Advancing Climate Literacy in Union Vocational Education and Training Programs in English Canada, Quebec, Europe and the US: Analysis, Findings and Lessons Learned

Appendix 5:
Differing Approaches to Embedding Low Energy Construction and Climate Literacy into Vocational Education and Training

Climate and Industry Research Team (CIRT) **August 2023**

Differing Approaches to Embedding Low energy Construction and Climate Literacy into Vocational Education and Training

CIRT Team[1]
Europe: Linda Clarke and Melahat Sahin-Dikmen, University of Westminster, and Christopher Winch, Kings College London
US: Vivian Price, California State University Dominguez Hills, USA
Canada: John Calvert, Simon Fraser University, Vancouver, and Pier-Luc Bilodeau and Evelyn Dionne, Université Laval, Quebec, Canada

Abstract
This chapter presents varied approaches across Europe and North America to embedding climate and energy literacy into construction occupations through programmes of vocational education and training (VET). These approaches involve different coalitions of stakeholders and range from those in which the public sector and the unions play a key role to those largely reliant on private sector, employer-driven initiatives. VET for low energy construction (LEC) may be mainstreamed into comprehensive, long-term programmes for all construction occupations or consist of short courses imparting the specific skills required to carry out individual tasks. The chapter draws on a project, Building it Green, seeking to embed climate literacy into the building trades and identify good practice examples in the coordinated market economies (CMEs) of Belgium, Germany and Sweden and the liberal market economies (LMEs) of Canada, the United States of America (USA), Ireland and the United Kingdom (UK). Each case is examined in relation to the involvement of different stakeholders, the VET model, and the approach taken towards including labour, whether Taylorist or aiming to empower.

The chapter reveals sharp differences in the importance attached to VET for LEC in Europe and North America. Examples of good practice are found in the comprehensive VET programmes of Belgium and Germany, the state-supported VET for LEC centres in Ireland, and a UK local authority direct labour organisation. While the unions have a significant role in Canadian VET, climate literacy is only recently emerging as a significant focus. The US has positive examples, particularly at state level, but is hampered by low union density and, as also in UK, lack of consistent government policy on climate mitigation. The chapter concludes that equity and valuing labour are key to combatting climate change.

[1] CIRT or the Climate and Industry Research Team is responsible for the research underpinning the Canadian Building Trade Unions' Building it Green project, funded by the Canadian government.

Introduction

The aim of this chapter is to identify the ingredients needed to embed climate literacy successfully into vocational education and training (VET) programmes for construction. The chapter draws on examples from North America and Europe, representing a wide range of approaches to low energy construction (LEC). Programmes for developing the LEC workforce range from long-term efforts to embed climate and energy literacy into comprehensive VET programmes for all construction occupations to short courses imparting the specific skills required to carry out individual tasks. The respective VET systems involve different coalitions of stakeholders, including national, regional, and local governments, employers, unions, and VET institutions, and range from those in which the public sector, social partners (unions and employers) and the state education system play a key role to those largely relying on private sector, employer-driven initiatives. Whatever the constellation has implications for what is needed to equip trainees and workers to understand and address the urgency of climate change and apply the knowledge, know-how and competences required. Whilst the chapter, therefore, focusses on VET for LEC, it seeks to place initiatives to embed climate and energy literacy within the context of their respective VET systems.

Globally, around 28% of carbon emissions from buildings are attributed to the operation phase (i.e. energy needed to heat, cool and power buildings) and 11% to the construction phase (i.e. materials and construction process/embodied carbon) (WBC, 2019). The European Union (EU) aims by 2030 to reduce emissions by 32.5% and increase the share of renewable energy and energy efficiency by 32% compared to 1990 levels (EC, 2019). In Canada, the targets are 40%- 45% reductions by 2030 and net-zero by 2050 (Canada 2021a,b), whilst the United States, which rejoined the Paris Agreement in 2021, aims for 50-52% by 2030 and net-zero by 2050 (US 2021) .

The chapter draws on a Canadian-based project, Building it Green, that seeks to embed climate literacy into the building trades and to identify good practice examples. The research involves interviews with stakeholders in Canada, the United States and different European countries, including Belgium, Britain, Germany, Ireland, and Sweden. Each case is examined in relation to the involvement of different stakeholders, including unions, employers and the state, the VET model involved, and whether equity and social justice are incorporated in efforts to reduce carbon emissions and energy consumption. Above all, our concern is with the approach taken towards labour, whether Taylorist, whereby each activity is broken down into small steps so as to reduce skill and training requirements, or aiming to empower through developing the potential of each worker by means of comprehensive VET programmes, encompassing a broad range of knowledge, skills and competences (Taylor, 1911). However, each case is also very different, as emphasis is placed on particular aspects and good practices are highlighted irrespective of their overall importance to the VET system. Indeed, it is often questionable whether there is a 'system' rather than disparate and even sometimes desperate attempts to develop the construction workforce for LEC. The chapter is not therefore strictly a comparison of different approaches to VET but a depiction of various scenarios, illustrating a range of possibilities.

We anticipate that, in covering such a large number of different approaches across two continents, the chapter is of value to other countries in the Global North with similar systems. It is, however, beyond our scope to embrace the Global South, which can have a different set

of priorities and issues, with many countries being also the victims of carbon-intensive policies and practices enacted in the Global North. The chapter begins with a framework for understanding the different VET systems covered, drawing on Hall and Soskice's (2001) distinction between liberal and coordinated market economies (LMEs and CMEs), before sketching the different components needed for effective VET for LEC. There follows a discussion of the CMEs considered, beginning with the Swedish education-based system, followed by Belgium, also college-based but with a more significant social partner component, and finally the German 'dual' system, regulated by the social partners and orchestrated by the state. The next section concerns the LMEs, from the Canadian system based on formal trade apprenticeships and with close union involvement, to the United States (US), where, in the absence of significant state involvement, VET for LEC relies on active promotion by unions and employers. In contrast to the close involvement of unions in Canada and US, the Republic of Ireland and the UK are employer-based, with the state playing a more proactive and unifying role in Ireland than the UK. The chapter concludes by considering the pros and cons of the different approaches to VET for LEC.

Framing VET systems

In considering many countries, a framework is needed for understanding the conceptual and institutional differences between VET systems. Comparative VET research has sought to characterise these in a variety of ways, including Marsden's (1999) distinction between 'training' and 'production' approaches. A 'training approach' is institutionally regulated, related to individuals' abilities and certified qualifications, usually collectively and industrially organised and long-term, by equipping them over a working life to operate in specific occupations and sectors. This contrasts with a 'production' approach, where 'skills' are work-based, with training largely dependent on individual employers and on-the-job learning. The distinction resembles Rauner's (2007) between VET systems educating for an occupation and those concerned with the 'employability' of individuals, as with micro-credentialing where workers are trained to perform a limited task.

For our purposes, faced with a range of countries, an appropriate starting point is Hall and Soskice (2001)'s Varieties of Capitalism (VoC) distinction between LMEs and CMEs, which considers groups of countries as representative of particular capitalist economies and hence VET systems (e.g. Hall and Soskice, 2001). In CMEs, most closely associated with European countries such as Germany, formal institutions play a central role in governing the economy and regulating relations with stakeholders, with VET systems characterised by relatively high levels of social partnership between employers and unions. In contrast, coordination in LMEs, associated with Anglo-Saxon countries, occurs primarily through market mechanisms and is hence more oriented towards shareholders, which can mean the relative marginalisation of VET.

The VoC approach has been criticised for its apolitical, institutionalist, and firm-centred nature, viewing labour as passive factor of production and ignoring potential antagonisms in capital-labour relations in the production sphere (Ebenau et al., 2015). Above all, it relies on national characterisations, thereby blurring the considerable disparities that exist within countries. Building closely on the approach, however, Bosch and Charest (2008) showed continued divergence of VET systems globally, resulting from historical differences in industrial relations, welfare systems and product markets. Despite its limitations, therefore, the CME/LME distinction of VoC provides a rough means to divide our countries into two groups, consisting of, on the one hand, Belgium, Germany and Sweden, and, on the other Britain, Canada, Ireland and USA.

VET research on the construction sector has further elaborated the institutional and conceptual contrasts between the national VET systems (Clarke et al., 2021a). The study of VET for bricklaying in eight European countries, for instance, applied four comparators - education, governance, labour market and competence – and identified qualitative differences between approaches (Clarke et al., 2013). At one extreme is an 'occupational' approach typical of Belgium and Germany, resting on a statutory framework, social partnership, recognised qualifications, comprehensive, broad, and recognised VET programmes, multi-dimensional competence, occupational capacity and knowledge, general and civic education, permeability, and educational standards related to curriculum content. At the other extreme is a 'skill-based' approach, typical of the British system, resting on weak statutory framework and stakeholder involvement and characterised as employer-based, with poor labour market currency, fragmented narrow skill sets, a functionalist-behaviourist conception of competence built on task descriptors, minimal underpinning knowledge, lack of permeability, and learning outcomes as performance criteria related to defined workplace tasks. Our cases are therefore best conceived on a spectrum, from the occupational approaches of CMEs, whether heavily dependent on the state and educational institutions or more reliant on social partnership, to the skill-based approaches of LMEs, whether involving employers and unions or entirely employer-based.

Such contrasting approaches reflect labour market differences, including the structure and organisation of firms, employment status of construction workers, degree of supervision required, and industrial relations (Brockmann et al., 2010). A critical issue is lack of equity, including gender diversity and the exploitation of migrant workers, attributable to barriers in VET and to employment and working conditions (Clarke and Sahin-Dikmen, 2021). Meeting the challenge of a green transition in construction opens the possibility to include women and other excluded groups and to change the status of migrant workers. Technologically up-to-date, well-resourced and high-level VET, leading to qualifications valued in the sector and equipping trainees for LEC, could help achieve a just transition to an environmentally and socially sustainable industry.

LEC VET components

LEC requires a highly qualified workforce and a broad scope of abilities incorporated in different construction occupations because it is fundamentally different from conventional construction. The building envelope is defined as a single thermal unit with renewable technologies made up of elements that come together through the social interaction of different occupations, including bricklaying, carpentry, plastering, floor laying, insulation, electrical engineering, and plumbing (Clarke et al., 2021b). LEC calls for upgrading existing VET systems to incorporate deeper *knowledge* of energy efficiency, higher technical and precision *skills*, and a holistic approach to the building process (Build up Skills, 2012). A broad set of transversal abilities is needed, involving *competences* not addressed in most VET systems, such as effective communication, project management, problem solving and autonomous working (Clarke et al., 2017; Relly et al., 2022). Cross-occupational coordination on site requires enhanced inter-disciplinary understanding and substantial and varied practical experience, particularly for eliminating thermal bridges in buildings, involving actions at the interfaces of different occupations, such as between the work of electricians and insulators. However, because of the 'skills' conceptualisation of workplace know-how, which goes together with the fragmentation associated with extensive subcontracting, especially in LEC countries, workers are expected to fulfil specified tasks without much reference to those in other occupations or regard to the integrity of the project as a whole.

The Build-up Skills (BUS) programme initiated by the European Commission in 2010 and covering 30 European countries revealed that VET systems are adequately equipped to integrate LEC competences into existing programmes in only a small number of European countries, such as Belgium, and Germany where significant progress has already been made in mainstreaming LEC competences (Clarke et al., 2019). There is persistent evidence that energy performance requirements specified are not met in practice because of incorrect and poor-quality installation, effectively jeopardising emissions savings targets, providing further evidence of the need for improved VET quality (Sunnika-Bland and Galvin, 2012; Zero Carbon Hub, 2014). Such shortcomings might be addressed through regulation and procurement policies but are instead frequently left unrectified for cost reasons as contractors, especially in LME countries, tend to compete on price rather than quality.

It is not just a question of developing the knowledge and know-how necessary to carry out a particular occupation to stringent zero carbon construction standards, but also important for trainees to become climate literate so that they know why they are doing what they are doing and how this relates to climate change. As one union trainer in Canada summarised:

> We do need to make sure that we bring it back to why we're making this energy transition and understand that there is severe impact to how we've been doing things for these decades upon decades and we're feeling those consequences now. Our time is running short of when we can really make change to avoid some of these disasters that are coming, so we need to make sure that the climate is part of the dialogue. That we're encouraging solar, not just because we want to put our members to work…we want to make people's lives more resilient…to make sure that the environment is there for future generations.

Yet interviews with trainers reveal a variety of different approaches to teaching climate material, depending on a specific occupation's direct involvement in low carbon construction practices and the interests of individual trainers. Thus, teaching how to install solar panels, wind turbines and electric charging stations facilitates electricians in making the link to climate change, just as for plumbers does teaching how to install energy conserving heat pumps and advanced HVAC (heating, ventilation, and air-conditioning) systems.

Coordinated Market Economies

CMEs are typically leading countries in Europe that belong to the EU, including Sweden, Belgium and Germany. As such, the transition to 'green' buildings is guided by EU legislation, including: the European Performance of the Buildings Directive (EPBD, 2021/2018/2010); the Renewable Energy Directive (2021/2009) and the Energy Efficiency Directive (2021). The legislation mandating the transformation of buildings is designed to deliver the EU's growth, energy and climate change strategies, articulated in the 2030 Climate Target Plan (2020) and the European Green New Deal (2019) as well as the Renovation Wave for Europe (2020) set in motion with the objective of reaching net zero in 2050. All member states are required to transpose EU legislation into national law so that these initiatives serve as important drivers. It is in this context that the VET systems associated with the CMEs discussed below are being developed.

Education/school-based systems

Of the countries covered in this chapter, both Sweden and Belgium can be classed as having

predominantly school-based systems, in the sense that the responsibility for VET rests predominantly with the state education authority. This does not, however, mean that there is no work-based element or that the social partners play no role.

Sweden

Sweden, along with other Scandinavian countries, has a long history of energy efficient building, insulation being common practice since the 1970s. In addition to EU legislation, the Swedish Government's Climate Policy Framework (2017) commits to implementing the Paris Agreement, reaching net zero emissions by 2045. As a school-based construction VET system, the country represents one end of the spectrum from education/state-based VET within CMEs to employer-based systems within LMEs. The Swedish National Agency for Education decides on the VET and qualifications framework and issues guidelines for teachers responsible for developing construction curricula and syllabi, whilst the role of the social partners is advisory. For the trainee, the first three years are spent in a school or college, followed by two years as apprentice in a firm. The result is a greater emphasis on the knowledge component in the curriculum than the skills and tasks required in the workplace (Grytnes et al., 2018).

The VET curriculum was reformed in 2010-2012, when the Swedish National Education Agency issued general guidelines relating to energy efficiency and sustainability. Whilst curricula, for instance, for carpenters, electricians, and plumbers cover technical aspects of LEC, the three 'school-based' years for those on the vocational pathway also follow the national secondary school curriculum, designed to ensure students develop general competencies, in addition to construction specific knowledge, understanding and skills. This includes subjects such as the Swedish language, mathematics, history, and social studies as well as exposing students to social and political issues including climate change. The national construction curriculum gives students opportunities to develop: understanding of the industry's role in society and in regard to sustainable development; knowledge of what rational, safe and environmentally sustainable development means for the sector and its responsibilities; knowledge of common professions and work processes; and the abilities to cooperate and communicate with others and use professional language appropriately as well as to use sustainable resources, such as material handling, storage, minimization of waste and sorting of construction waste.

In these respects, the curriculum is underpinned by climate literacy, offering a broader and deeper understanding of climate change and its relationship with building construction. It also encompasses components required for LEC, including a holistic understanding of buildings and transversal abilities such as communication, cross-occupational coordination and interdisciplinarity. However, a common refrain from interviewees was that guidelines are not sufficiently detailed or occupation-specific and that knowledge related to energy efficiency is insufficiently contextualised and related to climate change and to the United Nations (UN) Sustainable Development Goals (SDGs).

Following the reform of 2011, problems have been the lack of training for teachers and the focus only on pedagogical, rather than technical or occupational-specific, issues. As a result, the Swedish Construction Federation in collaboration with the social partner-led training boards developed a short continuing education programme in which a third of VET teachers participated (Tullstedt and Douhan, 2013). The remaining two-thirds remains a key challenge as enhanced energy efficiency competence in the workforce and having qualifications are not requirements to work in construction, except for electricians.

Belgium

As in Sweden, the construction VET system in Belgium is largely college-based, with only one quarter of the three-year education period spent with an employer. However, this is then followed by a two-year, paid apprenticeship, working for an employer and essential for achieving certification as a fully qualified person. In contrast to the Swedish system, VET is governed through social partnership whereby education boards for each construction occupation, involving representatives of employer associations, unions and teachers, work together in an advisory capacity to the National Education Agency. Like Sweden, the national curriculum for vocational secondary schools provides general guidelines that inform the development of occupation-specific course specifications.

Belgium has a national structure for handling construction VET through the long-established social partnership body *Constructiv*, which does not include electrical and plumbing. *Constructiv* is financed by a levy and involves both employers and unions in drawing up and updating occupational profiles, producing indicative syllabuses in the form of handbooks, and arranging onsite continuing VET. It is, however, the training institutions that are ultimately responsible for constructing programmes within the parameters of the occupational profiles. Whilst most of initial VET takes place in colleges, students receive extensive on-site experience and *Constructiv* finances the training of mentors working on-site and workplace-based training that meets certain standards. This also helps ensure that the existing workforce is kept up to date with new technologies, practices, and regulations, though continuing VET is largely demand-driven so dependent on employer initiative.

All occupational profiles, for example the *Couvreur-Étancheur* (roofer-installer), contain some common elements and have a common format that details Knowledge (*Connaissance*), Know how (*Savoir faire*) and Attitude (*Savoir être*), with knowledge applied to know-how (theory into practice) but with an appropriate attitude of commitment, consideration, attention to detail etc. Workers mastering the knowledge, know-how and attitudes set out in the occupational profiles and taught via a curriculum are able to act independently and in teams across broad interfaces.

VET for LEC is based on the principle that LEC-related competencies are incorporated or mainstreamed into existing occupational profiles and curricula of each occupation. Both Belgium and Germany are identified in the European construction social partner project, *Inclusive Vocational Education and Training for Low Energy Construction* (or VET4LEC - Clarke et al., 2019), as relatively well prepared. The Belgian VET system meets the five key requirements identified for successful LEC: communication, coordination, problem-solving, project management and precision. For example, the know-how requirement to 'keep labels and markings of materials used' in relation to 'quality awareness' for the Belgian occupation of *Couvreur-Étancheur* assumes the worker knows how to trace products and justify the work carried out. Furthermore, the know-how is exercised by working with care, precision, patience, economically, autonomously, with professional conscience and even aesthetically. Workers thus need to recognise the practical importance of the knowledge acquired and use their discretion and judgement, including in 'clarifying when others carry out poor quality work' (Clarke et al., 2020a).

Though deeper understanding of climate change and its relationship with construction associated with climate literacy is not embedded, nevertheless Belgium's standards-based approach to VET is paramount for meeting EU NZEB (nearly zero energy building) quality standards. There have been no major subsequent reviews of occupational profiles, as *Constructiv* focusses on combating serious labour shortages and improving workforce

diversity, which as in Germany is very poor. Though in both countries, for instance, women make up around 9 % of the construction workers, this is primarily women in administrative and office positions; the number actively working on construction sites is much smaller, and of those in VET the average percentage of female trainees is 1-2 % (Women Can Build, 2020).

Social-partner-based VET in Germany

Germany's construction VET system differs from Belgium's in its 'dual' nature, being regulated by the social partners with the state responsible for setting the legislative framework and supervision and unions and employers associations involved formally in training and education bodies at all levels. The system covers over 20 construction occupations, whereby trainees apply to a company and levy-funded training is spread roughly equally between three locations: the company (practical), training centre and vocational school. The three-year VET programme is stepped, whereby trainees begin in the first year with a broad introduction to all the different construction occupations, then specialise in the second year into finishing, building or civil engineering, and only concentrate on a particular occupation in the final year (Clarke et al., 2019b). This has the advantage of providing an overview of the work of different construction occupations and their interactions, so conceiving the building envelope as a single unit, though building services belong to a different sector from building, and hence come under different social partners.

LEC elements are as in Belgium mainstreamed into VET programmes of existing construction occupations, and national curricula for each construction occupation (including building services) incorporate these and provide detailed syllabi through pedagogic materials. For example, the textbook for the plasterer (*Stukkateur*) includes the purpose of insulation, internal climate control, costs of heating and energy use, environmental protection, and thermal bridging as well as explanations of the nature of climate change, so necessary for developing climate literacy (Handwerk und Technik, 2014: 172-9). VET programmes are constantly reviewed and adjusted, taking account of technological changes, economics, the legal framework and social conditions (Clarke et al., 2020b). Social partnership structures ensure the representation of all relevant perspectives and inclusion of critical elements, overseeing curricula and publishing detailed pedagogic materials covering both practical and theoretical elements of VET for LEC.

Considerations

Of the above CME countries, Belgium and Germany stand out as more advanced in embedding LEC elements into curricula, whilst Sweden and Germany also incorporate the wider context of climate change. For Belgium and Germany, BUS recommended only specific changes, including improving theory-practice integration and teacher training in Belgium and strengthening systems thinking and interdisciplinarity in Germany (EC, 2014). A high proportion of the existing workforce is skilled and holds a recognised qualification, signifying workers possess basic knowledge and competence to master new concepts and techniques. Both VET systems are resourced and up to date, combining school based and practical learning through a substantial off-site, workshop-based component as well as work placements. Their broad-based occupational capacity provides a suitable framework for developing knowledge and understanding of energy efficiency, a holistic view of construction to enhance occupational coordination, and transversal abilities (Clarke et al., 2013; Winch, 2014).

The broad understanding of agency imparted thus responds to the demands of a LEC labour

process that workers operate independently, apply expertise acquired appropriately, problem solve as necessary and take responsibility for meeting specified standards and quality. Levy-grant arrangements facilitate co-ordinated development and responses to new developments, such as insulation in Belgium and 'certified renewable energy specialists' in Germany. In both countries, the construction labour market is regulated and less fragmented than many others, providing an infrastructure for the work-based element of VET difficult to achieve elsewhere, so conforming to Marsden's (1999) 'training' approach. However, industrial relations are very different as unions are weaker in Germany, with a unionisation rate of 18% compared to 50% in Belgium and 68% in Sweden. Nevertheless, the works councils in Germany, designed as are the unions to protect the rights and interests of employees, must be consulted by the employer on VET issues and, since 2021, with the Act to modernise works councils (*Betriebsrätemodernisierungsgesetz*) can call the conciliation board if no mutual agreement can be reached.

Liberal Market Economies

VET systems in the LME countries considered – Britain, Canada, Ireland and US - differ significantly from each other and from those in CMEs, in the way they are organised, the terminology applied, and their policy frameworks. For instance, in contrast to reference to 'trainees', 'occupations', and 'skilled workers' in CMEs, Canada and the US refer to 'apprentices', 'trades' and 'journey workers' respectively, so underlining Clarke et al's (2013) distinction between occupational and skill-based approaches. These LME systems, therefore, whilst varied, represent skill-based systems, focussed more on labour output than developing labour potential or power.

Union and employer-based VET in Canada and US

North American VET for construction differs from that in Britain and Ireland in the closer involvement of unions, whilst the British and Irish systems are essentially employer-based.

Canada

Like the EU, Canada has a policy framework designed to meet its ambitious climate objectives including through: the *Pan Canadian Framework for Green Growth and Climate Change* (2016), co-ordinating provincial and federal climate policies; *Bill C-12* (2021) establishing a roadmap to achieve net zero by 2050; and the *Canada Green Building Strategy* (2022) with options to accelerate climate initiatives. The federal government has allocated significant funds to promote union-led training programmes through the *Union Training and Innovation Program* (UTIP) and increased regulatory tools such as building, energy, plumbing, fire and other construction codes to push the construction industry, incrementally, towards net zero (Canada Green Building Council 2020). While national model codes provide the templates, the Constitution allocates responsibility for VET largely to the provinces, which can adapt them to specific circumstances and control update timing (Lockhart et al., 2020; Pride, 2020). Code enforcement is a provincial responsibility, often delegated to municipalities, though inspections focus primarily on public safety, which takes precedence over such environmental concerns as monitoring higher LEC standards.

Canada Green Building Council (2020) companies have positioned themselves as leaders in LEC, having built model projects and promoted LEED (Leadership in Energy and Environmental Design) gold and platinum buildings, though LEED points can be awarded for features unrelated to reducing energy or carbon emissions. Despite the advances, mainstream

industry remains overwhelmingly wedded to conventional building practices and opposes government regulation, maintaining the market can address and industry shape climate measures.

Canadian VET system[2]

Canada's approach to VET in construction is based on formal apprenticeship in recognised construction 'trades', with provincial governments maintaining qualification standards and working with the Federal Government to harmonize these across the country. Apprenticeship lasts between three to five years, depending on the trade, in which – in contrast to CME countries - 80 percent is spent employed under certified journey workers with the remainder classroom-based (Canadian Apprenticeship Forum, 2018; Mate, 2020). Unions support their apprentices' employment by recommending them to employers with whom they have collective agreements, which normally establish ratios of apprentices to qualified trades' workers, thereby guaranteeing them jobs. Both Federal and provincial governments also support pre-apprenticeship programmes, particularly targeting those traditionally excluded from construction. Federal Government coordinates the national Red Seal Program, which oversees curriculum content through consultation with provinces, employers, colleges and unions, and administers national exams. Red Seal standards for each trade are amended periodically to reflect industry developments. Provinces also award Certificates of Qualification (CQs), reflecting their different climates, geography, economies and construction industries. About two thirds of graduating apprentices acquiring provincial CQs also obtain Red Seal certifications, confirming them as qualified 'journey workers' and thus enabling them to work in any province, facilitating national mobility.

Beyond the CQ, there is no 'higher level' trades' certification, although various upgrade micro-credentials are offered by manufacturers, public colleges, and private training organizations, such as the Canada Green Building Council, in specific areas such as Passive House construction, varying from a few hours to several months. Provincial authorities designate trades as either 'compulsory', whereby work is legally restricted to journey workers with a provincial CQ, or voluntary, whereby anyone can do the work. Unions favour compulsory trades to promote member employment and limit employers' ability to hire less skilled workers at lower rates. Government support for these standards thus facilitates unionization and guaranteeing worker competency. Unions fund trade-specific training facilities jointly with employers through collective agreements, enabling them to operate their own facilities and giving them a major role in apprenticeship training (Calvert and Tallon, 2017). Otherwise, provincial governments provide training through public colleges.

Apprentices bear the bulk of training costs themselves through their paid employment, though provinces partly subsidize the in-class components, while the federal government provides income support for apprentices' classroom time through Canada's employment insurance system, scholarships, and tax credits. Loss of earnings during classroom training is a financial problem. To be certified, apprentices must document having worked the required hours for each year of their apprenticeship. As construction is precarious, finding sufficient hours to graduate is challenging. Registered apprentices must leave their job to return to school for the required annual two months. Approximately half fail to complete. Unionized apprentices are more successful as collective agreements require employers to hire apprentices and unions are responsible for finding employment (Coe, 2013; Calvert, 2014).

[2] The content of this section mostly refers to English Canada; labour market policies in Quebec covering the construction industry are closer to those of CMEs (Charest, 2003).

As in CME countries, women and indigenous workers remain substantially under-represented in the construction trades despite efforts governments and unions to expand training opportunities through targeted projects (Construction Council of British Columbia, 2018). New registrations of women in traditionally male dominated Red Seal trades vary from 3% in Manitoba to 6% in Alberta and British Columbia. Whilst approximately 6% of apprentices are indigenous, completion rates remain low and indigenous workers are significantly underrepresented in many large resource projects in their traditional territories (Canadian Apprenticeship Forum, 2018, 2019; Arrowsmith, 2019; Buildforce Canada, 2018).

Including climate literacy in Canadian VET

Red Seal Standards focus primarily on specific tasks, not on climate science and more generic problem-solving capacity, whilst reference in provincial curricula to how construction is impacted by climate change or what the industry or the trade can do to mitigate or adapt is absent, though some mention sustainability, environment, LEED and other low carbon building systems. Instructors must teach the skills specified in the Red Seal Standards and complain there is insufficient time to incorporate new climate material. Modifying the Red Seal to include climate change is not easy; standards for each trade are revised approximately every five years and multi-stakeholder committees must agree on amendments. Additional classroom time is not generally supported by employers; provinces are reluctant to pay for extra classroom time; and, for the apprentices, more classroom time means less paid time on the job. Some instructors consider that the skills currently taught in their apprenticeship programmes can be applied to new climate-related challenges, whilst others recognize the potential role of their trade in addressing climate change and consider systems thinking, teamwork, understanding buildings as integrated projects and shared responsibility for outcomes should be in the curriculum. As expressed by one trades' trainer, the system teaches apprentices the 'how' of construction work, not the 'why' of achieving climate objectives. The curriculum lacks emphasis on worker agency and the positive role of the industry and its construction workforce in meeting climate goals.

The siloed training system also presents a barrier to developing a climate literate workforce as each trade has its own curriculum and there is limited cross trade interaction though the need for trades to know more about others on sites is widely accepted. Construction unions normally represent one trade or group of related trades and negotiate to maintain jurisdiction over work they regard as theirs, upholding clear trade demarcations. These distinctions are reflected in the 'green book', while in Quebec they are part of the by-laws of the province and enforced by the labour relations board.

The role of unions in VET for LEC

The unionisation rate for construction in Canada in 2021 was 31%, though varying between provinces, being significantly higher in Quebec, at 40%, with collective agreement coverage at 57%. Despite Red Seal constraints, unions play an important role in VET for LEC, though there are differences between trades and across the country over how to raise climate change awareness and implement climate literacy training. Examples range from unions including climate material in their curricula, incorporating energy efficiency and green skills into apprenticeship training programme, developing climate literacy modules for instruction, remodelling training facilities to prepare apprentices to work with green technology, and actively organizing to leverage public policies to promote employment in the green economy. Unions support public funding of new 'green' construction and major retrofits and advocate community benefits agreements (Calvert and Tallon, 2016; Bridge and Gilbert, 2017). For

example, the Canadian Building Trades Unions (CBTU), representing 600,000 workers in 14 construction unions, successfully applied to the Federal Government for funding for a 5-year project focused on addressing emerging climate issues and involving consultation with affiliates on the climate literacy content of a future curriculum, to be tested in training programmes and potentially resulting in changes to the Red Seal curriculum (Calvert, 2022).

As affiliates of the US international unions, Canadian construction unions also cooperate on training, even modelling programmes on their US counterparts. For example, UA Canada, representing plumbers, pipefitters and allied trades, uses US training modules from the Urban Green Council's Green Professional or GPRO programme.

Union and Employer-based VET in US

Whilst in many respects similar to Canada, the construction VET system in the US has structural particularities that affect how it addresses climate change (Belman and Ormiston, 2021). There is, for example, far less government funding of apprenticeship, placing more responsibility on individual workers, their unions and employers to train the workforce.

US VET system

One critical difference from the Canadian model is the lack of national testing and certification, magnifying the challenge of broad-based integration of subject matter such as climate literacy across the US. Most trades have centralized curriculum development, such as electricians, plumbers and pipefitters and sheet metal unions, with centres providing core curriculum and modules that local union organisations, known as locals, around the country can request depending on their regional economies, capacity, and preference for developing new areas of work (Woods, 2012).

The primary role of the North American Building Trades Unions (NABTU) is to work with local unions in the 14 affiliate trades in the US and Canada along with state and local building trades councils (Lerman and Rauner, 2012). The unionisation rate in the US, whilst varying across the country, is considerably lower than in Canada, at about 12.6% of the construction workforce. In terms of VET, NABTU's focus is to support and promote their apprenticeships and pre-apprenticeships and partner with stakeholders to diversify the trades and protect labour conditions. To replace retiring workers and increase diversity, they organize the Apprenticeship Readiness Program using a Multi-Core Curriculum, which requires 120 hours of instruction and began in 2007. NABTU maintains an extensive portfolio of course material including a core set of classes and the highly respected GPRO Climate Change Fundamentals, as well as courses NABTU develops or that have been donated by various locals, ranging from detailed training in wind turbine and solar installation to labour history, anti-racist, sexual harassment, and anti-homophobic training. The local Building Trades Council and its educational partners (e.g. high schools, colleges, transitional programmes for the formerly incarcerated, women's programmes) determine what training to offer.

As in Canada, VET programmes that are jointly run by unions and employers are funded with member contributions matched by employers, and based on negotiated clauses in collective agreements (Glover and Bilingsoy, 2005). In practice, this gives unions the ability to operate their own facilities and play a strong role in curricula development. In some states, joint apprenticeships work together with community colleges, and trades classes may be given credit towards matriculation; in some, unions have also successfully pushed legislation to require that trade workers pass a state licensing test and then periodically take a continuing

education course. In many unions, upgrades and certifying courses are also offered, providing possible entry points for a climate literacy class for those who have journeyed out.

Embedding climate literacy in US VET

US national climate policy has been stymied, especially due to the power of the fossil fuel industry to underwrite political candidates at federal level. Opposition to addressing climate change in Congress and the Supreme Court leaves city and state led initiatives to generate policies that motivate employers and training programmes to plan for a zero or low emission economy. For example, US Ironworkers have developed excellent climate manuals, though these are not widely used. Electrical workers have incorporated solar, wind farm and electric vehicle charging content into their curriculum and one local also includes extensive material on climate science. Mechanical insulators teach energy audits and GHG savings from insulation. An instructor interviewed argued that training should include climate science because apprentices need to think not only about their jobs, but about contributing to a greater good.

While most construction trades are eager for work in the renewable arena, they also seek to retain existing employment. At a trade union's train-the-trainer course on clean energy, for example, the director explained that climate change education and training in green skills did not represent lack of support for members continuing working in the oil and gas industry. The course used the GPRO fundamentals curriculum, which explicitly addresses global warming and the causal link to fossil fuel and is followed by GPRO trade-specific sessions. Training directors and instructors from around the country attending this multi-day session revealed that teaching about climate change is controversial in many locals but becoming more common with the growth of low carbon jobs.

Equity issues

The building trades struggle with inclusiveness despite efforts for change. The 1937 National Apprenticeship Act (NAA) grants the Federal Government certain powers, such as permitting the US Department of Labor (DOL) to issue regulations protecting the health, safety, and general welfare of apprentices, to which equity was later added. Since the 1970s, the DOL has responsibility to monitor diversity among apprentices by race and gender, and government intervention has made a difference in diversifying the trades though they remain male dominated (Luke et al, 2017). While concentrated in manual trades, Latinos have gained ground in many construction unions and constitute 32.6% of the construction workforce, while African Americans constitute only 6.3% of the trades. The proportion of women in the overall construction industry is 11%, though those working on the tools is approximately 3% (Gallagher, 2022).

Some building trade unions recognize that legislation and funding for LEC jobs calls for plans to recruit, train and employ women and those from low-income groups. Biden's National Building Performance Standards Coalition, for example, overtly connects electrification and equity with working with low-income communities. Unions in various states have formed coalitions with environmental justice communities to develop programmes for youth and unemployed adults as part of their green jobs legislative package, for example the Illinois Climate and Equitable Jobs Act. Unions competing with non-union companies often appeal to local governments for project labour agreements, so that public money goes to union or signatory contractors, arguing these offer a career path for workers. Unions have also utilized 'community benefits plans' to show they are serious about

recruiting underrepresented groups for publicly funded jobs though this, as well as preparing members for a low carbon economy, remains a challenge.

Employer-based VET in Ireland and UK

Unlike USA, Canada and the CME countries, unions play a more marginal role in VET in the LME countries in Europe considered, Ireland in the EU and Britain outside. The overall unionisation rate in Britain and Ireland, at about 24%, is nevertheless higher than in Germany, though considerably lower than in Sweden and Belgium and also for the construction industry. Unlike Ireland, in Britain unions are explicitly marginalised from the VET system, as are employer associations, as it is based on individual employers, though at local level and for building services involvement can be significant, particularly in local authorities and on large projects.

Republic of Ireland

In Ireland, in contrast to Britain, the government plays a proactive role in driving forward the national climate strategy, aligning Irish national plans to EU policies for decarbonising building construction, and including stakeholders (e.g. employers, training providers and union representatives) in developing LEC training. Meeting new building standards is a key measure in the Government of Ireland's Climate Action Plan (2021a), which specifies the obligation to upskill contractors and other industry players in deep retrofit, NZEB and new technology installations. Taking a 'just transition' approach, it commits to: improving the fabric and energy efficiency of existing buildings; rolling out zero-carbon heating solutions, predominantly heat pumps and district heating networks; planning for the full phase out of fossil fuels in buildings by 2050; progressive strengthening of building standards for all buildings types; and promoting the use of lower carbon materials and behavioural change in occupants' energy use.

A National Retrofit Plan is part of the Climate Action Plan, and the Public Sector Energy Efficiency Programme foresees an enhanced role in setting standards through good practice examples. Support for expanding LEC training centres is part of the government strategy to upskill the construction workforce. The Action Plan for Apprenticeships (2021-2025) aims to review and upgrade apprenticeships across all industries to respond to skill needs, create a more inclusive system and double apprentice numbers in the next ten years (Government of Ireland 2021b). As a result, workshop and classroom-based elements of the VET system have been considerable improved, with, for instance, LEC centres set up in Waterford for new build and retrofit, with very-well equipped workshops, including a 'mock' house to demonstrate air tightness and insulation examples.

LEC curricula and training

As part of the EU's Build-up Skills programme, the QualiBuild project (2014-2016) addressed challenges identified through two pilot training schemes: The Foundation Energy Skills Programme (FES) and Train the Trainers. A key feature of QualiBuild was to involve a range of stakeholders, supported by a steering group from industry and education, and to set up an online register of LEC-trained construction workers. The FES course was adapted to different trades through ten separate short courses, designed to support the upskilling of experienced workers but suitable for adaptation for apprentices or initial VET. The courses are 'assured' by City & Guilds, which works with governments, organisations and education centres to validate work-based learning programmes, and are at the equivalent of the apprenticeship completion level, whilst the courses for qualified construction workers are

higher. Syllabi were agreed and the first course delivered in 2018, and the first trade-specific course in 2019, with a steady increase in attendance, including for LEC fundamentals, electrical, retrofit, plumbing, ventilation, and carpentry. A notable feature of this process has been collaboration, including with employer organisations and unions, training bodies, and private companies with expertise in energy-efficient construction, and the active support of the Irish government.

VET in UK

Though there exists an apprenticeship framework, construction VET in Britain is hampered by the undervaluing of Further Education (FE) Colleges responsible for classroom and workshop elements and lack of regulation and of a training infrastructure for the work-based element given extensive self-employment, subcontracting and dominance of micro-firms (Relly et al., 2022). Consequently, most construction trainees are full-time in colleges, in anticipation of obtaining a work placement. For instance, in a London FE College covering all construction occupations, there were 500 full-time and 200 part-time students and only 150 apprentices. Young people can enter an FE college full-time, acquire a construction qualification after two years and in principle go on to an apprenticeship with an employer, so echoing the Swedish system.

Individual employers responsible for reviewing the plumbing or electrical apprenticeship frameworks are themselves members of employers' associations and of the Joint Industry Boards covering the building services of electrical, plumbing and heating and ventilating and consisting of employers and unions. As a result, unions and employers' associations in these areas have a say, albeit indirectly. Electrical contractors should be registered on the Microgeneration Certification Scheme, requiring work such as heat pump installation be done correctly, and the Electrical Contractors Association (ECA) encourages members to use PAS35 as a framework for installation for local authority and housing association work, which ensures coordination of work carried out. However, electrical and plumbing work is beset by private training providers and companies purporting to train electricians to, for instance, install solar panels in a few weeks. The union demands a competent person be a judicial entity, but only in Scotland is a minimum level of competency specified.

The Electrical Joint Industry Board (JIB) has introduced LEC elements into the domestic electrician apprenticeship framework, which focuses on new technologies and includes on-site generation, such as small wind energy storage, heat pumps, load control, and smart technology to reduce energy consumption and maximise efficiency, control systems etc. Of the pathways to becoming an intermediate craft plumber, few sign up to environmental technologies and gas remains popular, though the plumbing qualification framework is set for review through an employer-led process in which educationalists are not involved. A qualification handbook is given to training providers, such as FE Colleges, based on an assessment plan containing plumbing and electrical apprenticeship standards.

VET for LEC initiatives

Attention is increasingly given to the VET required for retrofit programmes, largely focussed on technical issues concerning insulation and the installation of heat pumps, though including transversal skills such as communication as well as the roles of Retrofit Coordinator and Retrofit Assessor. The statutory levy-based Construction Industry Training Board (CITB) is developing national occupational standards for insulation and LEC skill requirements. However, incorporating climate literacy into the curricula of different construction occupations is at a low level, due largely to lack of government regulation and recognition of

national occupational standards, insistence on an employer-led system, and marginalisation of unions and employers' associations.

Many initiatives by different industry organisations and regions represent attempts to overcome these restrictions. For instance, a Welsh FE college visited has a flourishing apprenticeship programme, knowledgeable staff and extensive college-based construction programmes, with well-equipped workshops, including a mock house to demonstrate air tightness, solar panels and heat pumps. Procurement policy is used to drive LEC through for example the government agency National Resources Wales and the Welsh Government's own housing programme. Colleges across Britain rely on initiatives from local and metropolitan authorities, for instance, the Greater London Authority's Mayor's Construction Academy, which coordinates and promotes 'green skills' through hubs of key stakeholders, including employers, universities and local authorities but rarely unions. A key problem, however, is the facilities, though FE Colleges envisage that more stringent procurement requirements, including for supply chain contractors to adhere to PAS35 standards, will help create demand.

In Scotland, City Building Glasgow provides an inspiring alternative approach, revolving round an alliance between the local authority – Glasgow City Council, unions, and a housing association (Clarke and Sahin-Dikmen, 2019). All 2,200 staff are directly employed on the construction and maintenance of public works such as social housing, care homes and schools. The accredited apprenticeship scheme delivered at City Building's own Training Centre is a comprehensive, four-year programme, with a diverse intake of about 60 apprentices a year and high completion rates. The programme covers LEC (e.g. insulation, installation of renewable technologies) and provides all-round care to apprentices, including substantial on-site practice, support plans and post-training employment opportunities, with 80% staying on as employees. City Building's LEC schemes contribute to the Scottish Government's ambitions to reduce carbon emissions and tackle fuel poverty, with social housing schemes delivering two-thirds reduction in energy costs. One project involves a district heating network installation, utilizing air source heat pump to 350 properties, and part funded by British and Scottish governments. Collaboration with the Council's in-house architects, a comprehensive training programme, direct employment of the workforce, monitoring subcontractors through a framework agreement and setting employment and quality standards provide a favourable set up for meeting energy efficiency standards. The high unionisation rate and active union engagement with management through the Joint Trade Union Council underpin this strong social ethos.

All in all, much effort is being put into developing and training a workforce for green construction across Britain, particularly by FE Colleges and local authorities. Everywhere, colleges are improving workshop facilities, such as model houses and renewably energy installations. Most noteworthy are events organised to promote green construction to women, combining greening the industry with improving its inclusivity. Many local authorities have declared a climate emergency and set carbon emission reduction targets to address climate change. Many are carrying out assessments of the green construction employment and training required in their areas and drawing up retrofit strategies. The sector is, however, beset with structural problems, partly connected with the domination by micro-businesses and self-employment, leading to difficulties in meeting low energy design specifications, providing training and integrating interdependent processes on site. With half the workforce classed as 'self-employed' and over 95% of firms classed as small, the construction labour

process remains extremely fragmented and hardly provides an infrastructure for the work-based training needed for young people to transition from FE colleges into the labour market.

Conclusions

LEC means a transformation of VET systems to encompass deeper knowledge of energy efficiency, higher technical and precision skills and, above all, a holistic approach so that the building envelope is conceived as a single thermal unit and the social interaction of different occupations is understood. The high-quality construction labour process required involves teamwork and cross-occupational coordination, which imply interdisciplinarity, as well as transversal abilities such as communication, project management, precision, problem solving and coordination. But over and above this, climate literacy is needed to give meaning to the knowledge, skills and competences acquired, so that trainees and workers are empowered and can appreciate why they are doing what they are doing and recognize their contribution to creating a safer and more equitable society. Climate literacy is tied to social equity and climate justice, comprising affirmation of the social contribution and responsibility construction workers, their unions, and the industry have to reduce emissions and the influence they have in determining policy direction.

In addressing these LEC requirements, each of the VET systems outlined has its own strength and weakness. With the CMEs, whilst the construction curriculum of the Swedish school-based system, with its emphasis on knowledge and general competences, is underpinned to an extent by climate literacy and the inclusion of transversal abilities, it is insufficiently detailed or occupation-specific. The curriculum of the other largely school-based system, Belgium, succeeds in mainstreaming LEC elements, breaking down broad occupational profiles into knowledge, know-how and attitudes and developing transversal abilities, so facilitating trainees to work independently and in teams across broad interfaces. Yet, climate literacy is not directly embraced. The other CME, Germany, has the advantage of a stepped programme of gradual specialisation, helping trainees to understand the whole building envelope, as well as covering climate change relating to different occupations, but is weakened by low unionisation and dependence on individual employers to take on trainees.

In many respects the construction VET systems of LMEs, more constrained by market conditions, are at a disadvantage in their ability to meet LEC requirements and incorporate climate literacy. They have nevertheless the advantage of being less constrained in developing new initiatives, particularly at local level and by the unions, as evident in the countries considered. The regulatory and joint funding arrangements for the Canadian apprenticeship system, for instance, which allows unions to have a say in construction VET and even to run their own training facilities, has potential to develop climate literacy in the curriculum and strengthen worker agency. It is, however, limited in doing so by lack of time allocated to classroom and workshop-based training and by siloed trade divisions, leading to demarcation disputes and impeding the development of a holistic, industry-wide approach. A similar situation applies regarding the US VET for LEC system, whose strength lies in the active promotion by unions of effective equity measures and courses such as GPRO, which explicitly address global warming and its causes, but which is thwarted by lack of standards for the trades and low union density.

VET for LEC initiatives in North American LMEs are rooted in the unions, but this is far less the case in LMEs such as Ireland and Britain, where unions play a marginal role in developing curricula and in the VET system. In Ireland, the state is pivotal in supporting LEC

and the training courses needed for the existing workforce through the Training Boards and Institutes of Technology, though curricula lack the emphasis on climate literacy and the impact of climate change on different trades evident in the US GPRO courses and efforts to embed climate literacy in apprentice training lack urgency. The success achieved in turning a pilot LEC training course into a (nearly) national programme tailored for different occupations owes much to a process that mimics aspects of co-ordination and stakeholder partnership found in CMEs. In Britain, despite the employer-based VET system, unions play a role in promoting LEC elements in building services curricula, and politically accountable local authority direct labour building departments together with the FE colleges provide an important alternative model. In other respects, VET suffers from lack of regulation and curricula are narrow and largely restricted to developing technical skills for LEC rather than the underpinning knowledge required or climate literacy.

Whilst each system has its pros and cons, what is evident is that the 'skill'-based LEC VET systems need to move towards the 'occupation'-based CME approaches if LEC requirements are to be addressed in curricula. Whether CME or LME, only rarely do curricula address climate literacy, though this represents an important means to empower construction workers, providing both a motivation for building a zero-carbon economy and a threat to the status quo. Above all, achieving equity remains a critical issue in construction and for construction unions if they are to be a positive force in transitioning to a green economy. Indeed, valuing labour is key to valuing the environment and combatting climate change.

References

Arrowsmith, Emily (2019). *Promoting Careers in the Skilled Trades to Indigenous Youth in Canada*. Ottawa: Canadian Apprenticeship Forum. www.caf-fca,org

Belman, D. and Ormiston R. (2021) Creating a Sustainable Industry and Workforce in the US Construction Industry. In: Belman, Dale, Druker J. and White G. *Work and Labour Relations in the Construction Industry*. New York: Routledge.

Bosch, G. and J. Charest (eds). 2008. *Vocational Training in the 21st Century: A Comparative Perspective on Systems and Innovations in Ten Countries.* London: Routledge.

Bridge, T. and Gilbert, R. (2017). *Jobs for Tomorrow - Canada's Building Trades and Net Zero Emissions*. Vancouver: Columbia Institute.

Brockmann, M., L. Clarke, and C. Winch (eds). 2010. *Bricklaying is more than Flemish bond: bricklaying qualifications in Europe.* Brussels/London: CLR.

Buildforce Canada (2018) Representation of Indigenous Canadians and Women in Canada's Construction and Maintenance Workforce. July. https://www.buildforce.ca/system/files/documents/Indigenous_Canadians_Women_in_Canadas_Construction_Workforce.pdf

Build up Skills (2012) *Vocational education and training for building sector workers in the fields of energy efficiency and renewable energy,* German report by Peter Weiss, Richard Rehbold and Elisa Majewski, Intelligent Energy Europe, September.

Canada (2016). *Pan-Canadian Framework on Clean Growth and Climate Change*. https://www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework/climate-change-plan.html

Calvert, John (2022). Labour and Climate Change, in *Canadian Labour Policy and Politics*. ed John Peters and Donald Wells. Vancouver: UBC Press.

Calvert, John and Corinne Tallon, (2017). *Promoting Climate Literacy in British Columbia's Apprenticeship System: Evaluating One Union's Efforts to Overcome Attitudinal*

Barriers to Low Carbon Construction. Toronto: York University ACW Working Paper 201

Calvert, John and Corinne Tallon. (2016). *The Union as Climate Advocate: The BC Insulators' Campaign to Green the Building Industry in BC*. Toronto: York University

Calvert, John (2014) *Overcoming Systemic Barriers to 'Greening' the Construction Industry: The Important Role of Building Workers in Implementing Climate Objectives at the Workplace.* Alternative Routes. https://www.alternateroutes.ca/index.php/ar/article/view/20596

Canada (2021a). Bill C-12: *An Act respecting transparency and accountability in Canada's efforts to achieve net-zero greenhouse gas emissions by the year 2050*. Chapter 22. June 29, 2021.

Canada (2021b). *Achieving a Sustainable Future: A Draft Federal Sustainable Development Strategy for 2022 to 2026*. Gatineau: Environment and Climate Change Canada.

Canada. (2022). *The Canada Green Building Strategy*. Natural Resources Canada Discussion Paper. July.

Canada Green Building Council. (2020). *Canada's Green Building Engine: Market Impact and Opportunities in a Critical Decade*. https://delphi.ca/wp-content/uploads/2021/01/canadas-green-building-engine.pdf

Canadian Apprenticeship Forum. (2018). *Making Apprenticeship a National Skills Priority*. Ottawa. August.

Canadian Apprenticeship Forum. (2019). *National Strategy for Supporting Women in the Trades*. Ottawa

Charest, Jean (2003) Labor Market Regulation and Labor Relations in the Construction Industry: the Special Case of Quebec within the Canadian Context, in Gerhard Bosch and Peter Philips (eds), *Building Chaos: an international comparison of deregulation in the construction industry*, London: Routledge, 95-113.

Clarke L. and Sahin-Dikmen M. (2021) Why radical transformation is necessary for gender equality and a zero carbon European construction sector, in *Gender, intersectionality and Climate Institutions in Industrialized States,* Routledge

Clarke L., Westerhuis A. and Winch C. (2021a) Comparative VET European Research since the 1980s: accommodating changes VET systems and labour markets, *Journal of Vocational Education and Training,* 73/2, 295-315

Clarke L., Duran-Palma F. and Sahin-Dikmen M. (2021b) Towards nearly zero energy building in Europe: challenges of vocational education, in **t**he *Encyclopaedia of the UN Sustainable Development Goals. Industry, Innovation and Infrastructure* edited by Filho W.L., Azul A.M., Brandli L.L., Salvia A.L., and Wall, T. Springer

Clarke, L., Sahin-Dikmen, M., & Winch, C. (2020a). Transforming vocational education and training for nearly zero-energy building. *Buildings and Cities*, 1(1), pp. 650–661.

Clarke L., Sahin-Dikmen M. and Winch C. (2020b), 'Overcoming diverse approaches to vocational education and training to combat climate change? the case of low energy construction in Europe', *Oxford Review of Education,* 46/5: 619-636

Clarke L, Gleeson C., Sahin-Dikmen M., Winch C. and Duran-Palma (2019) *Inclusive Vocational Education and Training for Low Energy Construction: VET4LEC,* a) Final Report; b) Country Summaries, European Federation of Building and Woodworkers and European Construction Industry Federation, Brussels

Clarke L and Sahin Dikmen M. (2019) 'City Building (Glasgow): inspirational model of low energy construction and direct labour', *Scottish Left Review,* 113, September/October

Clarke L. Gleeson C. Winch C. (2017) 'What kind of expertise is needed for low energy construction?', *Construction Management and Economics,* 35/3, pp 78-89.

Clarke L., C. Winch, and M. Brockmann. (2013). 'Trade-based skills versus Occupational Capacity: the example of bricklaying in Europe'. *Work, Employment and Society* 27(6): 932-951.

Coe, Patrick. (2013). Apprenticeship Program Requirements and Apprenticeship Completion Rates in Canada. *Journal of Vocational Education and Training*. Vol. 65, No. 4

Commissioner of the Environment and Sustainable Development for the Parliament of Canada. (2021c). *Report 5: Lessons Learned from Canada's Record on Climate Change*. Ottawa: Office of the Auditor General of Canada.

Construction Council of British Columbia. (2018) *A Community Benefits Agreement*. BC Infrastructure Benefits Inc. and Allied Infrastructure and Related, July.

Ebenau, M., Bruff, I. and May C. (eds). 2016. *New Directions in Comparative Capitalisms Research: Critical and Global Perspectives.* Palgrave

European Commission (EC) (2019). *Clean Energy for All Europeans*. Directorate General for Energy. Brussels.

European Commission (EC) (2014) *Build-up Skills: EU Overview Report*, Staff Working Document, Intelligent Energy Europe, Brussels

Gallagher, C.M. (April 2022) *The Construction Industry: Characteristics of the Employed, 2003–2022*, Bureau of Labor Statistics, U.S. Department of Labor

Government of Ireland (2021a) Climate Action Plan: Securing our future. Department of the Environment, Climate and Communication

Government of Ireland (2021b) *Action Plan for Apprenticeship 2021-2025,* Department of Further and Higher Education

Grytnes R., Grill M., Pousette A, Törner M. and Nielsen K.J. (2018) Apprentice or Student? The Structures of Construction Industry Vocational Education and Training in Denmark and Sweden and their Possible Consequences for Safety Learning, *Vocations and Learning*, 11, 65-87

Haley, B. and Gaede J. (2020) *Canada Needs an Ambitious Energy-Retrofit Plan for Buildings*. Ottawa: Policy Options. February 11:

Haley, Brendan. (2021). *Federal Mandate Letters Signal Changes to building Codes, Deep Retrofits and Electric Vehicles*. Efficiency Canada. December. 17.

Haley, Brendan and Abhilash Kantamneni. (2021). *Efficiency for All: A review of provincial, territorial low-income energy efficiency programs with lessons for federal policy in Canada*. Ottawa: Efficiency Canada

Hall, P. and Soskice, D. 2001. *Varieties of Capitalism*: *The Institutional*. *Foundations of Comparative Advantage*. Oxford: Oxford University Press.

Handwerk und Technik (2014) *Lernfeld Bautechnik Stuckateur Fachstufen,* Hamburg: Handwerk und Technik GmBH

Lerman, R. I., & Rauner, F. (2012). Apprenticeship in the United States. In *Work and Education in America*, 175-193. Springer, Dordrecht.

Lockhart, K. and Haley B. (2020). *Strengthening Canada's Building Code Process to Achieve Net-Zero Emissions*. Efficiency Canada/Carleton University. October.

Luke, N., Zabin, C., Velasco, D., & Collier, R. (2017). *Diversity in California's clean energy workforce: access to jobs for disadvantaged workers in renewable energy construction*. University of California, Berkeley Labor Center report.

Marsden, D. 1999. *Theory of Employment Systems: microfoundations of societal diversity*. Oxford: Oxford University Press

Mate, Gregory (2020) *A Critical Analysis of Apprenticeship Programs in British Columbia*. PhD thesis Faculty of Graduate and Postdoctoral Affairs, Carleton University

Pride, Andrew (2020). Tiered Energy Codes: Best Practices for Code Compliance. Efficiency Canada/Carleton University. September.

Rauner, F. 2007. 'Vocational education and training - A European perspective' in A. Brown, S. Kirpal, F. Rauner (eds) *Identities at Work.* Dordrecht: Springer

Relly, S.J., Killip, G., Robson, J., Emms, K., Klassen, M., Laczik, A. (2022) *Greening Construction - A complex challenge for jobs, skills and training*. Edge Foundation

Sunikka-Blank M and Galvin R (2012) Introducing the prebound effect: the gap between performance and actual energy consumption. *Building Research & Information* 40:3: 260-273

Swedish Government (2017) Climate Policy Framework, Ministry of Environment and Energy

Taylor, Frederick Winslow (2011). *The Principles of Scientific Management*. New York: Harper and Brothers.

Tullstedt, L and Douhan, A (2013), *Build Up Skills Sweden Roadmap: Building Skills for Energy Efficient Buildings*, The Swedish Construction Federation

US (2021) *The Long-Term Strategy of the United States* - The White House, 2021,

Winch, C. (2014) 'Education and Broad Concepts of Agency', *Educational Philosophy and Theory*, 46/6

Woods, J. G. (2012). An analysis of apprentices in the US construction trades: an overview of their training and development with recommendations for policy makers. *Education and Training* 54/5: 401-418.

Women can Build (2020) *Towards an equal construction industry,* European Union Erasmus Report, October https://www.womencanbuild.eu/wp-content/uploads/2021/01/WCB_IO2_Joint-Report_immersive_experience-for-women.pdf

World Building Council (WBC) (2019). *Bringing Embodied Carbon Upfront*, London.

Zero Carbon Hub. (2014) Closing the gap between design and as-built performance. End of Term Report