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

D2.3 – BIM for energy efficiency required roles and skills

WP 2	**Leader: Cardiff University**
Task 2.3	**Leader: Cardiff University**
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Abbreviations

CA	Consortium Agreement
DoA	Description of the Action
GA	Grant Agreement
ICT	Information and Communication Technologies
PC	Project Coordinator
PSC	Project Steering Committee
QA	Quality Assurance
WP	Work Package
WPL	Work Package Leader
BIM	Building Information Modelling
EE	Energy Efficiency
EQF	European Qualification Framework
ToC	Table of Content
Mx	Milestone date designating the start of a given task
My	Milestone date designating the end of a given document delivery deadline
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
ICT	Information and Communication Technologies
KSC	Knowledge – Skills – Competencies

1 Executive Summary

The report D2.3 covers the phase of requirements capture of the BIMEET project and identification of roles and skills. Whereas BIMEET project aims at offering specialised training and educational programs to support with BIM implementation agenda for energy efficiency in Europe, the current report is addressing the requirements elicitation phase. This phase involves training requirements collection and associated analysis in order to inform the training elaboration phase with regards to skills, competencies and required qualifications.

The report provides in-depth analysis and identification of roles and skills involved in BIM training for energy efficiency prior to integration with following training models and strategies. Social media analysis have been used alongside use-cases ,interviews and scientific publication as a method to collect roles and skills in order to inform future BIM practices and promote improved BIM training and education.

2 Introduction

This section elaborates on concepts related to roles and skills in the area of BIM for energy efficiency and provides an initial introduction of the key aspects that are involved is the evaluation of skills and roles.

The construction sector is highly fragmented, depending on a large number of very different professions and firms, which are mostly small in size, tend to respond to local market needs and control only one or very few elements of the building design, construction or maintenance process [1]. Construction projects involve various professions, including design teams, contractors, facility managers, product manufacturers and suppliers, user associations, clients and investors, and local/regional/national/international authorities.

The increasing complexity of buildings is reflected in the continuous introduction of new procurement paths and methods, construction technologies, materials and construction methods to meet various economic, environmental and societal challenges. This requires the involvement of not only the traditional disciplines and roles (architecture, structure, mechanical and electrical, etc.) but also many new professions and skills in areas such as energy, environment, waste and connected objects / Internet of Things. For instance, designing a hospital requires not only meeting tighter energy and carbon requirements but also reducing drastically infection rates by adapting architectural design.

The construction industry exhibits characteristics that differentiate it from other industrial sectors [2]. These are summarised below:

- It is one of the most geographically dispersed sectors with marked regional differences.
- The industry is project-oriented with a tendency for actors to be involved concurrently in several projects with similar, but sometimes different, roles and responsibilities.
- The industry is fragmented and structured into a variety of disciplines (e.g., architecture, civil engineering, building services, etc.) that have their dedicated codes of practice, regulations and use their own technical jargon.
- Each construction project is a one-off and unique prototype with distinct characteristics, including choice of construction system, materials, site topography and geology, and local environmental factors. The final product tends to be very durable, lasting several decades and longer, and represents one of the few non-transportable industrial products.
- It is highly regulated. Regulations and standards are increasingly rigorous, with the involvement of several levels of regulatory governance (local, regional, national, European).
- The entry-level for new companies is relatively low because the need for operational capital is small. The industry is dominated by SMEs.
- The sector is very labour-intensive, with high mobility of the workforce. Projects now demand an educated and trained workforce as construction technology becomes more sophisticated. The duration of contracts is often linked to the length of the project or design/construction phase.
- Business relationships are temporary and often short-term, bringing together partners who may never work together again.
- Values, norms and cultures tend to vary from one organisation to another, which is reflected in their work practices and business processes.

2.1 Building Information Modelling

Prior to the introduction of IT, and up to the early 1980s, the main concern of the construction industry was project data and information management [3]. As a large construction project may eventually result in the production of tens of thousands of documents, the concern of the industry was to provide easy and quick means to identify and locate the appropriate document [4]. This relied mainly on managing project documentation either on an ad-hoc basis or at best using traditional library archival methods. Documents were text-based and/or graphical information and knowledge carriers often shared in paper forms. Central to the idea of a document is usually that it can be easily transferred, stored and handled as a unit [3, 4]. In fact, project documents have remained similar for the last decades. Drawings (plans, sections, elevations, etc.) and text-based documents (bills of quantities, specifications, etc.) look much the same in terms of contents and form. However, the process involved in producing, distributing/sharing, approving, and updating these documents has evolved as a result of the introduction of IT [4]. The current situation in the Construction industry is that a mixture of different document management methods is used [5, 6]. Initial document management systems used basic file management capabilities found in operating systems, and included a number of functionality [6] such as: user authentication; a main retrieval mechanism based on either hierarchical folders or metadata; handling of revisions and change management; viewing of proprietary files using their native software; full text search capability. In a nutshell, documents are stored centrally on a server and users interact with this central repository through simple interfaces and then later on with the advent of the Internet, through the use of simple web browsers.

Some of these systems have been developed in-house or offered by third parties as ASP-services (application service provider). Electronic document management systems (EDMS) tend to treat documents as black boxes, while capturing meta-information, which enables humans, or document management systems to search for, retrieve and open documents. Meta-data were initially included in documents or cover pages, drawing headers etc., and then directly stored in the database that underpins the EDMS.

Although the manual referencing of paper based product data and building design has existed for centuries, it was the increasing use of Computer-Aided Design (CAD) facilities in design offices from the early 1980s which prompted the first efforts in electronic integration and sharing of building information and data [7, 8]. Here, the ability to share design data and drawings electronically through either proprietary drawing formats or via later de facto standards such as DXF (drawing/data exchange format), together with the added dimension of drawing layering had substantial impacts on business processes and workflows in the industry [5]. Although in these early efforts, sharing and integration was mainly limited to geometrical information, effectively the use of CAD files was evolving towards communicating information about a building in ways that a manually draughted or plotted drawing could not [7, 8].

This evolution continued with the introduction of object-oriented CAD in the early 1990s by companies such as AutoDesk, GraphiSoft, Bentley Systems etc. Data “objects” in these systems (doors, walls, windows, roofs, etc.) stored non-graphical data about a building and the third party components which it comprises “product data”, in a logical structure together with the graphical representation of the building [9–11]. These systems often supported geometrical modelling of the building in three dimensions, which helped to automate many of the draughting tasks required to produce engineering drawings.

When combined with the increasing ubiquity of electronic networking and the Internet, this allowed many companies to collaborate and share building information and data which in turn led to new ways of communicating and working [7, 11]. The opportunities presented by the move

towards collaborative working and information sharing led to the development in the early 1990's of frameworks to encourage the migration from document centred approaches towards model based, integrated systems [3, 12]. It became clear that in order to take best advantage of the potential for CAD and object / product model integration, there was a need for more coordinated standards which would encourage its uptake [13]. These standards defining efforts came in the form of the STEP application protocols for construction [14]. This work, inspired by previous work primarily in aerospace and automotive fields, formed part of ISO 10303, the International Standard for the Exchange of Product Model Data. Latterly, the International Alliance for Interoperability defined the Industry Foundation Classes, a set of model constructs for the description of building elements. Preceding and in some cases concurrent with this work, the academic research community produced several integrated model definitions including GARM [15], the AEC Building Systems Model [16], ATLAS [17], the RATAS model [18], OPIS [19], and the COMBINE Integrated Data Model [7]. These research efforts were generally predicated on the use of either an integrated tool set also furnished by the respective projects, or on a central database holding all model data for access by any application used in the construction project process via some form of adapter [20, 21]. One of the most recent incarnations of the central database idea can be seen in the IFC Model Server to host entire building models described in the IAI IFC format.

Within the last decade, researchers and commercial application developers in the construction domain have started to develop tools to manipulate complex building models [21]. By storing and managing building information as databases, building information modelling (BIM) solutions can capture, manage, and present data in ways that are appropriate for the user of that data. Because the information is stored in a logically centralised database, any changes in building information data can be logically propagated and managed by software throughout the project life cycle [18, 22]. Building information modelling solutions add the management of relationships between building components beyond the object-level information in object-oriented CAD solutions. This allows information about design intent to be captured in the design process. The building information model contains not only a list of building components and locations but also the relationships that are intended between those objects [7].

This new wave of BIM applications, embody much of the vision of previous academic research such as ATLAS, and COMBINE, whilst still relying on data exchange standards or API level customisation for interoperability/integration.

BIM is commonly defined as the process of generating and managing data and information about a building during its entire life cycle from concept design to decommissioning [23]. Industry Foundation Classes [24] are a commonly used form for BIM. They are open data model specifications for defining building components' geometry and other physical properties in a way that enable CAD users to transfer design data between different software applications [23, 25]. They are intended to provide an authoritative semantic definition of building elements, their properties and inter-relationships. Data associated with IFC can include: textual data, images (such as building schematics); structured documents, numerical models and designer/project manager annotations. The IFC specification is developed and maintained by BuildingSmart and has been included in several ISO standards. The IFC with its standard set of rules for data storage, data exchange and protocols provides an ideal framework to manage data related to a building throughout its lifecycle.

A number of semantic resources and information management standards have been developed for the construction domain. These include COBie (Construction Operations Building Information Exchange), agcXML, and BS1192:2007. COBie is developed as a standard data specification for structured information exchange [26]. The COBie approach and concept is to

input data and information during the processes of design, construction, and commissioning, which will essentially support the operations, maintenance, and the management of the facilities by the owner and/or facilities manager. It provides overall traceability and visibility of design, construction and handover information and decisions. agcXML, a buildingSMART project as part of the aecXML Domain framework, aims at producing a set of eXtensible Markup Language (XML) schemas of structured format for the exchange of information during the design and construction process through any number of documents including request for information and change orders amongst others [27]. BS1192:2007 is a standard for collaborative production of project information which provides a naming convention constructed using specific metadata fields. These standards complement the IFC development efforts and are a good contribution towards addressing some of the BIM shortcomings.

2.2 BIMEET project skills and roles

The aim of BIMEET is many-fold: (a) pave the way to a fundamental step change in delivering systematic, measurable and effective energy efficient buildings through BIM training with a view to effectively address European energy and carbon reduction targets; (b) promote a well-trained world leading generation of decision makers, practitioners, and blue collars in BIM for energy efficiency; (c) establish a world-leading platform for BIM for energy efficiency training nurtured by an established community of interest (see Figure 1).

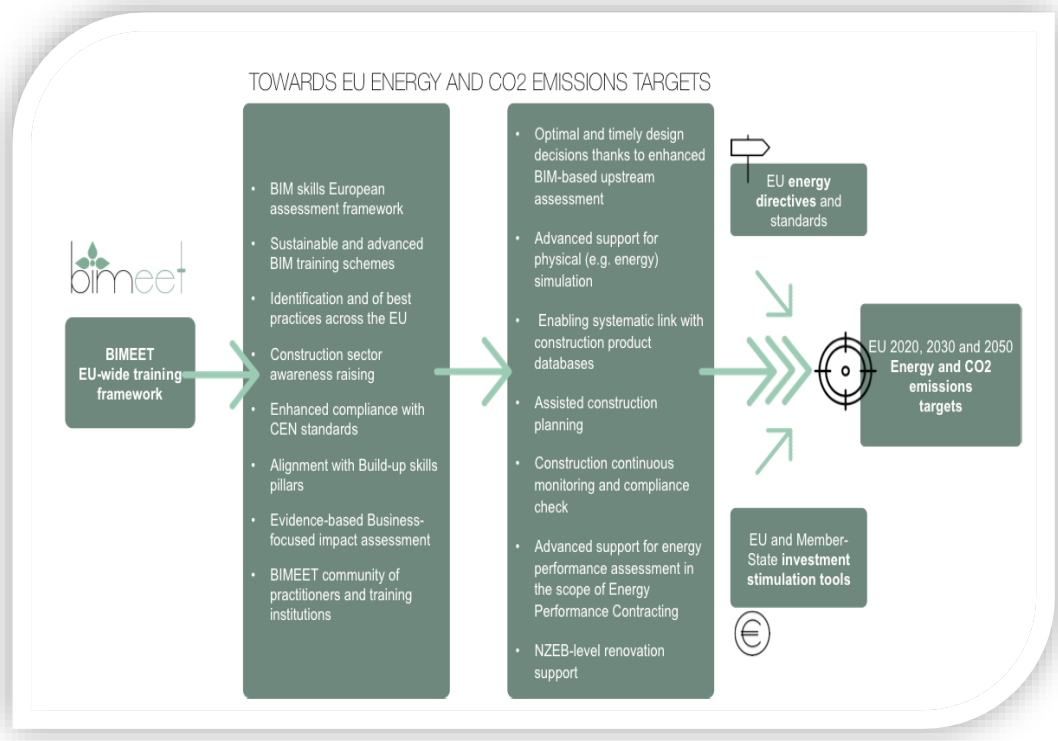


Figure 1: From BIMEET to EU energy targets - impact generation approach

These general aims translate into the following strategic objectives (STO):

- STO1: Screen and synthesize past and ongoing European, as well as national, initiatives and projects with a focus on assembling evidence-based quantitative /

measurable scenarios and use cases that demonstrate the role of BIM in achieving energy efficiency in buildings across the whole value chain.

- STO2: Benchmark existing Europe-wide BIM trainings across the building value chain (including lifecycle and supply chain), highlighting energy efficiency linkages, as well as qualification targets, delivery channels, skills, accreditation mechanisms, while highlighting training gaps and enhancement potential.
  - ✓ This will include: (a) better determination of future capability needs; (b) clear routes of entry and clear career progression pathways; (c) clear, standard means of recognising competence; (d) exploring the scope to make apprenticeships more flexible; (e) an industry review of the current skills and capability delivery mechanisms; (f) review of approaches to career planning, training and development with a commitment to rationalise.

- STO3: Harmonize energy related BIM qualification and skills frameworks available across Europe (Objective 1) with a view of reaching a global consensus through our BIM for energy efficiency expert panel.
  - ✓ The focus is on setting up a mutual recognition scheme of qualifications and certifications among different Member States supported by an effective strategy to ensure that qualification and training schemes are sustained after the end of the project.

- STO4: Map identified skills, qualifications, and accreditation into a BIM for energy efficiency overlay with a total lifecycle and supply chain (including blue collar) perspective.
  - ✓ There are country specific delivery and process variations that will be considered to ensure successful take-up of the BIMEET training program at a national level.

- STO5: Adapt the BIM4VET platform (delivered in the context of a related ERASMUS+ ongoing project) to provide a robust computer-based online and open-access environment for BIMEET.
  - ✓ The BIM4VET platform is already providing: (a) BIM stakeholder competence matrix, (b) classification of BIM training curriculums in Europe, (c) BIM qualification maturity assessment method, and (d) recommender system for BIM training selection.
  - ✓ The resulting BIMEET platform will be available on-line on an open-access mode, nurtured by an established community of interest underpinned by an adapted business model.

- STO6: Establish a governance, policy, and regulatory framework as well as adapted business models to ensure the long-term sustainability of the proposed BIMEET training agenda.
  - ✓ The consortium will be supported by a 200+ members of the BIMEET community of interest and a panel of experts (around 20 members).
  - ✓ The consortium members will adopt an incremental and participative approach engaging effectively all the above stakeholders.

- STO7: Disseminate within and beyond Europe the resulting BIMEET platform and training program.

This report addresses objective no. #2 and objective no. #3 and provides identification of roles and skills in relation to BIM training for energy efficiency prior to integration with following training models and strategies. In-depth analysis of use-cases, interviews, scientific publications and social media content have been used as a method to determine relevant roles and skills that need to be considered when devising BIM training programmes.

3 Related work

In this section we explore related works from the field of BIM with particular emphasis on roles and skills to inform the training programmes.
The use of BIM in projects can have significant impact on quality, resource efficiency, and reduction in construction time and cost [28]. Research studies such as Gillian and Kunz [29] have shown tangible benefits of BIM in projects. BIM can be used for various purposes throughout the project lifecycle, and increase the overall productivity. Since BIM relates to products, processes as well as people, the BIM way of working requires active collaboration and communication between the project participants. Team members from different disciplines need to work with BIM data, supported by the BIM professionals. BIM tools provide various possibilities for collaboration and exchange of data. A dedicated BIM manager for the projects is often seen as a requirement today. Thus, active cooperation between stakeholders is critical to successful BIM implementation.
Consequently, BIM education has become one of the key requirements in Architecture Engineering and Construction (AEC) education. BIM can empower the current and future AEC professionals to accomplish increase in productivity, waste reduction, and creation of a sustainable future through a combination of technical, methodological, procedural and organizational skills and competences. Thus, BIM education should also include individual as well as team skills and competences [30]. Nonetheless, because BIM is a relatively new topic in AEC education, and because the best practices in BIM education are yet to emerge, BIM courses are often taught as technology training without any theory or collaborative learning. In contrast, industry values both technical as well collaborative skills, as the base for better integration and growth of the future employees (Ahn et al. 2012).

3.1 ICT and BIM

Information and Communication Technologies (ICTs) have been recognised as key player for reducing energy consumption and to move forward to a more sustainable and smart society [32]. The building sector is responsible of the 40% of energy consumption and 36% of CO2 emission in Europe [33]. Because 35% of existing buildings are older than 50 years, increasing their energy efficiency could reduce the energy consumption from 5% to 6% and the CO2 emission of about 5%. Recent improvements in ICTs offer an archipelago of devices, software and communication paradigms that can enable the deployment of real smart-buildings and cities [34]. Devices, such as low-power Wireless Sensor Networks (WSNs) for environmental monitoring, and novel smart meters for electric load profiling and recognition, give the possibility of monitoring and characterisation of energy consumption behaviour of buildings and dwellings. On the other hand, recent improvements in Building Information Models (BIMs) [28].

According to Succar et al. [35] “Individual BIM competencies are the personal traits, professional knowledge and technical abilities required by an individual to perform a BIM activity or deliver a BIM-related outcome. These abilities, activities or outcomes must be measurable against performance standards and can be acquired or improved through education, training, and/or development.”
Several authors highlight the need for BIM skills in the AEC industry. For example, Fan et al. (2014) emphasize the need for a relationship between the BIM skills of a person and their understanding of intricacies of the field for which BIM is used. Mohd and Ahmad Latiffi [37] mention that skilled BIM workforce helps in cost reduction and improved time management through clash detection

Wu and Issa [38] anticipate BIM education as a solution to brisk up the BIM learning curve, though they recognize that the competencies of fresh graduates is not enough to satisfy the work-related demand. Instead, they suggest that BIM education prepares graduates to be ready to the extent that the organizations can shape BIM competencies of these graduates as per their own need.

Yarmohammadi and Ashuri [39] emphasize BIM competence regarding the coordination of building services, and how, a team leader with high BIM competence can have major impact on the progress and coordination of the project. Taiebat and Ku (2010) report that the construction industry prefers to have future employees with deep conceptual knowledge of BIM rather than those with BIM application skills only.

A growing trend of new positions such as BIM professor and BIM manager shows the increasing need for BIM competent workforce. Project managers are likely to have a role as BIM managers. However, Rahman et al. [41] state that skill sets needed for project managers and the BIM managers are different. The authors also highlight that skills like teamwork and communication are required in the curricula. Dossick et al. [42] emphasize that BIM curriculum should also include the understanding of computer application concepts and BIM processes. Davies et al. (2015) also focus on the soft skills like collaboration and communication, negotiation, teamwork, leadership and conflict management. Similarly, Barison et al. [44] look into individual competencies such as aptitude, qualifications, skills/abilities, knowledge and attitude, noting professional need for the position in both foundational and functional ways.

Table 1: Summary of key BIM skills based on the literature review [30]

No.	Authors	BIM Competencies and skills
1	Rahimi et al. [41]	Teamwork, communication, understand BIM standards & workflow
2	Succar et al. [45]	Leadership, estimation, documentation & detailing, model management
3	Eadie et al. [46]	Collaboration
4	Murphy [47]	Technical knowledge, planning & administration, strategy & policy, programme management
5	Sturts et al. [42]	Coordination and collaboration
6	Barison et al. [44]	Teamwork, leadership, analytical thinking, BIM applications, creativity
7	Succar and Sher [35]	Leadership, collaboration, facilitation, organizational management
8	Wei et al. [38]	3D coordination, modeling, design review, site utilization planning
9	Davies et al. (2015)	Conflict management, communication, negotiation, teamwork, leadership

Due to the recent and rapid increase in demand for BIM professionals, the current competence development, training, and educational practices are often based on reactive and a planning, while a well-researched and time-tested best practice for diverse BIM competence requirements is yet to emerge. Therefore, we need structured understanding, assessment, and measurement of BIM competence of a person or a team, contingent on their role in the BIM ecosystem [48].

3.2 Skills needs for Building Information Modelling (BIM)

Building Information Modelling describes the process of designing a building collaboratively using one coherent system of computer models rather than as separate sets of drawings [49]. In June 2011 the UK government published its BIM strategy announcing its intention to require collaborative 3D BIM (with all project and asset information, documentation and data being electronic) on its projects by 2016 [50].

Managing building information using a building information model can lead to substantial cost savings, from design and construction through to maintenance. The model saves time and waste on site, and extra coordination checks are largely unnecessary; the information generated from the model will lead to fewer errors on site caused by inaccurate and uncoordinated information [51].
Even before work begins on site there will be an increased demand for low carbon design-related skills to ensure that new buildings are designed for maximum energy efficiency, prior to technology being installed. Design and planning considerations relating to the type of material used or aspects of structure can yield cost-effective and appropriate low carbon solutions [44].
Research carried out to inform the 2011 BRE report 'Delivering Low Carbon Skills Wales – Low Carbon New Build Learning Project' included a workshop with built environment sector stakeholders to discuss skills issues associated with low carbon building projects in Wales. These were found to include the following higher level areas:

- Generally better knowledge is needed rather than skills with respect to low carbon building;
- Skills around quality requirements and checking could be better across the board;
- Architects' skills for low carbon residential developments;
- Standard Assessment Procedure (SAP) Assessors do not always have knowledge outside of the assessment and may not be able to help with practical achievement;
- Building Control functions need better understanding of the Code for Sustainable Homes (CSH) and skills required;
- Site agents need to adopt a different approach to the traditional;

Designers need to be fully knowledgeable around how to create buildable standard details that meet the requirements of the code (these details ultimately need to be shared with the trades). The research identified opportunities for improvement by bringing the code assessor on board at an earlier stage to simplify design and build; the CSH and SAP assessor could potentially be the same person; creation of details into a format that can be easily understood on site; more site-based time for trainee architects; and a low carbon coordinator on site from day 1 [52].
Technical knowledge and skills, including surveying, are essential to ensuring robust retrofit solutions are found for existing buildings of different ages and conditions through effective identification and solution prescription. In parallel, management skills development is critical to ensuring retrofit projects are planned and delivered in a cost and time efficient way [53].
The National Status Quo research (2012) established from employers and industry stakeholders that the following professional occupations and associated skills/knowledge needs need to be urgently addressed in order for the UK to meet the requirements of the EU 2020 energy efficiency targets [54] :

- Energy Advisor/Assessor (wide-ranging skills and knowledge needs)
- Architects (low carbon design skills; whole life costing)
- Planners (understanding of energy efficiency targets)

- Civil engineers (understanding of low carbon materials and installation processes; knowledge of energy efficiency targets)
- Surveyors (understanding of energy efficiency targets and impacts of energy efficiency measures – or lack of them)
- Site supervisors (understanding of the processes and quality standard of completed work needed to meet low carbon requirements).

Research carried out to inform the 2011 BRE report 'Delivering Low Carbon Skills Wales – Retrofit Learning Project' included interviews with Sector Skills Councils to explore intermediate skills issues. For those working at a professional level, it is likely that additional skills will be required to plan, assess and inspect building requirements; design and commission solutions; and inspect finished work. This was felt to be especially relevant to energy advisors and assessors, site managers and others responsible for the oversight and checking of work standards, as well as micro-generation commissioners/inspectors.
In 2011 the Construction Industry Council undertook a consultation [55] with construction industry employers, professional institutions and education and training providers to establish whether Advanced Technical and Higher Apprenticeships were the best way to deliver the higher level skills required by the industry. All of the key stakeholder groups indicated that they were interested in developing both Advanced Technical (level 3) and Higher Apprenticeships (level 4+) for a variety of professional, managerial and technical occupations.
Some Technical and Higher Level apprenticeship frameworks have been developed for use in Wales for example Construction Technical and Professional non-statutory (Wales) [52] which includes a level 3 Apprenticeship in Technical and Professional and level 6 Higher Apprenticeship.

3.3 BIM Training

As discussed in the section on Digitalisation of construction, digital technologies are drastically changing the way of working and therefore require the workforce to develop suitable skills to fully benefit from the opportunities opened up by the digitalisation of the construction sector. Considerable effort is therefore being put in by Member States to devise strategies and programmes that seek to integrate the use of digital tools, and particularly BIM, in the building process.
Most Member States introduced national strategies to foster the promotion and adoption of BIM by the construction sector. Many of these consist of action plans that entail a component of R&D, development of BIM standards and the set-up of task forces and working groups of experts and stakeholders to exchange best practices and knowledge. Such strategies are often broader in scope and, although they recognise the importance of training, they do not specifically focus on the definition of training initiatives, but rather on stimulating the uptake of BIM and knowledge-sharing, therefore providing a general direction and the initial framework for the subsequent creation of dedicated training and education schemes.
The most prominent examples can be found in countries such as Denmark and Germany, where the use of BIM is even compulsory under certain conditions. Indeed, Denmark was an early adopter of BIM, with its implementation in public construction projects being mandated as of 2007. Moreover, as of 2013, BIM is also mandatory for projects that are fully and partially funded by the government and that exceed DKK 5 million (EUR 672,300) [56]. Similarly, in Germany, the Federal Ministry of Transport and Digital Infrastructure announced that BIM would be made compulsory on all transport projects by 2020, whereas the German BIM Steering Group 'Planen Bauen 4.0' aims to set clear guidelines for the practical application of BIM methods by

introducing the BIM Level Plan (Stufenplan fur BIM in Deutschland), so as to raise awareness of BIM among relevant actors and address key questions such as the roles and responsibilities of each actors (what data has to be provided by whom, what the expectations are, etc.). Indeed, as part of this initiative, the establishment of a national BIM Competence Centre is foreseen, where the findings and experiences on the use of digital planning methods will be gathered into a new central point of contact [57].

In the Netherlands, the uptake of BIM is supported through initiatives that also aim to share information and best practices among the community. For instance, BIM Gateway (BIM Loket) is a national portal for information and management of open BIM standards in the Netherlands, thus stimulating their use. By bringing together open BIM standards into one coherent system, the BIM Locket will satisfy the need for a good information service which will answer the practical questions of users and facilitate knowledge sharing. Eastern European countries are also implementing initiatives to introduce BIM in the construction sector. In Lithuania, the Lithuanian Association of Builders, together with 12 other relevant associations, launched the Digital Construction action (Skaitmeninė Statyba) in 2014 to foster the development of BIM and introduce the National Construction Classification and Industry Foundation Classes (IFC) in the national building sector. In the Czech Republic, the Ministry of Industry and Trade set up an Interdepartmental BIM Expert Group comprising representatives from various stakeholders (ministries, universities, construction companies, design and pricing structures, etc.), so as to foster the exchange of best practices and bring about the implementation of BIM in the construction industry. Therefore, although not strictly skilling initiatives, the schemes implemented in these countries aim to raise awareness, stimulate knowledge-sharing and boost the uptake of BIM, thus ultimately leading to higher levels of skills and knowledge of BIM among the construction workforce.

Conversely, some Member States are directly addressing the need for BIM skilling and training among the workforce, either by explicitly setting training targets in their national strategies, or by offering BIM trainings and learning resources. The UK and France are leading examples of how the digital skilling of the workforce can be specifically initiated at the government level. One of the priority focus areas of the UK Construction Strategy 2016-2020, introduced by the Infrastructure and Projects Authority in March 2016, is the strengthening of the skill base in the sector, particularly with regard to digital skills. Namely, the Strategy seeks to support the creation of 20,000 new apprenticeships until 2020, ultimately aiming to integrating and increase the use of digital construction processes (e.g. BIM) through a skilled workforce. Likewise, in France the Building Digital Transition Plan (Plan pour la Transition Numérique dans le Bâtiment - PTNB) was launched by the Ministry of Housing to bring about the adoption and deployment of digital technologies in the construction sector, with a particular focus on improve the digital skill-base of construction professionals. To this end, and through a total budget of EUR 20 million for 2015-2018, the PTNB coordinates several actions. These include the assessment of the offer for BIM trainings and benchmarking of international initiatives, aiming to provide construction professionals with a comprehensive picture of all training opportunities available and thus guiding them in their digital transition, as well as providing training centres with the opportunity to further align their courses with the needs of the industry. A particular focus is also put on strengthening the competences and skills of trainers and teaching staff [58]. Aside from the strategic direction set out by the public sector, the practical delivery of dedicated trainings on BIM relies on the active involvement of non-governmental institutions, as well as cooperation with industry itself. In Ireland for instance, the Irish Green Building Council offers the BIM International training (BIM Level 2), a two-day course aiming to train building professionals in BIM by introducing best practices, standards, methods, and procedures. Similarly, in Spain, the Spanish Labour Foundation for Construction (Fundación Laboral de la Construcción) opened

up the Badalona training centre, aiming to become a benchmark for training in construction innovation with respect to the application of BIM and new construction techniques (e.g. lean construction), leveraging on tight partnerships with industry. Comparable initiatives are found also in Eastern European countries. The Latvian Association of Civil Engineers offers a series of seminars to enhance the skills of its members regarding BIM and digital technologies Private companies are also playing a role in training and informing construction professionals about BIM. In Bulgaria, coBuilder and Nemetschek have started educating the Bulgarian construction industry about the advantages of using BIM by organising events, such as the 'Second Scientific-Applied Conference with International Participation - Project management in Construction' and 'The different faces of BIM', which attracted over 150 construction and architecture professionals [58].

The main objective of this deliverable is to address the BIM engagement and training process by leveraging on the take-up of ICT and Building Information Modelling technologies through a significant upgrade of the skills, roles and capacities of the European Construction workforce, in order to dramatically improve the reliability and effectiveness of design and construction practices, with a view to achieve the objectives of the Energy Union. In the methodology applied for determining BIM skills and roles for energy efficiency, ICT based qualitative and quantitative methods are utilised to create a consolidate database of skills and roles in order to contribute to the process of training and education for BIM in energy efficiency.

4 Methodology

This report is based on qualitative and mixed-method research undertaking with NVIVO and additional heuristic content analysis for determining roles and skills based on the portfolio of interview, use-cases, scientific publications and social media content. This research leverages on the concept of exploring data types such as text and social media content in order to understand dependencies and associations between BIM for energy related concepts primarily related to roles and skills.
For the analysis we use two main methods that facilitates text crawling and mining:

- NVIVO , a tool 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
- Heuristic text mining algorithms and expression analysis for social media content

4.1 General methodology

The identification of roles and skills in the context of BIM for energy have been elaborated based on:

1 Consolidation of the use-cases collected in the requirements capture process and presented in D2.1. A higher order of analysis has been applied on the consolidated repository of use-cases in order to determine skills and roles specific for BIM for energy.
2 Consolidation of the interviews collected in the requirements capture process and presented in D2.1. A higher order of analysis has been applied on the consolidated repository of interviews in order to determine skills and roles specific for BIM for energy.
3 A scientific literature repository formed of 80 key publications relevant for the BIMEET roles and skills has been used and associated analytics have been applied to identify the set of roles and skills necessary for the training elicitation process and
4 A social media repository formed of around 40 million of tweets crawled from key actors in the field of BIM for energy and training based on which we conduct:
    4.1 Regular NVIVO social media analysis
    4.2 Heuristics expression analysis and mining on social media content

.

The entire analysis process and methodology has been supported by using the **energy-bim.com** with objectives for determining roles and skills with corresponding relationships. The web presence of the energy-bim.com portal has been monitored for a period of 6 months and by utilising forensics methods, a portfolio of companies and user that activate in the field of BIM have been identified and presented in ANNEX E. Social media profiles of these companies have been identified and content produced by these companies has been collected and analysed with the objective of creating a comprehensive list of roles and skills.
For the analysis we have utilised two main qualitative analysis methods:

- NVIVO analysis; NVIVO is a qualitative data analysis (QDA) computer software package that supports rich text-based and/or multimedia information, where deep levels of analysis on small or large volumes of data are required. NVIVO is used predominantly by academic, government, health and commercial researchers across a diverse range of fields, including social sciences such as anthropology, psychology, communication, sociology, as well as fields such as forensics, tourism, criminology and marketing. NVIVO accommodates a wide range of research methods, including network and organizational analysis, action or evidence-based research, discourse analysis, grounded theory, conversation analysis, ethnography, literature reviews, phenomenology, mixed methods research

- Heuristic content mining and expression analysis ; Due to the noisy nature of social media, where short, informal spelling and grammar are often used, we developed a set of regular expressions (RegEx) and pattern matching rules from our collection of BIM-related posts collected from social networking profiles identified in ANNEX E. These were annotated as part of the human annotation process conducted earlier and introduce language from short informal text related to the BIM related categories to assist the analysis process.

For elaborating the list of roles and skills, the following steps have been followed (see Figure 2):

Step 1: Consolidation of the energy-bim.com portal and monitoring of the web activity including visits and accessed content.
Step 2.1: Configuring and preparation of NVIVO for running analysis on interviews, use-cases, scientific publications and social media content.
Step 2.2: Scalable heuristic social media source identification and content consolidation.
Steps 3.1-3.4: Preparation of the content to analyse: interviews, use-cases, training descriptions, publications and social media facilitating compliance with NVIVO environment and overall importing.
Step 3.5: Implementation automated crawling techniques from twitter based on several identified twitter account which resulted into more than 20 million tweets repository.

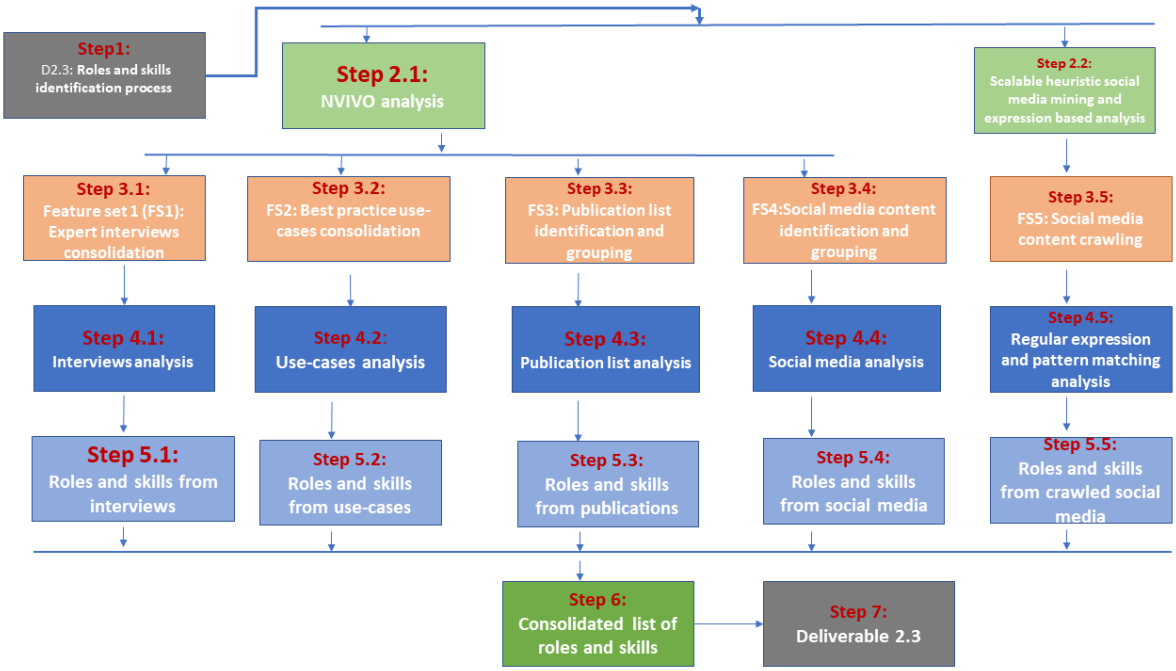


Figure 2: BIMEET requirements methodology (D2.1)

Step 4.1- 4.4: Apply analytics algorithms and mining methods on the consolidated content for skills and roles identification.
Step 4.5: Implementation of expressions and pattern matching algorithms to be applied on the consolidated content.
Step 5.1- 5.5 : Roles and skills identification with associated interests and key directions in the field of BIM for energy as resulted from interviews, use-cases, scientific publications and social media content analysis.
Step 6: Consolidation of the skills and roles complete list relevant for BIM for energy domain.

Step 7: Produce the resulting living deliverable D2.3.

4.2 Community platform for BIM content mining and analysis

To support with the process on content mining and analysis for BIM training monitored the web presence and activity for the www.energy-bim.com platform that provides integrated access to building information modelling (BIM) resources. The platform was published in November 2017 and is open, scalable and polymorphic context-based solution with modules enabling serendipitous BIM information and knowledge discovery by utilizing a symbiosis of technologies such as semantic web, social network.

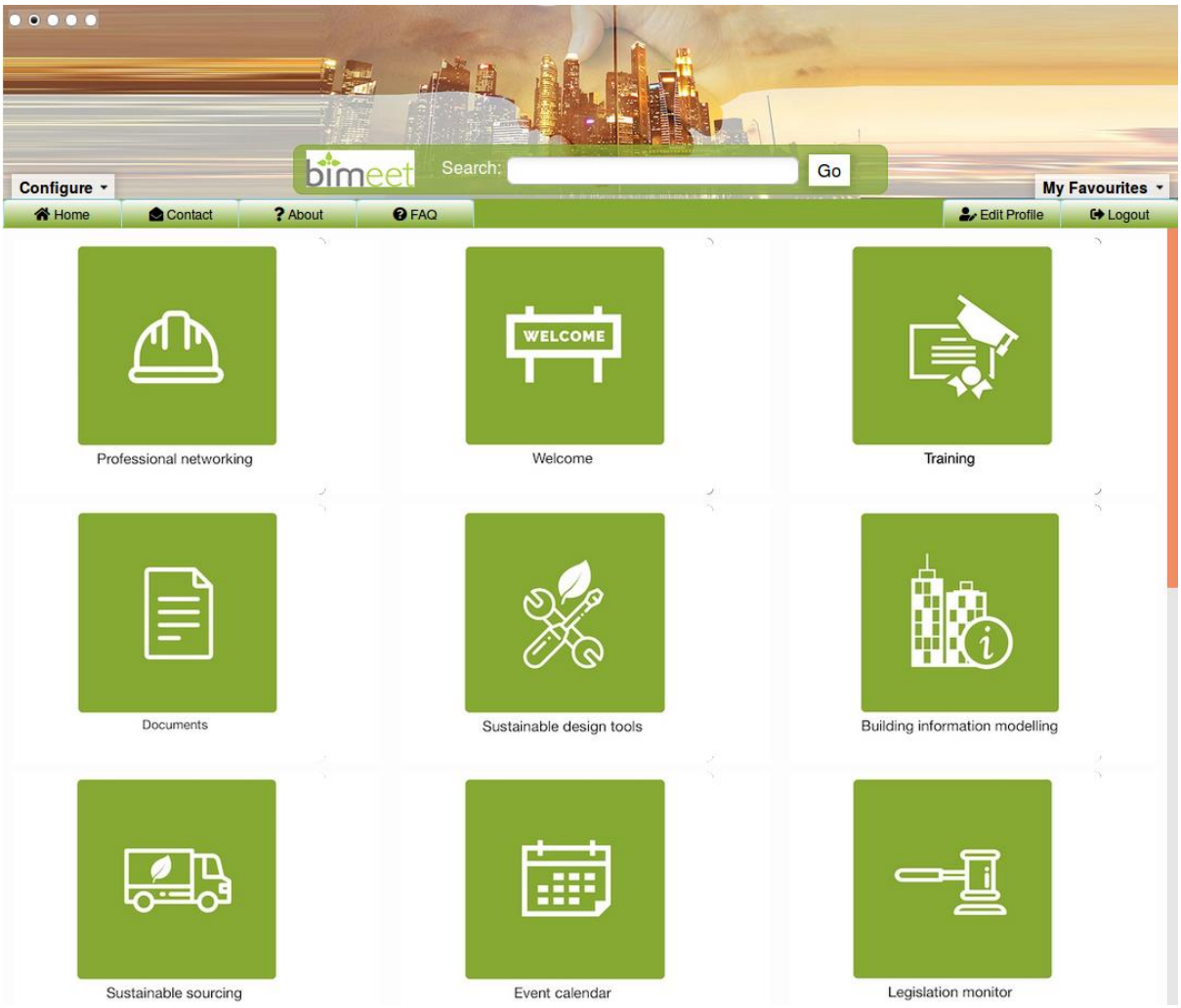


Figure 3: Improved version of the platform: [www.energy-bim.com]

This platform has helped in the process of content mining by informing on the portfolio of companies, institutions and organisation from Europe that have particular interest in the field of BIM for energy efficiency. The objective for the deliverables was to identify roles and skills and aggregate content for the analysis and to support with the project implementation phase in providing construction professionals with the necessary training to offer effective BIM expertise for energy efficient and low carbon solutions, while also enabling them to utilise the latest best practice and regulations (see Figure 3).

The list of visitors that have informed the process on social media mining in presented in Annex E and the resulted selection of institutions that activate in the field of BIM and relevant for the analysis is presented in Figure 4.

Name of organisation
Group CSI
INES Solaires
BRE Academy
Ecoles des Ponts ParisTech
ESTP
Universite de Liege
Universite Catholique de Louvain
Città di Modena
ORSYS Luxembourg
BEC partners SA
Middlesex University
House of Training
Sapienza Università
Scuola Pesenti
LeMoniteur
Technical University of Denmark
Norwegian University of Science and Technology
UIC Barcelona
Mensch und Maschine
Zigurat
BIMEET EU
H2020EE
H2020BIMplement
ECTPSecretariat

Figure 4: List of the organisations that informed the analysis process

4.3 Scientific publications selection

We undertook a broad critical review of the academic literature, international standards, legislation, and key economic and political events surrounding BIM, training and education, energy systems and their management. The body of literature was then broken down into chronological and thematic groupings. Following the observation of new challenges and opportunities arising imminently from a mismatch in these projections, key concepts were identified to address these from related fields and novel management paradigms. The rest of this section details the scope of the review and initial observations of the subject domain.

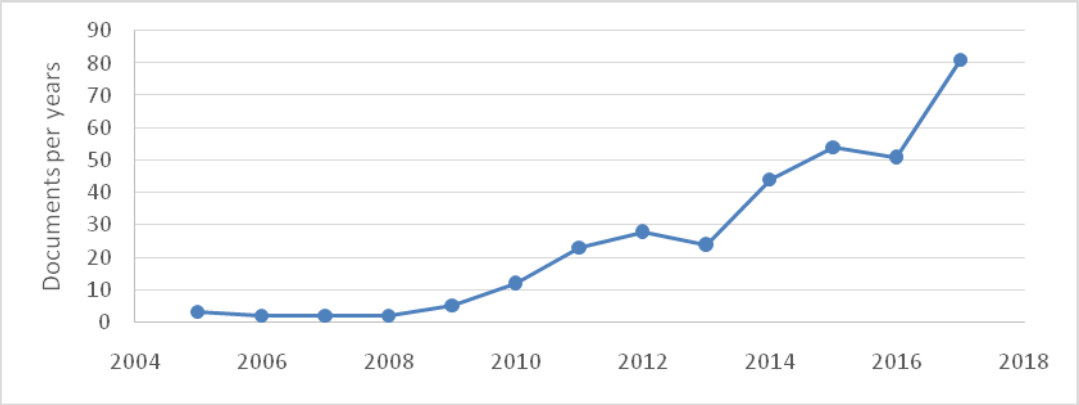


Figure 5: Popularity of BIM for Energy Efficiency research over time as number of relevant Scopus articles per year

Keyword: BIM for Energy Efficiency
Search Driver: Scopus
Period: 2005-2018
Number of documents: 331
Area: Engineering, Computer science, Energy, Environment science

It was apparent that as an emerging field, 'building information modelling for energy efficiency' encompasses many other fields, mandating a well-considered scope. We therefore disregarded papers which only focused on national or building level energy management, or which only considered the design phase of energy systems. We also placed an emphasis on recent publications due to the accelerating change in technologies and focused on BIM training for energy efficiency. Based on this, a trend of increasing popularity in the field was observed since circa 2005, as depicted in Figure 5. The sources were filtered to those deemed most relevant and influential, to a final bibliography of circa 250 references.
From these sources we have selected those which are strictly related to roles, skills and training which resulted in a total of 80 publications used for the analysis process.

4.4 Analysis process description

In the following sub-section we present in detail how each type of analysis has been conducted identifying use-cases, interviews, scientific publications and social media analysis. We have combined static skills and roles identification from traditional sources such as use-cases, interviews, and publication with the more dynamic side from social media content. We have adopted these approach starting from the hypothesis that social media analysis can address the more dynamic part of the skills and roles identification, as BIM for energy and construction is a dynamic process where the majority of new concepts are disseminated and spread on social media. Below we present the analysis scenarios implemented for skills and roles identification.

4.4.1 Use-case analysis

Based on requirement capture use-case template based on which we have aggregated a number of 38 best practice use-cases from the field of BIM for energy efficiency. In order to identify skills are roles the analysis process is presented below. The entire portfolio of use-cases can be accessed online and the results of these analysis are presented in Section 4.1 and data associated with the analysis in Annex A.

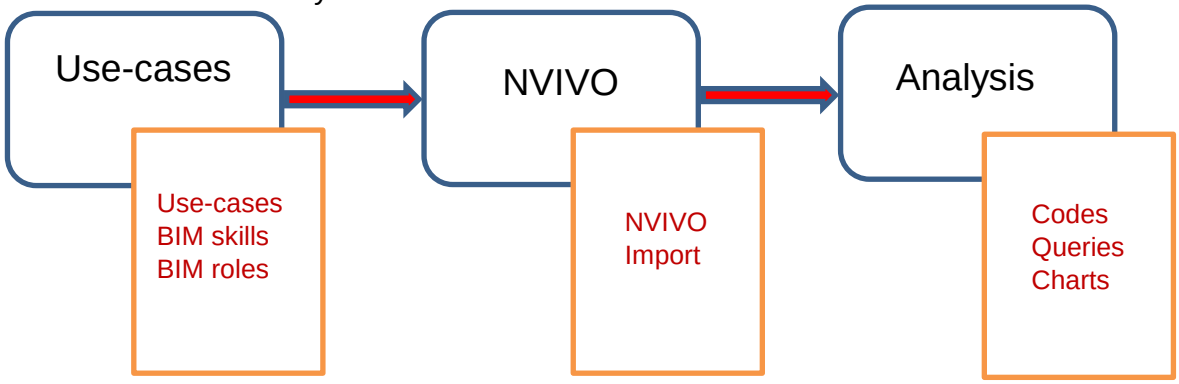


Figure 6: Progress of capture data from use-cases.

Objective: Identification of skills and roles based on NVIVO analysis
Outcome: A consolidate list of skills and roles with regards to BIM for energy
The process adopted identified three phases as in Figure 6, from use-cases consolidation to NVIVO import and analysis where roles and skills are determined.

4.4.2 Interviews analysis

Based on the portfolio of interviews utilised to get access to data and information in BIM and Energy Efficiency in all of the consortium's countries, we have applied the NVIVO analysis methodology for determining new skills and roles in the field of BIM for energy efficiency. Based on the conducted interviews with 15 BIM industry experts from Europe we have determined skills and roles in this field. The results of these analysis are reported below and the expanded analysis for the skills and roles is provided in Annex B.

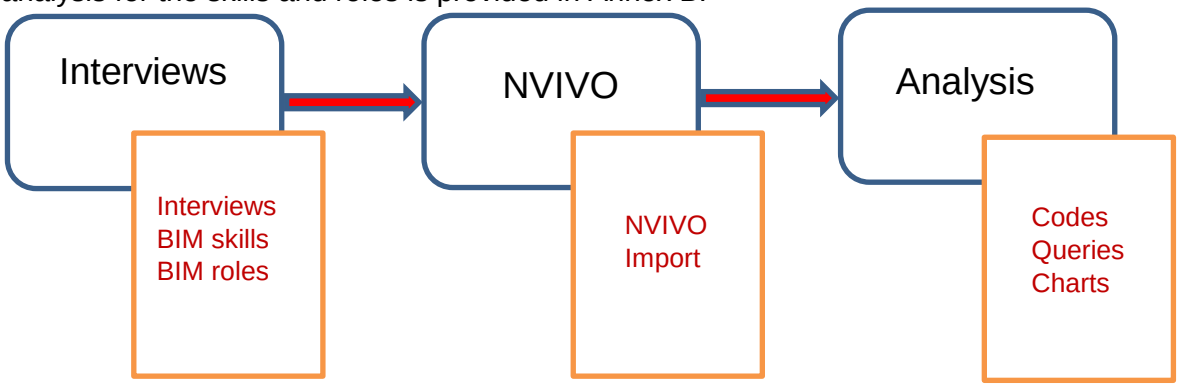


Figure 7: Progress of capture data from interviews

Objective: Identification of skills and roles based on interviews NVIVO analysis
Outcome: Provide a classification of skills and roles with regards to BIM for energy.
The process adopted identified three phases as in Figure 7, from interviews consolidation to NVIVO import and analysis where roles and skills are determined.

4.4.3 Scientific publications

We undertook a broad critical review of the academic literature, international standards, legislation, and key economic and political events surrounding BIM, training and education, energy systems and their management. The body of literature was then broken down into chronological and thematic groupings. The analysis process was conducted on a selction of 80 publications in the field of BIM skills and roles for energy efficiency.

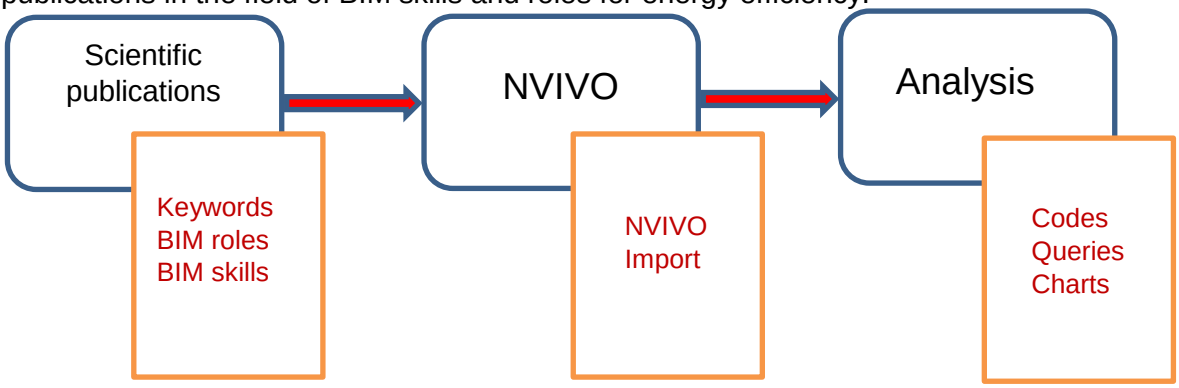


Figure 8: Progress of capture data from scientific publications

The process adopted identified three phases as in Figure 8, from publication repository consolidation to NVIVO import and analysis where roles and skills are determined.

4.4.4 Social media analysis

In this part social media analysis has been utilised by capturing the twitter activity of the identified company profiles. In this part, only tweets posted by a company have been used and analysed while an extension of this analysis have been provided within the scalable heuristic social media analysis. In total, for this phase of analysis we have utilised 50.000 tweets posted by the portfolio of companies presented in Figure 10.

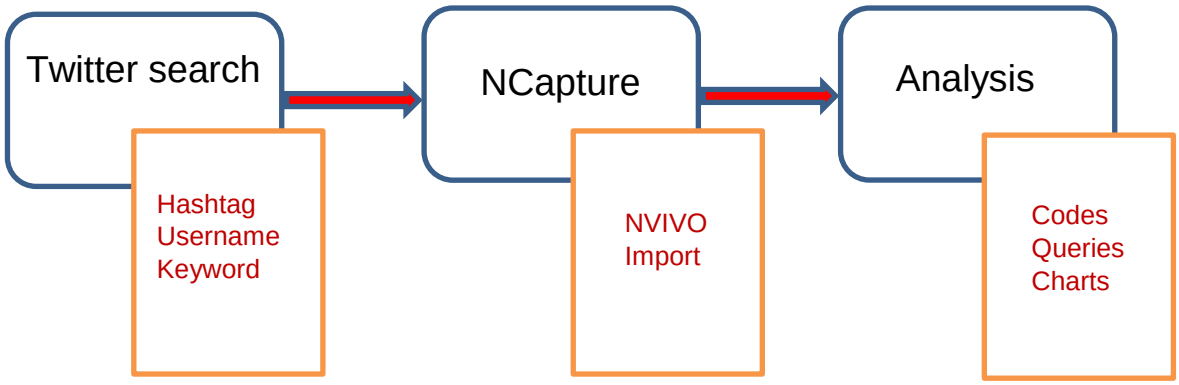


Figure 9: Progress of capture data from social media

The process adopted identifies three phases as in Figure 9, from social media aggregation using NCapture (a browser extension which allows twitter download) to NVIVO import and analysis where roles and skills are determined.
The list of the organisations utilised for the capturing process has been obtained from three sources: (i) forensics algorithms for IP detection and organisation identification, (ii) followers of the @BIMEET twitter account and (iii) partners indication of known BIM training institutions.

Name of organisation	Twitter account
Group CSI	https://twitter.com/groupecesi
INES Solaires	https://twitter.com/ines_solaire
BRE Academy	https://twitter.com/BREAcademy_
Ecoles des Ponts ParisTech	https://twitter.com/EcoledesPonts
ESTP	https://twitter.com/estpparis
Universite de Liege	https://twitter.com/universiteliege
Universite Catholique de Louvain	https://twitter.com/uclouvain_be
Città di Modena	https://twitter.com/cittadimodena
ORSYS Luxembourg	https://twitter.com/orsys
BEC partners SA	https://twitter.com/becpartners
Middlesex University	https://twitter.com/MiddlesexUni
House of Training	https://twitter.com/houseoftraining
Sapienza Università	https://twitter.com/SapienzaRoma
Scuola Pesenti	https://twitter.com/master_pesenti
LeMoniteur	https://twitter.com/le_moniteur
Technical University of Denmark	https://twitter.com/DTUtweet
Norwegian University of Science and Technology	https://twitter.com/ntnu
UIC Barcelona	https://twitter.com/uicbarcelona
Mensch und Maschine	https://twitter.com/mumdach
Zigurat	https://twitter.com/ziguratdigital
BIMEET EU	https://twitter.com/bimeetEU
H2020EE	http://twitter.com/H2020EE
H2020BIMplement	http://twitter.com/H2020BIMplement
ECTPSecretariat	http://twitter.com/ECTPSecretariat

Figure 10: List of the organisation name and their twitter account

4.4.5 Scalable heuristic social media analysis

We have used forensics algorithms to determine what companies, organisation and users from the field of BIM and energy are visiting the www.energy-bim.com platform. We have recorded all the statistics in Annex E and based on the list of visitors we have selected profiles of the most relevant companies that activate in the field of BIM for energy efficiency. We have identified other key twitter profiles and followers relevant for our analysis from the twitter followers list of @BIMEET project (see Figure 11).

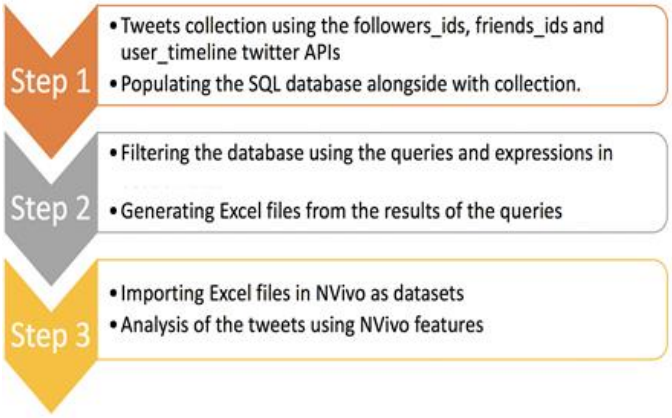


Figure 11: The progress of the tweets collection

In the analysis, the following sequence of steps has been applied:
1. Fetching friends and followers from the list of twitter accounts (using the friends_ids and followers_ids twitter APIs as in Table 2);
2. Fetching timeline tweets from all the friends and followers determined at step 1 using the user_timeline twitter API;
3. Importing all the tweets collected at step 2 in a MySQL database during collection;
4. Querying the SQL database using the regular expressions presented in the list below. The full list of SQL queries can be found in ANNEX F.
5. Exporting the SQL results in Excel format;
6. Importing the results determined at step 5 into NVIVO ;
7. Generating word clouds and word trees from NVIVO ;
8. Consolidating the final list of roles and skills.

Table 2: List of twitter accounts for aggregating analysis content:

Twitter account	Friends collected	Followers collected
https://twitter.com/groupecesi	Yes	Yes
https://twitter.com/ines_solaire	Yes	Yes
https://twitter.com/BREAcademy	Yes	Yes
https://twitter.com/EcoledesPonts	Yes	Yes
https://twitter.com/estpparis	Yes	Yes
https://twitter.com/universiteliege	Yes	Yes
https://twitter.com/uclouvain_be	Yes	Yes
https://twitter.com/cittadimodena	Yes	Yes
https://twitter.com/orsys	Yes	Yes
https://twitter.com/becpartners	Yes	Yes
https://twitter.com/MiddlesexUni	Yes	Yes

https://twitter.com/houseoftraining	Yes	Yes
https://twitter.com/SapienzaRoma	No	Yes
https://twitter.com/master_pesenti	Yes	Yes
https://twitter.com/le_moniteur	Yes	Yes
https://twitter.com/DTUtweet	Yes	Yes
https://twitter.com/ntnu	Yes	Yes
https://twitter.com/uicbarcelona	Yes	Yes
https://twitter.com/mumdach	Yes	Yes
https://twitter.com/ziguratdigital	Yes	Yes
https://twitter.com/bimeetEU	Yes	Yes
http://twitter.com/H2020EE	Yes	Yes
http://twitter.com/H2020BIMplement	Yes	Yes
http://twitter.com/ECTPSecretariat	Yes	Yes

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)**

The regular expressions included are built around the concepts of skills are roles. The overall objective was to create expression for filtering the inaccurate twitter context prior to analysis skills and roles identification. Word such as construction, skills, energy were frequently associated with roles whereas terms such as ‘training’ and ‘knowledge’ were more likely to be included in tweets where a skill or role is reported.

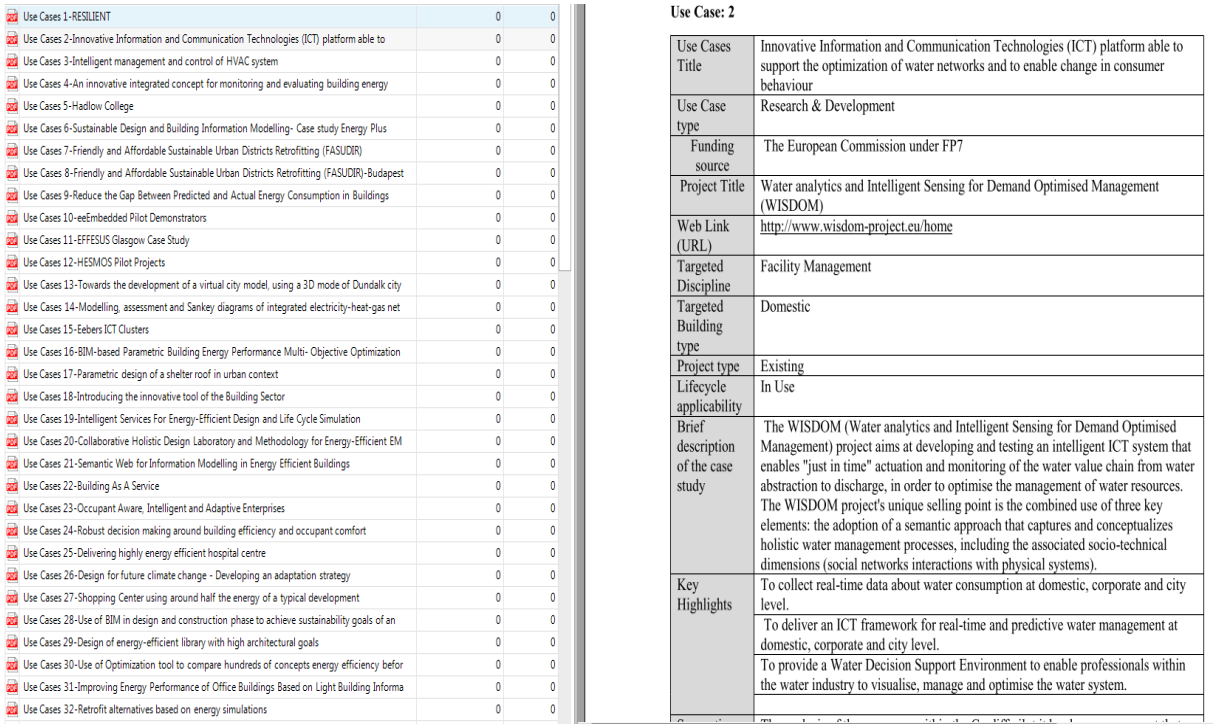
5 Evaluation

In this section 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.
- Word cloud 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.
- Word tree 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.

5.1 Use-cases analysis

The analysis has been conducted of the portfolio of use-cases determined in deliverable D 2.1. Based on the repository of use-cases analysis have been applied in order to find out the skills and roles for BIM for energy efficiency. The overall methodology has been presented in Section 3.4.1 and the portfolio of imported use-cases is illustrated in Figure 12.



Use Cases 1-RESILIENT	0	0
Use Cases 2-Innovative Information and Communication Technologies (ICT) platform able to	0	0
Use Cases 3-Intelligent management and control of HVAC system	0	0
Use Cases 4-An innovative integrated concept for monitoring and evaluating building energy	0	0
Use Cases 5-Hadlow College	0	0
Use Cases 6-Sustainable Design and Building Information Modelling- Case study Energy Plus	0	0
Use Cases 7-Friendly and Affordable Sustainable Urban Districts Retrofitting (FASUDIR)	0	0
Use Cases 8-Friendly and Affordable Sustainable Urban Districts Retrofitting (FASUDIR)-Budapest	0	0
Use Cases 9-Reduce the Gap Between Predicted and Actual Energy Consumption in Buildings	0	0
Use Cases 10-eeEmbedded Pilot Demonstrators	0	0
Use Cases 11-EFFESUS Glasgow Case Study	0	0
Use Cases 12-HESMOS Pilot Projects	0	0
Use Cases 13-Towards the development of a virtual city model, using a 3D mode of Dundalk city	0	0
Use Cases 14-Modelling, assessment and Sankey diagrams of integrated electricity-heat-gas net	0	0
Use Cases 15-Eebers ICT Clusters	0	0
Use Cases 16-BIM-based Parametric Building Energy Performance Multi- Objective Optimization	0	0
Use Cases 17-Parametric design of a shelter roof in urban context	0	0
Use Cases 18-Introducing the innovative tool of the Building Sector	0	0
Use Cases 19-Intelligent Services For Energy-Efficient Design and Life Cycle Simulation	0	0
Use Cases 20-Collaborative Holistic Design Laboratory and Methodology for Energy-Efficient EM	0	0
Use Cases 21-Semantic Web for Information Modelling in Energy Efficient Buildings	0	0
Use Cases 22-Building As A Service	0	0
Use Cases 23-Occupant Aware, Intelligent and Adaptive Enterprises	0	0
Use Cases 24-Robust decision making around building efficiency and occupant comfort	0	0
Use Cases 25-Delivering highly energy efficient hospital centre	0	0
Use Cases 26-Design for future climate change - Developing an adaptation strategy	0	0
Use Cases 27-Shopping Center using around half the energy of a typical development	0	0
Use Cases 28-Use of BIM in design and construction phase to achieve sustainability goals of an	0	0
Use Cases 29-Design of energy-efficient library with high architectural goals	0	0
Use Cases 30-Use of Optimization tool to compare hundreds of concepts energy efficiency befor	0	0
Use Cases 31-Improving Energy Performance of Office Buildings Based on Light Building Informa	0	0
Use Cases 32-Retrofit alternatives based on energy simulations	0	0

Use Case: 2

Use Cases Title	Innovative Information and Communication Technologies (ICT) platform able to support the optimization of water networks and to enable change in consumer behaviour
Use Case type	Research & Development
Funding source	The European Commission under FP7
Project Title	Water analytics and Intelligent Sensing for Demand Optimised Management (WISDOM)
Web Link (URL)	http://www.wisdom-project.eu/home
Targeted Discipline	Facility Management
Targeted Building type	Domestic
Project type	Existing
Lifecycle applicability	In Use
Brief description of the case study	The WISDOM (Water analytics and Intelligent Sensing for Demand Optimised Management) project aims at developing and testing an intelligent ICT system that enables "just in time" actuation and monitoring of the water value chain from water abstraction to discharge, in order to optimise the management of water resources. The WISDOM project's unique selling point is the combined use of three key elements: the adoption of a semantic approach that captures and conceptualizes holistic water management processes, including the associated socio-technical dimensions (social networks interactions with physical systems).
Key Highlights	To collect real-time data about water consumption at domestic, corporate and city level.
	To deliver an ICT framework for real-time and predictive water management at domestic, corporate and city level.
	To provide a Water Decision Support Environment to enable professionals within the water industry to visualise, manage and optimise the water system.

Figure 12: Present the use-cases in the NVIVO

.

The NVIVIO word frequency feature has been applied in order to find the most relevant words to our searching area as presented in Figure 6.2. By applying the word cloud method for the use-cases, concepts can be emphasized and new roles and skills can be identified. Word cloud feature is also representative for this type of analysis as it identifies the degree of importance of a concept in relation to other concepts greatly reflecting dependencies between concepts (see Figure 13).

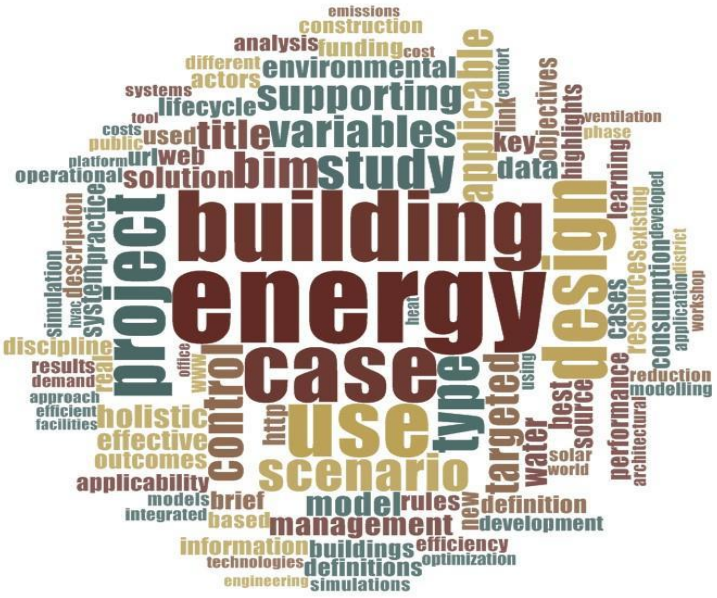


Figure 13: Word Cloud of word frequency for the use-cases section

To continue the process of skills and roles selection based on the analysis supported by the use-cases, NVIVO word three has been used. The NVIVO word three leads to the formation of word three facilitating relation visualisation between different concepts. It groups together words that appear frequently before and after a pre-determined concept and provides users the means to assess a particular scenario and determine concepts of interest.

Figure 14: Word Tree of “Practice” word in use-cases section

Based on the use-cases that we have imported in NVIVO we have generated several word-threes, one presented in Figure 14., and extensively reported in Annex A. From the analysis applied on the portfolio of use-cases, a list of skills and roles has been obtained and presented in Table 3.

Table 3: Consolidated list of skills and roles from use-cases

NO.	Roles	Skills
1	Architect designer	Optimal decision making
2	Construction engineer	Collaborative design open ICT platform
3	Facility manager	Operation energy running costs
4	Mechanical engineer	Operational energy demand
5	Structure engineer	Interaction between the project managers
6	HVAC engineer	Data management
7	Worker in ceramic sector	Adapted to changing environment conditions
8	BIM modeller	Performance measuring, monitoring and optimisation
9	Steel Contractor	Integrated information management framework
10	Electrical engineer	Establish energy modelling
11	Builder	Achieve energy “LEED” certification
12	Supply manger	ICT skills
13	Energy modeller	Teamwork skills
14	Construction engineer	Understand BIM standards
15	Energy simulation experts	Understand energy efficiency principle
16	Operation engineers	BIM tools updates skills
18	Electrical engineers	Searching and BIM development skills

5.2 Interviews analysis

The next round of analysis has been applied on 15 interviews as resulted from the requirements elicitation phased presented in deliverable D2.1. The input preparation phase has been necessary for importing the interviews in NVIVO (see Figure 15). The interviews have been modelled as word files then uploaded to the NVIVO where successive evaluations have been applied. As mentioned previously, NVIVO enables intensive analysis facilitate with word frequency, word count, word cloud methods and others.

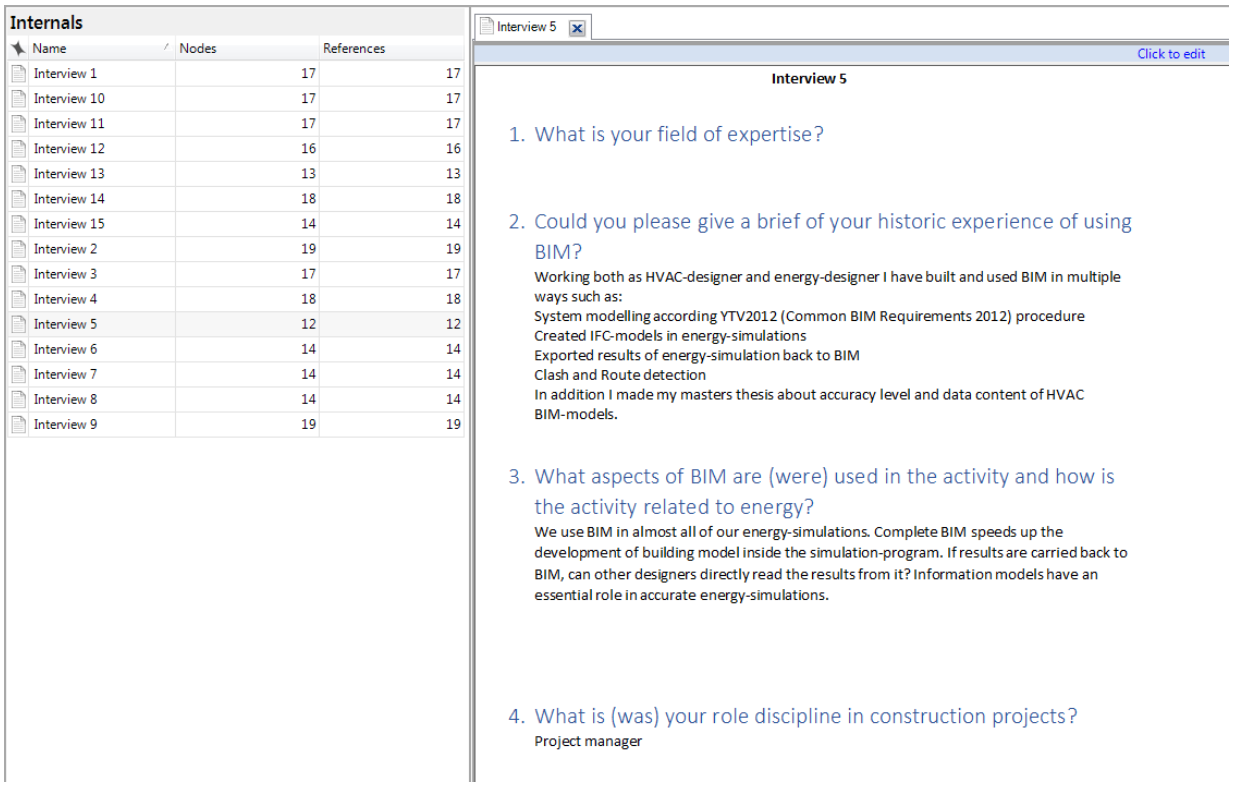


Figure 15: NVIVO interviews importing.

For the interviews, we have applied word frequency queries with the objective to identify new skills and roles leveraging on NVIVO advantages to enable words frequency determination with an associated percentage. This methods has facilitated a better understanding of the key concepts and their correlation as existing in the interviews portfolio. For instance, in our project the most frequent words as derived from the interviews are BIM, energy, efficiency, construction, skills but other relevant word dependencies are determined. The entire word cloud report is presented in Figure 16.

To

Figure 16: Word Cloud of word frequency for the interviews section

continue with the analysis we have chosen to apply methods related to word queries in order to explore a map of dependencies between words. As reported in Figure 17, terms such as ‘’skills, roles and training’’ are central, therefore the following analysis are based on exploration of skills, roles and training. The word three method can also group together words that appear frequently supporting the exploration of dependencies for Skills, Roles and Training and identification of new skills and roles. The results obtained from the analysis are presented below and the complete word three scenarios associated with the interview analysis are presented in Annex B.

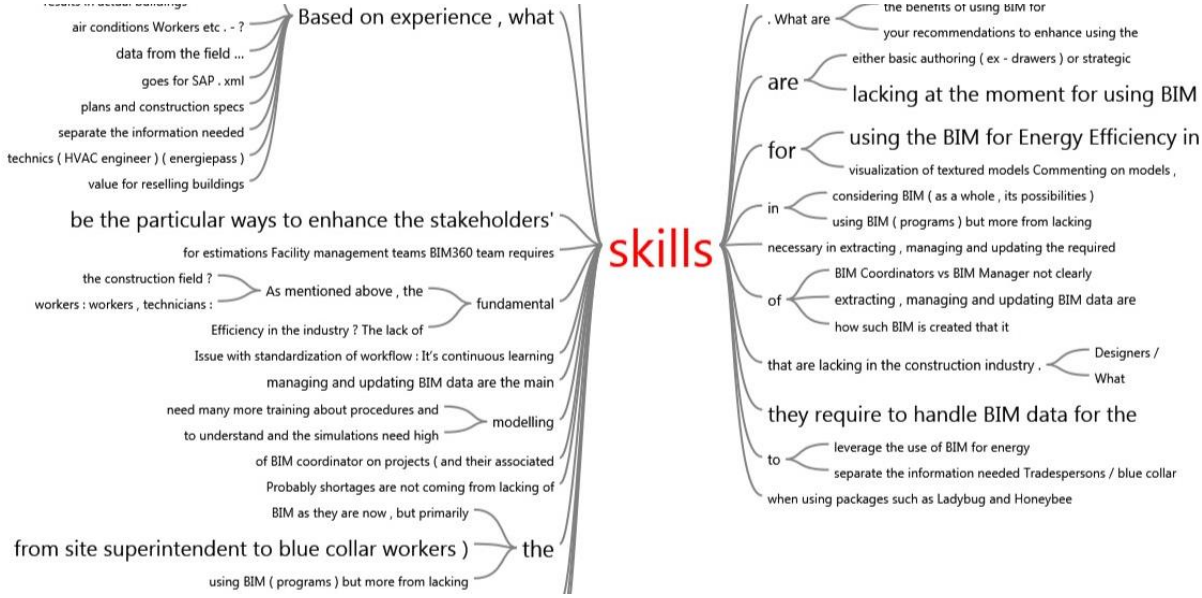


Figure 17: The word three illustration for term ‘’skill’’ associated with interviews.

For the determination of roles we have used term ‘’role’’ as central when compiling the three dependencies analysis. The objective of the analysis is to identify new roles for BIM for energy as reported in the set of interviews that have been imported into NVIVO. Figure 18 presented a sequence of the ‘’role’’ word dependencies with a complete list of roles presented in Table 4.

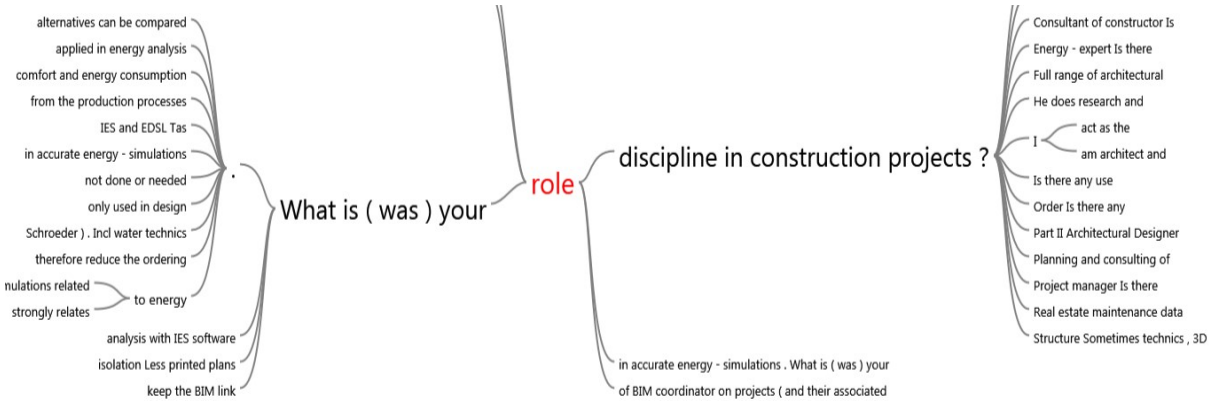


Figure 18: Word Tree of “Role” word in the NVIVO.

Analysis have been also conducted around the concept of ‘’training’’, as a third central concept identified by the analysis. This concept relates to a multitude of other important terms relevant for the analysis. As presented in Figure 19., assessment of the ‘’training’’ concept led to identification of new skills and roles all reported in Table 4.

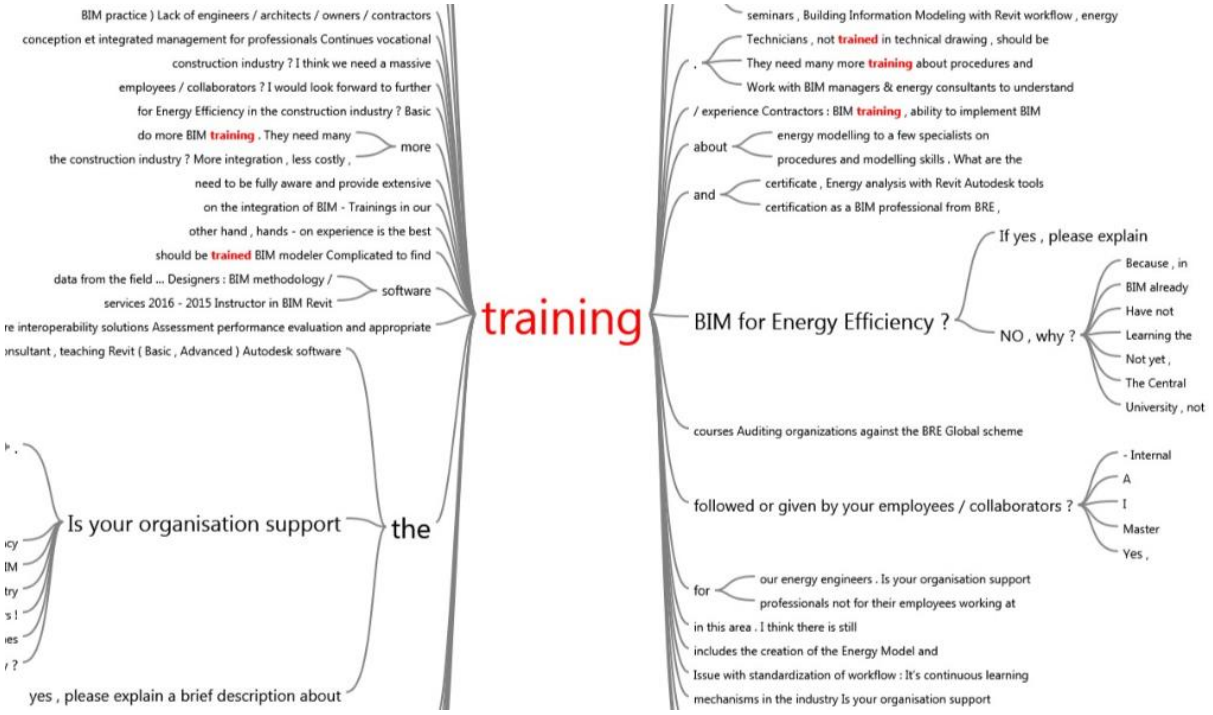


Figure 19: Word Tree of “Training” word in the NVIVO .

The analysis reported in this section have supported to creating a list of roles and skills which have been identified in Table 6.2. Through the diversity of roles and skills the list contains roles such as architect, project manager and BIM coordinator, and skills such as training of BIM and understanding of how graphical information can help to inform appropriate training program all related to addressing the process of BIM for energy efficiency.

Table 4: Consolidated list of skills and roles from interviews

NO.	Roles	Skills
1	Architect	Educating on BIM
2	Project manager	BIM training
3	BIM instructor	Practice Energy Modelling
4	Trainer	Link between different software
5	Consultant of constructor	Understanding of graphical information
6	Energy expert	Enhance the stakeholders' skills of BIM for energy efficiency
7	BIM manager	Site meeting for the comprehension of BIM data and energy features implementation
8	Planner and consultant of energy efficient buildings	Capability to use CAD programs and other EE software
9	Real estate maintenance data management consultant	Knowledge about the principle of EE & sustainable construction
10	Structure engineer	Formulating the model with EE simulation programs
11	BIM coordinator	Good communication between designers, client, supplier
12	Facility manager	Skills to separate the information needed
13	Researcher and teacher in University	Knowledge how to use BIM
14	Contractor manager	BIM training ability to implement BIM construction with energy space
15	Site manager	Collaborate with designer to manage the information from the model
16	HVAC engineer	Strategy management skills
17	Civil engineer	Managing and updating BIM data
18		Data management skills
19		Information managements standards

5.3 Scientific publications analysis

In this section, more than 80 scientific publications have selected and imported to NVIVO in order to identify the roles and skills as required for the study of BIM for energy efficiency. Mendeley has chosen to collect the scientific publications which has facilitated also selection of the most relevant scientific studies prior to integration with NVIVO (see Figure 20).

Authors	Title	Year	Published In	Added
Touloupaki, Eleftheria; Theodosiou, Theodoros	Optimization of External Envelope Insulation Thickness: A Parametric Study	2017	Energies	4:26pm
Wagner, A; Gossauer, E; Moosmann, C; Gropp, Th; Leonhart, R	Thermal comfort and workplace occupant satisfaction{\textemdash}Results of field studies in German low energy office buildings	2007	Energy and Buildings	4:26pm
	DesignGhosts: Mapping occupant behaviour in BIM	2015		4:26pm
Lagüela, S; D\'\jaz-Vilariño, L; Armesto, J; Arias, P	Non-destructive approach for the generation and thermal characterization of an as-built BIM	2014	Construction and Building Materials	4:26pm
Welle, Benjamin; Haymaker, John; Rogers, Zack	ThermalOpt: A methodology for automated BIM-based multidisciplinary thermal simulation for use in optimization environments	2011	Building Simulation	4:26pm
Preiser, Wolfgang F E	Post?occupancy evaluation: how to make buildings work better	1995	Facilities	4:26pm
Wong, Kam-din; Fan, Qing	Building information modelling (BIM) for sustainable building design	2013	Facilities	4:26pm
Miller, Norm	Estimating Office Space per Worker	2012		4:26pm
Che, L; Gao, Z; Chen, D	Using building information modeling for measuring the efficiency of building energy performance	2010	Proceedings of the International Conference on Computing in C...	4:26pm
	Listening to the occupants: a Web-based indoor environmental quality survey	2004		4:26pm
Eddie	Deliverable D3.2 Common Indicators for Continuous Performance Auditing	2017		4:26pm
Li, Kangji; Pan, Lei; Xue, Wenping; Jiang, Hui; Mao, Hanping	Multi-Objective Optimization for Energy Performance Improvement of Residential Buildings: A Comparative Study	2017	Energies	4:26pm
Schwartz, Yair; Raslan, Rokia; Korolija, Ivan; Mumovic, Dejan	Integrated Building Performance Optimisation: Coupling Parametric Thermal Simulation Optimisation and Generative Spatial Design Programming	2017	Building Simulation	4:26pm
Asl, M R; Bergin, M; Menter, A; Yan, W	BIM-based parametric building energy performance multi-objective optimization	2014	eCAADe	4:26pm
Turpin Brooks, S; Viccars, G	The development of robust methods of post occupancy evaluation	2006	Facilities	4:26pm
Howell, Shaun; Rezgui, Yacine; Hippolyte, Jean-Laurent; Jayan, Bejay; Li, Haijiang	Towards the next generation of smart grids_ Semantic and holonic multi-agent management of distributed energy resources	2017	Renewable and Sustainable Energy Reviews	4:26pm
Menezes, Anna Carolina; Cripps, Andrew; Bouchlaghem, Dino; Buswell, Richard	Predicted vs. actual energy performance of non-domestic buildings: Using post-occupancy evaluation data to reduce the performance gap	2012	Applied Energy	4:26pm
Abdelalim, Aly; O\textquoterightBrien, William; Shi, Zixiao	Visualization of energy and water consumption and GHG emissions: A case study of a Canadian University Campus	2015	Energy and Buildings	4:26pm
Cemesova, A; Hopfe, C J; Rezgui, Y	An approach to facilitating data exchange between BIM environments and a low energy design tool	2013	Proceedings of BS2013: 13th ...	4:26pm

Figure 20: The scientific publications in Mendeley

The overall methodology implemented for the analysis of the scientific publications has been presented in Section 3.4.3. The data had imported from Mendeley to the NVIVO where various visualisation and concept retrieval methods have been used to find out the roles and skills that are relevant BIM for energy efficiency. As a first round we apply the word cloud analysis to identify key concepts with associated degree of importance as derived from the portfolio of scientific publications. Such word cloud illustrated the most frequent words but also dependencies between concepts and keywords such as: building, energy, construction and design as reported in Figure 21.

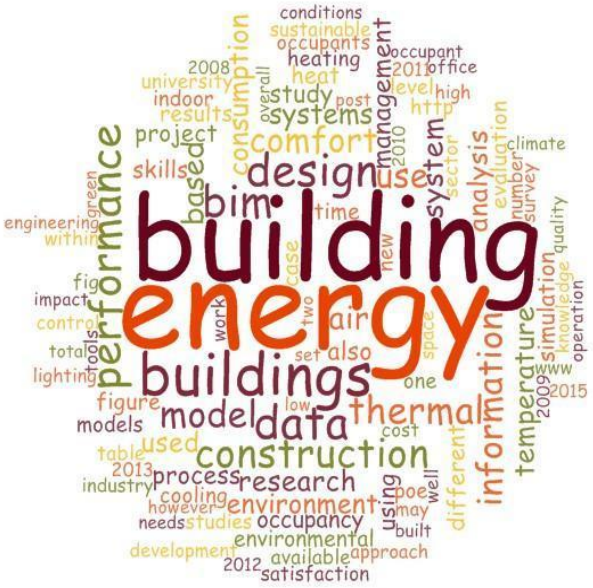


Figure 21: Word Cloud of word frequency for the scientific publications

To identify skills and roles we utilise similar concepts as in previous cases with central concepts such as ‘’role, skills and training’’ as from initial tests these concepts have proven to provide the best results in terms of skills and roles. For illustrating a sequence from the word three that has been generated with the central concept of ‘role’, Figure 22 presents the dependencies retrieved from the analysis.

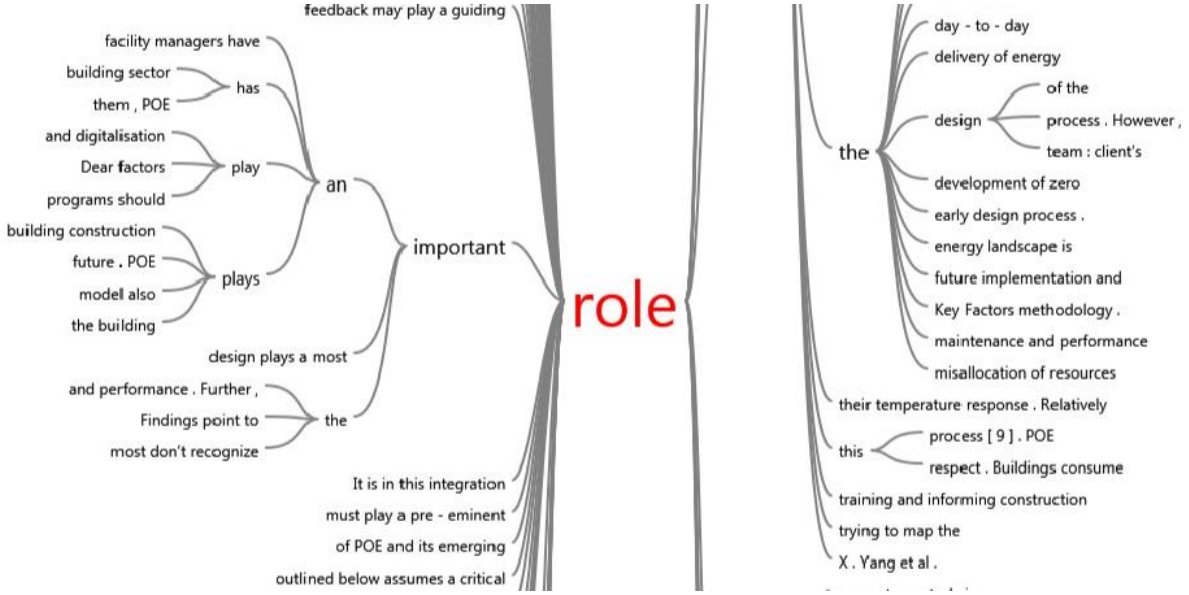


Figure 22: Word Tree of “Role” word in scientific publications section

For determining the list of skills we have applied word three analysis around the central concept of ‘’skills’’. From the interviews, skills seem to have the highest number of results as illustrated in Figure 23 and presented in Table 5. The main differentiation factor from the skills identified from use-cases and interviews is that skill identified based on the scientific publication are more generic and cover a large segment of applications for the use of BIM. However we consider that presentation of all skills and roles is important, especially for the following analysis to be

conducted in work package 3 where associations between skills and roles can be undertaken with a higher order of accuracy.

Figure 23: Word Tree of “Skills” word in scientific publications section

The analysis conducted around the concept of ‘’training’’ have also served to the process of skills and roles identification.

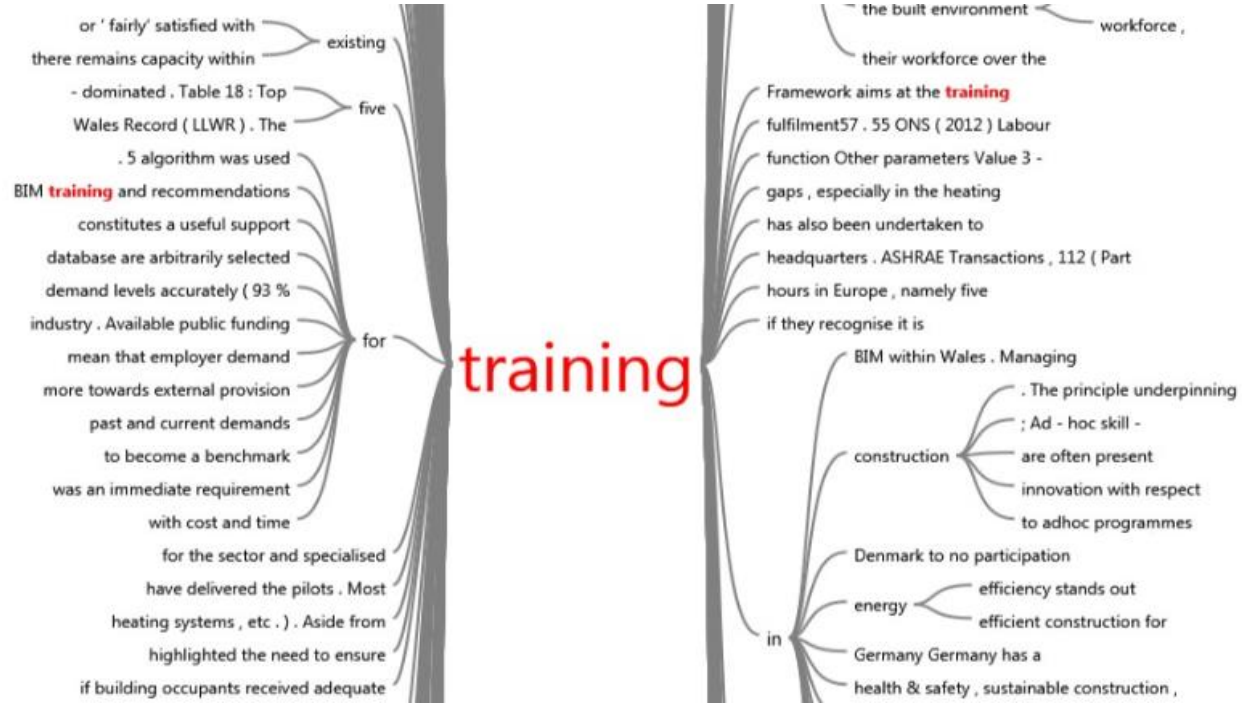


Figure 24: Word Tree of “Training” word in scientific publications section

The ‘’training’’ concept has returned results that facilitated new skills and roles identification, creating novel correlations between terms that exist in the same semantical space. A sequence of the word tree is presented in Figure 24 and results reported in Table 5. Annex C contains the entire three structure for all the identified concepts.

Table 5: Consolidated list of skills and roles from scientific publications

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
15	Quality assurance manager	Practices in facilitating information exchange to meet stakeholders’ business needs in BIM execution
16	Facility administration	Perspective with LCA and LCC applications
17	Sale manager	Increase the awareness of energy consumption
18	Production manager	Increase the awareness of building regulations and how they will continue to evolve over time
19	Purchasing manager	Understanding of the principles of heat loss, heat gain and moisture movement
20	Store manager	Knowledge of different types of low carbon materials – including the design lifecycle
21	Safety manager	Quality assurance specifically in relation to energy efficiency
22	Construction manager	BIM competence certification. Others suggest EU level certifications.

23	Acetic Designers	Transfer of Building Information Modelling Training Tool for Increasing Competence of Building Sector Competence
24	Mechanical engineers	Educational programmes and training
25	Electrical engineers	Teamwork skills
26	Team manager	Understand BIM workflow
27	Built environment experts	Understand BIM standards
28	Operation engineer	Leadership skills
29		Estimation skills
30		Documentation and detailing
31		Strategy and policy
32		Programme management
33		Technical knowledge
34		Planning and administration
35		Model management
36		Collaboration skills
37		Model coordination and collaboration
38		Analytical thinking
39		BIM applications
40		Creativity skills
41		Facilitation skills
42		Organizational management
43		3D coordination
44		Design review
45		Site utilization planning
46		Conflict management
47		Negotiation skills

5.4 Twitter analysis

To increase the list of skills and roles we have extended our analysis to a social media content domain. Parts of these social medial analysis is the search for tags and ids as a first step of the process to identify new skills and roles. Social media analysis addressees the more dynamic part of the skills and roles identification, as BIM for energy and construction is a dynamic process where the majority of new concepts are disseminated and spread on social media. The data that has been fetched from twitter includes the organisation name and their twitter account and associated generated list of tweets. Figure 25 presents the databases repository of tweets imported in NVIVO.
Adopting the workflow presented in Section 3.4.4, NCapture has been used to gather all tweets, mentions and retweets. Almost 50,000 tweets have been captured by using NCapture feature which has represented the base repository for the analysis conducted in this instance.

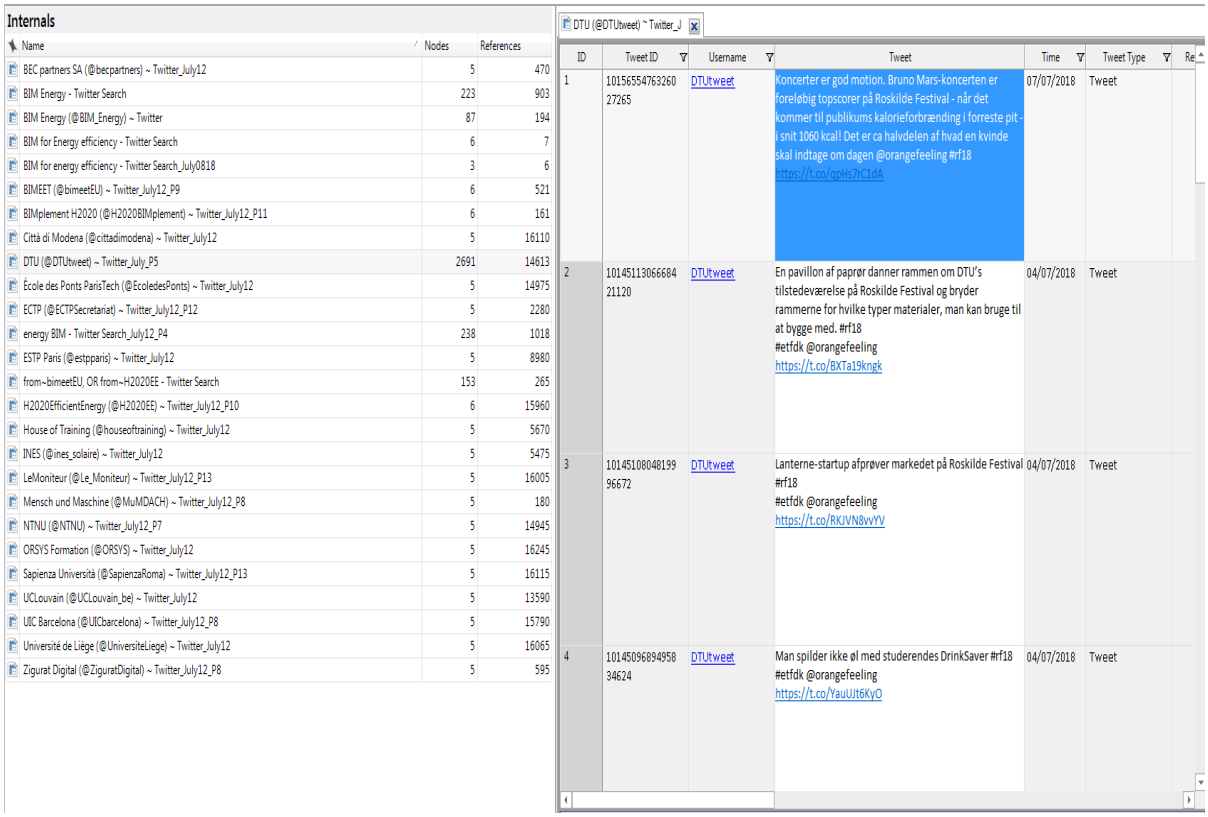


Figure 25: Present the twitter data in NVIVO

The analysis have been conducted around the same key concepts ‘’skills, roles and training’’ with the overall objective of retrieving novel skills and roles relevant for the process of BIM for energy efficiency. In the analysis of social media content, we have observed significant un-relevant concepts which have been eliminated with the mechanism of exclusion facilitated by NVIVO. However, in majority, the social media analysis have led to identification of extremely novel skills and roles proving that BIM for energy in a dynamic process where skills, roles and technologies are changing frequently.

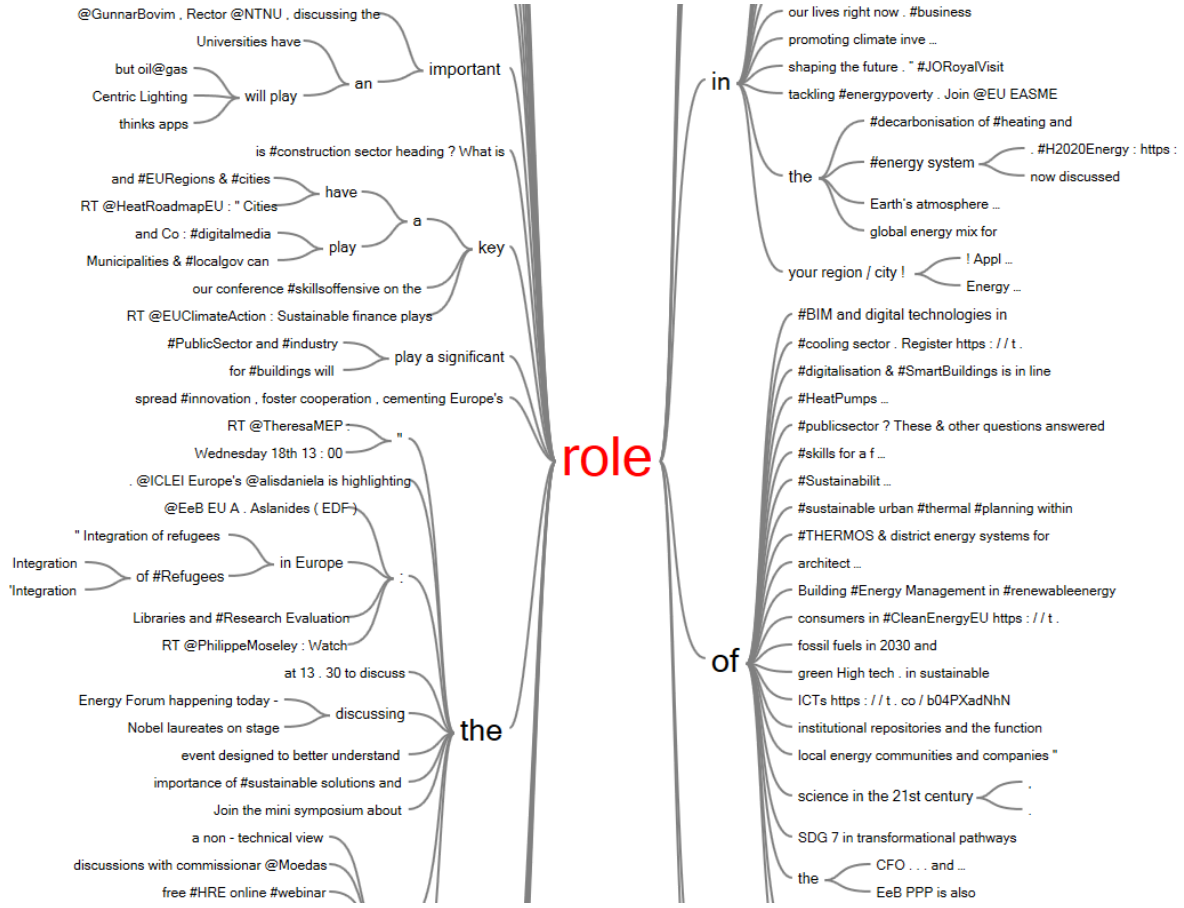


Figure 26: Word Tree of “Role” word in twitter section

The initial word three tested for the key concept ‘roles’ has results into a large three that is presented in Annex D1. A sequence of this three is presented in Figure 26 and the skills and roles retrieved are listed in Table 6.

The identification of skills has reported a similar problem in terms of the ‘’noise’’ existing in the results. After rounds of filtering on the social media content, we have managed to increase the relevance of the results and to determine new skills that have been reported by organisation and users that activate in the field of BIM and energy efficiency.

As it was not trivial to get access to all the media content for BIM and Energy Efficiency in all of the consortium’s countries, it was obvious that this approach topic was not mature enough so, we have conducted extensive and scalable social media analysis on an increases set of social media content seeking to identify more skills and roles. These are reported in Section 4.5., and complete structure of threes in Annex D1.

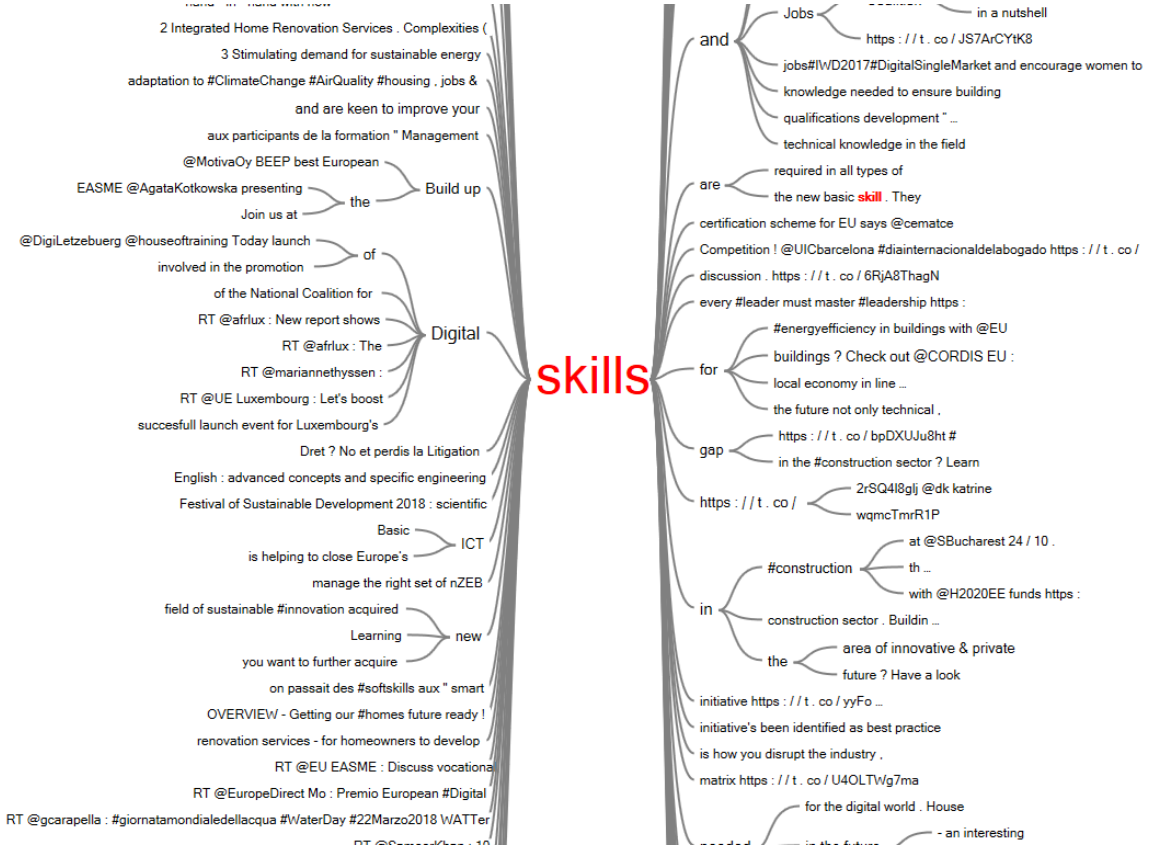


Figure 27: Word Tree of "Skills" word in twitter section

Figure 28: Word Tree of "Training" word in twitter section

The entire set of skills and roles that have been retrieved form the analysis of the central concepts ‘’skills, roles and training’’ applied in 50.000 tweets are reported in Figure 27, 28 and in Table 6. The complete three structure is reported in Annex D1.

Table 6: Consolidated list of skills and roles from twitter data

NO.	Roles	Skills
1	Architect	BIM education program
2	Energy manager	Certification scheme
3	Construction information manager	Good communication
4	BIM manager	Increase the awareness about BIM for energy efficiency
5	Digital technology designer	Training for energy efficiency skill
6	Facility manager	Build up energy efficiency core skill in construction
7	Designer	E-learning training courses
8	Energy expert	Understand the standards in construction supply chain
9	Project manager	Skills and knowledge needed to ensure building and renovation projects meet stringent energy efficiency requirements
10	Construction manager	Scientific skills and technical knowledge in the field of communication with respect to sustainability
11	Energy efficiency expert	Energy efficiency skills certification scheme for EU
12	Human resource manager	Cooperation skills
13	Team manager	Modelling skills
14	Researcher	Digital skills
15	Water manager	Sustainability skills
16	Structure engineers	Construction skills training material
17	Mechanical engineers	Management skills
18	Electrical engineers	ICT skills
19	ICT experts	Scientific skills and technical knowledge
20	Researchers and developers	Leadership skills
21	Supply chain managers	Teamwork skills

5.5 Scalable heuristic social media mining analysis

To increase the data repository, we have extended the social media analysis reported in Section 4.4, by creating an implementation of a social media crawler that has retrieved, also friends and followers activity based on the list of account presented in Section 3.4.6. We have applied similar analysis but on the database of 40 million tweets, that were filtered by the expressions / queries described Annex F. Figures 29,30 and 31 are presenting the information connected to the roles, skills and training in the form of a word tree. The context of these threes was extended to 25 words.

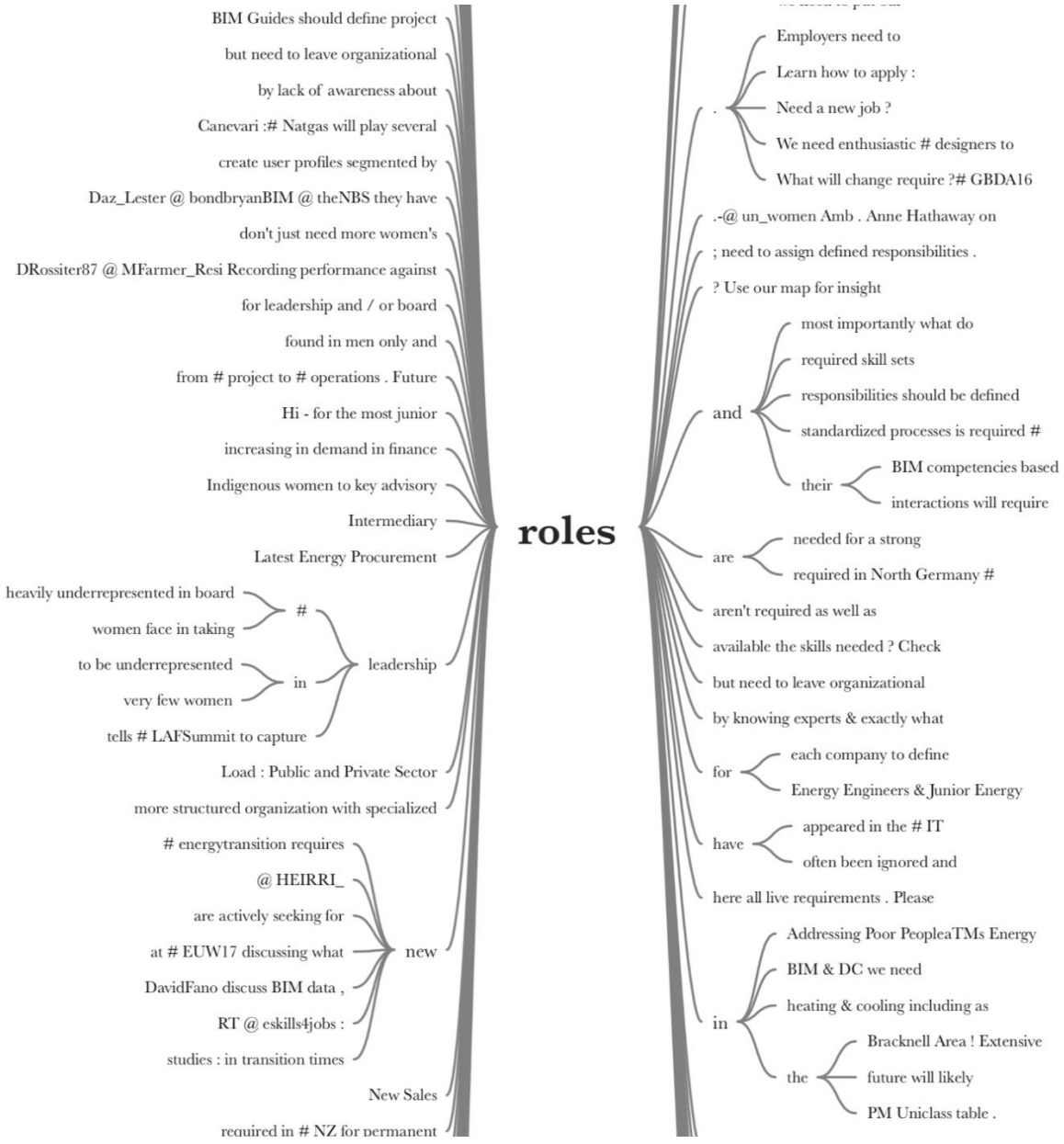


Figure 29: Roles word tree in scalable social media mining

When applying analysis on the central concept of ‘’roles’’, numerous skills and roles have been identified. An improvement to the previous analysis was the exclusion of ‘’neutral terms’’ and

linking words which has led to an improve accuracy in results and increased list of skills and roles. Figure 30, presents a sequence of the three which is presented in-extenso in Annex D.2.

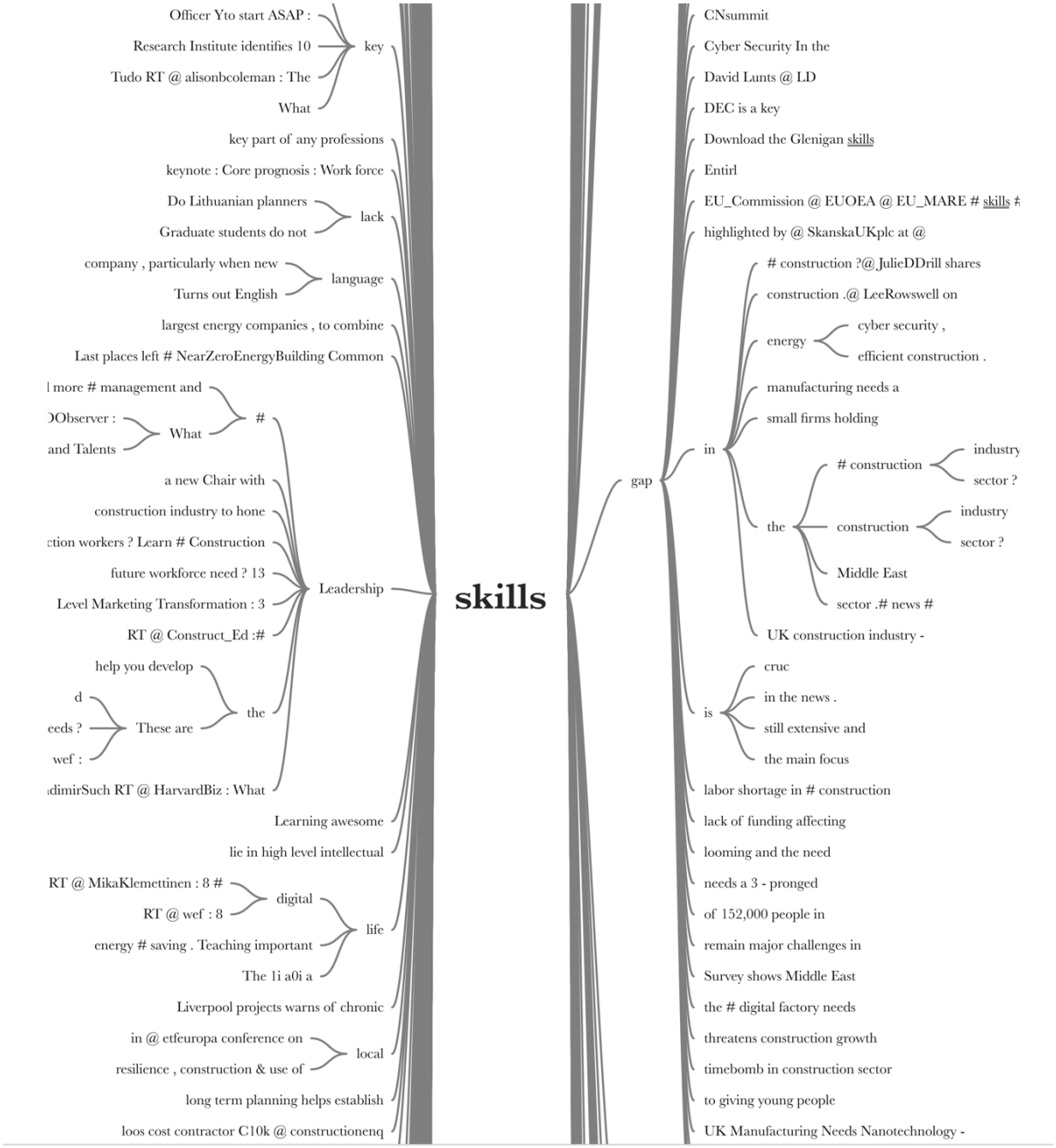


Figure 30: Skills word tree in scalable social media mining

For the determination of skills, analysis have been conducted by utilising the central concept ‘’skills’’, which led to relevant results and increased list of skills. Figure 6.24 presents an instance of the word three, extensively presented in Annex D2 and results in Table 6.5.

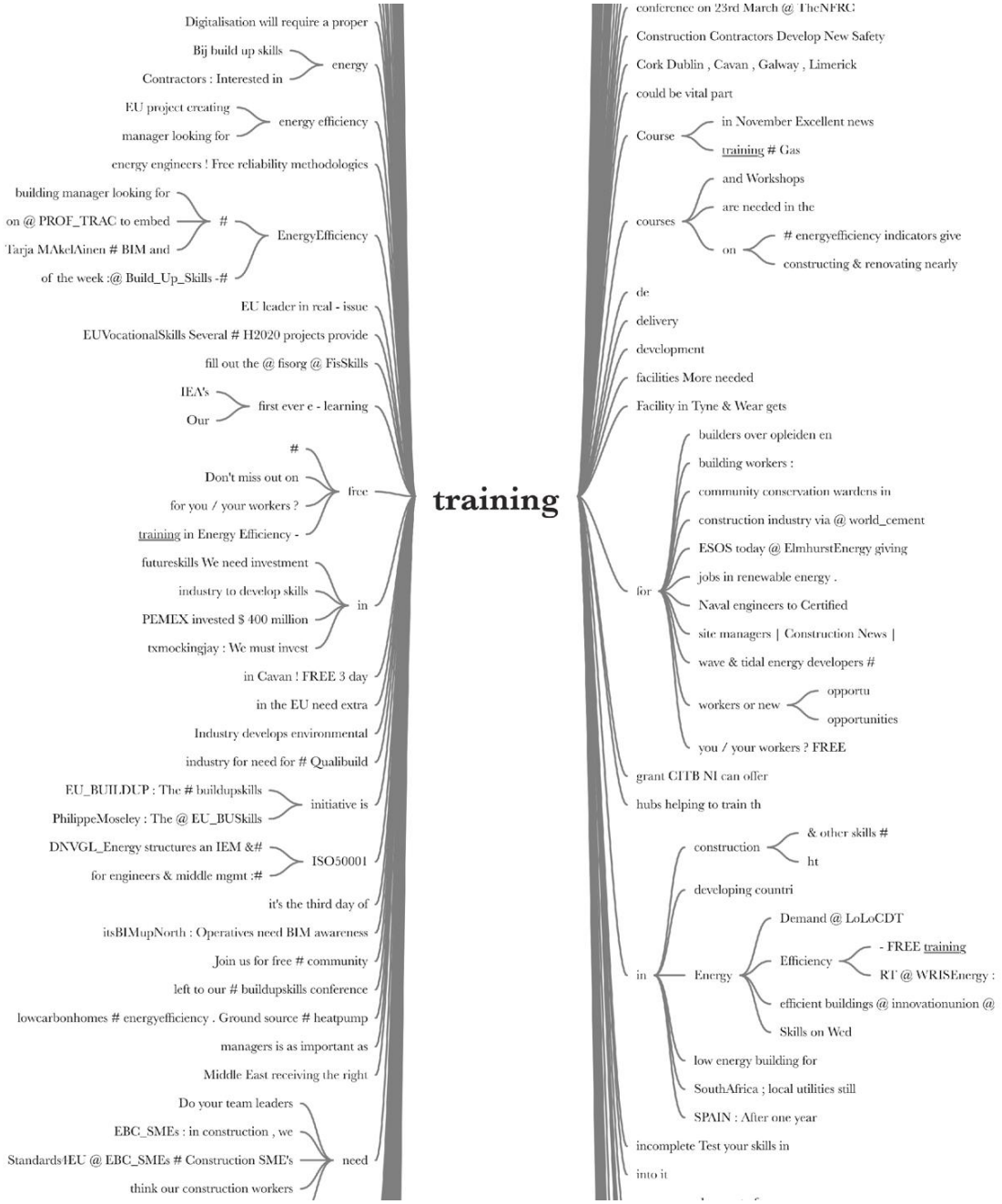


Figure 31: Training word tree in scalable social media mining

For the ''training'' key concepts analysis, a large set of dependencies have been determined which improved the identification of skills are roles but also provided new insights for the main interests and directions that are now active in the field of BIM for energy efficiency. Training three is reported in Figure 31 and Annex D.2. The roles and skills identified from the analysis of the word trees can be found in Table 7.

Table 7: Consolidated list of skills and roles from scalable social media

No.	Roles	Skills
1	Architect	IoT, ICT
2	Energy analyst	AEC organisations need to understand the power of analytics
3	Advisory roles	Negotiation, social, building the bridge between the worlds of education and work
4	Construction managers	Timber frame construction, educational game construction, solar panels
5	Data protection officers	Lifelong learning
6	Designers	Construction, IoT, ICT
7	Digital energy economist	Negotiation, social skills
8	Program manager	4d simulation
9	Energy procurement	Augmented reality
10	Finance	Automation skills
11	HMI operator	Construction skills
12	Human resources for big data professions	Cooperation skills
13	Information coordinator & information facilitator	Coordination skills
14	Information management in construction	Data science skills
15	Nanotechnology	Digitisation in construction
16	Supervisors	Digital & urban skills
17	Technicians	Entrepreneurial skills
18	Senior organisational roles	Energy harvesting
19	Aerospace engineer	Energy law
20	Architecture & construction project manager	Energy performance
21	Building professional	Energy storage committee
22	Chemical engineer	Energy transition
23	Communication officer	E-learning skills
24	Data protection officer	Energy policy decision making
25	Designer	Engineering skills
26	Energy engineer	ICT skills
27	Environmental scientist	Labour work skills
28	Government affairs manager	Leadership skills
29	Information facilitator	Low - zero energy buildings
30	Market acquisition manager	Management skills
31	Nuclear energy expert	Energy management skills
32	Private science panelist	Marketing skills
33	Researcher	Math skills
34	Solar energy specialist	Pooling skills
35	Technical manager	Python programming skills
36	Alternative energy	Revit programming skills
37	Automotive engineer	Renovation skills
38	Business unit director	SEO skills
39	Circular economy specialist	Socioeconomics development
40	Construction health & safety	Speaking skills
41	Data scientist	Structural analysis skills

42	Electrical engineering	Technological skills
43	Engineering, procurement and construction (EPC) service provider	Training skills
44	Expert in timber engineering	Structural engineering software operation skills
45	Human resources for big data professions	Virtual reality operation skills
46	Innovation manager	4d simulation
47	Mechanical engineer	Augmented reality
48	Passive house designer	Automation skills
49	Professor	Construction skills
50	Robotics specialist	Cooperation skills
51	Sustainability specialist, advocacy & policy design	Coordination skills
52	Timber frame and joinery	Data science skills
53	Architectural engineer	Digitisation in construction
54	BIM teaching assistant	Digital & urban skills
55	Carpenter	Entrepreneurial skills
56	Civil engineer	Energy harvesting
57	Cyber security specialist	Energy law
58	Digital marketing	
59	Energy consultant	
60	Environmental engineer	
61	GEF small grants program coordinator	
62	Information coordinator	
63	Inventor	
64	Nanotechnology engineer	
65	PMP - energy oriented business developer	

6 Overall list of skills and roles

Table 8 and Table 9 shows overall lists of skills and roles, which combines and compares the results of the consolidated list that have been extracted by applying the different research methodologies.

Table 8: Overall list of skills

Skills	Use-cases	Interviews	Scientific publication	Twitter	Scalable heuristic social media mining
Optimal decision making	✓				
Collaborative design open ICT platform	✓			□	
Operation energy running costs	✓				
Operational energy demand	✓				
Interaction between the project managers	✓				
Data management	✓	✓		✓	✓
Adapted to changing environment conditions	✓				
Performance measuring, monitoring and optimisation	✓				
Integrated information management framework	✓	✓			
Establish energy modelling	✓				
Achieve energy “LEED” certification	✓			✓	
ICT skills	✓			✓	✓
Teamwork skills	✓		✓	✓	✓
Understand BIM standards	✓		✓		
Understand energy efficiency principle	✓			✓	
BIM tools updates skills	✓		✓		
Searching and BIM development skills	✓				
BIM Educating		✓	✓	✓	
BIM training		✓	✓		
Practice Energy Modelling		✓			
Link between different software		✓			
Understanding of graphical information		✓			
Enhance the stakeholders’ skills of BIM for energy efficiency		✓	✓		✓

Site meeting for the comprehension of BIM data and energy features implementation		✓			
Capability to use CAD programs and other EE software		✓		✓	
Knowledge about the principle of EE & sustainable construction		✓			
Formulating the model with EE simulation programs		✓	✓		
Good communication between designers, client, supplier		✓		✓	
Skills to separate the information needed		✓			
Knowledge how to use BIM		✓			
Collaborate with designer to manage the information from the model		✓			
Strategy management skills		✓			
Managing and updating BIM data		✓			
Assess respondents' perception of BIM competence and requisite skills			✓		
Applying theoretical knowledge and eventually facilitating the entry into the labour market			✓		
Developing contractual specifying owner's BIM requirements			✓		
An imbalance between the demand and supply of skilled labour in construction sector			✓		
Focus on soft skills like collaboration and communication, negotiation, teamwork, leadership and conflict management.			✓		
Knowledge of building commissioning and building commissioning strategies			✓		
BIM model review – Automatic model check			✓		
Drawing skill with BIM tools			✓		
Practices in facilitating information exchange to meet stakeholders' business needs in BIM execution			✓		
Perspective with LCA and LCC applications			✓		

Increase the awareness of energy consumption			✓	✓	
Increase the awareness of building regulations and how they will continue to evolve over time			✓	✓	
Understanding of the principles of heat loss, heat gain and moisture movement			✓		
Knowledge of different types of low carbon materials – including the design lifecycle			✓		
Quality assurance specifically in relation to energy efficiency			✓		
BIM competence certification. Others suggest EU level certifications.			✓	✓	
Transfer of Building Information Modelling Training Tool for Increasing Competence of Building Sector Competence			✓		
Understand BIM workflow			✓		
Leadership skills			✓	✓	✓
Estimation skills			✓		
Documentation and detailing			✓		
Strategy and policy			✓		
Programme management			✓	✓	
Technical knowledge			✓		
Planning and administration			✓		
Model management			✓		
Collaboration skills			✓		
Model coordination and collaboration			✓		
Analytical thinking			✓		
BIM applications			✓		
Creativity skills			✓		
Facilitation skills			✓		
Organizational management			✓		
3D coordination			✓		
Design review			✓		
Site utilization planning			✓		
Conflict management			✓		✓
Negotiation skills			✓		✓
Build up energy efficiency core skill in construction				✓	
E-learning training courses				✓	✓

Understand the standards in construction supply chain				✓	
Skills and knowledge needed to ensure building and renovation projects meet stringent energy efficiency requirements				✓	
Scientific skills and technical knowledge in the field of communication with respect to sustainability				✓	
Energy efficiency skills certification scheme for EU				✓	
Cooperation skills				✓	✓
Modelling skills				✓	
Digital skills				✓	
Sustainability skills				✓	
Construction skills training material				✓	
AEC organisations need to understand the power of Analytics					✓
Timber frame construction, Educational game construction, Solar panels					✓
Lifelong learning					✓
4D simulation					✓
augmented reality					✓
automation skills					✓
data science skills					✓
digital & urban skills					✓
entrepreneurial skills					✓
energy harvesting					✓
energy law					✓
energy performance					✓
energy storage committee					✓
energy transition					✓
energy policy decision making					✓
low - zero energy buildings					✓
marketing skills					✓
math skills					✓
pooling skills					✓
Python programming skills					✓
Revit programming skills					✓
renovation skills					✓
socioeconomics development					✓
speaking skills					✓

structural analysis skills					✓
virtual reality operation skills					✓

Table 9: Overall list of roles

Roles	Use-cases	Interviews	Scientific publication	Twitter	Scalable heuristic social media mining
Architect designer	✓	✓	✓	✓	✓
Construction engineer	✓				
Facility manager	✓	✓	✓	✓	
Mechanical engineer	✓		✓	✓	✓
Structure engineer	✓	✓			
HVAC engineer	✓	✓	✓		
Worker in ceramic sector	✓				
BIM modeller	✓		✓		
Steel Contractor	✓				
Electrical engineer	✓		✓		
Builder	✓				
Supply manger	✓				
Energy modeller	✓				
Energy simulation experts	✓				
Operation engineers	✓		✓		
Electrical engineers	✓			✓	✓
Project manager		✓		✓	✓
BIM instructor		✓			
Training and informing consultation professionals about BIM		✓	✓		✓
Consultant of construction		✓			
Energy expert		✓		✓	✓
BIM manager		✓	✓	✓	
Planner and consultant of energy efficient buildings		✓			
Real estate maintenance data management consultant		✓			
BIM coordinator		✓			
Researcher and teacher in University		✓		✓	✓
Contract manager		✓	✓		
Site manager		✓			
Civil engineer		✓		✓	✓
Facilitator of sustainable			✓		

Energy manager			✓	✓	
BIM consult			✓		
Regulators			✓		
Technical manager			✓		✓
Finance manager			✓		✓
Maintenance manager			✓		
Quality assurance manager			✓		
Facility administration			✓		
Sale manager			✓		✓
Production manager			✓		
Purchasing manager			✓		
Store manager			✓		
Safety manager			✓		
Construction manager			✓	✓	✓
Team manager			✓	✓	
Built environment experts			✓		
Construction information manager				✓	✓
Digital technology designer				✓	
Energy efficiency expert				✓	
Human resource manager				✓	✓
Water manager				✓	
ICT experts				✓	
Supply chain managers				✓	
Advisory roles					✓
Data Protection Officers					✓
Digital energy economist					✓
Extensive Sales experience					✓
Energy procurement					✓
HMI Operator					✓
Information coordinator & information facilitator					✓
Nanotechnology					✓
Supervisors					✓
Technicians					✓
Senior organisational roles					✓
aerospace engineer					✓
building professional					✓
chemical engineer					✓
communication officer					✓
data protection officer					✓
energy engineer					✓
environmental scientist					✓

government affairs manager					✓
information facilitator					✓
market acquisition manager					✓
nuclear energy expert					✓
private science panelist					✓
solar energy specialist					✓
alternative energy					✓
automotive engineer					✓
business unit director					✓
circular economy specialist					✓
construction health & safety					✓
data scientist					✓
engineering, procurement and construction (EPC) service provider					✓
expert in timber engineering					✓
innovation manager					✓
passive house designer					✓
robotics specialist					✓
sustainability specialist, advocacy & policy design					✓
timber frame and joinery					✓
carpenter					✓
cyber security specialist					✓
digital marketing					✓
environmental engineer					✓
GEF small grants program coordinator					✓
information coordinator					✓
inventor					✓
Nanotechnology engineer					✓
PMP - Energy Oriented Business Developer					✓
program manager					✓

7 Conclusion

This report conducts intensive analysis for identification of skills and roles for the process of BIM for energy efficiency. From the evaluation of process we have implemented four analysis scenarios identifying use-cases analysis, interviews analysis, scientific publication analysis and twitter analysis.

The findings show that the evaluation that has been employed for skills and roles identification has helped to understand better the training requirements and gaps for the BIM training process and has the ability also to support the implementation process which has an impact on energy practices and BIM implementation program in Europe. The evaluation of the stage referred to as ``social media analysis'' showed that the resulted list of roles and skills is novel and can bring new insights into the process of BIM training and education. The new technological capabilities proposed by social media gave a unique opportunity to re-engineer and improve the existing methodology and to extend on the existing state of knowledge for BIM in energy efficiency. In addition to the acknowledged role of social media, the analysis have suggested that some organisational characteristics had to change in order to facilitate change and support the implementation of the new BIM processes leading to the conclusion the BIM is a dynamic process that cannot be captured with traditional analysis methods. The analysis have also shown that this stage was crucial due to the number of supporting concepts which play a major role in the BIM process characterisation and a holistic methodology is required for the assessment of BIM with associated competencies and training programmes.

Finally, the analysis also demonstrated that an organisation in the field of BIM for energy and construction needs to pay attention on organisational and human skills involved in BIM process and adapt a ``continuous improvement'' approach to change. From the related work, it was determined that the role of these BIM roles and skills concepts is very often neglected in the existing BIM studies. For example, all the studies reported the urgent need of training in order to use efficiently the existing BIM skills and competencies and utilise the full potential of the new system in order to increase productivity and improve quality. Also, the analysis of the research results showed that there is a potential danger of resistance to change which might constrain the overall change process. As a result, the analysis we have conducted has shown a need to involve the end-users more closely in the decision-making process as well as in the implementation process.
Our approach has started from the consultations process that identified, analysed, and assessed construction sector stakeholders' requirements for BIM training to ensure engagement with energy management in construction. From this consultations and use-cases we have applied NVIVO qualitative and quantitative analysis to determine skills and roles of BIM for energy efficiency. The aims of this report is to determine skills and roles which will inform the training process which can greatly educate a community of users in the field of BIM and promote energy efficient practices among companies and users.

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ANNEX A – Use case analysis
ANNEX B – Interviews analysis
ANNEX C – Scientific publication analysis
ANNEX D1 – Social media analysis
ANNEX D2 – Scalable heuristic social media analysis
ANNEX E – Forensics based evaluation of energy-bim.com visitors and statistics
ANNEX F – Query implementation and expression search