferation of e-commerce (Amazon, etc.). There are two main approaches for recommendation.

On the one hand, collaborative filtering approaches build a model from a user's past behaviour (in the Amazon example, the previously purchased items) as well as similar decisions made by the other users. This approach needs many data to recommend accurately items to users. This is not acceptable in our case since:

- We do not store the previously completed training for the users.
- Users have different goals.
- We need a recommender from the very beginning: these approaches suffer from cold start problem.

On the other hand, content-based filtering uses the description of an item to propose items with similar description. This is more convenient in BIM4VET and BIMEET since we use the same referential to describe trainings prerequisites and learning outcomes, etc.

To address the training recommendation problem, we chose to use a fuzzy expert system to check if the training prerequisites match with user competencies and if the training outcomes match with the user's goal.

Fuzzy logic has been intensively applied to recommendation, by fuzzifying collaborative filtering and content-based filtering approaches [2].

The recommender of the BIMEET platform is based on the fuzzy expert system ExpressIF© developed by CEA since 2010. It aims at modelling expert knowledge with rules written as close as natural language as possible in order to reproduce automatically a human expert reasoning on data [3], as shown in Figure 40.

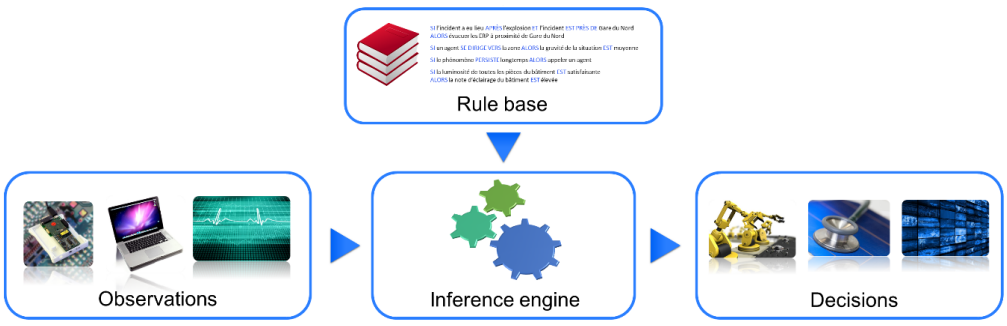


Figure 40. Overview of ExpressIF™

ExpressIF™ allows to model knowledge using Fuzzy Logic. This logic, introduced in 1965 by L.A. Zadeh [4] [5], is a multi-valued logic which truth values are comprise between [0;1], instead of the classic two values "true" and "false". Introducing continuous truth-values, fuzzy logic can handle the uncertainty of the knowledge (e.g., a « hot temperature ») and the inaccuracy of the input values. To achieve that, terms close to natural language are formalized by simple-shaped mathematical functions instead of mathematical operators (e.g., comparison operators). Figure 41 shows an example of three terms modelling respectively a

cold, average and hot temperature: “temperature” is called a linguistic variable. Fuzzy logic allows using rules, which are close to the natural language, without mathematical operators, which tend to more comprehensible rule bases, particularly by non-mathematician users.

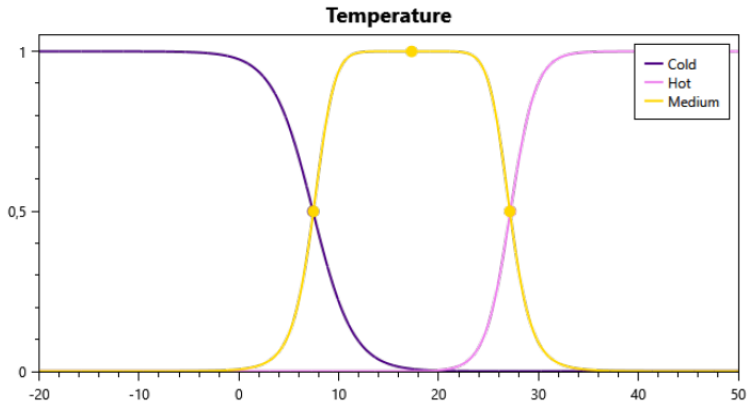


Figure 41. Linguistic variable "temperature" and its three terms

In BIMEET, ExpressIF© is used to perform a common-sense recommendation to address the lack of data about users’ preferences. We can distinguish two use cases for the recommender.

The first one is the same as BIM4VET, that is to say it consists in ranking the trainings regarding the user’s competencies and goals. The more the user’s competencies fit the training prerequisites and the more the training learning outcomes fit the user’s goals, the higher the ranking value.

The second one has been introduced for BIMEET. The goal is to recommend where it would be suitable to organize a training. This type of recommendation is for training centres that want to create a new training.

In the next section, we describe the rule base that is used to perform common-sense recommendation.

3.3.4.1 Rule base definition

The rule base is used to indicate to training centres how much a prospective training is relevant in a given geographical region. This region can be a city, a country, or whatever geodesic polygon. The recommendation can be based on:

- the list of the existing trainings, geolocated in order to map them with a region,
- statistics about the potential audience of a training, also geolocated for the same reasons.

In practice, statistics are difficult to gather and the rule base we tested in the project do not consider them. Eventually, the rule base can be completed later with more rules about this information: it is also an advantage of expert systems.

The list of existing trainings brings us this information:

- Trainings characteristics as the duration, the price, the languages, etc.
- Trainings profiles.
- Trainings learning outcomes.
- Trainings prerequisites.

Learning outcomes and prerequisites are defined over the same referential, with 272 learning outcomes and 5 levels of maturity for each one. Moreover, 20 profiles have been identified.

The common-sense we want to achieve is based on the fact that we want to recommend a training if there is no other training in the given region that share: the same characteristics, the same profiles, the same prerequisites and the same learning outcomes.

The fuzzy logic is used to avoid the binary decision recommend/not recommend and give a real value instead. The idea of the formalization is to check each criterion separately and then aggregate all the results.

We decided to base the recommendation on the concept of coverage, i.e., the number of existing trainings in the given region that satisfy a given criterium. For instance, if the prospective training is in English, we query the database for the number of trainings in English in this region.

As regions can have different sizes and different densities, we use the coverage as a percentage, by dividing with the total number of trainings in this region. This also simplifies the modelling because all the linguistic variables about the coverage will share the same terms definition. As shown in Figure 42, we chose to have a high granularity for the coverage, with 7 terms that specify the coverage is either null, partial or total.

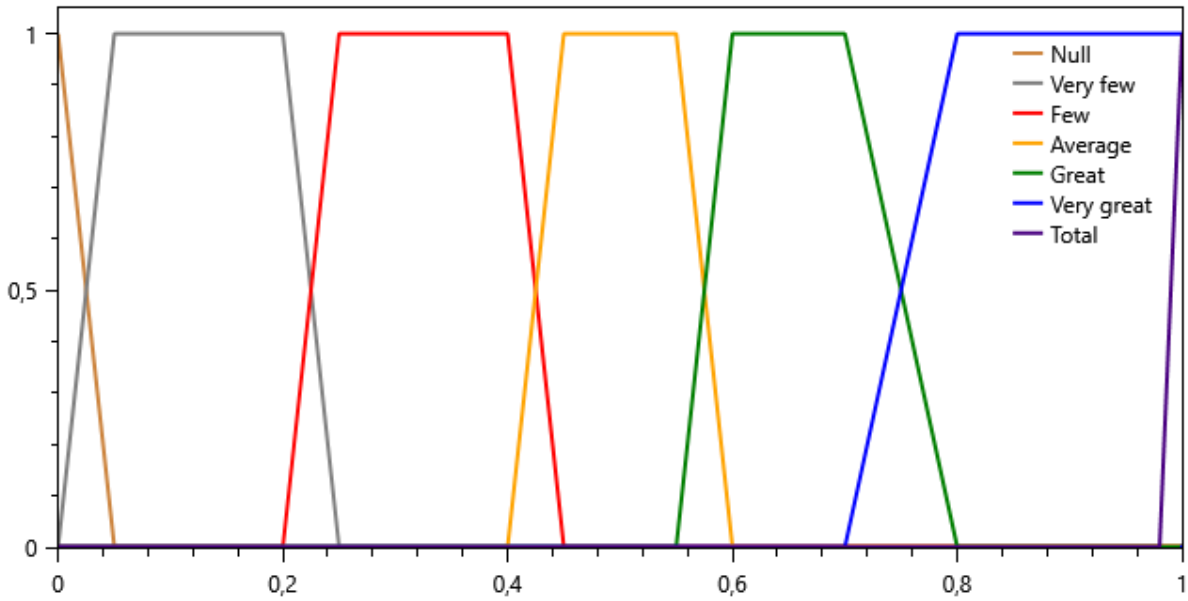


Figure 42. Linguistic terms definition for coverage

The “null” and “total” terms are very sharp, and the other terms are trapezoid. The “average” term is centred on 0.5 to support its semantic.

We also define the output linguistic variable called score (Figure 43). The higher the score, the more recommended the training. We chose to define it as a real value between 0 and 100. We use different 5 terms to qualify the score. We can see than the trapezoids are not symmetric: since each criterion is taken separately, we wanted to emphasize the low scores.

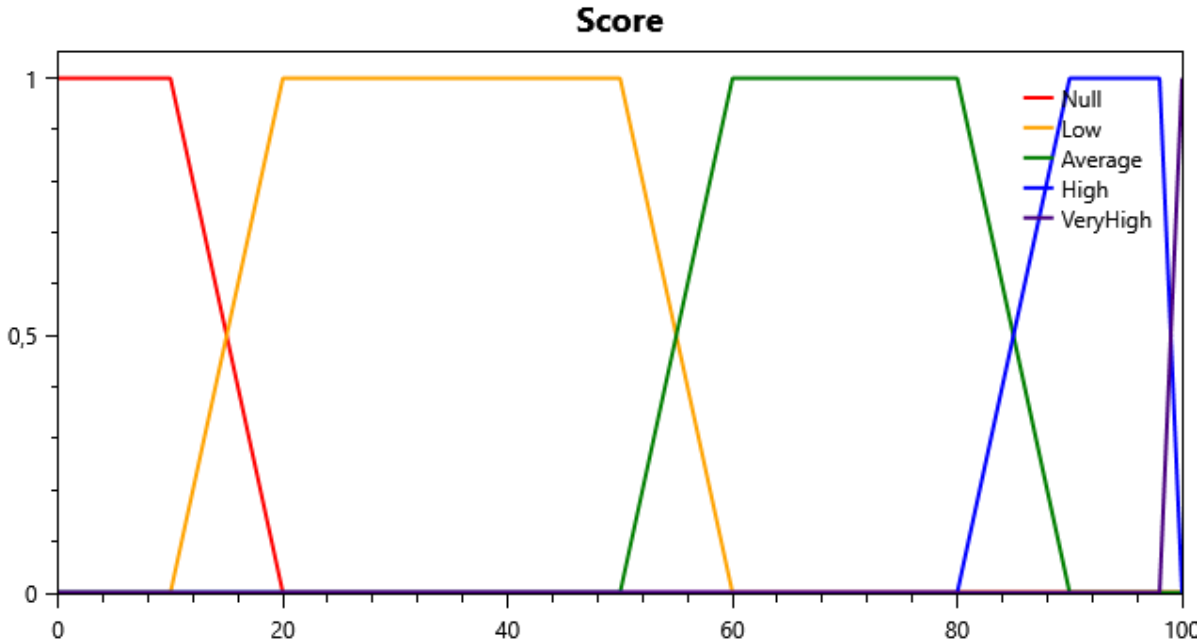


Figure 43. The linguistic variable "Score"

The rule base is constituted of 6 kinds of rules like:

- IF coverage of … language is … THEN score is …
- IF coverage of price is … THEN score is …
- IF coverage of duration is … THEN score is …
- IF coverage of profiles is … THEN score is …
- IF coverage of prerequisites … with maturity … is … THEN score is …
- IF coverage of learning outcomes … with maturity … is … THEN score is …

The generation of the total rule base is difficult, because we cannot know the covered languages, the different prices before the database query. Moreover, considering only profiles, prerequisites and learning outcomes will lead to a number of rules that will slow the rule base loading.

Instead of generating the complete rule base, we create on-the-fly the rules that are needed for the prospective learning. Hence, if some fields are not given, they are not used for the comparison. For instance, if the prospective learning defines only 3 profiles, the rules for these 3 profiles are created. Thus, the number of rules in contained.

To aggregate the results of the different rules, we use for aggregation and defuzzification methods the weighted centroid methods. It consists in computing the centroid of the fuzzy set of each activated conclusion independently and perform a sum weighed by the area under the curve. This allows having a flexible aggregation and suits well with the use case and the modelling of the problem.

3.3.4.2 Querying the recommender

To allow an easy access to ExpressIF©, we use it web service version, a REST API that uses JSON as exchange format (Figure 44).

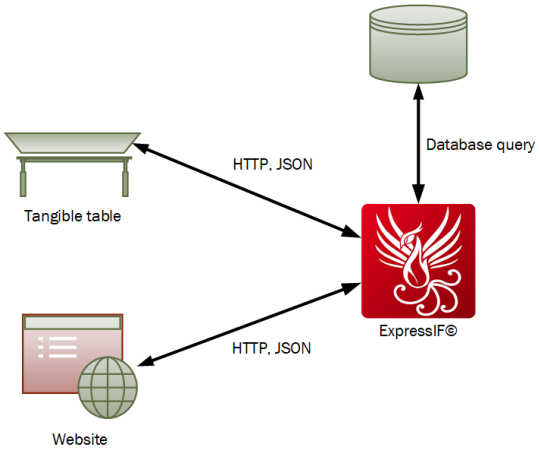


Figure 44. Recommender REST API principle

For the use cases of BIMEET, when a message is received, the service must query the database to fetch the relevant data. Moreover, as we seen before, when the query is received, the rule base is generated to fit the prospective training. Then the engine is fed with the data of the region and outputs a value between 0 and 100. Figure 45 shows the workflow of the REST API.

Figure 45. Recommender REST API workflow

The input JSON looks like:

```
{
	"Regions": [ { Region coordinates } ],
	"Training": {
		"DurationInDays": ...,
		"PreRequesites": { LO: maturity ... },
		"TrainingType": ...,
		"Outcomes": {
			LO: maturity,
			...
		},
		"Language": "...",
		"ProfileIds": [ ... ],
		"DeliveryType": 1
	}
}
```

The output JSON looks like:

```
[
	{
		"Regions": [ { Region coordinates } ],
		"Score": ...
	},
	...
]
```

3.3.5 Tangible User Interface

From the tangible user interface perspective, most of the work done in the scope of the BIMEET project was focused on the design and the implementation of the scenario, leveraging already existing blocks and functionalities to do so. The BIMEET application thus uses, besides the Tulip core package, the Tulip-CPS (see 3.2.2.1) and the Tulip-GIS (see 3.2.2.2) extensions.

3.3.5.1 Scenario

The geo-referenced nature of the repository content more or less calls for a map-based scenario. The integration and manipulation of maps and spatial data is hugely simplified thanks to functionalities provided by the Tulip-GIS extension.

3.3.5.1.1 Map Layers

The Tulip-GIS extension introduces the concept of layers (see Figure 46), allowing the visualisation of data from OGC compliant Web Map Services (WMS) as well as spatial data (geometries). The layers are stackable and are ganged spatially, meaning, zooming or shifting one layer entails all layers following suit. A dedicated **Zoom Widget** gives the users the possibility to zoom and pan the displayed layers in unison.

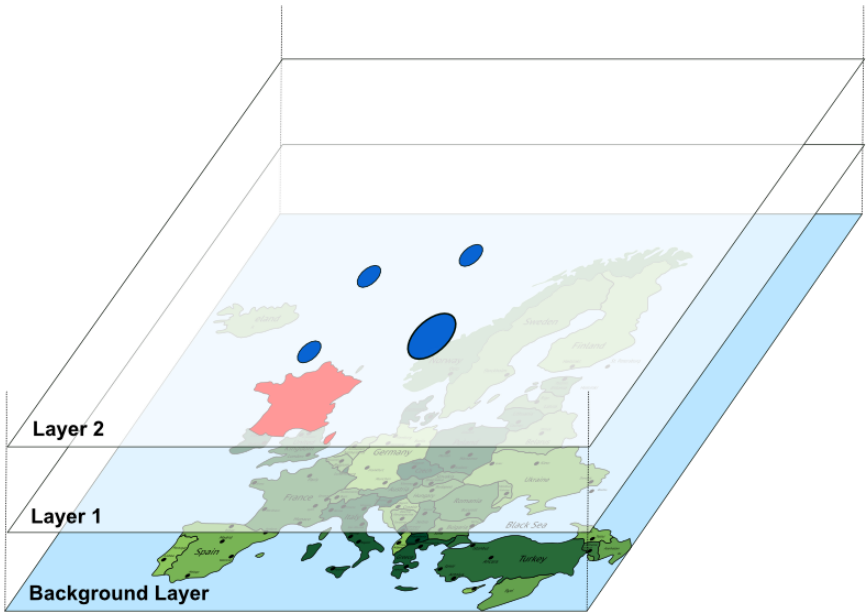


Figure 46. Stacking of Layers

Each layer is associated to one dedicated tangible object, whose presence on or absence from the table controls the visibility of the corresponding layer. The relative vertical position of the different objects furthermore controls the stacking order of the layers, i.e., the object further up (or north with respect to the map), is the topmost layer. It's also possible to show multiple data sets on one single layer. Switching between the different data sets is simply achieved by rotating the object.

3.3.5.1.2 Layer Definition File

Which layers are available and which data is shown is controlled via a dedicated **Layer Definition file**. Similar to the Tulip **Scenario** file, this file is an XML file.

```
<!-- ============ -->
<!-- Widget ID 23 -->
<!-- ============ -->

<layer class="marker" displayName="Architects" template="activityTypeLayers" widgetID="23" priority="0" default="true"
       name="architects" touchable="true" srs="EPSG:3857" format="image/png" />

<layer class="marker" displayName="Engineering" template="activityTypeLayers" widgetID="23" priority="0"
       name="engineering" touchable="true" srs="EPSG:3857" format="image/png" />

<layer class="marker" displayName="Construction" template="activityTypeLayers" widgetID="23" priority="0"
       name="construction" touchable="true" srs="EPSG:3857" format="image/png" />

<layer class="marker" displayName="Facility" template="activityTypeLayers" widgetID="23" priority="0"
       name="facility" touchable="true" srs="EPSG:3857" format="image/png" />

<layer class="marker" displayName="HVAC" template="activityTypeLayers" widgetID="23" priority="0"
       name="hvac" touchable="true" srs="EPSG:3857" format="image/png" />
```

Figure 47. Excerpt from Layer Definition File

Figure 47 shows an excerpt from the BIMEET Layer Definition File. Each layer is represented by a dedicate **layer** tag. The **class** attribute defines the type of the layer. In the shown example this attribute is set to *marker*. Marker Layers are generally layers showing locations on a map. The given example shows the definition of a multi-layer object, namely the one showing the locations of the available AEC professionals. Whenever multiple layers are associated with one single object, in our case the widget with the ID 23, the object will allow switching between the different sibling layers. The various attributes of the different layer tags control a number of properties for the layer to be shown.

3.3.5.1.3 Shape Layers

Shape Layers are able to display spatial geometries. The following shows an example of the definition of such a layer.

```
<!-- ============ -->
<!-- Widget ID 26 -->
<!-- ============ -->

<layer class="shape" displayName="Territorial Units" template="singleLayerWithHelp" shapeTemplate="countryOutlineMySql"
       widgetID="26" priority="0" default="true" name="territorial_units" touchable="true"
       selectionGroup="CountrySelector" exclusive="true" variable="CountrySelection" srs="EPSG:3857" format="image/png" />
```

Figure 48. Shape Layer showing boundaries of NUTS and LAU entries

The given example shows the definition of the layer responsible for showing the various territorial units available in the training repository.

3.3.5.1.4 GIS Layers

The layers shown Figure 47 and Figure 48 are populated with data from a local database, they do not depend on external services. GIS layers however, require access to an OGC compliant Web Map Service. Even though it is possible to setup such a service locally, most of the time we pull data remotely from existing Web Map Services. The drawback of unpredictable response times caused by temporary high server loads or network bandwidth bottlenecks is offset by the fact that shown maps are always up to date.

```
<!-- ============ -->
<!-- Widget ID 31 -->
<!-- ============ -->

<layer class="gis" displayName="Satellite" template="singleLayerWithoutLegend" widgetID="31" default="true" priority="0"
       name="ArcGis-Satellite" type="REST" srs="EPSG:3857" format="image/jpeg"
       url="http://server.arcgisonline.com/arcgis/rest/services/World_Imagery/MapServer/export?"/>

<!-- ============ -->
<!-- Global       -->
<!-- ============ -->

<layer class="gis" displayName="Streetmap" template="multipleLayersWithoutLegend" background ="true" widgetID="32"
       default="true" inverted="true" priority="0" name="OSM-WMS" type="WMS" srs="EPSG:3857" format="image/jpeg"
       url="http://ows.terrestris.de/osm-gray/service"/>
```

Figure 49. GIS layers from Layer Definition File

Figure 49 shows the definition of two GIS layers, obtaining their data from two different sources. The first one, associated with widget ID 31, is a regular layer showing satellite images of the currently shown map excerpt. The source of the satellite images is a map server specified by the **url** attribute of the layer definition, in this case a server located at http://server.arcgisonline.com.

The second GIS layer defines our background layer. Background layers are layers which are always visible, independently from whether their associated object is on the table or not. Setting a layer's **background** attribute to true enables this behaviour. The layer's **url** attribute points to the German map service provider (http://ows.terrestris.de), caching central Europe OpenStreetMap map tiles up to a scale of 1:25.000.

3.3.5.2 User Story

The BIMEET application is basically an interactive map, relying on a natural user interface to explore a.) the potential target audience for a given area and b.) the available trainings in the same region. The general idea is to provide training institutions with data required for identifying market needs when designing a new training.

Figure 50. OpenStreetMap background layer with NUTS boundary overlay

Figure 50 shows the OpenStreetMap background layer with central Europe in the center. The widget with ID 26 is on the table, superimposing the layer showing the available NUTS boundaries. The shown geometries are selectable, i.e., touching them selects and highlights them. It is important to note that the granularity of the **Territorial Units** layer is dependent on the map scale. The default level as shown in Figure 50 is NUTS-0 level, i.e., country level. When zooming in, using the Zoom Widget, the granularity level of the layer increases through the available NUTS levels all the way down to municipality (LAU) level.

Direct interaction with territorial units does not yet have a purpose, but it could be used to call up regional statistics which might be of interest when designing a new training. Identifying and collecting these datasets was outside the scope of this project, but once these data sets are available, they could be integrated quiet easily. We already implemented such a statistics exploration tool in the scope of a former national project (LetzSee – CNS/LIST/Sofpital S.A.) aiming at getting a better understanding about medical demography in Luxembourg. We collected socio-economic, demographic and infra-structure related regional data sets, all made available via the Luxembourgish governments open data portal (http://data.public.lu) and linked them to an interactive map as described earlier.

3.3.5.2.1 Exploration of potential target audience

As already described in 3.3.2.4, we added a repository of AEC professionals to the training repository. Since the repository currently only contains data about Luxembourg, we'll zoom in on Luxembourg to show how to identify potential target audience.

Figure 51. Location of professionals with activities related to the architectural design role

Figure 51 shows the map after zooming in on Luxembourg and placing the **Professionals** token on the table. As described in 3.3.5.1.2, the multiple layer definitions for

one and the same widget, in combination with a common template definition (*activityTypeLayers*), automatically translates into a widget with six positions. Individual dots vary in size depending on the number of employees captured for the respective professional.

Locations marked with an symbol identify clusters of professionals, the displayed number showing the number of professionals inside the cluster (see Figure 52). Professionals are clustered if their geographical locations are too close for a given zoom level. We're using a technique called *geohashes* to determine geographical proximity of individual locations. The concept of geohashes consists in dividing the world into a grid of 32 cells, each cell being identified by a base-32 alphabet character (Letters A -Z extended with the numbers 2 to 7, one and zero being excluded to avoid confusion with letters 'O' and 'I'). Each cell in turn is further sub-divided into 32 cells, again identified by a base-32 identifier, appended to the parent's identifier and resulting in a base 32-character string. This process is repeated until the desired level of detail is reached. As an example, the first level results in cells covering a huge area of 5000 by 5000 kilometres. At the ninth level already, each cell measures merely 4.77 by 4.77 meters. Our clustering algorithm determines for the current zoom level the required level of detail. Each company location is then converted into a geohash identifier, down to the previously determined level of detail. All locations returning the same geohash string are considered too close to be differentiated and are thus grouped in their own cluster.

Figure 52. Location of professionals with activities related to the engineering role

Another way of *manually* exploring the potential target audience consists in combining both regional boundaries and company profiles. By placing the Activity Density token on the table, the application aggregates company profiles by municipalities and produces a kind of heat map representing the currently selected activity type (see Figure 53).

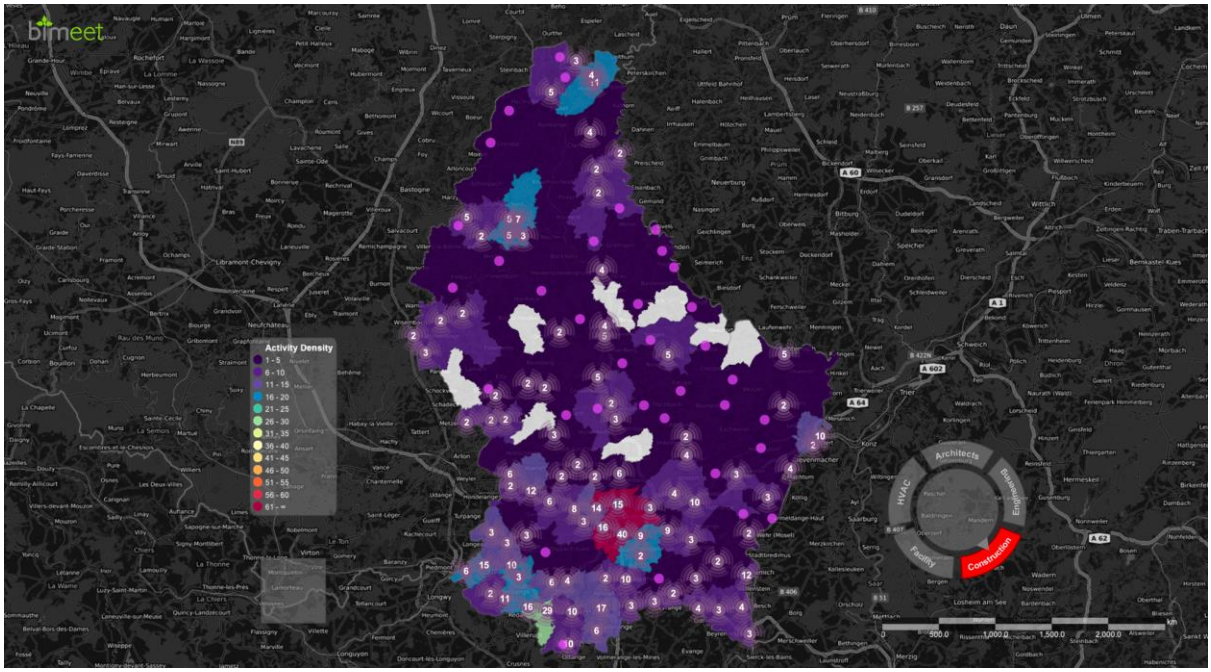


Figure 53. Activity Density per municipality for construction role

Besides this more classical and manual approach, we were looking for a simpler and more effective way to find the required information, namely, how are the company profiles distributed in terms of headcounts for a given area of interest. We thus created a dedicated **Target Audience** widget (see Figure 54), which displays in an aggregated manner the number of employees associated with a given role. The following figure shows this widget on the table. Since we haven't defined a region of interest yet, all roles currently show a headcount of zero.

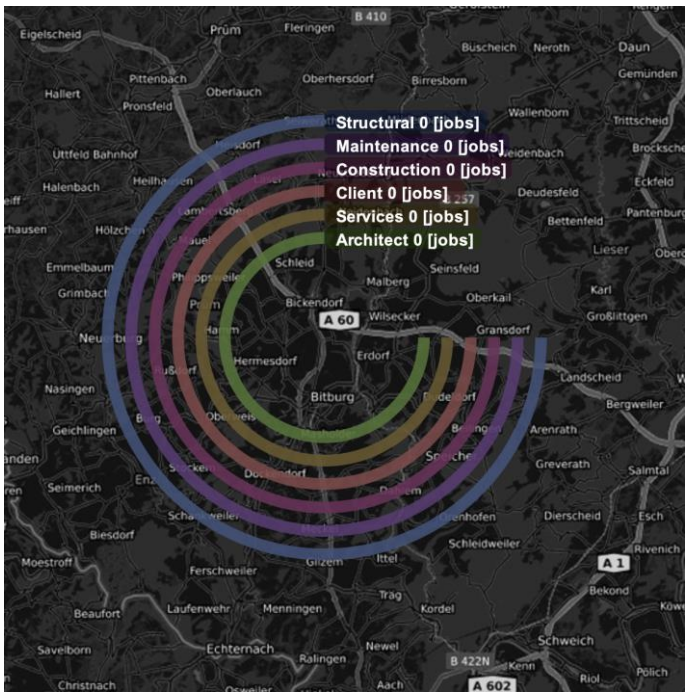


Figure 54. Target Audience Widget

Another widget gives users around the table the possibility to define a region of interest. In our example, our hypothetical training institution is planning to organize a training in Arlon, a town in Belgium close to the Luxembourgish border. To do so, they have to place the **Region of Interest** token on the table and move the *crosshair* at the tip of the widget to the desired location (see Figure 55).

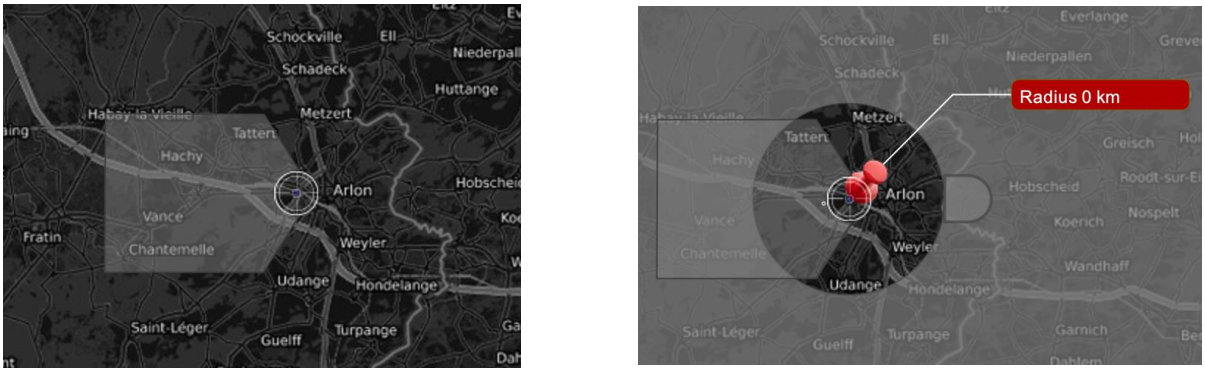


Figure 55. Selecting the origin of the region of interest

By touching the crosshair with a finger, the origin of the region of interest is selected, state which is visually reflected by a *thumbtack* appearing at the given location and the map being masked, except for a small region around the origin. By placing the finger on the little tab, which is draggable, the user is able to adjust the radius of the region of interest. The Target Audience indicators are updated as soon as the radius tab is released.

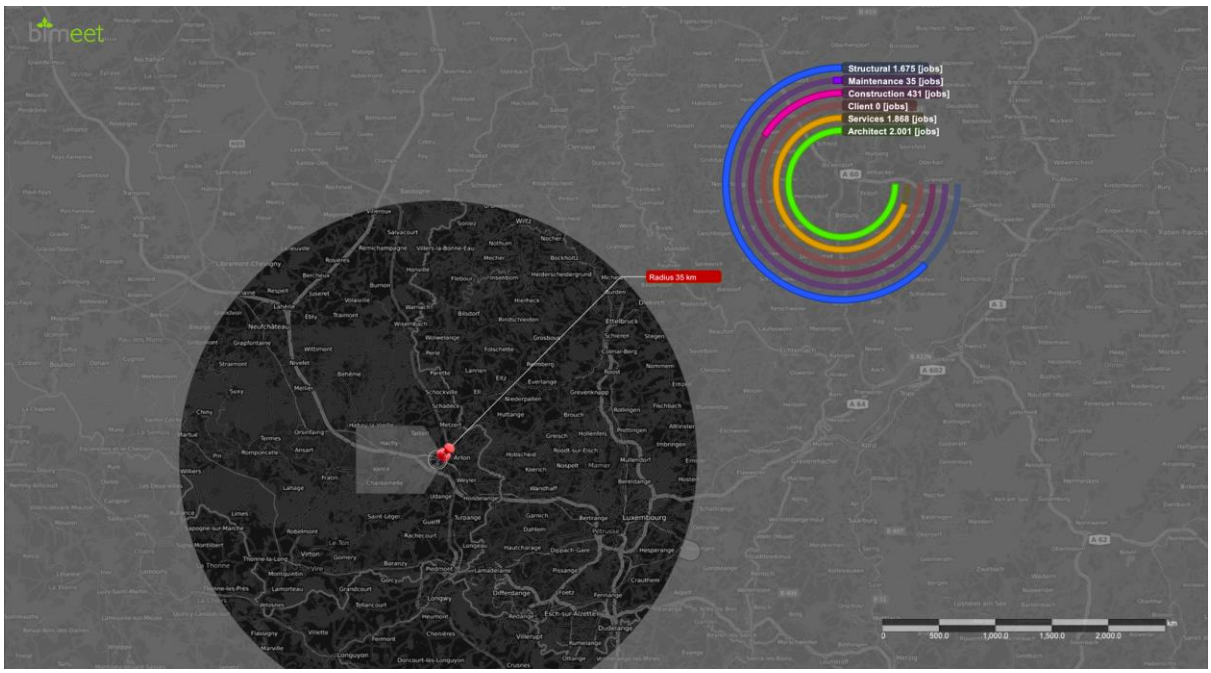


Figure 56. Target Audience break down for given region of interest

In the given example (see Figure 56), it appears that the **Architect** role has the highest head count, followed by **Building** Services and **Structural** Design. The other roles appear to

be proportionally underrepresented, so a new training may not necessarily target those roles but shall be more focused on three better represented ones.

3.3.5.2.2 Manual exploration of available training offer

The second question of interest when designing a new training is, which trainings are already available, who do they address and what is being covered. To get a quick glance on where trainings are available, all it takes is to place the **Training Locations** token on the table (see Figure 57).

Figure 57. Location of trainings compiled in deliverable D3.3

Just as we did for the target audience earlier, we need to define a region of interest in which we'd like to analyse the available trainings. In our example, our hypothetical training institutions thinks about hosting a training in Paris and expects attendees to be willing to attend the training within a radius of approximately 780 kilometres (see Figure 58).

Figure 58. Hypothetical Region of Interest

Thanks to the granularity of the data captured for the trainings in the repository, training institutions are able to find a wealth of information about their competitor's offer and thus enables them to create trainings distinguishing themselves and complementing already available training offers. For a given region of interest, the **Profile Coverage** token displays which profiles are already covered by existing trainings.

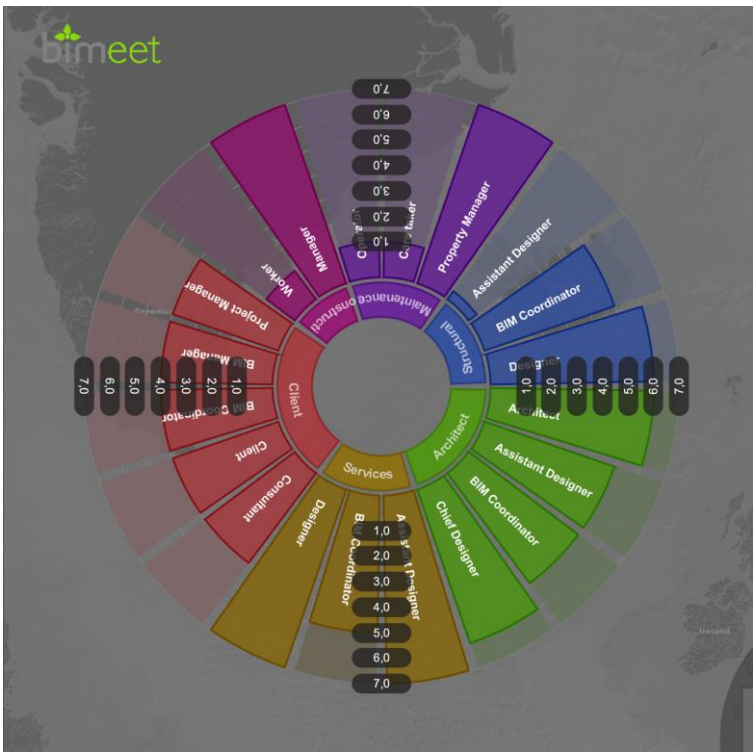


Figure 59. Profile coverage in region of interest

Figure 59 shows which profiles are covered by how many trainings in the given region of interest. In this example, certain profiles are fairly well covered; however, three profiles stand out as being underrepresented. In the **Structural** design role for instance, the Assistant Designer is covered by no training at all. In the **Maintenance** role, the **Operator** and **Caretaker** profiles appear to be covered by one single training. The **Worker** profile in the **Construction** role has the same low coverage.

By placing the **RIBA Stage Coverage** token on the table, the users are able to explore how the various stages of the building life cycle are covered by trainings in the region of interest. This knowledge will help in deciding which roles and profiles might need to be addressed and may influence the content of the training to be delivered.

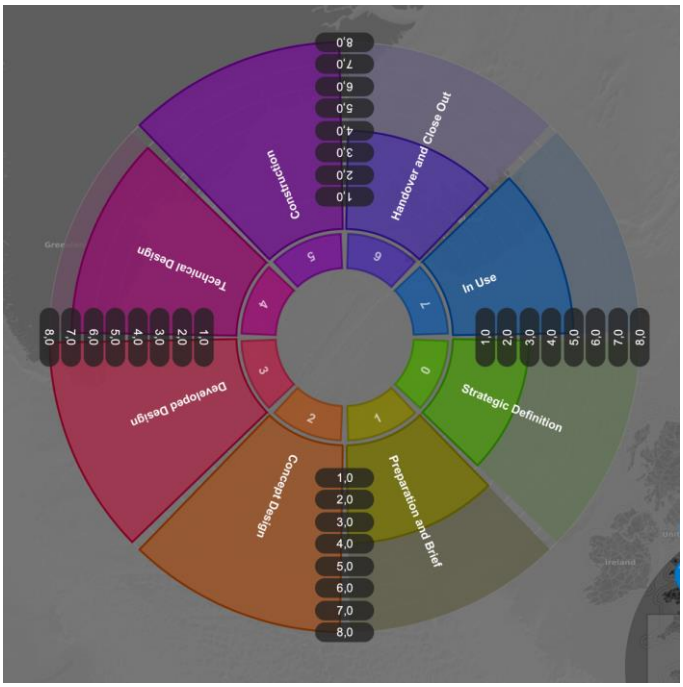


Figure 60. RIBA Stage coverage

Figure 60 shows that trainings within our region of interest mostly cover the centre RIBA Stages from **Concept Design** (Stage 2) up-to **Construction** (Stage 5). The very early stages as well as the later stages starting with **Handover and Close Out** appear to be less frequently covered. Even though there might be subjacent reasons for this uneven distribution, like for instance a lack of AEC professionals active in the respective construction stages, this observation might be a potential lead to follow-up on.

Once we have determined which roles, profiles and RIBA stages to cover, it's time to have a more detailed look on the content of the trainings, namely which learning outcomes are addressed by trainings in the region of interest, and last but not least, which maturity level do they a.) expect as a pre-requisite and b.) which level will attendees reach after attending. This is where the **Learning Outcomes** token comes into play. Unlike the previous token presented, the Learning Outcomes token is a *modal* and *multifaceted* token, i.e., it requires a number of interactions to deliver the desired information.

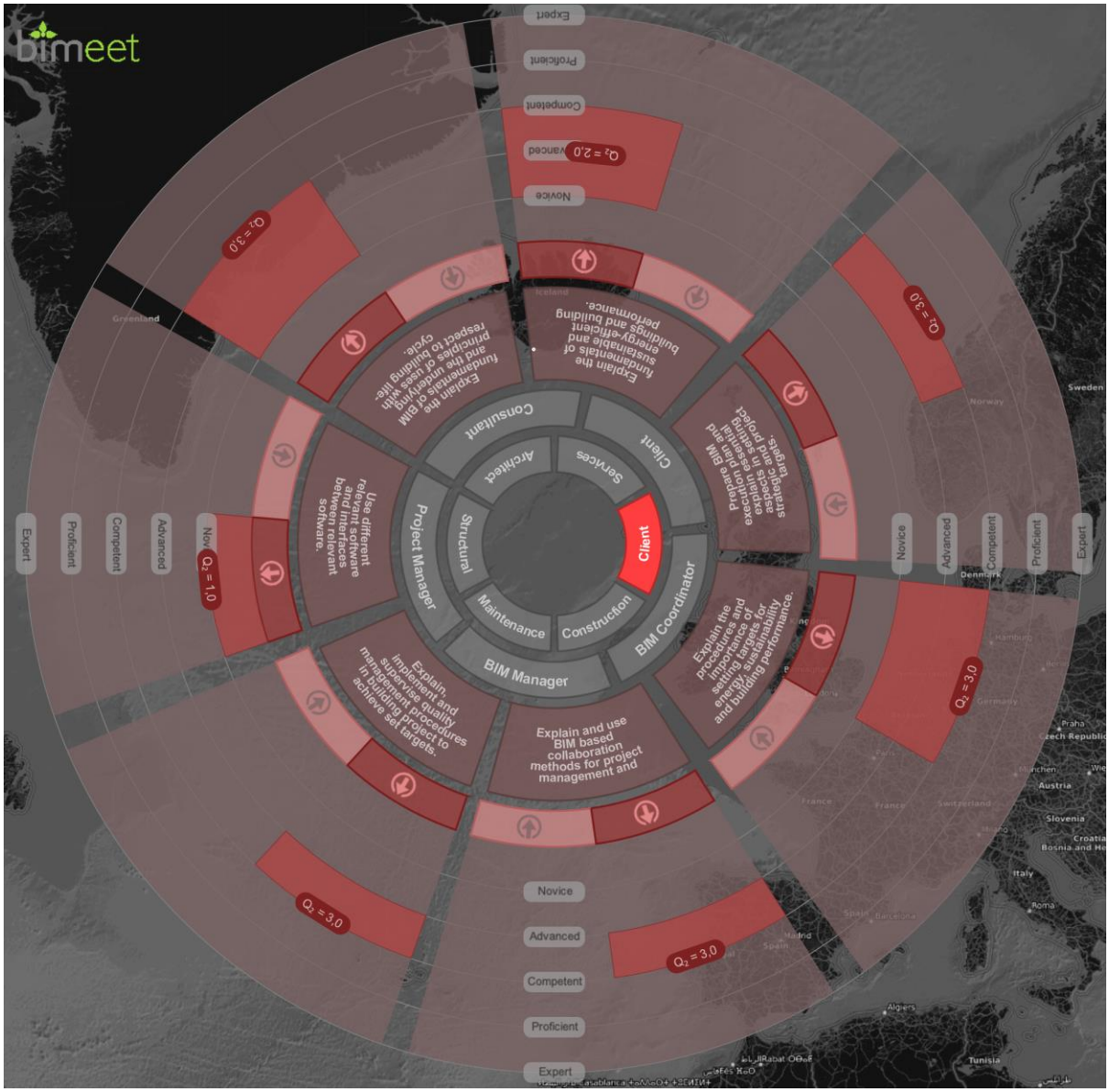


Figure 61. Learning Outcomes for Client role

Figure 61 depicts the learning outcomes addressed by the trainings in the region of interest for the **Client** role. When placing the token on the table, the users will only see the central ring of buttons showing the six **Roles** as defined by the LO Matrix. The users first need to select the role they wish to further explore, in our example the role of choice was the Client role. After selecting one of the roles by touching the corresponding button on the central ring, the token toggles into **Role** mode, displaying information about the respective role. We'll have a look at the displayed information from the inside towards the outside. A second ring of buttons orbits the central ring, the buttons corresponding to the **Profiles** defined for the selected role. Those buttons will be of importance during the training design process and are of no importance during the exploration phase, we will thus discuss them later (see 3.3.5.2.3). The third ring represents the actual learning outcomes for the currently selected role. As described in 3.3.2.1, given the great number of learning outcomes, learning outcomes are organised in a hierarchical manner. To limit the number of displayed items, only the high-level or parent learning outcomes are shown at this level. By touching one of the high-level learning outcomes, the token toggles into **Child** mode, displaying the learning outcomes further sub-

dividing the selected parent learning outcome. Touching the learning outcome once more brings the token back into Role mode.

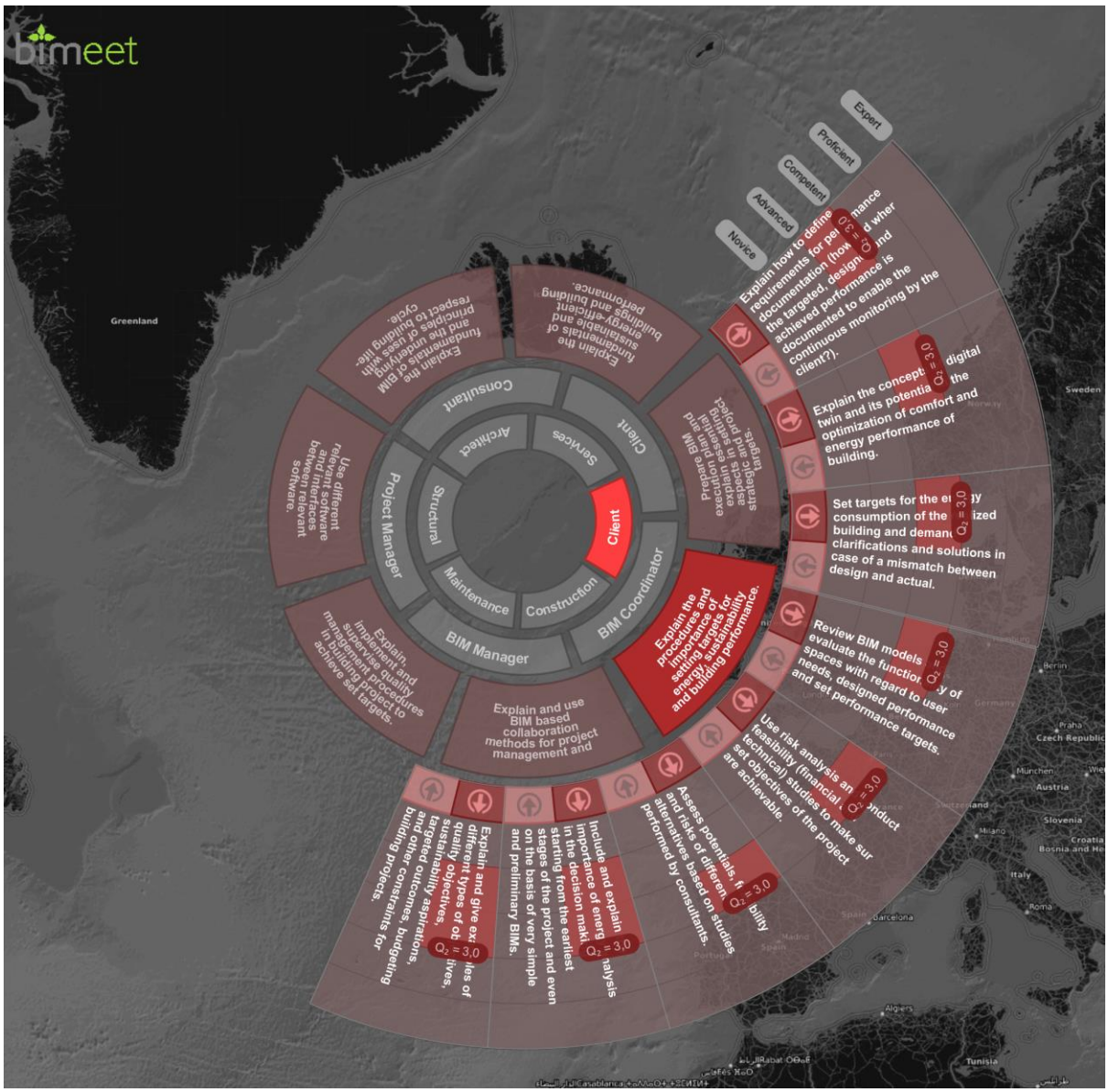


Figure 62. Sub Learning Outcomes of selected parent Learning Outcome

Irrespective of whether we're looking at Figure 61 or Figure 62, maturity levels for individual learning outcomes are shown in a similar manner. First of all, each learning outcome is represented by a pair of coxcomb slices, identified by a pair of icons.

Represents the prerequisite, i.e., the maturity level required to attend a given training.

Represents the actual learning outcome, i.e., the maturity level an attendee is expected to have after successfully completing the training.

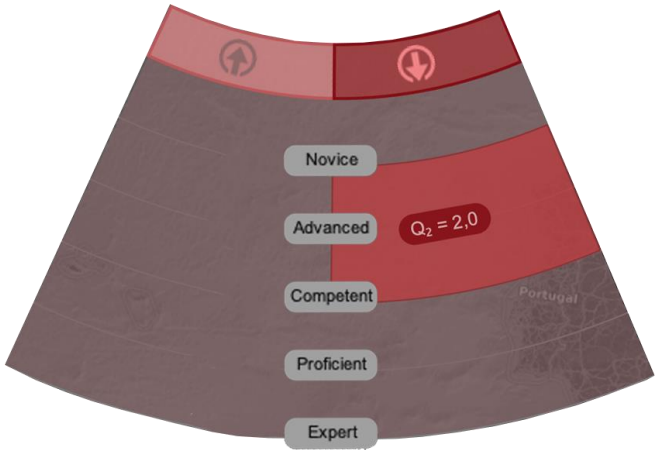


Figure 63. Learning Outcome Coxcomb Slice

Figure 63 depicts the coxcomb slice pair for an example learning outcome. The left-hand side, identified by the icon with the arrow pointing inside, in general shows the respective outcome's prerequisites, aggregated from all trainings in the region of interest. Since nothing is shown here, no prerequisite exists for the given learning outcome. The right-hand side, identified by the icon with the arrow pointing outside, shows the aggregated maturity levels of the respective learning outcome. The outcome slice extends from **Novice** (Level 1) to **Competent** (Level 3). This means that, whenever this particular learning outcome was assigned a maturity level for a given training inside the region of interest, the overall lowest level was "Novice" and the overall highest level was Competent. The additional indicator saying Q_2=2.0, shows the median (Q_2 for second quartile) maturity level of all defined levels and should help in assessing whether the distribution of maturity levels is *positively skewed*, i.e., mostly lower values, *negatively skewed*, i.e., mostly higher values or *uniformly distributed*. In our case, maturity levels appear to be uniformly distributed since the median value sits right in the middle of the minimum and maximum values. The closer the median value gets to the minimum value, the higher the positive skew and inversely, the closer the median gets to the maximum, the higher the negative skew (see Figure 64).

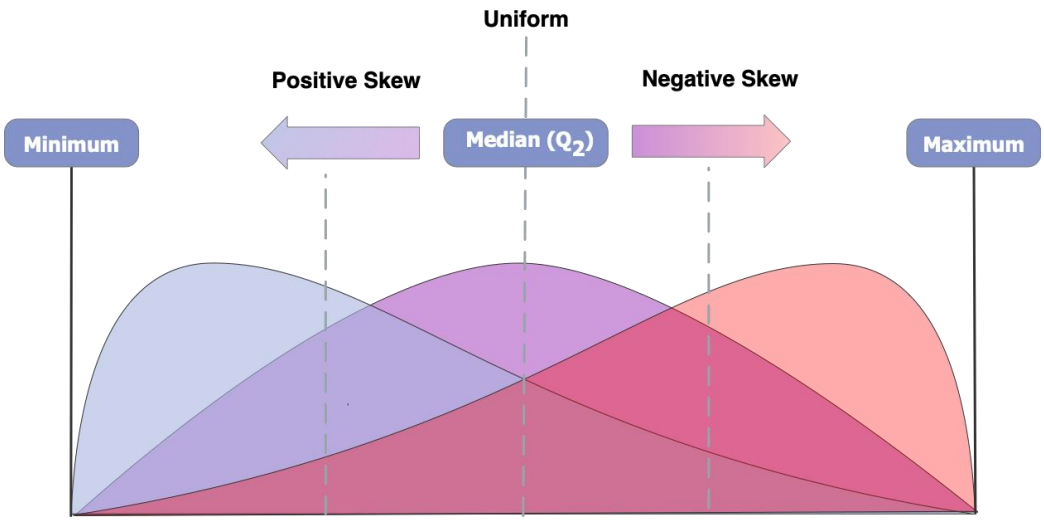


Figure 64. Median and Skew of Maturity Level Distribution

3.3.5.2.3 Training Design

Information and insight gained through the exploration of the training and AEC professionals repository should help in taking informed decisions when designing new trainings. It is important to note that the Training Design process implemented in the Tangible User Interface covers only the collaborative portion of the overall process. The more administrative tasks such as defining titles, descriptions and delivery related data are handled via a dedicated Training Form in the energy-bim portal. The collaborative portion of the design process consists mainly in defining which roles and profiles to address, which learning outcomes to cover and to define the maturity levels both for the prerequisites and actual maturity gains themselves. All of the necessary interactions are available in the **Learning Outcome** token.

3.3.5.2.4 Target Profile Selection

Already introduced during the presentation of the Learning Outcome token (see Figure 65), upon selecting a Role from the central ring of buttons, a second button ring displays all the Profiles defined for the selected Role. In the example depicted on the left, the selected role is the **Client** role, which contains the **Client**, **Consultant**, **Project Manager**, **BIM Manager** and **BIM Coordinator** profiles. The user is able to select the target profiles for the Client Role by selecting any combination of profiles. A profile is selected by touching the corresponding button with the finger. Touching a selected button for a second time deselects the profile again. Selecting profiles from another role is simply achieved by first selecting the role of interest and then selecting the available profiles.

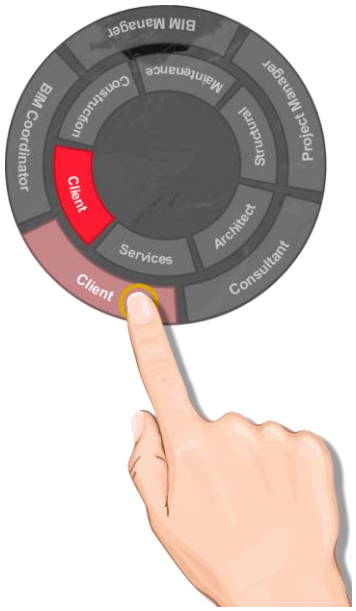


Figure 65. Selection of target profile

3.3.5.2.5 Maturity Levels of included Learning Outcomes

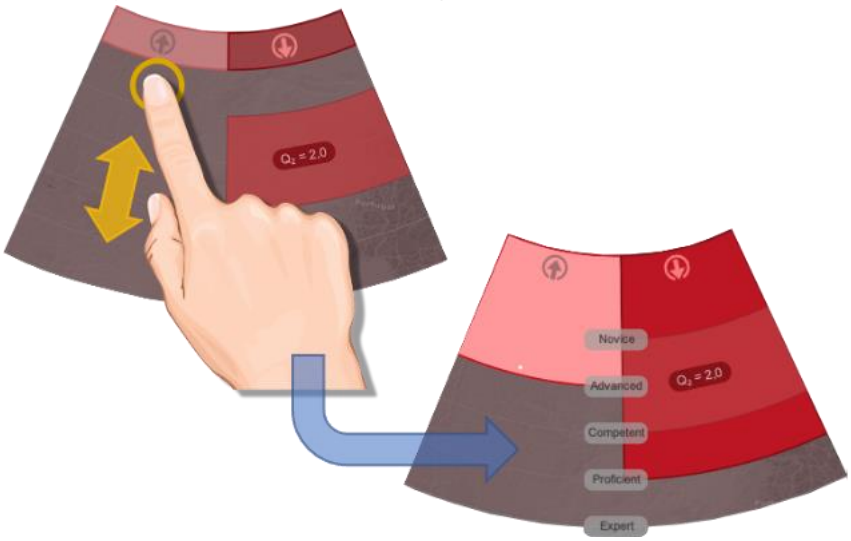


Figure 66. Learning outcomes selection

Selection of learning outcomes (see Figure 66) to cover in the newly designed training and which maturity levels to assign to both the prerequisites and outcomes themselves is done in a similar fashion. The first step consists in selecting the role for which the user wishes to include learning outcomes.

A learning outcome is only associated with the training being designed if and only if at least one maturity level is set for either the prerequisite, the learning outcome or for both. Setting a maturity level is achieved by touching the slice corresponding to the prerequisite or outcome and dragging the finger to the desired level. In the example depicted in **Error! R eference source not found.**, the user has set the required maturity level (prerequisite) for the given learning outcome to the **Advanced** level, whereas he specified that the training will increase the attendees' maturity level (outcome) to the level of **Proficient**. This process is repeated until all desired learning outcomes have been assigned their respective maturity levels.

3.3.5.3 Integration of the Recommender Engine

The rational for integrating a recommender engine into the design process was motivated by the desire to provide training institutions with as much information and support as possible. At the time of writing only one simple use case was implemented, i.e. determining for a newly designed training whether a given region of interest is suitable or not. In future evolutions of the training platform, we could imagine much more advanced recommendations such as determining for a given region of interest the best suited combination of learning outcomes, or inversely, finding for a given training the best region to deliver it. The platform would thus become a decision support system, relying on augmented intelligence to assist training designers.

3.3.5.3.1 Implemented use case

As already mentioned before, a very first use case involving the integration of a recommender engine has been implemented. The implemented use case provides for a newly designed training and a given region of interest a percentage of **differentiation** from already existing trainings. The higher the value of differentiation, the more the new training distinguishes itself from available trainings, presumably making it more attractive to a particular target market.

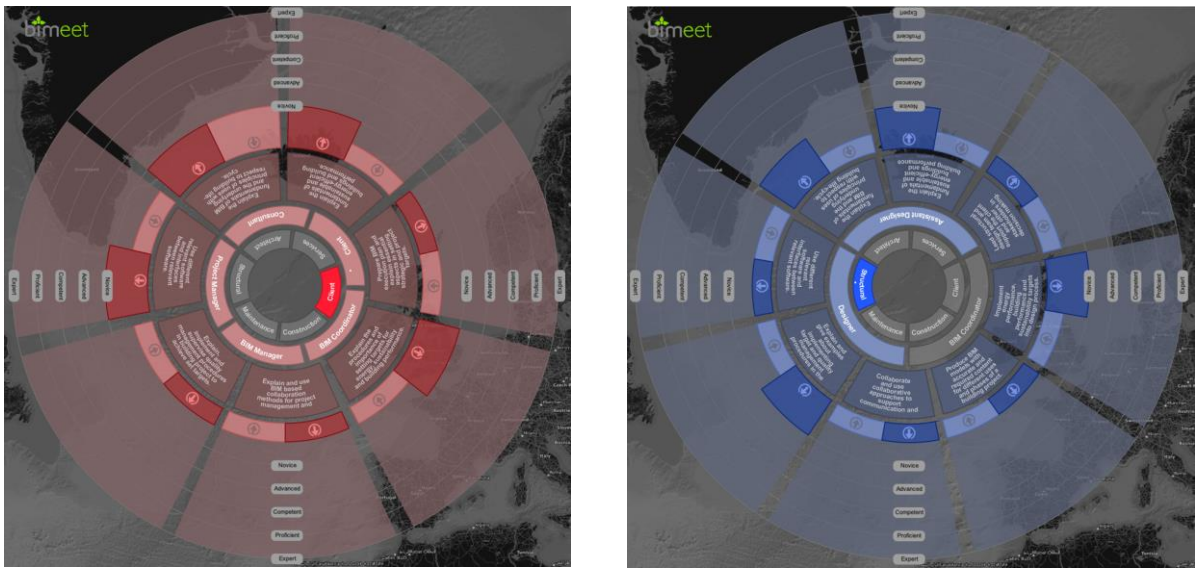


Figure 67. Learning Outcomes of newly designed training

Figure 67 shows a hypothetical new training for which Learning Outcomes are defined for the **Client** role, addressing all profiles within that role, and the **Structural Design** role, addressing only the **Designer** and **Assistant Designer** profiles. Next, let's assume that our training institution wishes to host the training in Paris and expects to attract attendees within a radius of approximately 780 kilometres. By placing the crosshair of the **Region of Interest** token on Paris and defining a region of interest with the desired radius, the recommender engine is invoked, getting the region of interest as well as the composition of the new training as parameters. The recommender engine uses those parameters to analyse all available trainings in the given region and determines how different the specified training is with respect to the analysed trainings.

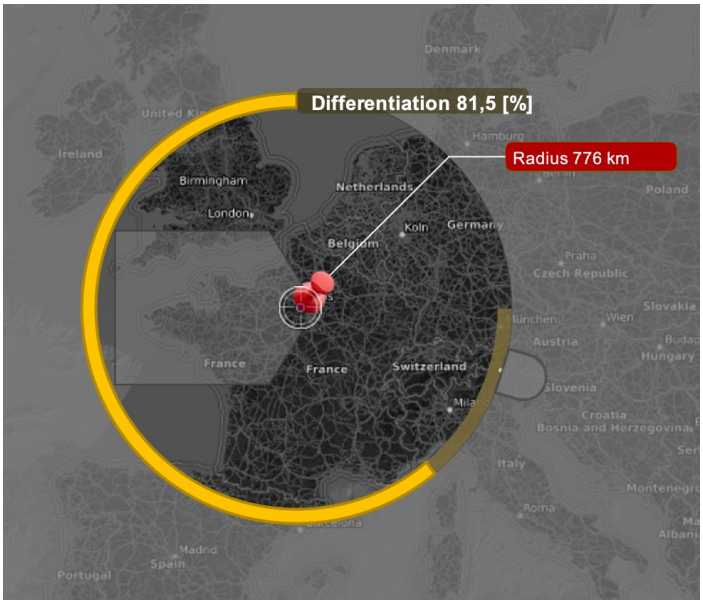


Figure 68. Differentiation value of new training

Figure 68 shows the result returned by the recommender engine. In our case, the newly designed training appears to differ by 81.5% from already existing trainings in the given area. By using the **Learning Outcome** token, our hypothetical training institution would next evaluate in which areas, or more specifically, for which learning outcomes, the training could be adapted to perhaps further increase this score.

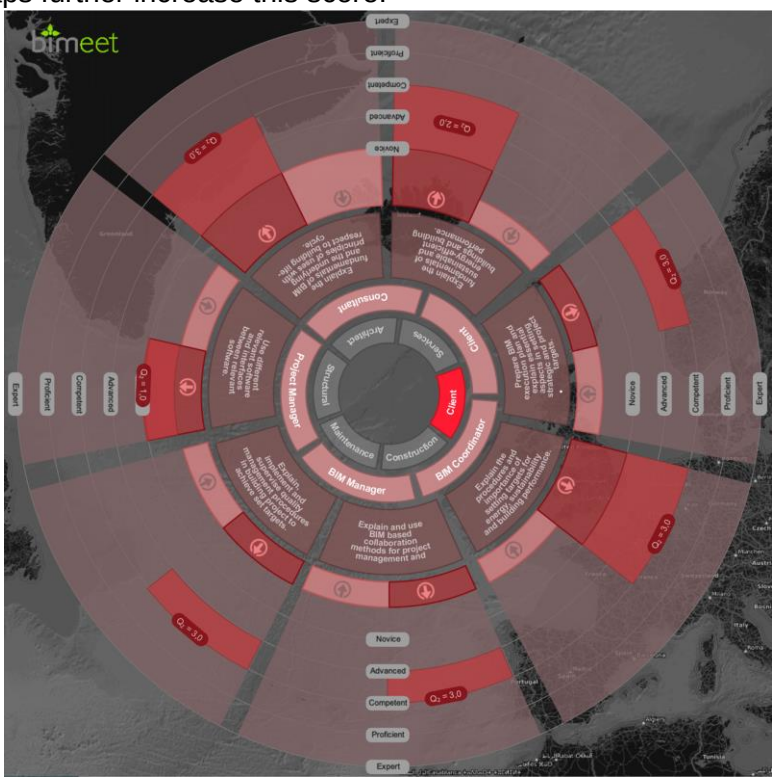


Figure 69. Compiled Learning Outcomes for Client Role

In Figure 69 we can see, that for similar learning outcomes, our training only reaches to a **Novice** level, whereas most already existing trainings seem to aim for a **Competent** level. We also see that our training doesn't cover a number of outcomes covered by other trainings.

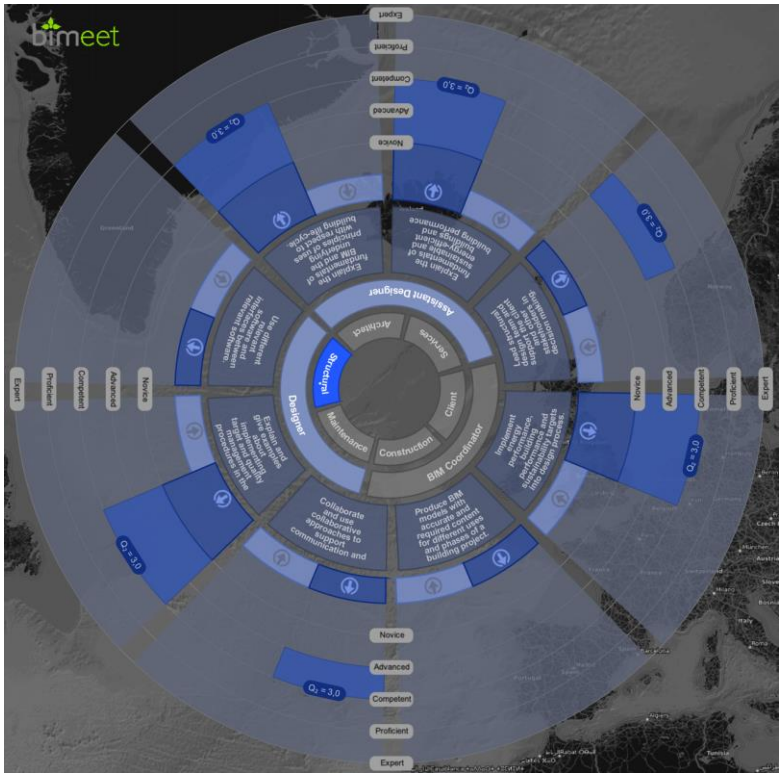


Figure 70. Compiled Learning Outcomes for Structural Design Role

Figure 70 shows a similar picture for the Structural Design role. At first sight our new training, which, given the low maturity levels it is targeting, is to be considered as a more introductory training, appears to be well positioned among the more expert trainings in the area. There's perhaps some room of improvement for other roles. Our training institution can further explore those roles, decide upon profiles and learning outcomes to include in order further increase the differentiation score of the new training. All this happens collaboratively, with all the stakeholders gathered around the table, discussing and exchanging ideas while testing different hypothesis until a consensus is ultimately reached

4 Conclusion and prospects

When studying the existing BIM+EE training courses, it appeared that the offer was near from inexistent in EU (see D2.2 for more details).
Consequently, the question of supporting the design of new courses appeared as a priority for helping the host institutions and practitioners in this task. Based on the collection of requirements from experts (see Table 5 and D4.1 for more details), the BIMEET application relies on an interactive map deployed on a natural user interface to explore data about the potential target audience and existing training courses. The general idea is to provide training institutions with information required for identifying market needs and consequently improving the consistency of the training offer.

This report presents the results from the development stage of the BIMEET application and all the technical component of this platform:

- The training repository (see section 3.3.2),
- The map server (see section 3.3.2.3),
- The BIM/EE training data web form (see section 3.3.3),
- The recommender engine (see section 3.3.4),
- The tangible user interface a (see section 3.3.5).

At this stage, this prototype has been presented in events/workshops and the first feedbacks are very positive. This tool allows to visualize data about the existing training offers. It enables good understanding of the gaps that the host institutions have to fill in when wanting to propose a consistent training for professionals in a specific location.

Table 5. Functionalities resulting from the analysis of user's needs/ BIM/EE training course design support (Extract from D4.1)

Axis 1	**BIM/EE training course design support**		
User	Expert of the domain, target representative, training expert		
Step	**Funct.**	**Description**	**User**
Explore	**F1.1**	**Visualize the BIM/EE existing training courses**	**A, B, C , E**
		F1.1.1 Filter by targeted public	
		F1.1.2 Filter by addressed responsibilities	
		F1.1.3 Filter by RIBA stage	
		F 1.1.4 Filter by location	
		F 1.1.5 Filter by language	
		F 1.1.6 Filter by cost	
		F1.1.7 Filter by duration	
Explore	**F1.2**	**Visualize the targeted public statistics**	**A, B, C , E**
		F1.2.1 Filter by location	
		F1.2.2 Filter by targeted public	
Explore	**F1.3**	**Visualize the existing BIM/EE standards, regulation**	**A, B, C , E**
		F1.3.1 Filter by location	
Design	**F1.4**	**Design a new training course**	**A, B, C , E**
		F1.4.1 Define parameters (targeted public, RIBA stage, language, duration)	

		F1.4.2. Obtain recommendation of BIM/EE responsibilities to be addressed (based on the gap between what the targeted public needs and the scope of the existing training courses	
		F1.4.3 Select the BIM/EE responsibilities to be addressed for the new training course	
Check	**F1.5**	**Check of the originality of the new training course in comparison with the existing training courses scope**	**A, B, C, E**
Check	**F1.6**	**Check of the potential profitability of the training course**	**A, B, C, E**
Validate	**F1.7**	**F1.7.1 Validate the training parameters selection**	**A, B, C, E**
		F1.7.2 Send by mail (and add to my profile) the training details as designed, the related learning outcomes, training materials, potential speakers and BIMEET labeling process	**A, B, C, E**

Legend, code for user

Type of user	Code	Type of user	Code
Expert of the domain BIM/EE	**A**	AECO professionals (Architecture, Engineering, Construction & Operation)	**D**
Target public representative (e.g., member of chamber or professionals association)	**B**	Host institution	**E**
VET expert	**C**	BIMEET label administrator	**F**

When considering the table of functionalities imagined in the D4.1. which was an exhaustive view of requirements, we can see that most of the functionalities related to the exploration and design of the application have been developed. The prioritisation of the development has conducted to limit the development at these stages. Consequently, the prototype presents currently some limits and valuable prospects are already identified for next developments:

- Only statistical data from Luxembourg are already available in the system. It would be very interesting to extend to all EU countries.
- Some functionalities such as the originality or the profitability checking could be added in order to support the internal process of host institution of training course design.
- The process of BIMEET labelling is currently not connected with the BIMEET application. This could be integrated in the energy-bim platform and associated to the TUI in order to have a continuous process from design to labelling.
- Finally, the recommender allows to recommend where it would be suitable to organize a training, but its use could be extended to the recommendation of BIM+EE responsibilities to be addressed in priority according to a predefined location.

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