



# Climate literacy and labour agency in vocational education and training

RESEARCH

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## ABSTRACT

How far can climate literacy be embedded into the construction vocational education and training (VET) systems? This is investigated in North America (US and Canada) and six European countries (Belgium, Denmark, Germany, Ireland, Sweden and the UK). Climate literacy entails understanding the impact of climate change on society, the sector and its different occupations. Achieving zero carbon building (ZCB) is shown to involve respecting construction workers' embodied knowledge and experience, and empowering them to make informed decisions regarding their actions through climate-literate VET programmes, thus enhancing labour agency. Drawing on research for Canada's Building Trade Unions' programme Building It Green, involving interviews and analysis of case study VET systems in eight countries, this article defines climate literacy and adapts a transparency tool to map and evaluate the range of knowledge, know-how and competences required for climate-literate construction workers. The findings reveal wide variations between case studies in coordinated and liberal market economies in the incorporation of climate literacy and obstructions to this, reflecting conflicts between approaches minimising workers' discretion and those facilitating building workers acquiring abilities and agency to make informed decisions. Understanding the value of achieving socially beneficial climate outcomes can add meaning and purpose to construction work.

## POLICY RELEVANCE

ZCB requires a climate-literate construction workforce, and a VET system capable of providing the necessary knowledge, skills and competences. Worker agency is important for delivering effective ZCB outcomes. To achieve this, policymakers need a clear definition of a climate-literate construction worker and an understanding of how this applies to construction VET systems. A transparency tool is created that can be used to describe various attributes for inclusion into construction qualifications to achieve climate literacy

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and identify conditions under which VET programmes can promote this. In assessing the strengths and limitations of VET systems in Europe (Belgium, Denmark, Germany, Ireland, Sweden and the UK), Canada and the US, policy guidance is provided for governments, unions and employers to achieve a climate-literate workforce.

## 1. INTRODUCTION

The built environment is the largest emitter of greenhouse gases (GHGs), accounting for 37% of anthropogenic global emissions (from both embodied and operational performance), while using inputs such as cement and steel with a significant carbon footprint (UNEP 2023). Construction workers through their labour are key actors in transforming materials into buildings and infrastructure, with the aid of machines and equipment, and they experience the impact of climate change on building sites, often working outside in extreme weather conditions. Their knowledge of how the industry contributes to climate change thus becomes experienced reality, ‘embodied environmental knowledge’ (Schaupp 2025). Achieving zero carbon building (ZCB) requires knowledge of climate science and making this environmental knowledge transparent by embedding climate literacy into the curricula of construction vocational education and training (VET) systems (Cole 2019). Workers can thereby become empowered to make informed decisions when applying the scientific and environmental knowledge they acquire to address GHG emissions and climate impacts over the course of a building’s life. Implementing climate literacy therefore implies considerable enhancement and broadening of labour power or agency (Winch 2014).

How can VET programmes incorporate climate literacy, enhance labour agency in construction and what are the obstacles to achieving this? Climate literacy means acquiring knowledge of climate change and recognising its impact on society, the industry, different construction occupations and areas of activity, whether in terms of carbon emissions, energy efficiency or the health and safety of workers, and whether in relation to the materials and equipment used or the method of construction (Limaye et al. 2020; Suhaimi & Mahmud 2022).

VET systems in Europe and North America vary considerably in how far they develop labour potential, empowering workers to manage projects within their occupation and wider construction activity (Clarke et al. 2024). Some, such as the German VET system, characterised as a coordinated market economy (CME), are comprehensive, promoting a broad range of knowledge, know-how and competences (defined as personal characteristics) in each occupational curriculum with the intent to facilitate worker autonomy, including through project-based learning (Hall & Soskice 2001; Bosch & Philips 2003; Clarke et al. 2020). In contrast, the UK VET system, typical of a liberal market economy (LME), leans towards a Taylorist, employer-dominated, market-based approach, with narrower occupational profiles and a focus on the ‘skills’ and performance needed to achieve specific outputs (Bosch & Charest 2008; Winch & Burgess 2024). The former approach implies significantly less supervision than the latter, which relies on close worker monitoring and more extensive management structures. The extent that environmental concerns are incorporated into VET programmes and the obstacles to achieving this vary according to the particular approach, as does the degree to which equality and inclusivity are integral, whether through embracing embodied and Indigenous knowledge or the participation of women (Ramsarup et al. 2024).

Unions are critical to enhancing labour agency to address climate change through representing and promoting workers’ interests. Their impact reflects their strength in achieving this, their role in VET and their ability to address climate change (Primc et al. 2025). Within construction, their density varies from very high rates in Denmark and Sweden, to relatively high in Belgium, to lower rates in Germany, Ireland, the UK and North America (Darvas et al. 2023). However, union strength does not necessarily correlate with their role in VET, which is significant in Canada, whilst the social partnership between unions and employers underpins the Belgian, Danish and German VET systems. Nor do union strength and involvement in VET necessarily imply a commitment to addressing climate change and embedding both scientific and embodied climate literacy into construction curricula. Though unions generally argue for a just transition to a zero carbon

economy, this may not percolate down to the membership or translate into a transformative agenda (Clarke & Sahin-Dikmen 2020; Calvert 2022, 2024).

This article disentangles this complex picture by evaluating climate literacy and environmental aspects in the construction VET systems of the European countries of Belgium, Denmark, Germany, Sweden, Ireland and the UK, and the North American countries of the US and Canada. Drawing on research for Canada's Building Trade Unions' programme Building It Green, the range of knowledge, know-how (skills) and competences required of a climate-literate construction worker are mapped onto a transparency tool. This acts as a guide to assess the extent to which VET programmes promote climate literacy and enhance labour agency, and the obstacles they face. Based on a broad definition of climate literacy, its actual and potential incorporation will be shown to reflect an inherent conflict between approaches minimising workers' discretion and those aimed at ensuring building workers acquire the abilities and agency to make informed decisions. To address these concerns, specific actions are recommended to ensure that climate literacy underpins construction VET, secures worker agency and transforms construction into an eco-industry.

## 2. CREATING CLIMATE LITERACY

### 2.1 DEFINING CLIMATE LITERACY

Defining climate literacy stems from a growing need to understand how to respond to climate change and, as outlined by President Joe Biden's US Secretary of Commerce, Gina Raimondo, to prepare:

a new generation of climate-literate and specially skilled workers who can help communities address a wide range of climate impacts—from sea level rise, flooding, and water quality issues—so that we can tackle the climate crisis.

(Allen 2024: n.p.)

The first usage of environmental literacy appeared in a 1968 issue of the Massachusetts Audubon Society, enquiring 'How shall we know the environmentally literate citizen?' (Roth, cited in McBride et al. 2013: 3). Four decades later, the US National Oceanic and Atmospheric Administration (NOAA) (2009) sponsored a climate literacy workshop that produced an interagency guide laying out how to define a climate-literate person. This was updated by drawing from broader sources (USGCRP 2024; Crimmins et al. 2023), including the Intergovernmental Panel on Climate Change's (IPCC) *Sixth Assessment Report* (2023), social science disciplines, Indigenous, place-based and practical knowledge and solutions, and just transition principles (Limaye et al. 2020; Suhaimi & Mahmud 2022). Drawing on these sources, a synthesis of broad climate literacy principles can be produced that clarifies the definition of a climate-literate person.

Accordingly, a climate-literate person needs to understand the essential principles of the Earth's climate system, including the GHG effect, and to know how to access and assess scientifically credible information about the climate, communicate it to others and act upon it. This involves respecting ecological and Indigenous knowledges and practices that protect biodiversity and promote equitable and healthy ecosystems, as well as knowing that historical inequities in power and resources expose marginalised people disproportionately to climate change impacts. Awareness that climate change is already affecting every inhabited region and person globally is necessary, and that human influence contributes to the many changes observed in weather and climate extremes. A climate-literate person also understands that fighting climate change can have uneven and potentially disruptive effects on the economic and social wellbeing of people and communities. Finally, they can take informed decisions and actions that may affect the climate, the environment and the workforce, and look for ways to apply this knowledge responsibly.

In brief, climate literacy involves, first, understanding how one's everyday work and actions are part of a wider social and economic system producing the carbon emissions heating the planet, and second, recognition that positive changes in society to promote biodiversity, sustainability

## 2.2 CLIMATE LITERACY IN CONSTRUCTION VET FOR ZCB

Research shows that a broad knowledge and understanding of the causes and consequences of climate change is essential to include in occupational VET for the construction sector (Killip 2020; Cole 2019) to enhance labour's capacity to play an active role in tackling emissions and to meet current and future ZCB targets and standards (Relly et al. 2022). The complexity of ZCB and the necessity for high-quality work to ensure design specifications are met under safe and healthy conditions require a workforce able to work effectively and flexibly on a project and to respond to contingencies and problems (Gleeson 2015; Clarke et al. 2020). The European Commission's Build-Up Skills programme highlighted that workers' agency is enhanced by a holistic understanding of the project, their role in it and the roles of other occupations (European Commission 2014). Building on this, the authors' previous research has shown that to achieve ZCB, the workforce needs to act with a considerable degree of autonomy, equipped with the manual and intellectual know-how to carry out sustainable construction, and the transversal abilities to plan, communicate, coordinate, evaluate work and solve problems collectively and in coordination with other occupations (Clarke et al. 2019). These abilities entail considerable skill, working with others, having knowledge of local conditions, as well as systematic knowledge of the building processes, equipment and materials to carry out many routine operations (Clarke & Winch 2004). Acquiring these abilities requires a combination of classroom instruction, simulation in a controlled environment and the possibility of integrating knowledge, problem-solving and project management abilities in operational conditions, necessitating a well-organised, high-quality VET system.

In previous research for the European construction social partners, supported by the European Commission and carried out by some of the authors, a framework, termed a 'transparency tool', was developed as a guide to incorporating ZCB abilities into the construction VET programmes of eight European countries (Clarke et al. 2019). This had been applied originally in 2010 to evaluate bricklaying qualifications in 10 European countries (Brockmann et al. 2010). In this article, the transparency tool has been further adapted by incorporating a broad definition of climate literacy for construction in order to evaluate the extent to which the different case study construction VET systems are equipped to develop a climate-literate workforce.

## 3. METHODS

This article addresses the extent to which climate literacy is embedded in VET programmes and the barriers to equipping workers with the required expertise. It draws on findings from the multi-partner Building It Green project,<sup>1</sup> supported by a CA\$5 million Canadian federal government grant, led by Canada's building trades unions, completed between 2021 and 2025, and aims to embed climate literacy in the curricula of apprentices and skilled construction workers in Canada. This involved a review of current practice and an investigation of examples of climate literacy evident in VET systems in Europe and North America. These systems serve as case studies representing a variety of CMEs (Belgium, Denmark, Germany and Sweden) and LMEs (Canada, Ireland, the UK and US), each with a particular set of institutional and labour market structures and relations and a different approach to climate literacy and labour agency. Analysis of the different cases enables a systematic and in-depth understanding of the context within which climate literacy efforts are forged, and the institutional and structural dynamics underlying the disparate approaches, as well as barriers to progress (Yin 1994). The study thereby contributes to the growing literature on what constitutes climate literacy in the building trades and the broader measures needed to achieve it.

The research involved a literature review of developments in Canada and internationally and, subsequent to ethics approval, collecting extensive evidence, in-depth interviews with stakeholders and site visits to training facilities by project partners from the Climate and Industry Research

The literature and evidence review includes analysis of the following:

- the academic literature on climate change and the construction industry, VET, and climate literacy for construction workers
- the construction labour market and industrial relations regimes
- climate policies and legislation at European, national, state and federal levels
- union and employer policies
- VET programmes, curriculum documents and qualification frameworks to identify examples and examine the extent climate literacy is embedded.

Interviews conducted include the following:

- A total of 14 in English Canada, with union training providers supplemented by discussions with union officials and employer organisations.
- A total of 21 in Quebec, with union representatives and discussions with members of the *Commission de la construction du Québec* (CCQ) members.
- A total of 20 in the US, with trainers, union leaders, third-party educational development agencies, community organisations involved in coalitions with unions and representatives of apprenticeship standards.
- In Europe, the VET systems selected were those making significant attempts to mainstream climate literacy in construction programmes, as indicated in previous research ([Clarke et al. 2019](#)). They represent a variety of approaches to climate literacy, including: from CME countries, education based (Sweden), social partner based (Denmark and Belgium), and dual-industry and education (Germany), and from LME countries: employer based (Ireland and the UK). Across the six case studies, 40 interviews took place, one to one and in groups, with participants including union and employer representatives, VET providers, teachers, building workers, trainees, and construction companies.

In evaluating the different VET systems, this analysis entailed, first, identifying general and sector-specific elements of climate literacy and then embedding these into the skeleton transparency tool developed in previous research ([Brockmann et al. 2010](#); [Clarke et al. 2019](#)). The transparency tool then served as a broad framework for evaluating the extent to which climate literacy is addressed in the case study VET systems, through analyses of their approach, structure and stakeholder involvement, examples of specific programmes, and interviews with stakeholders. Interviewees represented a range of expertise and specialisation in both initial and continuing VET, covered a variety of construction occupations, and cited examples illustrating the strengths and weaknesses of the different approaches adopted for embedding climate literacy.

## 4. ADAPTING THE TRANSPARENCY TOOL

The purpose of the transparency tool is to make transparent the embodied knowledge of construction workers ([Schaupp 2025](#)) and embed it in green building VET ([Cole 2019](#)), so raising awareness of climate change and strengthening the agency of workers. It represents a synthesis of the literature review of research on the attributes of a climate-literate construction worker and presents a framework to assess the extent to which different VET systems have the capacity to provide their respective workforces with the required climate literacy attributes.

The tool ([Table 1](#)) is broadly categorised into three pillars: vocational, civic and liberal attributes, a common classification in many European countries, reflecting their ‘dual value’ in the labour market and educational progression ([CEDEFOP 2011](#)). *Vocational* refers to the technical and on-site knowledge required to implement building targets, which, for a climate-literate workforce, implies an understanding of how the work being performed can contribute to positive climate outcomes. This is subdivided into both *systemic* and *non-systemic* forms of *knowledge*, the former encompassing basic climate physics and understanding of how to assess, communicate

and act upon climate information in the workplace. Applied to construction and referring back to the definition of a climate-literate person outlined above, non-systemic knowledge involves understanding the role of buildings as contributors to the emissions that result in climate change, the impact of embedded carbon in building materials, the benefits of conserving buildings, minimising energy use, and reducing the demand for new, carbon-intensive materials. It means being aware that construction workers can play a unique role in addressing climate change and promoting safe and energy-efficient building projects that deliver quality work and serve people's needs. Under local conditions, this entails grasping the link between environmental sustainability, social inclusion, equity and strong labour standards to produce good, green employment and healthy communities. And, regarding specific occupations, it means both understanding how sources of energy, methods and materials used contribute to GHG emissions, and applying environmental principles to practical workplace situations to reduce energy use and emissions.

**Table 1** Transparency tool for a climate-literate construction worker.

| AIM OF THE QUALIFICATION                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                           |               |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| VOCATIONAL <i>yes/no</i>                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                          | CIVIC <i>yes/no</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | LIBERAL <i>yes/no</i>                                                                                                                                                                                                                                     |               |
|                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | ABILITIES                                                                                                                                                                                                                                                 |               |
| KNOWLEDGE                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                          | KNOW-HOW                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | COMPETENCES                                                                                                                                                                                                                                               |               |
| <i>Systematic</i><br>Understands the essential principles of the Earth’s climate system, including the greenhouse gas (GHG) effect, and knows how to access and assess scientifically credible information about the climate, communicate it to others, and act upon it                                                                                                       | <i>Non-systematic</i><br>Is aware that construction workers can play a unique role in addressing climate change and promoting healthy, safe and energy-efficient building projects that deliver quality work and serve people’s needs                                                                                                                                                                    | <i>Skills</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <i>Individual</i>                                                                                                                                                                                                                                         | <i>Social</i> |
| <i>Technical theory</i><br>• Construction procedures<br>• Carbon costs of manufacture and construction<br>• Properties of construction materials                                                                                                                                                                                                                              | <i>Local procedures</i>                                                                                                                                                                                                                                                                                                                                                                                  | <i>Transversal abilities</i><br>• Effectively communicates with colleagues to ensure occupational interfaces are dealt with so that design specifications are met under safe conditions<br><br>• Has the ability to evaluate work in progress, and on completion to minimise rectification procedures                                                                                                                                                                                          | <i>Wider personal and civic implications of transversal abilities</i><br>• Respects ecological and Indigenous knowledge and practices that protect biodiversity and promote equitable and healthy ecosystems                                              |               |
| <i>General education and occupational underpinning</i><br>• Understands evidence, including in numerical, graphical and tabular forms<br>• Understands complex argument based on evidence<br>• Is aware that climate change is already affecting every inhabited region and person globally with human influence contributing to many changes observed in weather and climate | <i>Local conditions</i><br>• Understands that, in the short term at least, fighting climate change can have uneven and potentially disruptive effects on the economic and social wellbeing of people and communities<br><br>• Grasps the link between environmental sustainability, social inclusion, equity and strong labour standards to produce good, safe, green employment and healthy communities | <i>Project management</i><br>• With appropriate vocational education and training (VET), can make informed and responsible decisions, problem-solve, collaborate with others, and apply knowledge dynamically to enhance sustainability in the workplace<br><br>• Has a holistic understanding of buildings and related energy systems, the role of their occupation, and how their activities interact and overlap with those of adjoining occupations in producing a zero carbon environment | <i>Wider personal and civic implications of project management abilities</i><br>• Understands personal responsibility for working to design specifications, ensuring the wellbeing and safety of colleagues, and reporting unethical and unsafe practices |               |
| <i>Social science theory</i><br>• Knows that historical inequities in power and resources expose marginalised people disproportionately to climate change impacts                                                                                                                                                                                                             | <i>Materials</i><br>• Understands how sources of energy, methods and materials used in their occupation contribute to GHG emissions, and can apply environmental principles to practical workplace situations to reduce energy use and emissions                                                                                                                                                         | <i>Occupational capacity</i><br>• Can adapt, adjust and integrate the knowledge, skills and competences required to exercise their occupation to the exigencies of zero carbon buildings                                                                                                                                                                                                                                                                                                       | <i>Wider personal and civic implications of occupational capacity</i><br>• Recognises the interconnectedness of stakeholders during the life of the built environment                                                                                     |               |

*Civic* refers to know-how or skills, relating to the ability to practise the occupation and exercise the skills needed to carry out the tasks involved and deploy techniques in operational conditions. It encompasses, first, *transversal abilities*, such as evaluation of work-in-progress and communication skills to overcome occupational interfaces and ensure climate specifications are met. It also encompasses the *project management abilities* needed to carry out (possibly in conjunction with others) a sustained sequence of tasks under safe conditions, resulting in a recognisable product or service. With appropriate VET, the climate-literate person can make informed and responsible decisions, problem-solve, collaborate with others and apply knowledge dynamically to enhance sustainability in the workplace. This goes together with a holistic understanding of buildings and related energy systems, the role of their occupation, and how their activities interact and overlap with adjoining occupations in producing a zero carbon environment, as emphasised in the Build-Up Skills programme (European Commission 2014). Finally, *occupational capacity* refers to the ability to work across the range of the occupation, keeping up-to-date with intra-occupational developments, adapting these to one's work, and understanding interfaces between occupations and the impact of the climate-literate person's occupation on society, again echoing the Build-Up Skills findings. It means having a sufficient capacity to adapt, adjust, and integrate the knowledge, skills and competences required to exercise that occupation to the exigencies of ZCB.

*Liberal*, the third pillar, in turn, refers to competences, including attitudes and a sense of responsibility, both individually and collectively, for climate outcomes, and characteristics that recognise building as a social process requiring collaboration among all those involved and the interconnectedness of stakeholders. It concerns respect for ecological and Indigenous knowledge and practices that protect biodiversity and promote equitable and healthy ecosystems. These characteristics encompass the qualities required to practise the occupation successfully, taking personal responsibility for working to design specifications, ensuring the wellbeing and safety of colleagues, and reporting unethical and unsafe practices. They are valuable in contexts outside the workplace and critical to the ability to manage oneself, work cooperatively and in teams, take responsibility for work, support colleagues, and recognise the broader impact of one's activities on health, the environment and society.

By incorporating transversal and project management abilities, the tool serves as a guide to assessing construction VET systems in different countries and how effectively they embed climate literacy, the extent this goes together with enhancing labour agency and the restrictions to doing so. The population of the transparency tool for climate literacy is not intended to be definitive or comprehensive but to show how the different characteristics can be incorporated into a template to specify an occupational profile and corresponding curricular needs. Both the climate literacy definition and the transparency tool thereby serve as a framework, informing the questions put forward in this empirical work and feeding into curriculum recommendations. Their elaboration has, in turn, been informed by the findings so that, as presented in Table 1, the tool contains the attributes of a climate-literate construction worker and acts as a guide adaptable to other kinds of work.

## 5. FINDINGS: CLIMATE LITERACY IN CONSTRUCTION VET

The following case studies exhibit different approaches to VET and enhancing workforce agency and represent different means to incorporate ZCB requirements (Clarke et al. 2024). This creates difficulties in generalising because labour markets and VET systems are not homogenous, so for each country the authors sought to identify good practice examples and the obstacles faced by different stakeholders, particularly construction unions and the state.

### 5.1 CANADA'S BUILDING TRADES

Canada's construction industry contrasts with the US and the UK in that the state and particularly unions play a significant role in supporting apprenticeship (Bosch & Philips 2003; Charest 2003). Its VET system reinforces clearly differentiated construction occupations. Union apprentices learn the classroom content of their respective occupations in trade-

specific learning facilities, which limits opportunities to understand other occupations' work, encouraging a narrow focus on mastering a specific suite of marketable skills rather than acquiring a broader understanding of building science (Calvert 2024). Incorporating climate modules is also hampered by limited classroom time and a curriculum overflowing with other training material, with a time-consuming revision system requiring consensus from employers, unions, colleges, and federal and provincial governments. Canada's Red Seal system establishes criteria for apprentices obtaining trade certification (CCDA 2025). Apprentices must pass the national exam to receive their interprovincial trade certificate after completing the required classroom hours, normally 20%, in a four-year apprenticeship, with the remaining time on-site (Barnetson 2018). Unions reinforce occupational silos with their 'green book', defining each occupation's work and enforcing demarcation between trades, so encouraging the view that union members 'own' their area of work and confining worker agency to this rather than the wider construction process (AFL-CIO Building and Construction Trades Department 2011). The VET system thus promotes highly detailed knowledge of relatively narrow trades-specific skills, while limiting acquiring broader understanding of the construction process and workers' role within it. Occupational silos thus impede cross-trade collaboration, the development of transversal skills, workers' understanding of building as a holistic, integrated process, and shared responsibility for climate outcomes.

A major challenge is apprenticeship completions. While varying significantly between trades, fewer than half of those who enrol never complete (CAF 2024a). The system also fares poorly in recruiting women, who represent about 6% of the on-site workforce. An unwelcoming on-site culture also adversely affects Indigenous workers (Mills & Clarke 2009; Fernandez & Silver 2017; SkillPlan 2017). Indigenous communities' role as stewards of land and water and their environmental perspectives are, nevertheless, gradually being recognised and incorporated into the trades' curricula, paralleling efforts to recruit more Indigenous workers (Su & Jin 2023; Fernandez 2024; CAF 2024b).

Interviews with Canadian apprentices, tradespersons and training instructors indicate that those completing an apprenticeship have the technical skills to practise sustainable construction. However, as one union instructor noted during an English Canadian interview:

We are teaching apprentices the 'how' to perform their trade competently, but not the 'why', that is, the climate benefit of doing the work properly.

Awareness of the climate impact of construction work varies among unions, reflecting the nature of the work their members perform. Electrical workers learn about installing solar panels, light-emitting diodes (LEDs) and wind turbines, creating opportunities to reflect on climate implications. Plumbers and pipefitters install heating, ventilation and air-conditioning (HVAC) systems and heat pumps whose energy consumption and cost trigger attention to conservation. Mechanical insulators audit energy and GHG impacts from boilers and ductwork. While these activities have the potential to develop climate literacy, they are normally viewed narrowly in terms of improving efficiency and reducing energy costs (Calvert 2016).

Basic knowledge about climate change is widespread in Canada and in construction. Increasingly, large contractors and employer organisations, such as the Canada Green Building Council, market their projects as environmentally responsible. A gap often exists, nevertheless, with their on-site climate practices. Progress is also being undermined as employers lobby for shorter apprenticeships, reject greater state regulation, and seek delays in implementing tougher building and energy codes (Barbasch & Watt-Malcolm 2010; Calvert 2024). However, growing climate awareness has begun to influence VET programmes (Calvert & Tallon 2017; Calvert 2019). Prior to 2022, Canada's national Red Seal accreditation programme contained no reference to climate change in its detailed 32 trades curriculum modules. In 2022, its secretariat released the first climate curriculum guidelines. After noting the adverse impact of climate change on the construction industry and its workforce, this outlined what apprentices should know:

Apprentices and tradespeople need to increase their climate literacy and reinforce their own understanding of energy issues and environmental practices. It is important for them to understand why these changes are happening and their effect on trades' work.

(Red Seal Secretariat 2022: 1)

The union-administered Building It Green programme has developed generic curriculum modules on how climate change impacts society, the construction industry and its workers, supplemented by modules highlighting how each trade can advance climate outcomes. However, implementation has been limited and depends on Canada's building trades unions incorporating the modules into their classroom training programmes.

Canada's fossil fuel industry employs many of unions' highest paid member and promotes climate-denial narratives to its workers (Carroll et al. 2021). This negatively influences union efforts to promote climate literacy in VET programmes, a problem compounded by the 'spill over' of the current US government's hostility to climate science. A key barrier too is that government and industry do not recognise that successful ZCB requires a knowledgeable, well-trained and motivated workforce. Instead, they promote micro-credentials to shorten—and cheapen—training, resulting in workers acquiring limited skills.

As in other LME countries, climate literacy is also hampered by the structure of the industry, with its preponderance of small contractors and 'independent operators' (Bosch & Phillips 2003). It has a large unregulated 'underground' sector, accounting for about 20% of the workforce (Meredith 2011; Prism Economics and Analysis 2017; BC Building Trades 2022). In English Canada, unions represent approximately one quarter of the construction workforce, with wide variations in union density between and within provinces, different trades, and different industry sectors (Statistics Canada 2024). Consequently, most construction workers do not participate in union apprenticeship programmes, a major barrier to expanding workforce climate literacy.

### 5.1.1 Quebec's building trades

With a union density of around 60% and a high level of coordination and regulation enshrined in the Act Respecting Labour Relations, Vocational Training and Workforce Management in the Construction Industry,<sup>2</sup> Quebec is closer to a CME, in contrast to English-speaking Canada (Charest 2003). The key features of the construction industry include compulsory union or employer association membership and province-wide bargaining of four multi-trade sub-sectoral collective agreements (residential, institutional and commercial, industrial, and civil engineering and roadwork), enforced jointly by five unions, four employers' associations and the CCQ. The CCQ is a public body, jointly administered by representatives of labour and contractors, regulating workforce development and employment matters not bargained between unions and contractors. It plays an important role in administering the mandatory initial and public VET system covering 35 trades.

Interviews with building trades' representatives and VET curricula analysis reveal a lack of climate literacy content and minimal awareness of its relevance across many trades. VET courses are slow to adapt. Centralised tripartite institutional rigidity hinders innovation, and, though strong demand for trade-specific continuing VET activities is reported, significant difficulties arise in gaining approval for new initiatives. Despite their potential, social dialogue mechanisms are not leveraged to promote climate literacy, stemming from limited awareness of climate-related concerns, institutional rigidity, underfunding of Quebec's public education system and, until recently, lack of leadership from the CCQ. While in theory unions are co-administrators of the apprenticeship system, in reality employers shape the system to meet their economic requirements, and unions have been unable to exercise their formal powers effectively.

Quebec's response to its skilled workforce shortages, lowering the criteria for the Apprentice Certificate of Qualification, has been detrimental to VET and school-based construction education, and undermined the incorporation of climate literacy into VET programmes. Several local union representatives have sought partnerships with trade schools outside Quebec and hired trainers

directly, with one opening Quebec's first union-run training facility despite lacking access to the sector's collectively bargained training fund. While inter-trade coordination is crucial for ZCB (Clarke et al. 2017, 2021), Quebec's current approach shares the North American division of labour between siloed trades, despite efforts by employers and the province to 'flexibilise' skilled labour through greater permeability.

## 5.2 US BUILDING TRADES

Construction is a major industry in the US, employing 10 million people, about one in 16 workers. Union density in the building trades has fallen from 42.0% of construction workers in 1971 to 12.6% by 2019, paralleling overall unionisation decline (Jacobs et al. 2022). Anti-union employer organising and resulting legislation make it difficult for unions to protect labour standards and fight anti-worker policies (Erlach & Grabelsky 2005). The building trades' main approach has been to recruit contractors to become signatory, rather than recruiting workers. Consequently, the industry has become bifurcated into growing 'low-road' and diminishing 'high-road' sectors, low-road construction referring to projects paying below prevailing wages and requiring lesser training standards (Manzo et al. 2016). Building trades unions have their strongest presence in the 'high-road' Northeast, Midwest and West Coast urban areas, especially in commercial and industrial activities, but even here, union density is diminishing and residential construction is almost entirely non-union. Contractors often reduce labour costs by paying low wages, provide no health benefits, have long subcontracting chains and pay workers off-record (Jacobs et al. 2022). Despite having a growing membership in unions, immigrant workers are particularly recruited for low-paid jobs by non-union firms (Iskander & Lowe 2010).

While similar to Canada, the US construction VET system has structural particularities (Belman & Ormiston 2021) affecting how climate change is addressed, including less government funding of apprenticeship, so placing more responsibility on unions and individual employers to train the workforce. The structure of apprenticeship training is decentralised and there is no national testing or certification, complicating any strategy for waging a national climate literacy campaign. Many trades have centralised curriculum development and centres provide core curriculum and modules that local unions around the country can request, depending on their regional economies, capacity, preferences for developing new areas of work and political inclinations.

Non-union apprenticeships are employer-run, generally less rigorous, of shorter duration and with lower completion rates than for unionised apprentices (Glover & Bilginsoy 2005). Union apprenticeships are through a combination of state and federal regulation, either overseen by the Department of Labor through the Office of Apprenticeship or run by state apprenticeship agencies. In each case, committees routinely review union apprenticeship standards and are potentially able to integrate climate literacy into these.

The primary goal of most apprenticeship programmes is to introduce members to technical skills to practise on the job. The VET mandate is to prepare workers for employment, and the nature and quality of work is often secondary to the standard of pay and benefits. This approach renders the concept of climate literacy problematic to the VET system. The extent to which apprentices also gain theoretical knowledge varies widely according to trade. The mechanical trades (electricians, pipe trades and sheet metal) tend to provide more theory, but other trades such as insulators and operating engineers are also involved in system installation, warranting a deeper understanding of materials. In many unions, upgrades and certifying courses are offered, providing possible entry points for climate literacy for qualified construction workers.

Several unionised trades dispatch apprentices to jobs to alleviate the burden of hunting for work and provide contractors with certified apprentices. Support for employment, scheduled courses for apprentices to become experienced in many aspects of their trade and regular increases in pay make union apprenticeship a more resilient career path than working non-union. As an electrical union training director interviewed in 2023 explained, union apprenticeships routinely incorporate energy efficiency skills into curricula, as these are important to contractors, clients and government, but whether their relationship to reducing carbon and addressing climate change is clear rests

on regional and national policies. Many examples exist of building trades' efforts at preparing members to learn methods of energy and resource efficiency, but little discussion about why these are needed to address climate change. An insulator training director interviewed explained that he had never thought of doing this; others were cautious about alienating members. For example, in a rare instance of a foundational climate literacy course being included in a regional training session, the facilitator introduced it by stating:

We are not planning to throw our brothers in fossil fuel jobs under the bus.

Despite conflicting messages about climate change, unions pay attention to ZCB, symbolically and practically. Union training centres in major urban centres have renovated their buildings to showcase low-energy technologies that members are trained to build. The Chicago plumbers' hall boasts a green rooftop, rainwater, grey water systems and solar vacuum-tube water heaters. The St. Louis sheet metal training centre has the latest technology for green HVAC installations and maintenance, while the electricians and ironworkers have innovative solar and wind instruction to prepare members. Several trades also work closely with the Urban Green Council on developing a curriculum that embeds climate literacy in their Green Professional workshops.

The lack of a strong climate policy depresses processes by which climate literacy is valued. The private sector tends not to advocate for decarbonisation, high labour standards or equity. Union trainers observe that developers and contractors do not embrace green building standards unless required by government action through building codes or other incentives. Federal climate legislation and funding under the Biden administration was a historic acknowledgement of the need for massive federal action to mitigate climate change. However, with the inauguration in 2025 of the new Donald Trump administration, there is a campaign to eliminate climate and equity from policy, funding, education and implementation.

### 5.3 EUROPE'S CONSTRUCTION VET SYSTEMS

Efforts by European Union (EU) members to develop ZCB VET in Belgium, Denmark, Germany, Ireland and Sweden are driven mainly by legislation. The European Climate Law (2021) sets the overall target for climate neutrality by 2050,<sup>3</sup> whilst the Energy Performance of Buildings Directive (EPBD) (European Union 2021) requires nearly zero energy buildings. Member states transpose targets into national legislation and develop initiatives to facilitate implementation. The UK's Climate Change Act 2008, which was amended in 2019 (UK Government 2008/2019), commits to reaching net zero by 2050 and, accordingly, the government has included energy-efficient standards in its revised building regulations though its post-Brexit ZCB policy framework is characterised by short-term initiatives and inadequate funding (Clarke et al. 2023).

As CMEs, Belgium, Denmark, Germany and Sweden represent an 'occupational approach', governed through social partnership and offering broad VET programmes cultivating multiple competencies, including specialist knowledge and general and civic education (Clarke et al. 2013). The construction VET system in Belgium is led by the social partner organisation Constructiv, which develops detailed occupational profiles with input from experts and training providers. In Germany, social partners are formally involved in VET bodies at all levels, with the state setting the legislative framework and regional governments playing an active role (CEDEFOP 2021). In Denmark, the VET system is jointly governed by the social partners, with unions involved in its development and monitoring at national, local and occupational levels. Competency outcomes for construction occupations are agreed by a national advisory board involving employer and union representatives. In Sweden, the government has overall responsibility through the Swedish National Agency for Education (Skolverket), setting goals and learning outcomes supported by the social partners who are less actively involved than the other CMEs and play an advisory role as members of the national council for each VET programme (Clarke et al. 2023).

In contrast, as LMEs, Ireland and the UK represent a 'skill-based approach', characterised by weak stakeholder involvement and narrow conceptions of competence, whereby VET is oriented towards developing skills for completing specific tasks, with limited attention paid to general

and civic education (Clarke et al. 2013). The state leads education policy, including for VET, with social partners playing a limited advisory role at a national level in Ireland and marginalised in the employer-based UK system.

The EU's green transition policy for construction recognises the importance of equipping the workforce with appropriate knowledge, skills and competencies. In 2011, it launched the Build-Up Skills initiative to support participating countries in enhancing ZCB training (European Commission 2016). The national reports and follow-up evaluations reveal disparities in approaches to developing climate literacy. Belgium, Denmark, Germany and Sweden mainstream ZCB competencies into VET for all construction occupations and incorporate them into national curricula (European Commission 2014; Clarke et al. 2019). In contrast, in Ireland and the UK, climate literacy has not been systematically embedded in the curriculum. ZCB training is mainly delivered through short courses by a range of providers and as an add-on for qualified workers such as electricians, e.g. in installing solar panels and heat pumps (European Commission 2016). However, Ireland, bolstered by EU-led initiatives, is diverging from the UK in adopting a more systematic approach; 10 occupation-specific Foundation Energy Skills (FES) courses have been rolled out nationally to upskill the existing construction workforce, and the Action Plan for Apprenticeships (2021–25) focuses on upgrading apprenticeships, including enhancing climate literacy education (Qualibuild 2017).

Where climate literacy is included in the curriculum, the extent to which all dimensions—knowledge, know-how and competences—are addressed varies. In Belgium, Germany and Denmark, comprehensive VET programmes mainstream climate literacy for all construction occupations (European Commission 2014), and emphasise civic education and personal development to enhance worker agency within and outside the workplace. Sweden, too, offers comprehensive VET addressing all three dimensions of climate literacy, with VET schools following the general education curriculum, which includes theoretical knowledge of climate change, plus covering vocational content. And in Ireland, short FES courses explicitly link climate change and ZCB, and underline the importance of interfaces and collaborative working.

Stakeholders interviewed, however, identified areas for improvement. In Belgium, for instance, interviewees stressed the need to enhance knowledge through systematically introducing climate change and its connection to ZCB and strengthening the project management aspect of transversal education to underline collaborative working. Germany's interviewees' concern was in enhancing systems thinking and interdisciplinarity, whilst Denmark's emphasised improving collaboration and communication to avoid performance gaps while enhancing theoretical knowledge to connect energy efficiency to climate change and address embodied carbon. In Sweden, training providers and employer organisations find national guidelines too general, with limited content on climate literacy and nothing connecting climate change and construction in the occupational curricula, with VET becoming increasingly practical as trainees progress through the programme. Finally, in Ireland, general knowledge content was reported to be limited, with much training focused on technical knowledge and courses delivered online and in demonstration suites, providing no opportunity for hands-on practice.

Despite differences between countries, common challenges to developing climate literacy are apparent. These include lengthy VET and curriculum review processes, slow responses to legislative and technological changes, training the trainers, resourcing and funding. For example, Swedish National Education Agency guidelines were last reviewed over 10 years ago, whilst in Denmark, reviewing and changing core modules taught in the first two years of apprenticeship takes 18 months. In Sweden, teachers' competencies are described as pedagogical rather than technical as teachers have little opportunity to keep up to date with the latest technological developments. In Ireland, tutors may have extensive practical construction experience but lack formal teaching qualifications. In the UK, there are problems recruiting, training and retaining teachers for further education colleges and regulating their training, though one-off introductory courses in ZCB are found. VET is better funded in Belgium, Germany and Denmark, but the cost of maintaining workshops equipped with ever-changing energy efficient technology, such as heat pumps, solar

panels, automation and insulation materials, is an issue and difficult to justify in remote areas with small student populations, e.g. in Sweden.

Embedding climate literacy in VET is also bound up with problems in the construction industry and labour market, though here there are significant differences between the CME and LME countries. The structure of the industry, dominated by small firms and self-employment, particularly in LMEs, undermines the work-based training infrastructure as firms lack the capacity, portfolio of future contracts and ZCB expertise to provide work-based learning. A total of 81% of the workforce is employed in small firms in Ireland, 65% in Denmark and 59% in Sweden, though Germany has a significant number of medium and large firms. The self-employed comprise a smaller segment of the workforce in Belgium (25%), Sweden (17%) and Germany (11%) than in Ireland and the UK, where they constitute nearly half (Eurostat 2019). There is also often poor coordination between employers and training centres, particularly in England where trainees are commonly on full-time courses with little opportunity to undertake work placements, let alone ones requiring the application of ZCB expertise.

In LME countries, where the labour market is poorly regulated, qualifications have a relatively low currency, and monitoring compliance and auditing are weak, formal qualifications are often not sought for many construction roles, except electricians and those working with gas, undermining the drive to equip workers with the deeper systematic knowledge and high technical skills needed for ZCB. Consequently, many construction workers lack formal qualifications, limiting their ability to undertake further training and to project manage. For example, one interviewee in Ireland explained he had no chance to upskill in his 25 years in construction despite changes in materials and regulations. Lack of investment in climate literacy and continuing VET ignores evidence of the impact of inadequate VET on the performance gap between design intent and implementation (Gleeson 2015).

In contrast, in CME countries, the VET system caters to the current workforce including, in Belgium, through the training of 'mentors' who support apprentices on-site, and, in Germany, introducing programmes dedicated to developing ZCB competencies and providing participants with recognised qualifications. In Denmark and Sweden, the comprehensive general education element in construction VET means workers are prepared for further training throughout their working lives. In Sweden, there is, for instance, continuous investment in continuing VET, and Build-Up Skills funds were also used to train one-third of the current workforce in ZCB, though the three-to-four-day course was described as inadequate. Despite these initiatives, continuing VET is not a priority in the case study countries. For example, an internal study of union membership by the Danish *Bat Kartallett* found that workers are not equipped with knowledge of the transformation underway, what this means for them or the importance of continuing VET for taking advantage of emerging opportunities.

The key constraint in developing a climate-literate workforce lies in the extent to which workers are empowered to apply the knowledge acquired. Trainees in the CME countries—Belgium, Denmark, Germany and Sweden—learn to project manage and problem-solve and to exercise autonomy within their occupation, on the basis of recognised qualifications, albeit to varying degrees (Grytnes et al. 2018). In contrast, in the LME countries of the UK and Ireland, in part because of the narrower scope of the occupational profiles, lower levels of unionisation, more fragmented labour markets and weaker recognition of qualifications, worker autonomy is restricted.

## 6. CONCLUSIONS

Through the application of the transparency tool with its three pillars—vocational, civic and liberal—to the different cases, wide variations are revealed in the capacity of vocational education and training (VET) systems to promote climate literacy. While approaches vary in the role of school-based or on-site learning opportunities, coordinated market economy (CME) VET systems attempt to provide trainees with theoretical knowledge as well as workplace skills and competencies through well-structured, comprehensive programmes. Though their climate literacy curriculum material is limited, their social partnership models have considerable potential

to introduce this and to equip workers with the knowledge, know-how and competences needed, empowering them to make informed decisions regarding their actions and to seek ways to apply their environmental knowledge.

In contrast, liberal market economy (LME) VET systems focus on developing narrow, trades-specific skills. Their construction sectors rely extensively on a fragmented, Taylorist approach to work organisation that does not value worker agency. The decline of construction unions in the US and lack of state support for zero carbon building (ZCB) effectively excludes the bulk of its workforce from gaining access to apprenticeships and limits climate literacy. English-speaking Canada provides a more structured VET system with potential, recently being realised, to incorporate climate material in its comprehensive, national Red Seal curriculum. However, apprenticeship opportunities remain out of reach for most workers, limiting the system's capacity to deliver climate knowledge to them. Quebec's unique state-based union-employer-governed VET system has the possibility to incorporate climate modules in its detailed curriculum. However, progress is impeded by employer pressure to reduce training duration and qualification standards and lack of union involvement in promoting climate literacy.

Overall, countries that give workers greater agency offer more promise, even if only partially fulfilled. There is an inherent conflict between approaches minimising workers' discretion and giving management exclusive responsibility for making climate choices, and approaches that assume building workers themselves can make informed decisions. The ability of workers to exercise climate-informed agency can conflict with employer priorities to maximise efficiency and profits when workers are directed to follow building practices that ignore environmental and energy impacts (Schaupp 2025). This creates tension between workers' understanding of—and commitment to—climate priorities and management supervisory practices. From the perspective of workers, promoting greater agency while incorporating climate priorities into construction practice gives workers opportunities for fulfilment from exercising their knowledge, know-how and competences on building sites. Understanding the value of implementing climate objectives properly can give work added meaning beyond the reward of doing a good job and receiving a fair wage. Knowledge that one's work contributes to positive environmental and climate outcomes can be a major source of job satisfaction and reinforces the attractiveness of pursuing a construction career.

## NOTES

- 1 See <https://www.buildingtrades.ca/en/building-it-green/>.
- 2 See <https://www.legisquebec.gouv.qc.ca/fr/document/lc/R-20?langCont=en/>.
- 3 See [https://climate.ec.europa.eu/eu-action/european-climate-law\\_en/](https://climate.ec.europa.eu/eu-action/european-climate-law_en/).

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