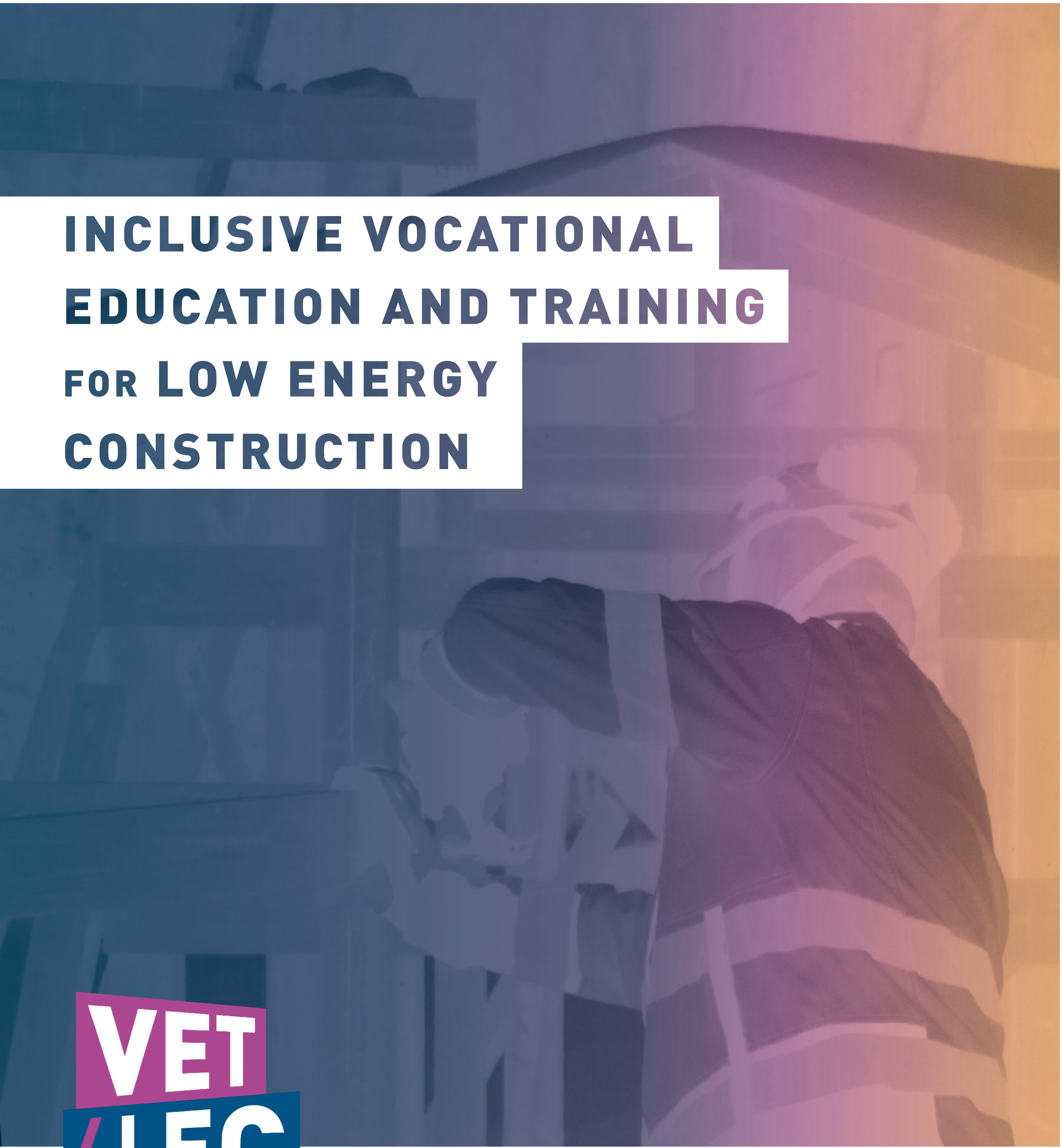
INCLUSIVE VOCATIONAL EDUCATION AND TRAINING FOR LOW ENERGY CONSTRUCTION



VET 4LEC

FINAL REPORT
FEBRUARY 2019

European Federation of Building and Woodworkers

EFBWW

FIEC

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PHOTOS: left: EFP vocational training college, Brussels, Belgium; above left: Metsatammi housing development, Finland; centre: Low energy construction using hemp insulation, Venice, Italy; above right: CEFME CTP training centre, Rome, Italy

INTRODUCTION

WITHIN THE CONSTRUCTION INDUSTRY we are confronted with a labour market contradiction: on the one hand unemployment rates remain at high levels in many Member States, in particular amongst youngsters, whilst, on the other hand, many vacancies are available in the construction industry. Workers and construction companies are confronted with difficulties in matching the right skills and professional qualifications with the needs of the companies.

Several factors can explain this situation:

- Innovation and technological changes, very often driven by external providers, are growing at an increasingly rapid pace. They have a strong influence on market needs and are thereby putting pressure on existing training schemes, which have to take such changes into account. Anticipating future skills needs is therefore a significant challenge for companies, as well as for training providers.
- “Green” policies, and in particular energy efficient work, require close coordination between the different occupations on a worksite, placing demands on these occupations that go beyond their immediate scope of responsibilities to understanding the building fabric as a unified system. This requires enhanced technical knowledge and soft skills associated with, amongst others, communication, team working and self-management.
- Despite a number of initiatives to make the construction sector more attractive, there are still difficulties in attracting and retaining women and, in several countries, young people in general. Combined with an ageing workforce, there is therefore a clear need to address such recruitment problems in the industry, amongst others through a more open and permeable labour market and construction process.

For the European Union (EU) Social Partners for the construction industry, the EFBWW (European Federation of Building and Woodworkers) and FIEC (European Construction Industry Federation AISBL), addressing these challenges is a priority and they have therefore been included in the multi-annual work programme of the "Construction" Social Dialogue Committee.

This project, which has been undertaken in cooperation with the University of Westminster and which was co-funded by the European Commission (DG EMPL), aims at providing some answers to the above mentioned challenges by looking at the situation in 10 different Member States and by developing some guidelines and recommendations, based on practical case studies.

Both the EFBWW and FIEC are convinced that strong cooperation between workers' and employers' representatives, as well as with vocational education and training (VET) providers, is key for improving the attractiveness and inclusiveness of our industry and thereby also its overall competitiveness.

We would like to thank all the colleagues who contributed to the achievement of this project, which constitutes a strong basis for future joint initiatives.

Dietmar Schäfers
EFBWW President

Kjetil Tonning
FIEC President

GLOSSARY

APEL	Accreditation of Prior Experiential Learning
BIBB	Bundesinstitut für Berufsbildung (Federal Institute for VET)
BUS	Build Up Skills
CEDEFOP	European Centre for the Development of Vocational Training
CHP	Combined Heat and Power
CIC	Construction Industry Council (UK)
CVET	Continuing Vocational Education and Training
DH	Detached House
ECVET	European Credit Recognition and Transfer System
EE	Energy Efficiency
EPBD	Energy Performance of Buildings Directive
EQF	European Qualifications Framework
ESCO	European Skills and Competences for Occupations Classifications
HLC	Heat Loss Coefficient
HVAC	Heating, ventilation and air conditioning
IVET	Initial Vocational Education and Training
KSC	Knowledge, Skills and Competences
LEC	Low Energy Construction
LZC	Low and Zero Carbon
NACE	Statistical classification of economic activities in the European Community (Nomenclature statistique des activités économiques dans la Communauté européenne)
NPV	Net Present Value
NZEB	Nearly Zero Energy Buildings
PE	Primary Energy
PH	Passive House
Psi values	Measure of heat loss along a meter of junction between two thermal elements
RES	Renewable Energy Systems
SQF	Sectoral Qualifications Framework
U values	Measure of heat loss per square meter of thermal element
VET	Vocational Education and Training

EXECUTIVE SUMMARY

Background

The Energy Performance of Buildings Directive (EPBD) requires all new buildings to be nearly zero energy buildings (NZEB) by 2020, with major implications for vocational education and training (VET) in construction. Low energy construction (LEC) calls for a different set of knowledge, skills and competences (KSC) to be deployed, as revealed in the Build Up Skills (BUS) investigation, which found that existing VET needs upgrading to incorporate a deeper knowledge and understanding of energy efficiency, higher technical skills, and a holistic approach to the building process. The cross-occupational co-ordination demanded implies interdisciplinarity, broad occupational profiles and transversal abilities, including problem solving and communication.

Objectives and methodology

The main aim of the VET4LEC project is to determine the expertise required for NZEB and contribute to developing a trans-European framework for VET for LEC. The objectives are:

- To evaluate different approaches to developing and delivering VET for LEC;
- To provide criteria for curricula development and outline components of a core energy literacy curriculum compatible with the European policy tools;
- To develop guidelines and recommendations on how to address the weaknesses identified.

Ten EU countries participated, representing different VET systems and industrial relations models: Belgium, Bulgaria, Finland, Germany, Hungary, Ireland, Italy, Poland, Slovenia and Spain. The first stage involved scoping each national VET system, including: the extent of VET for LEC provision; the construction labour market and workforce; and NZEB implementation. In the second stage, initial VET (IVET) and continuing VET (CVET) examples were assessed, particularly for building envelope occupations, to identify core KSCs required, aided by a conceptual framework developed to increase the transparency of construction VET and by visits to seven countries to interview VET for LEC providers, social partners, LEC contractors and LEC site personnel. Guidelines were then drawn up for VET providers and recommendations proposed for addressing weaknesses identified.

VET for LEC Developments

In all partner countries, VET is being developed to respond to NZEB requirements through upgrading existing IVET, introducing new qualifications for emerging specialisations, and CVET initiatives for the existing workforce. VET for LEC development and delivery are shaped by the VET model in place. In Belgium and Germany, VET for LEC KSC have been integrated into existing occupational profiles and curricula, reflecting the underlying broad occupational approach. Similarly in Finland, although LEC content is limited for envelope occupations. In Bulgaria, Ireland, Poland and Spain LEC courses are being introduced into IVET, though content can be limited and courses just add-ons, concentrated on renewable energy systems (RES) and only available at higher levels for building services occupations or technicians. Poland is incorporating LEC competences into its Sectoral Qualifications Framework, whilst in Hungary LEC competences have not yet been integrated into IVET programmes and, as in Slovenia, training is available as short, work-based courses. This variation presents a challenge to achieving consistency and transparency in VET and qualifications for LEC across Europe. CVET for LEC is varied, limited in scope and provided by a range of private and public organisations, except in Germany where it is co-ordinated and directly builds on IVET. Courses tend to target technical LEC aspects, e.g. RES installation, and higher VET levels (e.g. Poland, Spain), though opportunities for building envelope occupations at lower levels exist in Ireland, Finland and Italy.

Challenges and strengths in developing VET for LEC

Despite construction labour market and VET system diversity, countries face similar challenges in preparing the workforce for NZEB and providing effective VET for LEC, including:

- The high proportion of micro firms, each with limited scope to provide placements and/or work-based learning covering a broad range of activities, to contribute to training funds, and to afford CVET in LEC (e.g. Ireland, Italy, Spain).
- Skill and labour shortages, also manifest in LEC related specialisations, with shortages aggravated by difficulties for VET providers in recruiting trainees and EU labour mobility.
- Apart from Germany, levels of general education tend to be low in construction, with many workers lacking formal training and qualifications, deterring CVET participation.
- Often limited engagement for IVET and CVET and limited funding.
- Lack of adequate opportunities for the practical learning essential for LEC, except in Belgium and Germany, though dual-training and other forms of employer involvement are considered in, for instance, Hungary, Slovenia, Bulgaria, and Spain.
- Better resourced, up-to-date VET systems, as in Belgium, Germany and Finland, have greater capacity for integrating LEC KSC, though elsewhere VET has been upgraded, regulatory and governance arrangements improved and qualification frameworks aligned with the European Qualifications Framework (EQF)
- Stronger consultative structures facilitate stakeholder collaboration in addressing NZEB.

Guidelines for integrating LEC into VET and identifying core KSC

The guidelines enable construction IVET and CVET providers to ensure programmes prepare workers to meet EPBD requirements. Whilst more detailed work is required in each country, it is important to draw out core KSCs common for all, establish elements of effective systems for providing VET for LEC, and develop a framework applicable across the EU though flexible enough for adaptation to different contexts. Examples have been identified from partner and other countries of distinctive approaches to VET for LEC, suiting different contexts but also possible in combination:

1. *Common syllabus (Germany):* A prescriptive framework detailing the IVET curriculum, covering transversal abilities, and useful for developing specific training programmes.
2. *Common curriculum (Ireland):* Based on an introductory course for building operatives, specifying areas to be covered in the curriculum, and potentially forming a basic LEC IVET and/or CVET curriculum.
3. *Specific modules (Finland and Slovakia):* Based on standalone training modules developed for supervisory and managerial grades and useful for training at higher levels.
4. *Sector framework (Poland):* Setting out LEC requirements across construction occupations, based on EQF but with more detailed KSC, and valuable for developing occupational profiles and potentially identifying occupational overlaps.
5. *Occupational profiles (Belgium):* Developed into curricula by VET providers, with some content discretion, facilitating incorporation of transversal abilities.
6. *Content guidance (UK):* Setting out indicative content and learning outcomes by occupational area, emphasising different occupational roles and addressing occupational overlaps.

Through the VET4LEC project, a construction VET transparency tool has also been developed for building envelope occupations, facilitating curriculum designers in setting out core KSCs applicable to new build and retrofitting.

Conclusions/recommendations

Approaches to VET for LEC vary considerably, though countries face similar challenges and all need to ensure that VET is effective for meeting NZEB requirements, incorporates LEC-related KSC, and is sufficiently broad to cover transversal abilities and cross-occupational understanding. Deep integration of energy literacy into existing occupational profiles, curricula or syllabi at all levels is preferable to just adding LEC-related topics onto IVET programmes. CVET for LEC presents a challenge, particularly in the short term, as short courses and a range of delivery methods are needed, catering to different existing training and qualifications levels. Course content must be carefully considered, where possible specific modules should be part of a comprehensive and longer CVET programme, and funding is essential for providing an upgraded, comprehensive and accessible VET programme. Factors hindering VET for LEC development and undermining efforts to achieve an integrated construction process need addressing, including limited work-based learning opportunities, low VET participation by the self-employed and small firms, low construction VET currency, often weak labour market regulation, and fragmented organisation of work on site.

CONTEXT AND METHODOLOGY FOR THE STUDY

BACKGROUND

Low energy construction and implications for VET

The energy policy stipulated by the EU 2020 strategy aims to reduce CO_2 emissions by 20% compared to 1990 levels and increase the share of renewable energy and energy efficiency by 20%. The built environment is responsible for 40% of end-use emissions in the EU and identified as a major area of transformation. Article 9(1) of the Energy Performance of Buildings Directive (EPBD-2010/31/EU) requires Member States to take measures to ensure that by 31 December 2018 all new buildings owned and used by public authorities, and by 31 December 2020 all new buildings, are nearly zero energy buildings (NZEB). The EBPD sets out the general definition of NZEB and the Member States are tasked with transposing the Directive into national law and with implementation, submitting regular progress updates to the European Commission (EC)[1]. Despite differences in interpretation and implementation, these new specifications mean higher than existing energy performance requirements for all Member States (EC 2016a).

The EU strategy to improve the energy performance of buildings has major implications for the VET of the construction workforce because achieving the targets stipulated by EPBD and the Renewable Energy Directive (2009) depends on an adequately trained workforce. NZEB differs fundamentally from previous forms of construction as buildings must meet specific and stringent energy performance requirements for maximum energy use to be achieved through such measures as air-tight building envelopes, thermal bridge-free construction and on-site renewable energy sources, calling for a different set of knowledge, skills and competences (KSC) to be deployed in new buildings and the retrofitting of existing buildings. The question for VET providers in construction is therefore twofold: what KSC are required in low energy construction (LEC) and how can these be integrated into initial (IVET) and continuing (CVET) VET?

The scale of the task facing the construction sector is revealed by the findings of the Build Up Skills investigation (2010-2017), launched with the aim of increasing the number of workers qualified in energy efficiency measures and the installation of renewable energy systems (RES). In Pillar I (2010-2012), the 'quantitative' (i.e. the number of workers to be trained in LEC) and 'qualitative' (i.e. changes needed in existing VET) "skills gaps" in 30 European countries were identified and road maps developed, subsequently addressed in Pillar II (2014-2017) through projects developed by organisations in 22 Member States (EC 2016b and 2018). The analyses indicate that, whilst all Member States need to upgrade existing IVET in order to integrate LEC elements and provide CVET for the existing workforce, the scale of what is required varies greatly between countries. Whilst LEC training is being integrated into national IVET provision in some countries, in others it is non-existent except for short, one off courses provided, for instance, by RES manufacturers. This challenge is compounded by structural barriers, such as under-resourced VET systems in need of upgrading, weak regulation that undermines the value of qualifications, lack of awareness and interest, and limited government investment particularly in countries impacted by recession. Nevertheless, an unequivocal message is that LEC needs knowledge and understanding of energy efficiency and all aspects of construction, implying both theoretical and interdisciplinary learning.

1 https://ec.europa.eu/energy/en/topics/energy-efficiency/buildings

Problems in meeting low energy targets

The significance of the improved quality of training required is evident from the energy performance gap, which is the difference between the energy performance standards intended and actually achieved, as recognised in the 2016 Impact Assessment of the EPBD (Sunikka-Blank and Galvin 2012; EC 2016c). NZEB necessitates a construction industry capable of providing continuous insulation, controlled ventilation, heating/cooling and hot water heating, thermal bridge-free and airtight buildings supported by renewable heat and power. The assessment of buildings by their energy rating in kWh/m² implies a significant change from traditional construction evaluation methods where energy performance *per se* has been secondary to completion on time and on budget. Achieving such energy performance standards means a step change in the KSC of construction professionals and workers and a reconfiguration of: VET availability, scope and curriculum; occupational qualifications and access to continuing VET; site organisation, mechanisation and planning; and the employment model. It means greater communication between designers, builders and site occupations, team working, and a focus on the building as a single unit of envelope and services, installed and commissioned to meet an overall energy target.

Notwithstanding the challenges of collecting data on the performance gap, the construction phase is an important factor explaining its existence, raising questions about the skills deployed on site, VET quality, the organisation of the work process and employment practices. Short, technology-and firm-specific courses that do not provide the depth and breadth required have consequences for quality standards in NZEB. And low carbon performance is in jeopardy where only low levels of VET provision are in place or less qualified personnel are employed in installation, without the necessary depth of knowledge or precision skills. It is also jeopardised by current sharp divisions between professionals, managers and the operative workforce, divisions aggravated by subcontracting, low qualification levels, and difficulties in career progression, though these organisational, occupational and employment aspects of LEC have received all too little attention.

Multiple challenges: skills shortages, the recruitment crisis and women in construction

The issue of quality and standards in VET is also pertinent to the long-standing recruitment crisis. The shortage of skilled workers and the difficulty of attracting young people into the sector are common themes across the EU, prompting consideration of the potential role of VET and employment in construction in discouraging entry into the sector. The changing nature of the construction process in response to technological developments and climate change, however, opens up the possibility for a significant extension of the recruitment base. If VET in construction meets the higher levels of knowledge and competency required, it can become an attractive option amongst the many education pathways available to young people.

There is also a need to address the issues that deter women from entering construction. The dominant male presence in skilled construction work has changed little over the past 30 years, despite initiatives taken to improve the participation of women across Europe. Obstacles to integration have been shown in various research studies to relate to recruitment practices and working and employment conditions (Clarke et al 2004; Clarke et al 2015). The necessity for LEC introduces new factors including: the greater educational input required for thermal literacy; broader qualification profiles to overcome interfaces between different occupations; and integrated team working and improved communication given the complex work processes involved. Such requirements potentially open up the possibility to include more women, especially considering their generally higher educational achievements and greater presence on environmentally-oriented courses and in technical areas. In administrative, technical and clerical functions in the construction industry, women are also present in significant numbers, whilst their employment participation in some building professions, such as architecture, is much greater than in electrical work or civil engineering. The high levels of training required for LEC amplify the challenges of construction VET and the urgency for upgrading it to meet the needs of the sector.

METHODOLOGY

Aims and objectives

The Build Up Skills investigation established the scale of VET for LEC requirements, but the issue of the type of VET remains central, one which is addressed here. The project's main objectives are:

- to evaluate the different approaches to developing and delivering VET for LEC
- to provide criteria for curricula development and outline components of a core energy literacy curriculum compatible with the European policy tools
- to develop guidelines and recommendations on how to address the weaknesses identified

In addition to these elements, one should keep in mind that technological changes and possible new combinations of technical systems and work processes have a direct influence on career paths, working conditions, etc. based at company level. Through their decision-making companies have therefore some possibilities to influence future developments. This aspect is reflected indirectly in this report, but was not developed in depth.

Determining knowledge, skill and competence (KSC) requirements of VET for LEC

The evaluation of different approaches to and development and delivery of VET for LEC is based on assessment and comparisons of the construction labour markets and VET systems of ten EU countries to identify the broad structural barriers that impact on its development. The approach adopted has been developed in previous projects of the European construction social partners that aimed to identify future construction KSC needs and increase the transparency of construction VET and qualifications across Europe. These projects include SQF/CON (Syben 2009), Bricklayer (CLR 2010) and Bolster-up (IG Metall 2014), each of which played a role in developing the practical and easy-to-use transparency tool shown in Table 1 and an emerging strategy to facilitate the development of a sectoral qualifications framework (SQF) for construction, incorporating different construction occupations. The study here seeks to go beyond these earlier projects by identifying the KSC components required to achieve thermal literacy in construction in alignment with the European Qualifications Framework (EQF) and indicating adjustments in current qualification structures that might be made to incorporate these. This has involved initially refining the transparency tool and subsequently developing it with details and examples from the results of this VET4LEC project so that the construction social partners and VET institutions can compare the KSC components of VET and qualifications for LEC.

Key problems confronted in determining LEC KSC requirements are:

- their scope and level and how far they are distinct from traditional requirements;
- their need to be recognised by all construction actors in the process, including the designer, contractor and construction operatives;
- how the interfaces between construction elements (where energy losses commonly occur) is managed and the different occupations and subcontractors involved; and
- how far cross-disciplinary energy literacy is developed.

Green construction implies a singular approach to the building envelope and energy services required, hence the need to embrace the entire building process and cycle. However, the project focuses on the building envelope occupations, though low carbon technologies, such as heat pumps and micro-combined heat and power (micro-CHP), complement the envelope but are also sensitive to correct design and installation by building services professionals (e.g. electricians and plumbers).

Another complication in any attempt to determine requirements for LEC is the wide variation in construction VET systems and qualifications across Europe, including differences in the range of activities encompassed, both manual and non-manual, such as planning, communicating and coordinating – transversal abilities predicted to assume increasing importance

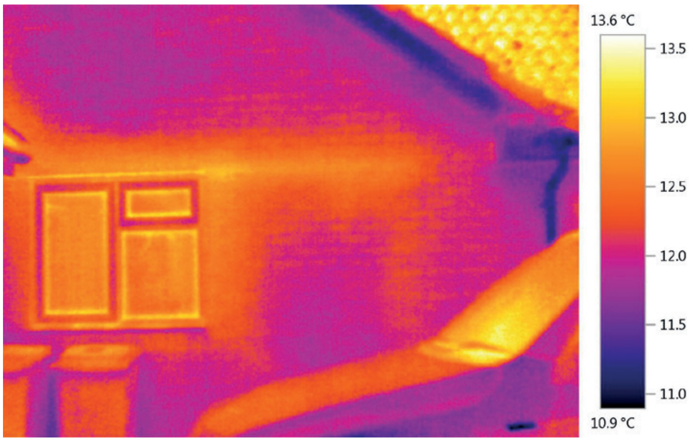


Photo: Oikonomou/Gleeson

Thermal image showing incomplete cavity wall insulation around window'

TABLE 1
Outline of a Transparency Framework
for NZEB qualifications

Aims of qualification

Vocational

Yes

Civic

Includes critical appreciation of construction industry and NZEB barriers

Liberal

Yes, allows scope for continuing personal development

Attributes

Knowledge

Know-how

Possession of each characteristic (apart from skill) presupposes personal development

Personal characteristics

(sometimes known as Competence or Attitude)

Knowledge

Systematic

Technical theory,

including some physics and engineering, knowledge of climate change theory. e.g.: Principles of 'quality' building:
- airtightness and
- thermal bridging,
- moisture and ventilation,
- significance of window quality and positioning.

Normative theory Health and safety legislation. EPBD.

Legislation governing NZEB and barriers to making it effective

Social science theory

Understanding NZEB role in contemporary debates and constraints on its introduction.

Non-systematic

Contingent facts

(e.g. local conditions)

To be acquainted with site layout, areas of potential danger, drainage channels.

Local procedures

e.g. site procedures for disposal of waste.

Materials

Insulation

Know-how

Mastery of technique

Skill: specific abilities connected with installation and evaluation of NZEB technologies, including development of appropriate tacit knowledge. e.g. waste management (see Table 6)

Transversal abilities

Co-ordination, Communication, Evaluation, Negotiation, e.g.
- Designing repair to moisture damaged structures.
- Supervising wet room installations.
- Controlling circulation onto and on site.
- Reacting to diverse situations
- Analysing state of site, diagnosing problems and solutions

Process management ability

Understanding of NZEB building process

Occupational capacity

Displaying conduct, way of thinking and behaviour necessary to practise occupation.

Personal characteristics

Individual

Curiosity, Independence Self-evaluation, e.g.
- possessing a sense of initiative, tackling problems arising by oneself.
- possessing a critical and analytical frame of mind.

Workplace	Other Locations
Yes	Yes, including simulations and classroom

Social

Co-operation, ability to see different points of view, e.g.
- exchanging information with colleagues and clients in friendly and constructive manner.
- having courage to accept colleagues' remarks relating to work and security and taking responsibility for pointing out dangerous situations.
- assisting colleagues so that team can work ergonomically.

Workplace	Other Locations
Yes	Yes, including simulations and classroom

At least one of these locations will be involved in know-how above a threshold level

Source: Elaboration of Transparency Tool (CLR 2010) applied to NZEB

(CEDEFOP 2010). This variation poses a particular and almost insurmountable challenge to developing trans-European curricula. By identifying KSC components of VET for LEC, the project is intended to strengthen and deepen EU VET policy tools in alignment with future requirements and promote transparency, innovation and greater mobility of construction labour and expertise. How these components are introduced into different VET systems will, however, vary considerably, whether forming part of a self-standing module or incorporated in IVET programmes in key occupations concerned. They should be of value to trainers and educators and facilitate VET co-operation around future needs, helping partner organisations to promote energy literacy within their respective VET programmes.

Participant countries

The synthesis presented here is based on analysis of VET for LEC provision in the ten EU partner countries participating in the project: Belgium, Bulgaria, Finland, Germany, Hungary, Ireland, Italy, Poland, Slovenia and Spain. These represent different VET systems, approaches to VET for LEC and industrial relations models:

- *Centre/Germanic Group – Belgium & Germany* have established social partnership arrangements, strong and encompassing collective institutions, juridically-defined industrial relations procedures, and substantive regulation of employment conditions.
- *Scandinavian model – Finland* has a well-established school-based system with social partnership and a significant work-based accreditation system. Employment relations are based on strong collective organisation of employers and trade unions and integration in para-state labour market regulation institutions.
- *Mediterranean model – Spain and Italy* have limited social partnership in their predominantly school-based VET systems, but with emerging dual system approaches. The development of stable VET structures is a policy priority for further economic development and in order to reduce deep-seated youth unemployment. There is formal union/employer involvement in this development and elaborate legal regulation of substantive employment conditions.
- *East European model – Bulgaria, Hungary, Poland, and Slovenia* all inherited developed school-based VET systems that have undergone varying degrees of reform, whilst retaining an element of general education. There have been policy moves towards developing dual apprenticeship (work based learning), which in some countries such as Hungary have been significant. Social partnership structures exist to varying degrees.
- *Anglo-Saxon model – Ireland* is identified as belonging broadly to the Anglo-Saxon liberal market economy model, rather than the coordinated market economy associated with the German system. VET is the responsibility of the state, including funding, with policy implementation and delivery divided between quasi-governmental bodies and regional education boards and minimal input from social partners. It is a mainly school-based system involving limited work-based learning, though with a historically substantial apprenticeship stream.

The study was completed in two parts. The first addressed the objective of establishing the *status quo* in each country with regards to the development and current provision of IVET and CVET in LEC in relation to the national context. This involved a mapping of the situation in the partner countries and included:

- *Analysis of the National Status Quo Reports (SQRs),* drafted by project partners and covering:
  - (i) the construction labour market and workforce characteristics;
  - (ii) the policy context of EPBD and NZEB implementation;
  - (iii) the national VET system and current LEC training, whether as IVET or CVET;
  - (iv) other initiatives relevant to VET for LEC developments.
- *Analysis of construction labour markets*
- *Review of European Construction Sector Observatory country reports*[2]
- *Reviews of Build UP Skills reports*[3] *and CEDEFOP country reports* on VET in the partner countries[4]
- *Review of EU NZEB national progress reports and evaluation of low energy building projects:* Partners were required to identify low energy building schemes, representing energy efficiency outcomes and included in the National SQRs.

In addition, visits were made to Belgium, Bulgaria, Finland, Germany, Italy, Ireland and Poland with the aims of:

(i) investigating VET for LEC provision in depth through interviews with VET providers and social partners;
(ii) exploring site organisation and energy efficiency achievements through interviews with contractors of low energy buildings.[5]

2 European Construction Sector Observatory Country Reports for all partner countries, available at: https://ec.europa.eu/growth/sectors/construction/observatory_en

3 Build Up Skills National Status Quo Analysis and Pillar II activities for all partner countries, links to national pages available at http://www.buildup.eu/en/skills

4 CEDEFOP Spotlight reports on all partner countries, available at http://www.cedefop.europa.eu/en

5 Summary reports of the visits available on a separate document.

Through a detailed analysis of information gathered from a wide range of sources and primary data based on first hand interviews, it was possible to identify both the challenges to developing and delivering effective IVET and CVET for LEC and the factors supporting the objective of equipping the workforce with the expertise needed to deliver the energy efficiency improvement anticipated in the EPBD. However, finding information about workforce characteristics and site arrangements on LEC schemes proved challenging, though data about technical specifications were plentiful and easily accessible. Similarly, gaining access to LEC sites and contractors during our country visits was not easy. Consequently, it was not possible to explore the relationship between energy efficiency outcomes, site practices (e.g. communication, co-ordination between occupations, employment relationship) and workforce characteristics, particularly the LEC training received. This would be a valuable subject for future study.

The second part of the study was concerned to:

(i) develop guidelines for VET providers to support the provision of LEC training to equip the construction workforce with the necessary KSC and
(ii) make recommendations for improving the inclusivity of the sector to recruit more women and to attract young people in the context of a LEC-driven increase in technical requirements and higher standards of training.

The guidelines have been developed through assessment of examples of IVET and CVET for LEC identified in collaboration with project partners, including (see Section 4):

- Occupational profiles from Belgium (IVET)
- Curricula from Germany (IVET and CVET)
- A sectoral framework from Poland (IVET)
- Specific modules from Finland (CVET)

These are supplemented with 'good' examples from two EU countries not partner to the project, which can be used in different national contexts:

- A module based training programme relating to higher level VET for construction professionals from Slovakia, developed as part of a Horizon 2020 project and
- Course content guidance from Britain, developed by Leeds College of Building for the Construction Industry Council (CIC 2017).

Whilst this study focuses on building envelope occupations, examples from Finland and Slovakia target other construction professionals (e.g. site/ project managers, architects, engineers) and were included to illustrate a modular approach to training the existing workforce, one which can be adapted for building envelope and services workers.

The findings were elaborated in discussions with project partners held at regular steering group meetings, two seminars and a final conference.

DIFFERENCES BETWEEN COUNTRIES AND THEIR IMPLICATIONS

One of the main challenges confronting the research has been the considerable disparity between the ten countries with respect to their labour markets, their interpretation and implementation of NZEB, their different VET systems, and the very different approaches to the development of VET for LEC. At the same time, certain similarities are observable between particular country groups in terms of, for instance: the mainstreaming of VET for LEC into the existing construction occupations in Belgium and Germany; the concerted attempts to embrace NZEB and develop VET for LEC in a comprehensive way in Finland and, to a lesser extent, in Ireland; the many regional and local initiatives, in particular in terms of CVET, in Italy, Spain, Slovenia and Poland; and the more limited and sporadic efforts observable in Bulgaria and Hungary. Such groupings have overlaps with, but also diverge from, the traditional industrial relations ones (see page 13). With these differences in mind, this section presents a synthesis of the constraints facing the development of VET for LEC and draws out the implications for the different IVET and CVET systems and for the implementation of NZEB.

Innovation in the construction industry in the form of LEC has to contend not only with a labour market bound to existing and often traditional practices but with the current and newly recruited workforce largely lacking in the energy literacy required. To be effective both the labour market and the VET system need to change considerably. The value of this project has been to examine both – the labour market and the VET system – for the ways in which the development and effective implementation of NZEB are constrained. It thus builds on the considerable efforts associated with the EU's *Build Up Skills* programme and at the same time seeks to enhance understanding of the transformation needed in the construction industry itself if climate change targets are to be met.

CONSTRUCTION LABOUR MARKETS

Differing sizes of labour market, number and types of firms

Our ten countries differ significantly in terms of the size of the construction sector. This is perhaps best gauged from the size of the workforce, as indicated in Table 2, based on statistics given in the national reports on the number of employees, which show that, according to the size of the country:

- Germany has the largest construction workforce, followed by Italy, Spain and Poland;
- Hungary, Belgium and Bulgaria have medium-size construction workforces;
- Finland, Ireland and Slovenia have the smallest construction workforces.

As can be also seen from Table 2, the picture in terms of number of construction firms, as reported by our partners, can be rather different from the size of the workforce. Here the largest number of firms is found in Italy, having 529,103, followed by Poland with 480,000 and Spain with 406,682. Hungary, at 85,000, Germany at 73,664, Ireland at 61,965 and Finland at 41,616 each has fewer firms, whilst Belgium (24,331), Slovenia (17,757) and Bulgaria (4,862) report a very low number. However, these figures need to be treated with caution not only because they may appear at odds with the size of the workforce (e.g. Germany and Poland) but also because there are important differences in the definition of construction in different countries. This means that figures are not directly comparable, in particular for Germany where they refer only to the main building specialisms and a narrow range of NACE categories. In the German national report, for instance, while 73,664 construction firms are reported, elsewhere estimates were as high as 338,535 in 2014, having increased from 238,924 in 2010 (Eurostat 2018)!

TABLE 2
The construction sector and workforce

	No. Enterprises	Small firms %	No. persons employed	Self-employed %	Women %	Non-national workers %
BELGIUM	24,331	93 (<20)	251,360	24.7		15
BULGARIA	4,862	87 (<50)	216,400	5.0	7.0	
FINLAND	41,616	99	176,800		7.9	17
GERMANY	73,664	89 (<20)	2,272,627	11.0	12.0	14
HUNGARY	85,000		317,500	12.5		
IRELAND	61,965		142,500	36.7	9.2	18
ITALY	529,103	96 (<9)	1,444,700	43.0	<10	30
POLAND	480,000	98 (<9)	853,000		9.1	30
SLOVENIA	17,757	96.5 (<10)	54,314	58.9	9.0	32
SPAIN	406,682	97 (<10)	1,000,000	29.0		16

HIGH MEDIUM LOW

Source: National reports for the VET4LEC project

TABLE 3
Eurostat Key indicators: construction sector 2015

	No. Enterprises (000s)	No. persons employed (000s)	Turnover (€ million)	Value added (€ Million)	Apparent labour productivity (€ 000s per head)	Personnel costs (€ million)	Average personnel costs (€ 000s per head)
BELGIUM	22.8	81.2	24,197.4	4,554.4	56.1	2,786.3	49.9
BULGARIA	7.1	56.8	2,628.7	520.9	9.2	258.2	4.9
FINLAND	18.1	71.0	13,604.3	3,349.4	47.2	2,436.1	40.9
GERMANY	25.3	291.9	58,079.7	17,682.0	60.6	11,551.5	41.8
HUNGARY	13.7	56.1	4,462.2	806.6	14.4	394.0	7.8
IRELAND	13.8	27.5	6,240.9	1,318.7	47.9	937.9	44.3
ITALY	119.4	320.1	56,501.0	11,517.9	36.0	7,605.7	35.1
POLAND	62.1	265.9	25,304.0	3,973.5	14.9	2,239.6	11.2
SLOVENIA	2.9	1387	1,136.3	253.3	18.4	203.7	16.2
SPAIN	195.7	428.8	48,436.4	12,675.6	29.6	8,219.3	30.3
EU 28	869.3	3122.6	575,915.2	149,948.1	48.0	82,087.3	32.3

HIGH MEDIUM LOW

Source: Eurostat statistics [6]

6 https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:T4aKey_indicators,_Construction_of_buildings_(NACE_Division_41),_2015.png and https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:T4bKey_indicators,_Construction_of_buildings_(NACE_Division_41),_2015.png

TABLE 4
Persons employed in construction by enterprise size in 2015

	Total (000s)	SMEs (% of total)	Micro (% of total)	Small (% of total)	Medium-sized (% of total)	Large (% of total)
BELGIUM	81.2	89.1	47.5	21.7	20.0	10.9
BULGARIA	56.8	94.2	20.61	38.1	35.5	5.8
FINLAND	71.0	86.0	42.6	30.2	13.2	14.0
GERMANY	291.9	90.4	23.9	44.3	22.2	9.6
HUNGARY	56.1	85.0	48.4	36.6		
IRELAND	27.5	88.1	64.6	23.5		
ITALY	320.1	97.9	64.9	25.2	7.7	2.1
POLAND	265.9	89.9	52.8	19.7	17.3	10.1
SLOVENIA	13.8	82.1	43.7	22.0	16.5	
SPAIN	428.8	97.5	73.6	18.1	5.8	2.5
EU 28	3,122.6	87.8	45.2	26.8	15.7	12.2

HIGH MEDIUM LOW

Source: Eurostat statistics[7]

From available Eurostat statistics (Table 3) from 2015, a further general picture, one often at variance with the figures reported in national reports, can be gleaned of some of the differences between our ten countries and how far the different labour markets form distinct patterns. A perhaps more reliable indicator of the size of the sector than the number of firms is the value of turnover, with Germany, Italy, and Spain having the highest, followed by Poland, and then Finland, whilst Ireland, Bulgaria Hungary and Slovenia in declining order have the lowest. Whilst turnover size is associated with the amount of personnel costs, this is not the case for apparent labour productivity or for average personnel costs, as again evident in Table 3. Thus, though construction turnover overall in Belgium is much lower than in Germany, average personnel costs per head are higher and apparent labour productivity only a little lower. Ireland and Finland too each has a relatively high labour productivity and average personnel costs per head, though the size of the sector as measured by turnover is small. High labour productivity is also generally associated with comprehensive and good quality training systems (see Clarke and Herrmann, 2004).

A more important indicator than number of firms with regard to the nature of the construction industry in the different countries is firm structure. This is particularly significant for VET because, if extremely fragmented, it can be difficult to provide broad work-based training in a range of activities, especially in employer-based systems where the trainee is bound to a single employer. The problem is overcome or alleviated in: a) group-based VET systems, where trainees rotate across a number of firms; or, b) dual and school-based systems, where there is a substantial simulated or off-site and workshop-based VET component, as in Germany and Belgium. A broad-based VET system is particularly pertinent in relation to LEC, which, as the *Build-up Skills Overview* (EC 2014) stresses, requires cross-trade knowledge and skills, coordination between occupations, and interdisciplinary training opportunities in order that trainees gain a holistic view of the construction process.

Where there is a myriad of micro firms, therefore, we would expect little substantial work-based training to take place. As evident from Eurostat figures from 2015 shown in Table 4, about two-thirds or more of firms in Spain, Italy, and Ireland are micro firms, compared with less than a quarter in Bulgaria and Germany and a half in the remaining countries: Belgium, Finland, Hungary, Poland and Slovenia. In addition, nearly 98% of firms in Italy and Spain are SMEs, compared with just 82% in Slovenia. Only in Finland, Poland, Belgium and Germany do we find a relatively high proportion of large firms, between 10% and 15% of all firms. In Bulgaria, followed by Germany, Belgium, and Poland

7 https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:T6aNumber_of_persons_employed_by_enterprise_size_class,_Construction_of_buildings_(NACE_Division_41),_2015.png

around a fifth or more of firms are medium-sized and thus in a good position to provide a broader work-based training, covering a wide range of activities and occupations.

A more extreme picture than that given in the Eurostat data in terms of the mushrooming of small and micro firms is presented in the national reports (Table 2). Here in Finland, Poland, Spain, Slovenia and Italy over 96% of firms employ less than 9 or 10 workers, implying a weak infrastructure for work-based training, whilst in Belgium 93% and in Germany 89% of firms employ less than 20.

Characteristics of the workforce

The figures in the national reports give an impression of the patchy nature of employment in the sector. In Slovenia as much as 59% of the construction workforce is self-employed and in Italy 43%, followed by Ireland at 37%, Spain at 29% and Belgium at 25%. Only in Hungary (13%), Germany (12%), and Bulgaria (below 5%) does self-employment not appear to be significant. Those employed may also be on temporary contracts, as in Finland (7%) or Belgium (1%).

The nature of employment and the high proportion of self-employed workers and micro firms provides no great inducement to firms to take on trainees. This is particularly the case in those southern and eastern European countries that saw very dramatic declines in employment during the recession from 2008-2016. Spain, for instance, saw its construction industry nearly halved, while Italy, similarly, lost half its direct employees as output decreased by 42%. In Eastern Europe, for example Slovenia, one-third of construction employment was lost between 2008 and 2013, with many leaving the country; Hungary too saw 85,000 leaving the sector. In contrast, in Germany between 2008 and 2014 construction turnover increased by 30% and the workforce rose from 2.9m to 3.8m. Given this weakening of the work-based infrastructure for training and the dramatic changes in employment, it is hardly surprising that most countries complain of skill shortages, including Bulgaria and Germany, with both Hungary and Ireland claiming that an estimated 30,000 skilled workers are needed. Many countries have consequently come to rely heavily on non-national workers, who constitute 30% or more of the workforce in Italy, Slovenia and Poland (where as many as 200,000 are from the Ukraine). In Ireland 18% of the construction workforce are non-nationals, especially bricklayers, plasterers and carpenters, in Finland 17%, Spain 16%, Belgium 15% and Germany 14%.

Many countries report varying skill levels. In Belgium, for instance, with its comprehensive and largely school and workshop-based VET system, 62% of the workforce is classified as skilled, 32% as semi-skilled, and 16% as labourers. Similarly, in Germany, between 67% and 72% of the workforce holds a recognised vocational education qualification, whilst 10%-14% holds no qualification. Elsewhere, however, qualification levels are often lower in construction, including in Ireland where levels of education are generally low, only 20% having completed a final secondary level exit exam and 18% in possession of a third level qualification compared to 33% amongst the workforce as a whole. In Finland, general education levels are higher than for many other European countries, compensating to some extent for the fact that only 20% of the workforce participate in post-secondary VET. A similar situation holds for Slovenia, where 72% of the workforce holds Upper Secondary school qualifications and a further 10% has higher qualifications. In Poland too those with qualifications hold only an estimated 30% of jobs requiring Level 3 and 4 qualifications.

The construction industry across Europe is also characterised by its exclusive, white, male and ageing character. Women constitute less than 10% of the workforce, except in Germany where the figure is 12%, and the average age, for instance in Italy and Finland, is 35.

Implications of LEC for the workforce

What then are the implications of LEC for the workforce and the construction labour process and can it contribute to improving the inclusivity and attractiveness of the construction sector? In terms of expertise, LEC requires a sound knowledge base, not only theoretical (e.g. physics) but also practical, concerning, for instance, the elimination of thermal bridges. Know-how is also needed in relation to thermal performance, whilst the broader occupational profiles and interdisciplinarity implied in the *Build-up Skills Overview* suggest a far more qualified and technical workforce (Clarke et al 2017). New LEC occupations are also reported in a number of countries, for instance, in relation to: insulation in Belgium, Bulgaria, and Poland; heat pump, boiler, biomass and cooling device installation in Bulgaria, Finland and Ireland; timber frame work in Belgium; air permeability testing and energy assessment in Ireland; and 'certified renewable energy specialists' in Germany. At the same time, skill shortages are often reported in specialist and technical areas, such as in: Finland, communication and supervisor skills; Italy, specialists; and Slovenia, social and 'green' skills and façade makers. These are generally all areas requiring relatively high technical qualifications.

Given the requirement for high level qualifications with LEC, good communication and coordination skills, and the ability to project manage, the way is opened up for a more diverse workforce. In this respect, it is worth noting that higher proportions of women in construction are in the more technical as opposed to traditional trade occupations. Figures for the UK, for instance, show that there are far higher levels of women in technical positions in construction (24%), such as quality assurance technicians (39%) and quality control and planning engineers (19.1%), than in the skilled trades (3%). Across Europe, Eurostat figures on female engineering workers employed as a share of the total engineering workforce also show relatively high proportions, including in: Bulgaria (30%); Slovenia, Poland and Italy (20%); Belgium and Hungary (19%), Spain (17%); and Germany, Ireland and Finland (15%) (Clarke et al, 2015).

The need for a workforce qualified in technical and engineering areas is well expressed in relation to one of the Irish LEC case studies, where careful planning and quality control are highlighted:

"Your procedures flow. You can get into really good detail in terms of planning. Because the model is done – there's no guesswork anymore. Our detailing was done. It affects all trades – blocklayers, carpenters, right through the spectrum. So we write into the contractors' package what we expect from them. And we go into detail about airtightness."

"In phase 2 a clear on-site process was introduced that continued in phase 3; everyone is aware as to what they are to do and who to report to onsite, which created a good atmosphere on site. We've got good quality control."

This requirement for high levels of planning was also evident from the modular construction assembly plant visited in Germany.

DISPARITIES IN NZEB INTERPRETATION AND IMPLEMENTATION

What is NZEB?

If LEC requires higher quality, more planning, and a technically more qualified workforce, why is this the case, what is NZEB and how can this standard be met? NZEB differs fundamentally from previous forms of construction in that success depends on energy performance being specified as meeting a specific maximum *primary energy* (PE) *per metre squared per year* (kWh/m²/y) and thus a specified carbon dioxide emissions target (kgCO_2/m²/y).

With regard to NZEB, the EPBD (2010) stipulates in qualitative terms that:

Member States shall take the necessary measures to ensure that minimum energy performance requirements for buildings or building units are set with a view to achieving cost-optimal levels,

and that:

The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including...on-site or nearby.

Based on subsidiarity, each member state is required to introduce a definition of NZEB that will apply to all new and retrofitted buildings by 1 January 2021. Thus, the European construction industry is faced with a general requirement to meet new LEC demands whose specifics vary depending on the particular member state. To achieve NZEB, one of two methods may be adopted: a cost optimal calculation for maximum PE/m²; or pre-setting a maximum PE/m² with or without a percentage of renewables. Thus NZEB is defined as very high energy performance plus on-site (or nearby) renewables, where the final definitions of 'very high energy performance', 'significant extent of renewables' and 'nearby' are left to individual member states.

Table 5 presents an overview of NZEB definitions for the ten partner countries based on the most recent national updates submitted to the EU at the time of drafting (EC, 2016a). It shows that definitions are at different stages of development, including 'under development' in four countries: Germany, Spain, Finland and Hungary. In Bulgaria, the definition is in the approval process, and only in Belgium, Ireland, Italy, Poland and Slovenia is an approved NZEB definition in place. The definitions also vary significantly in terms of: building typologies, classifications, balance of renewables and physical boundaries included; the energy uses considered; and varied system boundaries for the generation of renewable energy sources.[8]

Cost optimal solutions

Cost optimal solutions are based on the prime cost of the energy efficiency products and technologies offset by their life cycle operating cost using a net present value (NPV) calculation over time – either 20 years (commercial) or 30 years (dwellings). The results are expressed in €/m² and PE (kWh/m²/y) where PE is defined as energy from renewable and non-renewable sources that has not undergone any conversion or transformation process, such as coal into electricity, gas/oil into heat or the PV/hydrogen/electricity cycle (PV – electrolysis for hydrogen storage – fuel cell – electricity + heat).

Typically, a cost optimal model compares a range of envelope and heating/cooling solutions with their PE consumption and life cycle operating costs. Figure 1 (above) compares a range of construction concepts and simulated net energy needs for a reference detached house of 171 m² (Kurnitski, 2011), demonstrating how their corresponding different levels of insulation, window specification, air tightness, ventilation efficiency, etc., result in varying heating power demands (kW). As can be seen, all envelope options demand a high standard of on-site knowledge and skills allied to both traditional materials such as insulation, as well as those associated with more complex, newer demands such as thermal bridge details and low carbon heating technologies.

Varying heating power demands may be met through a variety of heating sources such as conventional condensing boiler, district heating, ground source heat pump, etc. The initial and operating costs and the primary energy consumed will therefore also depend on the type of low and zero carbon technology (LZC) installed. Figure 1 (below), shows that NPV calculations based on envelope options and heating solutions provide two optimal solutions for meeting NPV criteria, but with quite different PE demands (Kurnitski, 2011). The first one involves envelope option 3 (modelled detached house or DH 0.76) plus a ground source heat pump (approx. 110 kWh/m²/y), and the second one, also envelope option 3 (DH 0.76) but with a condensing gas boiler (approx. 170 kWh/m²/y). Consequently, in order to comply with a maximum PE condition, the second solution would need a larger renewable energy installation to offset its additional 60 kWh/m²/y consumption.

The energy performance gap

The calculations assume that the model describes the as-built construction. However, various researchers have identified an energy performance gap between predicted and measured energy when testing building envelopes before occupation. For example, Figure 2 illustrates the difference between predicted and measured increase in heat loss coefficient (HLC) for a number of dwellings in Britain, as reported by Johnson (2016). Note that dwellings 28 to 33 are of Passivhaus (PH) construction and therefore must meet the quality control requirements for PH certification. Although in these cases there is still a performance gap, it is very small and similar in size across an admittedly small sample of passive houses, providing evidence of enhanced on-site quality control.

Similarly, monitored LZC heating installations, such as solar thermal, heat pumps, combined heat and power (CHP) and fuel cells – the types of heating systems identified as 'renewables', demonstrate a wide range of performance associated with inadequate design, sub-optimal installation, commissioning and operation. VET for renewable heat must encompass maximizing the thermodynamics of such technologies as heat pumps, their need for low temperature heating, continuous operation, etc., if they are to perform as intended. The design and operation of domestic CHP, heat pumps and emerging fuel cells must be recognized as complex, different from conventional systems and in need of enhanced VET. Thus the energy performance gap, in both envelope construction and building services installation, is evidence of the current failure to meet consistent LEC practice.

Building subcategories
considered in NZEB definition

Building typology, building classification,
balance and physical boundary in NZEB definition

Energy uses included in NZEB definition

System boundary generation
for RES in NZEB definition

8 Please see Appendix for detailed accounts of NZEB definitions in partner countries.

TABLE 5
Overview of national NZEB definitions

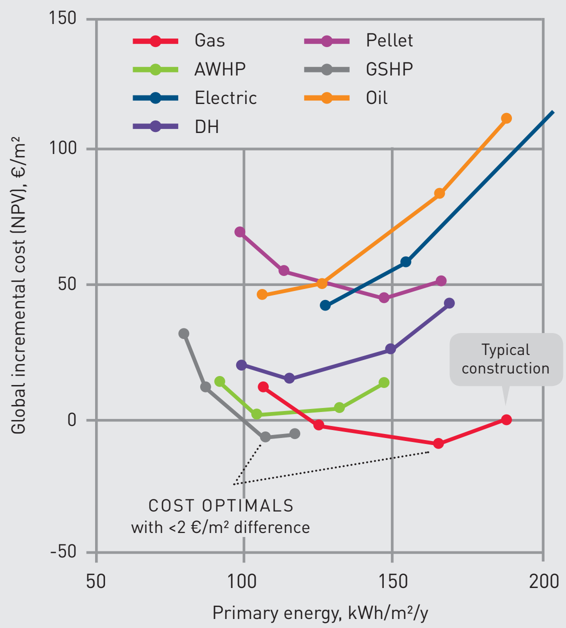
	BE	BG	DE	ES	FI	HU	IE	IT	PL	SI
OFFICIAL STATUS	In official document	To be approved	Under develop-ment	Under develop-ment	Under develop-ment	Under develop-ment	In official document	In official document	In official document	In official document
RESIDENTIAL/ NON-RESIDENTIAL	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
SINGLE FAMILY HOUSES	✔	✔			✔	✔		✔	✔	
APARTMENT BLOCKS	✔	✔			✔	✔		✔	✔	
OFFICES	✔	✔			✔	✔		✔	✔	
EDUCATIONAL BUILDINGS	-	✔			✔	✔		✔	✔	
HOSPITALS	-	✔			✔	✔		✔	✔	
HOTELS/ RESTAURANTS	-	✔			✔	✔		✔	✔	
SPORT FACILITIES	-	✔			✔	✔		✔	✔	
WHOLESALE AND RETAIL	-	✔			✔	✔		✔	✔	
BUILDING TYPOLOGY	New/ retrofit	New/ retrofit	New build		New/ retrofit	New build	New build	New/ retrofit	New/ retrofit	
BUILDING CLASS	Private/ public	Private/ public	Private/ public		Private/ public	Private/ public	Private/ public	Private/ public	Private/ public	
BALANCE	-	-	E demand/ E generation		-	E demand/ E generation	-	E import/ E export	-	
PHYSICAL BOUNDARY	Single building	Building unit	Single building		Building unit	Single building	Single building	Building unit	Building unit	
HEATING DHW	✔	✔	✔		✔	✔	✔	✔	✔	
VENT, COOL, A/C	✔	✔	✔		✔	✔	✔	✔	✔	
AUXILIARY ENERGY	✔	✔	✔		✔	✔	✔	✔	✔	
LIGHTING	✔	✔	✔		✔	✔	✔	✔	✔	
PLUGS, IT, APPLIANCES	✖	✔	✖		✔	?	✖	✖	-	
CENTRAL SERVICES	✖	✔	✖		?	-	✖	✔	-	
ELECTRIC VEHICLES	-	✖	✖		-	-	✖	✖	-	
EMBODIED ENERGY	✖	✖	✖		-	-	✖	✖	-	
ON-SITE RES	✔	✔	✔		✔	✔	-	✔	✔	
OFF-SITE RES	✔	✔	✔		✔	✔	-	✔	✔	
EXTERNAL GENERATION	✔	✔	✔		-	✔	✖	✔	✔	
CREDITING	-	✖	✖		✖	✖	-	✖	-	
PRIMARY ENERGY INDICATOR (kWh/m²/y)	✔	✔	✔	✔		✔	✔	✔	✔	✔

Source: based on EC (2016a) *Synthesis Report on the National Plans for Nearly Zero Energy Buildings*, JRC Science for Policy Report

Note: Since the publication of JRC Science for Policy Report in 2016, new developments exist in this regard, for example the NZEB definition adopted in Spain by Real Decreto 564/2017 that modifies Real Decreto 235/2013.

FIGURE 1
Envelope options and NPV calculations
of a "reference" detached house of 171 m²

	CONSTRUCTION CONCEPTS			
	DH 0.42 NEARLY ZERO	**DH 0.58**	**DH 0.76**	**DH 0.96** TYPICAL CONSTRUCTION
Specific heat loss coefficient H/A, W/(K m²)	0,42	0,58	0,76	0,96
External wall 170 m²	20cm LECA block, plaster + 35cm EPS-insulation U 0.1W/m²K	20cm LECA block, plaster + 25cm EPS-insulation U 0.14W/m²K	20cm LECA block, plaster + 20cm EPS-insulation U 0.17W/m²K	20cm LECA block, plaster + 15cm EPS-insulation U 0.23W/m²K
Roof 93 m²	Wooden beams, metal sheet, 80cm min. wool insulation, concrete slab U 0.06W/m²K	Wooden beams, metal sheet, 50cm min. wool insulation, concrete slab U 0.09W/m²K	Wooden beams, metal sheet, 32cm min. wool insulation, concrete slab U 0.14W/m²K	Wooden beams, metal sheet, 25cm min. wool insulation, concrete slab U 0.18W/m²K
Ground floor 93 m²	Concrete slab on ground, 70cm EPS insulation U 0.06W/m²K	Concrete slab on ground, 45cm EPS insulation U 0.09W/m²K	Concrete slab on ground, 25cm EPS insulation U 0.14W/m²K	Concrete slab on ground, 18cm EPS insulation U 0.18W/m²K
Leakage rate q50, m³/(h m²)	0,6	1	1,5	3
Windows 48 m² U-value glazing/ frame/total	4mm-16mmAr-SN4mm 16mmAr-SN4mm Insulated frame 0.6/0.7W/m²K 0.7W/m²K	4mm-16mmAr-4mm 16mmAr-SN4mm Insulated frame 0.8/0.8W/m²K 0.8W/m²K	4mm-16mm-4mm 16mmAr-SN4mm 1.0/1.3W/m²K 1.1W/m²K	4mm-16mmArSN4mm Common frame 1,1/1,4W/m²K 1,2W/m²K
g-value	0,46	0,5	0,55	0,63
Ext. door 6 m²	U 0.7W/m²K	U 0.7W/m²K	U 0.7W/m²K	U 0.7W/m²K
Ventilation rate l/s, specific fan power SFP, temperature efficiency AHU HR	80l/s, SFP 1.5kW/(m³/s), AHU HR 85%	80 l/s, SFP 1.7kW/(m³/s), AHU HR 80%	80 l/s, SFP 2.0kW/(m³/s), AHU HR 80%	80 l/s, SFP 2.0kW/(m³/s), AHU HR 80%
Heating capacity, kW	5	6	8	9
Cooling capacity, kW	5	5	5	8



Source: Kurnitski 2011

Retrofit

Buildings are responsible for approximately 40% of energy consumption and 36% of CO_2 emissions in the EU. Currently, about 35% of the EU's buildings are over 50 years old and almost 75% of the building stock is energy inefficient, while only 0.4-1.2% (depending on the country) of the building stock is renovated each year.[9]

In order to address the existing building stock, the EPBD includes 'major renovation' within its scope. Modelling energy savings for renovation or retrofit is particularly challenging due to uncertainties such as: structural element U values and Psi values; existing levels of heating/cooling; and occupant adaptation to achieve affordable comfort, resulting in 'prebound' (Sunikka-Blank & Galvin, 2012) and 'rebound' effects (Sorrell, 2007; Gupta, et al, 2015) and leading to over-estimation of post-retrofit energy savings. In addition, renovation work is qualitatively different from new build in that it is replete with unforeseen complexities. Often only by exploration are building defects identified and their solution resolved on site. Thus the renovation process is reliant on a rounded knowledge and competency component and is generally less amenable than new build to prefabricated solutions. Renovation requires high levels of KSC and therefore enhanced VET for LEC.

Implications

The potential technical constraints identified encompass the entire planning and production process: 'local and regional authorities…architects and planners… installers and builders are critical for the successful implementation of this Directive' (EPBD, 2010). For the construction industry, therefore, constraints apply from the initial design through to final operation:

DESIGN PHASE

- Detailed technical design calculations, drawings and the construction plan – architect, engineers, planners, suppliers, construction managers, sub-contractors

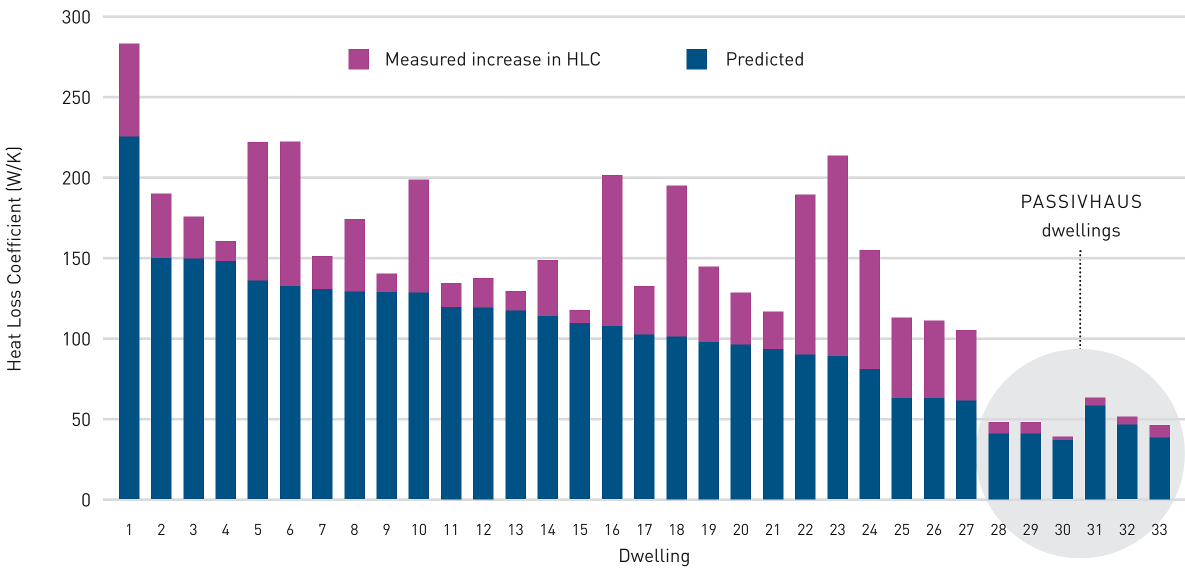
CONSTRUCTION PHASE

- Knowledge – based on why and how
- Skills – appropriate on-site practice
- Employment contract – conditions that enhance quality and intrinsic motivation for personal satisfaction, continuous learning and feedback

HANDOVER

- User-focused communication of operation and maintenance for optimum life cycle operation

FIGURE 2
Co-heating test results



Source: Johnson, 2016

9 https://ec.europa.eu/energy/en/topics/energy-efficiency/buildings

VET SYSTEMS AND DIFFERENT APPROACHES TO DEVELOPING VET FOR LEC

As well as the labour market conditions and NZEB implementation policies and possibilities, the development and delivery of VET for LEC are constrained by the characteristics of the existing VET system in each country.

VET conditions and VET for LEC developments

The VET system is generally better equipped in Belgium, Finland and Germany compared to the other seven countries in our study, providing a more stable base from which to develop VET for LEC. In Bulgaria, Hungary, Ireland, Italy, Poland, Slovenia and Spain, the Build Up Skills (BUS) investigations saw conditions prevailing in the existing VET system as a barrier and recommended major changes, including: upgrading teacher training, improvements to facilities and teaching resources, increasing work-based learning, improving co-ordination of the existing fragmented VET provision, strengthening the institutional framework of governance, regulation of training and qualification standards and increased funding. The importance and at the same time lack of effective monitoring systems for identifying and responding to changing training needs of the sector were also emphasised.

For these same countries, with the exception of Italy, the BUS national reports show LEC elements within mainstream IVET to be either completely lacking or very limited and mainly catering to technical/building services occupations. More training was reported within CVET, organised by a combination of further education organisations, technical colleges, and private providers (training providers, construction companies or manufacturers of EE/RES related systems and materials), with most courses in RES installations. However, overall, CVET was found to be fragmented and not co-ordinated, limited in occupational range and geographical reach, with most courses at higher levels and catering to those with some existing technical training. As emphasised in the BUS reports, most courses were stand-alone and did not provide comprehensive, standardised and broad VET for LEC; nor were they all monitored. A general lack of awareness of energy efficiency within the construction sector, including amongst employers, workers, policy makers and the general public was also noted as a barrier to increasing demand for LEC and related VET.

Not surprisingly, the BUS Pillar II programme and the subsequent Horizon 2020 projects developed in these countries prioritised developing capacity and the infrastructure of future VET for LEC, including: the development of learning/teaching materials (Bulgaria, Ireland, Spain), the training of teachers (Bulgaria, Poland, Ireland, Spain), setting up training centres (Bulgaria, Ireland), developing introductory courses for the existing operative workforce (Ireland, Italy, also Finland), and setting up a register of qualified workers to regulate the newly emerging occupations (Hungary). VET for LEC developments in these countries are not only triggered by EU requirements but also rely on EU funds, particularly in the context of recession, where the sector has been severely affected.

The BUS investigation has thus been a major impetus for introducing LEC into IVET. However, compounding the challenge of developing LEC training, major reforms have taken place in the VET systems in the last decade, including:

- A review of the national qualifications framework to align it with the EQF (Bulgaria, Hungary, Slovenia);
- The development of national (Italy) and sectoral (Poland) qualification frameworks;
- Initiatives to strengthen work-based learning (Bulgaria, Hungary, Slovenia, Spain);
- The introduction of apprenticeships (Slovenia and Hungary);
- The introduction of mandatory work-placement schemes (Hungary);
- Restructuring of the regulatory framework and governance arrangements (Ireland, Poland, Slovenia);
- Increased autonomy for schools and teachers (Slovenia);
- The introduction of a competence based system (Slovenia).

Whilst these countries need to invest in VET for LEC infrastructure, in Belgium, Finland and Germany, in contrast, there is greater capacity to update existing VET to embrace energy efficiency. The progress made in the development of VET for LEC should therefore be seen in this context. Countries are at different stages, with greater and more established expertise and knowledge present in the VET systems of Belgium, Germany and Finland, where LEC has a longer history than in the other countries. Here, topics related to energy efficiency and renewable energy sources were already part of the mainstream IVET curriculum at the time of BUS and a wide range of CVET courses in LEC were also available. As a result, whilst for Finland BUS found the theoretical content inadequate and learning and teaching materials out of date, for Germany and Belgium more specific changes were recommended, such as strengthening systems thinking, interdisciplinarity, theory-practice integration and improving teacher training (Belgium).

Governance structures and the development of VET for LEC

The governance and regulation of VET, which determines the role of social partners in the development of VET for LEC, differs significantly between our countries. For provision that is responsive to the changing needs of the sector, appropriate in terms of content, level and delivery methods, and congruent with the perspective and the actual experiences of the workforce, all stakeholders need to be involved in development, monitoring and continuous upgrading. The social partnership model of governance allows the input of all stakeholders and this is most comprehensively implemented in Belgium, Germany, and Finland, although with stronger state involvement in Germany and Finland. In all three countries, social partners alongside educationalists are involved in the development and implementation of VET policy at the national, regional and local levels. This involvement can include, more specifically, input into policy development, drawing up occupational profiles, regional adjustments (Belgium and Germany) and the development of VET programmes and curricula at the local level. Thus, these three countries have fairly unified VET systems that allow for regional variations but within nationally applied frameworks.

In Bulgaria, Hungary, Ireland, Poland, Slovenia and Spain, VET is the responsibility of the state and the input of social partners is varied, involving close collaboration in Spain but being elsewhere more limited or not facilitated at all by the regulatory framework in place (Ireland). The state develops and implements VET policy under the leadership of one or more Ministries. The involvement of social partners may be in an advisory capacity and involve commenting on policies at the national level and participating in coordinating bodies (Bulgaria, Hungary, Poland, Slovenia, Spain), joint responsibility at sectoral levels (Italy, Poland), or participation at the local level (e.g. sitting on examination boards as in Bulgaria). In Slovenia, regulations have been put in place to improve the involvement of social partners in the development of occupational standards. In Ireland, there is no regulatory platform in place to facilitate social partnership in the governance of VET.

Cutting workshop:
Plasterers' Training College, Stuttgart/Germany

The regional element of the governance model is also significant as it allows a degree of adaptation to local employment and training needs. In Belgium and Germany, regional autonomy is exercised within a binding national framework that sets out the overall standards, occupational profiles, learning outcomes and qualification structure. The regionally autonomous structure of governance means that in Italy VET provision is varied and fragmented, presenting a challenge to the introduction of any standardised VET for LEC programme into the IVET system across the country. A degree of regional variation is facilitated in Slovenia and Poland by allowing schools to vary a small part of their teaching to respond to local needs, but, by and large, these are nationally unified systems, as are the VET systems in Bulgaria, Hungary, Ireland and Spain.

Limited involvement of employers has implications for funding, the availability of work-based training and experience, and the ability of the system to respond to the needs of the sector. In the social partnership model, joint funding arrangements (state and employer levy) and the dual system combine to give employers a responsibility to invest in the training of workers and the opportunity to influence VET policy and its implementation at strategic and local levels. In countries where the funding is mainly or completely provided by the state, social partner involvement is limited and the VET system is mainly school-based (Bulgaria, Hungary, Ireland, Italy, Poland, Slovenia, Spain), employer input is limited on many levels. It is also in these countries that lack of investment by employers (whether through the training levy or as providers of work placements/ apprenticeships) in VET was emphasised as a significant barrier to upgrading the VET provision to include a greater work-based component. Some employers' associations run their own training centres and it is possible that these fill a gap in VET provision. In Bulgaria, Hungary, Poland and Slovenia, employers are reportedly involved in VET for LEC through providing short, in-house courses, but these are not standardised or regulated and do not amount to a comprehensive programme. There are also attempts in all four countries to involve employers more, but within the framework of the national VET programmes, particularly by providing work-placements or apprenticeships.

Structure of IVET and implications for delivering VET for LEC

VET systems also differ in terms of approach and the structure of education. The dual system, for example, provides the opportunity to combine studying in the classroom with practice in the workshop and work-based learning. Whilst, in theory, practical learning is part of IVET programmes in all countries, this may take place in a workshop, rather than in a workplace. More emphasis is being placed on work placements and dual training and/or apprenticeship are being introduced in several countries (Hungary, Bulgaria, Slovenia, Spain), but there is a shortage of employers willing or able to take on trainees. IVET also has a tiered structure in several countries and entry at different ages and levels is possible (Spain, Bulgaria, Poland). What VET for LEC is available tends to be provided at the higher levels of the IVET system, though there are plans in most countries to introduce it also at the lower VET levels. This implies that the content and level of VET for LEC is likely to vary between the types of VET institution and that those trainees not continuing onto a higher level may not receive adequate VET. This fragmented structure of IVET has implications for where and how VET for LEC is delivered and for what is offered as continuity and complementarity need to be ensured across both different types VET institutions and different levels of VET.

Different approaches to VET for LEC delivery

The partner countries also adopt different approaches to VET for LEC provision. In Belgium and Germany, LEC related competencies are integrated into existing occupational profiles and curricula for each occupation, a strategy that is guided by the underlying occupational approach to VET. In other countries, LEC training is organised on the basis of (emerging) specialisations, such as insulation or solar panel installation, and targets the development of specific skills. Looking at developments since the BUS investigation, according to the national report summaries prepared for this investigation, in Belgium and Germany VET for LEC has been fully mainstreamed, with LEC KSC integrated into existing occupational profiles, training programmes, curricula and exam regulations for all relevant occupations. In Finland, LEC topics are similarly reported to be included in IVET pathways, but the content continues to be described as basic.

In Bulgaria, Ireland, Poland, Slovenia and Spain, LEC related competencies are being gradually introduced into IVET through a process partly supported by participation in BUS Pillar II and Horizon 2020 projects. However, the actual content and level of VET vary, and the courses can be 'add-ons' rather than knowledge and competencies being integrated into existing occupational training pathways. For example, Bulgaria introduced nine hours of training over 3-4 years into the relevant professional pathways, which is expected to be a basic introduction to energy efficiency. In Ireland, the introductory CVET course that is expected to be rolled out nationally will be run as a stand-alone course, rather than as an integral part of any IVET programme, or tailored to any specific occupation. In Spain and Poland, most LEC training in IVET is offered at higher levels. In Hungary, LEC training has not been integrated into IVET programmes yet, progress being stalled through lack of funds, and LEC training is provided as short courses by a variety of organisations.

It is difficult to draw a comprehensive picture of LEC for CVET as provision is fragmented and varied and by a range of public and private bodies. The definition of CVET also varies: in Bulgaria, courses entered by those aged 16+ are classified as CVET, while in Finland IVET begins at 16. Some higher-level VET schools/colleges (Spain, Poland) are for those aged 18+ and require the completion of some other initial education (general or lower level VET). Only in Germany is there a nationally regulated CVET system that builds directly on IVET and leads to recognised qualifications, equivalent to university degrees or masters. These are provided for under Federal law and developed jointly by social partners. A distinction needs to be made between VET for the existing operative level workforce (e.g. introduction to energy efficiency, building physics and renewable energy) and higher level, more technical and specialist VET (e.g. RES installations, building automation systems). Most CVET is provided as one-off courses and at higher levels (EQF 4-6) and targets specific LEC aspects.

A TRANSNATIONAL SYNTHESIS OF VET FOR LEC

CHALLENGES AND STRENGTHS IN VET FOR LEC AND THEIR IMPLICATIONS

The detailed analysis presented above shows that, despite the constraints, the development of VET for LEC is gaining speed in the ten partner countries, including through:

- *new qualifications and the upgrading of existing ones*, helping to cope with the challenges of LEC/NZEB (e.g. in Belgium, Finland and Germany) for IVET and providing good examples to learn from. For example, Finland has extra credits for LEC topics in four 'basic degree' qualifications; Poland is developing new qualifications both within and outside its integrated qualification framework; in Germany there is some 'deep integration' of LEC/NZEB elements within existing curricular structures, for example the bricklayer, plasterer, plumber and electrician qualifications; and a similar process has taken place within the Belgian construction occupational profiles, where LEC/NZEB elements are apparent from close scrutiny (e.g. roofer).
- *CVET for LEC*, as found in most partner countries, for example at higher technician level (4/5) in Spain and at supervisory level in Germany, where new CVET curricula and qualifications incorporating a project-oriented approach (e.g. in renewable energy, requiring 200 hours of study) in addition to 315 new units closing gaps in IVET have been introduced.
- *An increasing number of profiles for new LEC related occupations*, some at higher technician level (EQF 4/5 e.g. Spain), others at EQF 3, e.g. the Technical Assistant (Energy Management) in Germany.
- *An increasing number of existing profiles incorporating LEC elements* (e.g. in Germany in at least 26 construction-related occupations), though there is no evidence that these curricular elements ensure inter-occupational co-ordination and plug existing knowledge gaps through CVET credits.

Despite the diversity in construction labour markets and VET systems, countries face many similar challenges in implementing VET at both IVET and CVET phases, including:

1. *Structural features*, in particular a very high proportion of micro firms in all countries, rendering problematic the mobilisation of resources for IVET and CVET, and investment in plant, as well as co-ordination to meet EU and national targets regarding LEC/NZEB. In some countries there is a high failure rate in these smaller enterprises, negatively impacting on trainee development.
2. *Varying qualification levels* of the workforce, again presenting challenges for CVET given the generally low take-up by those with low or no qualifications. In contrast to other economic sectors, many construction workers and trainee recruits do not have upper secondary completion, although there are exceptions such as Germany.
3. *Workforce diversity or lack of it*, including significant numbers of non-national workers whose qualifications may be unknown or unrecognised and for whom communicative ability may be an issue. In some countries, the workforce is ageing; in some, there are difficulties in recruitment; and in all countries there are few women in the workforce.
4. *Skill shortages*, due in part to recovery from the economic recession of 2008 and in part to workers leaving the sector, and manifest in LEC related occupations in all the countries though particularly significant in some (e.g. Slovenia).
5. *Rapid technological innovation*, particularly in LEC/NZEB techniques as well as in digitalisation of the sector, leading to needs in both CVET and IVET that may remain unfulfilled, including for new qualifications and the upgrading of curricula for existing qualifications.

At the same time, through analysis of existing VET for LEC, factors enabling and supporting effective training provision can also be identified:

- *Social partnership and consultative structures,* facilitating the setting of common goals and national and EU VET targets and the solution of problems (e.g. Belgium, Germany).
- *Levy style funding arrangements for VET,* facilitating response to new developments within the sector and promoting co-ordinated skills development (e.g. Belgium), though there is little detail about their actual results for VET in LEC.
- *A relatively highly qualified workforce* (e.g. Belgium, Germany), which is important for successful CVET activity in giving employees the basic knowledge and competence to master new concepts and techniques.
- *Broadly based IVET* (e.g. in Belgium, Germany) emphasising LEC underpinning knowledge such as of Building Physics and Materials and giving workers an overview of the sector and of the construction process, as well as stressing transversal abilities such as communication, co-ordination and teamwork.

Finally, analysis of examples of VET for LEC suggests outstanding issues for all those concerned with developing effective training in energy efficiency in construction:

a. *More awareness of relevant inter-occupational interfaces* is necessary, particularly through broadly based IVET such as the three year *Stufenausbildung* (stepped training programmes) in Germany.

b. *More emphasis on transversal abilities* is necessary both for IVET and CVET, particularly communication and co-ordination, important for managing occupational interfaces, not just at supervisory but also at operative levels. Abilities to understand the whole project are also needed to supplement inter-occupational co-ordination, with implications for the overall educational level of the workforce and for national recruitment strategies for the sector.

c. *CVET is critical to equip the existing workforce for LEC/NZEB,* though there may be resistance to different ways of working (e.g. Finland). Skill requirements may, in the medium term, be addressed through work-based CVET leading to qualifications at level 4/5, 6 and 7, as in Germany, which already has a well-developed career path through CVET up to EQF level 7.

d. *Particular challenges exist where CVET relies just on learning outcome-based* competence certification and where it remains patchy and uncoordinated, though a number of countries make progress through use of the levy system and social funds.

DEVELOPING VET FOR LEC CAPABILITY

With respect to CVET, the ambitious EU targets for reducing energy consumption for new and existing buildings mean that the construction sectors in each partner country need to adopt a mix of short and long term measures. The existing workforce has to become capable of operating in such a way that the technical ability exists to meet design specifications. Different approaches can be adopted for workforces with different capabilities. In some countries, there is evidence of changes to IVET curricula, as in Belgium, and strong efforts to remedy deficiencies at CVET level,

Carpentry workshop: Vantaa Vocational College, Varia/Finland in particular in Germany, Poland, Finland, and to some extent Spain and Italy. Globally, there is very good evidence that higher levels of education are associated with higher levels of take-up of CVET, so that those partner countries such as Germany with a workforce with a relatively high educational level, and especially those with broad IVET, are in a better position to implement CVET for LEC/NZEB, provided adequate funding mechanisms are available. For these countries, CVET can build on existing underpinning theoretical knowledge and broad sectoral knowledge to incorporate new techniques, greater holistic understanding and improved communicative, teamwork and coordinative abilities.

For those countries lacking appropriate qualification levels, another possible strategy for CVET is to introduce a more protocol-driven approach, whereby workers are trained to carry out highly specific LEC activities and the coordinative role takes place either at supervisory level, for which more systematic preparation has been made (e.g. supplementary CVET for the *Polier*/foreperson in Germany), or through the development of higher level technical LEC/NZEB specialists (e.g. Spain). Both the protocol-driven and the coordinative elements of the LEC labour process still require, however, the development of appropriate curricula, though this appears to be taking place only on a piecemeal basis, for example in Ireland. Indeed, the picture of CVET for LEC/NZEB gives some cause for concern, particularly as a number of partner countries report a patchy and uncoordinated approach to implementation (Ireland, Italy, Spain, Slovenia, Hungary and to some extent Bulgaria and Poland).

IVET also needs in the longer term to change, as is already occurring in some countries, such as Ireland, Belgium and Germany, which have relatively well-developed VET systems. Despite the growing interest in dual system approaches (e.g. Hungary, Spain, Italy), the disaggregated nature of enterprises within the sector and extensive subcontracting pose obstacles to making work placements available so that changes may need to be handled in workshops through school-based forms of IVET. Broad-based IVET systems are in a stronger position to adapt to LEC/NZEB requirements as sound underpinning knowledge and a holistic approach to the construction sector (including the building process and an emphasis on attitude and transversal abilities as well as an awareness of project management – the 'big picture') are conducive to adaptation through relatively easy to manage changes to the curriculum.

Where a high proportion of the workforce has only low levels of education, the mathematical abilities and energy literacy required for LEC may necessitate increased emphasis on literacy and numeracy, as in Slovenia. In the longer term, for the application of scientific knowledge, project understanding and inter-occupational teamwork in the labour process, a workforce with an overall higher level of education than is currently the case in some countries (e.g. Hungary) is required. One way to achieve this is for employers to broaden their recruitment base. Recruitment patterns for IVET in the construction sector in some countries such as Germany do show quite a high level of qualifications, with only 6% not qualified (Bundesagentur für Arbeit 2017). On the other hand, widespread use of *post facto* competence certification, serving both IVET and CVET may struggle to address LEC/NZEB requirements, including acquaintance with new techniques and practices, and new occupational configurations, especially if little or no high quality LEC is anyway taking place.

Mock-up of low energy house:
EFB Vocational Training College, Brussels

GUIDELINES, EXAMPLES AND RECOMMENDATIONS

GUIDELINES

What are the Guidelines for?

These guidelines provide a basis for EU Member States and for organisations responsible for VET to develop LEC curricula for IVET and CVET. Although they can be used independently, they have also been developed to be compatible with the EQF and the European Credit Recognition and Transfer System (ECVET)[10]. The guidelines are intended to enable national, regional and local providers of construction VET to ensure that their programmes provide adequate preparation for workers in the sector to meet the requirements of the EPBD.

The purpose of this section is to:
- present our guidelines and recommendations;
- outline the different ways LEC elements can be incorporated into VET;
- provide examples for trainers and others of different approaches to VET for LEC

It is not the intention to provide either detailed syllabi or curricula but guidelines and criteria allowing providers to address weaknesses in VET for LEC. It is appropriate that the more detailed work required is undertaken by VET institutions in each country in conjunction with social partners and stakeholders. However, whilst different countries have different requirements and different VET systems and need to develop solutions that are appropriate to these, this does not mean that core KSC cannot be drawn out that are common for all and that the weaker systems cannot learn from and take advantage of those that are more developed. Thus, though the guidelines adopted will reflect the particular context to which they are applied, this does not obviate the need to provide appropriate LEC framing across the EU and to address this need in different systems.

Addressing different national IVET and CVET needs is a priority. In general, the needs of both new build and retrofit LEC operations can be managed within common IVET curricula and profiles. The forms that CVET in particular take will, however, be very varied and require more tailored solutions. CVET is often related to quite specific issues and may differentiate between requirements of new build and retrofit, particularly in relation to short-term and bespoke CVET.

Terminology

Unavoidably, educational guidelines may involve the use of technical language. The EU provides some common vocabulary, but is too general for our purposes. Below are definitions compatible with 'official' EU terminology that enable understanding of our proposals:

- o *Syllabus:* detailed setting out of a curriculum in terms of pedagogic materials such as lesson plans, teacher notes or supporting textbooks (e.g. Germany)
- o *Curriculum:* detailed prescribed content for a qualification or programme of learning to be used as the basis for planning delivery of a qualification (e.g. Ireland)
- o *Qualification profile:* the knowledge, know-how and attitudes involved in an occupational qualification cross-referenced with the operations necessary to carry it out (e.g. Belgium).
- o *Qualification framework:* A structure within which qualifications can be compared with each other and typically constructed at national and/or European level. (e.g. EQF and SQF).
- o *Module:* segment of a qualification, usually with guidelines for the type and amount of learning necessary for a candidate to complete it (e.g. Slovakia, Finland and Ireland).
- o *Guidance notes:* set of instructions and suggestions for the development of qualification profiles, curricula or syllabi (e.g. Construction Industry Council, UK).

10 For a description of EQF, please refer to: https://ec.europa.eu/ploteus/content/descriptors-page and of ECVET to: http://mavoieproeurope.onisep.fr/en/european-tools-for-mobility/the-ecvet/

- o *Occupational overlaps:* areas of activity covered by the profiles of more than one occupation in a sector. Belgium draws attention to these in its occupational profiles.
- o *Sector framework:* profile of the knowledge, know-how and attitudes required within a particular economic sector any typically used to provide parameters for occupational profiles. Poland has developed a construction SQF.
- o *European VET policy tools:* structures within which qualifications can be compared (e.g. EQF, ECVET) or systems of classification of activities that can be used as the basis for the construction of curricula and qualifications e.g. European Skills and Competences for Occupations Classification (ESCO). The Polish SQF is designed to be compatible with the EQF and ECVET.
- o *Accreditation of Prior Experiential Learning (APEL).* The awarding of qualifications for knowledge and know-how acquired informally, usually in the workplace. Slovenia makes extensive use of APEL, but some versions can be found in most EU countries.

Different models for the integration of LEC principles into VET

The project has identified six distinct approaches or options to integrating LEC principles into construction VET within Europe, some more suited to the production and implementation of detailed guidelines than others. These can be summarised as:

1. *Common syllabus*
   This approach can be found, for example, in Germany. It is based on a common curriculum but a committee of social partners, teachers and technical experts takes the nationally agreed curriculum and converts it into teaching materials specifying the curriculum in detail and providing highly specific content for teachers. This represents a very prescriptive framework, too detailed for use across a range of different countries. The teaching materials used in Germany may, however, prove useful in the development of specific programmes in other countries.
2. *Common curriculum*
   An approach also found in Germany (filled out with detailed syllabi) but not encountered elsewhere. However, the model curriculum to be found in the Qualibuild documents in Ireland could form the basis for a LEC curriculum for both IVET and CVET programmes, though Qualibuild only specifies the areas that should be covered, giving a brief explanation of each. It could only form the basis of a curriculum and is in some respects less detailed than the Belgian occupational profiles (see below).
3. *Specific modules*
   In some cases specific content with its own assessment has been developed that can form part of a qualification, as found in Slovakia and Finland where LEC modules are available for supervisory and managerial grades. It may be suitable if an organisation seeks to locate LEC expertise specifically at a higher level than that of the skilled construction occupations.
4. *Sector framework*
   This approach, found in Poland and setting out the requirements for LEC across the construction occupations, is based on the structure of the EQF but more detailed in terms of knowledge, know-how and attitudes. It can be used to develop occupational profiles and, if necessary, to identify and plan for occupational overlaps.
5. *Occupational profiles*
   This is an approach developed in Belgium, where the profiles are developed into curricula by VET providers and there is thus some discretion as to what goes into curricula and syllabi.
6. *Content guidance*
   This approach developed in Britain by the Construction Industry Council (2017) sets out indicative content for LEC appropriate to the construction occupations, as well as supervisors, managers and designers. It can be reconfigured in order to move the boundaries between these different categories of worker.

Photo: Linda Clarke/Melahat Sahin-Dikmen

Solar panels used for training and supplying electricity to CEFME CTP training centre for Rome province

What works best for IVET?

The key requirement for an IVET programme adequate for LEC is that KSC are spelled out in a way that can be used by curriculum designers. A further consideration is to identify occupational overlaps and build them in where this is deemed to be desirable to achieve better inter-occupational co-ordination. Many countries will be reluctant to create new occupations, preferring to update or extend the scope of existing ones. Where one exists, a SQF is helpful in doing this. For those countries that do not have centralised VET curricula, a more flexible approach is desirable. Approaches 1, 2 and 5 above, supplemented by 4, if that is available, are better suited to IVET development than 3 or 6.

It is recommended that the appropriate national, regional or sectoral bodies responsible for drawing up profiles use the Belgian profiles, the *Qualibuild* framework and the CIC (2017) guidelines as a basis for reviewing existing profiles. In addition a list of all the different items covered by these approaches is given in Table 6, which can be used as a reference, as can the transparency tool in Table 1, which shows how KSC can be detailed. Examples of the different approaches, provided by partners to the project countries and others outside, are shown below to demonstrate good practice. Taken together, these examples provide sufficient resources for upgrading existing occupational profiles and for identifying occupational overlaps where needed, for instance at crucial interfaces in the building process and if there is a risk of suboptimal execution leading to design standards not being met.

There are two further provisos:

1. There needs to be a consultative procedure for reviewing and updating profiles, preferably involving social partners and technical and pedagogic specialists.
2. Profiles cannot on their own identify the academic content to be applied in the detailed implementation of some of the profiles in curriculum documents. It is recommended here that resources be devoted to the translation of some up to date syllabi such as those found in Germany in order to more closely specify academic content in building physics, environmental science etc.

What works best for CVET?

It is more difficult to lay down detailed specifications for CVET than for IVET as this covers a very heterogeneous set of activities, ranging from the short-term addressing of highly specific deficits to long term programmes for the development of senior, technical, supervisory or managerial staff. Particular care needs to be taken with competence-based and/or APEL approaches to accreditation. By its nature, LEC is concerned with innovation and the rationale of CVET for LEC is to introduce construction workers to these innovations and incorporate them into their practice. APEL procedures on their own are unlikely to guarantee that candidates have acquired the latest knowledge and practices since they may well not have encountered these in their work. APEL can at best only be a component of a CVET LEC qualification.

EXAMPLES OF APPROACHES TO DEVELOPING VET FOR LEC

Examples 1-6 below represent different ways identified of introducing LEC elements into VET, whilst Table 6 sums up the different KSC components covered in these.

1

EXAMPLE OF COMMON SYLLABUS: GERMANY

As with other construction occupations in Germany, LEC requirements are embedded in the syllabus of the *Stukkateur* (plasterer).

PRINCIPLE
Considerable detail embedded in occupational profile

TYPE
IVET

LEVEL/TARGET GROUP
up to Levels 3/4: highly structured *Lernfelder* (learning fields); regular cyclical updating coordinated by the Federal VET Institute (BIBB) and involving negotiation with social partners.

CONTENT
includes as examples:

- Heat retention: season, heat exchange, room temperature, etc. considerations
- Climate change: energy costs and use, environmental protection, building protection
- Thermal bridging: bridge types, measures against thermal bridges, etc.
- Calculating heat loss

2

EXAMPLE OF COMMON CURRICULUM: IRELAND

Foundation Energy Skills course was developed as part of a Build Up Skills project and intended for CVET, thought it can also be adapted to IVET.

PRINCIPLE
Standalone introductory module with moderately detailed curriculum

TYPE
CVET, adaptable to IVET

LEVEL/TARGET GROUP
Level 2/3, building envelope occupations

CONTENT
Short course that covers: the principles of 'quality' building, airtightness and insulation, thermal bridging, moisture and ventilation, significance of window quality and positioning and the recent changes to building regulations.

3a

EXAMPLE OF SPECIFIC MODULES: SLOVAKIA

A set of stand-alone training modules were developed as part of IngREeS, a Horizon 2020 project. The project involved partners from Slovakia, the Czech Republic and Austria and targeted middle and higher level construction professionals such as engineers, architects, planners, site supervisors and site managers and assessors of energy efficiency post-construction.

PRINCIPLE
Training delivered in specific modules

TYPE
CVET for construction professionals

LEVEL/TARGET GROUP
Supervisory, managerial and higher professionals.

CONTENT
Specific content for each of the following modules:

- Advanced Climate Adaptive Design
- Internal Comfort and Indoor Air Quality Green Construction Products
- Building Physics and Energy Efficiency Project Life Cycle Management
- Quality Control
- Legal Requirements

3b

EXAMPLE OF SPECIFIC MODULES: FINLAND

The Construction Industry Education Centre RATEKO is owned by the Confederation of Finnish Construction Industries and organises a training programme of short courses delivered by external trainers in all aspects of construction including energy efficiency. Most of these courses are aimed at site supervisors, site & project managers and designers.

PRINCIPLE
Standalone module

TYPE
CVET

LEVEL/TARGET GROUP
Professionals, site supervisors, site/project managers

CONTENT
Courses cover the subjects of building physics, moisture and heat and ventilation.
Certificates awarded include:

- Designer of repair works to moisture damaged structures
- Building investigator of moisture damaged structures
- Building Health Expert
- Site manager of repair works to damaged structures
- Indoor air specialist
- Measurer of air tightness of buildings
- Structural moisture measurer
- On-site heat loss IR measurer
- Supervisor of wet room installations
- Bridge deck water proofing installer
- Installer of loose fill thermal insulation products
- Certified persons for thermographic surveys of buildings

4

EXAMPLE OF SECTOR FRAMEWORK: POLAND

The Sectoral Qualifications Framework (SQF) for the Construction Industry is under development by the Sectoral Council for Competence in Construction Industry, set up in March 2017. The SQF reflects the structure of EQF and indicates the knowledge, skills and competences required at different levels.

PRINCIPLES

Indicates LEC KSC required.

TYPE

IVET

LEVEL/TARGET GROUP

EQF Level 4+ (Supervisory and managerial grades)

CONTENT

The SQF describes the key KSC required in the four phases of construction process, by identifying the 'typical' activities involved in each phase. These phases are:

- Planning & design
- Construction & installation
- Maintenance
- Demolition.

The KSC required are then outlined for each level of qualification. The SQF can serve as indicative content for occupational profiles and curricula.

5

EXAMPLE OF OCCUPATIONAL PROFILE: BELGIUM, ROOFER/INSTALLER

Occupational profiles developed by *Constructiv* and through paritarian consultation and negotiation, with the example of the roofer/installer

PRINCIPLE

LEC (colour coded) elements embedded in national occupational profiles rather than specified separately and then turned into curricula by the training organisations.

TYPE

Levels 3 and 4 with regular cyclical updating through *Constructiv* and social partner consultation and negotiation

CONTENT

competence based on blocks of activities, expressed in terms of:

- *Knowledge:* what a roofer needs to understand e.g. roof lining installation; characteristics, types and commercial dimensions of panels and materials used
- *Know-how:* everything a roofer has to do to practise occupation e.g. install roof linings according to norms and manufacturer instructions
- *Attitude:* conduct, way of thinking and behaviour needed to display to practise occupation e.g. precision and care

OCCUPATIONAL ACTIVITIES are in turn divided into four blocks:

1. Common to all construction e.g. maintenance of work site
2. Basic activities e.g. diagnosis of roof condition
3. Specific occupational activities e.g. installation traditional materials and bituminous seals
4. Green transversal skills e.g. installation of insulation or external sealing

EXAMPLE OF BLOCK OF ACTIVITY: ENVIRONMENTAL AWARENESS, QUALITY AND WELL-BEING

KEY ACTIVITY: ENERGY PERFORMANCE OF BUILDING

- *Knowledge:*
  general principles, consequences of poor installation on insulation and ventilation
- *Attitude:*
  Understanding consequences of each intervention for internal climate and overall energy performance

KEY ACTIVITY: QUALITY AWARENESS

- *Knowledge:*
  Traceability of products, justification of work carried out.
- *Know-how:*
  Keeping labels and markings of materials used
- *Attitude:*
  Working with care, diligence, precision, attention to detail together with the patience necessary to execute detailed work; economic attitude in using materials, tools and time; waste avoidance; having an aesthetic sense and taking into account, where possible, aesthetic aspects of the work; a spirit of autonomy and care for quality; professional conscience; clarifying when others carry out poor quality work.

KEY ACTIVITY: WASTE MANAGEMENT

- *Knowledge:*
  distinguishing between dangerous and non-dangerous products; triage categories, recyclables and materials to be disposed of; categories of disposables and/or disposal procedures with particular reference to asbestos; importance of role of enterprise in the triage and disposal of certain disposables and enterprise and environmental advantages of doing this; understanding handling risks and rules for removal of disposables containing asbestos and other dangerous materials.
- *Know-how:*
  protecting environment and protecting oneself and colleagues from harmful materials and substances; organising sorting methods through trays and containers; sorting disposables; identifying and separating from other disposables those containing asbestos and other dangerous materials, packing and removing them in secure manner.
- *Attitude:*
  having ecological awareness and awareness of possible financial consequences of poor management of disposables; prudence; being systematic in the gathering of disposables; determination to sort disposables; in case of doubt, to determine destination of disposables; care; acting when container full.

EXAMPLE OF GUIDELINES FOR VET FOR LEC: RECOMMENDED LEARNING OUTCOMES BY OCCUPATIONAL AREA*

CONSTRUCTION TRADES

THEME	LEARNING OUTCOMES

LOW ENERGY/ LOW CARBON BUILDING	• Understand role of the trade in achieving required energy and carbon performance to minimise energy demand and associated costs over the life of the building.
	• Understand principles of airtightness and requirements for effectively installing the air barrier (sealing at junctions and penetrations etc.)
	• Understand principles of effective insulation, including:
	  • insulation fitting and placement for different insulation types
	  • thermal bridging and condensation risks
	  • thermal bypassing.
	• Understand impacts of trade on the design and installation of efficient energy and ventilation services.
	• Understand basic principles of air quality & ventilation, and main causes of overheating and how to reduce.

SUSTAINABLE PRODUCTS	• Know and identify responsibly sourced products
WASTE, REUSE AND RECYCLING	• Understand principles of materials storage, recycling and reuse opportunities, in order to minimise waste.
WATER	• Have working knowledge of water efficiency on construction site.
WHOLE BUILD PROCESS	• Know sequence of works and role of dependent trades in the build process.

BUILDING SERVICES ENGINEERING TRADES

THEME	LEARNING OUTCOMES
LOW ENERGY/ LOW CARBON BUILDING	• Understand effect upon building fabric of remedial or new installation work (e.g. installers should know the effects of walls and windows on heat loss; heating designers should be able to accurately calculate U-values). • Understand ventilation and its effects on health, condensation, dampness etc. • Understand principles of renewable energy technologies systems installation, commissioning, handover and maintenance including heat pumps, solar thermal and photovoltaics, water harvesting/reuse and biomass systems. • Understand how heating technologies, such as radiators and under floor heating, and combustion and heat pumps, can be integrated. • Understand effect that control systems (including weather compensation, thermostats, individual room control and internet-based controls) have on heating. • Understand difference between insulation types and how they are incorporated into the building fabric. • Understand main causes of overheating and how to reduce it. • Understand basic life cycle costing (e.g. capital cost, energy consumption, energy costs, business case) for lighting and heating systems. • Understand principles of flexible heating, ventilation and air conditioning (HVAC) and lighting systems in creating adaptable spaces.
SUSTAINABLE PRODUCTS	• Know and identify responsibly sourced materials.
WASTE, REUSE AND RECYCLING	• Understand principles of materials storage, recycling and reuse opportunities in order to minimise waste.
WATER	• Have working knowledge of water efficiency on a construction site. • Communicate to customers appropriate resource-efficient water systems.
WHOLE BUILD PROCESS	• Understand role of dependent trades in build process. • Understand main requirements and objectives of commissioning process, various standards and how to meet them. • Understand the importance of post-occupancy building performance evaluation.

* Extracted from the CIC (2017) *Sustainable Building Training Guide*, produced by the Leeds College of Building, UK.

TABLE 6
LEC KSC covered in VET for envelope occupations
(based on the examples from Belgium, Germany, Ireland and UK)

	KNOWLEDGE AND UNDERSTANDING
CLIMATE CHANGE	• energy costs and use • environmental protection • building protection
LOW CARBON BUILDING/ ENERGY EFFICIENCY AND BUILDING PHYSICS	• principles of energy performance • building envelope • heat retention and loss (season, heat exchange, properties of materials) • air tightness and insulation (types of insulation, consequences of poor insulation, thermal imaging) • thermal bridging (bridge types, measures against thermal bridges) • moisture and ventilation (condensation risks, consequences of poor installation) • window quality and positioning
LOW CARBON BUILDING	• understanding principles of renewable energy systems and technologies • understanding how heating technologies can be integrated • understand effect that control systems have on heating
RETROFITTING	• Understanding effect upon building fabric of remedial or new installation work
WHOLE LEC PROCESS	• Understanding sequence of works and roles of occupation/dependent occupations in achieving energy performance required
EFFICIENT RESOURCE USE AND SUSTAINABLE PRODUCTS	• understanding water efficiency on site • knowledge of responsibly sourced products and justification for using them • understand principles of materials storage, recycling and re-use opportunities
LEGAL REQUIREMENTS	• knowledge of regulations, rules and standards in low energy construction • EPBD and NZEB • national policies and building Regulations
THE EXAMPLE OF WASTE MANAGEMENT	• distinguishing dangerous and non-dangerous products, triage categories, recyclables and disposable materials • categories of disposables and/or disposal procedures with particular reference to asbestos; • importance of role of enterprise in triage and disposal of certain disposables and advantages of doing this; • understanding handling risks and rules for removal of disposables containing asbestos and other dangerous materials
	SKILLS/KNOW-HOW
QUALITY AWARENESS	• Keeping labels and markings of materials used
THE EXAMPLE OF WASTE MANAGEMENT	• protecting environment and oneself and colleagues from harmful materials and substances; • organising sorting methods through trays and containers; • sorting disposables; • identifying and separating from other disposables those containing asbestos and other dangerous materials packing and removing them in secure manner
EFFICIENT RESOURCE USE AND SUSTAINABLE PRODUCTS	• Identify and use sustainable products
	COMPETENCES (PERSONAL AND SOCIAL)
	Displaying conduct, way of thinking and behaviour necessary to practise occupation (e.g. precision, care)
	Able to coordinate the sequence of works and occupational roles to achieve necessary energy performance
	Able to anticipate the consequences of each intervention for internal climate and overall energy performance
QUALITY AWARENESS	• working with care, diligence, precision, attention to detail, with the patience necessary to execute detailed work; • economic attitude in using materials, tools and time; • waste avoidance; • having aesthetic sense and taking into account, where possible, aesthetic aspects of the work; • spirit of autonomy and care for quality; • professional conscience; • clarifying when others carry out poor quality work
WASTE MANAGEMENT	• having ecological awareness and awareness of financial consequences of poor management of disposables; • prudence; • being systematic in gathering disposables; • determination to sort disposables; • in case of doubt, to determine destination of disposables; • care; • acting when container full

RECOMMENDATIONS

The guidelines and the recommendations below are intended to address VET for LEC weaknesses. Guidelines and tools for doing so (page 31) can be identified within Approaches 1–6 set out above. Four of these provide criteria for curriculum development (Approaches/examples 2, 3, 5 and 6), which can be supplemented by developing Approach/Example 4 to address occupational overlaps. Above all, the transparency tool given in Table 1 (page 12) is recommended to be used as a mechanism for curricula design and a check as to whether existing criteria are comprehensive and up to date, supplemented by the KSC checklist given in Table 6 (page 36).

The following recommendations complement the curricular guidelines to be found above:

1. *LEC content needs to be embedded* within syllabi, curricula and occupational profiles and not separate from other occupational content, whether in IVET or CVET.
2. *CVET courses should, whether short term, long term or ad hoc, preferably be incorporated within a comprehensive LEC programme* that sets out content. Different models may be used to do this, including the English guidelines and Irish broad curriculum.
3. *VET for LEC should be interdisciplinary,* taking account of sectoral requirements and occupational overlaps. It should not just focus on the technical requirements for LEC, but also involve self-management, improved communication, cross-occupational co-ordination and teamwork.
4. *VET for LEC requires a holistic approach,* imparting an understanding of the whole construction process, the roles and sequences of each occupation, and the contribution of each to energy efficiency.
5. *For VET for LEC to be effective, it should include process management*, involving also detailed planning so that workers know the requirements for LEC, how to comply with energy targets set, and to be successfully audited.
6. *VET for LEC should be high quality in order to improve attractiveness and facilitate labour market entry.* This is a key measure for improving the demographic, educational and social profile of the workforce. Quality VET for LEC is also important to promote inclusiveness, or the recruitment of groups that have previously avoided the sector or are currently under-represented within it.
7. *VET for LEC needs to be tailored to different entry levels,* so catering for new entrants as well as the existing workforce (CVET as well as IVET) and taking account of the potential for those with suitable previous experience and/or qualifications.
8. *VET for LEC should be developed and updated jointly by the key stakeholders:* employers, trade unions, local authority and educational institutions.
9. *Policymakers need to address VET for LEC financing and resources to take account of structural and labour market challenges.* These include the prevalence of: self-employment; micro enterprises; and different layers of subcontracting. Related to this is the need for CVET for LEC to apply to the entire workforce, including non-national workers.
10. *Where there are differences in NZEB and EPBD definitions,* each European state needs to consider the implications for VET for LEC implementation in its own jurisdiction.
11. *Practical learning for LEC is essential,* and should be well integrated with knowledge requirements, whether taking place at the workplace, in workshops or in the European NZEB Centre of Excellence in Wexford, Republic of Ireland.
12. *Further research is required on VET for LEC requirements and labour process links between envelope occupations and building services.* Not only should building services develop VET for LEC curricula, but interdisciplinary (occupational overlap) issues should be addressed by these occupations.

CONCLUDING REMARKS

As apparent from this report, there is considerable variation in the approaches taken to VET for LEC, despite the common requirement for an energy literate construction workforce aware and able to meet the European LEC and NZEB requirements. Some countries have developed a range of different KSC components for addressing IVET and CVET needs for the future. However, these need to be adapted to national, regional or local conditions before they can be put into effect elsewhere, with structures set up that are capable of doing this on a continuing basis, involving all LEC occupations (not just the strictly sectoral ones). Other countries appear to be weaker, though often providing good and inspiring examples. Nevertheless, none of the countries examined appear to be systematically addressing the main weakness originally identified in the Build Up Skills reports, the need for cross-occupational coordination and a holistic approach to the building envelope, though the Belgian VET system does tackle occupational overlaps.

The lack of gender diversity in construction is a critical issue, one that relates to barriers in terms of the nature of VET and employment and human resource policies and practices. Yet many of these are also barriers to achieving effective LEC, including the need for a more holistic and high standard VET system (Clarke 2017). The suggestion is that meeting the LEC challenge opens up the possibility to include more women. Raising standards in construction VET could also help address the recruitment crisis; technologically up-to-date, well-resourced and high level VET leading to qualifications valued in the sector could make a career in construction an attractive option for young people.

Another issue raised is how to close the performance gap and meet NZEB specifications. Inadequate, poor training jeopardises efforts to meet the high energy performance standards needed. Investment in high quality VET is crucial to reducing the contribution of the built environment to CO_2 emissions. Transforming construction VET can be seen as presenting the opportunity for the European construction industry to rebrand itself as a 21st Century eco-industry, meeting the challenges of climate change and fuel poverty through truly low energy and low carbon emissions buildings. Furthermore, investment in high quality VET is crucial to reducing the contribution of the built environment to CO_2 emissions and at the same time ensuring a safe and good quality construction process, using environmentally-friendly materials and free from asbestos.

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PROJECT PARTNERS

The final conference of this project has been an official event of the EU Vocational Skills Week 2018.

THIS REPORT presents the findings of a two-year project co-ordinated by the EU sectoral social partners for the construction industry, FIEC and EFBWW, and involving partner organisations from 10 EU countries: Belgium, Bulgaria, Finland, Germany, Hungary, Ireland, Italy, Poland, Slovenia and Spain.

The EU strategy to improve the energy performance of buildings has major implications for vocational education and training (VET) for construction and for the construction labour market across Europe. Meeting the standards of Nearly Zero Energy Buildings (NZEB) depends on an adequately trained workforce, which means that existing VET needs to be adapted to incorporate deeper knowledge and understanding of energy efficiency and higher technical skills. At the same time, the integrated teamwork and holistic approach to the building process required imply a less fragmented and more inclusive labour market.

A wide range of training initiatives is being trialled across the EU as Member States prepare for the transition to low energy construction (LEC). Based on an investigation and evaluation of different approaches to VET for LEC, the report identifies the knowledge, skills and competences needed and presents examples and guidelines of curricula. It provides all the ingredients of a core energy literacy curriculum adaptable to implementation in different VET systems, and compatible with the European Qualifications Framework.

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