D2.1. Requirements elicitation for BIM for Energy Efficiency

D2.3. BIM for Energy Efficiency required roles and skills

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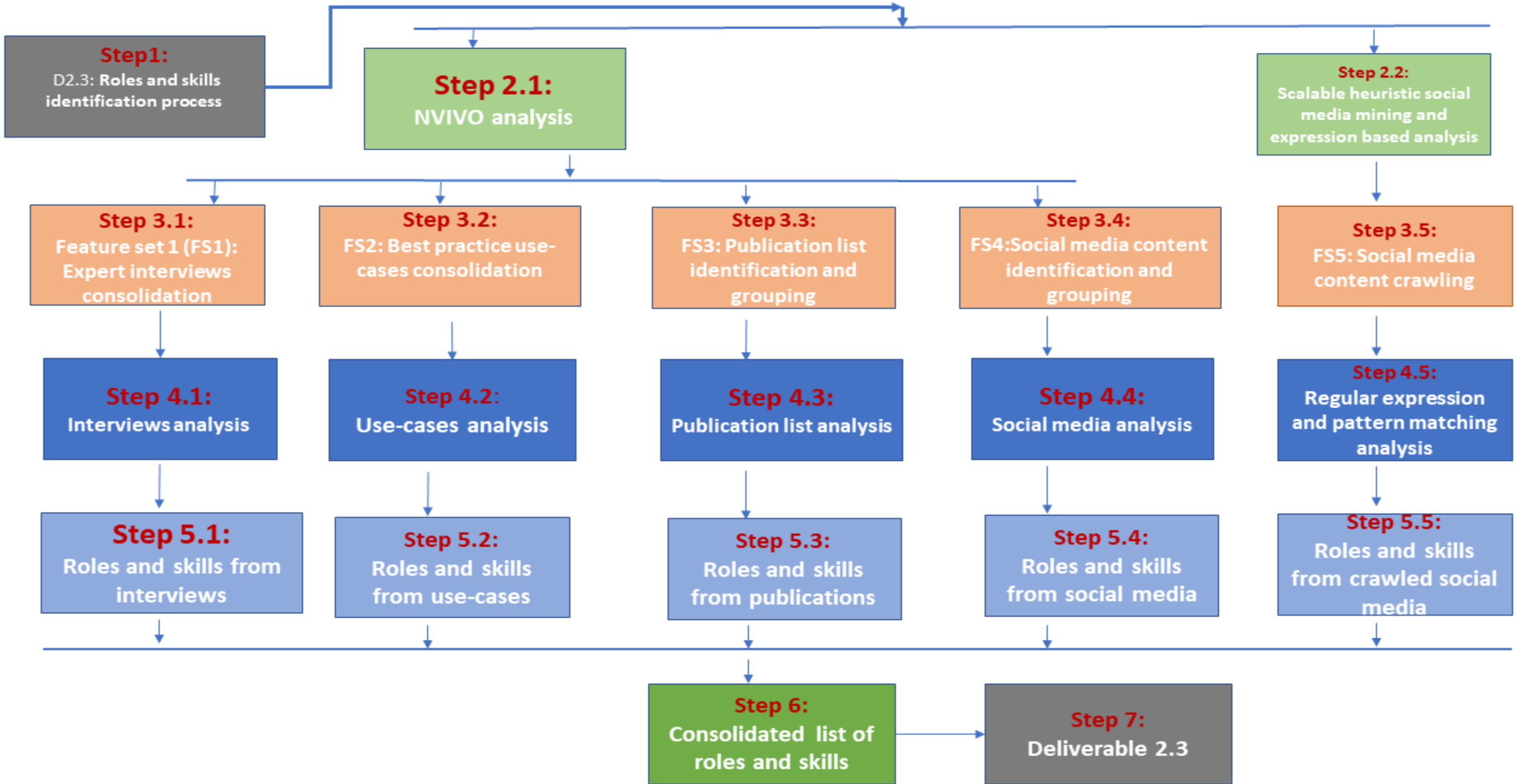
The objectives.

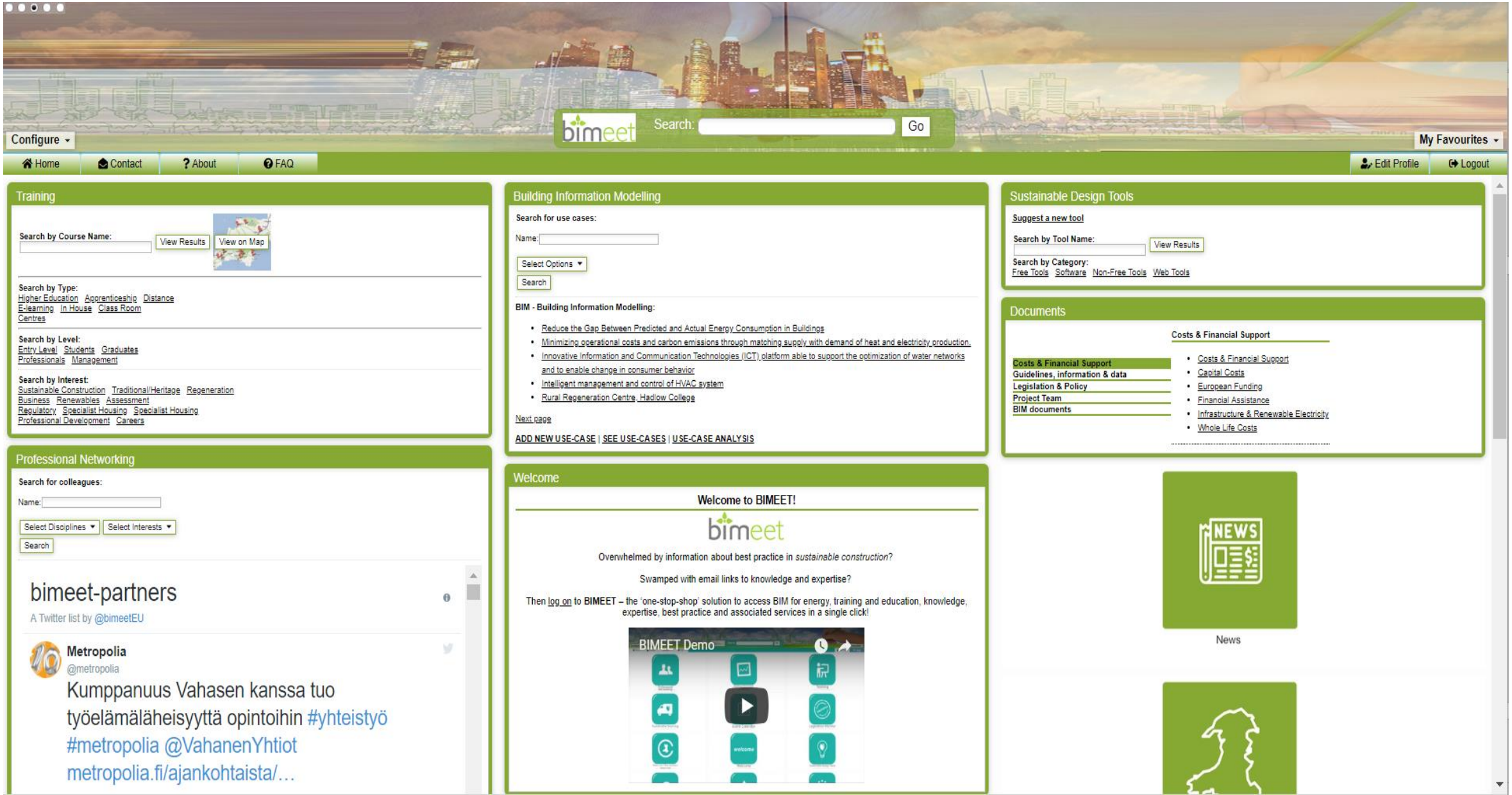
- **Task 2.1. List of required roles and skills (M2-M6)**
- Leader: CU, Participants: All
- This task will factor in (a) Best practise use cases analysis an effectively training workforce that exploits BIM to deliver energy efficient buildings.

- **Task 2.3. List of required roles and skills (M4-M9)**
- Leader: CU, Participants: All
- This task will factor in (a) evidence gathered from T2.1 and (b) training offers from T2.2 to map a **list of required skills and roles** to deliver an effectively training workforce that exploits BIM to deliver energy efficient buildings.

Methodology



The BIMEET platform



Deliverable D2.1

Best practice use-cases

36. Towards the development of a virtual city model, using a 3D mode of Dundalk city
37. Modelling, assessment and Sankey diagrams of integrated electricity-heat-gas networks in multi-vector district energy systems
38. Eebers ICT Clusters
39. GreenOValley buildings by Schneider Electric in Grenoble
40. Improving indoor climates in retrofitted buildings
41. Strategies for a nearly Zero-Energy Building market transition in the European Union
42. Best practice creating analytic model for energy simulation via gbXML (from Revit)
43. Common BIM requirements 2020, COBIM
44. A zero energy house in Finnish climate (BLOK)
45. RATINA shopping center
46. BIM application to building energy performance visualisation and management
47. Continuous-time Bayesian calibration of energy models using BIM and energy data
48. Integrated BIM-GIS based design for high energy efficiency hospital buildings
49. BIM for energy efficiency in housing refurbishments
50. Optimising energy consumption in building designs using BIM
51. Harmonised Building Information Speedway for Energy-Efficient Renovation
52. Integrating BIM and energy analysis tools with green building certification system to conceptually design sustainable buildings
53. Energy aware BIM Cloud Platform in a Cost-effective Building Renovation Context

Introduction

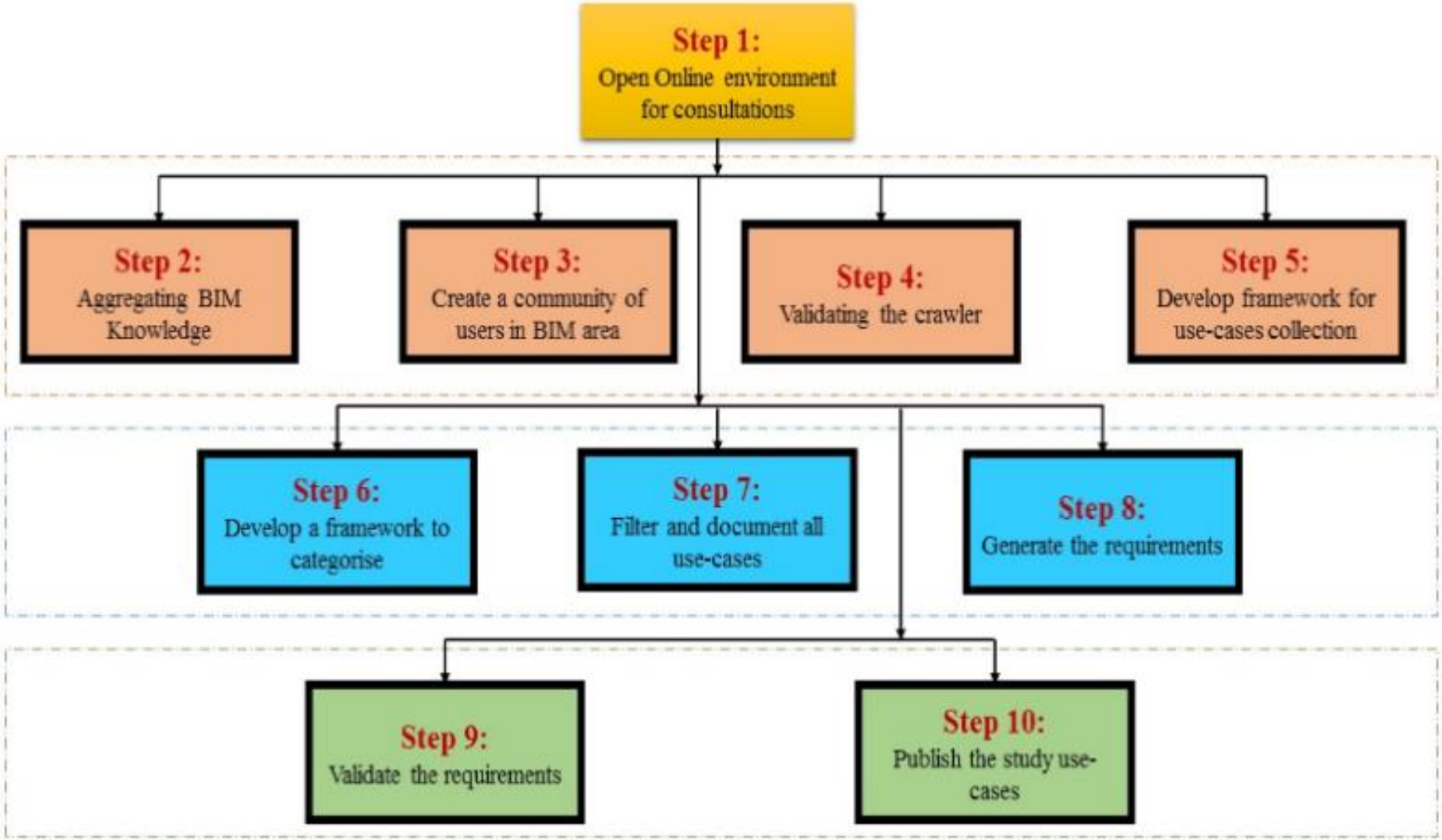
- **This paper investigates what are the key aspects that can support the implementation of BIM for energy efficiency by undertaking an in-depth analysis and gaps identification of skills and competencies**

- **Consultations and interviews have been used as a method to collect requirements and a portfolio of use-case has been created to understand existing BIM practices and determine existing limitations and gaps in BIM training.**

- **The research presented in this paper is part of the EU H2020 BIMEET project delivering training and education for BIM implementation for energy efficiency.**

- **This paper provides an evaluation of the key criterions and strategies that can promote BIM as an efficacious tool for facilitating energy efficiency.**

- **We explore how different use-cases variables influence the impact of BIM on energy efficiency and provide useful insights on how building lifecycle, discipline and buildings types can influence different BIM energy efficiency scenarios.**


Step 1:
Open Online environment for consultations
Step 2:
Aggregating BIM Knowledge
Step 3:
Create a community of users in BIM area
Step 4:
Validating the crawler
Step 5:
Develop framework for use-cases collection
Step 6:
Develop a framework to categorise
Step 7:
Filter and document all use-cases
Step 8:
Generate the requirements
Step 9:
Validate the requirements
Step 10:
Publish the study use-cases

Collection of use-cases

- Step1: Created a template to collect use-cases
- Step2: Implementing the web-based form of the template(*www.energy-bim.com*)
- Step3: Use-cases collection phase
- Step4: Use-cases analysis phase

Best Practice Use-Case Study Form

Use Case Title:	
Use Case type (R&D, Real-world application, BIM guideline, Other):	
Funding source (Research Council name / Client name):	
Project title:	
Web Link (URL):	
Targeted Discipline (Architectural Design / Structural / Mechanical Engineering, etc.):	
Targeted Building type (Public, Domestic, Industrial, Other):	Public
Project type (Existing, New Build, Renovation, Extension):	Existing
Lifecycle applicability (RIBA Plan of Work):	
Brief description of the case study	
Key Highlights	
Supporting best practice case study	
-Scenario definition	
-Control Variables	
-Objectives	
-Effective Environmental Variables	
-Control rules	
-Actors	
-When applicable	
Learning Outcomes: Specific role of BIM in achieving energy efficiency	
Supporting resources (publication, deliverable, open source software, API, etc.)	

Submit Reset

PORTOFOLIO OF EXISTING USE-CASE STUDIES:

1..Reduce the Gap Between Predicted and Actual Energy Consumption in Buildings	Edit	Delete
2..Minimizing operational costs and carbon emissions through matching supply with demand of heat and electricity production.	Edit	Delete
3..Innovative Information and Communication Technologies (ICT) platform able to support the optimization of water networks and to enable change in consumer behavior	Edit	Delete
4..Intelligent management and control of HVAC system	Edit	Delete
5..Rural Regeneration Centre, Hadlow College	Edit	Delete
6..Sustainable Design and Building Information Modelling: Case study Energy Plus House, Hieron's Wood, Derbyshire UK	Edit	Delete
7..Friendly and Affordable Sustainable Urban Districts Retrofitting (FASUDIR) - Heinrich-Lubke housing area, Frankfurt, Germany	Edit	Delete
8..Friendly and Affordable Sustainable Urban Districts Retrofitting (FASUDIR) - Budapest Residential District	Edit	Delete
9..An innovative integrated concept for monitoring and evaluating building energy performance (the gap between predicted and actual building energy performance is addressed by the project).	Edit	Delete
10..BIM-based Parametric Building Energy Performance Multi- Objective Optimization	Edit	Delete
11..Parametric design of a shelter roof in urban context	Edit	Delete
12..Introducing the innovative tool of the Building Sector	Edit	Delete
13..Intelligent Services For Energy-Efficient Design and Life Cycle Simulation	Edit	Delete
14..Collaborative optimisation of building performance during concept design phase	Edit	Delete
15..Robust decision making around building efficiency and occupant comfort	Edit	Delete
16..Delivering highly energy efficient hospital centre	Edit	Delete
17..Design for future climate change - Developing an adaptation strategy	Edit	Delete
18..Parametric modeling for architectural form finding	Edit	Delete
19..Shopping Center using around half the energy of a typical developement	Edit	Delete
20..Use of BIM in design and construction phase to achieve sustainability goals of an office building	Edit	Delete
21..Design of energy-efficient library with high architectural goals	Edit	Delete
22..Use of Optimization tool to compare hundreds of concepts energy efficiency before actual design	Edit	Delete
23..Improving Energy Performance of Office Buildings Based on Light Building Information Model (BIM)	Edit	Delete
24..Retrofit alternatives based on energy simulations	Edit	Delete
25..Energy properties of solar shading devices and their impact on the visual comfort of occupants	Edit	Delete
26..Collaborative Holistic Design Laboratory and Methodology for Energy-Efficient EMBEDDED Building	Edit	Delete
27..Semantic Web for Information Modelling in Energy Efficient Buildings	Edit	Delete
28..Occupant Aware, Intelligent and Adaptive Enterprises	Edit	Delete
29..Building As A Service	Edit	Delete
30..De Lacy Row	Edit	Delete
31..Use of BIM for ESD Analysis of BCA Academic Tower	Edit	Delete

Variables/ Use-Cases	Use Case 1	Use Case 2
Title	Reduce the Gap between Predicted and Actual Energy Consumption in Buildings: KnoholEM project	Shopping Center using around half the energy of a typical development
Use Case Type	Research & Development	Real-world application
Target Discipline	Facility Management	Architectural design / Structural engineering / HVAC engineering / Electrical engineering / Builders / Construction companies / Building managers
Target Building Type	Public	Commercial
Lifecycle Applicability	In Use	Preparation and Brief, Concept Design, Developed Design, Technical Design, Construction, In Use
Brief Description	This study presents a novel BIM-based approach with the objective to reduce the gap between predicted and actual energy consumption in buildings during their operation stage(Yuce and Rezgui 2017).	The project is a large shopping center and commercial development in Pori, southwestern Finland. The development was designed to LEED Gold and has won a global BIM award for its innovative use of modeling during design and construction (Skanska 2014).
Impacts	The use of BIM has helped achieve a reduction of 25% energy compared to baseline figures.	BIM was effectively used in a project where 50 % energy savings were achieved compared with Finnish Code and 50 % savings in water consumption compared with conventional retail development in Finland. Also measured energy production of geothermal heat pumps and gains of free energy for heating and cooling have exceeded expectations.

Use-cases analysis phase

Figure 1: Use-case type

No.	Use Case Type	Many of use cases
1	Research &Development	17
2	Real world application	13
3	BIM Guideline	1
4	Other	-

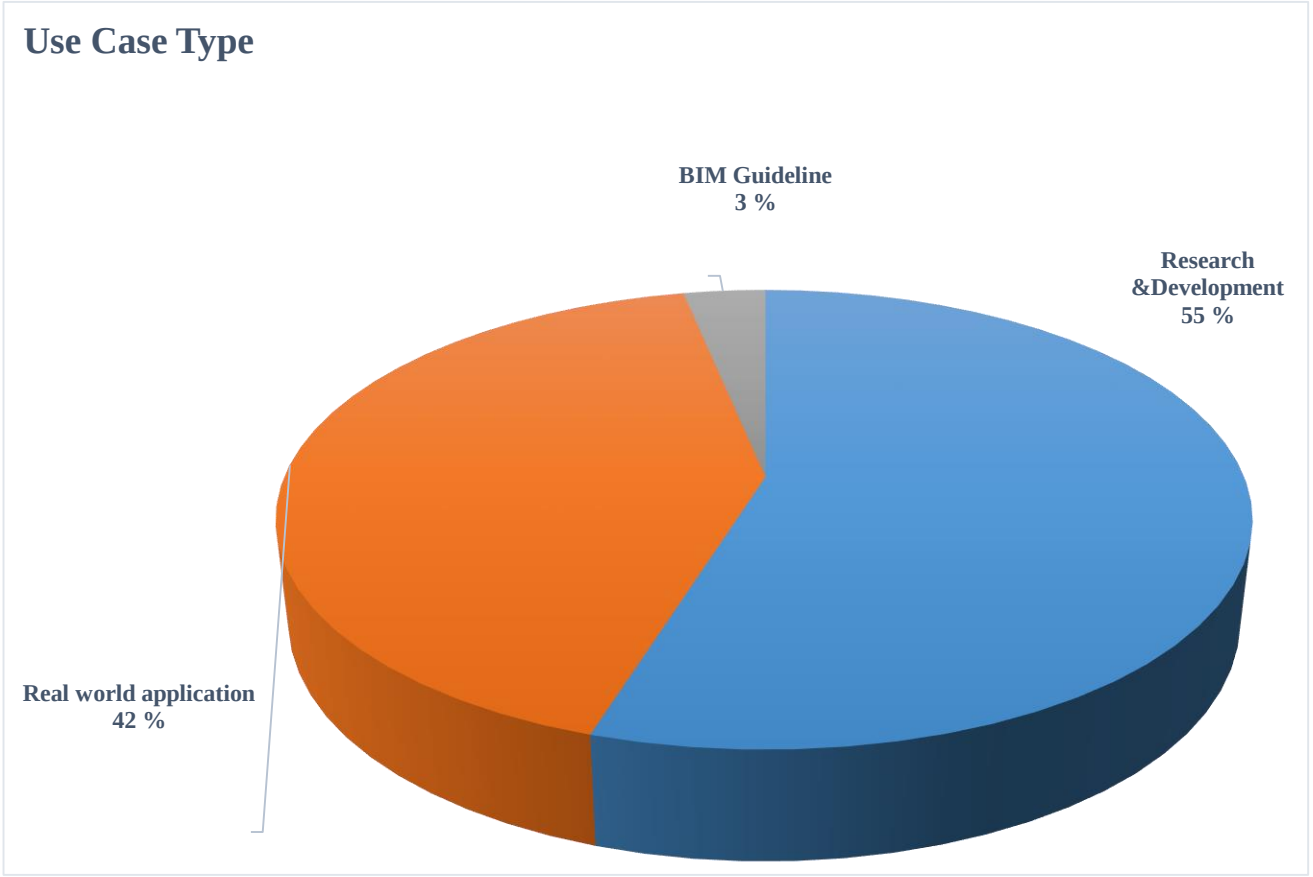


Figure 2: Target Discipline

No.	Target Discipline	Many of use cases
1	Architecture design	20
2	Facility management	17
3	Structure engineer	11
4	Mechanical engineer	10
5	Other	11

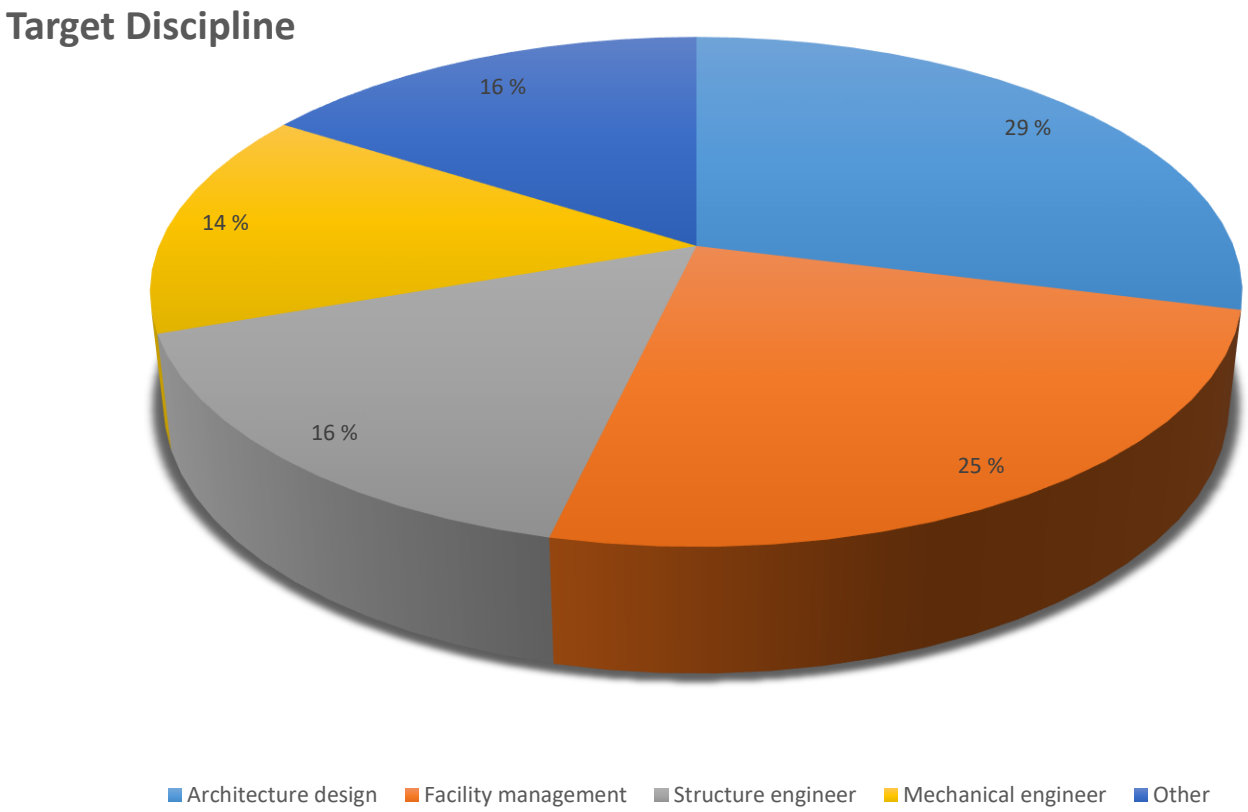


Figure 3: Building type

NO.	Building Type	Many of use cases
1	Public	26
2	Domestic	7
3	Commercial	4
4	Industrial	3

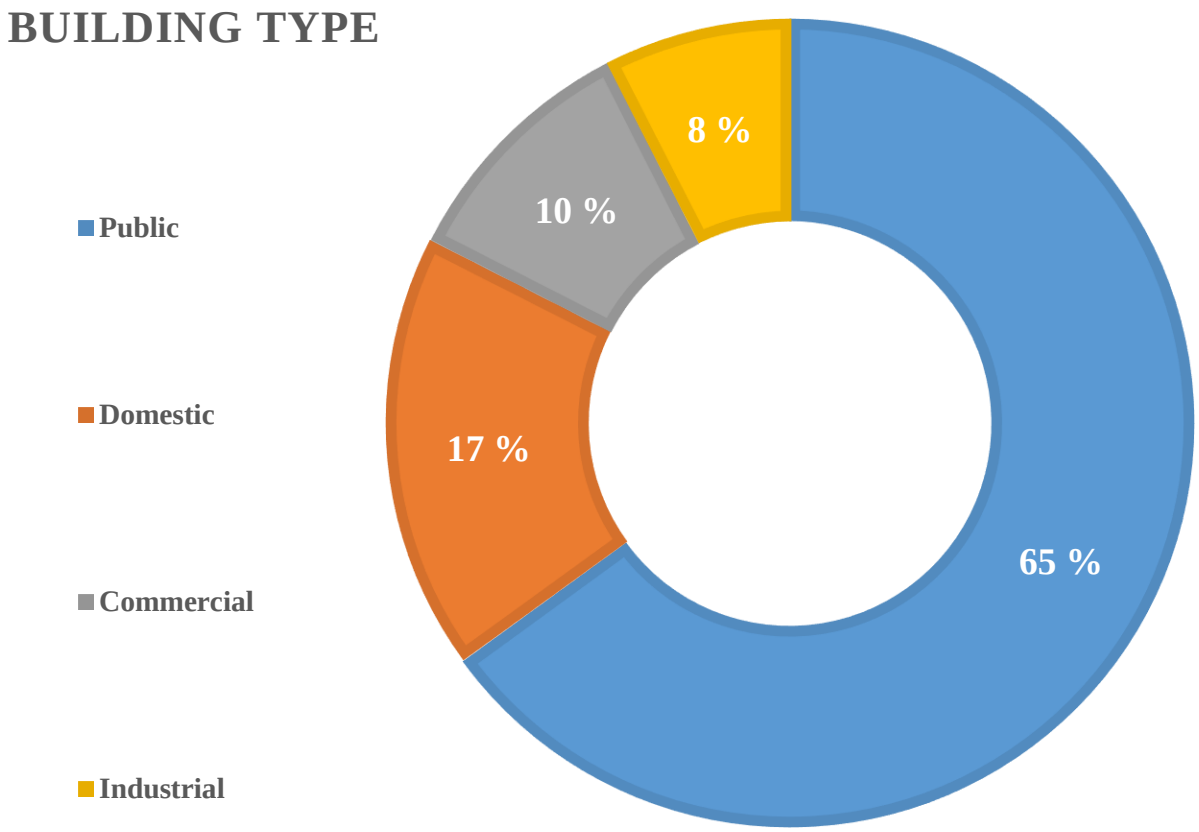


Figure 4: Lifecycle Stage

No.	Lifecycle stage (RIBA)	Many of use cases
0	Strategic Definition	4
1	Preparation and Brief	6
2	Concept Design	15
3	Developed Design	14
4	Technical Design	13
5	Construction	6
6	Handover and Closeout	4
7	In Use	13

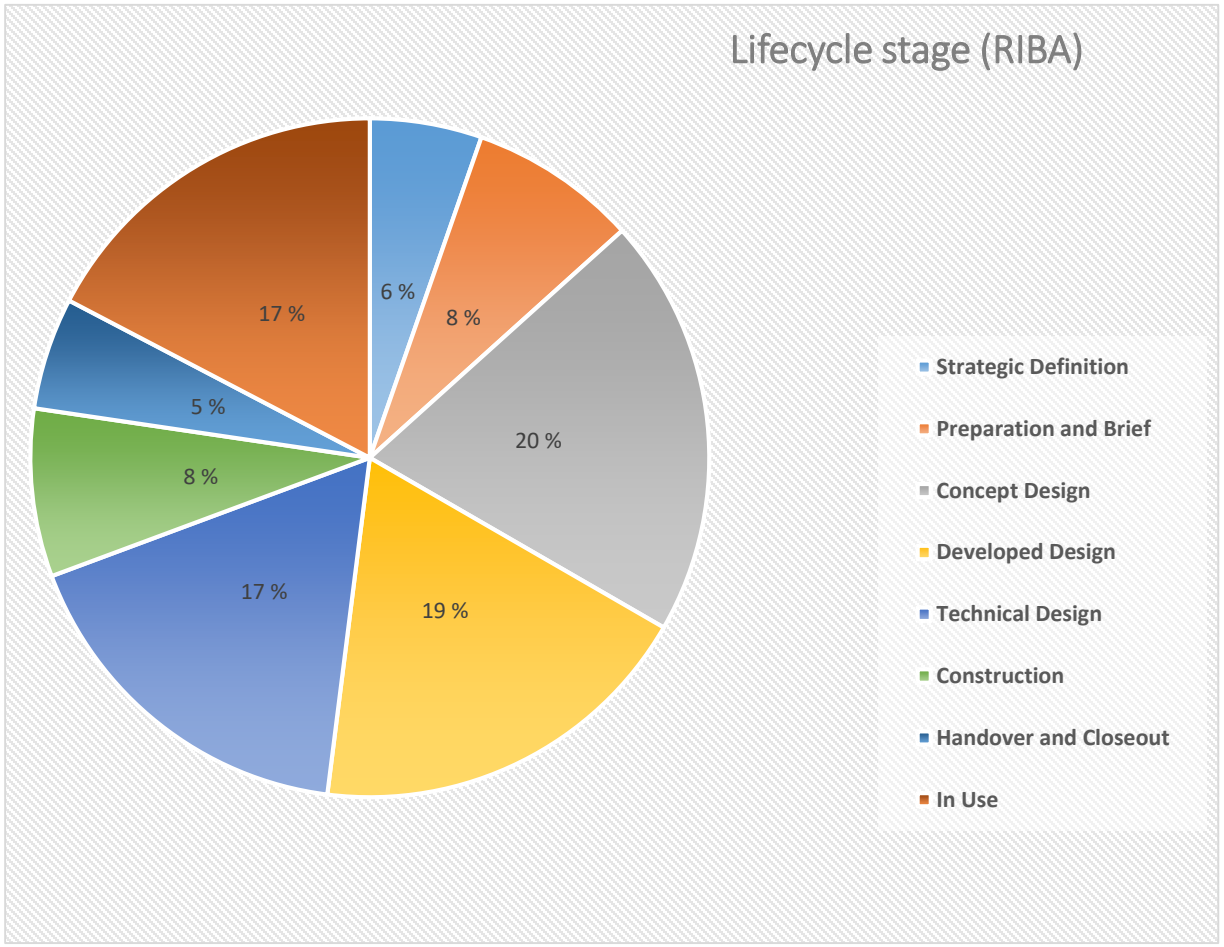
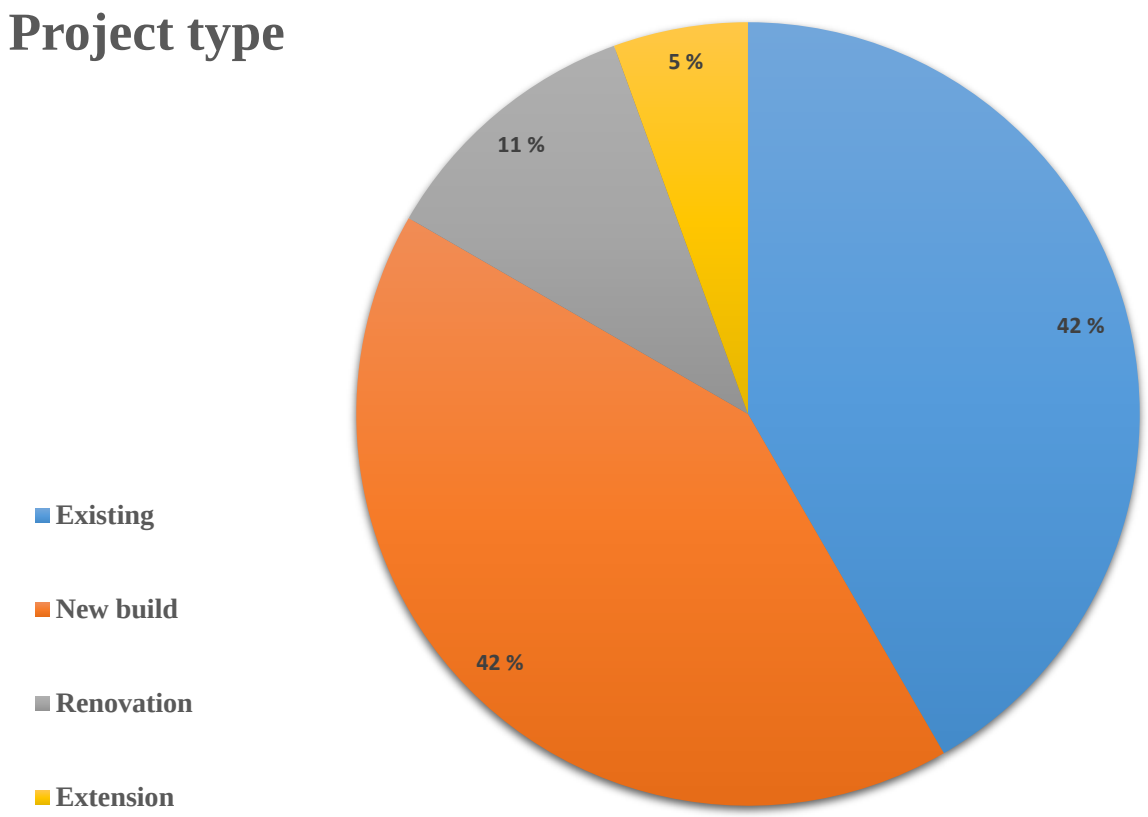


Figure 5: Project type

No.	Project type	Many of use cases
1	Existing	15
2	New build	15
3	Renovation	4
4	Extension	2



No.	Use cases/ Target discipline	Architecture design	Facility management	Structure engineer	Mechanical engineer	Other	Impacts
1	Reduce the Gap Between Predicted and Actual Energy Consumption in Buildings						Reduction of 25% energy compared to baseline figures.
2	Minimizing operational costs and carbon emissions through matching supply with demand of heat and electricity production.						Leading to a 32% increase in profit and 36% reduction in CO2 emissions.
3	Intelligent management and control of HVAC system						Up to 30% of Energy Saving Up to 30% Emission reduction
4	Friendly and Affordable Sustainable Urban Districts Retrofitting (FASUDIR) - Heinrich-Lubke housing area, Frankfurt, Germany						GWP reduction of 60%. Operational energy consumption reduction of 35%
5	Friendly and Affordable Sustainable Urban Districts Retrofitting (FASUDIR) - Budapest Residential District						Operational energy reduced by 35% and energy running costs reduced by 35%
6	An innovative integrated concept for monitoring and evaluating building energy performance (the gap between predicted and actual building energy performance is addressed by the project).						Achieve building energy performance
7	Parametric design of a shelter roof in urban context						Early BIM for parametric optimization through simulations
8	Building As A Service						Optimize energy performance in the application domain of non-residential buildings
9	Delivering highly energy efficient hospital centre						41% reduction in fabric loss heat, 29% reduction in carbon emissions,15% reduction in overall energy usage
10	Shopping Center using around half the energy of a typical development						50 % energy savings , 50 % savings in water consumption
11	Design of energy-efficient library with high architectural goals						Energy optimization results impacted for the building and HVAC design
12	Use of Optimization tool to compare hundreds of concepts energy efficiency before actual design						Use of Optimization tool has the potential to save money and time while directing to more optimal energy efficiency solutions.

Relation between the variables and the impacts: Target discipline and the impacts

Validation

Requirements for developing a training scheme :

(a) socio-organisational and legal requirements and

(b) technical requirements

No.	Parameters	Requirements and training
1	Use case type	Users need training in understanding and applying BIM Guideline see (Fig. 1).
2	Building type	Training is required for enhancing skills and competencies for using BIM for industrial and commercial buildingssee (Fig. 3).
3	Project type	Training is required for expanding BIM applicability for renovation and extension projects see (Fig. 5).
4	Target discipline	Training is required for education on BIM methodology towards mechanical and structure engineers see (Fig. 2).
5	Lifecycle stages	Training is needed to address other RIBA stages lifecycles such as Strategic Definition, Preparation and Brief, Construction, and Handover and Closeout see (Fig. 4).
6	Impacts on discipline	Increase BIM applicability and impact for architecture and design, structural engineers, mechanical engineers see (Fig. 6).

Consolidated list of requirements

NO.	Parameters	Requirements
1	***The skills they require to handle BIM data for the purpose of energy efficiency***	**Designer:** Formulating the model with EE simulation programs, Maintaining data of different variation and solutions, Good communication between designers, client, and supplier. **Blue collar worker:** Simulate use cases scenarios for the design, Communication with client and contractors to ensure best practice met. **Contractors:** Knowledge how to use BIM, BIM training ability to implement BIM construction with energy space, Collaborate with designer to manage the information from the model (See Table 17)
2	***The skills are lacking at the moment for using BIM for Energy Efficiency***	Link between different software-tools, Understanding to find good solutions to get to fine level of EE, Understanding what the impacts of using BIM for EE (See Table 18)
3	***The particular ways to enhance the stakeholders' skills for using the BIM for Energy Efficiency***	**Blue collar workers:** Training and field meetings to explain the specific plans. **Designers/Engineers:** Energy, BIM and data management training and educating, Understand the essence of simulation and to apply the result in practice (See Table 19, 20, 21, and 22)
4	***The training in BIM for Energy Efficiency by organisation***	Teaching software programs; BIM for EE, Continuous learning: issue with standardization, Skills of BIM coordinators and BIM manager should be defined. **Contractors:** Educating and training understand the needs. **Facility management teams:** Ability to extract and update information from BIM model(See Table 23)
5	***The common barriers to use BIM for Energy Efficiency***	Lack of understanding the use and potential of BIM, Different software-tools, Lake of expertise that able to use this difficult programs (See Table 25)
6	***Recommendations to enhance using the BIM for Energy Efficiency***	Assessment performance evaluation and appropriate training mechanisms, The useful tools should be utilized as early stage of the project, Incentivise the adoption of BIM for EE (See Table 26)

Deliverable D2.3

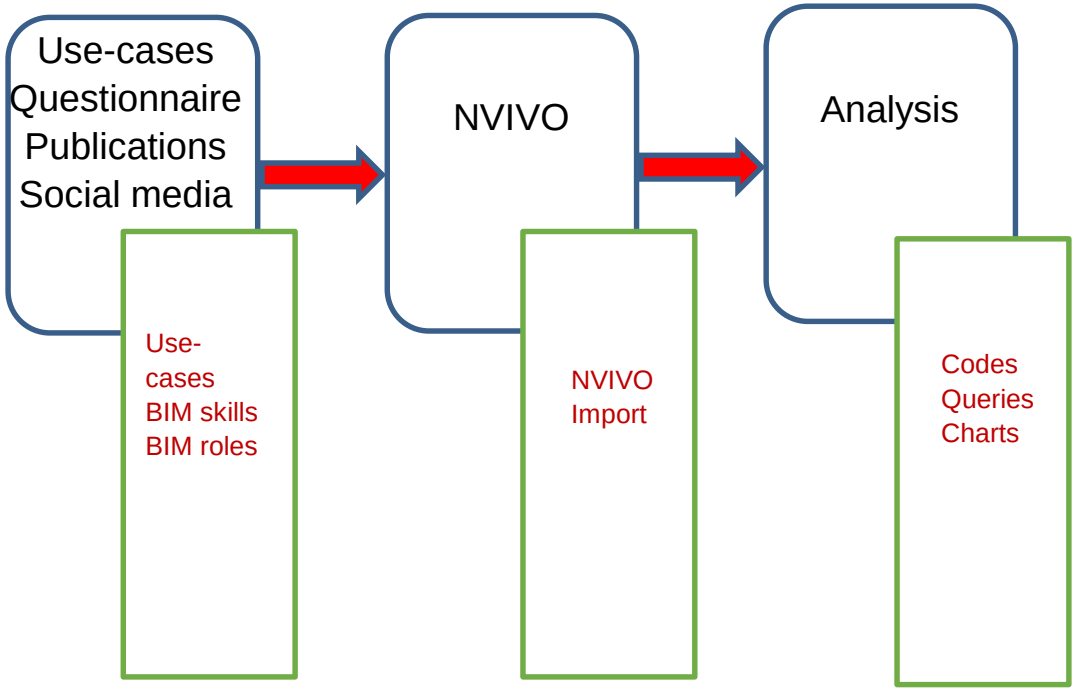
D2.3 methodology

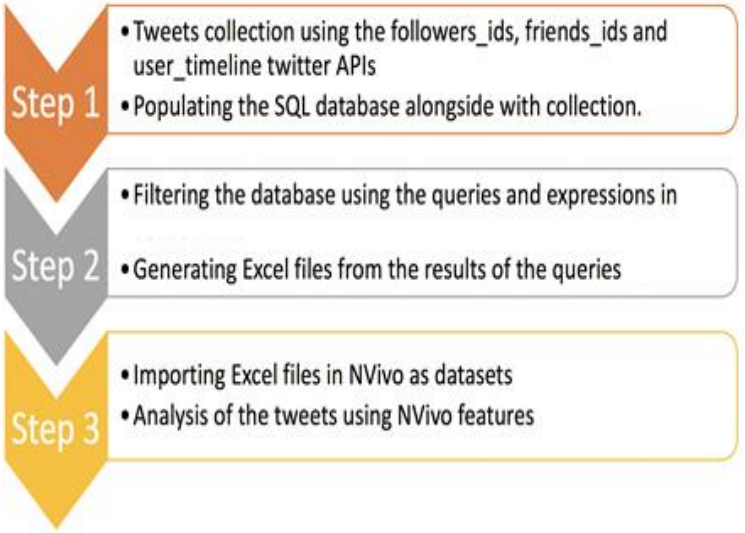
- We use NVIVIO
  - designed for qualitative studies with very rich text-based and/or multimedia information, where deep levels of analysis on small or large volumes of data are required
- We apply analysis on:
  - Interviews and use-case analysis as from D2.1
  - Training descriptions from BIM4VET
  - Literature review
  - Social media tweet analysis (6 millions of tweets)

Interviews and use-case analysis

- Based on the portfolio of use-cases captures from D2.1
- 40 use-cases and 15 experts interviews
- Objective: Identification of skills and roles based on NVIVO analysis
- Outcome: Provide a classification of skills and roles with regards to BIM for energy

The analysis phase in phases





Social media tweet analysis

- We have used forensics algorithms to determine what companies from the field of BIM and energy are visiting the www.energy-bim.com platform.
- We have identified other key twitter profiles and followers relevant for our analysis such as: @EU_EASME and @H2020EE
- We have identified twitter followers of the @BIMEETEU account

TOTAL: We have fetched a total of 6 millions tweets with text associated and description based on which we conduct text analysis and expression mining for determining skills and roles for BIM for energy.

Queries

- TOTAL: We have fetched a total of 40 million tweets with text associated and description based on which we conduct text analysis and expression mining for determining skills and roles for BIM for energy. The set of expression utilised to determine skills and roles are presented below.
-
- **+ ((contractor\manager\designer\engineer\client\)|\skills|\).+ (\energy| \construction)**
- **+ ((\BIM\construction\energy)|\skills|\).+ (\need| \require)**
- **+ ((\BIM\construction\energy)|\roles|\).+ (\need| \require)**
- **+ ((\BIM\construction\energy)|\actors|\).+ (\skills| \competencies)**
- **+ ((\BIM\construction\energy)|\knowledge|\).+ (\requirements| \require)**
- **+ ((\BIM\construction\energy)|\skills|\).+ (\need| \require)**
- **+ ((\BIM\construction\energy)|\competencies|\).+ (\need| \require)**
- **+ ((\skills\competencies\knowledge\expertise)|\BIM|\).+ (\energy| \construction)**

Use-cases, questionnaire, scientific publication and standards and social media content

We present the findings of the NVIVO analysis with reflection of roles and skills. To conduct the analysis and for identification of skills and roles NVIVO facilitates the following methods and operations:

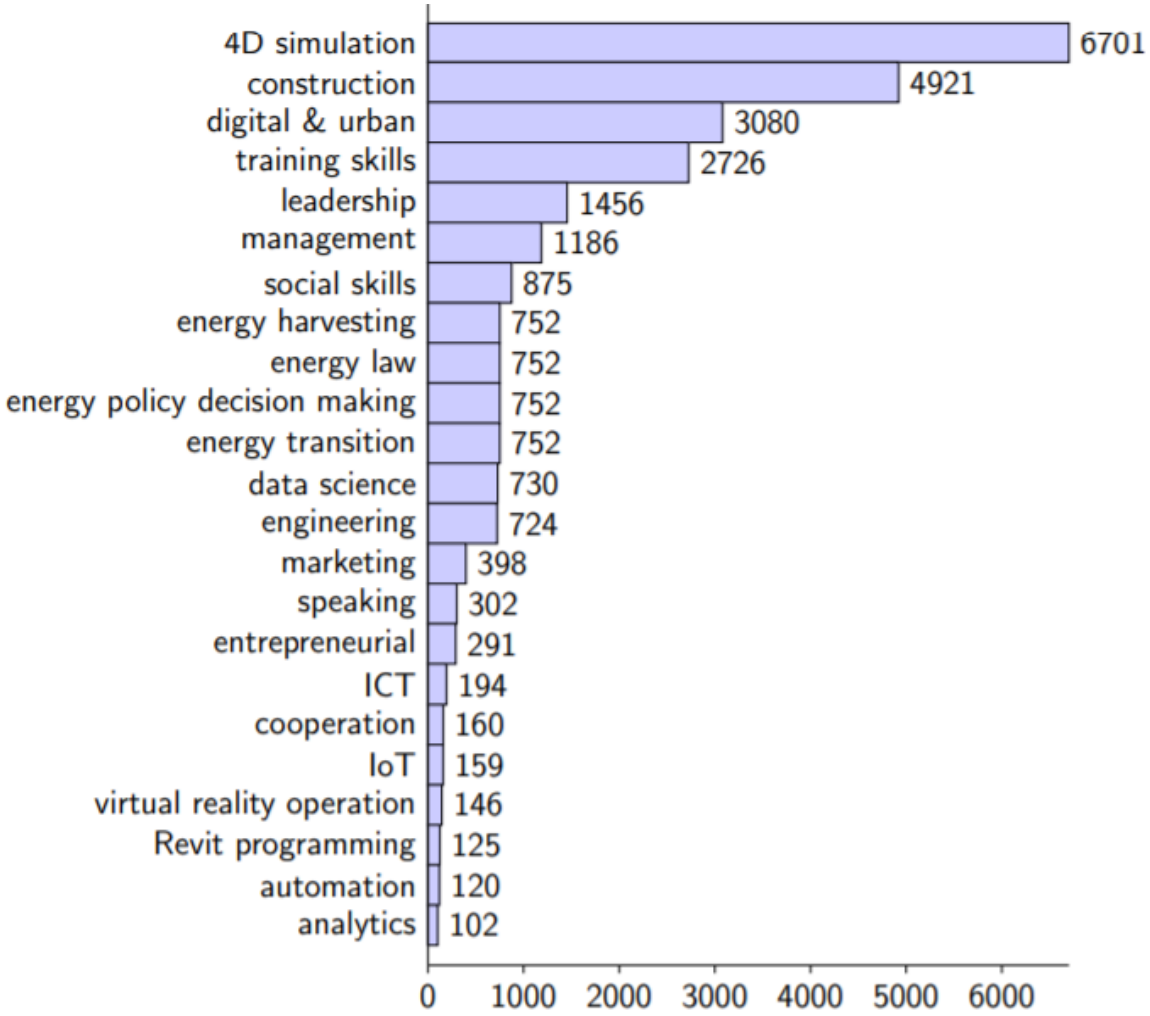
- **Word count and frequency analysis** – a method for exploring appearance of the key terms in a document and the associated frequency. This can be efficient in determining when specific words appear in a data repository and how many times. The degree of importance for each analysed concept identified with this method has been used to conduct the next analysis.
- **Semantical analysis** – A more visual representation of words based on their frequency and position on a graph of concepts. Based on word cloud analysis, a selection of central concepts has been identified and used to run the three analysis.
- **Dependencies analysis** – a method for exploring the maps of concepts associated with a repository of data. For our analysis, this method has been employed to observe dependencies between key concepts and determination of roles and skills.

Skills analysis

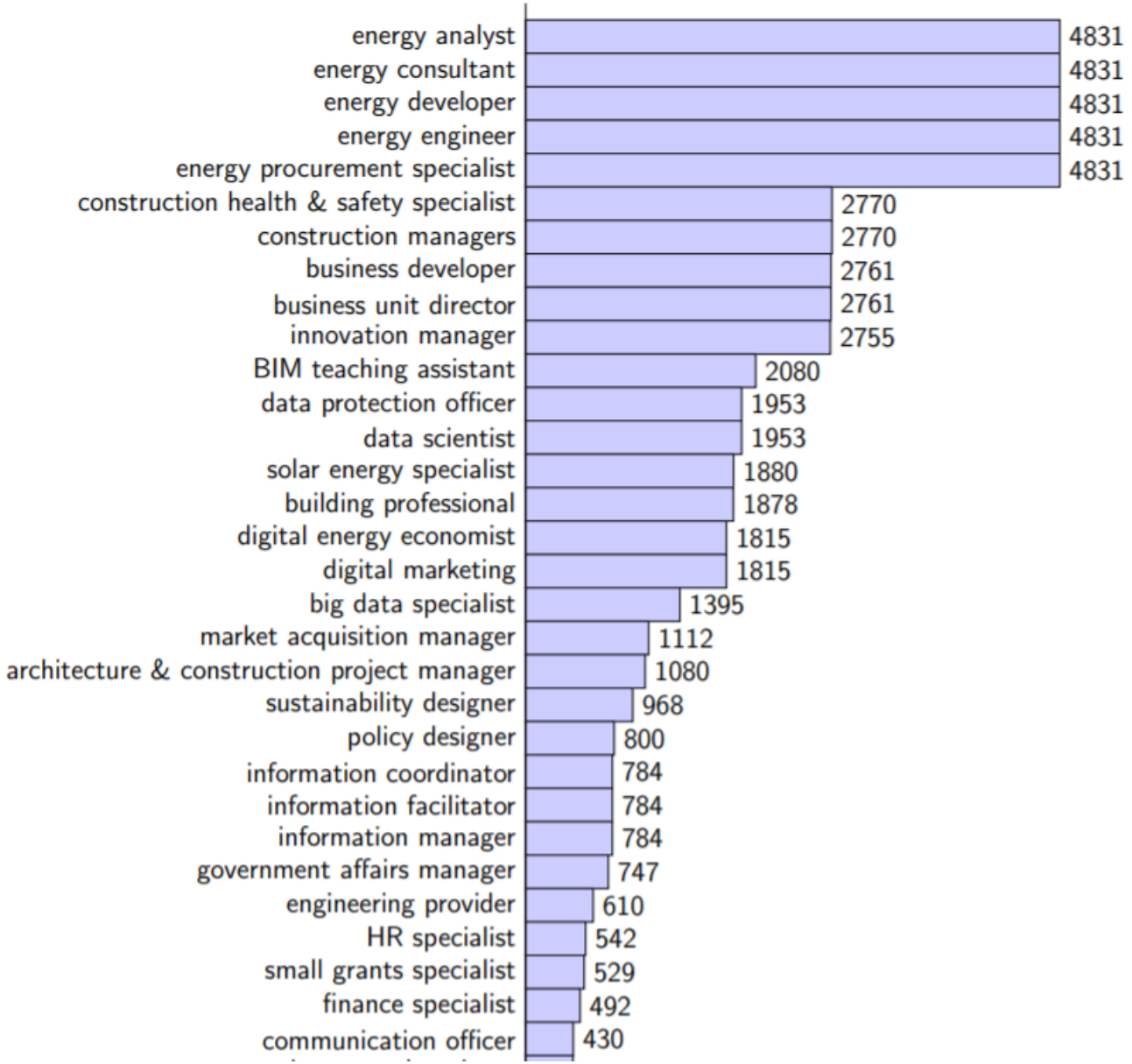
Outcome of analysis: List of roles and skills

NO.	Roles	Skills
1	Facilitator of sustainable	Simulation programs
2	BIM manager	BIM education
3	BIM modeller	Assess respondents' perception of BIM competence and requisite skills
4	Facility manager	Knowledge of BIM standards
5	Energy manager	Applying theoretical knowledge and eventually facilitating the entry into the labour market
6	Training and informing consultation professionals about BIM	Developing contractual specifying owner's BIM requirements
7	BIM consult	Training should be developed in BIM for energy efficiency
8	Structure Engineers	Knowledge about BIM standards
9	Regulators	Update knowledge about BIM developments
10	HVAC engineers	An imbalance between the demand and supply of skilled labour in construction sector
11	Technical manager	Focus on soft skills like collaboration and communication, negotiation, teamwork, leadership and conflict management.
12	Contract manager	Knowledge of building commissioning and building commissioning strategies
13	Finance manager	BIM model review – Automatic model check
14	Maintenance manager	Drawing skill with BIM tools

Skills and roles selection

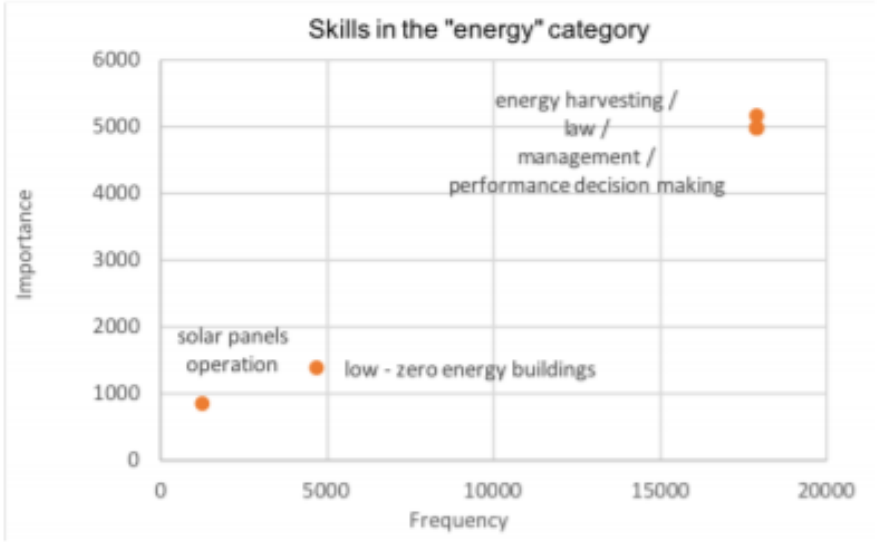


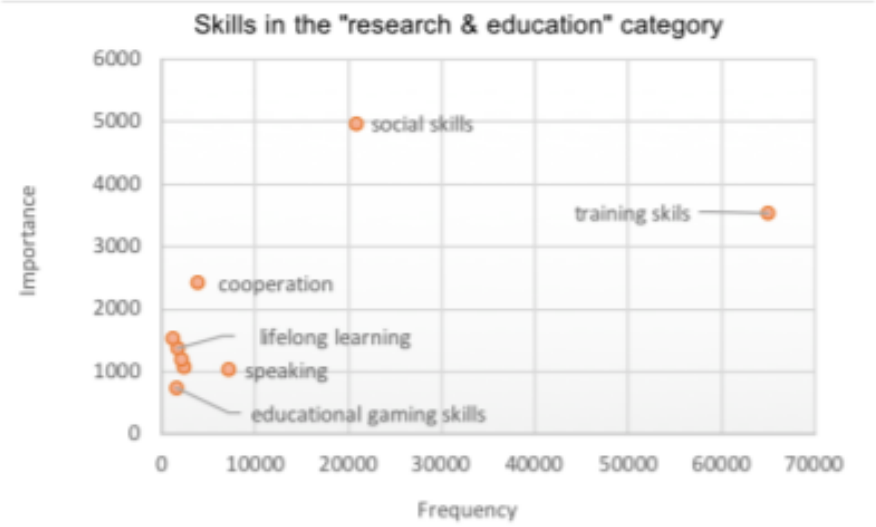
SKILLS

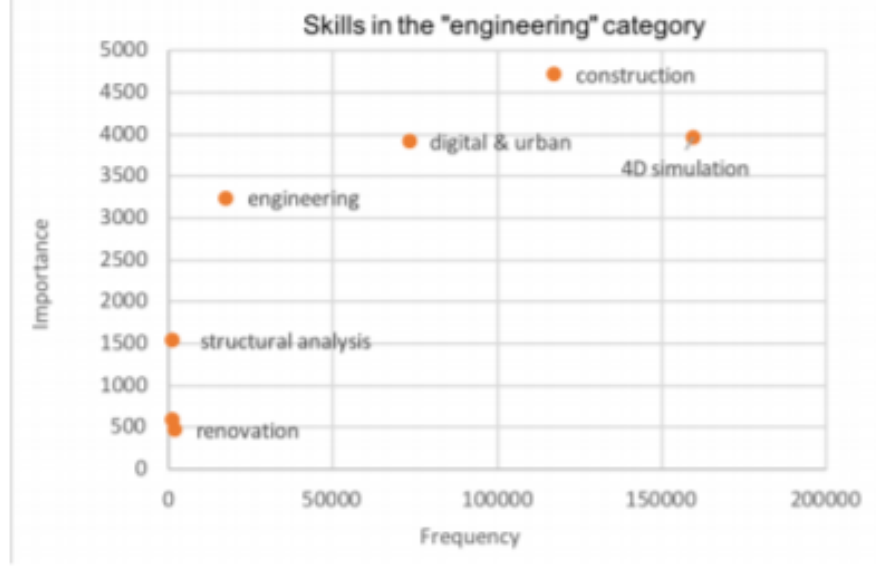


ROLES

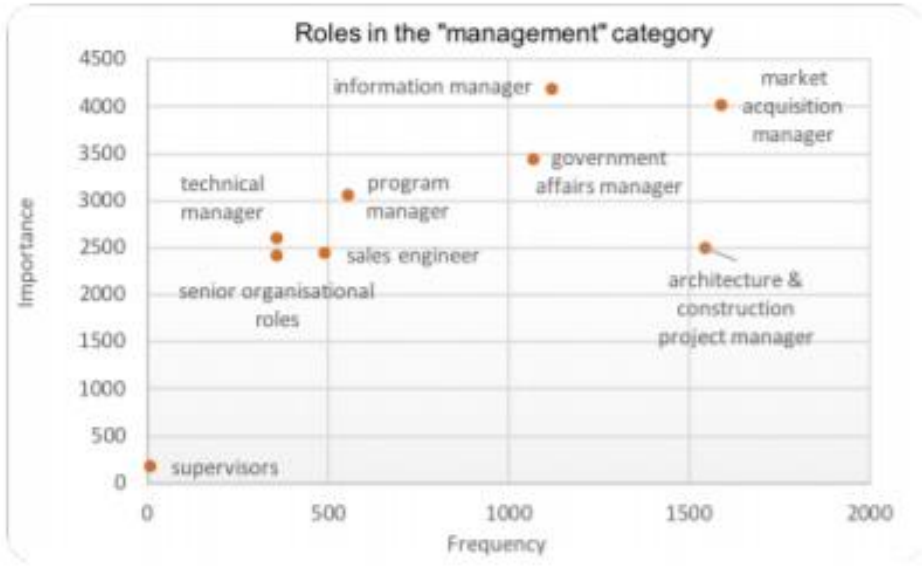
Skills classification and correlation

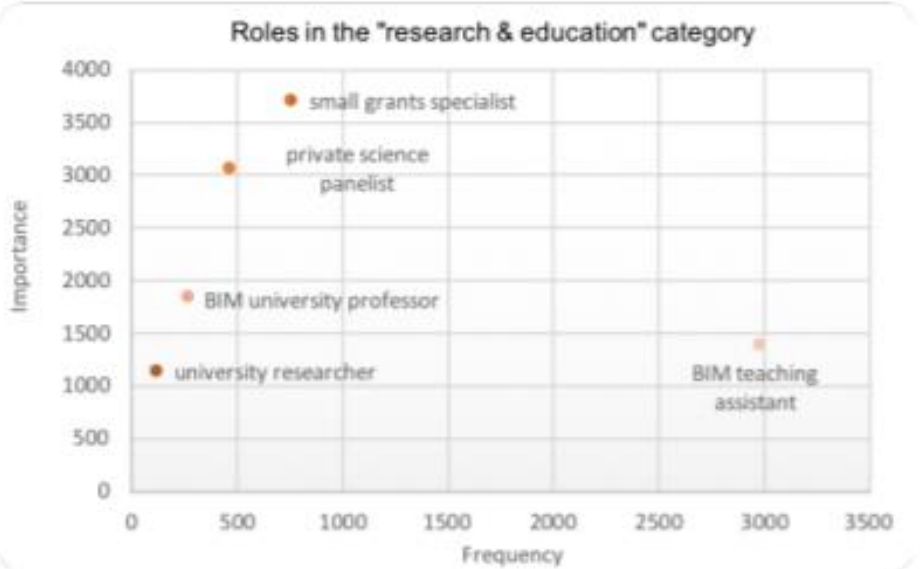


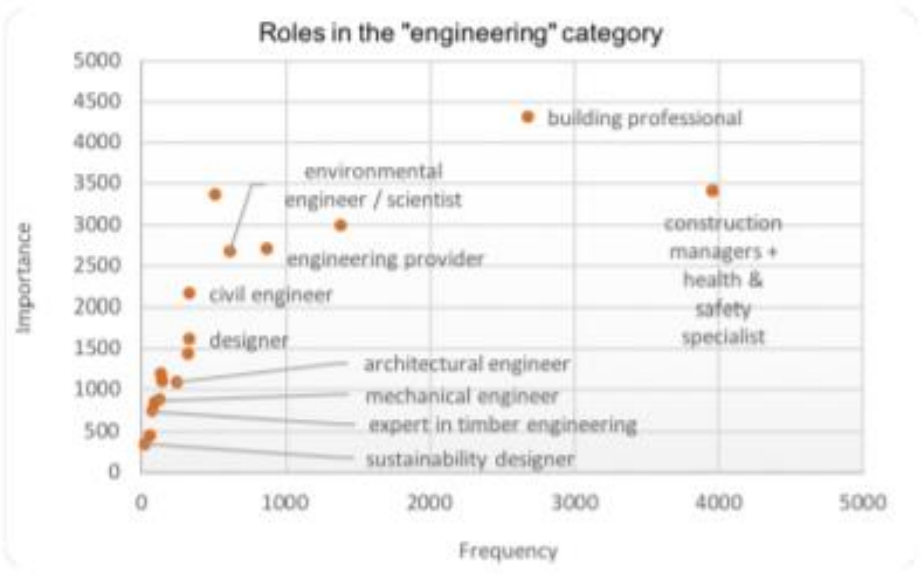


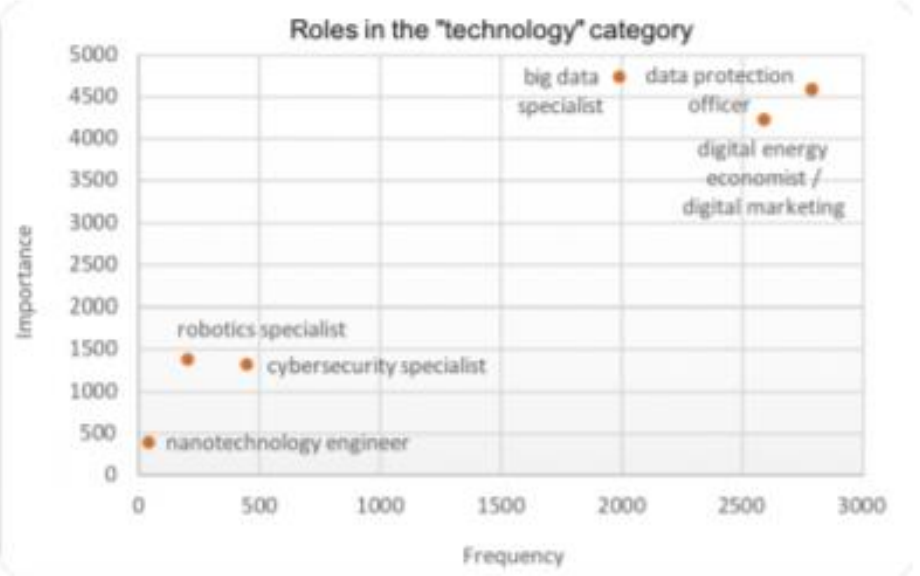


Roles classification and correlation

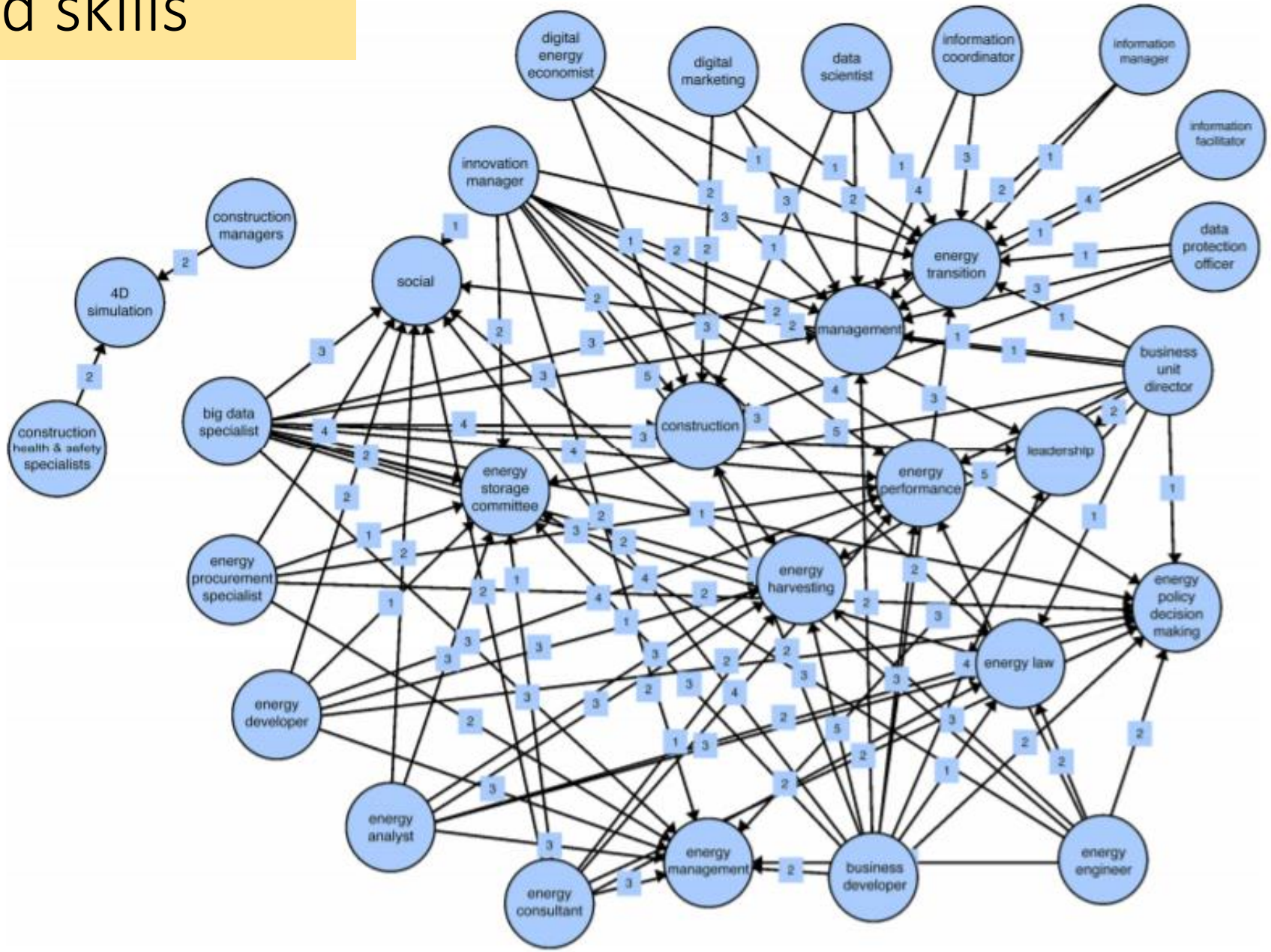








Ontological dependencies of BIM roles and skills



New use-cases

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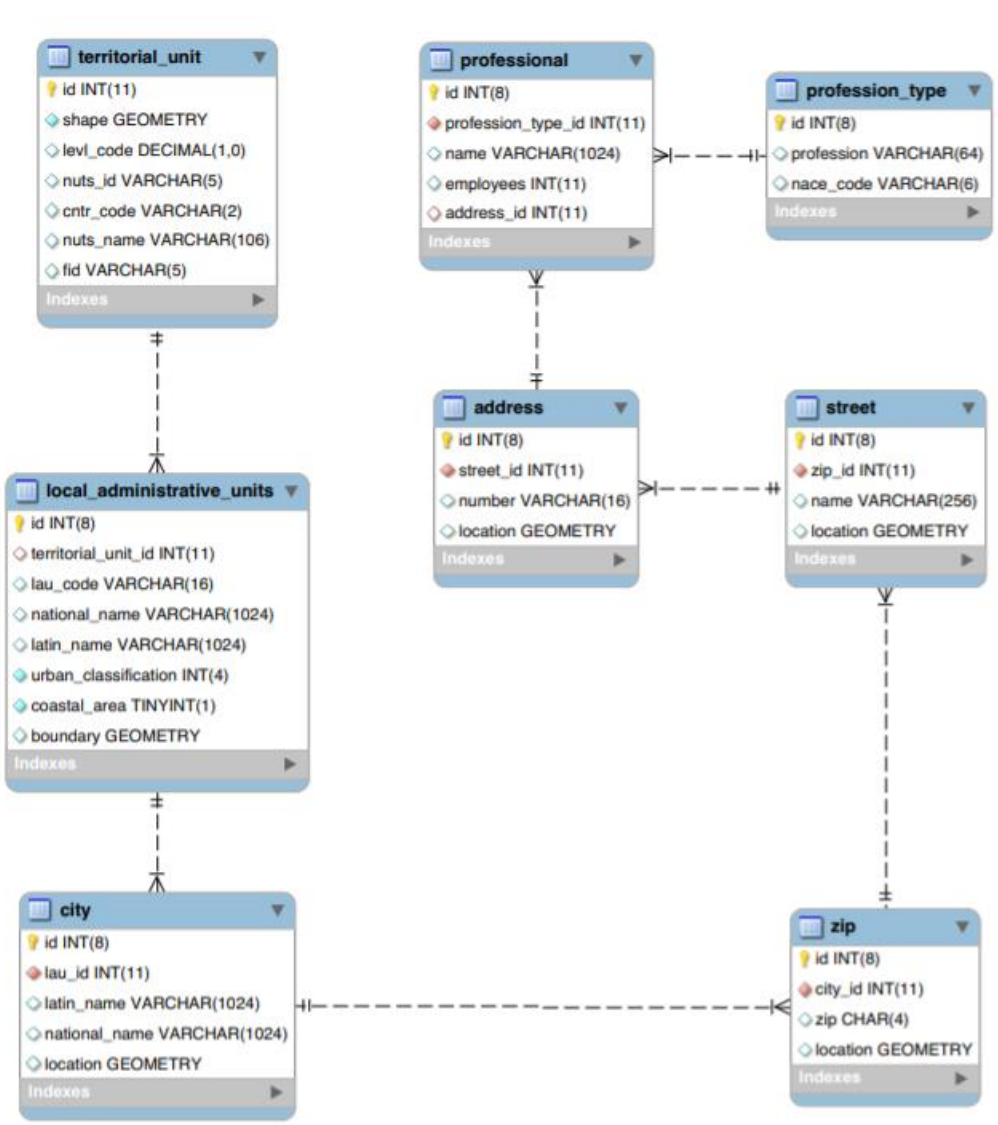
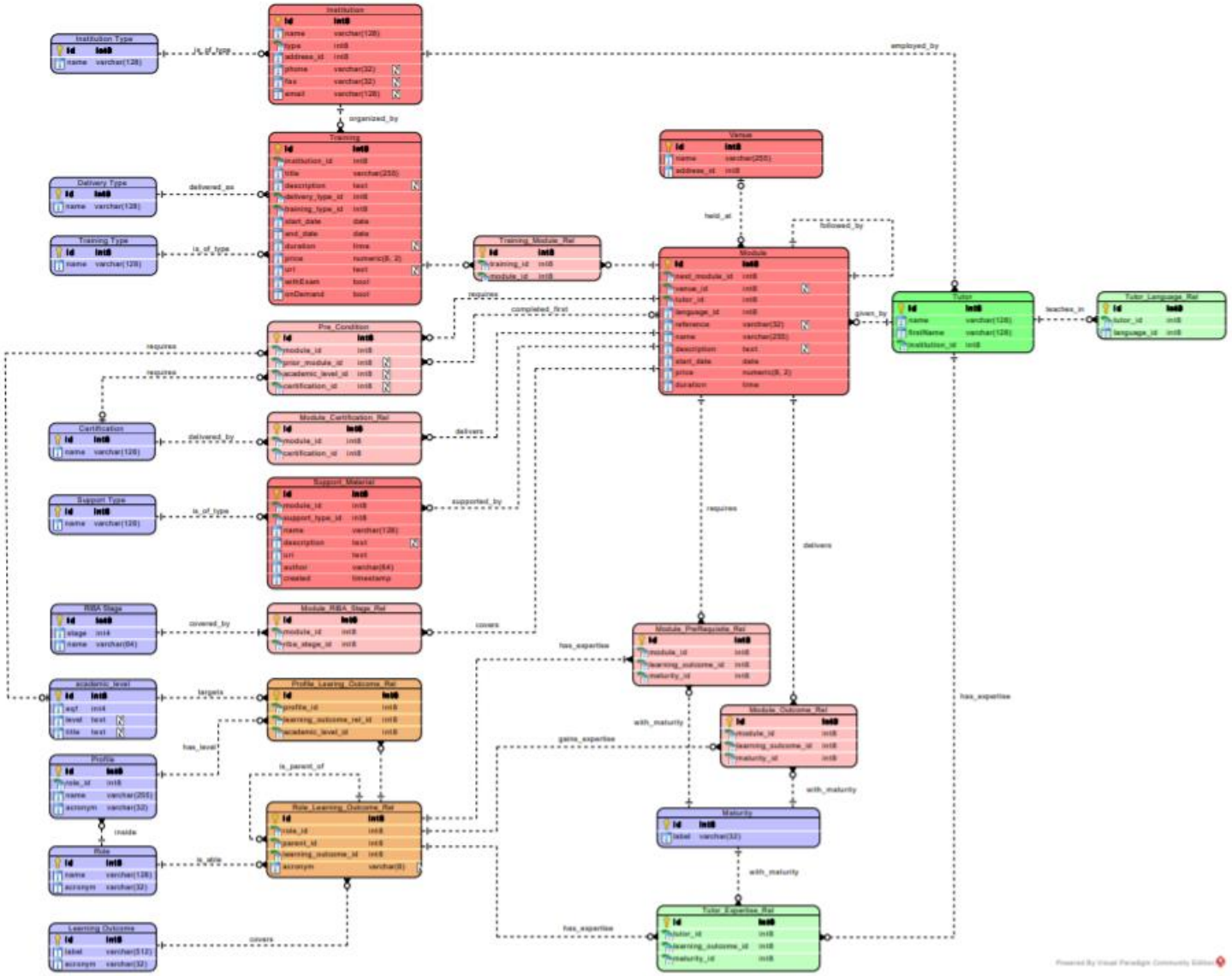
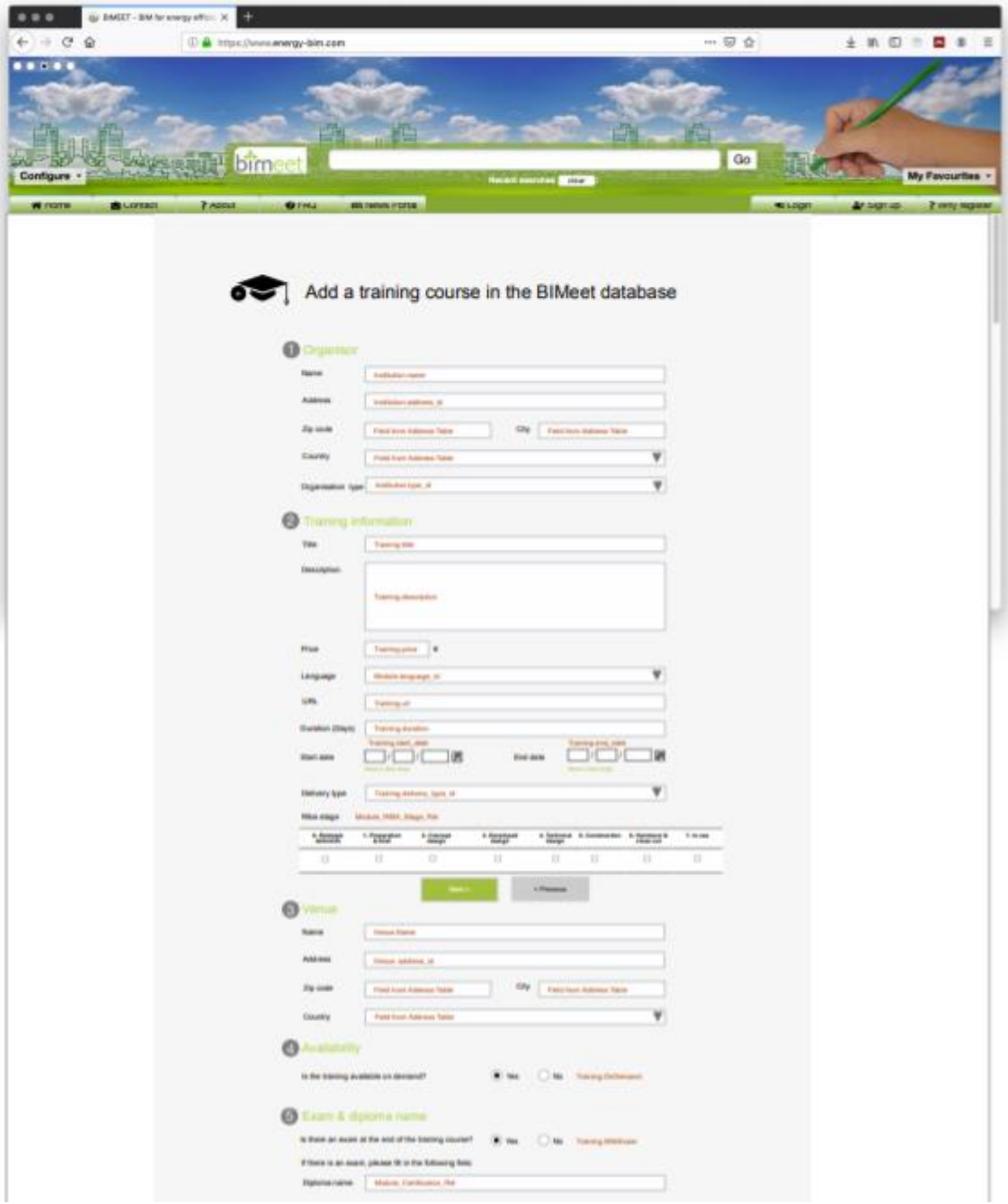
53. Energy aware BIM Cloud Platform in a Cost-effective Building Renovation Context

New database schema integrated



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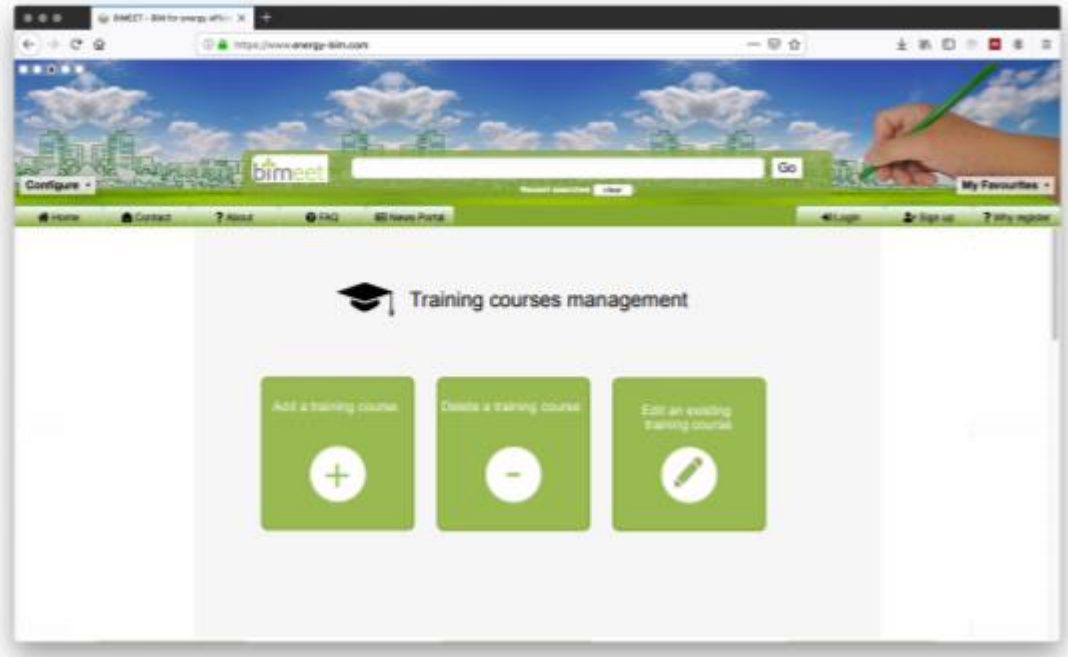
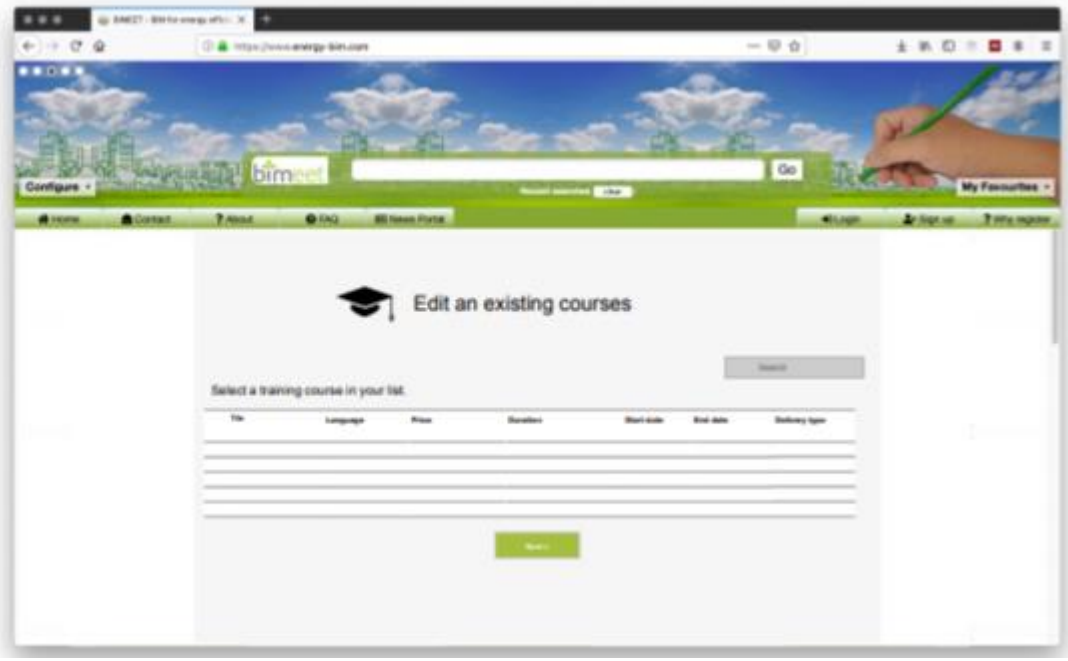
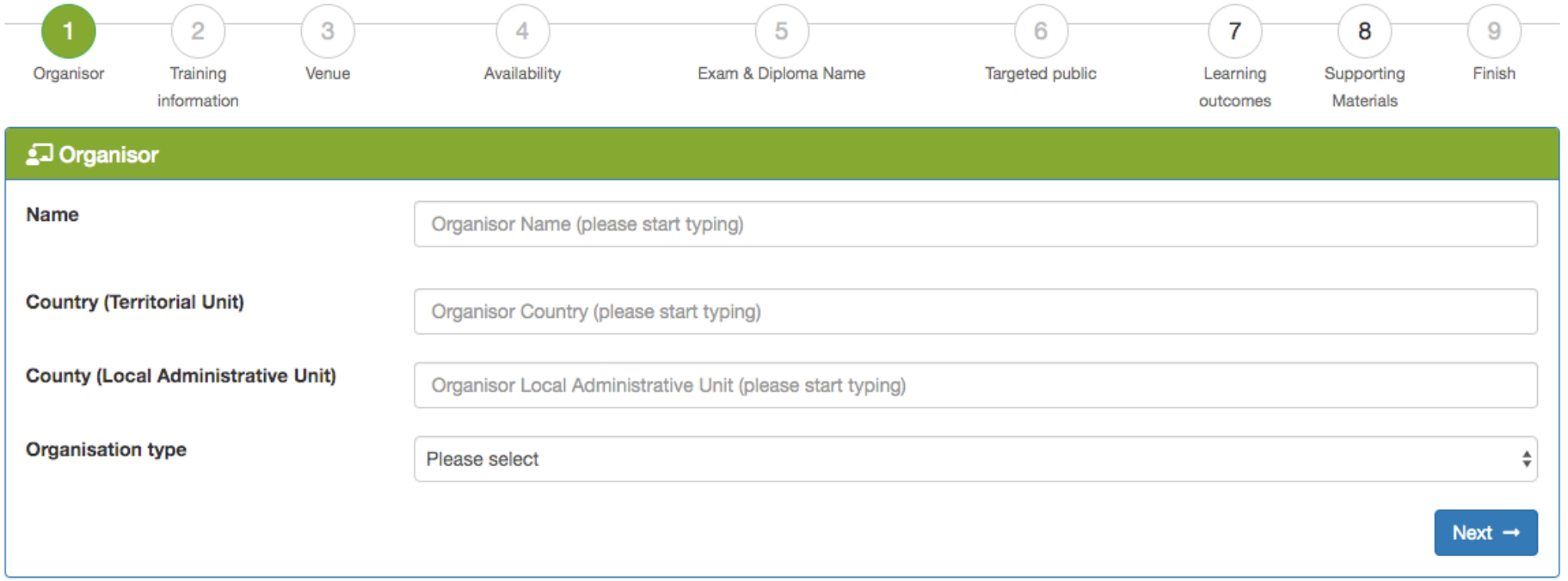
bimeet
Go
My Favourites
Add a training course in the BIMeet database
1 Organizer
2 Training information
3 Venue
4 Availability
5 Exam & diploma name


Configure
bimeet
Go
My Favourites
Training courses management
Add a training course
Delete a training course
Edit an existing training course


Configure
bimeet
Go
My Favourites
Edit an existing courses
Select a training course in your list.

Training database

Step 7: Learning outcomes



- Organisor → Training information → Venue → Availability → Exam & diploma name → Targeted public → Learning outcomes → Supporting materials

1 Organisor
2 Training information
3 Venue
4 Availability
5 Exam & Diploma Name
6 Targeted public
7 Learning outcomes
8 Supporting Materials
9 Finish

Venue

Name technopôle Savoie Technolac

Country (Territorial Unit) Technopôle Savoie Technolac

County (Local Administrative Unit) Venue Local Administrative Unit (please start typing)

Next →

1 Organisor
2 Training information
3 Venue
4 Availability
5 Exam & Diploma Name
6 Targeted public
7 Learning outcomes
8 Supporting Materials
9 Finish

Availability

Is the training available on demand?

Yes

No

Next →

1 Organisor
2 Training information
3 Venue
4 Availability
5 Exam & Diploma Name
6 Targeted public
7 Learning outcomes
8 Supporting Materials
9 Finish

Exam & Diploma name

Is there an exam at the end of the training course?

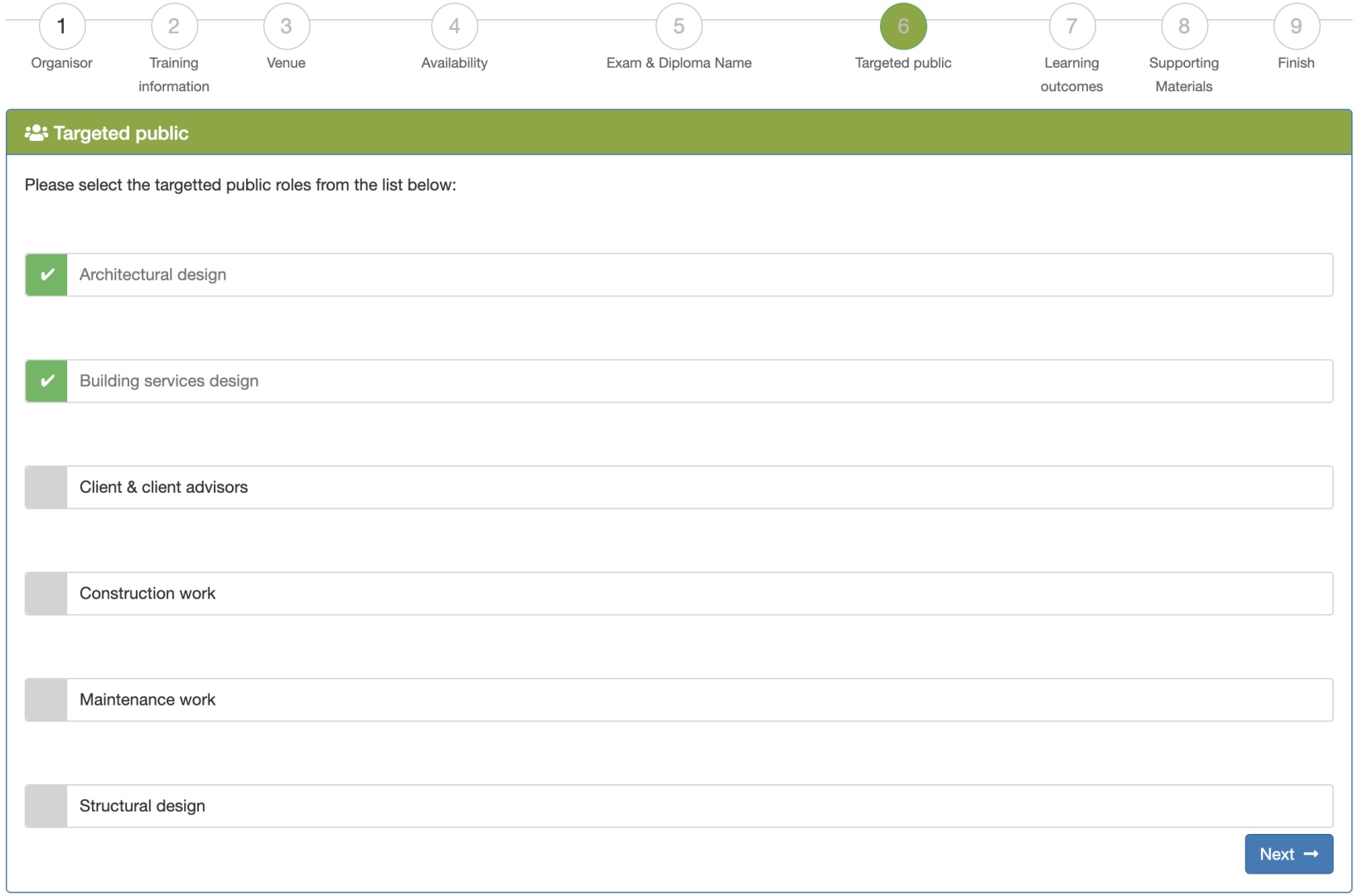
Yes

If there is an exam, please fill in the following field:

Diploma name

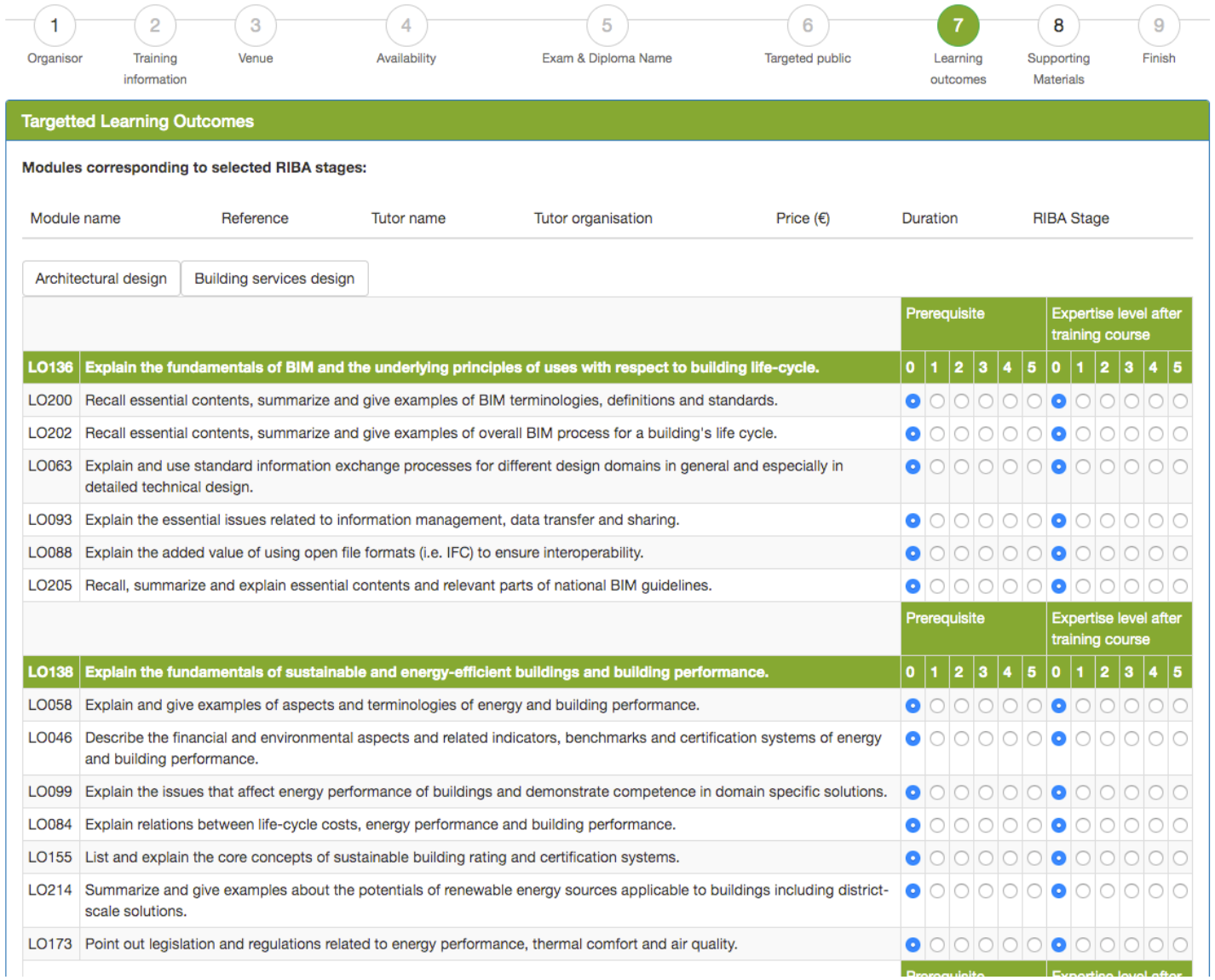
Enter Diploma Name

Next →



- We need to complete the information in the required fields. Otherwise, we are not let to progress to the next step;
- Selecting these is essential for the next step.

Step 7: Learning outcomes



- Table for selecting learning outcomes prerequisites and expertise maturity levels are generated based on the information selected at *Step 6*.
- The modules are generated based on the RIBA stages selected at *Step 2*.

CONCLUSIONS

- In this paper we present an in-depth BIM analysis process for determining gaps and new strategies in delivering BIM training for energy efficiency.
- The analysis provided in the evaluation part of the research show how BIM is implemented and approached in the engineering community and also assesses the role of BIM in achieving energy efficiency in buildings across the whole value chain.
- Based on a portfolio of 38 best practices use-cases from the field of BIM for energy efficiency, we have conducted in-depth analysis in order to understand which are the gaps in BIM for energy efficiency and propose training and possible areas of improvement.
- The portfolio of use-cases are collected, stored and maintained on a web platform (www.energy-bim.com) and exposed to potential users across Europe. The evaluation process included several criterions such as stage and discipline, highlighting stakeholder targets ranging from blue collar workers to decision makers.

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