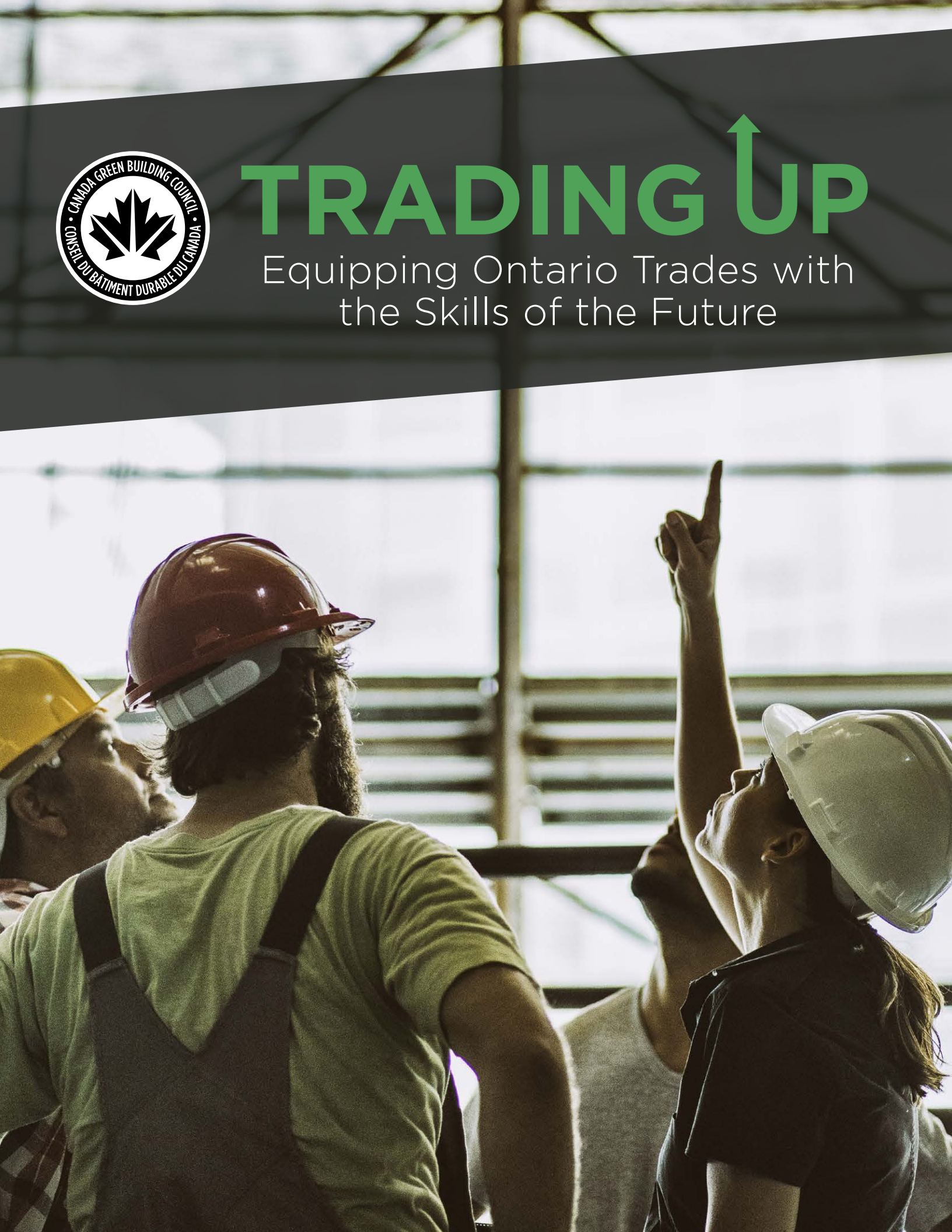
TRADING UP

Equipping Ontario Trades with the Skills of the Future



ACKNOWLEDGMENTS

The Canada Green Building Council (CaGBC) received support from the Ontario Ministry of Training, Colleges and Universities to conduct a study on the skill gaps and training needs for skilled trades for the construction of energy-efficient, high-performing buildings in Ontario. CaGBC partnered with Mohawk College, mcCallumSather, The Cora Group and The City of Toronto to complete this study. We received further input from our Advisory Group with members from the Toronto & York Region Labour Council, Ontario Building Officials Association, British Columbia Institute of Technology, Mohawk and George Brown College.

This paper puts forward solutions to address the existing gaps in the skills required to construct high-performing buildings throughout Ontario, Canada`s most populous province. It also identifies training requirements and recommends delivery models to drive low-carbon building skills training.

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EXECUTIVE SUMMARY

A strong economy and environmental leadership are interconnected. Ontario now has a great opportunity to prove that economic growth, job development and combating climate change can be achieved at the same time.

In Ontario green infrastructure, investments are expected to increase along with demand for skilled tradespeople and a green workforce in the construction industry.

The transition to a low-carbon economy impacts all economic activity. It will inevitably bring about changes in occupations and workforce competencies. At the same time, the construction industry faces a wave of attrition with more than 85,000 retirements forecasted for the coming decade. For the Toronto region alone, it has been estimated that there will be 147,000 job openings in the construction industry over the coming 15 years. The impact of the skills gap in Ontario is estimated at $24.3 billion of Gross Domestic Product (GDP) in foregone company revenues, with an additional $3.7 billion lost in foregone taxation. Adequate education and training will be important to transition the labour force to the economy of the future. This study starts with the observation that, to date, insufficient attention has been paid to how the labour market needs to adapt to meet current and future challenges. Much attention has been paid to how carbon emissions can be reduced, as well as to the possible implications for economic and employment growth. However, to meet Ontario's greenhouse gas reduction targets, fundamental changes to the structure of various occupations are needed to support the transition of the economy.

This report provides an education roadmap and insights on which technical and soft skills are necessary from the trades and the entire project team to achieve the successful construction of low-carbon, high-performing buildings.

Overall, the requirements for improved technical skills fall into the following areas:

- **Geothermal systems, particularly heat pumps;**
- **Photovoltaic and solar thermal systems;**
- **Air and vapour barriers including sealing techniques and airtightness testing;**
- **The building envelope, including insulation, wall assembly and thermal bridging, especially on balconies or around fenestration;**
- **Temperature bearing systems;**
- **Plumbing and pipefitting;**
- **Installation of forced air mechanical systems including balancing air flow for ventilation;**
- **Building Automation Systems, mechanical and electrical systems and equipment and commissioning.**

Also, embodied carbon and the selection of materials is a new subject for the entire building industry. Knowledge of the carbon embodied in building materials needs to be improved industry-wide so that material choices are not left to tradespeople alone.

However, one of the main findings of this report is that technical skills alone will not satisfy the requirements of low-carbon buildings. Changes to the larger construction approach and acknowledgment of soft skills are necessary to deliver high-performing buildings. We therefore need to increase overall levels of "green literacy" or said another way, the ability to understand the broad implications of key building activities on the environment and the market infrastructure. This works in concert with changes to the way construction projects are undertaken. The threshold for mistakes in high-performing buildings is slim and demands a higher level of sophistication and precision for the entire project team. The trades are extremely important for achieving high-performing buildings, but they need the support of the remaining construction ecosystem to succeed. This also means that the trades should be brought into the design and construction process early on. It also relies heavily on communication and collaboration among the trades as well as an allowances for more time to ensure better project outcomes.

It is not only the trades who need to upgrade their skills and knowledge base. The entire construction ecosystem including designers, architects, engineers, buildings officials and buildings managers also need to add skills to successfully complete complex high-performing buildings.

Retraining the trainers is also critical. Coaches and professors who teach the construction ecosystem need to be brought up to speed. Different delivery modes for training, ranging from full-time in-class courses to short online training modules and project specific instructions on-site to videos are now required to better serve the needs of tradespeople.

On-site training will play an important role as it offers the opportunity of ad-hoc training and a continuous feedback loop that can involve multiple trades at the same time and cross traditional trade roles. The industry and the trades in particular need to develop a willingness to invest in lifelong learning and to continuously upgrade their skill sets to meet the demand of energy-efficient, high-performing buildings.

A major challenge will be retraining those already in the workforce as there are few incentives available at this time to upgrade their skills, especially when there is high demand for trades working on traditional building projects. There are highly capable skilled trades that have a good knowledge of high-performing building practices and jumped at the chance to become leaders in their industry. However, others seem to miss the basic understanding of building science necessary for a successful low-carbon building.

When planning for the shift to low-carbon buildings, it is recommended that Ontario undertake the following steps:

A Improve green literacy

Foster a broader ecological mindset and awareness throughout the construction industry.

Develop new green training and education that address the skills needs and training gaps identified in this report.

Train all stakeholders in the construction industry ecosystem on the importance of developing low-carbon buildings – from architects and engineers to designers, building officials and building managers.

B Amend the modes of training

Incorporate low-carbon skills into all available courses, including Ontario apprenticeship programs, for people entering the construction industry.

Make continuing education a requirement for professional development and to maintain credentials and make low-carbon skills a mandatory requirement for the certification of tradespeople.

Consider making more construction apprenticeships compulsory to ensure a high-quality workforce for high-performing buildings.

Leverage the existing educational infrastructure: Engage professional organizations, trades unions, colleges, universities and manufacturers to assist with low-carbon skills development, including continuing education.

Train multiple trades in cross-disciplinary, hands-on training as low-carbon buildings require skills that cross traditional trade roles.

Support a diversity of media and formats for training and education that addresses different learning styles, lifestyles and access to learning opportunities. Offer training in a range of formats – from extended, in-person sessions to short online videos or articles.

Train the trainer: Create a peer-network for trainers, professors and coaches where people can learn from one another about how to include low-carbon technologies and take a more holistic approach to construction.

Embrace new technologies and digitalization to develop new ways of working to construct high-performing buildings and retrofit older facilities.

C Adapt the market infrastructure

Support a holistic view and work with an integrated design approach that brings in the trades early to improve the overall design and construction process. An alternative design-build-operate model can also help educate both tradespeople and designers on a new-building delivery process with stronger connections between intentions and actual performance.

Improve communication and collaboration on-site and during construction as this helps reaching a significantly higher level of sophistication and precision needed for high-performing buildings. Ensuring continuous communication allows for feedback and training opportunities for the entire team.

Adapt the bidding process and amend contract agreements so tradespeople are required to either demonstrate experience with low-carbon buildings or attend in person or on-the job training for the skills needed to execute their tasks.

Allow more time for complex construction projects so that the tradespeople can complete their work in an efficient manner.

Institute quality assurance practices as continuous feedback loop and ad-hoc training opportunities on-site that ensure high-performing building projects avoid delays and perform as intended.

D Identify and create incentives

Leverage government funds to subsidize training and lower the cost barriers for trades to participate.

Develop a certificate for low-carbon skills that would help the labour market identify and secure skilled trades for their projects.

E Further research into training and opportunities

Undertake a detailed gap analysis of current curricula used in part-time certification programs, professional development and continuing education workshops and seminars, college courses, diploma and degree programs, and university degree programs. This research focuses on skilled trades, but there are significant gaps remaining for the rest of the construction ecosystem that need to be analysed in more detail. More research also needs to be done on the residential building sector and residential building retrofits, especially for low-rise single-family homes to get low-carbon buildings up to scale.

This study provides an education roadmap for Ontario's labour force, government, educational institutions and industry. Ultimately, CaGBC and its partners intend for this plan to strengthen workforce training and technical capabilities, and thereby reduce greenhouse gas emissions over the long-term – in effect encouraging the widespread adoption of energy-efficient, high-performing building practices as industry standards.

Ontario has an opportunity to take on a national and international leadership role by supporting its workforce to the skills and capabilities needed to create the energy-efficient, high performing buildings. To tackle the challenges of the future and the changes that will come to Ontario's economy and workforce by climate change, Ontario needs to be ready to support its workforce to be prepared for the jobs of the future.

1 WHY DOES ONTARIO NEED AN EDUCATION ROADMAP FOR THE TRADES?

1.1 INTRODUCTION

Within the continuous process of structural economic change, the transition to a low-carbon economy will deeply impact all economic activity. It will inevitably bring about changes in sectors and occupations, and therefore in workforce skills and competencies.

This study starts with the observation that, to date, insufficient attention has been paid to how the labour market must adapt to meet these challenges. Attention has focused on how carbon emissions can be reduced, as well as on the possible implications for economic and employment growth. However, to meet Canada`s 2030 strategic targets, fundamental changes to the structure of the Ontario economy are required.

With Ontario being the economic powerhouse of Canada, it has been chosen by CaGBC for conducting this low-carbon building skills gap analysis of the construction trades. This study provides an education roadmap for the construction trades in Ontario that will lead to changes in the labour market.

Ontario can take a leadership role nationally and internationally in making its labour force ready for the future. When planning for the coming transition to energy-efficient, high-performing buildings, the province needs to determine the skills required of employees and employers, as well as skills availability and skills training for people employed in the construction trades.

Ontario is committed to strengthening its economy and labour force. The green future and existing building infrastructure will add to the provinces efforts for a strong economy. Nearly 300,000 Canadians are currently employed in the green building sector, more than half of them in Ontario. According to Skills Canada, 40% of the jobs that will be created in Canada over the coming decade will be skilled trade positions. In construction alone, it is forecast that there will be more than 85,000 retirements and a need for 80,000 new recruits by 2026 to sustain the sector. The construction sector already has a workforce utilization rate of 93%. The impact of the skills gap in Ontario is estimated at $24.3 billion of Gross Domestic Product in foregone company revenues, with an additional $3.7 billion lost in foregone taxation[1].

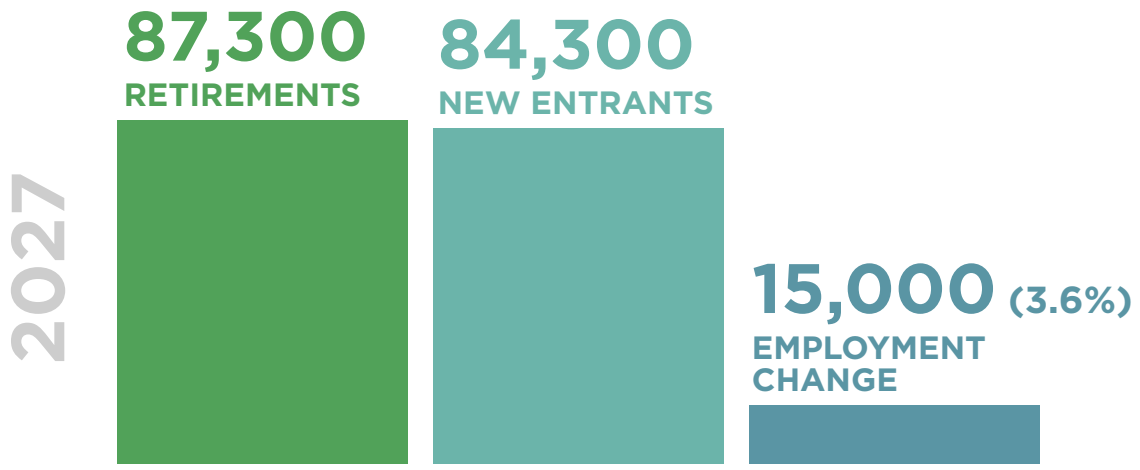
[1] The Conference Board of Canada, 2013.

These statistics signal that the construction of energy-efficient, high-performing buildings is an opportunity to transition Ontario's skilled trades to the jobs of the future. Not only will it strengthen the economy, our research indicates that if all new large buildings are built to zero carbon standards by 2030, this will lead to a 17% reduction in sectoral greenhouse gas (GHG) emissions compared to 2005 levels, and a further 51% reduction would be achieved by retrofitting existing buildings[2]. Meeting the objectives of an energy-efficient, high-performing building sector requires investing in the workforce that plans, constructs and maintains it.

Furthermore, Canada's Building Trade Unions[3] emphasize that, as building processes evolve to become more collaborative, codes and policies are growing more complex, furthering the need for continuous education. Tradespeople play a significant role in supporting low-carbon goals through their construction and maintenance of energy-efficient, high-performing buildings. Addressing skills training shortages in the trades is critical to delivering buildings that achieve meaningful GHG reductions.

A more sustainable and energy-efficient economy can be achieved in congruence with employment growth, but to do so requires greater integration of low-carbon knowledge with measures that support employment and skills development. Workplace learning is critical to update the skills of people employed in the building sector. Recognising the vital role education and training need to play in low-carbon strategies is essential to ensuring that skills gaps will not hold back the needed transition. To prevent significant shortages of green building tradespeople, efforts have to be made to enhance the understanding of technical and soft skills specific to green buildings, and foster green literacy and better coordination and communication between individual trades and the rest of a project team to achieve high-quality, high-performing energy-efficient buildings. Growing the green building labour force will also require government leadership to drive public policy development and incentivize the uptake of workforce training.

10-YEAR WORKFORCE OUTLOOK FOR ONTARIO



Source: https://www.constructionforecasts.ca/sites/forecast/files/highlights/2018/2018_ON_Constr_Maint_Looking_Forward.pdf

[2] CaGBC. (2016). Building solutions to climate change. How green buildings can help meet Canada's 2030 emission targets.
[3] Bridge, T. and Gilbert, R. (2017).

1.2 RESEARCH QUESTION AND METHODOLOGY

The purpose of this research is to identify shortages in skills training for the trades, and offer an actionable roadmap for labour, industry, educational institutions and governments to create an education and training market for low-carbon skills.

Data was collected through an industry survey, focus groups and individual expert interviews, leveraging knowledge and experience of four low-carbon building case studies, as well as secondary sources, including a review of relevant literature and college curricula (see *Appendix A*).

In 2017, The Canada Green Building Council (CaGBC) launched its Zero Carbon Building Standard. The Standard pioneers low-carbon building design and operations in Canada, in recognition of increasing demand for an interdisciplinary, systems-based approach to continuous education and training in support of a green building economy. Discussions with pilot participants have highlighted a need to strengthen the overall business case for low-carbon practices among tradespeople.

An industry survey was widely distributed through the networks of CaGBC and its project partners in Ontario (see *Appendix B*). The survey garnered firsthand insights into green building skills requirements. The survey was complemented by a focus group and individual interviews based on four live low-carbon building projects. CaGBC partnered with the Mohawk College's Joyce Centre for Partnership & Innovation, Cora Group's Evolv1 urban office building (both pilot projects of CaGBC's Zero Carbon Building Standard), mcCallumSather's heritage retrofit of the Westinghouse Building in downtown Hamilton, and the City of Toronto and Toronto Atmospheric Fund's social housing retrofit project (see *Appendix C*).

This research was complemented by feedback from industry partners. An advisory group composed of industry supporters and interested parties provided advice on the research approach, findings and future roadmap (see *Appendix D*).

All of the collected data was augmented by a literature review of low-carbon building skills shortage strategies in other national and international jurisdictions, as well as research on existing programs and an environmental scan of (non-apprenticeship) college curricula in Ontario (See section *2.3. Current pathways for education and training options*).

The purpose of the research report is to:

1. **Describe the skills training required to meet the demand for the construction of low-carbon buildings.**
2. **Identify the barriers to the uptake of low-carbon building skills training among tradespeople.**
3. **Propose the delivery models necessary to optimize training uptake.**
4. **Create an actionable education roadmap for Ontario labour, government, educational institutions, and industry to use to drive low-carbon skills development.**

1.3 WHAT IS A LOW-CARBON BUILDING?

The focus of this research is on energy-efficient, low-carbon, high-performing[4] building skills of construction trades in Ontario.

This study focuses on large commercial, institutional and residential buildings, and considers both new construction and retrofits. It does not tackle green buildings in general, which is a much broader concept but rather high-performing, low-carbon, energy efficient buildings[5].

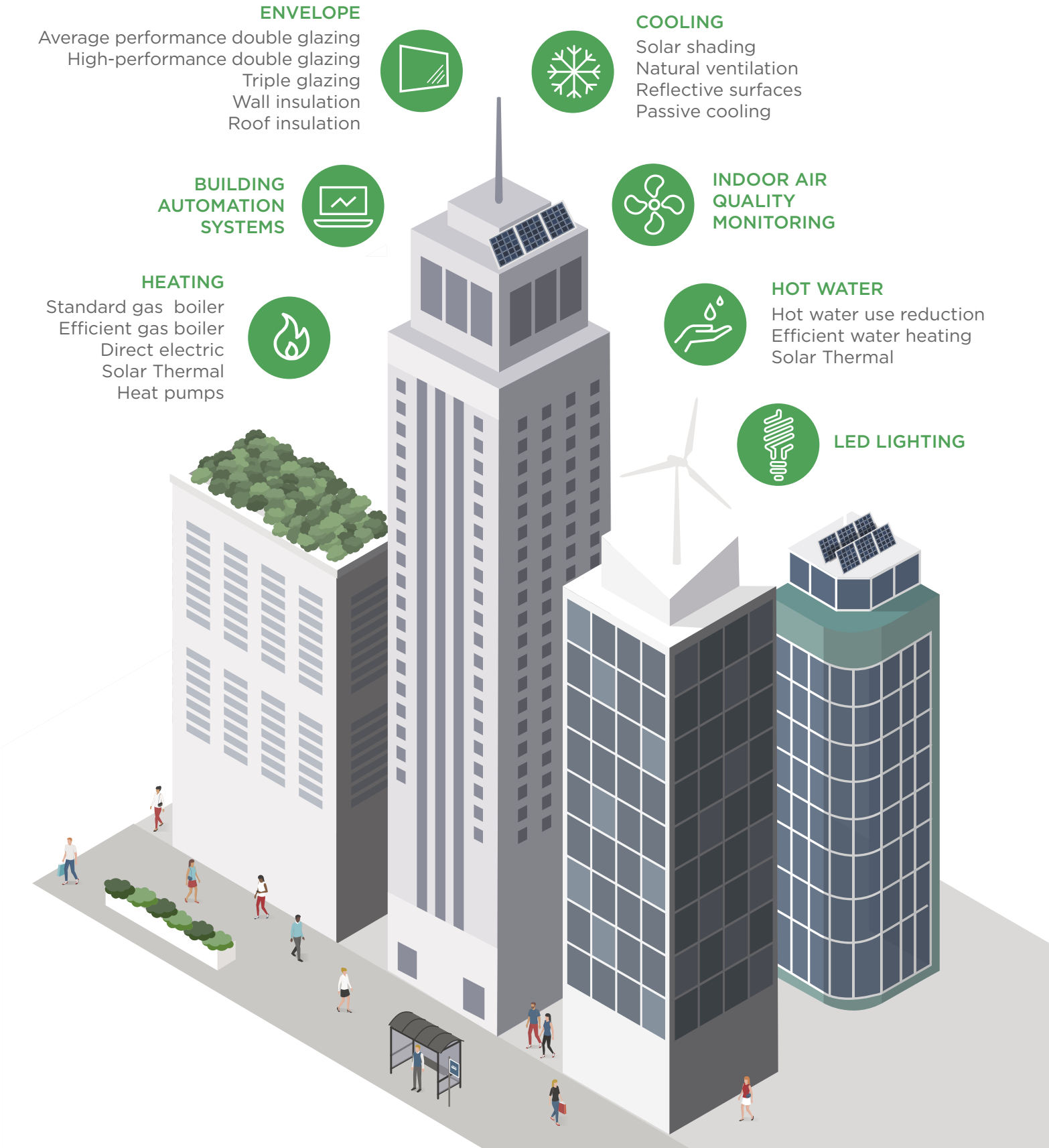
A high-performing building is defined as one that is highly energy-efficient and produces on-site, or procures, carbon-free renewable energy in an amount sufficient to offset the annual carbon emissions associated with its operations.

Design features for hot water, heating, cooling and the envelope, as well as site location and orientation, and the materials used need to be chosen carefully in order to integrate renewable energy generation and select technologies that avoid the combustion of fossil fuels. Construction for high-performance buildings is the practice of designing, constructing, operating, maintaining, and removing buildings in ways that conserve natural resources and limit greenhouse gases emissions. Using low-carbon building principles can reduce the impacts on land use and energy consumption, and improve the indoor and outdoor environment along with worker conditions. It can also boost productivity, increase energy, water and material efficiency, and reduce overall costs.

[4] CaGBC defines high-performing buildings as energy-efficient, low or near zero-carbon buildings. High-performing and low-carbon are used as synonyms within this report.

[5] Green buildings are holistic buildings that are designed, constructed, and operated to achieve clearly defined environmental, economic and social performance objectives that are measurable above and beyond the norm. (CaGBC Green Building Toolkit: A guide to sustainable communities: www.cagbc.org/greenbuildingtoolkit).

HIGH-PERFORMING BUILDING



1.4 RESEARCH FRAMEWORK: WHAT ARE LOW-CARBON SKILLS?

Low-carbon skills comprise the skills, capacities and knowledge needed to support the construction of new buildings and retrofitting of existing buildings so that they have the lowest possible carbon dioxide emissions.

High-performing buildings must handle the installation of new technologies and low-emissions mechanical systems, be it geo-thermal energy systems, photovoltaics, biomass boilers, ground source heat pumps, high-efficiency lighting technologies or similar equipment for heating, cooling, ventilation and air-conditioning.

In general, the same number and type of skilled tradespeople work on low-carbon buildings as work on conventional constructions (see *Appendix E*). Not all types of trades are impacted the same way.

Skill requirements are often not specific to particular trades but instead crossover among numerous traditional trade roles and require the successful collaboration of several trades, e.g. in assembling building envelopes or installing thermal breaks on balconies. Therefore, existing job categorization of trades may be insufficient for identifying skills gaps[6] for high-performing buildings but cross over among traditional trade roles.

"While the perception is that trades need to understand green building, I think there's an equal if not larger gap in that of sustainability professionals / organizations who need to understand construction. Understanding construction law, contractual relationships, and industry structure would allow for a more tailored (and effective) approach to increasing the adoption of green building strategies, as opposed to painting the industry broadly".

- Quote from industry survey participant

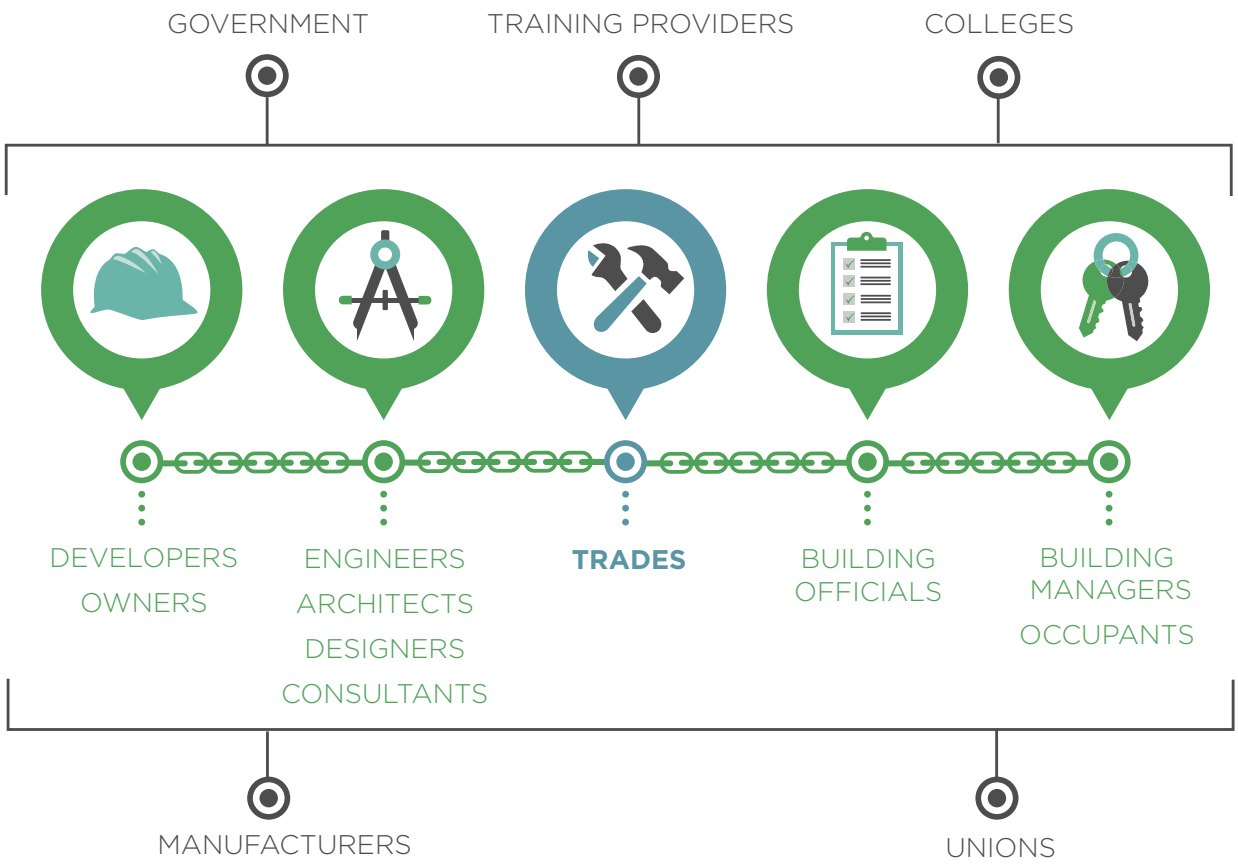
[6] ILO 2014. CEDEFOP 2013.

The main focus of this work are construction tradespeople in Ontario. However, CaGBC's findings reveal that other professionals in the construction ecosystem, such as building officials and building operators, need to have certain skills when dealing with low-carbon buildings as well, and they play a vital role in constructing and operating high performing buildings. Beside the construction ecosystem that is concerned with designing, constructing and maintaining a low-carbon building, there are other actors that influence it. These are governments with codes, laws and regulations; colleges and other training providers such as CaGBC that offer training. In addition, manufacturers deliver the products used by the trades and unions act as the voice of the trades and support them, for example with training opportunities.

Training for other building and construction professions:

- **Developers and owners.**
- **Engineers, architects, design professionals and consultants.**
- **Building trades and general contractors.**
- **Building officials and building inspectors.**
- **Building operators, managers and occupants.**
- **Coaches, teachers and professors.**

THE CONSTRUCTION ECOSYSTEM



CASE STUDY

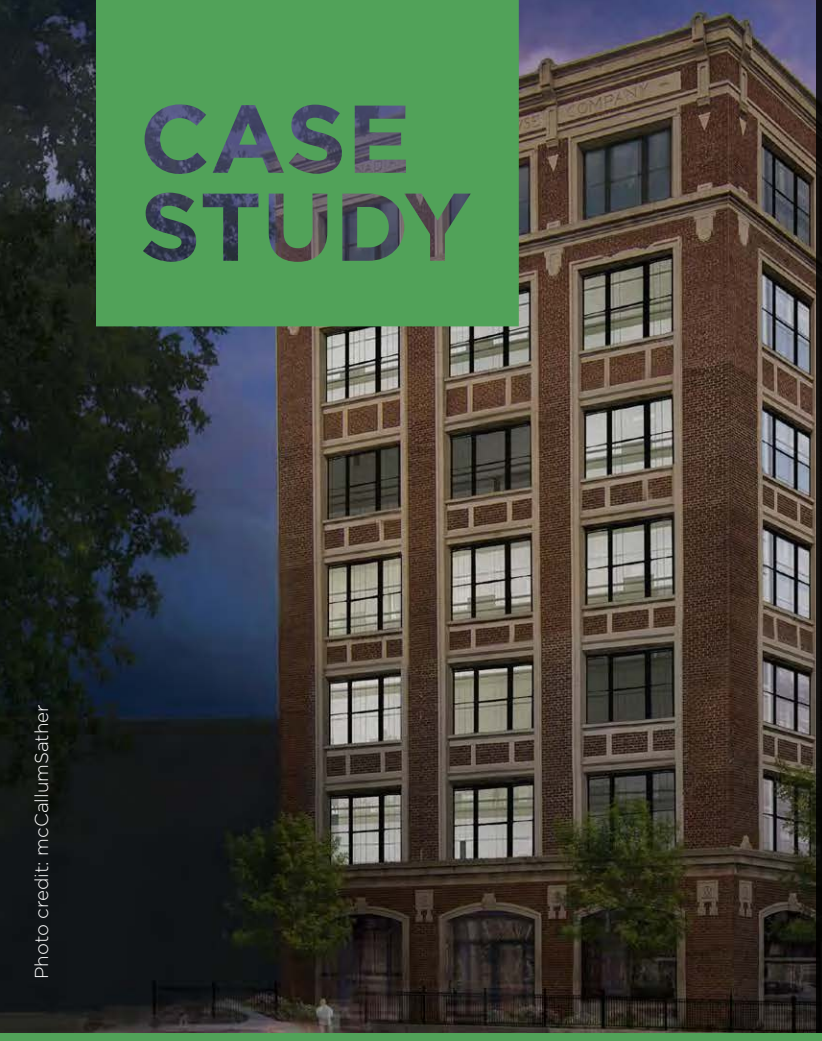


Photo credit: mcCallumSather

mcCallumSather's heritage retrofit of the Westinghouse Building (Hamilton)

Location
Hamilton, ON
Year of Completion
2018
Consultant Team
mcCallumSather (Architecture/Heritage/ Mechanical/Interiors), MTE (Structural/Civil),RDH (Sustainability), Seguin Engineering (Electrical)
Construction Manager
Collaborative Structures Limited
Gross Area
80,000 s.f. (existing building)
Building Use
Commercial and Retail
Certification
Second floor fit-out for mcCallumSather offices targets LEED Platinum
Energy Targets
Zero net carbon performance

Westinghouse HQ is the reimagining of the former Westinghouse headquarters as a new suite of offices and retail spaces. The existing structure has been standing since 1917 in Hamilton's north end and was the former Canadian headquarters of Westinghouse Electric Corporation. The structure was designated under the Ontario Heritage Act in 1988, acknowledging the importance of the architecture, and the Corporation's contributions to Hamilton's industrial past. The structure had been unoccupied since 1980 and extensive work was underway to both conserve important heritage features and to reimagine the facility as a modern suite of offices which target zero net carbon performance. The design was specifically driven by the principles of sustainability including environmental, economic and social. The renovation for the core and shell involved intensive building envelope and energy analysis to retrofit the facility for maximum energy efficiency without impairing the integrity of the masonry enclosure. The form of the seven-storey building is characterized by a long and narrow footprint which facilitates maximum use of natural light and natural ventilation strategies.

Design strategies included:

- High-performance enclosure
- High-performance water loop heat pump mechanical system (gas fired boiler)
- New roof with infrastructure for roof top photovoltaic system
- High quality double glazed operable windows, Low E, argon filled
- Maximum use of natural materials
- LED lighting

Sustainable Features

The architects have placed an emphasis on barrier free design, the integration of bike storage and facilities which support and encourage commuting.

https://mccallumsather.com/projects/westinghouse-hq/.
https://www.westinghousehq.com/.

2 SKILLS AND CAPABILITIES FOR THE LOW-CARBON BUILDING SECTOR: ARE THERE GAPS?

There is a range of skills and capabilities needed by construction trades and other members of the construction workforce involved with low-carbon buildings as described in the scope of this research study.

These skills will likely increase in importance and variety as more high-performing buildings are constructed. The knowledge and skills needed across all tradespeople can broadly be described as "technical" and "soft skills." Technical skills include the ability to work with certain equipment or installation systems. Soft skills involve the ability to communicate and collaborate effectively and are critical to the success of low-carbon construction projects. These skills also include increasing the levels of "green literacy" of the green building workforce that supports achieving high-performing buildings. Said in another way, the trades need the ability to understand the broad implications of key building activities on the environment. It also means that their needs to be a higher level of green literacy of the broader construction ecosystem and the market infrastructure which influences they way we design and construct high-performing buildings. While the skills needed are the same for both current professionals and students and trainees, the opportunities and modalities used to teach them are quite different.

2.1 GREEN LITERACY: SOFT SKILLS AND MARKET INFRASTRUCTURE

Improving green literacy of the construction workforce supports achieving high-performing buildings.

Green literacy refers to the need to develop a broad ecological mindset and awareness throughout the construction industry. Some skills we identified in this research fall somewhere in the middle between technical and soft skills and can be broadly described as green literacy. Others are not related to soft or technical skills but are rather about the process of designing, bidding for and constructing a low-carbon building and thus require adapting the market infrastructure. Green literacy plays a very important role for successful high-performing buildings, with communication and cooperation among trades as well as time management being most important. Due to the collaborative requirements brought on by complex new technologies, creativity, problem solving and critical thinking are essential as well. Soft skill development has been mostly overlooked in training and research in favour of technical skills. This report finds that soft skills and the changes to how we construct low-carbon buildings are equally important to effectively deliver low-carbon buildings as they involve the entire construction ecosystem and support the successful application of more technical skills and tasks[7].

A Gaps in Soft Skills

1 Communication and cooperation among the trades

Tradespeople are usually not on-site at the same time, nor do they discuss the final product. An understanding of the goals and objectives of a project, as well as the rationale are important factors in the success of low-carbon projects. In our interviews, we heard that tradespeople on construction projects tend to be siloed, coming to the construction-site, completing their tasks and leaving without much interaction or communication with other tradespeople. Communication and interconnection among tradespeople as well as integrating them into the design process seems to be an important factor in making low-carbon building projects successful.

Instead of focusing on a specific task, and as a result of not being conscious of the impact of their work on other tradespeople, the understanding of how components work together and the effect they have on achieving a low-carbon building needs to be made clear. When issues arise, it is mostly the project managers and architects who address problems, sometimes without communicating it back to the tradespeople. Communication is typically limited to what the trades need to complete their specific job. However, a big picture understanding is needed in order for tradespeople to understand the reasoning behind decisions, and how different components of a project interact. As a result of this lack of understanding, sometimes the quality of the building can suffer.

[7] CEC 2013.

2 Allowing more time for complex projects

Time is money, so trades have an interest in completing their work in the most efficient manner possible. If the available time has been used up or if not enough time has been planned for a project, this can cause problems as following the instructions and blueprints for a low-carbon building might be more time consuming.

Mechanical, electrical and building automation tradespeople tend to be the last ones on construction projects. If the contingency money and available time have been used up, they often feel pressure to complete their work within a compressed time-frame.

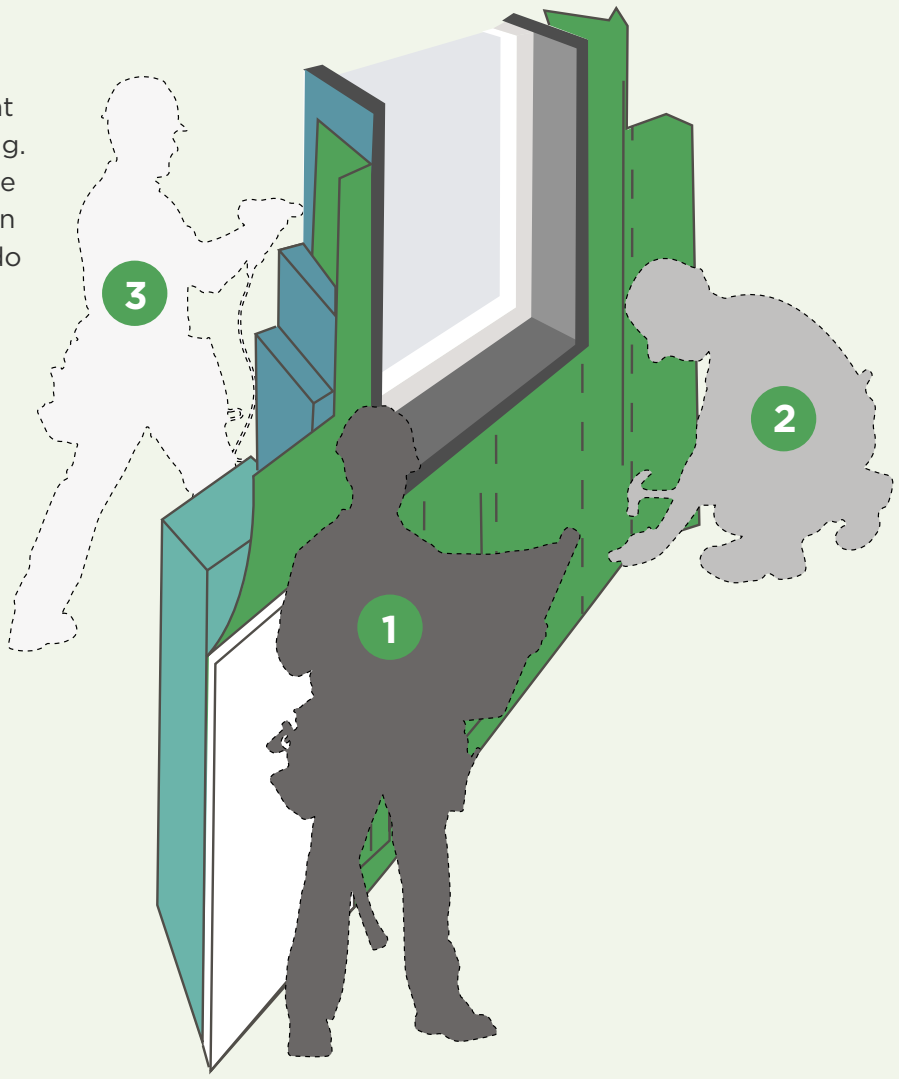
Many tradespeople do not have experience with green or low-carbon buildings and may not be aware that their construction can take more time and that the specifics of a design are essential for the performance of the building. Therefore they might change the approved design on-site without reporting that but doing "business as usual" and ignoring or omitting important requirements.

EXAMPLE OF COLLABORATION ON-SITE: **BUILDING ENVELOPE**

The building envelope is an important element of a high-performing building. It requires the cooperation of multiple trades and allows only for slim margin of error, especially as they typically do not work on it at the same time.

Tradespeople include:

- BRICKLAYERS
- CARPENTERS
- CEMENT MASONS
- DRYWALL MECHANICS
- ELECTRICIANS
- PLUMBERS



B Gaps in the market infrastructure

1 Holistic view of the building as a system in an integrated design process

Tradespeople are trained for the specific tasks of their trade. However, for low-carbon buildings to be successful, they require a working knowledge of the building as a system and an understanding that a building is not just a sum of its parts. The conventional design-bid-build delivery model for real estate tends to institutionalize a separation of functions that work against this goal. In a conventional process, design professionals (architects, engineers, planners, commissioning authorities and consultants) are responsible for producing designs that meet building codes and requirements of clients, and for documenting designs that become part of a legal contract between the owner and the contractor who are undertaking the project. As a result, various disciplines in a building project typically have different drivers.

"Contractors are incented to maximize profits by building as inexpensively as possible, [...] while design professionals are loath to admit any design imperfections, due to liability concerns. As a result, construction contracts frequently foster adversarial relationships that can impair operating performance. Alternative approaches typically include an integrated development process, which can include building operations and maintenance. This requires more unconventional financing, contract creation and team management efforts and skills.[9]"

2 Capacity building – lifelong learning

For many trades, there has never been a need to update their skills as many tasks and technologies have stayed the same for many decades. However, low-carbon buildings are making use of new technologies. As a result, tradespeople are faced with absorbing and understanding the complexities of new technologies related to low-carbon buildings. Many tradespeople have not seen much change to their skills and knowledge during their careers, whereas others, such as electricians, have had to deal with new or enhanced technologies on a regular basis. These changes in low-carbon technology require tradespeople to update or develop new skills. Once they get exposed to the concept of a low-carbon building, many adapt quickly to the new requirements, others – due to lack of adequate training opportunities – are left behind. This, and also a limited motivation to upgrade their skills and expertise because training does not involve billable hours, could be detrimental to increasing the number of high-quality, low-carbon buildings. If education and training systems only emphasize low-carbon skills acquisition at the beginning of a career, than over time significant skills shortages and mismatches will develop in Ontario's labour force[10].

"I meet hundreds of tradespeople that have not attended any training in the last 15 years. Lots of training courses are offered and no trades attend. They should be required and paid to attend. There should be requirements for continuing education and scope of work for a project should require training."

- Quote from industry survey participant

[8] CEC 2017; Essex and Hirst, 2011; UNESCO, 2017.
[9] CEC, 2013.
[10] Cedefop 2012 and 2013.

2.2 TECHNICAL SKILLS

Construction tradespeople are the ones most directly involved with actually creating, assembling and installing the elements that become a building.

Technical skills are the practical abilities and knowledge needed to perform specific tasks, with the help of tools or other equipment.

Traditionally, tradespeople are concerned with efficiency of their work flow, safety on the job, and, of course, wages. Their responsibilities relate to quality and timeliness, but also to coordination with other trades to allow the project as a whole to progress effectively.

Not all trades are impacted by low-carbon buildings in the same way, and to the same degree. Some, such as mechanical and electrical trades, experience this transition more than others.

TECHNICAL SKILLS GAPS FOR HIGH-PERFORMING BUILDINGS

AIRTIGHTNESS AND AIR VERSUS VAPOUR BARRIERS

PLUMBING AND PIPEFITTING

GEOTHERMAL HEAT PUMPS AND PHOTOVOLTAIC SYSTEMS

EMBODIED CARBON AND MATERIAL SELECTION

MECHANICAL, ELECTRICAL AND BUILDIUNG AUTOMATION SYSTEMS

INSULATION

BUILDING ENVELOPE AND THERMAL BRIDGES

COMMISSIONING

Many of the green products currently on the market require little or no learning curve versus traditional products, especially for electricians and plumbers. The installation requirements for many green products do not differ in a significant way from conventional products. However, being more diligent and following instructions and blueprints is much more important in green buildings than in conventional construction, and either the trades themselves or the foreman need to understand the importance of precision for low-carbon buildings.

Designers also need to be very clear when specifying their design ideas in a blueprint, especially if a specific design or installation differs from regular construction. Energy retrofits done poorly are likely to risk "green backlash" if the expected energy savings are not achieved or, worse, buildings are damaged by moisture that becomes trapped due to added insulation and air sealing[11]. Much of the difference with the green building products is their interaction with one another. There are also some newer technologies used for low-carbon buildings, such as geothermal and photovoltaic systems. These require some trades to learn entirely new skills whereas others merely need an updating of their existing skills.

Certain technical skills and capacities for performance testing, such as using blower doors and thermography, will be necessary for trades working on low-carbon buildings. Generally, poor installation practices, e.g. installation of proper backflow devices; puncturing and damaging building envelope components, improper sealing of HVAC systems, as well as lack of familiarity with adaptive lighting systems (e.g. occupancy sensor controls, daylight harvesting), and putting sensors in unsuitable places are also areas that need improvement.

Some industry observers argue that it is unrealistic to expect tradespeople to understand and install properly the myriad of interconnected systems that make up large commercial buildings and that manufacturers should do more in terms of systems integration, prefabrication and even ongoing responsibility for the performance of their systems[12]. One example would be lighting companies, which are beginning to use a leasing model to manage the installation, performance and replacement of the products and lease them to building owners.

However, without addressing the gaps in green literacy of the overall construction workforce and adapting the market infrastructure, improvements in technical skills of the trades alone will not necessarily result in successful high-performing buildings.

Overall, technical difficulties tend to show up in the following areas:

Geothermal heat pump and photovoltaic systems

One area that challenges tradespeople because it crosses traditional trade roles on a job site is the installation of photovoltaic systems on rooftops, which demands new knowledge and capabilities of manufacturers specifications from both electricians and roofers. Solar thermal systems place similar demands on plumbers[13].

[11] CEC, 2013.
[12] CEC, 2013.
[13] CEC, 2013.

CASE STUDY

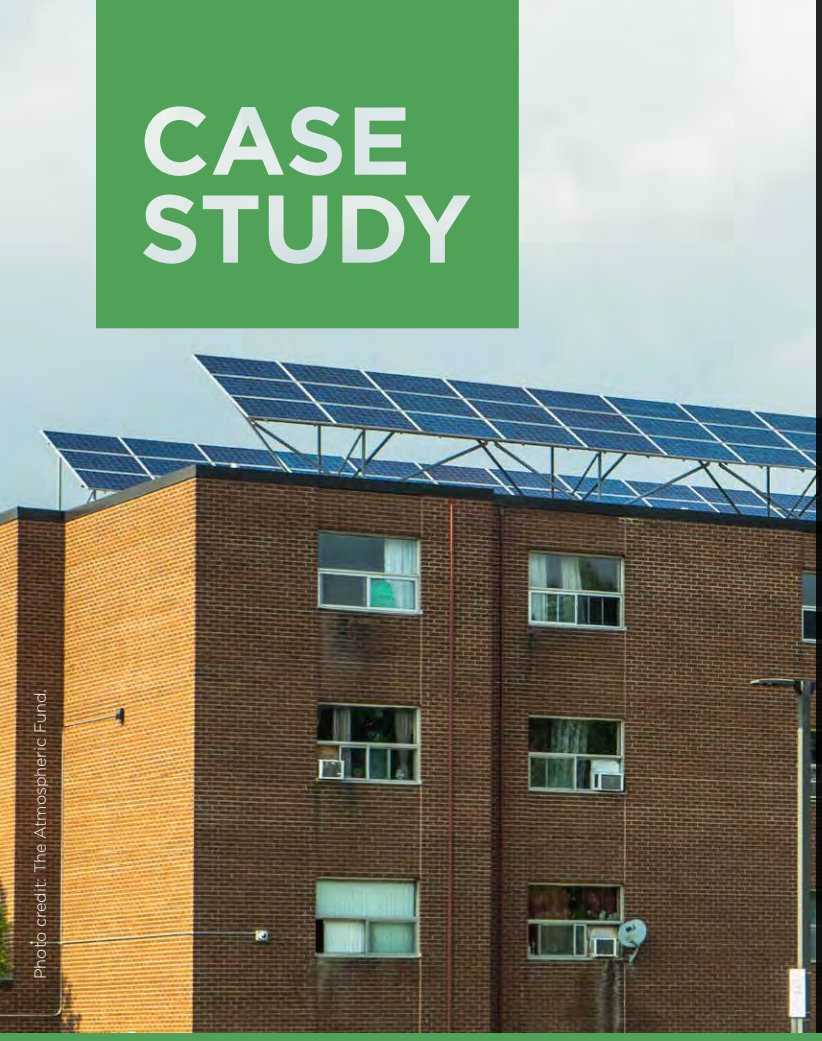


Photo credit: The Atmospheric Fund.

City of Toronto and The Atmospheric Fund's TowerWise Retrofit Project

Location
Toronto, ON (7 Buildings in 3 locations)
Year of Completion
2017
Consultant Team
Ecosystem Energy (Design/Build)
Gross Area
75,220 s.q. meter
Building Use
Multi-Unit Residential
Project Cost
$4.27 million
Energy Targets
Reduction in greenhouse gas emissions by 30% and utility costs by 20%

The TowerWise Retrofit project evolved from an agreement between The Atmospheric Fund and Toronto Community Housing to dramatically reduce energy use, water use and greenhouse gas emissions in more than 1200 households across seven Toronto Community Housing buildings. The structures ranged from four to nineteen storeys and were constructed between 1965 and 1974 and included bachelor's apartments, senior's suites, and family units.

The buildings and units were retrofitted with a number of features to help achieve the project targets. Attention was given to improve air quality, as a means to increase occupant comfort levels through fresh air. Smart thermostats were installed to monitor and better control indoor air temperature. Improvements to lighting included LED lights and motion sensors, in particular in low occupancy spaces such as stairwells and garages. Water conservation retrofits included low flow faucets and toilets, and old boilers providing heat and domestic hot water were replaced with highly-efficient condensing models.

Smart metering and monitoring ensure that the project is able to track and document energy use. Intensive monitoring of the retrofit performance will provide valuable data that will benefit the field of retrofit design and optimization. Indoor comfort and air quality in the buildings will be monitored before and after the retrofits as part of a research partnership with the University of Toronto. The research findings will provide valuable insight into the potential for energy retrofits to improve health and comfort in multi-unit residential buildings.

https://torontoist.com/2015/10/tchc-invests-in-energy-saving-repairs/.
http://taf.ca/wp-content/uploads/2015/09/TCHC-TAF-Backgrounder.pdf.

Airtightness and air versus vapour barriers

Without deeper knowledge of building science, trades that are working on air sealing around fenestrations may not pay proper attention to moisture, air or vapour barriers, or where to place these in a building's assembly. This can be a big challenge to contiguous air barrier installation and is compromising the performance of the building. Air barriers and vapour barriers are often improperly installed, as the difference between the two is not properly understood[14]. Often, there is no blower door air leakage test done during construction, which contributes to creating low performance buildings. The myth that buildings need to 'breathe' by allowing air leakage to prevent moisture problems that lead to rotting, mildew and mould is still prevalent throughout the industry[15].

For a low-carbon energy-efficient building, the function and protection of the air barrier, the knowledge of how to design an airtight building envelope, and the capacity to deliver airtight construction is essential. This includes air leakage detection and control, the use of thermographics to identify cold or hot spots, and managing envelope penetrations. Airtightness testing is done by placing the building under both positive and negative pressure to test form leaks (e.g. the blower door test), which needs to be factored into the project scope and schedule. In addition to this, knowledge on the difference of air barriers and vapour barriers is critical in understanding low-carbon buildings[16].

Building envelope and Thermal Bridges

Building envelope construction is a detailed and integrated process that often farms out individual components to different trades with no mechanisms to encourage them to work together or understand one another. The type, composition and quantity of the various components and layers of materials that go into the walls, roof and other exterior areas, and how they are put together, have significant impacts on how efficiently the building performs. For example, thermal bridging can result in an overall reduction in thermal insulation of the building. A thermal bridge is an area that has higher thermal conductivity than the surrounding materials, creating a path of least resistance for heat transfer into or out of conditioned space. Thermal bridges in buildings impact the amount of energy required to heat and cool a space, cause condensation within the building envelope, and result in thermal discomfort. Thermal bridging can be minimized through continuous insulation, thermally protecting exposed slab edges, and addressing balcony design to create thermal breaks.
Additionally, tradespeople often do not have the knowledge needed to do flashing and air barrier installation around fenestrations. Trades are often not aware of the importance of air sealing around fenestrations. Contiguous air barrier installation can be a challenge.

[14] A vapour barrier prevents vapour diffusion, and the job of an air barrier is to stop air leakage through differences in air pressure. A wall system should have one vapour barrier, but can have many air barriers. A vapour barrier can act as a very effective air barrier, but an air barrier does not (and should not) always stop vapour from diffusing. There are two main ways moisture will pass through walls— air leakage and vapour diffusion. Vapour diffusion is the process of moisture passing through breathable building materials, like drywall and insulation. Vapour barriers are tasked with preventing condensation from forming, a vapour barrier should be placed on the warm side of your insulation to stop warm, moist air from condensing on a cold surface inside your wall. Air leakage is due to air pressure differences between indoors and out, which forces air through any holes in your air barrier.

[15] The origin of this myth most likely lies in the supertight, superinsulated houses of the 1970s, when houses were not yet seen as a system. Houses were sealed, but mechanical ventilation was not added. Also often materials were used that trapped moisture. Tight houses like that often had the problem of poor indoor air quality, backdrafting of combustion appliances as wells as high humidity and mold growth.

[16] Modus Planning, Design & Engagement, Brantwood Consulting, 2017.

Insulation

Trades should be able to address heat loss and gain in the building envelope through the provision of adequate insulation in the walls, roof and other exterior areas. Similarly, insulation should be applied to any temperature bearing systems (mechanical equipment, pipework, etc.).

Plumbing and pipefitting

Another area of common mistakes is plumbing and pipefitting. Tradespeople need to know how to minimize pumping energy, as well as the concept of pressure drop as this influences how to install ductwork – especially flexible ductwork - and piping systems to minimize pressure drops in duct/pipe systems. Trades need to know how to install and balance forced air mechanical systems as well as balancing air flow for ventilation. Following installation instructions closely and having knowledge on the importance of an intact building membrane to avoid penetration of the membrane of a building. Contractors should understand the concept of pressure drop and apply that to how they install ductwork and piping systems so as to minimize pressure drop in duct/pipe systems.

Mechanical, electrical and Building Automation Systems

Heating, ventilation, and air conditioning systems (HVAC) and other mechanical and electrical systems require an expanded set of skills for tradespeople. Trades need to know the design, availability and installation of new efficient heating, cooling, ventilation and domestic hot water technologies, equipment and associated distribution solutions (e.g. heat pumps, low temperature hydronic solutions, direct current wiring) along with a range of heat recovery systems (heat recovery ventilators, heat scavengers and wastewater heat extractors). Also, knowledge of renewable solutions such as solar hot water heating and photovoltaic systems is necessary to construct a high-performing building. Increasingly, the communication systems between these devices and the user controls are more advanced and a Building Automation System is necessary to optimize performance. In all cases, metering, monitoring, commissioning and testing are required along with owner and occupant education.

"The majority of my residential experience has involved stapling Typar around the house. Trades generally don't know any better. In the past year we have stopped using 6 MiL poly and switched to smart vapour retarder but I know most of the trades are still covering the warm side walls with impermeable poly. Furthermore, sub-trades (electrical, plumbing, HVAC etc.) penetrate this membrane seemingly at will with little to no knowledge of the effects."

- Quote from industry survey participant

Commissioning

Commissioning has evolved from something akin to "close-out testing" to a more holistic review that begins during design and is widely considered invaluable as a way of ensuring that the owner's project requirements and the design team's intentions are reflected in the project as built, and in facilitating a good hand-off of a facility to building managers. The scope of that practice has expanded to include building-envelope commissioning. For existing buildings, recommissioning (if the building was commissioned previously) and retro-commissioning (if it is being commissioned for the first time) are recognized as cost-effective ways to improve the asset performance of existing buildings[17].

"Most of the newly constructed buildings I am aware of are not performing as anticipated. Commissioning is a huge part, and also correct installation and connection between trades is a huge part."

- Quote from industry survey participant

Embodied carbon and the selection of materials

The subject of embodied carbon is a new one for the building industry and has only recently entered discussions around low-carbon buildings. Knowledge of the carbon footprint of products and the time value of carbon is still not common in the industry. It is therefore not surprising that tradespeople only rarely have knowledge about this. Materials are often chosen from a cost perspective or other aspects such as durability or safety. Embodied carbon or other environmental issues are taken into account only very rarely, if at all. It is not clear if tradespeople need to have in-depth knowledge in this area. However, to achieve low-carbon buildings, embodied carbon needs to become a topic in an integrated design process and be included as a requirement in the bidding process. The knowledge of this needs to be increased throughout the entire industry so that material choices are not left to tradespeople alone. Designers also need to be given guidance on how and what to choose.

[17] CEC 2013.

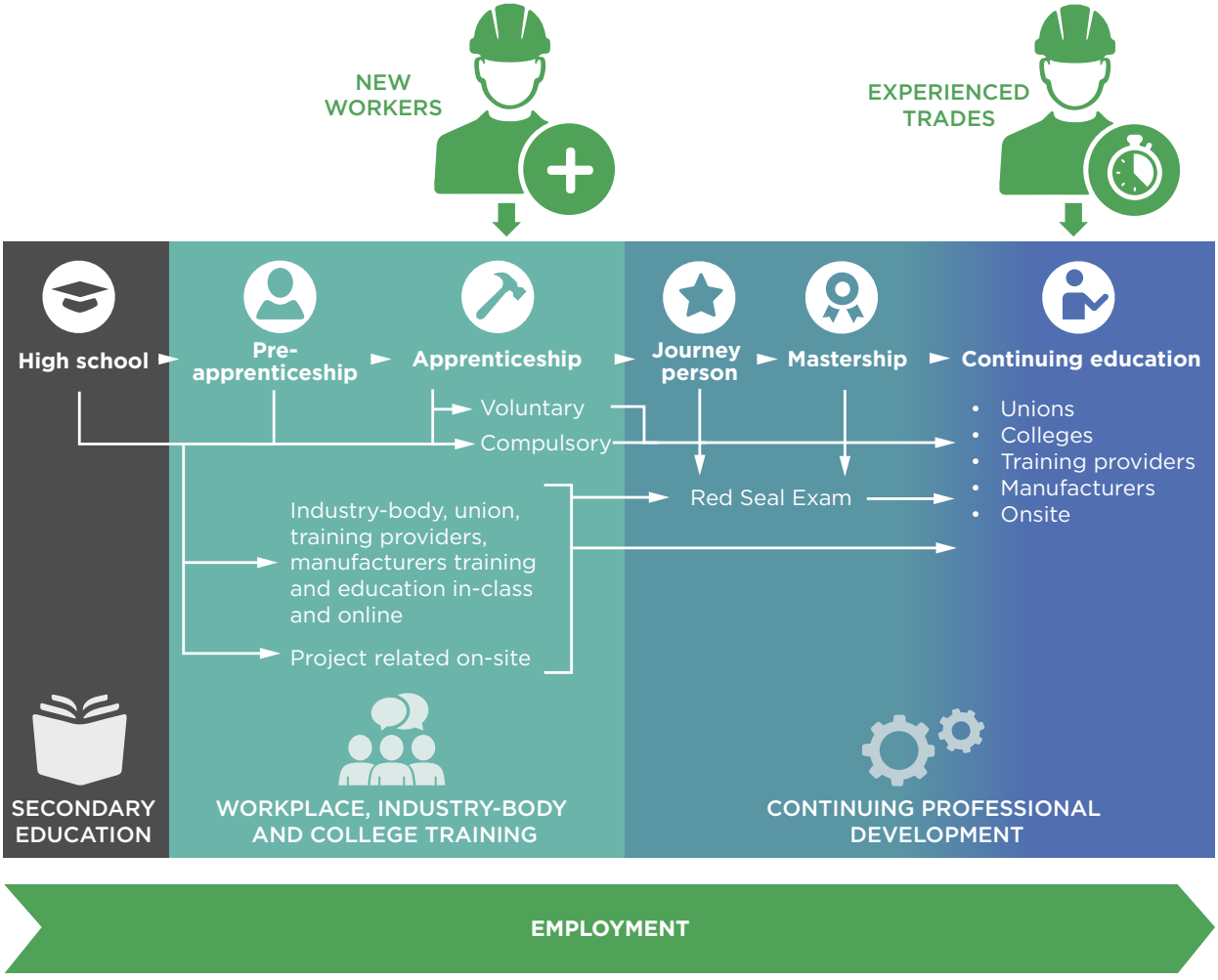
2.3 CURRENT PATHWAYS FOR EDUCATION AND TRAINING OPTIONS

The Ontario construction industry includes regulated and unregulated tradespeople.

There are 23 regulated or compulsory trades in Ontario, of which only a few are in the construction sector (plumber, electrician, sheet metal workers, tower crane operators, steamfitters and refrigeration and air conditioning mechanics (see a full list in *Appendix E*[18]).

The vast majority are voluntary trades. The compulsory trades are currently registered with the Ontario College of Trades (OCOT)[19]. Only registered journey persons can practice their trade legally.

CURRENT LANDSCAPE IN ONTARIO FOR SKILLED TRADES



[18] https://www.collegeoftrades.ca/trades-in-ontario.

[19] The Ontario College of Trades (OCOT) is an industry-driven, professional regulatory body that protects the public by regulating and promoting the skilled trades. One of the main responsibilities of the College is to ensure that individuals performing the skills of compulsory trades have the training and certification required to legally practice this trade in Ontario.
In late 2018, the Ontario government announced that it planned to update the apprenticeship system in Ontario and possibly reorganizing or dissolving OCOT in the process.

Apprenticeships and other pathways for new workers

Apprenticeship training typically involves several sessions of in-class training, as well as on-the-job training with an employer. The in-class training is typically handled by colleges and ends with an exam that has to be passed in order to get licensed. Apprenticeship programs are funded differently than traditional post-secondary programs, and are currently overseen by the Ontario College of the Trades (OCOT), which sets the curricula in consultation with a joint union-employer committee for each trade. However, these curricula often lag behind developments in the industry and do not always meet the needs of employers.

Although an apprenticeship is not compulsory for other trades, many still complete a voluntary apprenticeship. For voluntary trades there are several pathways to become a tradesperson. Naturally, recommendations to develop new training tools and instruments to accelerate uptake of training offerings will be different for voluntary and compulsory trades. However, we intend to show a variety of pathways for training opportunities to empower the trades in Ontario's labour market[20].

As described above, some trades require a compulsory apprenticeship in Ontario, some may also be included in the Red Seal program[21], and others have voluntary apprenticeship programs and therefore do not require mandatory coursework or exams.

Some trades may educate themselves through college courses or participate in continuing education that is offered at various institutions and organizations, such as union training centres, community colleges, in-house training by developers, industry and trade associations, government and not-for profit associations such as the Canada Green Building Council (CaGBC), training centres such as Canadian Institute for Energy Training (CIET), product manufacturers and construction service companies.

Continuing education

In addition to apprenticeship programs and courses that enable tradespeople to start working in their profession, continuing education programs[22] are also offered at Ontario colleges as well as unions and associations such as CaGBC. Continuing education courses and programs are traditionally part-time (evenings and weekends) offerings at Ontario colleges, most are not funded by the province, and they typically do not offer credentials aside from a local college certificate of completion. The courses and programs typically do not have to meet any sort of standard learning outcomes. Students do not have to apply to these programs, but pay by course to take the ones they want or need. Training offered by unions are mostly funded by union members. As such, unions can easily develop new training programs and sustain them even with low enrollment.

[20] The training within voluntary and compulsory apprenticeships has not been included in the environmental scan of this research. However, recommendations will include some ideas on the role of apprenticeship programs moving forward.

[21] The Red Seal Program is a program that sets common standards to assess the skills of tradespeople across Canada. Industry is heavily involved in developing the national standard for each trade. It is a partnership between the federal government and provinces and territories, which are responsible for apprenticeship training and trade certification in their jurisdictions. In order to be able to transfer from one province to another, trades need to pass the Red Seal exam. So even if a tradesperson is trained in low-carbon skills, he might not be allowed to work in Ontario without taking this extra exam – that does so far not cover green building skills.

[22] Continuing education is an all-encompassing term within a broad list of post-secondary learning activities and programs. The term is used mainly in the United States and Canada. Recognized forms of post-secondary learning activities within the domain include: degree credit courses by non-traditional students, non-degree career training, college remediation, workforce training, and formal personal enrichment courses (both on-campus and online). General continuing education is similar to adult education, at least in being intended for adult learners, especially those beyond traditional undergraduate college or university age. Frequently, in the United States and Canada continuing education courses are delivered through a division or school of continuing education of a college or university known sometimes as the university extension or extension school. https://en.wikipedia.org/wiki/Continuing_education.

Very few course offerings for tradespeople through colleges or other institutions have a focus on skills for high-performing, energy-efficient buildings. Within those offerings, many training courses do not see much uptake and need to be cancelled for lack of registered students. The 'green' courses offered in colleges in Ontario are often targeted more to engineers and architects than the trades themselves.

Unions are also offering a number of courses to their members. However, a limited number of these are courses on green building skills. That said, individuals who come out of courses taught by unions tend to be well-trained and have an advantage over those who have not been taught advanced skills through these courses.

Further research will be necessary to take a detailed look into college and union curricula and courses offered in continuing education by the various training delivery agents. Our assumption is that low-carbon skills are not being taught in regular trade courses and therefore it can be concluded that the absence of explicit mentioning of green or low-carbon skills means that these skills are not taught or at least not prioritized in mainstream training centres. If it is taught, it is often an add-on as low-carbon buildings are still seen by many as a niche market.

Review of non-apprenticeship Ontario college programs

The following list contains courses offered in green building related programs at Ontario colleges. However, there is a variety of training available through many different institutions. The list below may not be exhaustive as it only includes full-time and funded programs at Ontario colleges but not any apprenticeship or continuing education programs. Some significant programs may not be included. However, it is a useful indication of the range of training available at colleges.

Technical education in the construction trades is already well-established in Ontario. However, Ontario colleges offer very few 'green' courses. Evidence from the industry survey and focus groups suggests that programs have been reduced, particularly for retrofits.

Overview of full-time college programs	
Fleming	Sustainable Building Design
Centennial and St. Lawrence	Energy Systems Engineering Technician
Fanshawe and Niagara	Renewable Energies Technician
Centennial and Conestoga	Energy Systems Engineering Technology
Humber	Sustainable Energy and Building Technology
Mohawk	Energy Systems Engineering Technology
Algonquin	Green Architecture

2.4 CHALLENGES AND GAPS IN THE CURRENT OFFERINGS

When formal education courses are considered in the context of the low-carbon skills identified in this research there is a clear mismatch.

'Green' courses tend to be too widely focused and geared mainly on new entrants to the sector who intend to focus on sustainability as their initial area of work, but tend to lack in relevance for skilled trades. To say it differently: professionals can either seek a green career or become tradespeople. There are no trade specific skills being taught in the 'green' courses and hardly any 'green' content taught in trade course offerings.

"The problem is not with the availability of the training or the quality. Most 'green' products offer great training [...] but trades won't take the time [or can't] attend as there is no incentive or requirement to do so."

- Quote from industry survey participant

If so, 'green' content is not prioritized and merely an add-on and not integral to these courses. In addition, there are limited opportunities for professionals already in the workforce to follow a structured program of study that will allow them to develop the low-carbon skills they need.

This research shows that a training framework and a structured continuing education strategy are needed for professionals either already operating in the construction and built environment, or who would like to enter the sector without an apprenticeship program to develop their low-carbon skills and knowledge. Such a program would need to offer training for people at different stages of their career, and, at the same time, offer a variety of different training modes, such as college courses, online training that could include live webinars or online courses, or on-the-job training to ensure uptake. These education strategies need to focus on the competencies outlined earlier concerning technical and soft skills relevant for low-carbon construction.

This research clearly demonstrates the challenges facing the professional sector in Ontario when it comes to meeting the skills needed in delivering a low-carbon building. There are new skill sets and competencies that are becoming increasingly important and there is also a rapidly changing legislative and regulatory landscape that makes keeping up-to-date imperative. The development of low-carbon skills is challenged by the finding that professionals do not feel that current training is sufficient. As demand in low-carbon buildings grows, now is a good time to start thinking about developing and implementing green-building focused education and training systems. There is clearly an urgent need for additional training in Ontario to meet demand.

3 HOW DO WE GET THERE? AN EDUCATION AND TRAINING ROADMAP FOR THE TRADES IN ONTARIO

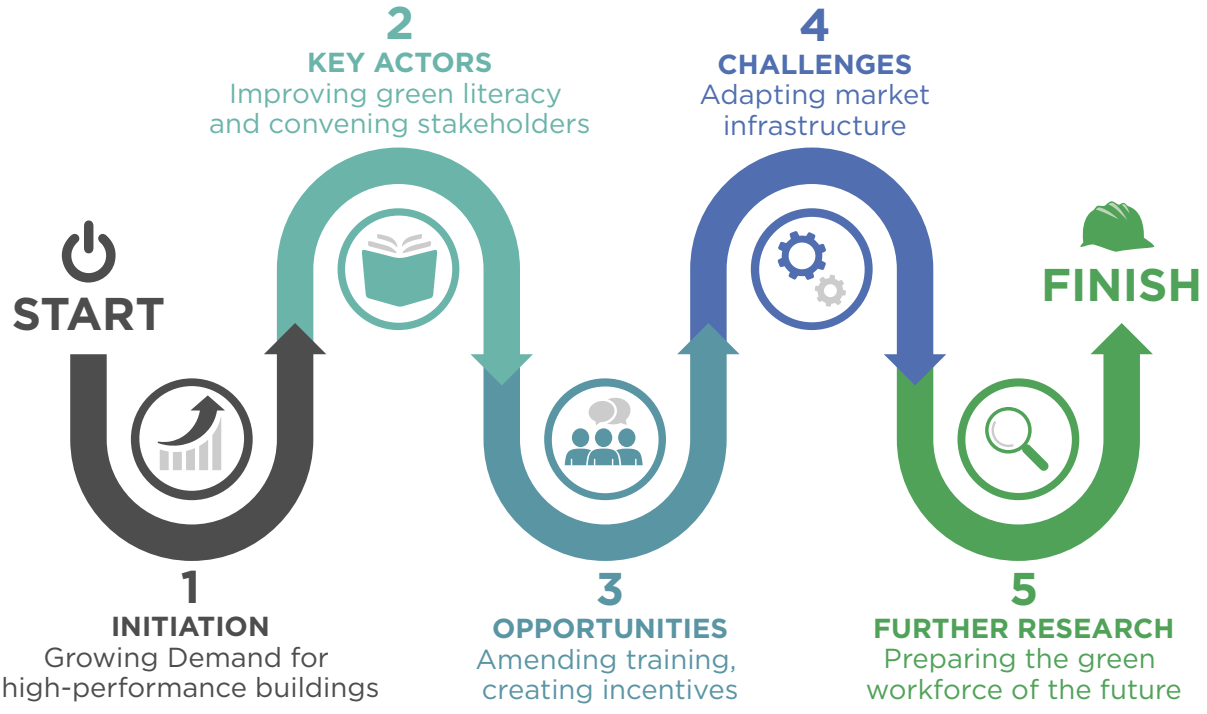
Recognizing that low-carbon buildings require specialized skills and capabilities on the part of tradespeople, this report sets out to develop an education and training roadmap for Ontario that identifies the skills needed now and in the coming years for constructing high-performing low-carbon buildings.

This plan also identifies both knowledge and skills gaps between existing educational offerings and makes recommendations for bridging those gaps.

This roadmap seeks to:

- Develop new education and training tools for Ontario tradespeople.
- Accelerate the uptake of training offerings for tradespeople.
- Leverage sectoral collaboration to build the competencies of current and future construction workers.
- Create a pathway for training and education that empowers tradespeople.

TRAINING AND EDUCATION ROADMAP



3.1 SPECIFIC SKILLS TRAINING REQUIRED FOR THE CONSTRUCTION OF LOW-CARBON BUILDINGS

Our research shows that there is a lack of knowledge and education related to the low-carbon skills of many tradespeople as these are not part of regular training courses.

However, well-trained and experienced tradespeople are more than capable of understanding and handling low-carbon systems. So it seems the problem is not general lack of capability but rather lack of appropriate training that causes the problems. Our research also found that technical skills are often not that different between low-carbon and regular construction. Many of the green products currently on the market require little-to-no learning curve versus traditional products, especially for electricians and plumbers. It is more about the process of designing and building a low-carbon building, and this tends to require soft skills rather than technical abilities.

It is also about creating an awareness and understanding of the "big picture" for tradespeople so that they understand the reasoning behind certain decisions, why specific instructions, e.g. for pipe fitting, need to be closely followed, that details and precision matter, how different components of a project interact and impact the overall project.

Due to a general lack of understanding, quality can sometimes suffer as tradespeople focus on the task at hand and are not aware of the interconnection of their work to other trades or how their work relates to the overall project. This challenge is often made worse by a shortage of appropriately skilled trades in smaller communities. Trades may be unwilling to travel between communities, and when they do travel, it involves higher costs.

Many of these issues in low-carbon buildings can be solved with better communication and an integrated design process. It has been proven beneficial to actual low-carbon building projects if tradespeople are involved from the very beginning in the design and development of the building so that the project, its requirements, and the thinking behind decisions, are understood. As construction is a very collaborative sector, the greater the understanding of the overall system the better the outcome.

CASE STUDY

Photo credit: Ema Peters

Mohawk College's Joyce Centre for Partnership & Innovation (Hamilton)

Location
Mohawk College, Fennel Campus, Hamilton, ON
Year of Completion
2018
Consultant Team
B+ H Architects in Joint Venture with mcCallumSather
Construction Manager
Ellis Don
Gross Area
96,000 s.f.
Building Use
Labs, Classrooms, Applied Research
Certification
CaGBC Zero Carbon Building Standard

The Joyce Centre for Partnership & Innovation is a facility on Mohawk College's Fennel campus. It opened in September, 2018 and provides the college with technologically advanced lab space, workshops, lecture theatres, industry training and showcases. The facility has targeted Net-Zero energy and has been named Ontario's first Net Zero Energy Institutional Facility. The JCP&I is one of 16 projects participating as a pilot project for the Canadian Green Building Council Zero Carbon Building Initiative and the World Green Building Council Advancing Net Zero Initiative. It is the first institutional building to earn a Zero Carbon Building Design certification. The building will be studied extensively through post-occupancy phases to illuminate the implications of net zero building and construction and to inform future processes in the collective move towards net-zero construction.

The projects includes the following energy features: Photovoltaics - 5,015m2 array producing 500KWp AC [Canadian Solar] and Geothermal Field - 28 vertical bore holes, 183m deep [GeoSource Energy]. The project also included an Energy Management Strategy which included an assessment of the needs and behaviour of the building's occupants to determine the energy requirements. Parameters included: building enclosure performance to reduce heating & cooling losses; mechanical system performance to optimize ventilation, heating, and cooling distribution; and electrical system performance to optimize lighting requirements. Additional sustainable features include: rainwater harvesting and water conservation measures, maximizing natural light and views, the selection of natural materials, using finishes strategically, and a vegetated roof.

https://www.mohawkcollege.ca/donors-and-supporters/mohawk-momentum-our-causes/joyce-centre-for-partnership-innovation.
https://mccallumsather.com/projects/joyce-centre-partnership-innovation/.
http://www.lowcarbonagenda.ellisdon.com/lessonslearned.pdf.

3.2 BARRIERS TO THE UPTAKE OF HIGH-PERFORMING BUILDING SKILLS TRAINING

There are significant barriers to training tradespeople to deliver low-carbon buildings.

In order to develop effective recommendations, it is important to recognize the challenges of delivering successful training.

Challenges[23]

Accessibility

In general, many tradespeople are not affiliated with any organization, association or union. For tradespeople working on commercial buildings this situation seems to be slightly different as a large percentage of those are unionized. However, there is no single organization or union that represents the construction industry as a whole, as would be the case in many European countries such as Ireland or Germany. Organizations such as the Canadian Building Trades Unions, the provincial and local Building Trades Councils, the Ontario Federation of Labour, Toronto and York Region Labour Council and other central labour bodies reach many local unions and tradespeople and employer based organisations such as the Canadian Construction Association, the Council of Ontario Contraction Association and the Ontario Skilled Trades reach many member firms. These organisations are important allies for outreach to skilled tradespeople and trade contractors.

Time and cost

Time and financial constraints limit the opportunity and desire for tradespeople to upgrade their skills. The benefit of additional training for low-carbon buildings is often not clear, so many people do not seek training in this area, especially as long as there are enough jobs available in conventional construction. Builders often rely heavily on self-employed sub-contractors that are not considered employees and therefore will not have the same access to training opportunities as regular employees. Unionized and larger-sized employers tend to invest more in training for their employees and send them on courses. For many tradespeople the motivation to train is low as they are hesitant to take unpaid time off work. The construction industry is busy and tradespeople do not see sufficient value in attending training, or a return on their investment in training. Many small and medium-sized business owners feel that incentives are necessary for employers to be able to support worker training.

Concerns about low-carbon buildings in the industry

The building industry often perceives low-carbon buildings as adding costs and time to construction projects. They also have concerns about the ability of a low-carbon building to achieve a desired performance. A main component to address these concerns is to improve the skills and capabilities of industry players, including tradespeople. It has been shown that the cost of delivering green buildings goes down as owners and their design / construction teams gain experience and skills, learning the most cost-effective ways of achieving goals[24].

Environmental awareness

Tradespeople that have been working with LEED® for many years often have the knowledge and experience to also work with low-carbon buildings as they are aware that

[23] CEC 2013; Modus Planning, Design & Engagement, Brantwood Consulting, 2017.
[24] CEC 2013.

green building construction differs from a regular construction project. In general, there appears to be a lack of awareness of the overall benefits that can be achieved through the construction of low-carbon buildings. By increasing knowledge of this topic, it could increase overall interest and motivation for working on these types of buildings. This is especially true for veteran tradespeople and it tends to be different for the younger generation.

Low-carbon skills not part of regular curricula

Low-carbon knowledge is not prioritized by programs that train the trades. It is mostly an add-on and seen as a niche market not as something that should be brought into mainstream construction practices. Low-carbon skills need to be integrated into regular teaching. Low-carbon skills are also an add-on in most construction text books, and not part of the Red Seal exam or apprenticeship programs in colleges.

No requirements for continuous learning

Trades are not required to complete continuous education after they finish their initial training or apprenticeship. There is a general need for more training and education targeted to tradespeople. The current trades training system focuses on getting workers ready for their first job without much consideration for continuous learning or career development. Low-carbon buildings rely on a range of design and construction best practices that could be translated into a valuable credential for the trades or made mandatory for obtaining and keeping a license or being able to bid on low-carbon building projects. Many participants of our survey and in our focus groups suggested that low-carbon skills be a mandatory requirement for certification of tradespeople working in the building sector and also required for the professional development of credential maintenance.

Lack of education opportunities

Currently, low-carbon education is largely unavailable to tradespeople except for some union-delivered courses and training from specific manufacturers related to green products.

Lack of qualified trainers

The demand for training tends to be highly connected with building code updates, so it is often difficult for teachers or educational institutions to develop and sustain their courses, programs and teaching staff.

Low demand for training

Many training providers will not run a program unless they have a minimum number of participants registered. The more specialized a program or the more rural the location, the harder it might be to get the minimum enrollment. Travel costs for trainees in rural areas can be significant, especially when forfeited income is factored in. It has also been shown that the uptake on courses offered in continuing learning programs is low and training often has to be cancelled due to an insufficient number of participants.

Lack of funding for

- Staff to administer and manage additional courses and larger intake of students.
- Curriculum development.
- Classroom space to accommodate students.
- Specialized facilities and equipment for training.
- Travel to provide training in remote communities.

3.3 DELIVERY MODELS NECESSARY TO OPTIMIZE TRAINING UPTAKE

In the design, architecture and engineering professions, there are courses and degree programs available that focus on green building skills. There are not as many opportunities for construction trades.

Some programs include green building features (solar water heating or photovoltaic electricity) as part of their curriculum, but most do not and on-site low carbon skills training does not exist. This means there is no first hand experience to encourage peer to peer learning and mentoring that provides the rationale as to why green building are needed.

Our research has shown that there needs to be different training offerings to ensure that the majority of new and existing tradespeople are reached and tackle the low-carbon skills necessary for new construction as well as retrofits. The best way to develop low-carbon building skills is through hands-on training. The professional career of a tradesperson should be viewed as an opportunity to build and upgrade their skills – from their apprenticeship through on-the-job activities.

There are currently very few opportunities for developing green building skills in a course-based environment. Generally, there is an understanding that the best way to develop green building skills is in a course-based setting before working on-site, in an apprenticeship or similar environment. However, as it might be some time before this can be achieved and it also would only target people entering the profession, there also needs to be a focus on existing trades and how to train people throughout their career.

Amend apprenticeship programs

To target new trades, the curricula for the courses offered in compulsory and voluntary apprenticeship programs in Ontario should be amended to include low-carbon skills that will ensure future tradespeople gain the necessary knowledge. This will also mean updating existing textbooks and training professors and coaches.

Introduce continuing education after apprenticeships

Courses that target compulsory and voluntary trades that have already gone through an apprenticeship program and are working in the profession should also be designed. Unions will play an important role in teaching low-carbon skills and should also ensure their course offerings and training are updated.

Provide different delivery modes

For continuing education to be successful, a variety of different training modes need to be on offer. It has been shown that tradespeople are often reluctant to invest the time and money for in-person courses. Comments in our industry survey and from our interview partners showed that in-person training is still a preferred means of being trained as it will enable them to get hands-on practice with technical skills that are required.

However, online resources seem to be equally important and would be valuable especially for on-site training. For example a YouTube video or augmented reality vignette showing specific steps to specific installation can help trades meet low-carbon building requirements

in a dynamic way. A combination of different media can be very efficient as well, such as a video followed by an in-person course.

Others clearly prefer on-the-job training that focuses on specific technical skills needed for a project and could explain more generally the difference between regular construction and low-carbon buildings, for example by using mock-ups. As low-carbon buildings often require different approaches and skills that cross traditional trade roles, it will be beneficial to train multiple trades at the same time. As trades are often not on-site at the same time, they need to be brought in for a kick-off meeting or be included in the design process from an early state.

There are a variety of different delivery modes, from YouTube videos to augmented reality learning, in-person workshops on-site to using mock-ups of design features to illustrate for example how to assemble a building envelope. On-the-job training courses that are included in a specific project scope could provide an opportunity for course-based training that does not have a negative impact on individual time and monetary constraints. It has also been shown to be successful to start with online training and combine it with in-class hands-on training. This can shorten the amount of time needed for in-class training.

MODES OF DELIVERY

By who?

Through unions, colleges, trade school or third party providers (e.g. CaGBC, CEIT, etc.).

Site supervisors and building officials through on the job training.

How?

Through specific green-building courses.

Through integrating green building into trades' education.

Through on-the-job training, as part of specific projects, in-person, online or audio/video or in a classroom.

When?

Early in a career, through apprenticeship programs or similar training.

Throughout the career through continuing learning (in-course/onsite).

Project specific knowledge (onsite).

Successful education and training programs have been proved to be most successful if they have one or more of the following characteristics[25]:

- Knowledgeable, charismatic trainers with experience in the field.
- Hands-on, peer-to-peer mentoring and training.
- Cross-disciplinary education and training opportunities.
- Online education that is accessible whenever the students can make time for it.
- Short-format instructional videos.
- A focus on the "why" of green approaches in addition to the "what."
- Demonstrate approaches rather than highly technical classroom settings.

[25] CEC 2013.

3.4 RECOMMENDATIONS

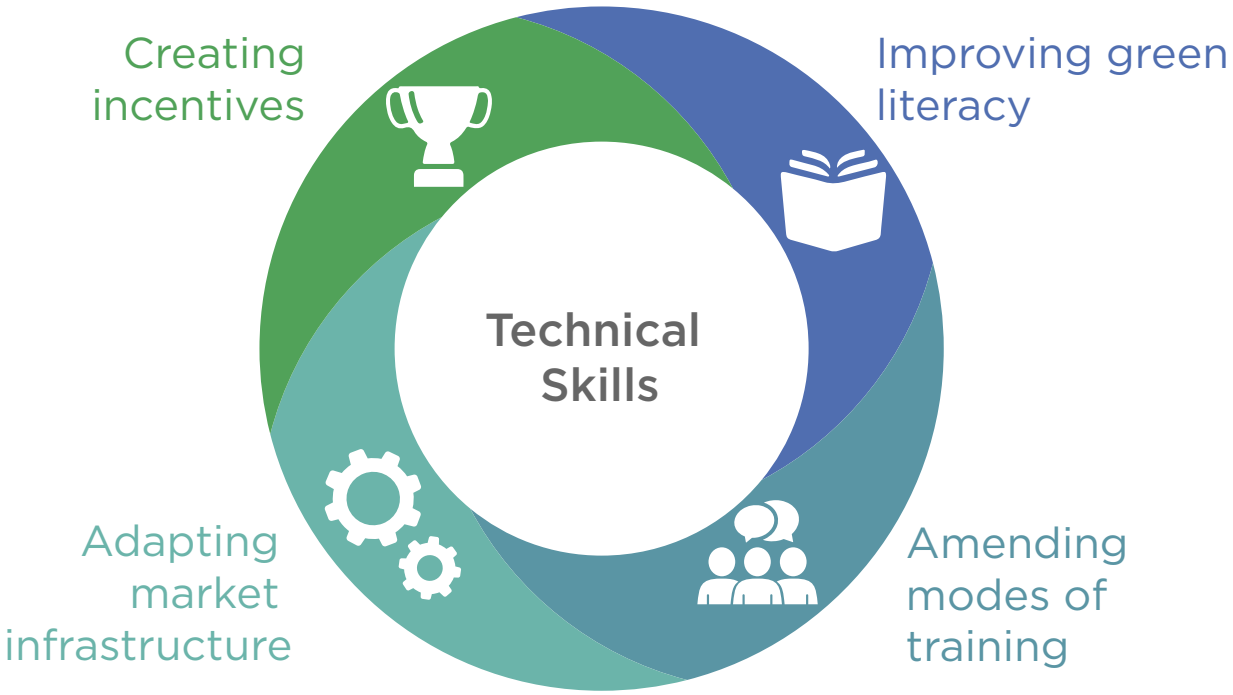
This report put together recommendations that include specific suggestions for disseminating best practices and incentives, along with steps for addressing the gaps and barriers outlined in the previous chapters.

CaGBC identified four barrier busters for our roadmap. In order to have technically well-trained trades, we need to improve green literacy, amend the modes of training, adapt the market infrastructure and create incentives for the trades to seek out training.

Teaching and improving technical skills of the trades will be immensely important, but even technically well-versed trades cannot do it alone. They need the necessary soft skills and a market infrastructure that supports their work. The whole construction ecosystem needs to be trained to achieve a higher level of green literacy if low-carbon buildings are to become the new industry standard.

We put together a list of 19 recommendations that will support developing new pathways to educate skilled tradespeople, amending the existing system and adjusting the process of constructing high-performing buildings.

BARRIER BUSTERS



A Improve green literacy

Foster broad ecological mindset

There is a need to develop a broad ecological mindset and awareness throughout the construction industry. We need to increase the ability to understand the implications of key building activities on the environment and building performance. A greater understanding of sustainability and its objectives informs the way we design and construct high-performing buildings. Without it, the specific requirements of high-performing buildings, such as wall assemblies or thermal breaks in balconies may contradict the standard construction approach that the trades are most familiar executing. Making clear to the tradespeople working on a low carbon project that it is not a business-as-usual assignment can help initiate greater environmental awareness. Any recommendations to increase the skills and capabilities of the trades must include consideration of how to raise the environmental awareness of the trades such that low carbon interventions can be understood in the context of the tradesperson's specific responsibility.

Develop low-carbon training and education

Develop training and education courses and curricula that address the technical skills gaps identified as attributes of low carbon, high performing buildings as well as the soft and green literacy gaps identified in this report. This will include training on how to assemble building envelopes, install low carbon mechanical systems, including heating, cooling, ventilation and air conditioning, as well as maintain energy efficient furnaces, boilers, water heaters, solar panels and geoexchange systems. The curriculum developed will target different trades and should consider how to address the application of systems and products for new construction and retrofits. It will be necessary for creating new course offerings for existing and experienced tradespeople, as well as for the retrofitting of older buildings.
To be able to create new programs and enhance and expand existing training, it will be important to engage key stakeholders such as trade unions, colleges and universities, professional organizations as well as product manufacturers. These organizations can assist with skills development, including continuing education. Collaboration will be needed to create an education system that reaches a maximum number of people.

Train other stakeholders in ecosystem

Our research revealed that in order to achieve high-performing low-carbon buildings, other actors of the construction ecosystem besides the trades must participate. Designers, architects, engineers, builders, building operators and managers need to be trained with low-carbon skills so that the build-up of capacities does not stop with tradespeople (See The Construction Ecosystem on page 15.)

Not all building officials have sufficient knowledge of low-carbon buildings. Education for building officials, including tools and materials to be used when working with the trades, would foster these practices. As the construction industry is hesitant to take the leap on low-carbon buildings, these concerns about additional costs, building performance and tenant well-being can be addressed by improving the skills and knowledge of all industry players.

Building managers also play a particularly important role in achieving high-performing low-carbon buildings. To keep occupants comfortable while keeping cost down, and

often without the necessary knowledge how to operate the increasingly more sophisticated building systems, they are merely reacting to acute problems but are investing not enough time in proactive maintenance and upkeep which might help prevent these problems in the first place. Educating building managers on the most efficient way to operate building management systems will help with the operation of high-performance buildings[26].

Training for other building and construction professions:

Developers and owners.

Engineers, architects, design professionals and consultants.

Building trades and general contractors.

Building officials and building inspectors.

Building operators, managers and occupants.

Coaches, teachers and professors.

B Amend the modes of training

Integrate low carbon skills into the existing design and construction education

Our research shows that knowledge of low-carbon skills needs to be included in all available courses, including the Ontario apprenticeship programs for people entering the construction industry and the Red Seal program and not be merely an appendix to existing training to make low-carbon skill sets part of a new industry standard and a broader, greener mindset. There needs to be more offerings and options for existing trades, ranging from full- and part-time college programs, to seminars, webinars and on-the-job training, and include specific training for retrofits and renovations. Overall, green building practices need to be added to all existing training programs and courses to ensure uptake.

A broad ecological mindset should be brought about through training and education programs, but also in textbooks. Along with broader awareness and a holistic view of green buildings and the house as a system, trades should improve their critical thinking and their communication skills along with their technical abilities.

To expand training and educational opportunities it will be important to embed low-carbon skills in all college-level, apprenticeships programs and continuing education courses provided to construction professionals. For this to be accomplished, collaboration with colleges and unions will be essential. Low-carbon skills should be taught in college or trade schools so that students know how to build responsible long-lasting buildings with as little impact on the environment as possible.

Low-carbon skills need to be integrated as part of regular training curriculum for trades and be provided for continuing education to learn skills while working.

Make continuing education credentials mandatory for trades

Today there is no requirement for compulsory or voluntary trades to invest in ongoing education. Many participants of our survey and in our focus groups suggested that low-carbon skills be included as a mandatory requirement for certification of tradespeople

[26] CEC 2013.

working in the building sector and that continuing education be required for professional development and credential maintenance. Low-carbon buildings rely on a range of design and construction best practices that could be translated into a valuable credential for the trades or made mandatory for obtaining and keeping a license and/or for being able to bid for low-carbon projects. Continuing education requirements would be a important mechanism to stay abreast of the latest technology, materials and approaches necessary to construct or renovate a building to a high performance standard.

Consider increasing the number of compulsory construction apprenticeships

Many trades working for low-carbon projects are highly experienced and often are union members who went through an apprenticeship program. Having undergone this rigorous training, they are highly qualified to take on low-carbon projects. From their point of view, making apprenticeships mandatory would be beneficial for quality of the industry as a whole and would improve the reputation of the trades. As of today, only 23 trades have compulsory apprenticeships, and very few of the central construction trades are included (electricians, plumbers). The trades that do undergo apprenticeship programs are on average very well equipped to tackle the new skills necessary for high-performing building projects. In our survey and interviews, many industry members suggested that it would be beneficial to the market and the quality of the work done if more trades had to go through apprenticeship training, starting with carpenters who are not licensed in Ontario.

Leverage existing education infrastructure

To be able to create new programs and enhance and expand existing training, it will be important to engage key stakeholders such as professional organizations, trade unions, colleges and universities, as well as product manufacturers. These organizations can assist with skills development, including continuing education. Collaboration will be needed to create an education system that reaches a maximum number of people. Product manufacturers need to take responsibility for the operations of their products. This will help improve the image of the trades' profession and make it easier to attract young people.

Train multiple trades through cross-disciplinary content

As skills requirements are often not specific to particular tradespeople but instead crossover among numerous traditional trade roles, there will be a need to develop cross-disciplinary education curricula and train multiple trades together at the same time. As trades are often not on-site at the same time, they might need to be brought in for a kick-off meeting that can include a training session with mock-ups of buildings elements and be included in the design process from an early state. It might also be necessary to put a clause in their contract that requires them to attend on-site or in-class training.

Support a diversity of media and formats

People have different learning styles and abilities to access learning opportunities. For that reason, it is important to offer training opportunities in a range of formats, from extended, in-person sessions to short online videos or articles. Experiential learning that combines theory with hands-on, real-world examples is particularly valuable with the emergent body of knowledge on green buildings. This also means to offer education at all levels, from a short seminar, online, college or diploma. Trade organizations and

unions should take a proactive role. Programs where graduates have dual certifications have potential for cross-disciplinary knowledge. Developing on-the-job training courses to increase skills and understanding of the project is also advisable. There are a variety of different delivery modes, from YouTube videos to augmented reality learning, in-person workshops on-site to using mock-ups of design features to illustrate for example how to assemble a building envelope. A combination of on-site and in-class training can shorten the time spend in class. On-site training gives also the opportunity to train multiple trades at the same time as many areas require the cooperation of several trades. Many tasks also cross traditional trades' roles.

Train the trainer: create a peer-network for trainers, professors and coaches

In addition, a network of educators and trainers would be helpful to teach each other about how to make their offerings include low-carbon technologies and a more holistic approach to construction and share those new capabilities with other teachers and trainers. This peer collaboration should enhance soft and technical skills. Top trainers will likely have to be paid for their time, at least initially[27]. The demand for training tends to be highly connected with building code updates so that it is difficult for teachers or educational institutions to develop and sustain their courses, programs and teaching staff. Mandatory training credits for maintaining licensing for the trades may ease this issue and stabilize the historically cyclical demand for trainers.

Embrace digitalization and new technologies

The nature of many trades is changing as digitalization of their work increases. Interestingly, our research reveals that this makes it, in some cases, easier to attract young people to the profession who would previously not have considered a career in construction. The younger generation of tradespeople also seems to have greater 'green' awareness than older workers, as younger people have grown up with an understanding of the need to improve the environment. However, the capability to deal with new technologies and the willingness to continue learning is something that is a soft as well as a technical skill. The growing digitization of construction presents a great opportunity to attract young people as they are attracted to technological advances.

C Adapt the market infrastructure

Support a holistic view and work with an integrated design approach

The conventional construction process institutionalizes a separation of functions that work against delivering projects that perform in line with design aspirations. An alternative design-build-operate model that includes tradespeople from a very early design stage will strengthen the connection between intentions and actual performance and educate both the trades and designers on a truly integrated new-building delivery process[28]. Not only the trades need to learn how to effectively participate in this process. Experience with our partners confirms that well-informed, integrated teams are essential for and more successful in delivering projects that perform well and meet set goals in line with their design aspirations, as they can better identify technologies and know how to ensure that commissioning and hand-off are implemented well. Low-carbon buildings are holistic in nature and therefore touch all aspect of construction. Facilitation, collaboration and integrative design process management, where components are part of a holistic system, are essential for designers

[27] CEC 2013.
[28] CEC 2013.

and builders. Integrating the trades into the design process - for example using the design assist approach – can help to overcome this challenge.

Tradespeople are rarely part of design meetings, although experience from low-carbon buildings reveals that they generally work well within that context and contribute to the success of projects. Integrated design and an integrated process - as required for the LEED® certification and suggested for the Zero Carbon Building Standard – necessitates deeper knowledge for tradespeople to ensure that a project's performance goals are not compromised. Trades need to understand those goals. To be able to do this they need to be integrated into the project at an early stage, preferably in the design stage of the project. This gives also the opportunity to bring in multiple trades at the same time to gather their feedback on the project. It can also be used as a training opportunity for the trades and the entire design team, for example by using mock-ups of certain design elements to demonstrate certain important elements of a high-performing building. This would also give them the chance to apply their experience related to how materials or systems are installed to propose better ways of designing and building the systems for which they are responsible. High-performing buildings typically require more collaboration, coordination and communications among different tradespeople. Many in the trades would benefit from project management and facilitation training. A project team would also benefit from training in how to leverage the advantages of an integrated design process and put a good team in place that can work collaboratively[29].

Improve communication and collaboration on-site and during construction

Many of the issues that are currently being faced in green building projects can be solved with better communication. Everyone from designers to management to building operators should communicate at the outset so that a project, its requirements, and the thinking behind decisions are well understood by the whole project team including the trades. This could be done in kick-off meetings or with the help of video.

Green building systems interact with one another at a significantly higher level than traditional buildings and building systems. At the same time, people involved in the building sector will need to communicate to ensure effective building systems. Trades need to learn what questions to ask when they are on a job site and have a general understanding of the things that they will need to succeed in a green building project.

Many areas of construction require collaboration between different trades. The knowledge of how one's work intersects with and supports the work of others is essential to successful outcomes. Often, multiple disciplines are required to work together to ensure success, such as in the case of eliminating thermal bridging at balconies. It can also be a simple collaboration, such as ensuring that plumbers and electricians understand the problems that inadvertent air and moisture barrier penetrations can cause[30].

Change bidding and hiring processes and contract agreements

Getting the right team together and having them talking early on is vital for successful low-carbon building projects. The conventional design-bid-build delivery model institutionalizes a separation of functions. This works against delivering projects that perform in line with their design aspirations; and suggests that an alternative design-build-operate model be leveraged that includes tradespeople from a

[29] CEC 2013.
[30] CEC 2013.

very early stage and strengthens the connection between intentions and actual performance.

Survey participants suggested adapting the bidding process and amending contract agreements in a way that requires the trades to either demonstrate experience with low-carbon buildings or to attend on-the-job training for the skills needed to execute their tasks. Construction bidding is the process of submitting a proposal (tender) to undertake or manage the undertaking of a construction project. The process starts with a cost estimate from blueprints and materials. If the bid is accepted, a legally enforceable contract is created. Even today, bids are often not chosen on cost alone. The content of the bid or offer can include 'green' requirements for tradespeople, such as a requirement for low-carbon skills, a certain certification or the willingness for low-carbon training before or during a project.

THE CLAYTON COMMUNITY CENTRE IN SURREY, BRITISH COLUMBIA

The City of Surrey is developing a new community hub in the Clayton neighbourhood in partnership with HCMA Architecture + Design. Completion is estimated for summer 2020. The developer had set a goal for achieving Passive House certification. A requirement was included in the contracts that tradespeople attend a five day Passive House Tradesperson Course with the British Columbia Institute for Training (BCIT) - a college that offers training for the trades. In addition, the new facility will be designed to meet high-performance energy standards that concentrates on a fabric first approach to buildings[31].

Allow more time for complex projects

The way low-carbon construction projects are designed and planned does not typically allow for the precision and sophistication needed of low-carbon buildings as not enough time is allowed for each task and the collaboration needed for successful implementation of the interacting elements of a low-carbon building. These projects tend to be more complex and time consuming than regular ones, especially if the members of the project team and the trades on-site do not have sufficient experience in constructing high-performing buildings. For this reason, it is essential to build in time buffers within the construction process so that tradespeople can complete their work in an efficient manner, without having to rush and be prone to forego some of the precision necessary for the project. Mechanical, electrical and building automation trades tend to be the last ones on construction projects. If the budget and available time have already been used up, they often feel pressured to complete their scope of work within a compressed timeframe. There are various ways to address this challenge by integrating the trades early on in the design and construction process, as well as with the increased experience of builders.

Create a quality assurance and quality control process

In addition to having an integrated design process for low-carbon buildings, it might be necessary to provide ongoing supervision and monitoring on-site, especially when dealing with less experienced trades who might not be as aware that departing from blueprints could have severe consequences. Quality assurance monitors construction processes, whereas quality control ensures that an end

[31] A 'fabric first' approach to building design targets mainly the energy-efficiency aspect of a building. It involves maximising the performance of the components and materials that make up the building fabric itself, before considering the use of mechanical or electrical building services systems. This can help reduce capital and operational costs, improve energy efficiency and reduce carbon emissions. A fabric first method can also reduce the need for maintenance during the building's life.

product has been installed or built correctly. The two mechanisms are closely linked.

Quality assurance throughout a construction process is implemented to make sure that the final result will pass a quality control test and deliver desired results. Both give the opportunity for foremen and building officials for a continuous feedback loop and ad-hoc training opportunities on-site with the trades they work with.

Quality assurance practices help to ensure that the end result of a project is consistent with design and implementation, avoiding delays and ensuring that certain methods are followed to make sure that a low-carbon building will perform as intended.

D Identify and create incentives

Leverage government funds to subsidize training and lower the cost barriers for trades to participate

To accelerate uptake of any of these offerings requires offering the right incentives to convince tradespeople and their employers to expand their training and include green building skills. Those who are already in the workforce are limited by time and financial constraints. Learning new skills and developing more advanced knowledge needs to be incentivised to educate the older generation of workers. Winning projects is not dependent on an understanding of green building skills, and many in the industry often do not have the time to work on increasing their skills base. It has been proven very successful to subsidize training courses to lower cost barriers for trades to participate. There are several other options for incentives. Including green building skills could be a requirement for building proposal requests and/or be included in contract agreements. It could also mean to add a premium to wages for having low-carbon skills. Another possibility would be to make low-carbon skills a mandatory requirement for certification of tradespeople working in the building sector and also as requirement for professional development and credential maintenance or license renewal.

Develop a certificate for low-carbon skills.

Developing a low-carbon certification or specialization would help project developers identify and secure skilled trades for their projects. Although the construction industry should strive to embed low-carbon skills as part of all curricula and course offerings, additional “green” programs can help the labour market transition to a low-carbon economy. These specialty programs or add-on courses will help to develop capacity and knowledge on the part of teachers and students and lead to a separate certification for low-carbon skills. This low-carbon accreditation for tradespeople could enable more contractors to bid for green building projects even without previous hands-on experience on a low-carbon building and facilitate finding a job. A separate low-carbon certificate for apprenticeships could also be designed. This could assist in growing the workforce capable of achieving the best outcome for this growing segment of the industry.

E Further research into training programs and opportunities

Further research will be necessary to undertake a detailed gap analysis of current college and union curricula and courses offered in continuing education by the various training delivery agents in part-time certification programs, professional development and continuing education

workshops and seminars, college courses, diploma and degree programs, and university degree programs. A detailed skills gap analysis would also be beneficial for the apprenticeship programs administered in Ontario.

This research focuses on skilled trades, but there are significant gaps remaining for the rest of the construction ecosystem that need to be analysed in more detail.

More research also needs to be done on the residential building sector and residential building retrofits, especially for low-rise single-family homes that involve a less unionized workforce than the projects used in this research report.

4 CONCLUSIONS AND FUTURE OPPORTUNITIES

This report encourages Ontario to take on a national and international leadership role by supporting its workforce to the skills and capabilities needed to create the energy-efficient, high-performing buildings of the future.

A starting point is directing more attention to updating the knowledge of the skilled trades. However, this report has shown that the whole construction ecosystem workforce needs support in transitioning their skills to the jobs of the future. Nearly 300.000 Canadians, more than half of them in Ontario, are already employed in the sector with 80.000 new recruits needed by 2026 to sustain the sector. To meet the economic challenges of the future, efforts need to be made to train the workforce and enable them to adapt to the coming changes in Ontario's economy. Other jurisdictions, like Ireland or New York City in the US are moving ahead fast. To make sure that Ontario continuous to be a leader within Canada and globally, the skills gap for high performing buildings needs to be addressed that will transform and boost Ontario's construction industry but also prevent a shortage of skilled labour in the future.

Ontario needs to show that it is committed to strengthen its economy and labour force. This report reveals several opportunities to close the skills gap for tradespeople working on energy-efficient, high-performing buildings, and accelerate the uptake of education and training offerings. However, not only the adaption of training and education programs needs to be considered. The whole process of constructing a building, beginning with the bid process, contract agreements and the design process itself need to be taken into account to get the construction of low-carbon buildings up to scale.

With this we hope to have created an educational roadmap for Ontario's labour force, government, educational institutions and industry to use going forward in order to drive low-carbon skills development. The green future and existing building infrastructure will add to the provinces efforts for a strong economy. Meeting the objectives of a high-performing building sector requires investing in the availability of the workforce that plans, constructs, and maintains it.

To tackle the challenges of the future and the changes that will come to Ontario's economy and workforce by climate change, Ontario needs to be ready to support its workforce to be prepared for the jobs of the future.

CASE STUDY

Photo credit: evolv1

Cora Group's evolv1 office building (Waterloo)

Location
Waterloo, ON
Year of Completion
2018
Consultant Team
The Cora Group
Construction Manager
Stantec
Gross Area
100,000 s.f.
Building Use
Offices
Certification
CaGBC Zero Carbon Building Standard, LEED Platinum
Energy Targets
Net Positive Energy

evolv1 is a modern, 110,000 square foot urban office space designed for today's millennial tech-savvy workforce. Located on the doorstep of Ion Light Rail Transit and showcasing an array of amenities and creative collision spaces, evolv1 offers a perfect light-filled new home for today's growing tech or professional services company.

Imagined in partnership with Sustainable Waterloo Region, evolv1 is constructed in accordance with LEED Platinum principles and is the first multi-tenant building of its kind in Canada established with a goal to achieve a net positive energy output. The building features a living wall, EV charging stations, and smart LED lighting. Evolv1 is located next to public transit amenities, parks and walking trails, and includes bicycle racks and on-site showers – both to promote the use of public transit.

http://www.coragroup.com/project/evolv1/.

APPENDICES

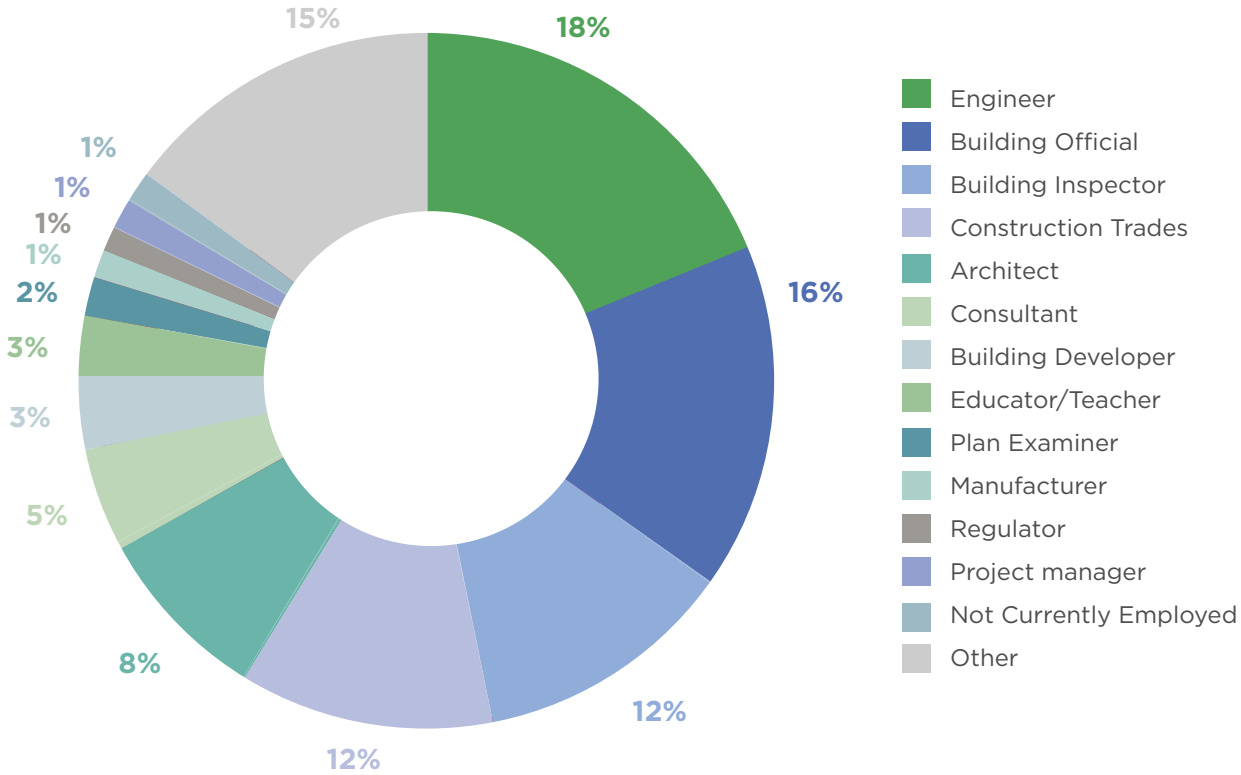
APPENDIX A: METHODOLOGY

This research provides a qualitative assessment of low-carbon skills training shortages in the building sector in Ontario. Providing the skilled trades' labour force with the skills necessary for designing, constructing, and maintaining low-carbon building infrastructure is critical to achieving a greener economy and reducing greenhouse gas emissions.

2.3.1 Industry survey

The survey was conducted in June and July 2018 in both English and French and closed with 215 participants in English and two in French (see *Appendix B*). We provided the possibility for comments and open questions throughout the survey to capture a large variety of insights. Respondents included 18% engineers, 8% architects, 16% buildings officials, 12% building inspectors and 12% trades plus a range of others professions. Of the trades, there were 45% carpenters, 13% electricians and 9% welders. A total of 57% of participants had more than 15 years of experience. The survey consisted of multiple choice and open ended questions, as well as the opportunity to add comments.

Which of the following best describes your current profession?



2.3.2 Focus groups and individual interviews of four low-carbon building projects

CaGBC partnered with Mohawk College's Joyce Centre for Partnership & Innovation, Cora Group's evolv1 urban office building – both pilot projects of CaGBC's Zero Carbon Building Standard. mcCallumSather's heritage retrofit of the Westinghouse Building in downtown Hamilton, Ontario, and City of Toronto and Toronto Atmospheric Fund's social housing retrofit project were also engaged to get their firsthand insights into green building skills requirements. For this project, individual, small group, and large group interviews were conducted between July and October 2018. The individual and small group interviews were one hour long and were conducted over the telephone. The large group was conducted in-person using a focus group approach.

To leverage direct experience and learnings of project teams working on low-carbon buildings, four low-carbon building projects were chosen for focus group workshops and individual interviews. The interviewees consisted of tradespeople, architects, project managers and site managers, among others involved in the development of the projects. The half-day focus group session with individuals involved with one of the projects took place in July and informed the other three project interviews. The updated discussion guide (see *Appendix C*), informed by the results of the industry survey as well as the first focus group was used for the one-hour interview sessions with individuals involved in the other three projects (for detailed project information see *2.4 Challenges and gaps in the current offerings*).

The first part of each interview focused on identifying gaps in green building construction knowledge and skills. The second part was aimed at thinking through potential solutions that could improve the training and education programs and curricula of low-carbon building skills. The variety of expertise of interviewees and focus group participants provided the opportunity for varied perspectives based on different experiences.

2.3.3 Literature review

The literature review examined a variety of sources, including research reports from government agencies, summaries of conferences or lectures, and peer-reviewed academic research papers in North America, Australia, and Europe including the United Kingdom. The reports that were reviewed included skills analyses for low-carbon buildings. Other reports focused on strategies to achieve low-carbon building solutions. A number of papers focused on educators or policy makers and identified educational opportunities for vocational training and strategies to address low-carbon building needs. Papers and reports that were reviewed included findings, recommendations, skills gaps and proposed educational solutions that are consistent with the conclusions of this study. In those reports, reference to construction trades often included the building of infrastructure projects along with buildings, as well as skill sets of construction professionals, clients and communities.

APPENDIX B: INDUSTRY SURVEY

SURVEY OF TRADESPEOPLE: HELP US BUILD THE WORKFORCE OF THE FUTURE IN ONTARIO

In order to support the green building industry and position the sector for future economic opportunities, the CaGBC has secured funding from the Ministry of Advanced Education and Skills Development (MAESD) to identify gaps in the knowledge and skills of Ontario`s trades workforce, as it relates to their involvement in constructing energy-efficient buildings. The information gathered will be used to outline specific training needed to ensure tradespeople have the knowledge and skills needed to be successful. The roadmap developed as a result of this survey will also be made publicly available.

We invite all trades working in the construction/building industry, and other building professionals who are working with the trades, to provide us with insights by taking part in this short survey. Please feel free to forward this to relevant contacts as well.

The survey will take approximately 10 minutes and must be completed by July 22, 2018. All responses will remain confidential and will only be used in aggregate form to identify common themes and recommendations.

INTRODUCTION

You are invited to participate in our ***Survey on the Trades: Help us build the workforce of the future in Ontario***. This survey will take approximately 10 minutes to complete. All responses will remain confidential and will only be used in aggregate form.

Survey Purpose: This survey aims to identify gaps in the knowledge and skills of the Ontario construction trades workforce as it relates to their involvement in constructing energy efficient and low/zero carbon buildings.

- If you are a construction trades-person, please consider the skills and knowledge that you and your fellow tradespeople may need to better enable you to work on energy efficient projects.
- If you are not a tradesperson, please consider your experiences working with construction tradespeople on previous projects, and the skills and knowledge you feel they need in order to be successful in working on energy efficient projects.

Please click “next” to continue.

Section A: General Information

1. Which of the following best describes your current profession?

a. Engineer
b. Architect
c. Building Developer
d. Construction trades
e. Not currently employed
f. Other (please specify)

2. (If trades) Please select the construction trade in which you are currently employed: (drop down menu)

a. Boilermaker
b. Bricklayer
c. Carpenter
d. Concrete Finisher
e. Construction Craft Worker
f. Electrician
g. Drywall Finisher and Plasterer
h. Gas Fitter
i. Heavy Equipment Operator
j. Instrument and Control Technician
k. Insulator
l. Ironworker
m. Lather
n. Machinist
o. Mechanic
p. Metal Fabricator
q. Millwright
r. Mobile Crane Operator
s. Painter
t. Plumber
u. Refrigeration and Air Conditioning Mechanic
v. Roofer
w. Sheet Metal Worker
x. Steamfitter/Pipefitter
y. Tilesetter
z. Tower Crane Operator
aa. Welder
bb. Other (please specify)

3. Where in Ontario do you work most often?

a. Northern Ontario (e.g. North Bay or further north)
b. Central Ontario (e.g. Muskoka, Haliburton, etc.)
c. Eastern Ontario
d. Greater Toronto Area
e. Southwestern Ontario
f. Other (please specify)

4. How many years of experience do you have working in a construction or trades related field?

a. Less than 1 year
b. 1 to 3 years
c. 4 to 6 years
d. 7 to 9 years
e. 10 to 12 years
f. 13 to 15 years
g. More than 15 years

5. Have you ever worked on a green building construction project (e.g. Leadership in Energy and Environmental Design (LEED) certification, Zero Carbon Building (ZCB) Standard, or other green building industry standards)?

a. Yes
b. No
c. Not sure

6. How many green building construction projects have you been a part of?

a. 1 to 3
b. 4 to 6
c. 7 to 9
d. 10 or more

7. How large are the buildings that you have worked on for green building construction projects? (select all that apply)

a. 49,999 sq. feet or less
b. 50,000 to 99,999 sq. feet
c. 100,000 to 149,999 sq. feet
d. 150,000 to 199,999 sq. feet
e. 200,000 to 249,999 sq. feet
f. 250,000 sq. feet or more

8. What types of buildings have you worked on for green building construction projects? (select all that apply)

a. Commercial buildings (e.g. office buildings, warehouses, retail buildings, etc.)
b. Institutional (e.g. government)
c. Academic (e.g. schools)
d. Healthcare (e.g. hospitals, nursing homes)
e. Low-rise residential
f. Multi-unit residential

9. Please identify the green building standards pursued on green building construction projects that you have worked on: (select all that apply)

a. Leadership in Energy and Environmental Design (LEED)
b. Zero Carbon Building (ZCB) Standard
c. BOMA Best
d. Living Building Challenge
e. Passive House
f. Toronto Green Standard
g. Other; please specify
h. Don't know

Section B: Green Building Construction Knowledge and Skills

For this section, consider the following questions from the perspective of your experience working with others on green building projects in Ontario, with a focus on energy and carbon emissions.

10. Please indicate how important you believe each of the following areas are for developing the necessary skills and knowledge for those working on green building construction projects:

	Very Important	Important	Somewhat Important	Not at all important
Broad awareness of climate change				
Knowledge of general building science principles (e.g. the building as a system, inter-connective elements, etc.)				
Knowledge of how your work connects with the work of other trades				
Overall understanding of green building construction strategies (e.g. water efficiency, energy efficiency, indoor environmental quality, etc.)				
Understanding of the environmental impact of green-house gas emissions				

11. Based on your experiences working on green building construction projects, please indicate how competent you believe tradespeople are with each of the following technical skills:

	Very Competent	Competent	Somewhat Competent	Not at All Competent	Don't Know
Installation of building envelope					
Building envelope, prevention of air leakages and moisture management.					
Embodied carbon (e.g. energy use for manufacturing and installing products, etc.)					
Integrated design and construction					
Installation of renewable energy systems					
Other (please specify):					

12. (If "somewhat competent" or "not at all competent" for any of the above) Please provide specific details about why you are not satisfied with the technical skills displayed by some tradespeople that you have worked with on green building construction projects:

13. Based on your experience working on green building construction projects in Ontario, please indicate how important you believe each of the following areas are for developing future trades' skills and competencies for the construction of high-performance buildings:

	Very Important	Important	Somewhat Important	Not at all Important	Don't Know
Building Envelope Commissioning					
Mechanical Systems Commissioning					
Building Performance and Verification					
Energy Modelling					
Building Science (envelope air tightness)					
Solar Renewable Energy Systems Installation					
Geothermal Renewable Energy Systems Installation					
Building Automation Systems					
Low-Carbon/ GHG Emissions Materials					
Integrated High-Performance Building Systems' Installation					
Energy Storage					
Other (please specify):					

14. What are some of the other specific technical challenges related to the trades that you have experienced while working with tradespeople on green building construction projects?

15. Please indicate how competent you believe that tradespeople are with the following project management skills:

	Very Competent	Competent	Somewhat Competent	Not at All Competent	Don't Know
Communication					
Problem-Solving					
Teamwork/ coordination with other trades					
Time Management					

16. (If "somewhat competent" or "not at all competent") Please provide specific details about why you are not satisfied with the project management skills displayed by some of the tradespeople you have worked with:

Section C: Education

17. Overall, how satisfied are you with the current education and training for trades in Ontario related to building green construction projects?

a. Very Satisfied
b. Satisfied
c. Dissatisfied
d. Very Dissatisfied

18. (If Dissatisfied or Very Dissatisfied) Please provide specific details about why you are not satisfied with the current state of green building construction skills' education and training in Ontario:

19. What type of educational programs are best suited to provide tradespeople with the knowledge and skills necessary for green building construction in Ontario? Please select three:

a. Part-time certificate programs
b. Professional development workshops/seminars
c. Job shadowing
d. College certificate programs
e. College diploma programs
f. College degree programs
g. Apprenticeship programs
h. University degree programs
i. Other (please specify):

20. What are the effective modes of delivery for providing formal or informal education for the trades that addresses the knowledge and skills gaps that are currently present? Please select three:

a. Online courses
b. In-person courses
c. Education on the job-site
d. Integration of operations' trades into early design meetings
e. Integration of trades into buildings-design phase
f. Physical job aids or instructional guides (e.g. paper-based checklists, etc.)
g. Electronic resources (e.g. online resources centre, electronic version of building codes, etc.)
h. Online community of interest (e.g. individuals ask questions and/or provide guidance to others)
i. Other (please specify):

21. Please provide any additional comments or concerns you have about the current capacity and roles of the trades sector in green building construction in Ontario

Section D: Optional – Additional Demographic Questions

22. What is your age?

a. 18-25 years old
b. 26-35 years old
c. 36-45 years old
d. 46-55 years old
e. 56-65 years old
f. 66 + years old

23. Do you consider yourself to be an Indigenous person? "Indigenous person" includes members of First Nations, Inuit, or Métis peoples.

a. Yes
b. No

24. You identify your gender as:

a. Female
b. Male
c. Other

Thank you for completing the survey. To be entered into the prize draw for a chance to win 1 of 2 Mountain Equipment Co-op (MEC) gift cards, please provide your name and email below. Your personal information is being collected strictly for the purpose of awarding the survey prizes.

First Name:

Last Name:

Email address:

APPENDIX C: DISCUSSION GUIDE FOCUS GROUP AND INDIVIDUAL INTERVIEWS

Zero Carbon Buildings: An Education Roadmap for the Trades in Ontario

Low-carbon Building Trade Skills Gaps Research

Project Stakeholder Interview

September 2018

Overview

To support the green building industry and position the sector for future economic opportunities, the Canada Green Building Council (CaGBC) is undertaking a study to determine the skills gaps and training needs for the trades in the construction of energy efficient, low/zero carbon buildings. We are seeking to determine solutions to these gaps from partners with hands-on experience in working on low-carbon construction projects.

According to Skills Canada, 40% of the jobs which will be created in Canada over the coming decade will be skilled trades' positions. In construction alone, it is expected that over the next decade there will be over 85,000 retirements and a need for 80,000 new recruits by 2026 to sustain the sector. The impact of the skills gap in Ontario is estimated at $24.3 billion GDP in foregone company revenues, with an additional $3.7 billion lost in foregone taxation. While these messages are stark, they also signal an opportunity to transition Ontario's skilled trades to the jobs of the future – the construction of energy-efficient, low/zero carbon buildings. We have partnered with Mohawk College, mcCallumSather, The Cora Group and the City of Toronto who have all constructed or renovated buildings to be energy-efficient and low-carbon. As one or our partners, we are looking forward to gathering your insight and perspective from your direct experience on these projects.

Structure of Interview Discussions

StrategyCorp is requesting a one-hour session with individuals involved in the xx project to be held via teleconference. Participants in the interview should be representative of key owner, general contractor, and skilled tradespeople involved in the development of the xx project. The interview will be facilitated by Chris Loreto, Principal, StrategyCorp, with support from Lexi Ensor, Associate, StrategyCorp.

The goal of the first part of the discussion will be to identify gaps in green building construction knowledge and skills. 'Green Building' refers to energy-efficient or low/zero-carbon buildings. The second part will be to think through potential solutions that could be proposed or implemented to improve the training and education programs and curricula for low-carbon building skills to build up workforce knowledge and capabilities required to meet the demand for the construction of low-carbon buildings.

StrategyCorp, on behalf of CaGBC, will be conducting four interviews in total for the education roadmap. CaGBC will review and synthesize the information gathered from each of these focus groups to inform the findings and recommendations of a final report on the education roadmap for low-carbon building skills.

The Canada Green Building Council

The CaGBC is a not-for-profit, national organization that has been working since 2002 to advance green building and sustainable community development practices in Canada. The CaGBC is the license holder for the LEED green building rating system in Canada and supports the WELL Building Standard and GRESB (Global Real Estate Sustainability Benchmark) in Canada. CaGBC's Zero Carbon Building Standard is Canada's first green building program to make carbon emissions the key indicator for building performance.

Acting as the voice of the green building industry, the CaGBC advocates for green building policies with all levels of government and the private sector across Canada. The Council has also educated over 45,000 green professionals to answer the demand for knowledge and jobs this new green marketplace created. Because of this advocacy, education, and the hard work of its members, thousands of commercial and government buildings, schools, homes, community centres and historical structures have been retrofitted or newly constructed to green building standards.

StrategyCorp has been retained by the CaGBC to assist with industry focus groups to support the development of low-carbon education roadmap for the skilled trades in Ontario.

Before We Begin

To ensure that we can get as much value out of these focus groups as possible, we ask that you please complete the below questions and return to Lexi Ensor at StrategyCorp ahead of the focus group.

General Introduction

1. What was your role or job, on the project?
2. What prior experience did you have in working on a low-carbon building project?
3. Which green building standards were pursued on green building construction projects that you have worked on?

Contact Information

Individuals who participate in the focus groups may send any additional comments and advice that may not have been raised in the focus group session via email to Strategycorp.

Focus Group Discussion Questions

1. **Please describe the low-carbon building project that you worked on. Was it a new build or a retrofit project?**

Part I: Current State and Skills Gaps

2. **What are some of the general challenges that you have experienced while working with tradespeople on low-carbon building construction projects?**
   - Carpenters
   - Electricians
   - Plumbers
   - Refrigeration and Air Conditioning Mechanics
   - Instrument and Control Technicians
   - Others

3. **What is your sense of the technical understanding that is missing for tradespeople (i.e., those listed above or others) working on low-carbon building projects?**

4. **What are some of the specific technical challenges that you have experienced while working with tradespeople (i.e., those listed above or others) on low-carbon building construction projects?**

5. **Are there other professionals with whom you have, or are, experiencing challenges (e.g., building officials, operators, etc.)?**

6. **How important are the skills listed below for low-carbon building? What is the gap between current skills in these areas and the required future skills in these areas?**
   - Building envelope commissioning
   - Building performance and verification
   - Energy modelling
   - Building science (general, envelope air tightness)
   - Solar renewable energy systems installation
   - Building automation systems
   - Low-carbon/ GHG emissions materials
   - Integrated high-performance building systems installation

7. **How important are other "soft skills" in low-carbon building projects? (e.g., project management, communication, problem solving, ecological awareness, etc.)**

Part II: Curing Skills Gaps

8. **What knowledge should tradespeople have from the moment they go on-site that is specific to low-carbon buildings? (e.g., green building construction strategies and trades interconnections, systems understanding, ecological awareness, etc.)**

9. **Who delivers green building/low-carbon building training and in what areas (i.e., formal program offerings versus continuing education)? What skills are being developed and taught well?**

10. **Understanding the desired knowledge (from question 8) and who currently delivers what training (from question 9), how should skilled trades training, education programming, and requirements be strengthened or enhanced in terms of courses, full programs, and on-site education/facilitation?**
    - (Please be specific in terms of the skills and knowledge that need to be included and what type of programming – diploma, certificate, apprenticeship, job shadowing – would be most effective to meet project needs).

11. **What should delivery of low-carbon building training and education courses and programs for the skilled trades (both new entrants and experienced tradespeople) look like in the future?**
    - What organizations are best positioned to deliver this training and education? Why?
    - How should it be delivered? (e.g., in-person, online, hybrid, other)

12. **What should on-the-job site training look like and how is it best be delivered, and by whom, when, and for how long? Do you have any specific recommendations related to specific trades?**
    - Carpenters
    - Electricians
    - Plumbers
    - Refrigeration and Air Conditioning Mechanics
    - Instrument and Control Technicians
    - Others

Part III: Other (Yes or No Questions)

13. **Should on-the-job site training be made a mandatory feature of bidding processes for low-carbon building project? (Y/N)**

14. **Should bidding processes be adapted so that trades that have individuals with a zero carbon certification / training in zero carbon have a competitive advantage – even if they are not the one with the lowest price? (Y/N)**

15. **For apprenticeship programs, should low/zero carbon training be made a mandatory component of training? (Y/N)**

APPENDIX D: PROJECT PARTNER

The project employed partners' technical expertise in low/zero carbon standards and leverage stakeholder networks to maximize uptake and dissemination of the final roadmap.

CaGBC is an Ottawa-based, national organization governed by a board of directors and led by a professional senior management team. CaGBC is Canada's foremost market transformation advocate and certification organization for greening the built environment. CaGBC is also Canada's foremost certification organization for greening the built environment. CaGBC is the exclusive Canadian license holder for the LEED green building rating system, and in mid-2017, launched the Zero Carbon Building Standard making carbon reductions a key indicator for building performance assessment. Through its Zero Carbon Building Pilot Program, CaGBC is uniquely positioned to explore low-carbon skills training shortages, with unparalleled access to real-world examples of low-carbon building projects, including seven pilot projects in Ontario. Understanding that as collaboration in green building advances, so too do the complexity of standards and best practices, the pilot program aims to address the increasing need to integrate skills training, project management, and certification standards.

CaGBC is the Canadian exclusive licence holder for the GPRO: Green Professional Building Skills Training program, a comprehensive training and certificate program teaching the principles of sustainability and trade-specific green construction knowledge to people who build, renovate and maintain buildings.

Accelerating the zero carbon building market is a priority for CaGBC. Its broader mandate focuses on reducing environmental impacts from the built environment through green building project certification, advocacy and research. It used its in-house technical expertise to lead research efforts, supported in its trades-specific research by the firsthand experiences of Mohawk College, mcCallumSather and the Cora Group. All three partners are leading the development of low-carbon buildings in Ontario (two of which are part of CaGBC's Zero Carbon Pilot Program). They include Mohawk College's Joyce Centre for Partnership & Innovation mcCallumSather's zero carbon heritage retrofit of the Westinghouse building in Hamilton, and The Cora Group's Evolv1 office building in Waterloo. These partners provided firsthand research insight and facilitated access to the architects and tradespeople involved in their projects. OBOA, as a key player in the development and delivery of building code technical training in Ontario, lend its expertise in professional development for building officials, builders, and other Building Code users to inform the research and roadmap.

The green building industry has demonstrated its commitment to a low-carbon future through its involvement in the development of CaGBC's Zero Carbon Building Standard. The consultation process for the Standard engaged 40 organizations in the building sector, supported by a collaborative Working Group of government bodies, industry members, and academia. This research project furthered these collaborative efforts, and also leveraged in-kind supports from the following Ontario-based supporters to inform the research and roadmap, and to disseminate it:

- EllisDon: Providing access to on-site tradespeople and site supervisors working at Mohawk College's new zero carbon building, the Joyce Centre for Partnership & Innovation.
- Toronto and Region Conservation Authority: Leveraging the research and roadmap as part of the upcoming zero carbon construction of its new corporate headquarters, and disseminating the information among its network.
- The Atmospheric Fund (TAF): Acting as subject matter experts to help refine the research methodology and scope, and support dissemination and implementation of the final roadmap.
- Oxford Properties: Leveraging the findings to inform and improve upcoming construction of its 30 Bay Street zero carbon office tower project, and disseminating the information among its network.

Throughout the project, an advisory council consisting of interested parties (partners and supporters) guided the direction of research, informed findings, and disseminated results within the networks of interested parties.

Working Group Participants

- Akua Schatz and Dr. Susanne Ruhle, CaGBC
- Rebecca Beatty, Professor, Building and Construction Sciences, Mohawk College
- Tony Cupido, Chief Building and Facilities Officer, Mohawk College
- Marco Iacampo, Program Manager Environment, City of Toronto
- Joanne McCallum, Co-founder and Director, mcCallumSather
- Adrian Conrad, Chief Operating Officer, Cora Group

Advisory Group Participants

- Akua Schatz, Alana Anderson, Mark Hutchinson, Jennifer Cossette, Dr. Susanne Ruhle, CaGBC
- Aubrey LeBlanc, Chief Administrative Officer, Ontario Building Officials Association
- Alexandre Hebert, Energy and Sustainability Manager, British Columbia Institute of Technology, (BCIT)
- John Cartwright, President of the Toronto & York Region Labour Council
- Joseph Sirianni, Chair, Technology & Trades Programs Continuing Education at George Brown College
- Wayne Ostermaier, Dean, Marshall School of Skilled Trades & Apprenticeship, Mohawk College

APPENDIX E: LIST OF CONSTRUCTION TRADES

Trade	Compulsory apprenticeships
Architectural Glass and Metal Technician	
Brick and Stone Mason	
Cement (Concrete) Finisher	
Concrete Pump Operator	
Boilermaker (Construction)	
Carpenter (General)	
Concrete Finisher	
Construction Craft Worker	
Drywall Finisher and Plasterer	
Drywall, Acoustic and Lathing Applicator	
Electrician (Construction and Maintenance / Domestic and Rural)	X
Exterior Insulated Finish Systems Mechanic	
Floor Covering Installer	
Gas Fitter	
Hazardous Materials Worker	
Heat and Frost Insulator	
Heavy Equipment Operator (Dozer, Excavator Tractor Loader Backhoe)	
Hoisting Engineer (Mobile Crane Operator 1 / Mobile Crane Operator 2 / Tower Crane Operator	X
Ironworker (Generalist, Structural and Ornamental)	
Millwright (Construction)	
Native Residential Construction Worker	
Painter and Decorator (Commercial and Residential/ Industrial)	
Plumber	X
Precast Concrete Erector	
Precast Concrete Finisher	
Powerline Technician	
Refrigeration and Air Conditioning Systems Mechanic / Residential Air Conditioning Systems Mechanic	X
Reinforcing Rodworker	
Roofer	
Sheet Metal Installer (Residential (Low Rise))	
Sheet Metal Worker	X
Sprinkler and Fire Protection Installer	
Steamfitter	X
Terrazzo, Tile and Marble Setter	
Welder	

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