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D.3.2 Maturity based model of digitization skills in sync with sustainable energy skills

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Publishable executive summary

This report includes a structured overview on how to develop a “Maturity based model of digitization skills in sync with sustainable energy skills”.

An introduction to the importance of upskilling in digitalisation in relation to energy efficiency is at the base of Chapter 1.

Chapter 2 describes the methodology and process used to build the model. Task based qualifications in relation to mapping of current and future skills are the backbone of the model.

The body of the model is laid out in Chapter 3. All elements from specialisms, (sub)tasks, ULOs, energy skills and maturity are described in relation to their position in the model.

The way the model relates to other work packages and deliverables in ARISE is described in Chapter 4.

Conclusions and References can be found in the Chapters 5 and 6 respectively.

List of acronyms and abbreviations

BIM	Building Information Modelling
EE	Energy Efficiency
EPBD	Energy Performance of Buildings Directive
NZEB	Nearly Zero-Energy Buildings
RES	Renewable Energy Source
BSI	Building Smart International
ISCO-08	International Standard Classification of Occupations (classification structure of professional profiles)
NQF	National Qualification Framework
VET	Vocational Education and Training
HEI	High Education Institutions
SME	Small and Medium Enterprises
OCN	Open College Network
CPD	Continuous Professional Development
EQF	European Qualification Framework
CEDEFOP	European Centre for the Development of Vocational Training
CEN	European Committee for Standardization
KSC	Knowledge, Skills, Competence
BEM	Building Energy Model
PA	Public Administration
FM	Facility Manager / Facility Management
OM	Operation and Maintenance
AEC	Architecture, Engineering and Construction
LO	Learning Outcomes
LU	Learning Units
ULO	Units of Learning Outcomes
RIBA	Royal Institute of British Architects
BoK	Body of Knowledge

EIR	Exchange Information Requirements
BEP	BIM Execution Plan
CDE	Common Data Environment

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1. Introduction

We live in times of digital transformation, where our lives are transformed by technology. The processes and tools we are used to working with, are disappearing and replaced by newer solutions. It can be challenging to face this transformation, as it is for the construction sector to adapt to new processes and patterns. But the construction sector cannot afford to lag behind.

Building Information Modelling (BIM) technology has the leading role in the digital transition of the construction sector. However, the definition of processes and agreements around basic terms and concepts is still ambiguous and lacks consistency (Building Smart Professional Certification Program, 2022).

Another challenge for the sector is to reach CO2, energy efficiency, and material efficacy targets raised by governments (McCormack, 2021). The energy transition is thus another challenge for the construction sector to face. However, digital technology and sustainability targets for the construction sector are strongly correlated, and this is where the importance of digitalisation skills comes in.

Energy efficiency can be enhanced by digital technology, which in turn also enhances the digital transition itself (McCormack, 2021). In fact, climate neutrality and sustainable energy targets will be very difficult to achieve without the digital operation of processes and the exchange of information and data among stakeholders involved in a building's life cycle.

It is crucial to adapt to digitalisation and apply digital technologies in the context of energy skills: Digital skills in the construction industry should be developed by its workforce, and deployed for energy efficiency (McCormack). This skill development should not only take place by existing employees, but also "to accommodate new jobs emerging from the gaps and needs in the industry" (E. O'brien, 2021).

The need to improve upskilling and educational trajectories is evident, and further work is needed to encourage upskilling. A benchmarking mechanism is needed, against which the competence of individual professionals can be measured (Building Smart Professional Certification Program, 2022). There should be a focus on skills recognition, rather than accreditation.

This report focuses on a maturity based model of digitization skills in sync with sustainable energy skills. The model was developed as a part of the ARISE project, and serves as a basis for the later development of the task-based qualification framework for renewable energy skills with digitalization as an accelerator.

The model is made to include four AEC professions (designers, contractors, clients, and public administration), to address the building life cycle (design, construction, operation), and is designed to be fit for maturity analysis. The model is developed to focus on BIM, in order to maximise the effect of sustainable energy skills.

The maturity analysis is integrated in the model so that organisations can gain a clear vision on how to proceed in the next steps of digitalisation. The model

connects maturity levels to skills and learning outcomes, so that organisational leaders will know what their employees will have to learn in order to make the organisation grow towards the next level of BIM and digitalisation.

The model is developed with a task-based qualification method for developing so-called Units of Learning Outcomes (ULOs), applied in H2020 projects BIMplement, NEWCOM, BUSLeague and BUS-Go Circular. It will be presented by first giving stage to how the model was developed, by explaining the methodology and what process was adopted. Then, the model itself will be described by focusing on the different elements. Deliverable 3.3 of the ARISE project will later focus on the establishment of the ARISE qualification framework with help of the maturity based model.

The main objective of this report is to provide a base qualification framework for establishing a BIM resource and skills recognition pathway that all stakeholders can utilise, deliver and stimulate.

Further objectives of this report are to...

- ...contribute to continuous professional development (CPD) recognitions for digitization skill in the construction sector.
- ...facilitate future development of an e-learning materials repository.
- ...contribute to industry-driven and accessible instruments for upskilling both blue and white collar professionals, increasing vocational mobility.
- ...facilitate future development of skills passports and registers.
- ...aim for widely recognised and standardised digital skills.

2. Development of the model

The development of the maturity based model of digitization skills is presented by first focusing on the methodology that was used to establish the model. Then, the process of development is described.

2.1. Methodology

To compile the model presented in this report, a methodology for compiling task-based qualifications has been used. This methodology was first established in the EU-funded H2020 NEWCOM project. In NEWCOM the first task-based qualification schemes for construction sector employees on cross craft skill have been developed. In this project, a basis for the recognition of those qualification schemes has also been generated.

2.1.1. Task-based qualifications

The purpose of the methodology is, on the one hand, to decide what specific tasks and subtasks a professional should tend to (hence 'task-based') in a certain area of expertise. On the other hand, each subtask is linked to a unique Unit of Learning Outcome (ULO). ULO's consist of a competence, and of skill and knowledge elements. Altogether, information needs to be added about which professionals are needed for each subtask. In connecting subtasks to corresponding professions, one can decide which learning goals should be possessed by members of a profession, and thus what learning outcomes need to be acquired. If a certain competence is applied to multiple (sub)tasks, the ULO has to be written only once (BUS-GoCircular Circular Construction Skills Qualification Framework, 2022). Figure 1 visualises how the different elements mentioned here relate to each other.

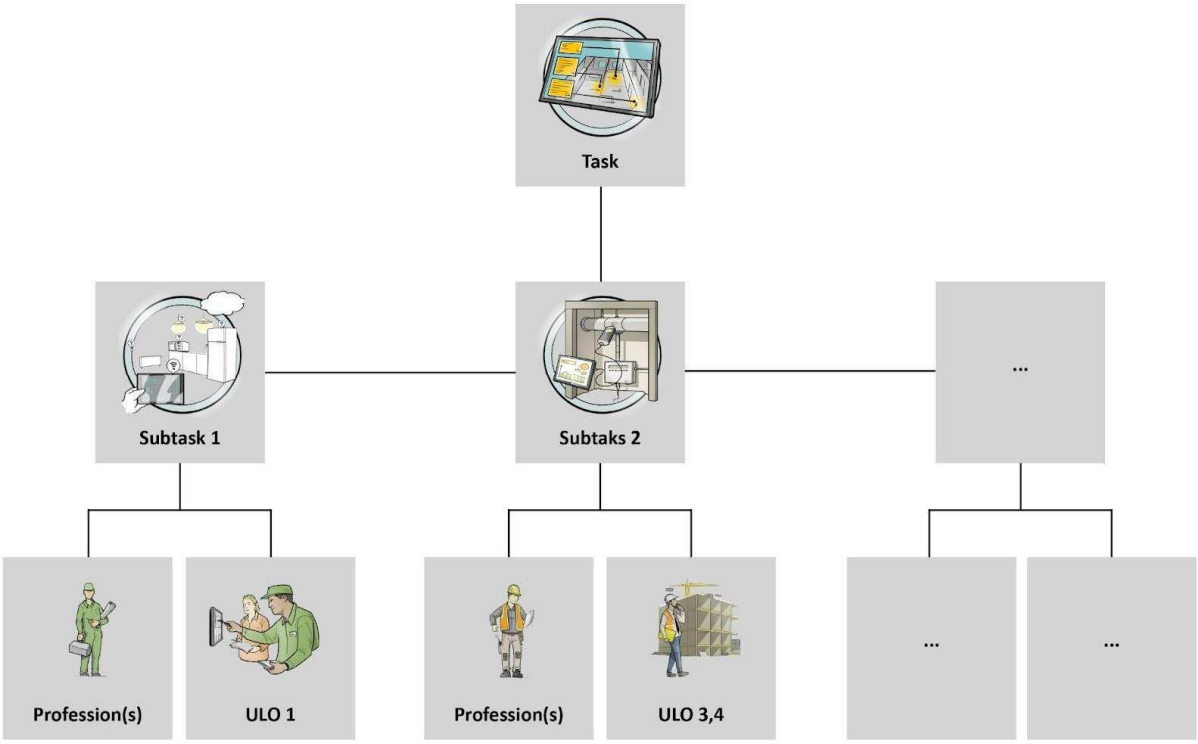


Figure 1. The relationship between tasks, subtasks, and ULOs

The outcomes of a set of task-based qualifications enables decisions about what an exact profile professionals should possess. It can help with standardising certification, developing new training materials, and connecting to micro-learning and micro-credentials. It allows one to unfold the pathway that is needed to reach professionals with the right competences (See Figure 2).

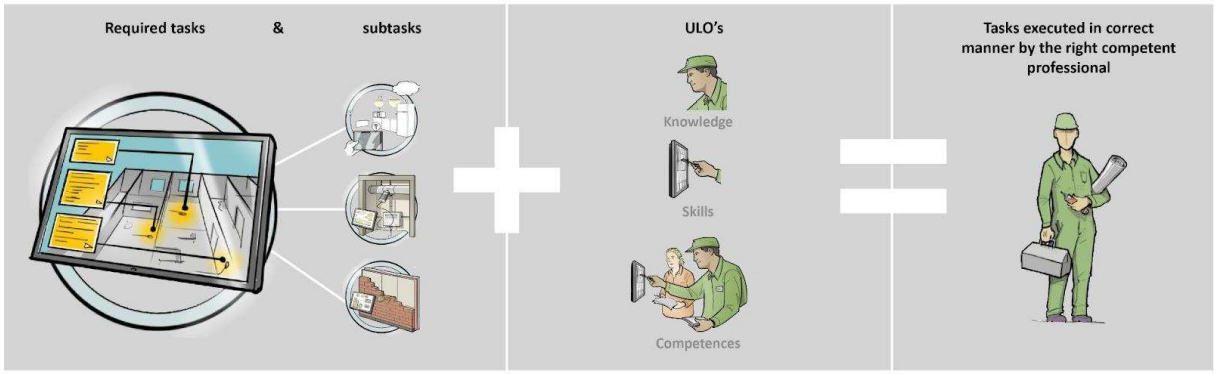


Figure 2. Tasks, subtasks, and ULOs lead the way

towards correctly executed tasks by the right professional.

In Chapter 3 of this report, the elements of the methodology mentioned above will be further elaborated upon. In the ARISE project, the methodology for compiling task-based qualifications is used to establish the maturity based model of digitization skills. This model will later be used to develop the ARISEs actual task-based qualification framework to enhance recognition of digital skills.

The methodology has been fine-tuned and validated throughout the course of several large-scale European-wide projects. Examples are PROF/TRAC and BUStoB, in which predecessors of the methodology were established. Here, qualifications were not yet task-based. NEWCOM took the qualification methodology and made major improvements to it, one of which was adding the task-based element. From then on, task-based qualifications have been implemented in projects BIMplement, TripleA-reno, BUSLeague, BUS-GoCircular and more. Stakeholder focus groups held within those projects ensured further validation of the methodology. The methodology is compliant with CEDEFOP recommendations for the construction of qualifications (Delivering VET and qualifications, sd).

2.1.2. Skills mapping

An additional element of the model is a so-called skills mapping. The goal of this method is to decide for which occupations and to what extent the dissemination of certain specialisms and corresponding skills and knowledge is needed. The outcome of the method can be joined with clear visualisations from which desired skill levels can be interpreted for each profession and specialism (See Figure 3).

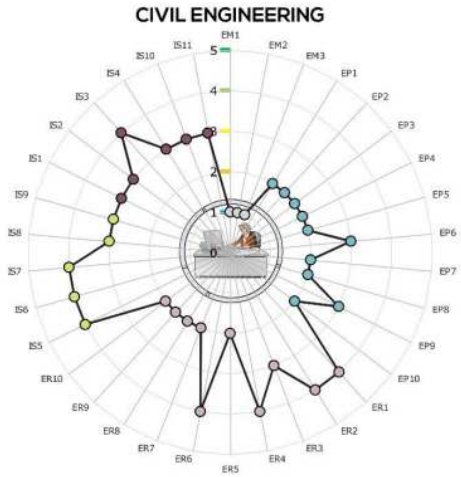


Figure 3. Visualisation of required skill levels for the civil engineer (PROF/TRAC project)

2.2. Process

The development of the maturity based model was a collaboration between partners from different EU-countries who joined the ARISE project. The team consisted of educational specialists on the one hand, and BIM and digitalisation experts on the other.

First, it was ensured that each partner was informed about the methodology discussed in the previous paragraph. Then, a plan with activities to be performed as part of the project task, was written. This plan, named 'Explanation', was accompanied with figures, tables, and visualisations, to further facilitate comprehension about the methodology for each and every one of the partners

involved. The result was a model which is to be used for implementation, meaning the plan will be executed fully; in which the empty framework will be filled with relevant content. In order to facilitate this implementation, some considerations were taken by the team.

2.2.1. Considerations prior to implementation

Firstly, an important consideration was about what professions to include in the model. In the task description of the project, AEC professions are mentioned: designers, contractors, clients, public administration. However, the four categories of AEC professions each consist of many more job roles. For the skills mapping, it was necessary to specify the job roles included, because differences and nuances in required skills levels are likely to occur between several professions in a profession category. Thus, a decision was to be made about what specific professions to include for each category. This resulted in the following list of professions for the skills mapping:

- Designers: Architect
- Contractors: Project Manager, Foreperson
- Clients: Building Owner/Operator
- Public Administration: Building Inspector

This means the maturity based model is largely consistent with the information from previous ARISE Deliverable 3.1, which focused on desk research on maturity analysis of digitalization and sustainable energy skills. This report included clients, construction site workers, facility managers, and designers in their comparative analysis of studied models of digitalisation skills. It also becomes clear that construction site workers are missing in the developed model. However, the model is highly suitable for flexible use, and new professions can be added to the skills mapping and subtask elements in a later stage - if deemed relevant.

Secondly, the consortium partners were to decide how to include sustainable energy skills in the model. There were/are a few questions on how to handle the relationship between digitisation and energy efficiency. This is a crucial decision for the project, which is why this report included a dedicated paragraph to explain the decision process (See Paragraph 3.2.3).

Lastly, a decision had to be made about how to include BIM maturity levels. This is a new element in addition to the existing parts of the methodology for compiling task-based qualifications. It is also an element that has not yet been standardised in previous BIM qualifications for individual professionals, so a new system had to be established. This is also elaborated upon in a separate paragraph (See Paragraph 3.3)

3. Maturity based model of digitization skills

The development of the maturity based model is a structured method, based on taking small interdependent steps (Table 1). The three different parts, specified with colours, are explained below in three different paragraphs: Skills mapping, Qualification framework model, and Maturity levels.

1. Define main specialisms
2. Define relevant professions
3. Map specialisms and professions using current and future skill levels
4. Enrich specialisms with tasks and subtasks
5. Define ULO's (link T3.1, WP2)
6. Map ULO's with enriched specialisms
7. Define and integrate sustainable energy skills
8. Define maturity levels
9. Add maturity levels to skills mapping
10. Appoint skills levels to professions for each maturity level

Table 1. Maturity based model of digitization skills

3.1. Skills mapping

Technological developments are accelerating, and the job market needs to keep up with many changes as a consequence. This urgency is evident when it comes to upskilling with regards to digital skills and sustainable energy skills.

A method to support upskilling methods is to conduct a skills mapping. A skills mapping shows where knowledge and skills gaps are in the field, and contribute to preventing those gaps in the future.

The methodology can be applied when insight into necessary topics for training programs is needed. It is also applicable when technological innovations need people with the skills to achieve dissemination of the innovation. Furthermore, professionals can use the outcomes of a skills mapping to determine their focus for upskilling projects.

First, it is to be decided which technologies are relevant and/or urgent in the field and need inclusion in upskilling interventions. Technologies can also be referred to as specialisms, which will be done in the current report. The result of this decision is a list of specialisms (see paragraph 3.1.1.).

Second, the question is asked for which occupations the development of certain specialisms and corresponding competences is needed. What professional occupations or work field are likely to be involved in working with the specialisms that have been listed? The result of this will be a list of professions (see paragraph 3.1.2.). When working in an international setting, it can be challenging to find the

right scope or level to pinpoint the occupations. To account for differences between job descriptions and professions across countries, it may be wise to categorise broad work fields during this step of the skills mapping. One could also include synonyms for professions in different countries.

Third, required skills levels are to be determined. Here, the specialisms and professions are being mapped together. In consultation with experts, it should be decided for each specialism to what extent each professional should be able to master the specialism. Both knowledge and skills are relevant here.

The outcome of the skills mapping is joined with clear visualisations from which desired skill levels can be interpreted for each profession and specialism. See Paragraph 2.1.2, Figure 3) for an example.

3.1.1. ARISE specialisms

The definition of ARISE specialisms is based on 4 main categories where most digitisation skills will take root:

- BIM Basics (BB)
- BIM Application (BA)
- BIM Utilisation (BU)
- BIM Support (BS)

These categories are interdependent as is shown in Figure 4.

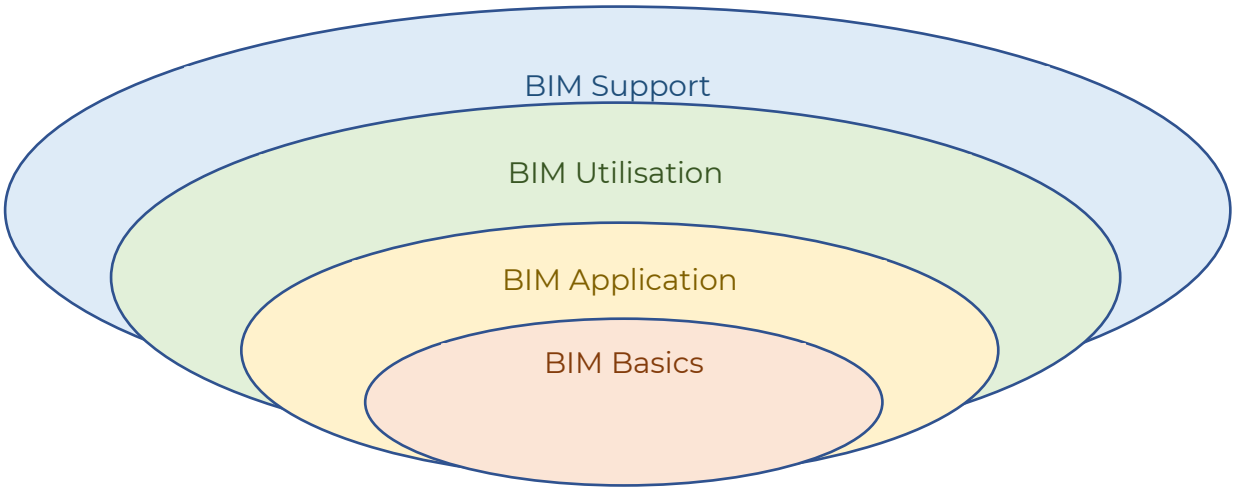


Figure 4. ARISE categories of digitalisation specialisms

The flexibility of the chosen methodology allows it for more specialisms or categories to be added in a later stage. It also allows for adding (BIM) maturity levels in a later stage.

Each category consists of one or more specialisms as shown in Table 2.

ID	Specialism	Category
BB-1	BIM Basics	BIM Basics
BA-1	BIM Management	BIM Application
BA-2	BIM Project Management	
BA-3	BIM Coordination	
BA-4	BIM Modelling	
BA-5	BIM Engineering	
BA-6	BIM Programming	
BU-1	Capturing and Representing	BIM Utilisation
BU-2	Planning and Conceptualizing	
BU-3	Simulating and Quantifying	
BU-4	Constructing and Fabricating	
BU-5	Operating and Maintaining	
BU-6	Monitoring and Controlling	
BU-7	Linking and Extending	
BS-1	Project Data Management	BIM Support
BS-2	System Administration	

Table 2. Main digitalisation specialisms per category

BIM Basics specialisms

ID	Specialism
BB-1	**BIM Basics**
	Requisite for all professions

BIM Application specialisms[1]

ID	Specialism
BA-1	**BIM Management**
	Management (strategic) level. Focus on BIM-implementation in the organisation. Creates conditions to use BIM in projects and implements (BIM) lessons learnt from projects. Relevant labels: BIM implementation plan, BIM work method …
BA-2	**BIM Project Management**
	Management (project), BIM-process level. Focus on BIM aspects of project management. Relevant labels: BIM/Information protocol, EIR, BIM Execution Plan, data drops …
BA-3	**BIM Coordination**
	Technical, BIM-process level. Focus on BIM use in projects and coordination of models. Relevant labels: model checking, clash control, model federation, open/closed BIM, BCF …
BA-4	**BIM Modelling**
	Technical level. Focus on vocation specific BIM-creation. Relevant labels: objects, families, discipline models, aspect models …
BA-5	**BIM Engineering**

[1] (Bouw in Balans, SBR CURnet)

	Technical level. Focus on vocation specific use (I/O) of information in BIM. Relevant labels: properties, parameters, discipline models, aspect models …
BA-6	**BIM Programming[2]**
	Technical level[3]. Focus on automation of BIM processes and AI-like BIM use. Relevant labels: scripting, parametric, algorithms …

Main source: Bouw Digitaliserings Raad [BDR] (The Netherlands)

BIM Use specialisms[4]

ID	Specialism
BU-1	**Capturing and Representing**
	Using software tools and specialized equipment to capture and represent/visualize current and future physical spaces and environments (such as 3D scanners, drones, Lidar, etc.)
BU-2	**Planning and Conceptualizing**
	Using software tools for conceptualization and planning
BU-3	**Simulating and Quantifying**
	Using software tools to conduct various types of (BIM)model-based simulations and estimations/quantifications
BU-4	**Constructing and Fabricating**
	Using (BIM)models for the specific purposes of (prefab/offsite)construction and assembling
BU-5	**Operating and Maintaining**
	Using (BIM)models to operate, manage and maintain a facility

[2] BIM Programming is not (yet) officially recognized by the Dutch BDR

[3] might be a different 'technical' than in previous specialisms

[4] (Succar)

BU-6	**Monitoring and Controlling**
	Using (BIM)models to monitor building performance (construction and exploitation) or (quality)control and assess its spaces, systems and equipment
BU-7	**Linking and Extending**
	Linking (BIM)models and their components to other databases such as material databases (e.g. Madaster)

Main Source: BIMe Initiative, BIM Excellence (Australia)

BIM Support specialisms

ID	Specialism
BS-1	**Project Data Management**
	Managing all project data in relation to BIM. Relevant labels: PIM, CDE, redundancy
BS-2	**System Administration**
	Making sure all hardware and software is functional and interoperable if needed. Relevant labels: ....

3.1.2. Professions

As explained in paragraph 2.2.1, the decision was made to include a selection of one or two professions for each profession category. The categories were: Designers, contractors, clients, and public administration. By including only a selection, execution of the skill mapping remained feasible for country partners, yet became a useful instrument where upskilling requirements for professionals are portrayed.

Thus, the professions element of the skills mapping looked like Table 3.

Designers	Contractors		Clients	Public Administration
Architect	Project Manager	Forperson	Building Owner Operator	Building Inspector
D1	Co1	Co2	Cl1	Pa1

Table 3. Professions as represented in the ARISE skills mapping

3.1.3. Process of execution

For executing the skills mapping, to gain insight in skills gaps in the field and upskilling needs, all elements as mentioned previously in this paragraph are collected in a spreadsheet. See Figure 5 for a fragment of what this looks like in the ARISE project. The "C" and "R" stand for 'current' and 'required' skill levels. Any difference between required and current levels on the same specialism, for the same profession, will represent a skills gap.

			Designers		Contractors			
Code	Specialism	Description	Architect		Project Manager		Forperson	
			D1		Co1		Co2	
			C	R	C	R	C	R
BA	BIM Application							
BA-1	BIM Management (Strategic)	Management (strategic) level. Focus on BIM-implementation in the organization. Creates conditions to use BIM in projects and implements (BIM) lessons learnt from projects. Relevant labels: BIM implementation plan, BIM work method …						
BA-2	BIM Management (Project)	Management (project), BIM-process level. Focus on BIM aspects of project management. Relevant labels: BIM/Information protocol, EIR, BIM Execution Plan, data drops …						

Figure 5. Elements of the skills mapping gathered in a spreadsheet

As stated before, 'it should be decided for each specialism to what extent each professional should be able to master the specialism'. After all, not all professions are expected to acquire a similar level of skills for all the identified specialisms (Cromwijk, 2022). Skill levels have been defined in order to appoint calibrated numbers (See Figure 6). The five skills levels were based on EU terms and on the Bologna declaration of 2010 (Cromwijk J. M.-C.-E., 2017).

SKILLS LEVELS		
	0	Not applicable/no knowledge and skills required
	1	Has little knowledge and skills with respect to the relevant field/ technology (mostly outside the own field of expertise)
	2	Understands basic knowledge and has pratical skills within the field/technology, is able to solve simple problems by selecting and applying basic methods, tools, materials and information (mostly outside the own field of expertise)
	3	Has comprehensive, factual and theoretical knowledge and skills within the field/technology, is capable of solving problems within the field
	4	Has advanced knowledge involving a critical understanding of theories and principles, and skills required to solve complex and unpredictable problems in the field, and is aware of the boundaries
	5	Has specialized knowledge and problem solving skills, partly at the forefront of knowledge in the field, in order to develop new knowledge and procedures and to integrate knowledge from different fields

Figure 6. Skills levels for the skills mapping

Expert knowledge is needed to make deliberate decisions when it comes to appointing skill levels. In the ARISE consortium, the experts within the consortium were asked to perform the skills mapping.

The skills levels used to map the current and future skills are interchangeable with the European Qualification Framework (EQF). The EU-funded project TRAIN4SUSTAIN has successfully demonstrated the use of skills levels in relation to EQF-levels (CEN Workshop Agreement (CWA 17939:2022 E), 2022).

The results of the skills mapping (See Figure 7 for a fragment) are to function as the origin for the development of a task-based qualification model, which will be elaborated upon in the next chapter.

			Designers		Contractors			
Code	Specialism	Description	Architect		Project Manager		Foreperson	
			D1		Co2		Co4	
			C	R	C	R	C	R
BA	BIM Application							
BA-1	BIM Management (Strategic)	Management (strategic) level. Focus on BIM-implementation in the organization. Creates conditions to use BIM in projects and implements (BIM) lessons learnt from projects. Relevant labels: BIM implementation plan, BIM work method ...	0	2	2	4	0	0
BA-2	BIM Management (Project)	Management (project), BIM-process level. Focus on BIM aspects of project management. Relevant labels: BIM/Information protocol, EIR, BIM Execution Plan, data drops ...	2	4	2	4	0	0
BA-3	BIM Coordination	Technical, BIM-process level. Focus on BIM use in projects and coordination of models. Relevant labels: model checking, clash control, model federation, open/closed BIM, BCF ...	1	3	2	4	0	2

Figure 7. A fragment of the skills mapping executed for Ireland

3.2. Qualification framework model

As mentioned in the introduction of the current report, the methodology for compiling task-based qualifications is used in the ARISE project to establish the maturity based model of digitization skills. This model will later be used to develop the project's final task-based qualification framework to enhance recognition of digital skills, in sync with sustainable energy skills. This paragraph shows how the model is structured when using the specialisms from the skills mapping as a point of departure.

3.2.1. Tasks and subtasks

A task-based qualification framework starts with defining tasks and subtasks for a certain specialism. To illustrate, an example of a task within the specialism of 'driving a car' could be 'starting a car'. A corresponding subtask would be to 'push the clutch', or to 'turn the key'.

The set-up for tasks and subtasks for the qualification framework is shown in rows number 4 and 5 of Table 4. They are added in this step. The exact tasks and subtasks are part of the content, which will, make the model into the final ARISE qualification framework (D3.3). It is important to consider precisely what a person should **do**, what activities are required. This way, the practical nature of the resulting framework is guaranteed.

Each task, or each subtask (depending on what is suitable) should be connected to one or more professions that should be attending to the (sub)task. This element is not visualised in the table.

If it adds value, each task or each subtask can also be connected to the skills mapping levels (as opposed to merely the skills mapping specialisms). When done so, one can apply a 'filter' to the framework that only shows, for instance, the required tasks within specialism X, level 3. It is suggested to make this connection in the ARISE qualification framework, with the maturity levels included (See paragraph 3.3 'Maturity levels').

Group	ID	Specialism	Task	Subtask
BIM Basics	BB-1	BIM Basics	BB-1 task 1	BB-1 task 1.1
BIM Application	BA-1	BIM Management	BA-1 task 1	BA-1 task 1.1
				BA-1 task 1.2
			BA-1 task 2	
			BA-1 task 3	
			BA-1 task 4	BA-1 task 4.1
				BA-1 task 4.2
				BA-1 task 4.3
			BA-1 task 5	BA-1 task 5.1
				BA-1 task 5.2
			BA-1 task 6	
	BA-2	BIM Project Management	BA-2 task 1	BA-2 task 1.1
				BA-2 task 1.2
				BA-2 task 1.3
				BA-2 task 1.4
			BA-2 task 2	
	BA-3	BIM Coordination	BA-3 task 1	BA-3 task 1.1
	BA-4	BIM Modelling	etc...	tbd
	BA-5	BIM Engineering	tbd	tbd
	BA-6	BIM Programming	tbd	tbd
BIM Utilisation	BU-1	Capturing and Representing	tbd	tbd
	BU-2	Planning and Conceptualizing	tbd	tbd
	BU-3	Simulating and Quantifying	tbd	tbd
	BU-4	Constructing and Fabricating	tbd	tbd
	BU-5		BU-5 task 1	BU-5 task 1.1

		Operating and Maintaining		BU-5 task 1.2
				BU-5 task 1.3
				BU-5 task 1.4
				BU-5 task 1.5
				BU-5 task 1.6
			BU-5 task 2	BU-5 task 2.1
				BU-5 task 2.2
			BU-5 task 3	
			BU-5 task 4	
			BU-5 task 5	BU-5 task 5.1
				BU-5 task 5.2
	BU-6	Monitoring and Controlling	tbd	tbd
	BU-7	Controlling and Extending	tbd	tbd
BIM Support	BS-1	Project Data Management	tbd	tbd
	BS-2	System Administration	tbd	tbd

Table 4. Model of the qualification framework with tasks and subtasks included

The tasks and subtasks to be added should reflect the general level of each specialism. The flexible structure of the qualification framework model makes it possible to add more detailed or specific tasks on an organisational or national level.

3.2.2. Learning outcomes: ULOs

The Unit of Learning Outcome (ULO) counterpart of the model focuses on appointing learning outcomes to each subtask. As Figure 8 shows, ULOs consist of knowledge, skills, and competences.

Experts are to be interviewed about what skills, knowledge and behaviour is required in order to perform the subtask in a correct manner. The competence of a ULO consists of a description of the learning outcome which includes behaviour and attitude. When ULOs have been appointed to subtasks, the qualification framework is finalised: It can then be decided who needs to learn what in order to close the skills gaps. Upskilling pathways can be determined for each professional included in the framework. This is the work that will be done later in the ARISE project.

ULOs are unique, but can be used for more than one (sub)task. If, for instance, task 4.1 (partly) requires the same learning outcomes as task 1.2, the relevant ULO number can simply be added to the subtask. ULOs can later be labelled with locations of existing learning content or upskilling interventions.

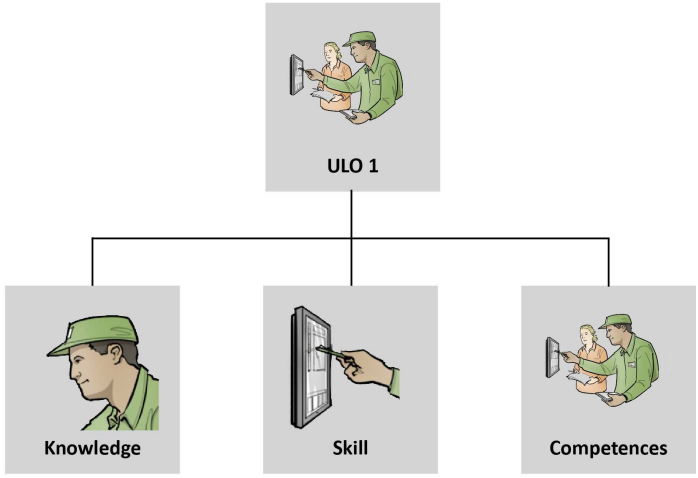


Figure 8. A ULO consists of knowledge, skill, and competence components

How the ULOs are to be added to the qualification framework is shown in row number 6 in Table 5. They are added in this step.

Group	ID	Specialism	Task	Subtask	ULO(s)
BIM Basics	BB-1	BIM Basics	BB-1 task 1	BB-1 task 1.1	1,5,7
BIM Application	BA-1	BIM Management	BA-1 task 1	BA-1 task 1.1	1
				BA-1 task 1.2	2
			BA-1 task 2		3, 4
			BA-1 task 3		5, 6
			BA-1 task 4	BA-1 task 4.1	2, 3, 7
				BA-1 task 4.2	etc...
				BA-1 task 4.3	tbd
			BA-1 task 5	BA-1 task 5.1	tbd
				BA-1 task 5.2	tbd
			BA-1 task 6		tbd
	BA-2	BIM Project Management	BA-2 task 1	BA-2 task 1.1	tbd
				BA-2 task 1.2	tbd
				BA-2 task 1.3	tbd
				BA-2 task 1.4	tbd
			BA-2 task 2		tbd
	BA-3	BIM Coordination	tbd	tbd	tbd
	BA-4	BIM Modelling	tbd	tbd	tbd
	BA-5	BIM Engineering	tbd	tbd	tbd
	BA-6	BIM Programming	tbd	tbd	tbd
	BU-1	Capturing and Representing	tbd	tbd	tbd

BIM Utilisation	BU-2	Planning and Conceptualizing	tbd	tbd	tbd
	BU-3	Simulating and Quantifying	tbd	tbd	tbd
	BU-4	Constructing and Fabricating	tbd	tbd	tbd
	BU-5	Operating and Maintaining	BU-5 task 1	BU-5 task 1.1	tbd
				BU-5 task 1.2	tbd
				BU-5 task 1.3	tbd
				BU-5 task 1.4	tbd
				BU-5 task 1.5	tbd
				BU-5 task 1.6	tbd
			BU-5 task 2	BU-5 task 2.1	tbd
				BU-5 task 2.2	tbd
			BU-5 task 3		tbd
			BU-5 task 4		tbd
			BU-5 task 5	BU-5 task 5.1	tbd
				BU-5 task 5.2	tbd
	BU-6	Monitoring and Controlling	tbd	tbd	tbd
	BU-7	Controlling and Extending	tbd	tbd	tbd
BIM Support	BS-1	Project Data Management	tbd	tbd	tbd
	BS-2	System Administration	tbd	tbd	tbd

Table 5. Model of the qualification framework with ULOs included

3.2.3. Sustainable energy skills

This report describes the development of a maturity based model of digitisation skills in sync with sustainable energy skills. The latter concept, sustainable energy skills, was crucial to include in the model, in order to reach a piece of work that allows for digitalisation and energy skills to reinforce one another. Energy efficiency can be enhanced by digital technology, and thus the workforce of the built environment should be skilled in applying specific energy-related tasks to their work with BIM and digitalisation.

During the process of development of the model, partners discussed in depth the different ways in which digitisation could be linked to the topic of energy efficiency. Three options for connecting sustainable energy skills and digital skills with each other were proposed during the process of establishing the model. They are mentioned below in Table 6, Table 7, and Table 8. Eventually, the third option was selected to proceed with towards the next steps of the ARISE project.

Option 1: Make EE topics part of the categories of specialisms

Energy Efficiency as a separate category within the framework will make it easily recognizable as an add-on to the qualification framework. And thus, all elements (specialisms, tasks, ULO's) are described on the same level of abstraction. The downside to this approach is that there seems to be no real integration, only an addition of individual specialisms.

Group	ID	Specialism
BIM Basics	BB-1	BIM Basics
BIM Application	BA-1	BIM Management
	BA-2	BIM Project Management
	BA-3	BIM Coordination
	BA-4	BIM Modelling
	BA-5	BIM Engineering
	BA-6	BIM Programming
BIM Utilisation	BU-1	Capturing and Representing
	BU-2	Planning and Conceptualizing
	BU-3	Simulating and Quantifying
	BU-4	Constructing and Fabricating
	BU-5	Operating and Maintaining
	BU-6	Monitoring and Controlling
	BU-7	Linking and Extending
BIM Support	BS-1	Project Data Management
	BS-2	System Administration

Energy Efficiency	**EE-1**	**Energy Efficiency Specialism 1**
	EE-2	**Energy Efficiency Specialism 2**
	EE-3	**Energy Efficiency Specialism 3**
	EE-4	**Energy Efficiency Specialism 4**

Table 6. Example of EE topics as part of the categories of specialisms

Option 2: Make EE topics part of the existing specialisms

It could be argued that EE topics should be positioned as separate specialisms alongside the already defined digitalisation specialisms. The downside is that this option might lead to a lot of blending between different specialisms, which would make them hard to distinguish.

Group	ID	Specialism
BIM Basics	BB-1	BIM Basics
BIM Application	BA-1	BIM Management
	BA-2	BIM Project Management
	BA-3	BIM Coordination
	BA-4	BIM Modelling
	BA-5	BIM Engineering
	BA-6	BIM Programming
BIM Utilisation	BU-1	Capturing and Representing
	BU-2	Planning and Conceptualizing
	BU-3	Simulating and Quantifying
	BU-4	Constructing and Fabricating

	BU-5	Operating and Maintaining
	BU-6	Monitoring and Controlling
	BU-7	Linking and Extending
	BU-8	**Energy Efficiency**
BIM Support	BS-1	Project Data Management
	BS-2	System Administration

Table 7. Example of EE topics as part of the existing specialisms

Option 3: Make EE topics part of the (sub)tasks of the specialisms

The main idea with this option is that digitisation is linked with EE topics on a level that is detailed enough to allow for good integration. The downside is that energy topics are not explicitly present in the skills mapping counterpart of the ARISE project. With this option, the primary focus of the model stays on BIM and digitalisation.

Another reasons for selecting this option as the most suitable course of action for the maturity based model, was that with this option it is easier to link EE specific ULOs to the framework.

Group	ID	Specialism	Task	Subtask
BIM Application	BA-1	BIM Management	BA-1 task 1	BA-1 task 1.1
				BA-1 task 1.2
			BA-1 task 2	
			BA-1 task 3	
			BA-1 task 4	BA-1 task 4.1

				BA-1 task 4.2
				BA-1 task 4.3
			BA-1 task 5	BA-1 task 5.1
				BA-1 task 5.2
			BA-1 task 6	
			BA-1 task 7	**BA-1 task 7.1**
				BA-1 task 7.2
			BA-1 task 8	

Table 8. Example of EE topics as part of the (sub)tasks of the specialisms

3.3. Maturity stages

Maturity stages (or maturity levels) are used in the digital construction sector to rank the level of digitalisation of an organisation. A workforce employed in an organisation with a higher maturity stage will have a different set of specialisms, tasks and ULOs and therefore different learning needs (and capabilities). A higher maturity stage also means more possibilities to contribute to energy efficiency.

Maturity stages are currently only very abstract and (ICT-)descriptive at best. The BIMplement project is one of the few (if not the only) places where a breakdown was made to assign variables to the stages on an organisational level (See Table 9).

Stage **Name** **Capability Stage**	**1** **Lonely BIM** **Object-based modelling**
Strategy & Collaboration	• Build a business case for BIM • Define information related paragraphs in contracts • Define roles and responsibilities (intra-organisational)
People & Culture	• Assign a BIM champion • Organise tool training

Process & Organisation	• Arrange for information exchange based on project specific codes and spatial co-ordination) • Use models for 3D geometry generation • Derive 2D information (drawings, details) from 3D geometry • Abstract quantities from model • Filter model data on object specifications • Use model for basic analyses
ICT & Data	• Implement and use object based (modelling) software • Use a Common Data Environment (CDE) • Structure objects in a library • Adopt an information hierarchy and naming conventions

Table 9. BIM maturity stage 1 description (BIMplement)

The ARISE qualification framework needs to address the maturity stages to further help the development of maturity growth, and thus energy efficiency. This implies that the ULO-database will thus be enriched with fields and entry forms for storage of the BIM maturity stages. And for this, the alignment matrices of learning outcomes from the different existing BIM course programmes for different professional roles, from ARISE D3.1, are used. However, these learning outcomes are/were not meant to be plotted as maturity stages. This will make it an Herculean task to enrich the ULO-database and therefore an alternative approach was sought.

The solution was found to include maturity levels in a separate maturity-based skills mapping (See Figure 9). This way, the required level of proficiency for each professional can be mapped per maturity level. This:

- Compatible with the BUILD UP Skills database (this upskilling database employed by the ARISE project does not support 1-on-1 linking of ULOs to maturity levels)
- In synergy with the mock-up of the skill maturity assessment tooling that was designed as part of Task 3.4 of the ARISE project (more on this can be found in later ARISE Deliverable 3.3).
- Useful for organisations who want to attain a specific level of BIM maturity, and thus need to find out what the most suitable upskilling pathways are for their employees - maturity levels are now directly linked to the skills gaps that need to be closed.

- Makes the work of appointing maturity levels to the future ARISE qualification framework more feasible.

			Profession category	Designers				Cont			
Code	**Specialism**	**Description**	**Profession**	Architect				Project Manager			
		Profession code	**Profession code**	D1				Co1			
		Maturity level	**Maturity level**	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**
BA	BIM Application										
BA-1	BIM Management (Strategic)	Management (strategic) level. Focus on BIM-implementation in the organization. Creates conditions to use BIM in projects and implements (BIM) lessons learnt from projects. Relevant labels: BIM implementation plan, BIM work method ...		1	3	4	5	1	3	4	5
BA-2	BIM Management (Project)	Management (project), BIM-process level. Focus on BIM aspects of project management. Relevant labels: BIM/Information protocol, EIR, BIM Execution Plan, data drops ...		2	2	3	4	2	2	3	4
BA-3	BIM Coordination	Technical, BIM-process level. Focus on BIM use in projects and coordination of models. Relevant labels: model checking, clash control, model federation, open/closed BIM, BCF ...		0	1	2	2	0	1	2	2

Figure 9. Fragment of the skills mapping that connects maturity levels to professions and specialisms

4. Model implementation

4.1. Connection to other ARISE activities for model implementation

The implementation of the maturity based model is linked with the work carried out by *WP5 - FILL agility e-tools* and *WP6 PILOT Digital Pathway energise*. Deliverable 5.2 aims to produce an initial selection of materials, assessment methods and delivery tools that will be put forward for the trials as part of *Deliverable 6.3 - Package of selected tools for pilot delivery*. This is also linked to *Deliverable 3.4 - Map of available resources linked to the developed qualification framework*.

4.1.1. To micro learnings

Currently, there are 19 recommended modules (Table 10), consisting of micro learnings. that will be available for selection for the piloting stage. To organise these modules to align with the BIM Specialisms, an upskilling pathway has been designed as presented in Figure 10 and Figure 11.

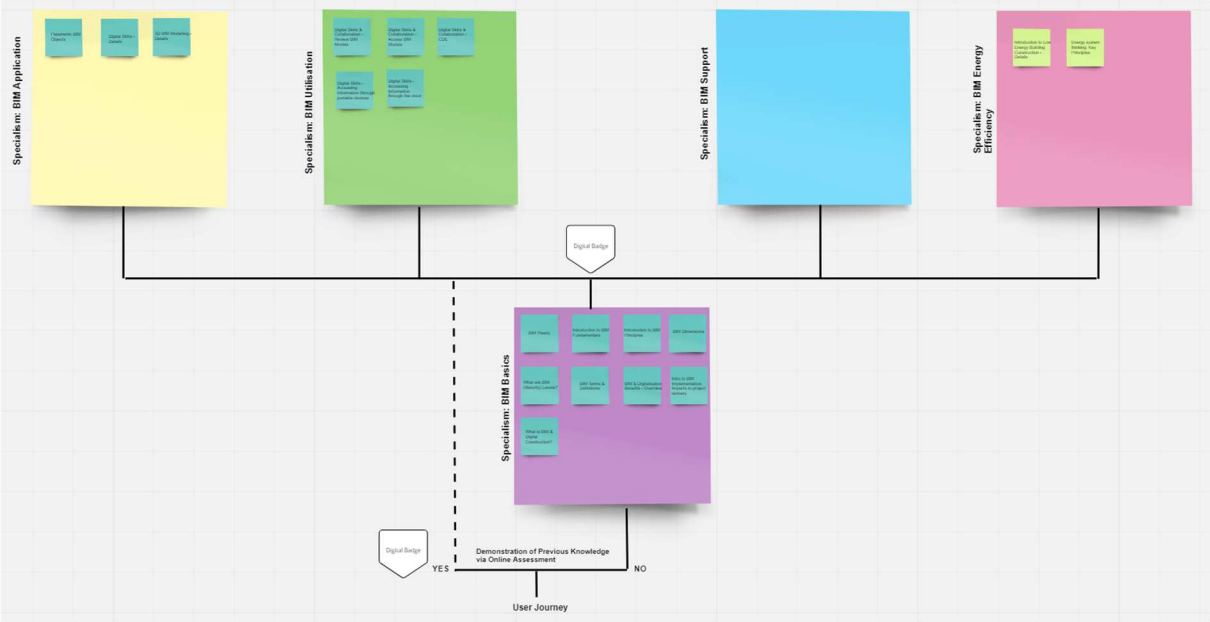


Figure 10. Early Concept of current learning materials integrated with the BIM specialisms

Out of the 19 modules, there are 17 that focus on digitisation skills and 2 in energy efficiency. All of which have their own set of learning outcomes, materials, delivery tools and assessment methods, thus providing a link to the recommendations put forward in *5.1 Definition of learning methodology, materials, and delivery tools framework*. The learning outcomes outlined in the selected modules will be linked back and mapped to the tasks and subtasks

that were identified in *Deliverable 3.2*. Once the mapping exercise has been completed, any of the current learning modules deemed not applicable to the tasks and subtasks will be removed from the *Qualification Framework* and *Selection of Learning Material* for the piloting schemes.

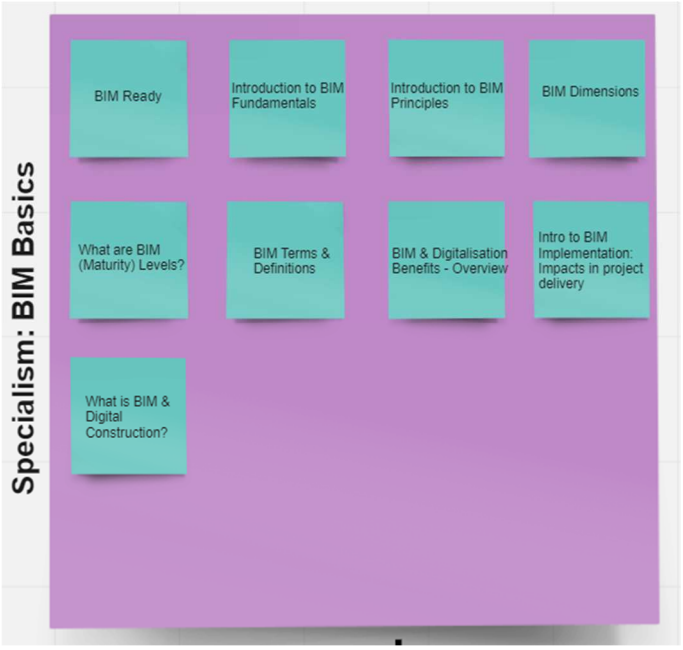


Figure 11. Learning modules placed under BIM Basics specialism

Through this approach of working from the finished material backwards, we can quickly identify where there are gaps in the learning content and will allow the project team to make a decision on what learning materials should be produced that aligns to the specialism, task and subtasks of the maturity based model. For example, as shown in Figure 10, there is currently no learning content that addresses the BIM Support specialism. This is an area that may need to be addressed for *D5.2* so we are demonstrating a working example(s) of learning content that meets the criteria for each of the specialisms. The succeeding deliverables of WP 5 will be aimed at producing the remaining learning content that will be linked back to the tasks and subtasks of D3.2 and units of learning outcomes of the Qualification Framework.

Materials	**Learning Outcomes**
BIM Ready	An introductory self-study tool, covering subjects such as: What is BIM, BIM process, BIM maturity levels, BIM terms, Benefits & Barriers, etc.
Introduction to BIM Fundamentals	1. Summarise your role and the roles of others within the Digital construction sector. 2. Define what BIM is and explain key terminology. 3. List the benefits & value of a BIM workflow.

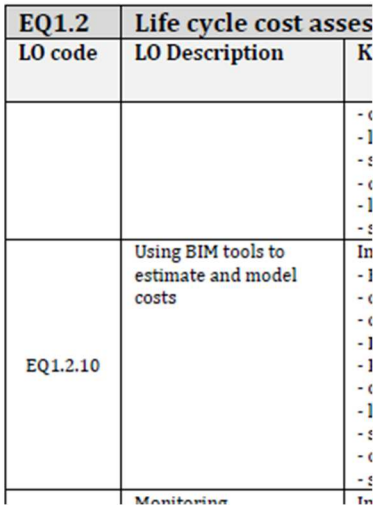
	4. Define the role of BIM in achieving improved sustainable construction and energy efficient performance.
Introduction to BIM Principles	1. Explain the context and essentials of BIM. 2. Detail the application and standards of BIM. 3. Define the technological requirements for BIM implementation and security.
Digital Skills - Details	1. Describe the use of digital skills and devices in construction. 2. Define how to use digital skills and devices to access digital information. 3. Demonstrate how to use BIM and digital skills across the construction supply chain. 4. Demonstrate how to use digital tools to perform a design review and evaluate a BIM model
3D BIM Modelling - Details	1. Define how BIM may be used within the construction and design industry. 2. Create a building model using industry-standard BIM software. 3. Implement and manage BIM. 4. Develop and publish information using BIM.
Parametric BIM Objects	1. Demonstrate the importance and use of parametric objects in digital construction. 2. Create templates. 3. Develop and create BIM. 4. Export, insert and use BIM objects.
What are BIM (Maturity) Levels?	Summarise BIM Maturity Levels (also referred to as BIM Stages)
BIM Terms & Definitions	Explain Key Terms and Definitions within BIM
BIM & Digitalisation Benefits-Overview	1. Understand one of the key components of the context and essentials of BIM. 2. Illustrate the benefits of BIM to the construction sector.
BIM Dimensions	Explain Key Terms and Definitions within BIM, specifically: BIM Dimensions
Introduction to Low Energy Building Construction - Details	1. Outline the impact of using different materials on energy usage in buildings and illustrate how the use of adequate insulation can mitigate against losses. 2. Outline how a building's heating and ventilation system consumes and discharges energy. 3. Measures for improvement of operational energy performance of a building, aimed towards low energy and near zero energy buildings. 4. Cost optimal energy performance. 5. Energy simulation by application of BIM.

	6. Understand how System thinking with regards to low energy building construction. Can be applied to deliver substantially better results. 7. Illustrate how BIM can be utilized to reduce energy loss.
Energy system thinking: Key Principles	1. Understand the objective of implementation of system thinking approach for overall energy performance of buildings. 2. Summarize the objectives of optimization of energy performance of buildings. 3. Understand role and importance of the design stage in energy efficiency optimization, participants and collaboration by BIM. 4. Summarize advantages of BIM for achieving optimal energy performance in the design stage. 5. Understand role and importance of the construction stage within the building life cycle, in aspect of overall energy efficiency optimization. 6. Summarize use of BIM in construction stage to optimize energy performance of buildings. 7. Understand role and importance of the operation stage in energy efficiency optimization. 8. Outline use of BIM in the operation stage to improve energy performance of buildings. 9. Outline energy simulation methods underpinned by BIM. 10. Summarize advantages of BIM applied in a system thinking approach for overall energy performance of buildings throughout their life cycle.
What is BIM & Digital Construction?	1. Understand and be able to explain the context and essentials of BIM, with a focus on: 1) What is BIM? 2) What and whom it involves. 2. Summarise the context of BIM in the wider digitalisation of the AEC industry. 3. Summarise the role of BIM as an enabler for energy efficiency and tool to tackle climate change.
Intro to BIM Implementation: Impacts in project delivery	Explain the impact of BIM Maturity Stage 2 requirements for project delivery.
Digital Skills - Accessing Information through the cloud	Explain the use of cloud-based storage to access and exchange information
Digital Skills - Accessing Information through portable devices	Explain the use of portable devices to access and exchange information.

Digital Skills & Collaboration – CDE & File Structure	1. Demonstrate Information and Communication Technologies (ICT) file management. 2. Explain the use of CDE, including arrangements for collaborative working and communication.
Digital Skills & Collaboration -Access BIM Models	Explain the use of cloud-based storage and portable devices to access and exchange information.
Digital Skills & Collaboration – Review BIM Models	Demonstrate the use of digital design review tools to access and evaluate a BIM model.

Table 10. Current learning material available for ARISE platform

As outlined in 2.1.1, the units of learning outcomes will consist of competence, skills and knowledge. A ULO identifier will also be introduced that will be linked back to the maturity based module. Figure 12 is an example of the use of Learning Outcome Codes in the TRAIN4SUSTAIN project.



EQ1.2	Life cycle cost asses
LO code	LO Description
EQ1.2.10	Using BIM tools to estimate and model costs

Figure 12. Learning outcome code as used in TRAIN4SUSTAIN

From the learning outcomes already available, these will be expanded upon to include competence, skills and knowledge. There is an opportunity to create shared learning outcomes for a selection of content that will be hosted on the ARISE platform. For example, learning content in the area of BIM Basics, such as *Introduction to BIM Fundamentals* will not require learning outcomes to suit specific roles / professions / competences as this is generic learning content. Whereas a module such as 3D BIM Modelling will be more discipline specific and will have learning outcomes to suit a user's profession. The maturity level of each module will also need to be taken into consideration when producing the units of learning outcomes. If we take the examples from above, *Introduction to BIM Fundamentals* won't go above Maturity: Level 1, thus will only need one set of shared learning outcomes. However, 3D BIM Modelling will begin with basic knowledge Maturity Level 1 and continue to more advanced learning in further

maturity levels. Each stage of maturity level will have a unit of learning outcomes that will be more advanced than the previous that is aligned to the maturity based model. This will be presented further in *Deliverable 3.3 - Qualification Framework*.

4.1.2. To upskilling pathways

Below in Figure 13 is the concept serving the user (with no prior knowledge) an upskilling pathway for the *Introduction to BIM Fundamentals* module. As recognised previously, the modules that will be placed under *BIM Basics* are recommended to have shared -units- of learning outcomes. Within Module 1 there will contain the materials, delivery tools and assessment methods which have been linked to *Deliverables 5.1 & 5.2* respectively. Upon completion of modules users will be awarded with a Digital / Open Badge that will be linked to the block chain, thus providing the micro-learning record store as developed in WP4.

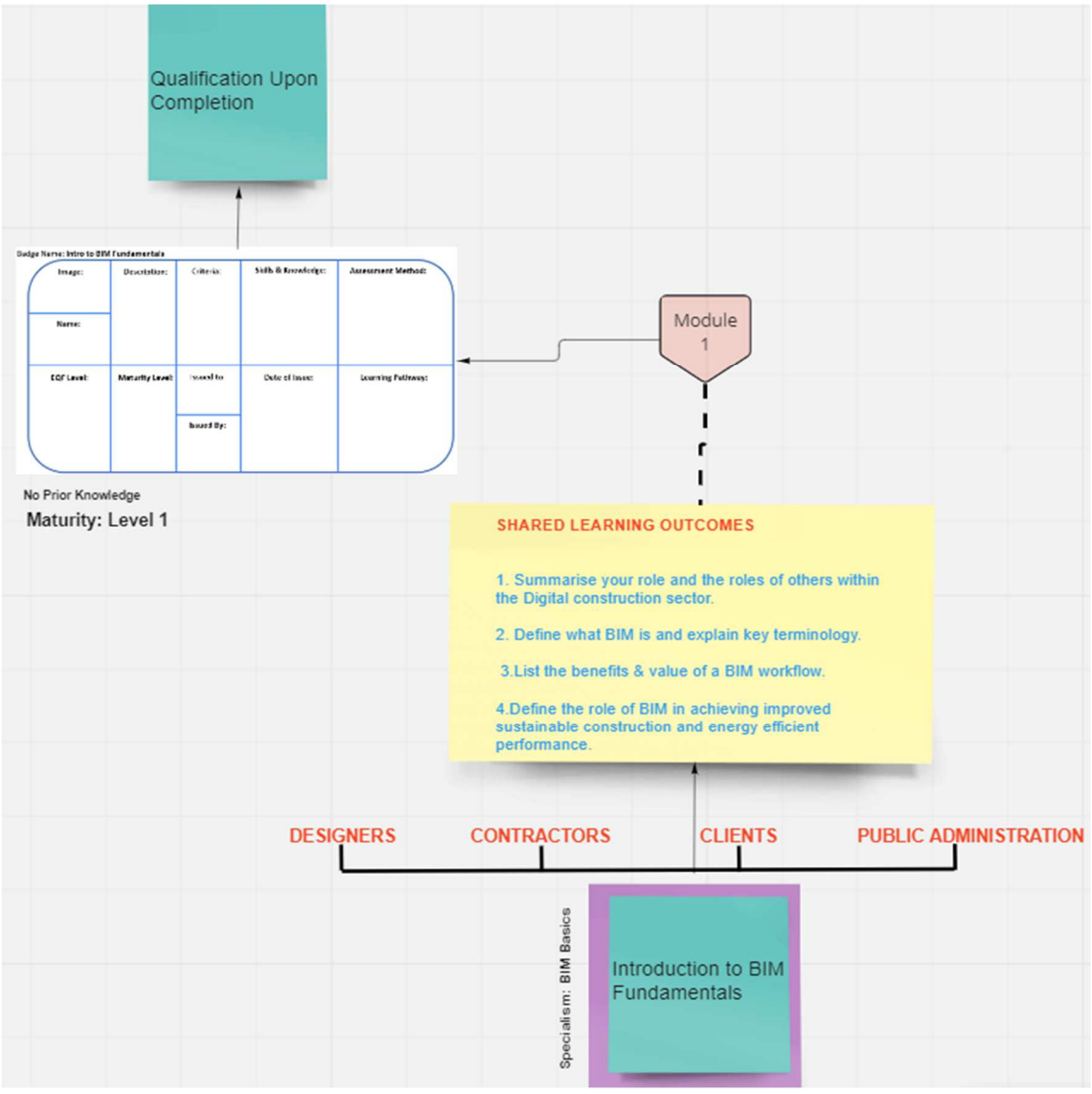


Figure 13. Concept of using shared learning outcomes for early maturity levels

As part of the digital badge strategy, a structured template with various inputs has been proposed for creating each digital badge.

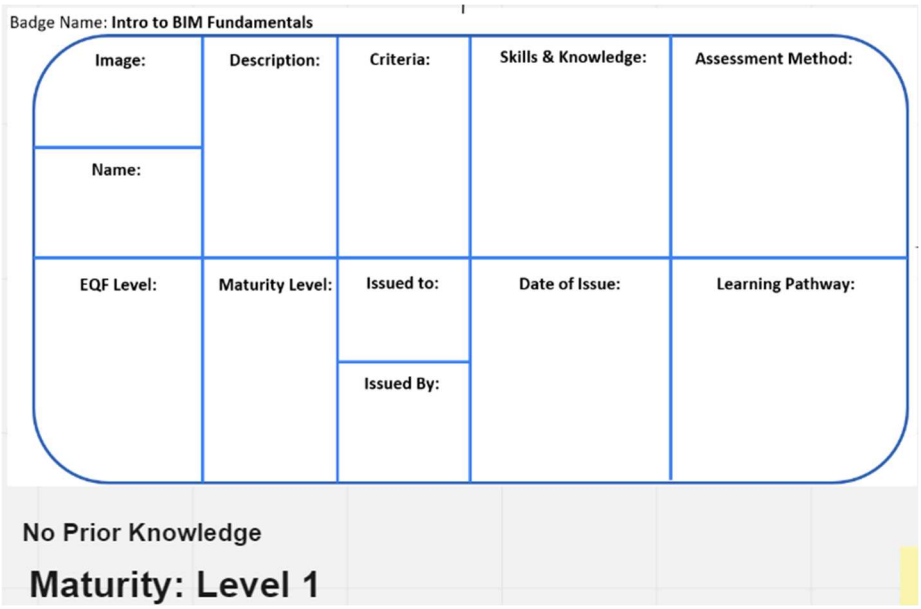


Figure 14. Proposal of Digital Badges used in completion of learning material

The following headings (Figure 14 & Figure 15) serve as a flexible, non-exhaustive list that can be revised in the next deliverable:

- Badge Image
- Name
- Description
- Criteria
- Skills & Knowledge
- Maturity Level (Link to Maturity Level with ULO ID Code)
- Assessment Criteria
- Assessment Method
- Issued to / by
- Date of Issue
- Learning Pathway

Image	Name	Description	Skills & Knowledge (Link to Specialisms)	EQF Level	Criteria	Assessment Method	Issued to:
BIM Fundamentals	Introduction to BIM Fundamentals	This badge is awarded when candiates successfully complete the module Upon completion users will be able to: 1. Summarise your role and the roles of others within the Digital construction sector. 2. Define what BIM is and explain key terminology. 3. List the benefits & value of a BIM workflow. 4. Define the role of BIM in achieving improved sustainable construction and energy efficient performance	BIM Basics	Level 3	1.1 Be able to summarise your role and the roles of others within the Digital Construction Sector. 2.1. Explain the basic principles of BIM and summarise the common terminology associated with BIM. 3.1 Summarise and list the overall benefits of BIM, particularly in relation to specific roles in the construction industry and energy management. 4.1 Identify the role of BIM in achieving improved. Sustainable construction and design.	Users are awarded with this badge when they complete the following assessment: Quiz: End of BIM Fundamentals Assement 1, 2, 3 etc.	RD

Figure 15. Example of content filled out in Digital Badge

In the instance that a user is overqualified in the area of *BIM Basics*, there is a proposal to include an option to demonstrate previous knowledge via an online skill assessment tool. Similar to the introductory self-study tool from *BIMCert, the* tool will allow users to skip any learning content that is not applicable. A digital badge could also be awarded here following completion of any online skill assessments to

allow users to have a record before following through with the rest of the online content. Should users want to refresh in any of the modules, this option will also be facilitated for.

5. Conclusion

This report portrayed the maturity based model of digitization skills in sync with sustainable energy skills, which will serve as a basis for the later development of the task-based qualification framework for renewable energy skills with digitalization as an accelerator (D3.3).

It was developed following the task-based method for developing ULOs which allows to determine the exact profile professionals should possess in order to perform specific tasks.

In addition, it was designed to be fit for maturity analysis, so that organisations can gain a clear vision on how to proceed in the next steps of digitalisation. The focus on BIM is aimed at maximising the effect of sustainable energy skills. The model includes four AEC professions (designers, contractors, clients, and public administration) to address the complete building life cycle (design, construction, operation).

In sum, this report provides a BIM resource and skills recognition pathway that all stakeholders can utilise, deliver and stimulate.

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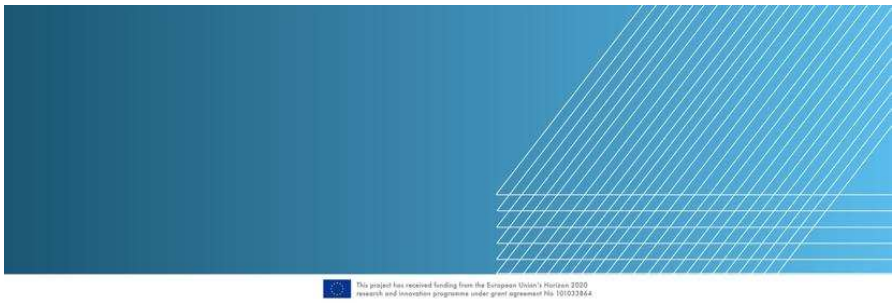
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