SKILLS
INSTRUCT
INSTRUMENTS
CONSTRUCTION

Requirements for new instruments for skills recognition in the construction industry

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 894756.

D2.4 “Requirements for new instruments”

Dissemination Level: Public
Lead Partner: Cardiff University
Due date: 31/03/2021
Actual submission date: 31/05/2021

Published in the framework of:
Evidence-based market and policy instruments implementation across EU to increase the demand for energy skills across construction sector value chain.

Authors:
Irini Barbero, Cardiff University
Dr. Ioan Petri, Cardiff University
Yasin Celik, Cardiff University
Professor Yacine Rezgui, Cardiff University

Revision and history chart

Version	Date	Editors	Comment
V1.0	20/04/2021	Y.Rezgui	
V2.0	30/04/2021	I.Petri	
V3.0	17/05/2021	I.Barbero	
V4.0	31/05/2021	A.Kowalska	

Glossary

Acronym	Full name
CA	Consortium Agreement
EC	European Commission
EASME	The Executive Agency for Small and Medium-sized Enterprises
GA	Grant Agreement
PC	Project Coordinator
WP	Work Package
TL	Task Leader
DoA	Description of Action
PSC	Project Steering Committee
SQM	Scientific and Quality Manager
DEC	Dissemination and Exploitation Committee
KOM	Kick-off meeting
ASM	ASM – Market Research and Analysis Centre
VTT	Technical Research Centre of Finland
LIST	Luxembourg Institute of Science and Technology
RIL	Finnish Association of Civil Engineers
CU	Cardiff University
R2M	Research to Market Solution France
DTTN	Distretto Tecnologico Trentino
ENEFFECT	Center for Energy Efficiency EnEffect
GER	General Exploitable Result
AB	Advisory Board
PM	Person month
M	Month
EE	Energy Efficiency

Table of contents

List of figures:

List of tables:

Executive summary

Given the fragmentation of the construction industry and the training support for blue and white collars, there is a pressing need for adapted instruments to promote mutual recognition of energy skills and qualifications across Europe.

This document elicits the requirements for new and existing tools facilitating the mutual recognition of energy skills and qualifications in the construction sector.
This is informed by a Europe-wide consultation using a mixed-method approach, involving secondary (in the form of industry studies and academic publications) and primary sources of evidence. The latter includes a survey (n= 52), a series of interviews (n= 27), an expert workshop, and 70 use cases drawn across Europe providing not only examples of the correlation between training and energy efficiency, but also insights as to the gaps and requirements for an impactful training landscape for energy efficiency in Europe. More specifically, these insights have helped shed light on:
a. the state of awareness, access to information, and dissemination of knowledge for energy efficiency in the European Construction sector.
b. the level of demand for skilled workforce in energy efficiency.
c. the state of the training programs for energy efficiency currently available in the industry (in terms of scope, quality, content, cost, etc.).
d. the state of the sector in terms of shared values and coordination of stakeholders across the supply chain for energy efficiency.
e. How efficient are legislative frameworks, policies, and government incentives.

As such, an overarching requirement is identified in the need for a widely accessible and trusted digital platform that can allow (a) training organisations to register their training offers and associated learning outcomes, (b) accreditation organisations to assess these and publish their accreditation outcomes, (c) white and blue workers to register their skills and trainings, and (d) employers to search and recruit the skilled workers most suited to their job across Europe. It is interesting to note that the job market has been deregulated as a result of the ongoing pandemic and the restriction of movements of staff. The recruitment of skilled workers, therefore, transcends existing geographical boundaries while promoting a competitive landscape for skilled workers adapted to a wide range of country-specific organisational and cultural work practices across Europe.

Blockchain is identified as a contender solution to deliver such a digital platform, which will be augmented with a wide range of services allowing the delivery of:

1. passports/registers for workers at regional/national level and support for their take up at EU level.
2. mobile applications facilitating the comparison of workers' skills and qualifications between countries,
3. new legislative frameworks or public procurement practices,
4. initiatives for home and building owners, and,
5. new partnerships with producers and retailers.

Chapter 1. Introduction

Given the forecast of growth of the global Construction market by over 70% by 2025, the industry is faced with the challenge and opportunity to reduce energy demand, improve process efficiency, and reduce carbon emissions in line with the Energy Performance of Buildings Directive (2010/31/EU). In this context, energy efficiency demands adapted technology solutions, strategies (including training and education), and policy-making approaches that should be embraced by the entire supply chain across the whole lifecycle of a project. One interesting example is the Energy Performance in Buildings Directive, revised in 2018, which defines the scheme for Energy Performance Certification, implemented by the various Member States. The related energy audits, energy management systems, and energy manager/assessor training and certification are awareness programs that are usually effective in promoting energy efficiency and increasing the demand for a skilled workforce.

It is worth noting that the training and education landscape in the Construction industry exhibits the following characteristics:

- ✓ Multiple entry points, a plethora of qualifications, a wide variety in the quality of training provision, and complex funding options.
- ✓ Fall in apprenticeship completions due to difficult economic conditions.
- ✓ Use of a more flexible self-employed workforce due to uncertainty in the market.
- ✓ Low training and development activity driven by the high number of self-employed tradesmen who often face an 'earn or learn' dilemma.
- ✓ The transient nature of the workforce and the evolving training demand of the industry deterring employers from investing in staff training.
- ✓ Lack of career planning and the tendency to adopt a supplier as opposed to a demand-driven model.
- ✓ Lack of strategic approach to Continuing Professional Development (CPD) and Continuing Craft Development across the industry.

In this context, there is a need to pave the way to adapted market and policy instruments to stimulate the demand for energy efficiency skills in the Construction industry. As such, the overall potential for energy efficiency would be higher if successful training initiatives and supporting policy instruments are put in place. In fact, staff training initiatives tend to be relatively low-cost activities and have been demonstrated to have large positive effects on the promotion of energy efficiency in industry, as evidenced by a recent study (Deliverable D2.1, 2021). Moreover, educational (both initial university curriculums and Vocational Education and Training) and informative programs are ideal pathways to maximise demand for sustainable energy skills in the Construction sector.

The skill formation process is influenced by the political, economic, and labour market as well as the historical pathway and culture of a country (Pan et al., 2021; Ashton and Green, 1996; Ashton et al., 1999; Bonoli and Wilson, 2019; Brown, 1999; Brown et al., 2001; Busemeyer and Trampusch, 2012; Thelen, 2004). Vocational education and training (VET) is a critical skill formation system that delivers post-school, non-university education and develops the skills of the vocational workforce (Pilz, 2016; Powell et al., 2012). The quality of developed skills is assured by mechanisms including qualifications framework (QF), occupational standards, training programs, occupational assessment, and certification as well as accreditation of VET institutes (Brockmann et al., 2008a, b; Clarke et al., 2013; Méhaut and Winch, 2012). Political stakeholders such as government agencies, employer associations, firms, trade unions, and training institutes take an active part in the shaping of vocational education and training. They interact in different ways to suit varying political-economic environments, thereby

producing various quality assurance mechanisms of unique advantages, meanwhile, facing distinctive challenges (Busemeyer and Trampusch, 2012; Clarke and Winch, 2007; Pilz, 2016; Thelen, 2004).

The aim of this report is to elicit the requirements for new, and existing, tools facilitating the mutual recognition of energy skills and qualifications in the construction sector. This translates into the following objectives:

a) identify best practice initiatives for energy skills recognition across Europe.

b) inform the development of new tools adapted to a wide range of country specific organisational and cultural work practices across Europe. Tools to be specified include:

i. sustainable energy skills passports/registers for workers at regional/national level and support for their take up at EU level.

ii. mobile applications facilitating the comparison of workers' skills and qualifications between countries.

iii. new legislative frameworks or public procurement practices.

iv. initiatives for home and building owners, and,

v. new partnerships with producers and retailers.

These proposed tools and instruments should take into account the structure of the industry where in excess of 95% of companies are SMEs.

The present document addresses the above objectives and is structured into 6 chapters. Following this introduction, Chapter 2 provides a thorough review of the related literature, identifying (a) secondary sources of evidence that corroborate the correlation between training & education and energy efficiency in the Construction sector, and (b) factors promoting energy skills recognition in Europe. Chapter 3 elaborates on best practice initiatives for energy skills recognition across Europe. Chapter 4 elicits the requirements for Energy skills recognition, informed by a large scale consultation led by the authors. Chapter 5 specifies a solution to promote Tools for Energy Skills Recognition using Blockchain technology. Finally, Chapter 6 concludes this report.

Chapter 2. Related Research

The review aims to evidence the fragmentation in the landscape of training for energy efficiency across Europe. This is present on many levels, from barriers in legislation to the quality and effectiveness of training. The review will highlight the need to further intensify efforts towards a cohesive, united front in terms of training for energy for efficiency, which transcends. To do so, the review will highlight evidence from the literature, both academic and from the industry, which points towards that direction. The analysis follows two main strands of thought: (a) presenting the current landscape and (b) presenting best practice examples, to strengthen the argument, in this direction. Overall, the analysis points towards an urgent need to make sure a unified, collaborative effort is within the imminent next steps in the European Context. This effort should also reflect and to be considering the nuances of different contexts, as well as the richness of feedback (gaps, problems) provided so far from the several and different training programs and institutions around the EU.

2.1 Background: State of Art and Barriers

The construction industry is a major player in the global economy, representing 6% of global GDP and having significant impacts on an environmental level (as displayed in Figure 1). There is significant evidence that despite the collective efforts that are currently taking place on a global level towards sustainability in the construction sector, there is an imminent need to intensify these efforts, for them to have a truly transformative effect (Rezgui & Miles, 2011; Petri and Rezgui, 2020). Beyond the critical importance of effective technologies, Backlund et al. (2012) argue the importance of energy management, where the focus on training plays a significant role (Figure 2).

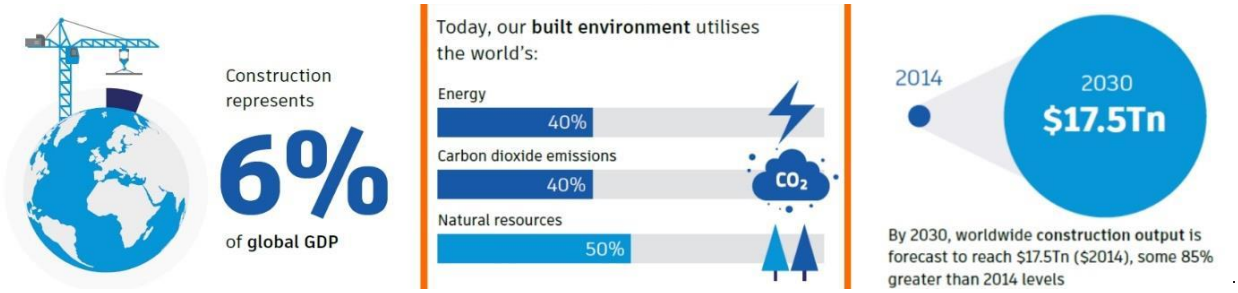


Figure 1. Impacts of the construction industry (Left: World Economic Forum, Middle and Right: Global construction 2030 as seen in Constructing with the power of digital, Autodesk Source: (Suwal et al., 2019)

Training for energy efficiency has proven to be one of the game-changers towards this aim, in helping improve outcomes and targets of energy efficiency in the industry (Bernstein et al, 2007). However, many barriers exist, and the current overall landscape in the industry presents a fragmented image (Rezgui & Miles, 2011; Alhamami et al., 2020). As argued by Rezgui et al. (INSTRUCT, 2020), "The academic literature points to several key energy efficiency barriers, including: Fear of technical risk/cost of production loss, perceived high cost of energy investment, the preference to support other capital investments, uncertainty about future energy price, lack of experience in technology, lack of information in energy efficiency and savings technology, lack of trained manpower/staff, lack of access to capital/budget, lack of government incentives, weak policies and legislations, resistance to change, and full reliance on legacy systems (Backlund et al., 2012). Legislation that facilitates a smooth collaboration and shared interests between stakeholders is crucial. The International Agency of Energy (IEA) argued how "The best way to implement a building energy codes policy, analysis for the Policy Pathway has shown, is for a governmental co-ordination body to ensure the development of training tools and compliance software and to give all stakeholders free access to them" (Oettinger

et al., 2013). In the EU context, specifically, the BUILD UP Skills initiative, focused on looking into the training of “craftsmen and other on-site construction workers and systems installers in the building sector” (BUILD UP, 2020) in the European Context, across 28 Member States.

2.2 Related work around new tools

As reported by the literature, in the context of education and training, several new tools and methods have been adopted to ensure training authenticity and labelling.
Sun, Wang, and Wang, 2018 propose a solution to the problems of course reliability, credit and certification, student privacy, and online education based on Blockchain technology demonstrating that Blockchain technology is promising for the future of education.
Blockcerts project was developed together with the MIT Media Lab Learning Initiative and the Learning Machine, an enterprise software vendor, as an open-source ecosystem for creating, sharing, and validating Blockchain-based education certificates. Training certificates contain basic information such as the name of the recipient, the name of the issuing organisation, and the date of issue. Education certificates are saved on a Bitcoin-based network, cryptographically signed, and protected against alteration. Transactions are possible to be verified by issuing certificates and the content of the certificate ("Digital Certificates Project", 2020) (Jirgensons & Kapenieks, 2018).

Another Blockchain-based solution called 'CredenceLedger' is a platform for stakeholders and relevant third-party organisations to store easily verifiable data evidence of digital academic qualification training in the Blockchain ledger (Arenas & Fernandez, 2018).
Lizcano et al., 2020 evaluate the benefits of Blockchain (or distributed ledger) technology and proposes a decentralised trust model for transactions based on an academic cryptocurrency. With this approach, Blockchain is used to manage content, teaching, and qualification processes that are consensually evaluated by students, instructors, and employers, eliminating problems between the academic and the business sectors. Such initiatives also address the current challenges of higher education and provide a model approved by employers in the industry and applicable in many educational institutions.

In July 2017, a SAP company introduced “TrueRec” as a secure and reliable digital wallet for storing professional and academic credentials based on Ethereum. TrueRec has been made available to people enrolled in the online “Touch IoT” course delivered by “SAP Leonardo”, with more than 4500 students being able to receive and manage their certificates through TrueRec. (Boeser & Klein, 2020). The Netherlands Applied Scientific Research Organization, TNO, launched a self-sovereign identity framework with Blockchain. This framework is designed to provide official information in a digital form and only share a minimum amount of personal data that is managed and stored in the form of a wallet on a person's own mobile phone. This information provides formal confirmation of the person's identity and remit. (Self sovereign identity framework, 2020).
Related initiatives analyse in-depth the primary advantages and risks of using Blockchain in the energy efficiency industry by introducing and analysing two case studies with Blockchain implementations (i) UK Energy Company Liability Scheme and (ii) Italian White Certification Program (Khatoon et al., 2019). Bcertificated-Study is the certificate verification problem solving initiatives in open and distance learning programs with Blockchain and has been specially designed for a professional development program provided by a state university in Turkey. The progress of the trainees is closely monitored, as the certification process of education is based on process evaluation of different actors (students, teachers, authorities) (Gülseçen et al., 2018).

Finema is a decentralised identity platform provider that offers a new service called "Document Verification System" through Blockchain for the identification and verification of procedure related to document management ("Finema – Decentralized Identity Platform", 2020). Other Blockchain based certification and verification platforms include Open Certs, BitDegree, BCertificateD, KRYPTED, BLOCKCERTS, EDGECOIN, BIMcert, Stampery, Gradbase Bulgarian Open

Source University, CertiK, Woolf, Proof Of Existence. Open Badges is a Blockchain platform that organisations use to create and publish open badges for people to create collections and share them on the web. The earned badges contain data about their skills and issuing organisation in a portable image file. This data helps people find information when viewing and sharing their badges. They can follow all the badges in one place ("Home | IMS Open Badges", 2020). Smart contracts can also be represented as "automated and enforceable agreements" that bring key differences and innovation with the use of Blockchain. Similarly, Mikroyannidis et al., 2019 describe the experience of creating and using smart Blockchain badges (Mikroyannidis et al., 2019).
Another digital online platform has been developed by Mozilla in 2011 for sharing and viewing transactions on social networks with e-portfolios. Open Digital Badges were developed for this platform to be portable, collectable where competencies obtained can be stored, modified, and rearranged as required. The badges had an image that responded to the designer's taste and the needs of the day, and the properties of the badges are updated periodically. Mozilla stopped distributing free open badges, but the specs are still available. The IMS Global Learning Consortium was launched by Mozilla in 2014 to offer access to the IMS web page requirements with digital open badges (Jirgensons & Kapenieks, 2018).

As identified by the literature survey, a variety of barriers were identified such as: 'Economic barriers (lack of time for training, cost of training), awareness-related barriers (lack of understanding of the importance of skilled / trained workers), legal barriers (delays in introducing energy efficiency-related definitions), market barriers (low demand for energy-efficient buildings and thus for the skills required to build them), and knowledge barriers (language, varying levels of competence of the trainees, and lack of facilities for practical training)' (European Commission, 2018). Further, more recently the INSTRUCT Project (2020) has so far highlighted five major themes, which structure the main barriers and issues that the EU is facing:
"1. Lack of access to useful information, knowledge, and best practice guides for energy-efficient interventions.
2. Lack of demand for skilled workforce in energy efficiency.
3. Lack of availability, or inadequate, training programs (in terms of scope, quality, content, cost, etc.).
4. Lack of shared vision and values for energy efficiency across the supply chain.
5. Inadequate policy landscape, including lack of government incentives" (INSTRUCT, 2020)

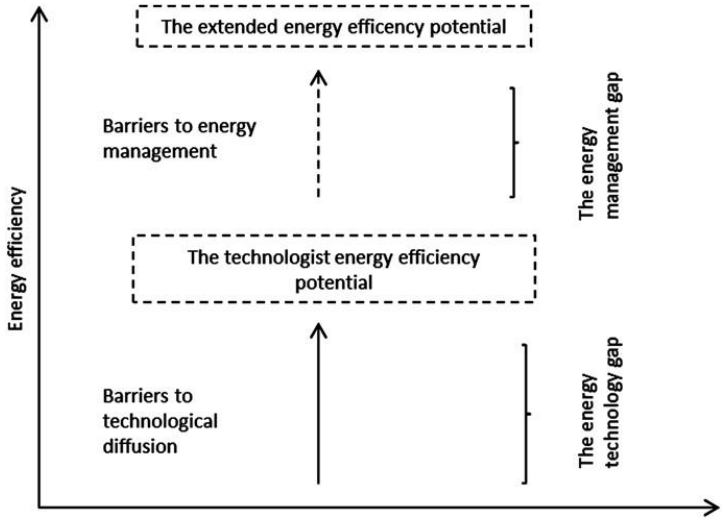


Figure 2. The extended energy efficiency gap. The energy efficiency potential level is increased if energy management practices are also included. Source: (Backlund et al., 2012)

Overall, these barriers contribute to an overall fragmented landscape in the field of training for energy efficiency, in the construction sector, in the EU. The problems are not only present at the macro level, in terms of policies, legislation, and stakeholders communication, but also on the micro-level, when, for example, it comes to the quality and efficiency of the training in itself.

BEET (FYROM)
BUS BEET made a pioneering step towards the introduction and validation of previous non-formal and informal learning in FYROM. During the project, a process for recognition of previous learning was developed. This process consists of identification, documentation, evaluation and certification. The process is completely compatible with the recommendations for necessary phases from the European Training Foundation. This new recognition process was well received. Most of the construction companies in FYROM acknowledged the new recognition process. During the project, 967 workers were certified through the process of recognition of energy efficiency skills. The candidates for skill recognition indicated the following benefits of the recognition of previous learning:

- Much shorter process than the previous training that led to the same qualification;
- Validated qualifications increase employability;
- Valorisation of previous knowledge, skills and experience;
- Qualifications can be acquired without formal training;
- The certificate is identical to the one obtained through more formal training;
- Insufficient competences can be completed by partial or modular training.

BUS BUILDEST II (Estonia)
BUS BUILDEST II can be considered as a good practice example in terms training material. The project provided video learning materials for VET trainers. Video materials covered many different fields, e.g. insulation of the cold-water piping with flexible foam covers, insulation of ventilation flume with strengthened aluminium paper covered flexible mat wool, insulation of heating piping with foil covered wool. These training materials were welcomed very positively by trainers and were largely supported by entrepreneurs.

In addition, BUILDEST II managed to integrate energy efficiency skills into professional standards. The project introduced incentives for more extensive awarding of occupational qualifications in the sector by developing an output-based evaluation of occupational competences. This included the accreditation of prior and experiential learning-based awarding of occupational qualifications in the construction sector. One of the lessons learned during the project is that the most effective method of training the non-qualified workforce is flexible integration of these participants into the existing vocational education system.

BUS N@W (Netherlands)
The project developed and implemented a qualification structure for post-initial training. This bridged the gap between initial and post-initial education in both building and installation sector. In post-initial education, the visualisation of the qualification structure made professional HR-advice for sustaining the built environment possible. In initial education, the developed qualification structure led to the development of several add-ons to the traditional curriculum.

Source: developed by the project team, based on the project reports

Figure 3. BUS project summary Source: (European Commission, 2018).

Initiatives such as the BUILD UP Skills, have allowed studying cases across the EU, and to identify successful practices. An example is presented in Figure 3. Further to that, projects like the St. Bricin's park by Dublin City Council, which was documented in the industry literature within the Fit – to – NZEB

project, point to optimistic outcomes, when efforts are properly coordinated. This is a case study "exceeded expectations and has set a feasible model for future reference" (INSTRUCT, 2020).

Within the INSTRUCT project "The INSTRUCT consortium partners have an established track record in working with vocational and academic institutions to identify new ways to face this Europe-wide training challenge. The consortium is drawing on (a) the engagement of internationally leading industry best practice, as well as vocational training, delivered by CPD through an established training value chain, (b) the educational excellence of leading institutions in Europe, (c) the robust experience of accrediting bodies in the construction domain, and the breadth of required industry-led research excellence. The consortium argues that this approach of engaging providers in the development and delivery of the material and standards will not only stimulate the demand for energy efficiency skills and competencies but also will align the level and calibration of the existing workforce (ranging from professional practitioners to blue-collar workers) and future industry professionals, thus providing a structure for lifelong development learning around in the field of energy efficiency" (2020). Moreover, research that was conducted by both the platforms of BIM4VET (Guerriero et al., 2019) and BIMEET (Petri et al., 2017), with regards to training for BIM, has resulted in useful insights, which need to be extended beyond the scope of BIM.

2.3 Conclusion

To conclude the literature and ongoing studies on the matter point towards an imminent need to structure a robust network and platform which tackles the issues, gaps, and barriers, within the EU context. The current barriers in the construction sector, but also successful examples in the field, are highlighting and further clarifying the landscape. As argued in the conclusions of the INSTRUCT project "By adopting a Europe-wide consultation that not only seeks to gather evidence correlating training with energy efficiency but also broadens the scope of the investigation beyond this mere objective (i.e. identifying the evidence correlating training with energy efficiency) to understand the complexity of the training landscape in energy efficiency and provide context to the resulting evidence, in a way that promotes generalisation of the results." Therefore, it is argued that a platform that coordinates the already present efforts and improves them is of utmost importance, to make sure that the potential of the current solution is fully adopted.

Chapter 3. Best practice initiatives for energy skills recognition

The following section includes a collation of data from D2.1 (interviews, questionnaires, and workshop insights), regarding training programs for energy efficiency in the construction sector, in the EU context. The consultation integrated insights from 33 participants for the questionnaire, 15 participants from 8 European countries for the workshop, and 28 interviewees from 9 European countries for the interviews.

The aim of this report is to a) highlight problems/barriers that are present in this relation and b) highlight best practices/solutions. Also, some suggestions for the next sensible steps are being presented, stemming from the analysis. The analysis revolves around the five themes that were present in D2.1, of the INSTRUCT Project report, and which were the focus in the consultation process:
1.Lack of access to useful information, knowledge, and best practice guides for energy efficiency interventions.
2. Lack of demand for skilled workforce in energy efficiency.
3. Lack of availability, or inadequate, training programs (in terms of scope, quality, content, cost, etc.).
4. Lack of shared vision and values for energy efficiency across the supply chain.
5. Inadequate policy landscape, including lack of government incentives.

For the scope of this analysis, however, more weight will be placed on theme 3 “Lack of availability, or inadequate, training programs (in terms of scope, quality, content, cost, etc.)”, due to its direct alignment with the purpose of argument. Ultimately, the analysis has as the main purpose to evidence the need to address the current fragmentation that exists in the landscape of training for energy efficiency, across the EU, and the imminent need to create a collaborative initiative.

3.1. Fragmentation in the construction sector

In this subsection, issues that contribute to the fragmentation of the construction industry (such as legislative barriers, conflicting interests, gaps, etc.) will be presented, by comparing the data from the questionnaires, interviews, and the workshop.

During the workshop sessions, with EU partners of the INSTRUCT project consortium what became evident was that the landscape across Europe, with regards to programs of training for energy efficiency, presents several limitations. The insights are presented in the table below: (Table 1).

Table 1. Workshop insights, theme 3 (INSTRUCT, 2020)

Lack of availability, or inadequate, training programs (in terms of scope, quality, content, cost, etc.).	▪ There are lots of training programs available, however they are similar in content, quality, and theory. They do not meet the needs of the workforce. ▪ Training for blue collar workers should be less theory based and more practical. ▪ ‘On the job’ training would be more suitable for blue collar workers. ▪ Whilst the participants agreed that ‘on the job’ training was the best approach. It was also highlighted that there would be challenges in providing such training on site. ▪ Lack of time is preventing workers from accessing training. ▪ Prioritising training would require a top-down approach. ▪ It is important to integrate qualifications into on-site training.

Overall, as argued by Rezgui et al., **"**The workshop participants agreed that a lack of training materials is not the issue, there is however a lack of relevant training for the workforce. This appears to be a European wide issue" (INSTRUCT, 2020). This information can be interpreted as indicative of an imminent need for coordination, management, and resolution of fragmentation in the landscape of training programs so that valuable resources do not go to waste, and, ultimately, the workforce can get the most out of the available material. Similarly, concerning the general focus placed on training for energy efficiency, most respondents sustained that, from their perception, it is not sufficient. (Figure 1).

ANSWER CHOICES	RESPONSES	
Yes	20.69%	6
No	44.83%	13
I do not know/I am not sure	34.48%	10
Total Respondents: 29		

Figure 4. Replies from Q19 of questionnaire "Overall, is the focus placed on training for energy efficiency sufficient, in the construction sector, in your opinion?" (INSTRUCT, 2020)

Despite these insights, the data from the questionnaires and interviews point to a more nuanced and complex argument, however. Overwhelmingly, participants who took part in the questionnaire, when asked about whether they thought the quality, frequency, and detail of the training that they received was overall satisfying (Figure 2), presented a more optimistic overview. Similarly, most interviewees, when asked about how comprehensive the material of training that they had been familiar with was, replied that it was overall comprehensive (Figure 3).

ANSWER CHOICES	RESPONSES	
Yes	59.26%	16
No	11.11%	3
I am not sure/I do not know	14.81%	4
Not relevant/I have not had experience with training	14.81%	4
If you answered "No", please briefly specify why	0.00%	0
Total Respondents: 27		

Figure 5. Replies from Q26 of questionnaire "Was the frequency and level of detail, including duration of the training that you have been involved with, appropriate?" (INSTRUCT, 2020)

Training Material-How comprehensive	28
Comprehensive	16
How it can be improved	15
No answer, other	7
Not comprehensive	5

Figure 6. Replies from Q14 of interviews: ¨How comprehensive is the training material for energy efficiency in the construction sector that you are familiar/involved with (and if you can elaborate on what that training is)? How can it be improved? (INSTRUCT, 2020)

With regards to barriers present in the construction industry on training for energy efficiency, and as seen in Figure 4, the data analysis points to training & education as being at the top of concerns. Most interviewees argued on how training is not effective as it should, referring either to the material, the way it is conducted, or of more profound and structural issues of education, awareness of the value of energy efficiency, and lack of skills in the field and education.

Barriers	28
Access to training	2
Awareness of environmental issue	3
Clients not paying for energy effic	1
Communication issues	2
Costs & Financial Issues	2
Lack of demand	2
Lack of interest	1
Legislation & regulation issues	5
Motivation & Incentives	4
No answer	1
No barriers	1
Perception of training for energy	2
Quality of training	6
State of industry & issues of coor	5
Time	6
Training & Knowledge not sufficie	6

Figure 7. Replies from Q4 from the interviews: "What barriers can you identify in the field of training for energy efficiency, in the construction sector?" (INSTRUCT, 2020)

On the same matter, the questionnaires offered further significant insights. When asked about common barriers of training for energy efficiency in the industry, participants highlighted several issues (presented in Figure 5), including: "not enough and proper information and awareness", "not enough time for training", as two of the most significant barriers, thus highlighting the road that is ahead in terms of next steps to be taken. It could be argued that a significant effort to properly disseminate knowledge and skills is an imminent need, but also to make sure that training is adapted to the trainees' needs.

To summarise, there seems to be a current gap, not only in the perception around training but also, it could be argued, around the eventual effectiveness of the training received. It is therefore important to make sure that the understanding of different stakeholders is coordinated, and that similar aims and standards are being taken into consideration.

ANSWER CHOICES	RESPONSES	
Not enough and proper information & awareness	42.42%	14
Procedural barriers	18.18%	6
Not enough interest in the field	39.39%	13
Financial/funding issues	42.42%	14
Inadequate number and quality of training programs	12.12%	4
Cost of training for energy efficiency	18.18%	6
Non-realistic & non-flexible timeframes for training	6.06%	2
Incongruence of values between sectors and layers of stakeholders involved in the construction industry	15.15%	5
Non-environmental friendly work procedures	6.06%	2
The challenge of replacing a retiring workforce	9.09%	3
The challenge of creating more demand for energy efficiency	24.24%	8
Inadequate understanding of the importance of a skilled workforce	24.24%	8
Not enough time for training	42.42%	14
Not adequate demand for energy efficiency buildings	27.27%	9
Not enough experience, and lack of expertise in energy efficiency technology	27.27%	9
Financial concerns and insecurities about the future that hinder investments in the field	30.30%	10
Lack of trained manpower/staff	24.24%	8
Difficulties in the access to capital	6.06%	2
Lack of government incentives	24.24%	8
Inadequate policies and legislations	12.12%	4
Resistance to change	36.36%	12
Language and communication issues	9.09%	3
Differences in competences of trainees	6.06%	2
Not enough facilities for training	9.09%	3
Other (please specify)	0.00%	0
Total Respondents: 33		

Figure 8. Replies from Q7 of questionnaire "What are the common barriers for training for energy efficiency in the industry?" (INSTRUCT, 2020)

When it comes to legislation, there appears to be an insufficient policy landscape, which is reflected both in the interviews (Figure 7), as well as from the insights gathered at the workshop (Table 2). This contributes to an overall problematic situation, which increases fragmentation in the industry and fails to coordinate common interests and values, but also to integrate them in practice.

Figure 9. Replies from Q17 of interview "With regards to policies & legislation, how effectively do you believe they integrate training? (e.g. the European Green Deal, which focuses on making EU's economy sustainable and EU climate neutral by 2050)", (INSTRUCT, 2020)

Table 2. Workshop insights, theme 5 (INSTRUCT, 2020)

Inadequate policy landscape, including lack of government incentives	▪ Government support is essential for any real changes in energy efficiency to occur. ▪ Policy landscape varies depending on the countries priorities. ▪ It was argued that pressure from industry can influence policy. There should be scope in the policy landscape that would allow for construction experts to mandate such policies. ▪ Better communication is required amongst countries to share energy efficiency instruments, best practice guides etc. and to improve policy landscape.

Further to that, some interesting observations emerge from the comparison between the perception of the questionnaire participants when it came to assessing the degree to which the importance of energy efficiency training is considered on a national and a European level. As seen in Figure 8, the EU context was assessed as an overall fervent ground for energy efficiency-with room for improvement, of course. On a national level, however, it was evident that there was a gap perceived (Figure 9). As argued by Rezgui et al. "this could indicate the importance of having a coordinated plan of action, perhaps stemming from a level of EU legislation, which helps level up the perception of training in the construction field"(INSTRUCT, 2020).

ANSWER CHOICES	RESPONSES	
Yes	41.38%	12
No	31.03%	9
I do not know/I am not sure	27.59%	8
Total Respondents: 29		

Figure 10. Replies from Q14 of questionnaire "In your opinion, is the importance of energy efficiency training being taken into consideration adequately by the construction industry, on a national level?" (INSTRUCT, 2020)

ANSWER CHOICES	RESPONSES	
Yes	31.03%	9
No	51.72%	15
I do not know/I am not sure	0.00%	0
I do not know/I am not sure	17.24%	5
Total Respondents: 29		

Figure 11. Replies from Q14 of questionnaire "In your opinion, is the importance of energy efficiency training being taken into consideration adequately by the construction industry, on a European level?" (INSTRUCT, 2020)

When asked about possible recommendations to improve training programs in the questionnaires, participants offered useful insights. It is of particular interest, for this analysis, to see the similarities between two different questions, the first one referring to an organisational level (Figure 10) and the second to a broader context, of the construction industry in general (Figure 11). Awareness, adequate promotion of training, the flexibility of training, and adjustments to the needs of trainees, and to make sure accreditation is part of the training are elements that emerge from both contexts. Securing funding to develop new materials was also part of the suggestions.

ANSWER CHOICES	RESPONSES	
Training taking place in specific periods	24.14%	7
Adequate promotion of training	44.83%	13
Make sure all parties and stakeholders involved are integrated in the process of developing training programs, from the start	34.48%	10
Make sure training is flexible and adjusts to the needs of those who undertake it	58.62%	17
Make sure training has a significant practical contribution for those involved	37.93%	11
Raise awareness for the need for training in energy efficiency	48.28%	14
Make sure certain parts of training are made core elements of curricula	17.24%	5
Make sure there is recognition/qualifications for the training undertaken	27.59%	8
Have a sense of responsibility for the future impact of the training	17.24%	5
Establish support for funding initiatives that support training	17.24%	5
Demand more ambitious results	27.59%	8
Make sure there are mandatory courses for construction workers	34.48%	10
Other (please specify)	3.45%	1
Total Respondents: 29		

Figure 12. Replies from Q15 of questionnaire "What are your recommendations to enhance training & skill development programs in your organisation?" (INSTRUCT, 2020)

When the interviewees were asked about specific ways that the training material can be improved, they offered a variety of answers, which tackle a range of issues. For example, the need for training to be more holistic in its approach, as well as to integrate new technologies available, was mentioned. Further to that, a better connection between training and legislative actions was highlighted as a need. Better cooperation among different stakeholders was part of the suggestions, to avoid problems of communication and to make sure the same values and goals are being taken into consideration. Furthermore, the importance of training to reflect not only academic insights, but also insights from the industry is very significant, and as such, to include the experience and feedback of practitioners.

ANSWER CHOICES	RESPONSES	
Training taking place in specific periods	34.48%	10
Adequate promotion of training	51.72%	15
Make sure all parties and stakeholders involved are integrated in the process of developing training programs, from the start	44.83%	13
Make sure training is flexible and adjusts to the needs of those who undertake it	55.17%	16
Make sure training has a significant practical contribution for those involved	58.62%	17
Raise awareness for the need for training in energy efficiency	51.72%	15
Make sure certain parts of training are made core elements of curricula	24.14%	7
Build up a database of companies involved in training	31.03%	9
Be supportive of any initiative that promote awareness in the field	24.14%	7
Make sure there is recognition/qualifications for the training undertaken	31.03%	9
Have a sense of responsibility for the future impact of the training	17.24%	5
Establish support for funding initiatives that support training	27.59%	8
Make sure training and educational programs involved in energy efficiency are integrated in national frameworks	31.03%	9
Demand more ambitious results	24.14%	7
Update relevant policies	27.59%	8
Make sure there are mandatory courses for construction workers	44.83%	13
Other (please specify)	0.00%	0
Total Respondents: 29		

Figure 13. Replies from Q16 of questionnaire "What are your recommendations to enhance training & skill development programs in the construction industry?" (INSTRUCT, 2020)

Some of the interviewees also pointed towards the importance of creating more comprehensive material (books, series of books, e learnings), and make them clearer and easier to use, for example, in terms of language. The need to improve the training of the trainers was also brought up. Lastly the importance of training for energy efficiency to contribute to the wellbeing of cities - therefore updating curricula, etc.

3.2. Examples of best practices of training for energy for efficiency

During the interviewing process, when interviewees were asked about whether they were aware of similar training programs, which they would deem successful, they offered a variety of replies. These answers offer insights on the type of (a) courses and training programs available (giving specific, concrete examples), and (b) descriptions/characteristics of such successful education, on the other hand. These two subcategories of data are grouped and presented below.

In the first category, we have institutions and platforms that provide such training, across Europe. Examples that were mentioned were the Bulgarian Sustainable Energy Development Agency, the Academy of Healthy Building, the Polish Passive House Association or the Green Building Council of Poland, FACE, The German Institute for Passive Construction, Train-to-nZEB – The Building Knowledge Hubs Fit-to-nZEB – training on deep energy renovation (towards nZEB), Kiinko, RIL, Metropolia, etc, the UP Academy, and the GBC. In the UK context, CIBSE was highlighted, as well as RIBA, BRE, as well as several Universities (Cardiff, Bath, UCL), and in the Welsh context, examples like the Centre for Alternative Technology. Further to that, institutions that offer training such as LEED, BREEAM, Well, were mentioned. In a European Context, a case of BUILD UP Skills consecutive projects was also mentioned, as a possibility of collaborative effort, where there were several stakeholders involved.
In the second category, the type of institutions that could help in this direction were discussed. NGOs, Universities, but also professional chambers, local courses, construction associations, summer schools, postgraduate studies, training for teachers, were among the ones that emerged.
Also, some suggestions were proposed. The need for training that reflects new activities, technologies, and prerequisites, was highlighted. The importance of an active engagement of the trainees and networking was also brought forth. There were suggestions on how schools should have training courses and assist in the process towards an overall raise of awareness. Lastly, the need for further training in passive design was mentioned.

In addition to that, during the interviews, the problem of fragmentation in the landscape of training for energy efficiency came up, due to extreme specialisation, the lack of understanding of how the entire value chain works, as well as the lack of a deeper awareness of the importance of energy efficiency. The importance to establish a robust certification system was also highlighted.

Furthermore, the BUILD UP Skills initiative, a similar initiative to the INSTRUCT project, was deemed not only as successful participants, but something that also emerged was as an overall agreement that similar initiatives need to be pursued in the future (Figure 12). As stated by Rezgui et al., “on a European Level, the BUILD UP Skills initiative created a basis for the education and professional development of “craftsmen and other on-site construction workers and systems installers in the building sector” (BUILD UP, 2020) in the EU, across 28 Member States” (INSTRUCT, 2020). The success of BUILD UP Skills, as accessed by interviewees, was connected to several factors. Up-to-date training material that is well organised and contributes to a general rise in awareness regarding energy efficiency in the construction sector, and a broader EU context that facilitates and organises actions, were among the positives that were discussed.

ANSWER CHOICES	RESPONSES	
Yes	65.52%	19
No	0.00%	0
I do not know/I am not sure	10.34%	3
I am not aware of the BUILD UP Skills initiative	24.14%	7
TOTAL		29

Figure 12. Replies from Q12 of questionnaire "Should initiatives like BUILD UP Skills be undertaken in the future?" (INSTRUCT, 2020)

To summarise, these observations could suggest that initiatives which transcend barriers in the EU and give the possibility to systematically investigate, research, and assess training in energy efficiency in the construction are not only welcome but part of a strong need to coordinate collective efforts in the field.

3.3. Conclusion

To conclude and summarise, this report aimed at presenting gaps and dissonances present in the current landscape of energy, as identified within the context of the INSTRUCT project. By collating and comparing data a more comprehensive overview is achieved. Some suggestions emerge from the analysis.

More specifically, this report highlights the need to:
1. Coordinate training and resolve dissonances that exist between national levels and the EU level, in terms of targets and quality of training.
2. Address the gap that seems to be present with regards to training and how well it adapts to the needs of the workforce, across the EU.
3. Create a robust legislative network of actions and policies which offer a point of reference across the EU and facilitates the application of actions for energy efficiency.

It is therefore highly suggested that this could all be facilitated through the establishment of a platform that addresses the overall phenomenon of fragmentation in the industry.

Chapter 4. Requirements for energy skills recognition

As elaborated earlier in this report, there is no authoritative solution supporting the standardisation and use of qualifications such as certificates, badges for learning, awards etc., (Suwal et al., 2019). Documents proving the authenticity of what has been achieved continue to be filed by trainees when obtaining educational attainment, education certificates and work experience records. In this process, the use of fake documents has been a problem for many years (Arenas & Fernandez, 2018). Due to this authenticity, and security problem, the adoption of new technologies is required with a full transition to digital records, resulting in a complex and time-consuming process for document verification. It is important to implement a more effective verification system to prevent document fraud as there is a limited capability for solving the training authenticity problem effectively. The resulting system may become so complex that it can cause delays to business activities and legal proceedings with multiple third-party agencies managing the online education certification inefficiently (Iqbal, 2020),(Sun et al., 2018).

As such, key requirements for such technology, include:

- **Trust**: An increased level of trust for a technical infrastructure that gives people enough confidence to handle transactions through the registration of skills and training certificates use of payments or certificates; Each user keeps a unique copy of training and certification related information in the network and all members must verify all changes collectively. These blocks are immutable, transparent, accessible, and allow members of the community to access their full history of transactions. There is a need to empower third-party providers as trusted administrators that check the credibility of the transaction in which all participants are involved. The key feature is immutability that reduces data breaches and increases confidence in the quality of data while decreasing the risk of fraud.
- **Self-sovereignty:** this essential for blue and white collars to identify themselves and at the same time to maintain control over the storage and management of their personal data and related skills and training information. Once a user has a fully complete self-sovereign identity, their personal data should be digitally stored on a platform with managed access and full user control. The truthfulness of that data is certified by third parties, such as an issuing or verifying institution where the certificates are also stored on the secured platform with the rest of the user data. This can give the user the power to fully own and control their own identity data and training records. The user can take the decision of what types of data will be stored and who has access to them. This can help reduce costs associated with identity management and offers complete transparency and increases trust.
- **Transparency:** it is essential for users that share their training information and personal data to carry out various services in a transparent and trusted manner.
- **Immutability: it is important that users** write and keep their personal and training records permanently without the possibility of alteration.
- **Decentralisation:** this is important for the elimination of a central control authority to manage training, certification, and job search transactions or keep records.
- **Collaboration:** this important to enable the training value chain to entire into all sorts of transactions directly with each other without the need for third parties.

Once the above requirements are met through a dedicated digital platform solution, the following services can be developed:

a. passports/registers for workers at regional/national level and support for their take up at EU level.
b. mobile applications facilitating the comparison of workers' skills and qualifications between countries,
c. new legislative frameworks or public procurement practices,

d. initiatives for home and building owners, and,
e. new partnerships with producers and retailers.

The architecture for such a digital platform and associated services are described in the following section.

Chapter 5. New tools for energy skills recognition

As reported by the literature, there is a need for new instruments to undertake energy efficiency training for the AEC sector (Suwal et al., 2019). In this report, we argue that Blockchain can be advantageous for energy efficiency training and can eliminate limitations that are identified in the delivery, certification, and verification of energy efficiency training.

5.1. Requirements for new methods in energy efficiency training

Blockchain is developing technology with numerous applications in the AEC sector including authenticity and privacy of data that exists across the sector. Blockchain provides significant opportunities for managing various industrial workflows with distributed, decentralised, persistence, and ability to execute smart contracts. Blockchain is used in many sectors such as medicine, food, construction, and finance with a recent implementation for the education sector. Blockchain technology can develop and facilitate development of various fields of education in relation to certification, licensing and accreditation, management of participation, management of intellectual property, and payments across associated activities (Risius & Spohrer, 2017).
In relation to training certification and labelling, Blockchain exposes a distributed ledger that provides a secured way for information to be recorded and shared by a community. In this community, each member maintains a unique copy of the information and all members must validate any updates collectively. The information could represent transactions, contracts, assets, identities, or practically anything else that can be described in digital form. Entries are permanent, transparent, and searchable, which makes it possible for community members to view transaction histories in their entirety. Each update is a new “block” added to the end of a “chain.” A protocol manages how new edits or entries are initiated, validated, recorded, and distributed. With Blockchain, cryptology replaces third-party intermediaries as the keeper of trust, with all blockchain participants running complex algorithms to certify the integrity of the whole. (Grech Alexander & F. Camilleri Anthony, 2017).
Blockchain technology is particularly suitable for securing, sharing, and verifying learning achievements within a digital platform (Smolenski, 2016). In the case of certifications, a Blockchain may keep a record of the certificate's issuer and recipient, including the document signature (hash) in a public database (Blockchain), which is stored identically on thousands of computers all over the world. Digital certificates that are encrypted on the Blockchain have considerable advantages over traditional and standard digital certificates. Such certificates are keeping a certain consistency and can be validated via transactions. The certificate was originally issued and received by those listed on the certificate. Certificate verification can be carried out using open source software and is easily accessible to those with access to the Blockchain. A certificate can still be checked even if the publisher no longer exists or has no access to that record. The hash is a "link" path to the original document held by the user. This means that the mechanism allows the signature of a document to be published without the document itself being published, thus protecting the privacy of the documents.
Blockchain technology can store learning records in a reliable, distributed manner while providing reliable digital certificates to support learning resource sharing with the smart contract and to protect intellectual property through data encryption (Sun et al., 2018). Blockchain technology will be able to permanently and reliably secure all kinds of certificates, especially the qualifications and success records given by educational institutions, rather than a paper-based system for certificates. Also, a more advanced Blockchain solution can be used to automate rewarding, identification, and transfer of credit, and to store and validate a complete record of formal and informal accomplishments throughout lifelong learning.
Blockchain technology enables therefore users to automatically check the validity of certificates against the Blockchain directly, without initially contacting the issuer. This can eliminate the need for educational institutions to validate credentials. It has been observed that the ability of Blockchain technologies to create data management structures in which users increase ownership and control of

their own data, can significantly reduce data management costs and liability exposure of educational institutions arising from data management issues (Belle, 2017).

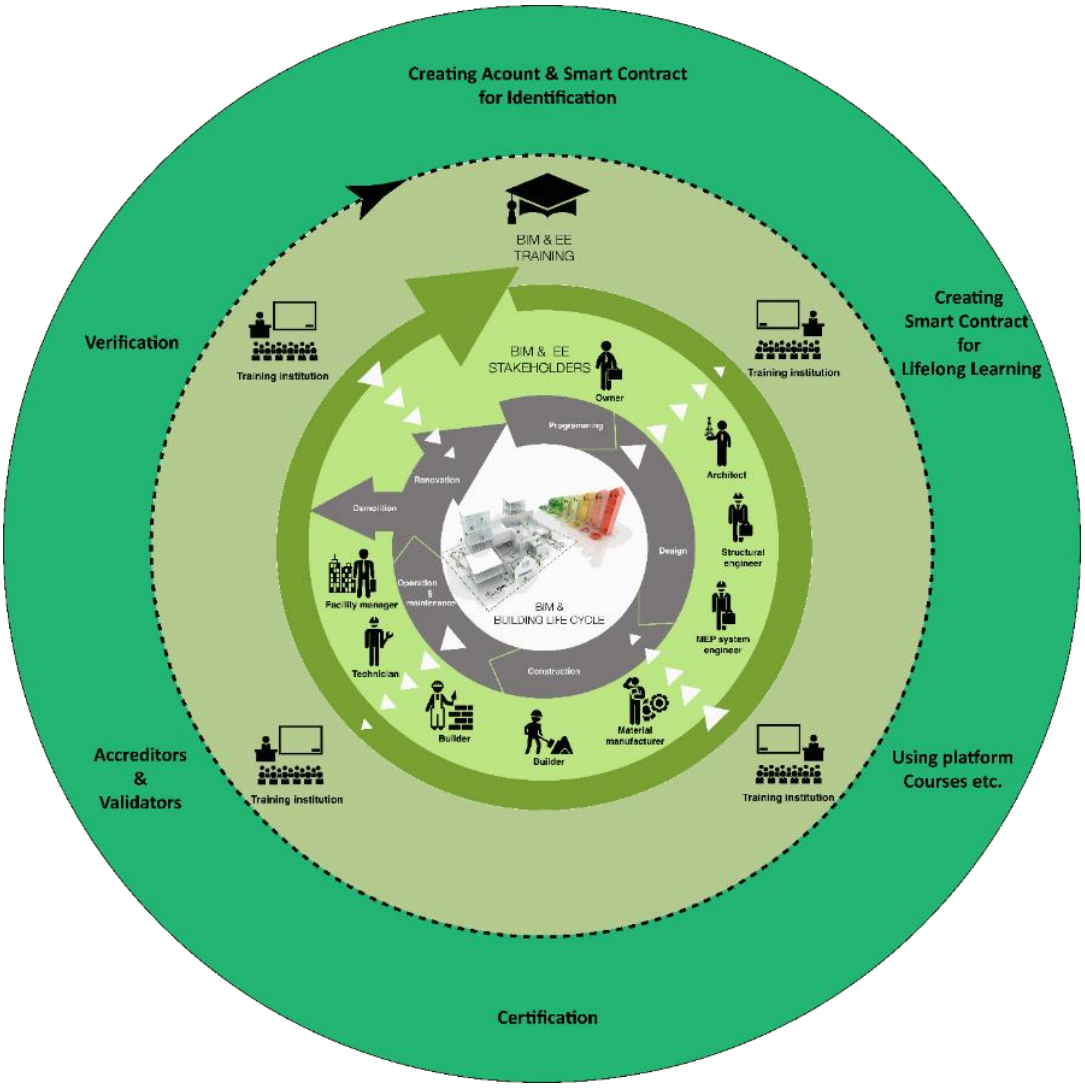


Figure 14: Energy efficiency training workflow

The certification processes from a Blockchain perspective, identify three main tasks (see Figure 14). Firstly, the identities of the certification authorities have to be created and maintained. Secondly, these certification authorities have to issue certificates to learners and the third main task is the verification of certificates by employers. These three tasks have to be supported adequately by a Blockchain-based infrastructure including the sharing of certificates by learners.

Learning data, including learning time, course files, and test results, can be stored in the Blockchain in chronological order. With this record, each data can be marked with a timestamp. The data accuracy is protected by the cryptographic-based recording method, eliminating the risks such as tampering or deletion. With the decentralisation, distributed database, and batch maintenance of the Blockchain, any education platform or organisation will be able to record users' learning trajectories across regions and time. This will increase platform efficiency and lower hardware cost (Sun et al., 2018).

Paper certificates for students have the advantage of being difficult to imitate due to built-in security features. However, there are some disadvantages, mainly related to the manual activity for third parties to validate the certificate or the need for certification authorities to maintain a record or

database for certificates over an extended period of time (Grech Alexander & F. Camilleri Anthony, 2017).
As courses and data security are connected to the online education platform with a centralised structure, the privacy of trainers is at risk. Due to the openness of the Internet and the falsifiability of data, users' intellectual property cannot be effectively protected. In order to make the learning process and its results reliable, it is necessary to develop a distributed and reliable data storage method to record the learning processes of users for making learning data public and to ensure the security and non-tamperability of the data (Sun et al., 2018). Blockchain technology is a desirable tool for solving the problems of online education and training including weak certification, lack of recognition, and data insecurity. It is imperative to ensure that the records of key entities in educational workflows, such as student enrolments, faculty enrolments, educational certificates shared with multiple stakeholders, are reliable (Salha et al., 2019). Blockchain technology allows the authentication and verification of certificates and enables a secured framework to hold these records consistently.
In addition, the use of Blockchain increases the collaboration between instructors and users. Blockchain allows users to own and control their own data, but does not change their grades or degrees, or certificates. Users can keep control of their own lifelong records and share their skills broadly. In addition, the distributed ledger technology allows new ways to pay for education so that more individuals can support users from different places and backgrounds. (Belle, 2017)(Tapscott & Kaplan, 2019).

As Blockchain technology can deliver mechanisms for the application of training labelling schemes, we develop our contributions around the following research questions:

Question 1: How Blockchain can be utilised to validate the authenticity of energy efficiency training programs across Europe?

Question 2: How Blockchain can support energy training by facilitating adapted training labelling and authenticity in training programmes in the Construction industry?

One of the major challenges identified in the AEC industry is the availability of a skilled workforce and experts with adequate energy efficiency skills. Some web applications support users to obtain and collect credentials involved in educational programs. But there is no platform supporting the standardisation and use of qualifications such as certificates, badges for learning, awards etc. (Suwal et al., 2019).
Documents proving the authenticity of what has been achieved continue to be filed by people when obtaining educational attainment, education certificates, and work experience records. In this process, the use of fake documents has been a problem for many years (Arenas & Fernandez, 2018). Due to this authenticity and security problem, the adoption of new technologies is required and a full transition to digital records, resulting in a complex and time-consuming process for document verification. It is important to implement a more effective verification system to prevent document fraud as there is a limited capability for solving the training authenticity problem effectively. The system is so complex that it delays valid business and legal proceedings with multiple third-party agencies managing the online education certification inefficiently (Iqbal, 2020),(Sun et al., 2018).

The current observations, have been obtained by using a thorough review of academic and conference papers, textbooks, reports, scientific documents and reliable Internet tools to understand current state-of-the-art Blockchain applications. To recognise common concerns in education and training, related literature and reported expert comments were critically reviewed. Through evaluating common problems in education, Blockchain models have been reviewed and solutions have been compared.

5.2 Labelling and learning outcomes for energy efficiency training

There are many definitions in the literature around learning outcomes. Commonly, learning outcomes are direct examples of what a learner should know, understand and be able to do when a learning activity is completed. Some action verbs used to define the taxonomy levels in the cognitive field are need and a basic structure of learning outcomes is needed. A learning outcomes methodology collects, develops, and verifies the required experience, skills, and competencies relevant to training including energy efficiency skills for various stakeholders. In relation to such correlation, there are educational institutions assigned to present skills, expertise, competence and learning outcomes in Finland based on a six-step protocol (Suwal et al., 2019).
Energy efficiency training labels are used to provide the necessary data to certify the user qualifications and to validate a certain standard (in the form of user category and level, usage, efficiency, or cost), to ensure the authenticity of training in different countries at a general level.
Educational institutions including governments are oriented towards valuing academic references and courses attended as examples of mastering certain competencies and skills. Such courses and references do not have much value if there is no standard in the trainings received. With the Blockchain labeling process, the value of such training can significantly increase and can be one of the important cornerstones that will contribute to lifelong learning (Alammary, Alhazmi, Almasri & Gillani, 2019).

5.3. Labelling and standards in energy efficiency training

The effect of energy efficiency standards and labels on the distribution of products in the market is illustrated in Figure 15 (Wiel & McMahon, 2003). As can be seen, time and cost will be optimised by reaching the awareness of the users with appropriate labeling and its contribution to the process.

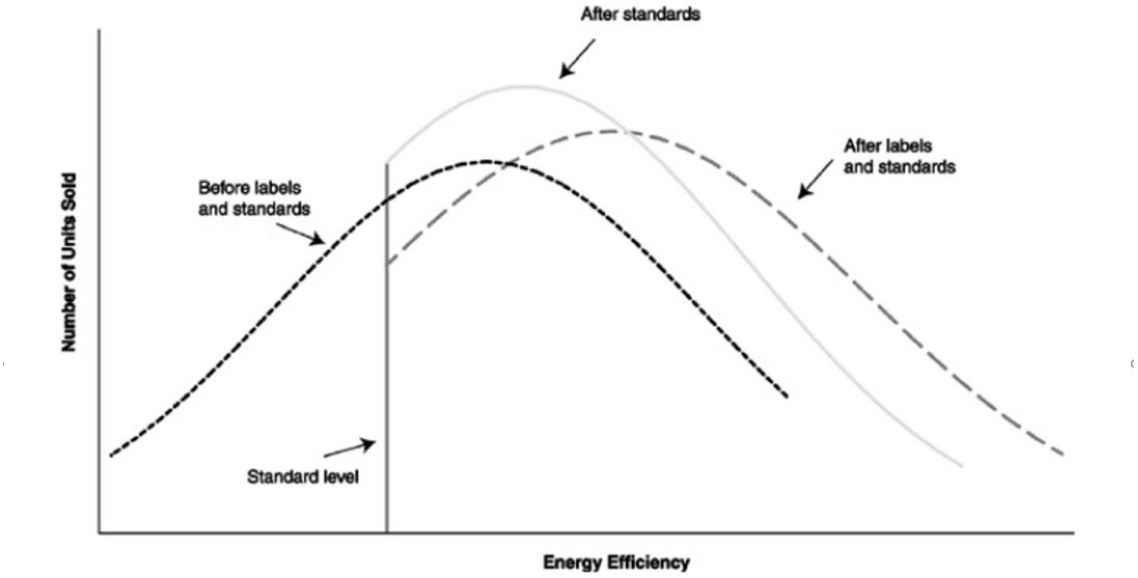


Figure 15: An example showing the basic structure of learning outcomes (Wiel & McMahon, 2003)

Labelling increases user welfare and strengthens competitive markets. Labelling of energy efficiency standards and developments in the market can make users qualified and adapted to new activities in the long term. Conversely, unnecessary, and inappropriate standards can undermine new emerging local industries and processes and can also confuse. Furthermore, labelling can save time and cost, increasing national economic efficiency and reducing unnecessary investment in infrastructure (Wiel & McMahon, 2003).

As such, Blockchain technology offers an infrastructure that provides permanent, stable, and secure management for multiple participants and supports secure governance for the advancement of

lifelong learning, giving users direct access and control to their achievements. Additionally, such technology promotes a positive approach to learning that respects user-centered and multi-faceted approaches to education. The features supported by Blockchain are in line with the quality assurance standards (QAS) and guidelines in the European higher education area. These are guidelines and standards that require a more learner-centered approach to education and recognition of flexible learning paths (Jirgensons & Kapenieks, 2018).
The following list of roles are subject to integration is a Blockchain based training: employers, trainers, accreditors, validators, testers, trainees, students, industry, academy, university, other users, contractors, manufacturers, training institutes, building professionals, facility manager etc. We present below the generic stages required for developing a Blockchain based energy efficiency training.

5.3.1 Registering a Blockchain acount for energy efficiency training

The idea of autonomous and non-transferable digital identity is associated with training labeling and indicates that no central administrator (such as a university, an academic examination organisation, or a licensing authority) may change or own identities and associated data anywhere in the world (Sun et al., 2018). Fridgen et al., (2018) have published a study on sending two smart contracts to the Blockchain using an accreditation authority to the platform. In this study, while the first smart contract is offered for the management of identities on the Blockchain platform for education, the second contract manages the life cycle of the certificates issued through the Blockchain.
General information provided by the user will be used for identification of the training which will keep a certain persistency over time (cannot be deleted or changed). This smart contract will be saved to the Blockchain and it will be used throughout the life span. Figure 16 presents several steps involved in the subscription and validation of energy efficiency training within a Blockchain system.

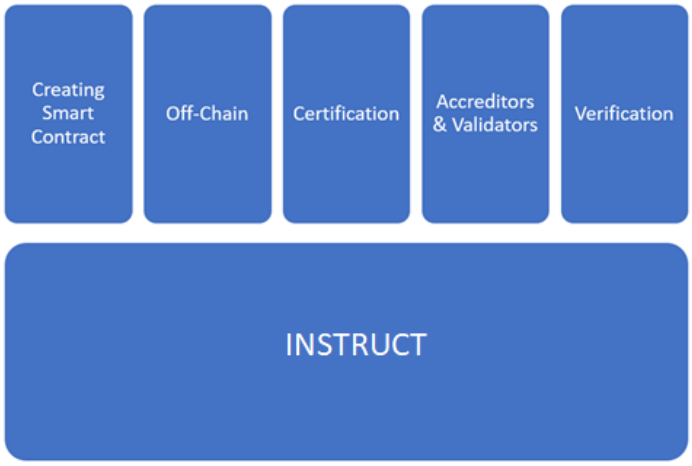


Figure 16: Steps in a training labelling workflow for INSTRUCT

Step 1: First contract for identification and recording a smart contract into the Blockchain
The training platform will first be started to register with two smart contracts. The first contract will be for the management of credentials as below (Figure 17): Person > Personal Data (Smart Contract - Hash) > Encryption > Hash of Identity stored on Blockchain

Contract name	Personal DATA
Person	Blockchain ID:
Input	Name:
	Birthday:
	Profession:
	Category/Class:
	Supported Documents if needed (CV-ID)
Timestamp	

Figure 17: Smart contract template for registering credentials

Step 2: Second Smart Contract (badge) for lifelong learning

The second smart contract will be prepared and used for recording data which is provided from the training platform and it will be an open ledger to save all accomplishments and data about the user throughout the life span. With the use of this second contract, the labeling process will continue for the entire lifetime and will provide an unchangeable ledger by keeping the user's own record (Figure 18): Person > Personal Data (Smart Contract - Hash) > Encryption > Hash of Identity stored on Blockchain

Contract name	Training DATA:
Person	Blockchain ID:
Input	Training:
	Grade average:
	Category / Skills:
Timestamp	

Figure 18: Smart contract (badge) template for lifelong learning

5.3.2 Course enrolment and labelling for energy efficiency

Blockchain can enable users (universities, companies, clients, trainer architect, instructor, etc.) to monitor and control energy efficiency training with appropriate labeling. The labeling is applied in accordance with the regulation and standards. Blockchain and IoT-based technologies can enable the education sector to transition seamlessly to full compliance with new labeling requirements. In general, technology can give the construction stakeholders the ability to receive, send and monitor data at all stages of the process, from training providers to training recipients.

When the registration has been completed successfully, the user will have a list of the trainings in the platform. Gained skills will be shared on the Blockchain network and the user account will be a link on the off-blockchain.

5.5.3. General structure of a Blockchain platform for energy efficiency training

All user accreditation information, studies, grades, input, and other data are stored within a network where the Blockchain can verify previous transactions. This generates a large set of data files that costs a significant amount than those that are normally not stored on the Blockchain. Such large files are then stored (off-chain) and referenced by means of a cryptographic hash.
The data lake is an independent data repository, known as stored-off Blockchain. The Blockchain is a transaction log that records all the changes that resulted in the data lake, while the data lake is an off-chain state database that holds the current values of a set of data. Some platforms are used to store documents and reduce storage costs while enabling document validity. We present below a platform that can support training labelling in energy efficiency based on Blockchain (Figure 20).

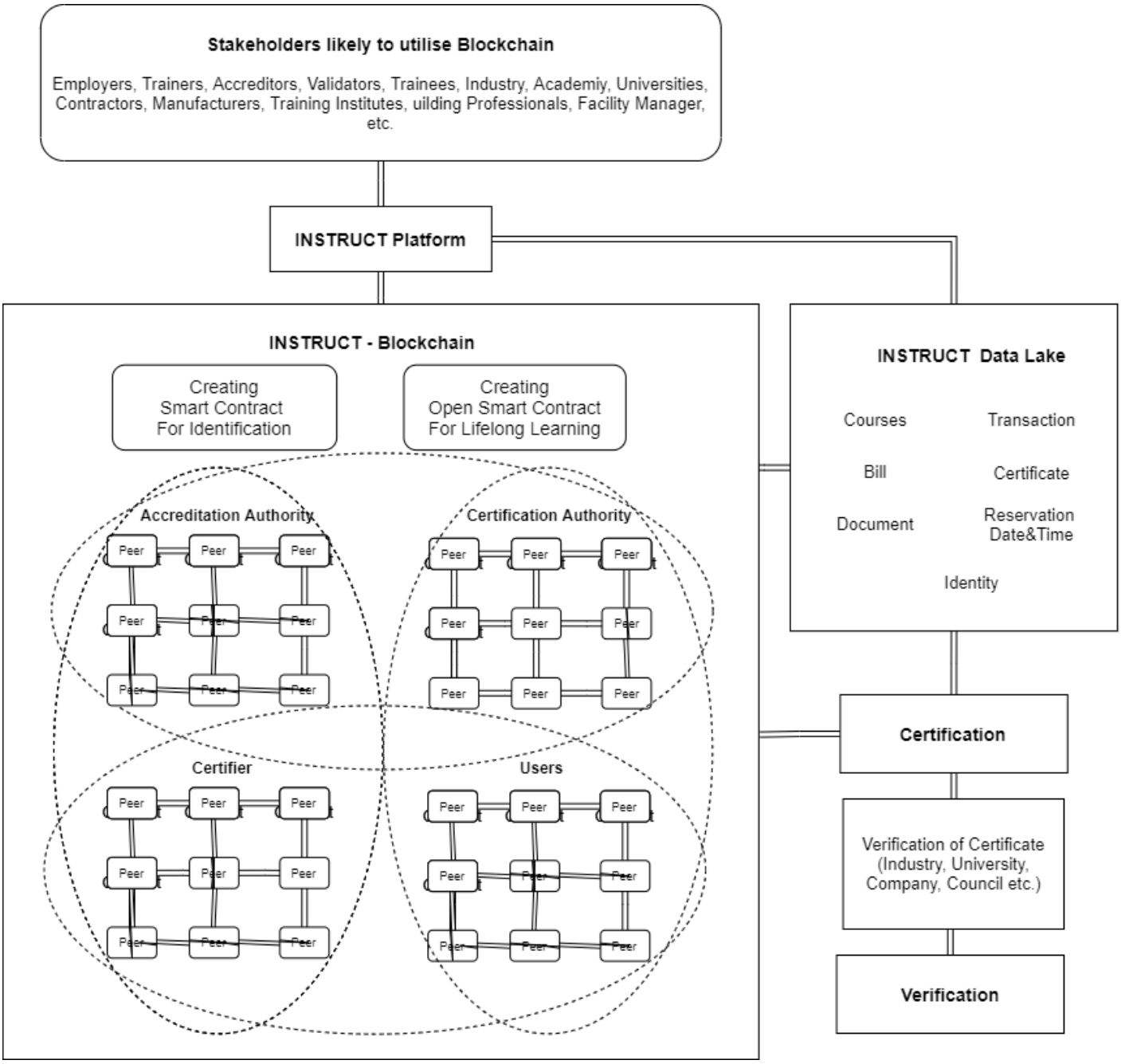


Figure 19: General structure of training labelling for INSTRUCT

In the profile designed for every user on the platform, smart badges allow for detailed digital recording of accreditation from both formal and informal learning contexts with additional dynamic features.

5.3.4. Label for lifelong training and control of knowledge

After the training program and associated examination when the result meets the smart contract requirements (i.e. grade >70%), the transaction will be recorded in the Blockchain. The smart contract can execute itself and on a year-based period like 5 years or 10 years, can launch a quiz to notify that the given label is still useable. This system can be also used as a reminder of the knowledge about energy efficiency training and education. The smart contract can run and update the given label and share it on the network automatically without the need for any third party. Optionally, the platform can send a question survey to participants. The system will recognise the certificate and will open the follow-up survey to generate a new certificate.

5.3.5. Certification

After successfully completing a course, users earn a certificate of completion. Certificates are available in all languages. The process of issuing a certificate involves the following steps (Schmidt, 2017):

- A digital file is created to contain basic details such as the name of the issuer and the recipient, the issuer name (Training Institution), an issue date, the credentials, etc.
- The Issuer then signs the details of the certificate cryptographically using an encryption key to which only the issuer has access.
- The Issuer adds the signing to the certificate itself.
- The Issuer of the certificate creates an encrypted hash of the credential file.
- The Issuer uses its private key to create a record on the Blockchain.

The workflow for recording a certificate involves all the stages from -> Issuer > Certificate (Hash) > Encryption > Signed Certificate > Hash of Certificate stored on Blockchain > Recipient to the user;

5.3.6. Verification

Training can be verified at any time in the Blockchain system using special hash code based on two phases:

Phase 1: Authorised users for certification
Currently, user records, learning courses, and other related regulations are controlled by authorised users, as well as test results inside databases or MS Excel sheets. This knowledge is used to grant learners' paper certificates. Consequently, the one significant function for authorised users is the import of data and test outcomes from legacy systems. Authorised users may browse the created certificates after importing the data. Furthermore, certification authorities the opportunity to scan for learners or to obtain an outline of learners and the outcomes of their qualifications according to learning courses. The summary encourages authorised users to list all training certificates once. The authentication of certificates and their preservation in the Blockchain is another key function for authorised users for certification (see Figure 8): Signer > Data (Hash) > Signed Document > share on the Network > Verifier > Checking Hash . If it matches the recorded hash, a user is allowed to use the system.

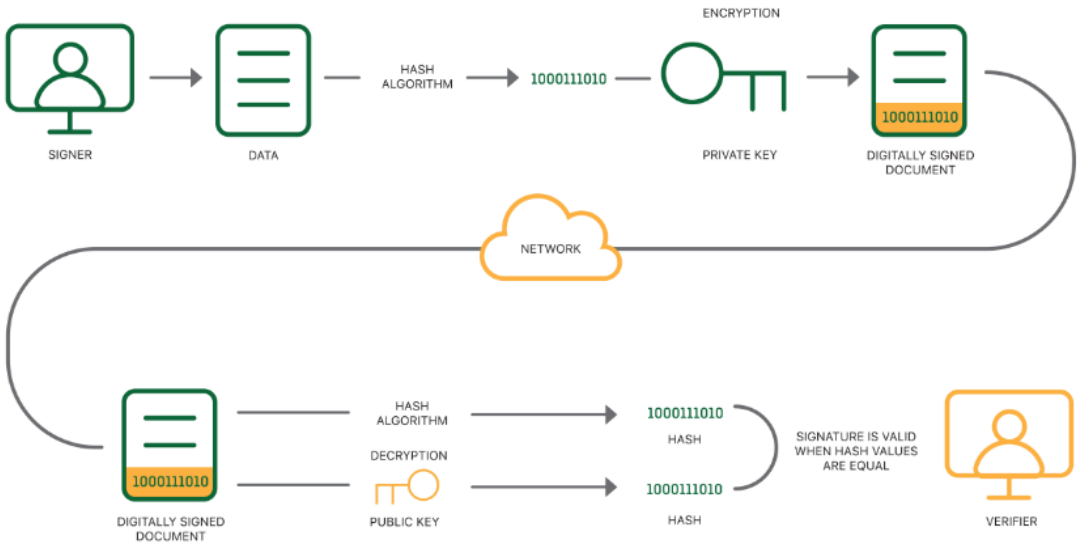


Figure 20: Training verification in Blockchain

Phase 2: Features for learners

Currently, learners often collect paper certificates with security features built-in. Learners often send digitised (scanned) copies or approved copies to potential employers via email. Importing certificates and creating an application portfolio is, therefore an essential feature of the viable product. In addition, learners need tools to manage their application portfolio and tools for distribution (Fridgen et al., 2018). With the use of Blockchain, a learner offers a secured artifact that can be used all over the world and can be shared with third parties such as an employer. The activities of these third parties such as reading or verifying certificates are digitally supported and easy to be verified.

Phase 3: Features for employers and blue collars

Employers usually only receive copies, often notarised copies of paper certificates from employees. In the first instance, the authenticity of the training is ensured by asking the issuing entity for the authenticity and validity of a certificate. This is a technique that employers often use to prove the validity of the copies which can be time-consuming and costly. Checking and verifying certificates is, therefore, an essential aspect of a product that needs a Blockchain-based solution (Fridgen et al., 2018).

Chapter 6. Conclusions

The aim of this report is to elicit the requirements for new, and existing, tools facilitating the mutual recognition of energy skills and qualifications in the construction sector. This translates into the following objectives:

a) identify best practice initiatives for energy skills recognition across Europe.

b) inform the development of new tools adapted to a wide range of country-specific organisational and cultural work practices across Europe.

As such, an overarching requirement is identified in the need for a widely accessible and trusted digital platform that can allow (a) training organisations to register their training offers and associated learning outcomes, (b) accreditation organisations to assess these and publish their accreditation outcomes, (c) white and blue workers to register their skills and trainings, and (d) employers to search and recruit the skilled workers most suited to their job across Europe. It is interesting to note that the job market has been deregulated as a result of the ongoing pandemic and the restriction of movements of staff. The recruitment of skilled workers, therefore, transcends existing geographical boundaries while promoting a competitive landscape for skilled workers adapted to a wide range of country-specific organisational and cultural work practices across Europe.
Blockchain is identified as a contender solution to deliver such digital platform, which will be augmented with a wide range of services allowing the delivery of:

1. passports/registers for workers at regional/national level and support for their take up at EU level.
2. mobile applications facilitating the comparison of workers' skills and qualifications between countries,
3. new legislative frameworks or public procurement practices,
4. initiatives for home and building owners, and,
5. new partnerships with producers and retailers.

However, several limitations need to be addressed for the solution to be viable. These are listed below:

- Blockchain technologies are in active development globally, and there may be new developments affecting our findings.
- The use scenarios selected may not adequately be covered as optimal approaches for the use of Blockchain in energy efficiency education.
- Lack of or insufficient roadmaps and examples for regulation and monitoring of Blockchain use in education. Further details on Blockchain operations in a learning environment are needed.
- In the context of integrating training with Blockchain, a lack of studies on labelling in the education sector makes it difficult to design a general framework.
- There are no systematic methods or views for assessing the process of learning and less methods to equate conventional forms of learning-books, courses, online learning, etc. with no common approach that can integrate all training elements within a comprehensive training framework.
- The problems of scalability and storage parameters are difficult to benchmark with a view to assessing the cost of hosting energy efficiency trainings in a Blockchain compliant framework.

These issues will be addressed in a follow-on deliverable.

7. References

1. Abraham, A. (2017). E-Government Innovationszentrum Whitepaper about the Concept of Self-Sovereign Identity including its Potential. 9. www.egiz.gv.at.

2. Alhamami, A., Petri, I., Regui, Y. & Kubicki, S. 2020. Promoting Energy Efficiency in the Built Environment through Adapted BIM Training and Education. Energies, 13, 2308.

3. Arenas, R., & Fernandez, P. (2018). CredenceLedger: A Permissioned Blockchain for Verifiable Academic Credentials. 2018 IEEE International Conference on Engineering, Technology and Innovation, ICE/ITMC 2018 - Proceedings, 1–6. https://doi.org/10.1109/ICE.2018.8436324.

4. Backlund, S., Thollander, P., Palm, J. & Ottonson, M. 2012. Extending the energy efficiency gap. Energy Policy, 51, 392-396.

5. Belle, I. (2017). The architecture, engineering and construction industry and blockchain technology. Digital Culture 数码文化 Proceedings of 2017 National Conference on Digital Technologies in Architectural Education and DADA 2017 International Conference on Digital Architecture, January, 279–284. https://doi.org/10.1308/147363508X260050.

6. Bernstein ET. AL, 2007. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom.

7. BUILD UP. 2020. About BUILD UP Skills. Available at: https://www.buildup.eu/en/skills/about-build-skills [Accessed 15/07/2020].

8. Boeser, B., & Klein, C. (2020). Meet TrueRec by SAP: Trusted Digital Credentials Powered by Blockchain | SAP News Center. Retrieved 13 September 2020, from https://news.sap.com/meet-truerec-by-sap-trusted-digital-credentials-powered-by-blockchain/.

9. Brockmann, M., Clarke, L., Méhaut, P. and Winch, C. (2008a), "Competence-based vocational education and training (VET): the cases of England and France in a European perspective", Vocations and Learning, Vol. 1 No. 3, pp. 227-244.

10. Clarke, L., Winch, C. and Brockmann, M. (2013), "Trade-based skills versus occupational capacity: the example of bricklaying in Europe", Work, Employment and Society, Vol. 27 No. 6, pp. 932-951, doi: 10.1177/0950017013481639.

11. Deloitte LLP. (2016). Blockchain: Democratised Trust. http://papers.ssrn.com/abstract=2662660.

12. Digital Certificates Project. (2020). Retrieved 13 September 2020, from http://certificates.media.mit.edu/ .

12. EUROPEAN COMMISSION.2018. Final Report on the Assessment of the BUILD UP Skills Pillar II. Available at: https://www.buildup.eu/sites/default/files/content/bus-d4.4finareport_on_assessment_april_2018_0.pdf [Accessed at 15/07/2020].

14. Fridgen, G., Guggenmos, F., Lockl, J., Rieger, A., Schweizer, A., & Urbach, N. (2018). Developing an Evaluation Framework for Blockchain in the Public Sector: The Example of the German Asylum Process. Proceedings of the ERCIM Blockchain Workshop 2018, Reports of the European Society for Socially Embedded Technologies, 10, 1–8. https://doi.org/10.18420/blockchain2018

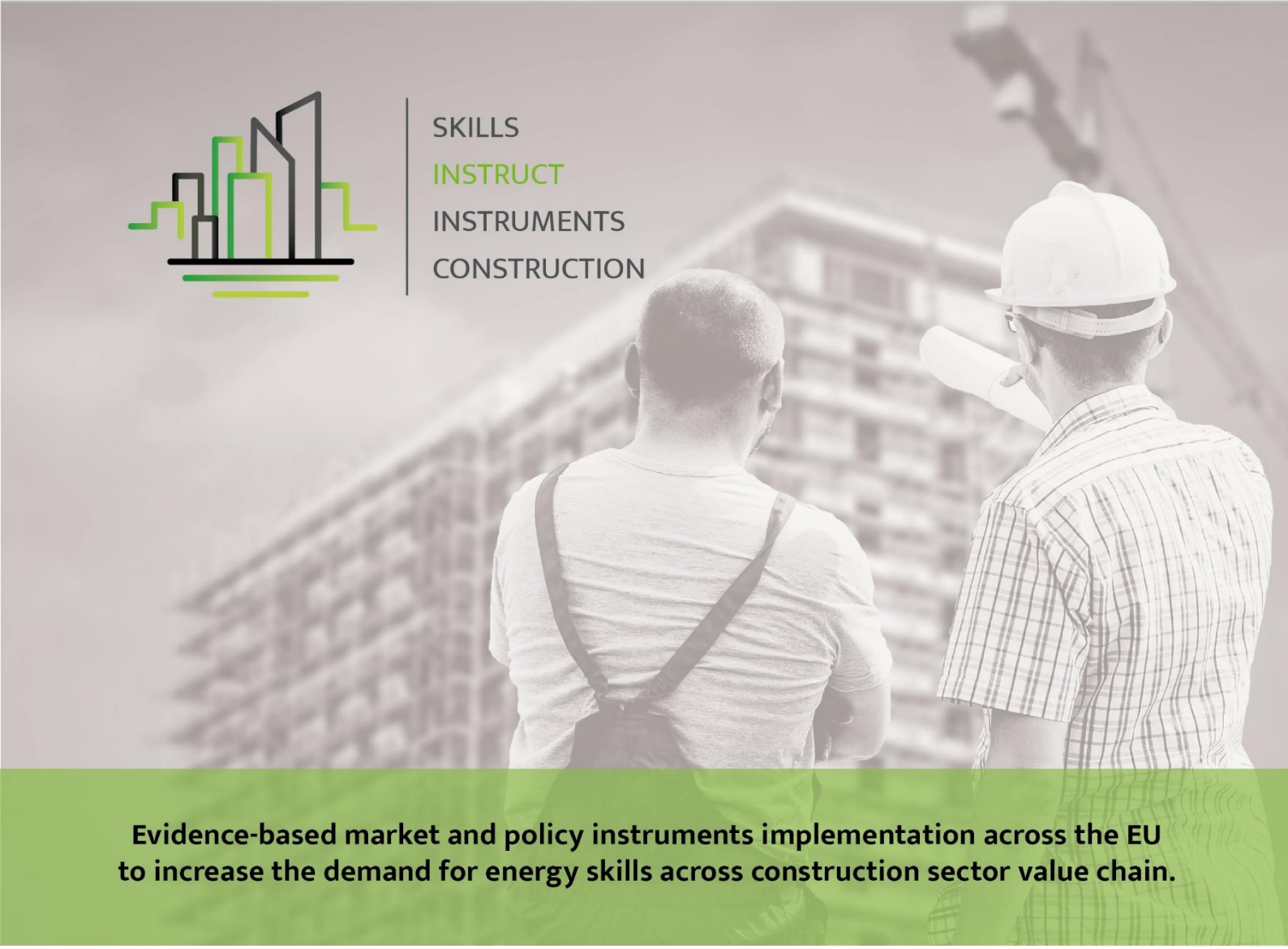
15. Finema – Decentralised Identity Platform. (2020). Retrieved 13 September 2020, from https://finema.co/.

16. Frischmann, R. M. (2020). Skills Label TM (Third Version).

17. Grech Alexander, & F. Camilleri Anthony. (2017). Utilising Blockchain Technology for Settlement in a Microgrid. In Jrc Science for Policy Report (Issue June). https://doi.org/10.2760/60649
18. Gülseçen, S., Erol, Ç. S., & Gezer, M. (2018). Future-Learning 2018 (FL2018), 7th International Conference on "innovations in Learning for the Future": Digital Transformation in Education.
19. Home | IMS Open Badges. (2020). Retrieved 1 October 2020, from https://openbadges.org/ .
20. Jirgensons, M., & Kapenieks, J. (2018). Blockchain and the Future of Digital Learning Credential Assessment and Management. Journal of Teacher Education for Sustainability, 20(1), 145–156. https://doi.org/10.2478/jtes-2018-0009.
21. INSTRUCT, 2020, D2.1 Evidencing the correlation between training and energy efficiency. Available from: < https://instructproject.eu/wp-content/uploads/2021/03/Evidencing-the-correlation-between-training-and-energy-efficiency.pdf > [17/05/2021].
22. Iqbal, W. (2020). Blockchain Application in Document Verification. Retrieved 13 September 2020, from https://medium.com/digital-realm/blockchain-document-verification-f9e40b708100 .
23. Khatoon, A., Verma, P., Southernwood, J., Massey, B., & Corcoran, P. (2019). Blockchain in energy efficiency: Potential applications and benefits. Energies, 12(17), 1–14. https://doi.org/10.3390/en12173317.
24. Li, Y., Kubicki, S., Guerriero, A. & Rezgui, Y. 2019. Review of building energy performance certification schemes towards future improvement. Renewable and Sustainable Energy Reviews, 113, 109244.
25. Lizcano, D., Lara, J. A., White, B., & Aljawarneh, S. (2020). Blockchain-based approach to create a model of trust in open and ubiquitous higher education. Journal of Computing in Higher Education, 32(1), 109–134. https://doi.org/10.1007/s12528-019-09209-y.
26. Méhaut, P. and Winch, C.A. (2012), "The European qualification framework: skills, competences or knowledge", European Educational Research Journal, Vol. 11 No. 3, pp. 369-381, doi: 10.2304/eerj.2012.11.3.369.
27. Mikroyannidis, A., Domingue, J., Bachler, M., & Quick, K. (2019). Smart Blockchain Badges for Data Science Education. Proceedings - Frontiers in Education Conference, FIE, 2018-Octob, 1–5. https://doi.org/10.1109/FIE.2018.8659012.
28. Oettinger, G., Rosenfield, A. & Tricoire, J.-P. 2013. VISUALISING the "HIDDEN" FUEL of ENERGY EFFICIENCY. J. Int. Energy Agency, 1-48.
29. Pan, W., Chen, L., W. (2021) Positioning construction workers' vocational training of Guangdong in the global political-economic spectrum of skill formation; Engineering, Construction and Architectural Management; ISSN: 0969-9988.
30. Pilz, M. (2016), "Typologies in comparative vocational education: existing models and a new approach", Vocations and Learning, Vol. 9 No. 3, pp. 295-314.
32. Petri, I., Kubicki, S., Rezgui Y., Guerriero A., & Li H. 2017. Optimising energy efficiency in operating built environment assets through building information modeling: A case study. Energies, 10 (8), 1167.
33. Powell, J.J.W., Bernhard, N. and Graf, L. (2012), "The emergent European model in skill formation: comparing higher education and vocational training in the Bologna and Copenhagen processes", Sociology of Education, Vol. 85 No. 3, pp. 240-258, doi: 10.1177/0038040711427313.
34. Review, A. S. (2019). Blockchain-Based Applications in Education :
35. Rezgui, Y. & Miles, J. 2011. Harvesting and Managing Knowledge in Construction: From Theoretical Foundations to Business Applications. London: Routledge.

36. Rezgui, Y. 2020, Methods, Tools, and Legislative Frameworks to Incentivise and Maximise Demand for Sustainable Energy Skills in the Construction Sector.
37. Risius, M., & Spohrer, K. (2017). A Blockchain Research Framework: What We (don't) Know, Where We Go from Here, and How We Will Get There. Business and Information Systems Engineering, 59(6), 385–409. https://doi.org/10.1007/s12599-017-0506-0 .
38. Salha, R. A., El-Hallaq, M. A., & Alastal, A. I. (2019). Blockchain in Smart Cities: Exploring Possibilities in Terms of Opportunities and Challenges. Journal of Data Analysis and Information Processing, 07(03), 118–139. https://doi.org/10.4236/jdaip.2019.73008 .
39. Self sovereign identity framework - Techruption | Community for Blockchain, Artificial Intelligence and Climate Change. (2020). Retrieved 13 September 2020, from https://www.techruption.org/usecase/xxcvxcvxcv/ .
40. Sun, H., Wang, X., & Wang, X. (2018). Application of blockchain technology in online education. International Journal of Emerging Technologies in Learning, 13(10), 252–259. https://doi.org/10.3991/ijet.v13i10.9455 .
41. Suwal, S., Laukkanen, M., Javaja, P., Hakkinen, T., & Kubicki, S. (2019). BIM and Energy Efficiency training requirement for the construction industry. IOP Conference Series: Earth and Environmental Science, 297(1). https://doi.org/10.1088/1755-1315/297/1/012037 .
42. Tapscott, D., & Kaplan, A. (2019). Blockchain Revolution in Education and LifeLong Learning: Preparing for Disruption, Leading the Transformation. April, 46. www.blockchainresearchinstitute.org/contact-us
43. Thelen, K. (2004), How Institutions Evolve: The Political Economy of Skills in Germany, Britain, the United States and Japan, Cabridge University Press, Cambridge.
44. Wiel, S., & McMahon, J. E. (2003). Governments should implement energy-efficiency standards and labels - cautiously. Energy Policy, 31(13), 1403–1415. https://doi.org/10.1016/S0301-4215(02)00199-4.

SKILLS
INSTRUCT
INSTRUMENTS
CONSTRUCTION



Evidence-based market and policy instruments implementation across the EU to increase the demand for energy skills across construction sector value chain.

ASM Market Research and Analysis Centre

R2M RESEARCH TO MARKET SOLUTION

ril

VTT

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

habitech
IL DISTRETTO ENERGIA AMBIENTE

EnEffect

LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY | LIST

www.instructproject.com

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 894756.