BC Clean Economy

Workforce Readiness Project:

Phase 2 Labour Market Information Research

SUMMARY REPORT

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DELPHI GROUP

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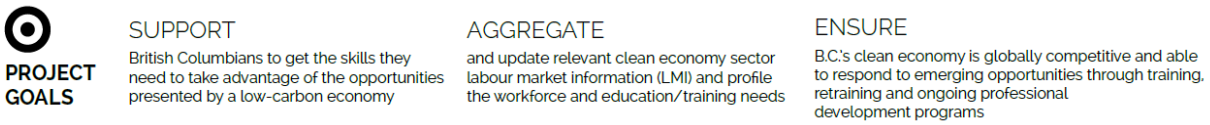
PREFACE

In December 2018, the Province of British Columbia (the Province) released CleanBC[1], a plan to reduce greenhouse gas emissions (GHGs) and provide economic opportunities across British Columbia. CleanBC sets a pathway to a more prosperous, balanced, and sustainable future; it outlines actions to reduce GHGs and provides a blueprint to build a thriving clean economy.

This Labour Market Information Research Summary Report is the culmination of a multi-phase Clean Economy Workforce Readiness Project (CEWRP). It draws on information from several sources, including previous clean economy and sector-specific studies, existing workforce development and capacity building efforts in BC, and comprehensive consultation. Three project goals were established at the outset to ensure the work would meet the needs of industry, as outlined below.



Guided by a Steering Committee established to oversee the work, the project team undertook the three phases of activity throughout the Project.

Phases of the Clean Economy Workforce Readiness Project

Phase		Purpose	Deliverable
1	Stakeholder Engagement	Engage a project Steering Committee and undertake broader stakeholder and public consultation, including community workshops	Engagement summaries
2	Research & Analysis	Conduct labour market information research, including statistical analysis, key informant interviews, industry surveys, and sector-specific focus groups. Analyse data on workforce demand and supply opportunities, challenges, and skills gaps in BC's clean economy in line with CleanBC	Clean Economy Sector Labour Market Information Summary Report (**this report**)
3	Strategy Development	Draft the Industry Strategy to: • Summarize the findings • Identify key recommendations and actions to advance the clean economy workforce in BC • Inform development of the BC Government's CleanBC Jobs Readiness Plan	Industry Strategy on Workforce Readiness for the Clean Economy

[1] See: https://cleanbc.gov.bc.ca/

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STRUCTURE OF THIS REPORT

Executive Summary

Provides a summary of the project, BC's clean economy, workforce demand and supply considerations, and key issues, gaps, barriers, and challenges identified through the research activities.

Introduction

This section provides background context for the reader, including definitions of the 'clean economy' and 'clean economy jobs', the CleanBC Plan and how it relates to the Workforce Readiness Plan project, as well as equity considerations and limitations related to the research.

Research Results

This section details the main findings of the LMI research activities undertaken for the Workforce Readiness Plan project. The section begins with a macro-level overview of BC's current clean economy profiling in detail each of the five clean economy sub-sectors. These sector-specific profiles within the report each contain:

- An overview of the relevant sub-sectors and key activities
- A list of relevant technology trends and market shifts affecting the sector in BC and globally
- An overview of key industries that make up the sector (by statistical industry code or NAICS)
- An overview of the key occupations in the sector (by statistical occupational code or NOC)
- A list of workforce demand drivers and forecast impacts of CleanBC policies relevant to the sector
- Common education and training pathways, and highlighted training programs through post-secondary institutions, industry associations, and labour organizations
- A discussion on emerging skills important to the sector

The Research Results chapter also includes a section on Climate Adaptation Considerations for BC's workforce.

Analysis and Discussion

This section provides an analysis of the LMI research results, including a socio-economic analysis (using a GBA+ lens) and specific insights gathered through the Indigenous-focused consultation. The Analysis and Discussion also includes a section on the workforce issues, gaps, and challenges that were highlighted through consultation with key informants, sub-committees, and the project's Steering Committee. These gaps, barriers, and challenges are first discussed for each of the five clean economy sectors, followed by a section on cross-sector issue areas, which form the foundation for the recommendations in the *Industry Strategy report on British Columbia's Workforce Readiness for a Clean Economy Future* (the "Industry Strategy").

Conclusion

The final section of the LMI report summarizes the key, high-level findings and takeaways from the research, revisiting the underlying barriers and issue areas, and introducing the draft strategic framework that was developed to support the Industry Strategy.

1. EXECUTIVE SUMMARY

1.1 KEY FINDINGS

- BC's clean economy consists of 60 different industries within five core sectors. In 2018, BC's clean economy was estimated to directly employ approximately 105,070 people and contribute $16.6 billion to provincial gross domestic product (GDP).
- The implementation of policies and actions coming from the initial CleanBC Plan released in December 2018 will likely result in new investments in clean economy projects and related initiatives that will create new jobs across all regions of the province. This project estimates that the initial CleanBC Plan will create on average 3,700 temporary construction jobs per year (in person-years of employment) between 2020 and 2030 and approximately 3,240 permanent jobs in operations / maintenance by 2030.
- The policy goals and targets set out in the initial CleanBC Plan are likely to result in significant job transformation impacts, resulting in more people working on clean economy related projects, as well as with related technologies, equipment, and/or processes – essentially greater market penetration within the existing labour force as existing workers shift focus and/or reskill / upskill. Employment modelling suggests that clean economy-related jobs in BC will grow from approximately 105,070 jobs in 2018 to more than 222,800 jobs in 2030. This shift in employment reflects the 'greening' of traditional industries, resulting in approximately 117,730 more workers active in BC's clean economy by 2030.
- Market forces, technology trends, and the broader global shift to a low-carbon economy have the potential to displace or eliminate some jobs in BC; however, this project estimates that the net number of jobs gained will be greater than the losses within the 2030 timeframe.
- Among clean economy employers surveyed as part of the labour market information (LMI) research, 78% reported experiencing staffing challenges in the last two years. Regional workshop participants also described barriers to building climate literacy in their communities, with specific challenges in attracting professionals with a current knowledge of clean technologies and CleanBC policies and incentives.
- Cross-sector issues identified through the LMI research include a lack of flexible and responsive programming, a lack of lifelong learning and demand for training, recruitment and retention challenges, and a lack of access and capacity in rural areas of BC.

1.2 BACKGROUND CONTEXT

British Columbia has been a leader on climate action for over a decade, since the release of the 2008 Climate Action Plan, which included policies and actions such as a revenue-neutral carbon tax, carbon neutral government operations, development of a Low Carbon Fuel Standard, and a voluntary Climate Action Charter committed to by nearly every local government across the province.

The combination of strong economic growth and established policy set the stage for the next phase of climate action through the December 2018 release of the CleanBC Plan. CleanBC aims to reduce climate pollution, while creating more jobs and economic opportunities for people, businesses, and communities.

CleanBC: A Pathway to Climate Action and Job Creation

The CleanBC Plan is focused on actions to reduce greenhouse gas (GHG) emissions by 40% by 2030, 60% by 2040, and 80% by 2050 from 2007 levels. Actions in the 2018 CleanBC Plan are designed to achieve 75% of the GHG emission reductions toward the 2030 target and include policies and incentives in the areas of clean power, buildings, transportation, industry, and waste.

Climate action includes both GHG emissions mitigation to limit future changes in the climate, and also resiliency measures to adapt to changes already being felt in natural systems we rely on. The Province of BC has announced work on a Climate Adaptation Strategy in 2020 under the broader CleanBC Plan, and climate adaptation activities are included in this research within the definition of a clean economy.

Successfully implementing the targets, policies, and actions in CleanBC and continuing the low-carbon shift will require participation and coordination from all sectors of the economy. With the global shift to a low-carbon economy, there is an opportunity to bring together BC's traditional resource sectors, emerging cleantech and technology sectors, and world-class training institutions to capitalize on opportunities and maintain a globally competitive clean economy. There is also a responsibility in this shift to ensure it happens in a way that provides opportunities for all, including those living in rural and remote areas, Indigenous Peoples, women, people with disabilities, newcomers to the province, and traditionally under-represented groups in the workforce.

Broader Policy, Market and Technology Factors

British Columbia does not exist in a bubble. The province is affected by broader policy, market, and technology trends and forces happening both domestically and internationally. Governments at all levels (international, federal, provincial, local, and Indigenous) are sending clear signals through policy, funding programs, and actions that support innovation, investment, and the development of the clean economy. This includes the UN's global Paris commitment, the Canada Infrastructure Fund, and the Green Municipal Fund as examples. Local Governments continue to drive climate action and clean economy initiatives and are key partners in the implementation of CleanBC through management of clean power generation, organics diversion and solid waste management programs, and zero emission vehicle fleet initiatives.

Broad technology trends associated with the Fourth Industrial Revolution are having an impact on all sectors of the economy. These trends include the digitalization of the energy system, high-performance and net zero buildings, the electrification of the transportation system, innovations in bioenergy and the production of renewable fuels, and waste-to-resource opportunities through the lens of a circular economy.

These technology trends are driving the demand for emerging technical skills that bring together systems management, digitization, advanced manufacturing, and energy and emissions management and accounting. Rapidly changing industries and an increasingly complex policy landscape are also driving the need for other work-related skills (also known as core or soft skills), including complex problem solving, critical thinking, social perceptiveness, and cultural awareness.

1.3 BRITISH COLUMBIA'S CLEAN ECONOMY

For the purposes of this project, the clean (or low-carbon) economy is defined as an economic state that results from the decarbonization of all industries through meaningful actions taken to address the impacts from climate change, in the pursuit of creating more resilient communities.[2]

The clean economy is a subset of the broader green economy which, in addition to a focus on reducing greenhouse gas (GHG) emissions, seeks to decouple economic growth from natural resource consumption and minimize negative impacts on ecosystems. The green economy also encompasses broader social issues such as advancing lasting reconciliation and self determination for Indigenous peoples, reducing poverty and hunger, and advancing gender equality. This definition aligns closely the one developed by the United Nations Environment Programme (UNEP) and the UN Sustainable Development Goals (SDGs).

BC's clean economy includes five core sectors which are responsible for supplying technologies, products, and services that have measurable environmental benefits for reducing GHG emissions, improving energy and process efficiency, and enhancing society's resilience in the face of climate change (see Figure ES 1 below). This broad sector-based framework encompasses a number of sub-sectors and green goods and service producing industries (including approximately 60 industry NAICS3 codes at the 3- and/or 4-digit level).

Source: The Delphi Group

Figure ES 1: Five core sectors of BC's Clean Economy

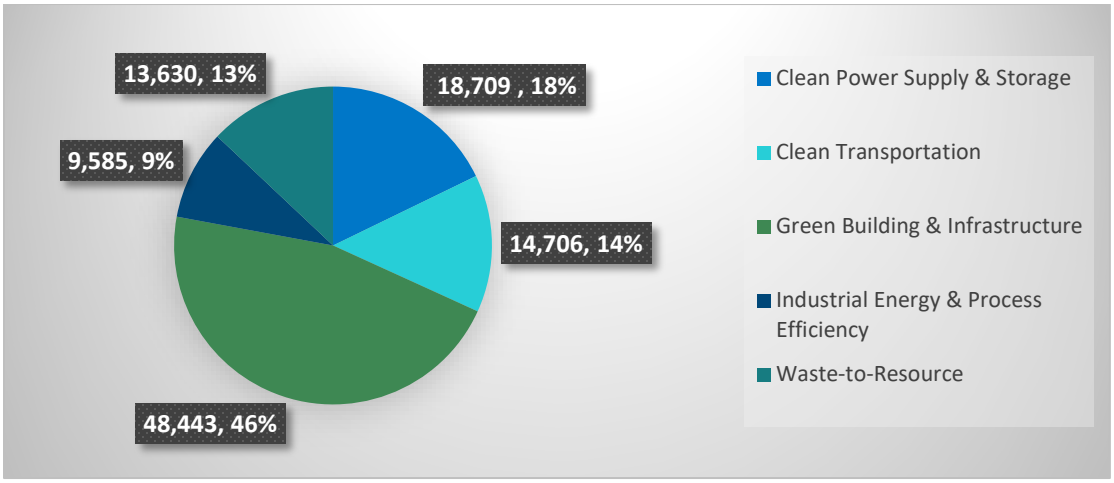
[2] This definition was developed by The Delphi Group in collaboration with the BC Climate Action Secretariat and is based on one developed by ECO Canada. See: https://www.eco.ca/pdf/Defining-the-Green-Economy-2010.pdf

[3] NAICS = North American Industry Classification System

Clean economy jobs, as defined by the International Labour Organization (ILO), are "decent jobs that contribute to preserving or restoring the environment, be they in traditional sectors such as manufacturing and construction, or in new, emerging sectors such as renewable energy and energy efficiency. Clean economy jobs help:

- Improve energy and raw materials efficiency;
- Limit greenhouse gas emissions;
- Minimize waste and pollution;
- Protect and restore ecosystems; and
- Support adaptation to the effects of climate change".[4]

In 2018, BC's clean economy was estimated to employ approximately 105,070 people across the five sectors (see Figure ES 2) and contributed $16.6 billion to provincial GDP.



Source: The Delphi Group

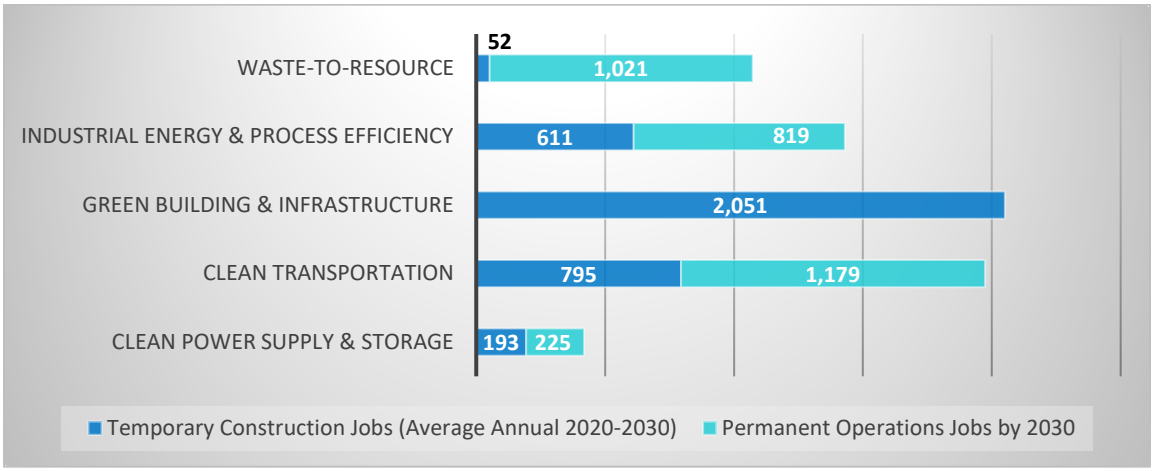
Figure ES 2: Direct clean economy jobs in British Columbia by sector, 2018

1.4 WORKFORCE DEMAND

Job Creation

Economic and employment modelling undertaken as part of labour market information (LMI) research for this project suggests that an average of 3,700 temporary construction jobs will be created per year between 2020 and 2030 and approximately 3,240 ongoing jobs in operations by 2030 in line with the policy goals and targets outlined in the initial CleanBC Plan (see Figure ES 3 below). The Green Building and Infrastructure sector is projected to see more than half (55%) of the temporary construction jobs, followed by the Clean Transportation sector (22%), and the Industrial Energy and Process Efficiency sector (17%).

[4] See: https://www.ilo.org/global/topics/green-jobs/news/WCMS_220248/lang--en/index.htm



Source: The Delphi Group

Figure ES 3: Projected job openings by sector based on modelled CleanBC policies

It was assumed that the construction investments related to the CleanBC policies are evenly spread between 2020 and 2030. However, investments related to some policies are likely to be made prior to 2025 (e.g., reductions related to methane emissions from the natural gas industry) while others may come after 2025 (e.g., scale-up of larger biofuel production facilities).

In terms of ongoing jobs in operations, the Clean Transportation and Materials Management and Waste-to-Resource sectors are projected to see approximately 1,180 and 1,020 jobs created by 2030, equal to approximately two-thirds (67%) of the total operational jobs.

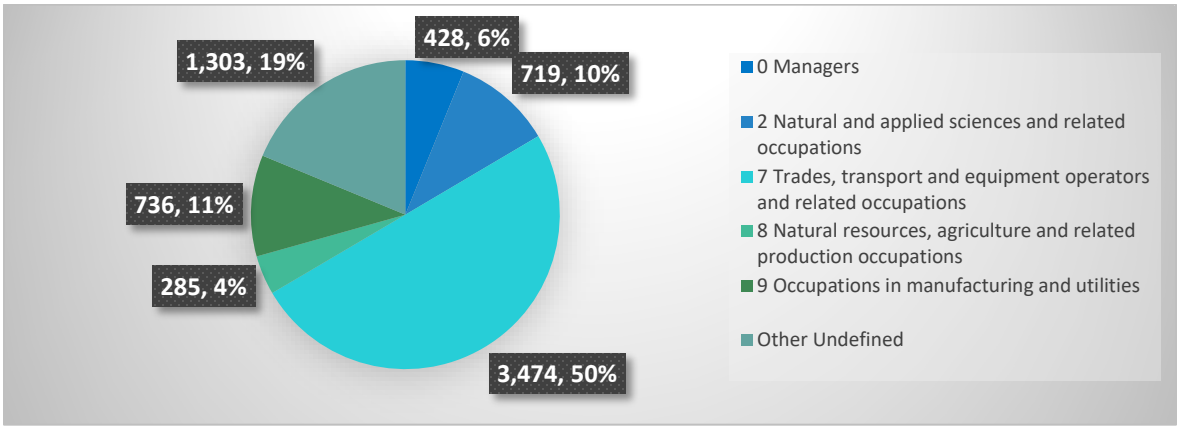
Figure ES 4 provides a better understanding of the types of jobs that will be required to meet the current CleanBC policy goals and targets. It includes a breakout of the forecasted expansion demand by occupational category based on the modelling.

A NOTE ON THE JOB FORECASTS IN THIS REPORT:

It is important to note that the results from the jobs modelling presented in this report do not represent the entire spectrum of employment opportunities from CleanBC but rather an initial subset based on the policy targets and goals that were quantified, representing only 75% of the GHG emission reduction pathways for the Plan. An additional 25% is yet to be determined and will likely have additional employment impacts.

Further, market trends and investments by the private sector and others are also having large impacts on job creation within BC's clean economy. For example, BC Hydro and independent power producers in the province will be investing millions into hydroelectricity and renewable power infrastructure as part of maintenance and upgrade projects. FortisBC is investing millions into its demand-side management (DSM) and energy efficiency initiatives, as well as a host of other efforts related to renewable, compressed, and liquefied natural gas (RNG, CNG, and LNG) for transportation (marine and road). BC Transit and Translink will be investing millions into transit infrastructure, as well as CNG and electric bus fleets.

These initiatives, and many more, are not captured in this report's economic modelling. As such, it will be important to remain flexible with workforce planning efforts and re-evaluate the opportunities over time in order to account for these additional initiatives and investments.



Source: The Delphi Group

Figure ES 4: Projected jobs by occupational category based on modelled CleanBC policies (average annual temporary construction job openings between 2020-2030 and permanent operations jobs by 2030)

More details on the projected employment impacts from the CleanBC policies on a sector-by-sector basis are provided in Table ES1 below.

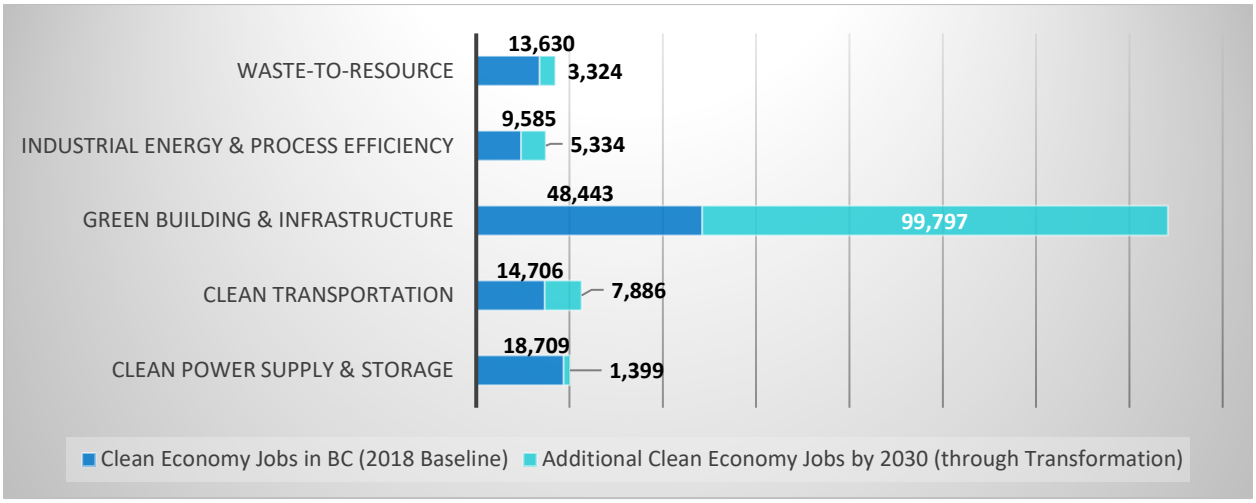
Table ES 1: CleanBC policy goals, regional distribution, and key occupations impacted

Sector	CleanBC Policy Goals	Regional Distribution	Occupations in Demand
Clean Power Supply & Storage Temporary Construction (average / year): 193 jobs Permanent Operations: 225 jobs	1. Increased renewable power for remote and Indigenous communities 2. Increased electricity transmission infrastructure for powering industrial operations	1. Rural and remote communities (Indigenous and/or diesel-dependent) outside of the Mainland / Southwest region 2. Northeast and North Coast / Nechako regions	• Electrical power line and cable workers • Residential and commercial installers and servicers • Contractors and supervisors, heavy equipment operator crews • Contractors and supervisors, other construction trades, installers, repairers and servicers • Electrical and electronics engineers • Facility operation/maintenance managers • Construction managers • Power engineers and power systems operators
Green Building & Resilient Infrastructure Temporary Construction (average / year): 2,051 jobs Permanent Operations: N/A jobs	1. All new buildings to be net-zero energy ready by 2032 2. 70,000 homes and 10 million m2 of commercial buildings retrofitted to use electricity in space heating by 2030 3. $400 million to support retrofits and upgrades for BC publicly-funded buildings	1. Dispersed throughout the province, but faster adoption for Vancouver Island / Coast, Mainland Southwest, Thompson-Okanagan, and Kootenay regions in line with current BC Energy Step Code adoption 2. 90% of activity in three regions based on population and climate considerations: Mainland / Southwest, Vancouver Island / Coast, and Thompson Okanagan 3. Evenly distributed across the province inline with the	• Electricians • Carpenters • Plumbers • Refrigeration / AC mechanics • Manufacturing engineers (fenestration, pre-fabrication) • Construction managers • Civil engineers • Concrete finishers • Facility operators / managers • Construction estimators • Sheet metal workers • Mechanical engineers • Roofers and shinglers • Architects • Electrical and electronics engineers • Ironworkers

		presence of public housing stock	• Welders and related machine operators • Construction inspectors • Insulators (mechanical) • Glaziers
Clean Transportation Temporary Construction (average / year): 795 jobs Permanent Operations: 1,179 jobs	1. 30% of all new LDV and truck sales to be ZEVs by 2030 2. Production of 650 million liters of renewable fuels per year by 2030 3. Investments in active transportation infrastructure	1. Largely in southwestern and urban centres in BC, linked to the EV passenger vehicle market 2. Potential for all regions, linked to feedstock access 3. Evenly distributed across the province	• Electricians • Petroleum / chemical process operators • Construction trades helpers and labourers • Contractors and supervisors, heavy equipment operator crews • Transport truck drivers • Process control and machine operators • Heavy-duty equipment mechanics • Construction managers • Chemical plant machine operators • Chemical engineers • Carpenters • Chemical technologists and technicians • Civil engineers • Steamfitters / pipefitters
Material Management & Waste-to-Resource Temporary Construction (average / year): 52 jobs Permanent Operations: 1,021 jobs	1. 95% of organic waste diversion target by 2030 2. 75% of landfill methane captured by 2030	1. Province-wide, although largely rural and remote areas. 2. Province-wide, although largely rural areas.	• Public works maintenance equipment operators and related workers • Transport truck drivers • Water / waste treatment plant operators • Supervisors, logging and forestry • General farm workers • Utilities managers • Managers in agriculture • Heavy equipment operators • Forestry professionals • Forestry technologists and technicians • Material handlers • Chemical technologies and technicians
Industrial Energy & Process Efficiency Temporary Construction (average / year): 611 jobs Permanent Operations: 819 jobs	1. Reduce industrial GHG emissions by 2.5 Mt per year 2. 15% renewable gas in the natural gas system by 2030 3. Reduce methane emissions from the natural gas sector by 45% by 2025	1. All regions of BC in line with GHG emissions intensive industrial activities (extraction, processing, and manufacturing). 2. Geographic distribution will be largely based on farm activities and in line with suitable landfill locations, as well as access to natural gas pipeline infrastructure and customers. Forestry-based opportunities distributed, largely for Vancouver Island / Coast and the Cariboo regions. 3. Northern BC regions, as well as along natural gas pipeline routes.	• Construction millwrights and industrial mechanics • Transport truck drivers • General farm workers • Steamfitters and pipefitters • Industrial electricians • Heavy-duty equipment mechanics • Managers in agriculture • Water / waste treatment plant operators • Petroleum, gas and chemical process operators • Plant and system operators • Pulp mill machine operators • Wood processing machine operators • Chemical technologists and technicians • Chemical engineers • Heavy equipment operators • Construction managers • Mining engineers • Industrial engineering and manufacturing technologies / technicians • Mechanical engineers • Industrial and manufacturing engineers • Gasfitters

Job Transformation

Perhaps more significant than the new job openings created by CleanBC are the job transformation[5] impacts within existing industries and occupations that will come from the CleanBC Plan, resulting in more people working on clean economy related projects, as well as with related technologies, equipment, and/or processes – essentially greater market penetration within the existing labour pool. Employment modelling as part of the LMI research suggests that clean economy related jobs in BC will grow from approximately 105,070 jobs in 2018 to more than 222,800 jobs in 2030, or a growth of approximately 117,740 more workers active in BC's clean economy (see Figure ES 5), including both core and secondary transformation jobs.[6]



Source: The Delphi Group

Figure ES 5: Projected clean economy workers in BC by sector due to job transformation, 2018-2030

The greatest impact in terms of job transformation is expected within the Green Building and Infrastructure sector, due largely to the policy goal for all new construction in BC to be net zero energy ready by 2032, which has ripple effects across the broad building value chain. The Clean Transportation sector is also expected to see job transformation impacts as a result of a greater market penetration of lower-carbon fuels and zero emission vehicles (ZEVs) by 2030 in line with CleanBC policy goals. In addition, the Industrial Energy and Process Efficiency sector will see more workers involved with clean technologies as they look to reduce GHG emissions across all carbon-intensive industries.

While not creating an overall net change in terms of jobs within the labour pool, the impact of job transformation is important to consider as it relates to specific occupations and the need for retraining / upskilling to align supply with demand due to climate action policy and broader market shifts. Examples include carpenters who need the

[5] Many existing occupations are seeing their jobs transformed and redefined as day-to-day workplace practices, skill sets, work methods, and job profiles increasingly integrate considerations related to climate change and low-carbon technologies, processes, and operations. Job transformation is different from job creation in that it does not result in a growing labour pool, but rather a 'greening' of existing occupations through reskilling.

[6] Transformation jobs include: (1) core transformation jobs, which are jobs identified as having a potentially direct impact on reducing GHG emissions; and (2) secondary transformation jobs, which are important to the sector but have an indirect linkage to reducing GHG emissions.

skills to build to net zero energy performance standards in construction and automotive service technicians who may need retraining for electric and zero emission vehicles.

Based on projected clean economy market and policy shifts in BC, a number of important occupations (listed in Table ES 2 in order of total numbers) will require specific knowledge and skills, and potential training / upskilling, in order to work in their relevant clean economy sectors on projects and initiatives.

Table ES 2: Clean economy job transformation in BC by occupation, 2018-2030

NOC - Occupation Title	Number of Transformation Jobs (2018-2030)
7271 Carpenters	9,795
7611 Construction trades helpers and labourers	5,882
7241 Electricians (except industrial and power system)	4,334
0711 Construction managers	3,191
7294 Painters and decorators (except interior decorators)	2,984
7251 Plumbers	2,829
0712 Home building and renovation managers	2,069
7284 Plasterers, drywall installers and finishers and lathers	2,010
7521 Heavy equipment operators (except crane)	1,986
7291 Roofers and shinglers	1,648
7512 Bus drivers, subway operators and other transit operators	1,511
7205 Contractors and supervisors, other construction trades, installers, repairers and servicers	1,404
7441 Residential and commercial installers and servicers	1,391
6733 Janitors, caretakers and building superintendents	1,106
7513 Taxi and limousine drivers and chauffeurs	938
8612 Landscaping and grounds maintenance labourers	905
7313 Refrigeration and air conditioning mechanics	754
2171 Information systems analysts and consultants	667
7511 Transport truck drivers	601
2131 Civil engineers	552
7321 Automotive service technicians, truck and bus mechanics and mechanical repairers	536
7292 Glaziers	532
7302 Contractors and supervisors, heavy equipment operator crews	516
7237 Welders and related machine operators	514
7362 Railway conductors and brakemen/women	459
9614 Labourers in wood, pulp and paper processing	442
0911 Manufacturing managers	399
7293 Insulators	399

7311 Construction millwrights and industrial mechanics	369
7231 Machinists and machining and tooling inspectors	352
9431 Sawmill machine operators	311
7361 Railway and yard locomotive engineers	298
0821 Managers in agriculture	284
7531 Railway yard and track maintenance workers	267
7312 Heavy-duty equipment mechanics	248
2151 Architects	243
7522 Public works maintenance equipment operators and related workers	223
8241 Logging machinery operators	195
8431 General farm workers	179
0912 Utilities managers	178

Job Displacement

In line with the policy goals and targets outlined in the initial CleanBC Plan, the risks for job displacement are relatively low. The shift toward more electrically heated buildings (e.g., to heat pumps and electric boilers) and away from natural gas equipment is expected to result in some job substitution and potential displacement within the HVAC sector as work shifts from gasfitters to refrigeration and air conditioning mechanics, plumbers, and electricians.

Based on initial modelling for the Part 9 residential sector, electric heating is expected to generate approximately 147 temporary construction jobs per year on average for HVAC trades between 2020 and 2030, while potentially displacing on 73 temporary jobs in construction per year (the most at risk being residential gasfitters). The overall net result is a creation of 73 temporary construction jobs per year related to the residential HVAC sector. Given population and climate considerations in BC, retrofit activities and related job displacement impacts are largely expected to be felt in the Mainland / Southwest, on Vancouver Island / Coast, and the Thompson Okanagan within the 2030 timeframe.

Job displacement may also occur for traditional automotive mechanics working on internal combustion engine (ICE) vehicles given the need for less regular maintenance of EVs (i.e., no oil changes, spark plug changes, less brake servicing due to regenerative braking, etc.) and warranties that require going direct to dealerships and manufacturers. The estimated displacement is approximately 1,460 permanent jobs by 2030. Given the adoption of EVs in the light-duty vehicle market is projected to be faster in the province's urban centres, and largely in Southwestern BC, job displacement is most likely to impact these regions within the 2030 timeframe. However, it is unlikely that sudden layoffs of mechanics would occur given existing vehicle market will still have considerable ICEs in 2030 and opportunities for retraining exist.

Finally, some additional job displacement may occur as demand for high-carbon products shift to low-carbon (e.g., from coke-fired cement kilns to biomass, from coal exported to Asia for metallurgic steel to carbon fibre alternatives, etc.), as well as due to broader macro-trends and disruptive technologies such as automation, pre-fabrication, modular construction, and additive manufacturing. These potential job displacement impact factors

were not modelled as part of this LMI research given the challenge of isolating the impact from CleanBC as opposed to broader macro trends and forces.

While the net employment benefits outweigh the losses in the short-term from potential job displacement due to CleanBC, it will be important to consider potential risks for workers and develop strategies to address the risks through retraining and other actions.

1.5 WORKFORCE SUPPLY

The supply of workers to fill clean economy job demand is a potentially limiting factor for the growth of BC's clean economy. Factors include current population forecasts, labour force participation rates, attrition rates, migration and immigration flows, and trends in the number of students graduating from training institutions across BC.

Relevant training programs exist in a wide variety of formats, starting with curriculum in K-12 education, to college and trades training, to undergraduate programs and advanced multi-disciplinary degrees. There are also a number of continuing education programs through industry-led training offering clean economy skills to mid-career professionals. This includes apprenticeship programs through the Industry Training Authority, reskilling programs through labour organizations, and opportunities provided by professional industry associations.

The Province of BC is investing in new models of training to support CleanBC, such as the Electric Vehicle Maintenance Training program which is a partnership with BCIT to develop and test an EV curriculum with 12 Red Seal mechanics working on the City of Vancouver's 120 vehicle EV fleet. This program will be available to the public as a part-time studies course in 2020.

Furthermore, to build the climate change resiliency required of our infrastructure, a collective effort is required to put resources into modelling future climate scenarios and adapt decision making processes to account for the impacts on BC's natural and human systems.

Many industry professionals are reporting they lack adequate tools, information, resources, and client support necessary to make this shift. Some industry associations have recognized this need and are working to incorporate climate adaptation-related training into current programs.

Occupations reported as BOTH important for clean economy companies AND difficult to staff include:

- Power engineers and power system operators
- Utilities managers
- Electrical and electronics engineers
- Chemical engineers and technologists
- Transport truck drivers
- Supervisors for supply chain and logistics planning
- Material handlers
- Home building, renovation, and construction managers
- Industrial and manufacturing engineers
- Construction millwrights and industrial mechanics

Source: CEWRP Industry Survey

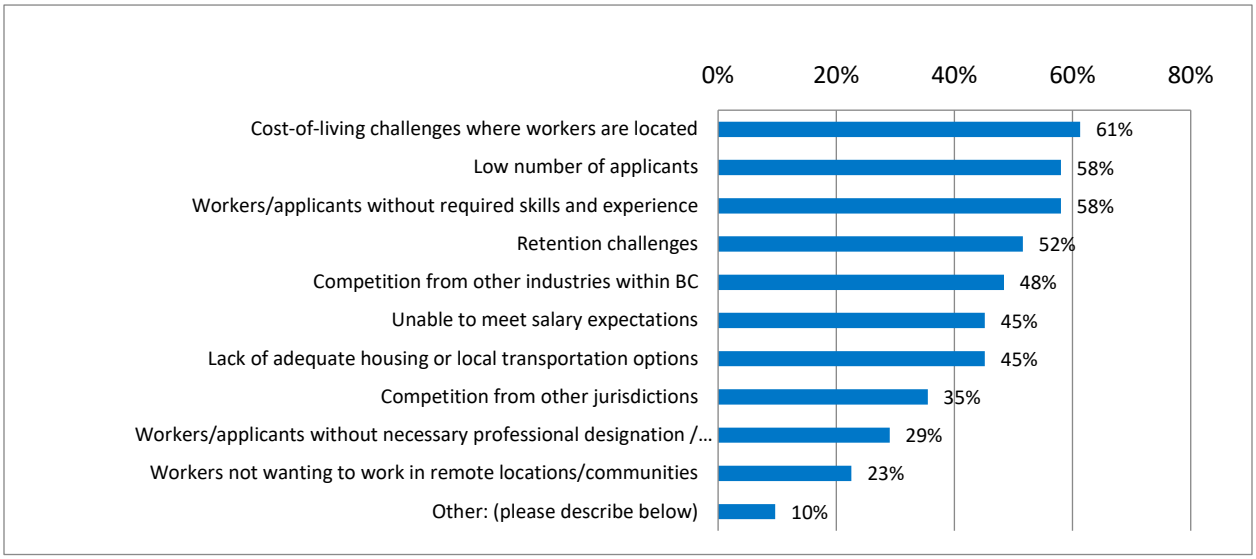
In addition to expanding the knowledge base of industry professionals, new skillsets are required by employees within industries endeavoring to adapt to climate change. These include skills in areas such as risk management, adaptive management, and scientific capacity. The need for more training and resources related to climate adaptation and natural systems is also an opportunity to incorporate Indigenous knowledge into curriculum for a wide range of training programs.

1.6 KEY ISSUES

Research to support the Clean Economy Workforce Readiness Project included an industry survey of employers and training providers, focus group discussions, regional workshops, and interviews with a wide range of businesses and organizations across the province. Several key themes and issues were highlighted through these research activities, some of which apply to specific regions while others to the province as a whole.

Employers across the province responded to the industry survey describing challenges filling openings for key occupations in their businesses. 78% of respondents reported experiencing staffing challenges in the last 2 years.[7] Regional workshop participants described challenges unique to their regions in attracting specific occupations and skillsets, and also finding trade contractors with a current knowledge of low-carbon technologies and CleanBC policies and incentives.

When asked to describe the issues in more detail, the most commonly reported reasons for staffing challenges included the high cost-of-living (61%), low numbers of applicants (58%), applicants without the required skills and experience (58%), and retention challenges (52%). Other challenges highlighted include seasonal work cycles, balancing working conditions with client expectations, and the high cost and time commitment required to train new employees. Figure ES 6 provides more detail.



Source: CEWRP Industry Survey

Figure ES 6: Reasons for current staffing challenges identified by clean economy employers (n=31)

[7] It should be noted that BC has been experiencing an overall tight labour market over the last couple of years, a situation which is not unique to the clean economy sector.

Gaps, Barriers & Challenges

Industry stakeholders participating in regional workshops, key informant interviews, and sector-specific sub-committees were asked to describe workforce-related gaps, barriers, and challenges they are experiencing.

In the Clean Power Supply and Storage sector, stakeholders highlighted challenges associated with the provincial policy focus on large hydroelectric projects. This policy focus is having a ripple effect across the renewable energy sector, reducing the demand for project development skills associated with smaller hydroelectric, solar, and wind projects. Among stakeholders who are developing clean power projects, a need was highlighted for broader skillsets related to community and government relations in order to navigate complex consultation and approvals processes.

In the Green Building and Resilient Infrastructure sector, challenges include the lack of trades with knowledge and experience in clean technologies (e.g., heat pumps, high-performance building), high employee turnover, and the lack of regulation and requirements for training. A lack of minimum training requirements for many trades impacts on the demand for apprenticeships and work-integrated learning opportunities, as well as impacting on safety and the quality of work done in the field. Carpenters, insulators, and glaziers are examples of occupations that will face both increased demand due to energy efficient building code upgrades and supply shortages due to anticipated retirements.

Other skills gaps reported that apply across the Green Building sector (both for new construction and retrofits, as well as for residential and non-residential buildings) include knowledge around airtightness, building envelope enclosures, effective HVAC sizing, and integrated project delivery (i.e., a systems-based approach to construction).

Challenges reported in the Clean Transportation sector include competition for employees from other industries, the negative stigma sometimes associated with ‘greasy’ jobs, and the increasing demand for a combination of both transportation-specific knowledge and information and communications technology skills.

Many of the challenges identified in the Clean Transportation sector have existed for over a decade, but stakeholders feel these challenges are even more pronounced today. Increasing electrification and digitalization of transportation technologies and services are creating a need for more nimble and flexible programming and greater hands-on learning environments.

In the Materials Management and Waste-to-Resource sector, stakeholders described gaps and challenges associated with systems approaches and the emerging field of circular economy. Technical skills will be needed associated with identifying feedstocks and connecting complex networks of resource inputs and outputs. There is also a growing need for proficiency in the operation and management of digital systems and data analysis. There is a greater challenge associated with developing these skills and industries in rural and less-populated areas, many of which do not even have basic recycling and waste management programs.

The Industrial Energy and Process Efficiency sector includes traditional resource industries which will require workers with updated skillsets for improving processes and operations. They are also vulnerable to boom-bust resource cycles and competition for resources from nearby jurisdictions with different climate policy landscapes.

Cross-Sector Issues

Common cross-sector challenges and issues were identified by a range of businesses and organizations across the province. These issues are grouped into four main categories below.

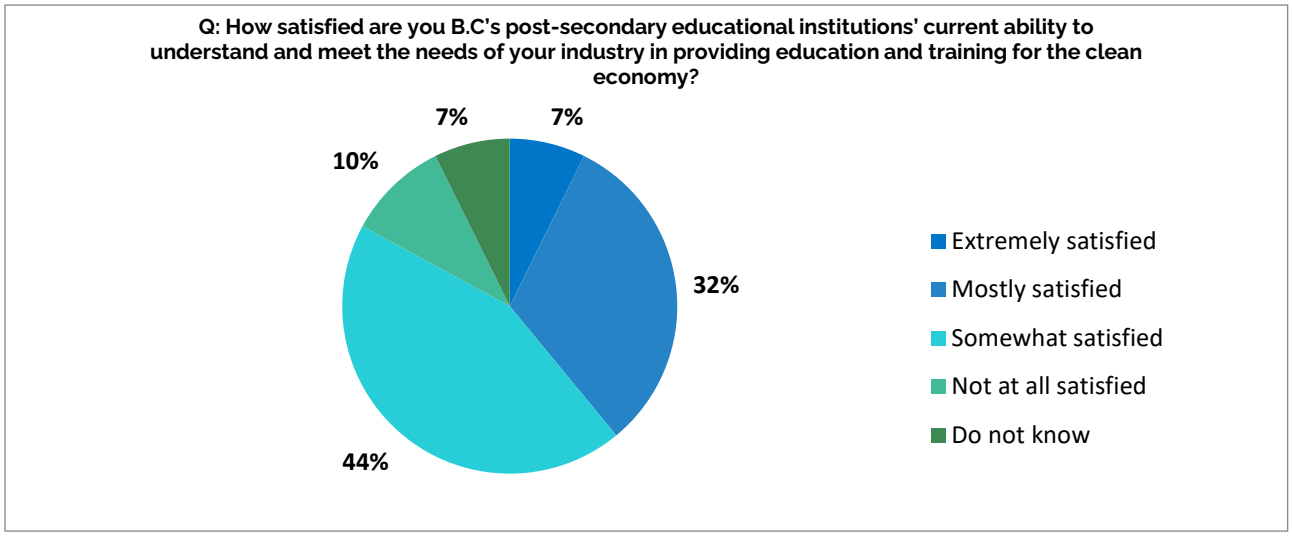
Lack of Flexible and Responsive Programming

Education and training programs need to be flexible and responsive to emerging industry trends and technology shifts. Without this flexibility, there is a risk that trainees are not sufficiently equipped with the skillsets and knowledge required for the dynamic needs of the clean economy.

BC has a world-class education and training system, including 25 public post-secondary institutions and a number of private training colleges, many of which provide the education and training programs required for meeting the clean economy. At the same time, many programs lack the flexibility required to meet rapidly emerging technology and market shifts relevant to the clean economy sectors.

Nearly half (44%) of the employers that responded to the industry survey were only "somewhat satisfied" with BC's post-secondary educational institutions current ability to understand and meet the needs of their industries in providing education and training for the clean economy (see Figure ES 7 below).

Survey respondents specifically suggested that post-secondary institutions could provide more exposure to applied research facilities where technicians can be cross-trained, and also provide more practical working time through co-op programs and site visits. Respondents also highlighted a need for programs combining both technical and management skills, and more offerings in rural regions of the province to mitigate the cost of travelling long distances to training.



Source: CEWRP Industry Survey

Figure ES 7: Employer satisfaction with BC post-secondary institutions (n=41)

Lack of Lifelong Learning and Demand for Training

Key occupations in the clean economy do not have effective incentives for continuous learning, which may impact factors such as safety, quality assurance, and accountability. This is in part due to a lack of clarity on how certain occupations and industries fit in the clean economy, and also impacted by the willingness of employers to allow the necessary time away for training and skills development.

In addition, the importance of more climate change-related programs that start in K-12 education to introduce youth to career options in the clean economy was repeatedly referenced during consultation efforts.

Recruitment and Retention Challenges

Many employers in BC struggle to recruit and retain employees, both in urban areas with a high cost of living, and also in rural areas where services and infrastructure are not sufficient to meet people's needs. Many groups (e.g., youth, women, Indigenous Peoples) also lack an accurate picture of their career options in the clean economy.

Gender balance in the clean economy workforce is an important consideration, as many occupations have traditionally been and continue to be male-dominated. With the exception of the Materials Management and Waste-to-Resource sector, workers in the top clean economy occupations in the 5 sectors are 80% or greater men and 20% or fewer women. The transition to a clean economy presents an opportunity to shift current training and workplace processes and cultures that may exclude certain groups.

Failure to address barriers to employment for under-represented groups also misses an opportunity to increase workforce participation in the current supply-constrained environment.

Lack of Access and Capacity in Rural Areas

Many rural and remote areas of the province do not have adequate access to training and/or mechanisms to build workforce capacity in line with clean economy sector needs. One of the key barriers to accessing the training and mechanisms to build key skillsets is reliable infrastructure to enable participation, including both transportation and internet connectivity.

Underlying barriers including poverty, literacy, and a lack of infrastructure can greatly affect access to training and employment, and Indigenous Peoples, women, youth, people with disabilities, and people living in remote communities are disproportionately affected by these barriers. Without continued and coordinated action, the shift to a low-carbon economy risks leaving groups behind.

Both Indigenous and non-Indigenous participants in workshops emphasized that there is a lack of information about CleanBC and associated opportunities. Many people felt that the development of the CleanBC Plan did not consider their unique community context and suggested that it would be helpful to incorporate more of a rural and Indigenous lens into the programs.

A recurring theme of feedback and recommendations is the need to empower more locally-based resources in the regions that can help interpret what CleanBC means for individual communities and help to coordinate action through existing networks.

1.7 IN SUMMARY

The industries that make up the core of British Columbia's clean economy are significant contributors to regional economic prosperity and jobs, responsible for employing 105,070 people in 2018 and contributing $16.6 billion to provincial GDP. Having an opportunity to participate in the growing clean economy is an exciting prospect for many individuals, with the transition to a low-carbon future presenting valuable opportunities to ensure a diverse and more resilient workforce.

The clean economy job creation and transformation opportunities that will emerge for BC are considerable. Those modelled as part of the initial CleanBC Plan represent 3,700 temporary construction jobs per year between 2020 and 2030 and approximately 3,240 permanent jobs in operations / maintenance by 2030, as well as an additional 117,730 more workers by 2030 active in BC's clean economy through the 'greening' of traditional industries. This, of course, is an underestimate given that it does not include the broader opportunities beyond the initial CleanBC policies that were part of the jobs modeling. Furthermore, as markets and industries globally shift toward a low-carbon future, BC is well-positioned to seize investment, cleantech product and service exports, and employment opportunities.

While the research for this project shows that the benefits from new clean economy project investments and related jobs will exist province-wide, the full potential of these opportunities can only be realized by addressing the issues highlighted in this report; some of which are broad and structural while others are sector-specific. Addressing these issues will involve providing more flexible and responsive training and education programs and supports; encouraging lifelong learning and skills essential for succeeding in the clean economy starting at an early age; focusing on the recruitment and retention of important clean economy occupations and encouraging more participation by under-represented groups that will ensure BC's workforce diversity; and addressing the lack of access and capacity to employment and training that exists for many rural and remote communities.

2. INTRODUCTION

As the effects of climate change are increasingly felt world-wide, the imperative for taking action is growing. A global shift to a clean, low-carbon economy is underway, being driven by international climate change concerns, a growing population transitioning from poverty to middle-income, and an improved business case for renewable energy and related clean technology.

New international policy efforts as well as national, provincial, and municipal policy initiatives in Canada are combining with private sector efforts to reduce greenhouse gas (GHG) emissions and develop solutions for a prosperous and sustainable future.

Given the colliding forces that include competition for resources, population growth and urbanization, technology trends, and policy drivers under the climate action agenda, the way forward presents an exciting suite of new and expanded business, investment, and job creation opportunities within the realm of the clean economy.

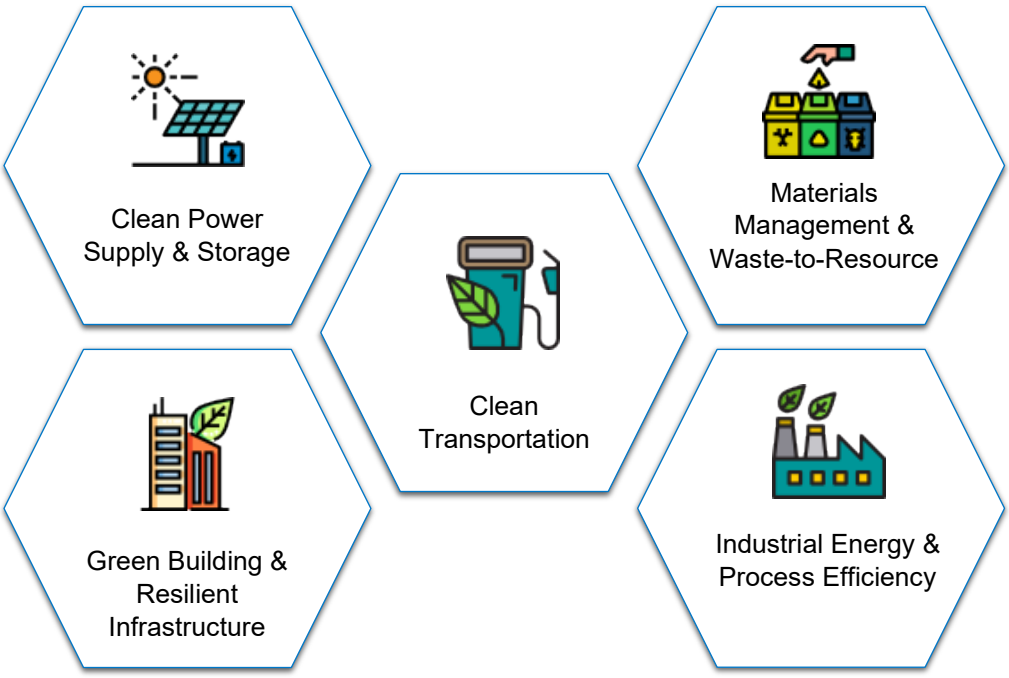
2.1 DEFINING THE CLEAN ECONOMY

The clean economy is defined as an economy that aims at reducing environmental risks and ecological scarcities, and that aims for sustainable development without degrading the environment. For the purposes of this study, the following definition was adopted for BC's clean (i.e., low-carbon) economy, which is based on ECO Canada's definition of the 'green economy'[8] and developed in collaboration with the BC Climate Action Secretariat:

> *A clean (or low-carbon) economy is defined as an economic state that results from the decarbonization of all industries and meaningful actions taken to address the impacts from climate change in order to create more resilient communities. There are key sectors and industries at the core of the clean economy that are responsible for supplying technologies, products, and services that have measurable environmental benefits in terms of their abilities to reduce greenhouse gas (GHG) emissions, improve both energy and process efficiency, and enhance society's resilience in the face of climate change.*
>
> *The "clean economy", as described above, can be thought of as a subset of the broader "green economy", which, in addition to including a focus on reducing harmful GHG emissions, seeks to decouple economic growth from natural resource consumption and minimize negative impacts on ecosystems to ensure economic activities are within planetary / ecological boundaries, as well as address broader social issues such as advancing lasting reconciliation and self determination for Indigenous Peoples, poverty and hunger reduction, and gender equality.*

In line with this production-focused definition, the clean economy includes five 'core' sectors as shown in Figure 1 below.

[8] See: https://www.eco.ca/pdf/Defining-the-Green-Economy-2010.pdf



Source: The Delphi Group

Figure 1: The five core sectors of BC's clean economy

The broad sector framework outlined above encompasses a number of sub-sectors and green goods and service producing industries (including approximately 60 NAICS codes at the 3- and/or 4-digit level).

- The **Clean Power Supply and Storage** sector includes electricity generation from hydroelectric and other renewable sources, transmission infrastructure that connects sources with users across the province, smart/microgrid solutions, and energy storage solutions in the form of dam reservoirs and an expanding array of battery technologies.
- The **Green Building and Resilient Infrastructure** sector is the built environment made up of residential, commercial, industrial, and institutional buildings. Industries in this sector include building design, engineering, and operations; construction and renovation; manufacturing of building materials and related equipment; and land use planning.
- The **Clean Transportation** sector includes the network of transportation modes within and between communities across the province. Within this network, key industries and sub-sectors include: low-carbon and zero emission vehicles; renewable and low-carbon fuels; public transit services and smart mobility solutions; low-carbon rail, marine, trucking, and air for the movement of people and goods; and land use planning and transportation infrastructure.

- The **Materials Management and Waste-to-Resource** sector includes some of the products and services to measure, prevent, limit, or minimize waste, efficiently process materials and resources, and manage GHG emissions. This sector also includes municipal and industrial waste and organics management, including methane capture, composting, recycling, and material recovery.

BC's clean economy includes 5 core sectors, 21 sub-sectors, and 60+ unique industries. In 2018, the clean economy employed approximately 105,070 people and contributed $16.6 billion in direct GDP.

- The **Industrial Energy and Process Efficiency** sector includes a mix of industries that produce goods or provide services that benefit the environment or conserve natural resources, and jobs and activities that involve making production processes more environmentally friendly and/or use fewer natural resources. Traditional industries that fall within this sector include extraction, processing, and manufacturing within the primary and secondary industries. Technologies being used to improve the energy and process efficiency of these industries include carbon capture, utilization, and storage, waste heat recovery, bio-products and fuel, and other energy efficiency technologies.

2.2 DEFINING CLEAN ECONOMY JOBS

Clean economy jobs, as defined by the International Labour Organization (ILO), are "decent jobs that contribute to preserving or restoring the environment, be they in traditional sectors such as manufacturing and construction, or in new, emerging sectors such as renewable energy and energy efficiency". Clean economy jobs help:

- Improve energy and raw materials efficiency;
- Limit GHG emissions;
- Minimize waste and pollution;
- Protect and restore ecosystems; and
- Support adaptation to the effects of climate change".[9]

For quantification purposes in line with the LMI research, the definition adopted for clean economy jobs comes from the United States Bureau of Labor Statistics (US BLS) definition of green jobs.[10] According to the US BLS, green jobs are either:

A. **Production Jobs** – Jobs in businesses that produce goods or provide services that benefit the environment or conserve natural resources; or
B. **Process Jobs** – Jobs in which workers' duties involve making their establishment's production processes more environmentally friendly or use fewer natural resources.

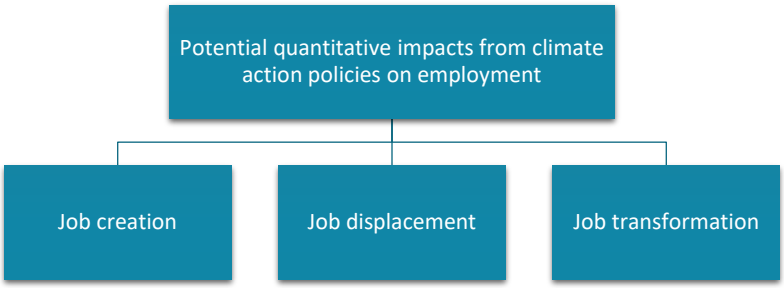
[9] See: https://www.ilo.org/global/topics/green-jobs/news/WCMS_220248/lang--en/index.htm
[10] See: http://www.bls.gov/green

Production or 'output-based' jobs are related to producing a specific set of goods and services and are in and of themselves not concerned with the environmental impact of the production process. These occupations, for example, include jobs in the clean technology design and manufacturing sector. Other examples of production jobs include hydroelectric facility engineers and electric vehicle technicians.

Process jobs, on the other hand, are concerned with deploying and adopting practices and/or technologies that have a favourable impact on the environment, regardless of the good or service produced. Process jobs can be found in any industry. An example of a process job would be a mining engineer who is working to lower energy consumption and the environmental impact of operations through the application of technologies or processes.

The clean economy jobs profiled in this research are primarily 'production' jobs as defined by the US BLS. The main exception is within the Industrial Energy and Process Efficiency sector, where certain occupations are focused specifically on the reduction of their companies' energy consumption and GHG emissions within more traditional industries, such as forestry, agriculture, oil and gas, mining, cement production, smelting and refining, and manufacturing. Both production and process jobs will be required to meet the CleanBC policy goals and GHG emission reduction targets.

From a workforce perspective, employment may be affected in three primary ways as a result of the climate action policies, programs, and related capital investments, as shown in Figure 2 and described in more detail below.



Source: Adapted from the UNFCCC

Figure 2: Potential quantitative impacts from climate action policies on employment

1. **Job Creation:** Job creation (which can also be referred to as 'expansion demand') can result from new capital investments in projects, regulatory drivers, and/or the expansion of clean economy products, services, and infrastructure that comes from greater labour demand across certain sectors. Examples include jobs in: renewable energy project development; energy efficiency (e.g., high-performance window manufacturing, zero emission vehicle component manufacturing, increased public transit services, etc.); and climate adaptation and green infrastructure projects (e.g., flood barriers, ecosystem restoration).

2. **Job Transformation:** Many existing occupations (such as construction workers and trades, heavy-duty mechanics, foresters, and engineers) are seeing their jobs transformed and redefined as day-to-day workplace practices, skill sets, work methods, and job profiles increasingly integrate considerations related to climate change and low-carbon technologies, processes, and operations. Job transformation is different from job creation in that it does not result in a growing labour pool, but rather a 'greening' of existing occupations through reskilling. For example, architects, mechanical engineers, plumbers, and electricians working on more

energy intensive buildings can be re-skilled / re-oriented to carry out similar work, but focused more on improved energy performance (e.g., net zero energy buildings). Transportation managers may increasingly work with intelligent transportation system (ITS) technologies to improve the efficiencies in terms of the movement of goods and people. As another example, forestry professionals and farmers are beginning to use more climate-appropriate seeds and growing methods.

3. **Job Displacement:** Job displacement (job losses) may occur due to economic and policy factors, such as structural changes or shifts due to GHG, energy, and/or material-intensive economic activities being significantly reduced or phased out entirely. An example includes employment in coal extraction and related export industries being curtailed significantly if global climate policies restrict the burning of fossil fuels in the future. Some existing jobs may also be lost (or substituted) as a result of shifts in the economy to lower-carbon products, or technologies, processes and/or operations. Examples include shifts: from fossil fuel-based technologies to renewable electricity (e.g., natural gas furnaces to heat pumps) and from the servicing of internal combustion engine vehicles to electric vehicles. These shifts can be rapid or gradual, both within and across some industries, impacting on key occupations and relevant skills.

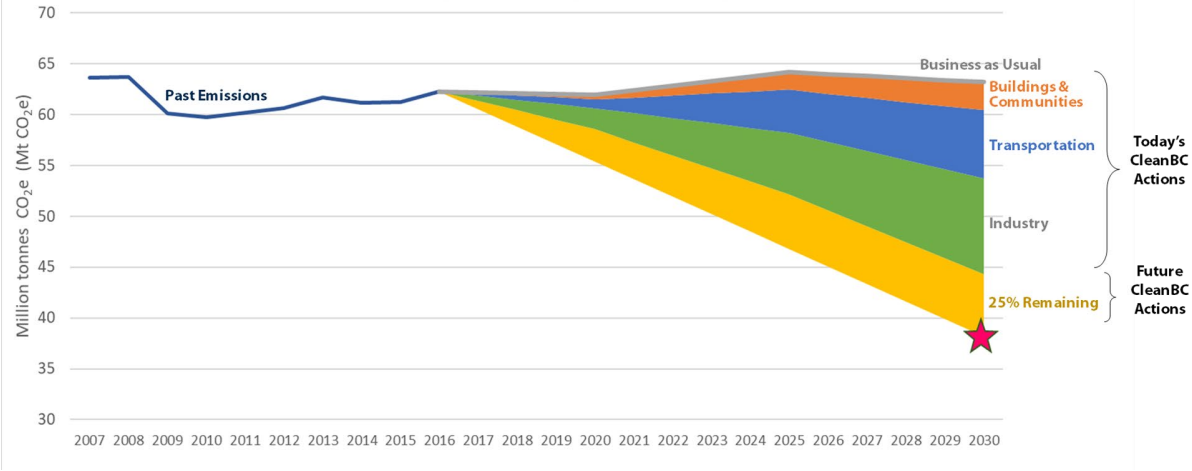
2.3 BACKGROUND ON CLEANBC

British Columbia has been a leader in addressing the causes and impacts of climate change for over a decade, since the release of the Climate Action Plan in 2008.[11] This plan led to a number of foundational policy drivers, such as the Greenhouse Gas Reduction Targets Act, the Greenhouse Gas Reduction (Renewable and Low Carbon Fuel Requirements) Act, the Local Government (Green Communities) Statutes Amendment Act, and the Carbon Tax Act. Together this suite of policies put BC in a leading group of North American sub-national jurisdictions taking action on climate change and helped to drive action at all levels of government from municipalities to other provinces to the federal government.

With the December 5, 2018 release of the CleanBC Plan, the Province of BC has a renewed set of GHG reduction targets, policies, and actions[12] (see Figure 3). CleanBC sets a pathway to a more prosperous, balanced, and sustainable future; it outlines actions to reduce GHG emissions and provides an effective blueprint to build the clean economy. Supported by a commitment of $902 million over three years in the 2019 budget, the 2018 CleanBC plan includes the following key initiatives:

- Directing a portion of B.C.'s carbon tax paid by industry into incentives for cleaner operations;
- Helping communities to achieve 95% organic waste diversion for agricultural, industrial, and municipal waste;
- Making industrial natural gas consumption cleaner by putting in place a minimum requirement of 15% to come from renewable gas;
- Expanding job training, research, and commercialization for electric and other zero emission vehicles; and
- Developing training programs for Energy Step Code and Certified Retrofit Professionals.

[11] See: https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/cap/climateaction_plan_web.pdf
[12] See: https://cleanbc.gov.bc.ca/



Source: CleanBC

Figure 3: Planned GHG emission reductions to 2030 through the CleanBC Plan

These initiatives, combined with forthcoming actions to address the remaining 25% of the plan, are expected to reduce BC's GHG emissions by 25.4 Mt CO2e by 2030, or 40% below the 2007 baseline. These reductions reflect the global commitment established in 2015 in Paris to limit global temperature increase this century to 2 degrees Celsius.[13]

Aside from climate change mitigation and GHG reductions, the initiatives under the CleanBC plan are designed to lead to a cleaner, better future with more opportunities for people and companies throughout the province. As described in CleanBC, this future includes higher-value jobs in both established resource industries and in emerging sectors of the clean economy.

Climate Adaptation and Resilience

From rising temperatures and sea levels to frequent forest fires and flooding, the effects of climate change are already being experienced across British Columbia.[14] Unfortunately, due to the quantity of GHGs already in the atmosphere, the negative impacts currently felt are not only going to continue but are likely to get worse in the subsequent decades.[15]

The Province of BC has announced work on a Climate Adaptation Strategy in 2020 under the broader CleanBC Plan. This work is expected to involve public engagement in early 2020 and be informed by the recent *Preliminary Strategic Climate Risk Assessment for British Columbia* report.[16]

While this work is still in progress, climate adaptation is included in this report within the definition of a clean economy. Climate adaptation workforce considerations can be found in the sector profile sections as well as the Analysis and Discussion section.

[13] See: https://www.canada.ca/en/environment-climate-change/services/climate-change/paris-agreement.html
[14] Ministry of Environment and Climate Change Strategy, Addressing Climate and Health Risks in BC, (accessed November 2019)
[15] IPCC, Climate Change 2014: Synthesis Report, Geneva, Switzerland, (2014) pg. 13
[16] See: https://www2.gov.bc.ca/assets/gov/environment/climate-change/adaptation/prelim-strat-climate-risk-assessment.pdf

2.4 CLEAN ECONOMY WORKFORCE READINESS PROJECT

To ensure British Columbians get the skills they need to thrive in a low-carbon economy, Government is funding the development of a Clean Economy Industry Workforce Readiness Strategy to address the labour and workforce opportunities that will emerge through the implementation of CleanBC.

The Clean Economy Workforce Readiness Project (CEWRP) is designed to support workforce capacity building, guide investment in relevant skills training, and highlight new opportunities for BC's workers in a low-carbon economy. The end goal of the CEWRP is to ensure that BC's clean economy is globally competitive and able to respond to emerging opportunities through training, retraining, and ongoing professional development programs.

This project is funded through the Canada-BC Labour Market Development Agreement's Sector Labour Market Partnerships program as administered by the Ministry of Advanced Education, Skills and Training (AEST). Key elements of the CEWRP include identifying education, training, and professional development needs that align with the growing demand for clean economy jobs and related skills in BC.

Approach

The approach to this project has involved interrelated phases of sector engagement and LMI research, followed by a strategy development phase (see Appendix A for more information on the research methodology).

Project Governance

A key component of the engagement and research efforts involved convening a Steering Committee representing a range of organizations and stakeholder groups to guide the project. The Steering Committee assembled to guide this project had a cross-sector focus on skills training and workforce capacity building and includes participation from relevant provincial government ministries, private sector companies, industry / professional associations, First Nations, leading interest groups and non-governmental organizations (NGOs), labour organizations, and post-secondary education and training institutions (see Appendix B in the Appendices document for the full list).

Engagement of key stakeholders through the Steering Committee and sub-committees helped to guide the project activities and labour market research and also helped to identify the key clean economy workforce issues that the Industry Strategy aims to address. More information about these issues can be found in the Analysis section of this report.

Labour Market Information Research

The multi-faceted approach to LMI research for this project involved primary data collection, analysis of a range of secondary and statistical sources, identifying relevant technology and workforce trends, and validating the highlighted issues through focus groups made up of sector-specific key informants. A more comprehensive description of the project methodology can be found in Appendix A.

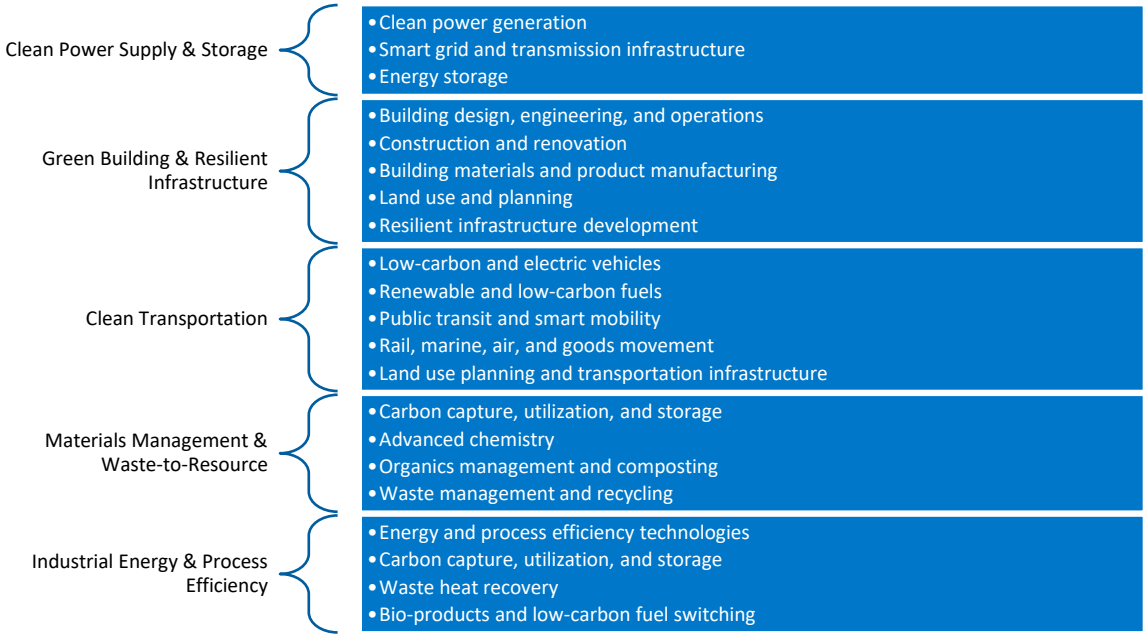
The following research questions were developed in line with the key goals and objectives of the project:

1. What are the largest clean economy employment opportunities in line with emerging trends and BC's competitive strengths and capacity?
2. Where do gaps in education, training, and workforce capacity exist in BC and how can they be addressed to maximize the social, economic, and environmental benefits and opportunities for the province as a whole?

3. How can Indigenous and non-Indigenous peoples work together as equal partners to take advantage of the workforce opportunities in a low-carbon economy?
4. How can under-represented groups in BC's workforce more fully participate in the growing clean economy?
5. What are future opportunities for rural communities across the province in a low-carbon economy?
6. What challenges and barriers exist to the successful implementation of the CEWRP and how can these be best addressed through collaborative solutions?

The first step as it relates to the LMI research phase was to establish a clear working definition and statistical framework for the sectors in scope for this project. The framework includes five 'core' clean economy sectors, 21 sub-sectors, and 60 industries at the 3 and/or 4-digit NAICS code level (see Figure 4 below).

Overall, these sectors and industries represent areas of employment growth potential in BC's clean economy; however, the opportunities vary to different degrees by sector and by region. The definitional framework above also aligns with previous work by the Delphi Group for the Pacific Coast Collaborative[17] and others, Clean Energy Canada's Canadian Clean Energy Jobs Study, as well as the current focus within the CleanBC Plan[18]. A statistical framework for these sectors is based on NAICS codes at the 4-digit level. More details on these five sectors, sub-sectors, and related industries are described in individual detailed sector profiles in the Results section of this LMI Research Summary Report.



Source: The Delphi Group

Figure 4: Clean economy sector framework

[17] See: http://delphi.ca/wp-content/uploads/2015/12/PCC-Clean-Economy-Report-FINAL.pdf
[18] See: https://cleanbc.gov.bc.ca/

Based on the above framework, detailed LMI research and data collection was conducted between December 2018 and December 2019 through a range of primary, secondary, and statistical research activities. Efforts were made to bring together a wide range of sources and perspectives into the research and strategy development.

Through the research, Delphi identified key occupations for the relevant industries that are part of the five core clean economy sectors. This was done by splitting out the total jobs in each sector into the key occupations using NAICS to NOC industry-occupation matrix data developed by the US Bureau of Labor Statistics[19] and similar breakouts published by Statistics Canada at the 3-digit NAICS code level. The key occupations in each sector were then evaluated to determine which are particularly relevant for the transition to a low-carbon economy and the success of the CleanBC Plan. In short, the criteria for identifying key occupations considered:

- The relevant importance of occupations in terms of their absolute numbers within each sector;
- The projected growth potential of each occupation identified through secondary and primary research; and
- The potential for the key occupations to have a direct GHG reduction impact and/or support the CleanBC Plan.

Primary Research & Stakeholder Consultation

More than 500 stakeholders were engaged throughout the Clean Economy Workforce Readiness Project. The project Steering Committee was engaged over a 12-month period, through three in-person meetings and a number of other online engagement sessions and surveys.

More than 50 key informant interviews were conducted as part of this LMI research. In addition, a series of 21 regional and Indigenous-focused community workshops were hosted between June and November 2019 in all eight economic development regions of the province. The Province of BC's EngageBC platform hosted four "open dialogue" forums on clean economy workforce related topics and a targeted industry survey of clean economy employers and training providers garnered additional public input.

Through the input of the sector-specific sub-committees and guidance from the Steering Committee, the issue areas were refined and a strategic framework or "Workforce Readiness Model" and recommendations were developed as part of the Industry Workforce Readiness Strategy for BC's Clean Economy (the "Industry Strategy").

BC STAKEHOLDERS ENGAGED THROUGH THE LMI RESEARCH	500+ Stakeholders	
PROJECT STEERING COMMITTEE	**27 Diverse Members**	• 16 women • 2 youth organizations • 2 Indigenous organizations • 8 regional perspectives
SECTOR-SPECIFIC SUB-COMMITTEES	**5**	
REGIONAL WORKSHOPS	**13**	
INDIGENOUS-FOCUS REGIONAL WORKSHOPS	**8**	

[19] See: https://www.bls.gov/emp/tables/industry-occupation-matrix-industry.htm

Equity Considerations for BC's Clean Economy

The land now known as British Columbia has a long history of Indigenous Peoples living in harmony with the natural environment. Across the varied landscape of the province, 42 unique Indigenous languages and over 90 dialects are spoken, representing 60% of all Indigenous languages in Canada.[20] Despite the rich and diverse historical context, Indigenous Peoples are under-represented in BC's workforce and face significant barriers to employment.[21]

In November 2019, BC became the first province in Canada to adopt legislation to implement the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP). With BC's history of colonial development and current commitment toward reconciliation with Indigenous Peoples, there is both a responsibility and opportunity to transition to a clean economy in a way that focuses on Indigenous Peoples and other traditionally under-represented groups in the workforce.

The approach to research and engagement for this LMI research project (and the ongoing development of the Clean Economy Workforce Readiness Plan Project) has used a Gender-based Analysis Plus (GBA+) approach,[22] as well as included considerations for Indigenous People's participation, in line with reconciliation efforts and the principles of UNDRIP.[23] It has also incorporated considerations for those with high barriers to employment, rural / remote communities (i.e., regional representation), youth and new professionals, and mid-career workers with retraining needs.

The GBA+ lens was used throughout the development of the Clean Economy Workforce Readiness project by asking questions such as the following (adapted from the Government of Canada's GBA+ approach):

- What are the current socio-demographic characteristics of the clean economy sector workforce? Are there any segments of the population that are under-represented (e.g., women, Indigenous people, youth)?
- What are the barriers to participation for under-represented groups (e.g., remote location, employer stereotypes)? Can measures be developed to address any perceived or identified barriers?
- In developing approaches to the issues, have a wide-range of stakeholders been consulted, including under-represented groups?

An overview of GBA+ considerations and an analysis of barriers to clean economy workforce participation by under-represented groups can be found in Section 5 (Analysis and Discussion) of this report.

[20] See: https://maps.fpcc.ca/languages
[21] Statistics Canada. Table 14-10-0364-01 Labour force characteristics by province, region and Aboriginal group
[22] See: https://cfc-swc.gc.ca/gba-acs/index-en.html
[23] See: https://www2.gov.bc.ca/gov/content/governments/indigenous-people/new-relationship/united-nations-declaration-on-the-rights-of-indigenous-peoples

2.5 RESEARCH LIMITATIONS

This Labour Market Information Summary Report has been produced at a stage in the project when engagement and research activities have been completed. While this is designed to be a standalone report, it represents one phase in the broader Clean Economy Workforce Readiness Project which includes the forthcoming Workforce Readiness Plan Strategy. The focus of this LMI Summary Report is to provide economic and employment modelling, based on CleanBC policies, that was undertaken as part of the statistical analysis of each of the five sectors of BC's clean economy. The results of the modelling were presented to the Steering Committee and sub-committees to validate the findings and guide the engagement process.

Within the scope of project timelines and the overall budget, a wide range of businesses, organizations, industry associations, and training institutions have been engaged through the various research and outreach activities. However, given the broad scope of the clean economy as defined for this project, including the five core sectors and 21 sub-sectors, there are thousands of potentially relevant companies and organizations in BC that could have been engaged. Limitations exist around outline outreach in that it is not always the most effective method to collect full context and content from stakeholders. Related to this, there is a risk of engagement fatigue among stakeholders, particularly First Nation communities, small businesses, and local representatives who are asked to provide feedback and advice on a wide range of issues and topics.

In consulting with the economic regions across BC, it also became clear that communities in the northern regions do experience a divide in culture, infrastructure, and economy in contrast to southern regions of the province. This does impact the type of feedback collected from northern regions, given they interpret or experience the targets laid out in CleanBC differently than regions across the southern interior, the Lower Mainland, and southern Vancouver Island.

The divide between culture and values between the northern and southern regions of BC also speaks to the limitation of climate literacy and the clean economy to varying degrees across all regions of BC. While CleanBC focuses on language and concepts that are well understood among businesses and organizations who operate in BC's clean economy, there is a lack of common understanding around the definition of the clean economy and the benefits it brings to communities, businesses, and individuals across BC.

Within the engagement process, there are also limits that exist around clear policy pathways. While CleanBC does outline the reductions targets for green buildings, clean transportation, and industry, there are details within the policy pathways that remain unknown. This lack of clarity does impact the specificity of which stakeholders can provide feedback and guidance on the structure and pathways within CleanBC. It also required a set of assumptions to be established in order to inform the workforce modelling and job forecasting, adding a certain element of risk around uncertainty.

Limitations in the engagement process also existed around the response rate to the industry survey, which impacted the statistical validity of the feedback specific to each sector. While many channels were leveraged through the Steering Committee, regional workshop participants, and relevant industry associations to circulate the survey, the limited response rate could be attributed to constraints on time and/or survey fatigue.

Within the data and statistical analysis that supports this project, there are limitations that exist around the pace at which industry progresses to meet the demands of skills and activities within the clean economy and how that is reflected in statistical tracking of those skills and activities. For example, there are jobs that will be demanded within the growing clean economy that are new and not captured by statistical National Occupational Classification

(NOC) codes. Although similar or equivalent existing jobs can be linked to new jobs, there is a limited degree of accuracy for some which can impact on job models and forecasts.

Also related to the data and statistical analysis is the availability or absence of employment data for certain groups. For example, there is no mention of Lesbian, Gay, Bisexual, and Transgender (LGBT) in the Labour Market Outlook data sets and very little qualitative or quantitative secondary data that speaks to the experience of LGBT people working in the clean economy. Furthermore, it was not possible to isolate age alongside gender or other characteristics to get a broader picture of whether gender-related issues are shifting according to age group or whether these issues are being perpetuated. Lastly, there are limitations that exist around the current state of updated supporting research and information. The EducationPlannerBC tool is an example of a resource for data, although the frequency of which it is updated varies and is not clearly stated within the tool.

3. RESEARCH RESULTS

3.1 BC'S CLEAN ECONOMY

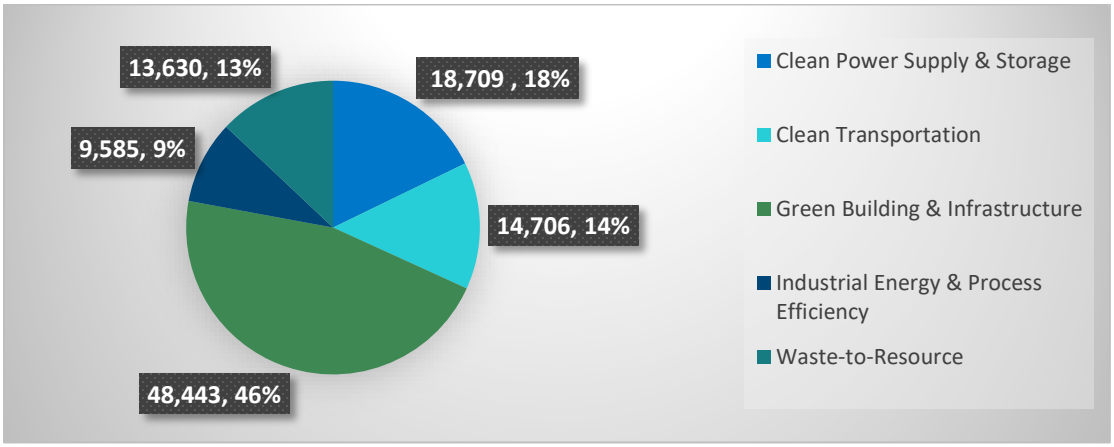
3.1.1 CURRENT JOBS & GDP

In 2018, BC's clean economy was estimated to directly employ approximately 105,100 people and contributed $16.6 billion to GDP. A summary of the economic and employment contributions of BC's clean economy can be found in Table 1and Figure 5 below.

Table 1: Employment and economic contribution of BC's clean economy in 2018 by sector

Sector	Clean Economy Jobs (2018)	Clean Economy GDP ($ Thousands)	Clean Economy Gross Output ($ Thousands)	Gross Output per Job ($ Thousands)
Clean Power Supply and Storage	18,709	6,439,130	9,390,450	501.92
Green Building and Resilient Infrastructure	48,443	4,469,561	9,496,452	196.03
Clean Transportation	14,706	2,957,708	4,105,678	279.18
Materials Management and Waste-to-Resource	9,585	1,336,088	1,354,296	163.69
Industrial Energy and Process Efficiency	13,630	1,354,296	3,132,273	326.79
Total Clean Economy	**105,073**	**16,556,783**	**28,355,876**	**269.87**

Source: The Delphi Group



Source: The Delphi Group

Figure 5: Direct clean economy jobs in British Columbia by sector, 2018

3.1.2 DEMAND-SIDE DRIVERS

Demand-side factors influencing BC's clean economy include a broad range of policy drivers (including the CleanBC Plan and its targets), major projects and investments by industry and governments, as well as broader technology and global market trends and shifts.

Policy Drivers

The low-carbon transition is being driven by policy at many levels, from international agreements to federal policy, to provincial climate leadership, to regional and local-level targets, policies, and actions.

International & Federal Policies

On a national and international level, governments are sending clear signals through policy and funding programs that support innovation, investment and development of the clean economy. Table 2 outlines a sample of the leading policies and funding programs that play a key role in driving the development of BC's clean economy.

Table 1: Sample of international and federal policies and programs relevant to the clean economy

Policy	Relevance / Focus Area
UN Paris Agreement	Global Climate Policy to limit temperature rise
Mission Innovation	$775m in federal clean energy investment
Pan-Canadian Framework	30% reduction of GHG emissions from 2005 levels
Low Carbon Economy Fund	Federal funding to support the Pan-Canadian Framework
Innovation Superclusters Initiative	Digital Technology Supercluster in B.C.
Investing in Canada Infrastructure	$4b in B.C. infrastructure over 10 years
Mid-Century, Low Emissions Development Strategy	Living document to inform the conversation about how Canada can achieve a long-term, low-carbon economy.
Green Municipal Fund	$625m FCM program for sustainable community development
Clean Energy Innovation Program	$49m to support clean energy innovation
Clean Tech Working Group Strategy	Report on options to transition to a low-carbon economy

Provincial Policies & Programs

The CleanBC Plan is the primary focus of this LMI research (and sole focus of the jobs modelling) and includes initiatives in four areas: buildings, transportation, industry, and waste. In addition to CleanBC, Table 3 outlines other key provincial policies and programs that support BC's shift towards the clean economy.

Table 2: Sample of BC policies and programs relevant to the clean economy

Policy	Relevance / Focus Area
CleanBC Climate Plan	Provincial climate plan to reduce GHGs by 18.9 Mt by 2030
CleanBC Communities Fund	$63m green infrastructure fund
BC Energy Step Code	Code for high-efficiency buildings
BC Tech Fund	$100m for early-stage funding to emerging tech companies
Smart Communities Pilot Project	Grants to help small communities use data and connected tech
Small Business Venture Capital Program	Credit to resident investors who invest in BC cleantech companies
Innovate BC	Several programs to support cleantech growth
Clean Growth Program for Industry	Fund for large industrial emitters to make operations cleaner
Carbon Neutral Government	Streamlined procurement of clean technologies for public sector
Innovative Clean Energy (ICE) Fund	Fund to support pre-commercial clean energy projects and tech

Targets and policy actions to reduce GHG emissions in the current CleanBC Plan are focused on a number of specific areas. The primary goals and targets are outlined in Table 4 below. Broad targets include a 40% reduction in GHG emissions in buildings and infrastructure and a 20% reduction in fossil fuel use in transportation.

Table 3: Current CleanBC goals and targets by sector

Sector	CleanBC Policy Goals / Targets
Buildings & Infrastructure	• 60% of homes and 40% of commercial buildings heated by electricity • New buildings 80% more efficient than today (net-zero energy ready buildings) by 2032 • 70,000 homes and 10 million m2 of commercial buildings retrofitted to use electricity in space heating by 2030 • Public buildings reduce GHG emissions by 50% by 2030 • Development of a Remote Community Clean Energy Strategy to reduce the dependence on diesel by 80% by 2030
Transportation	• 30% all new light-duty car / truck sales will be ZEVs by 2030 / 100% by 2040 • Production of 650 million liters of renewable fuels per year by 2030 • Carbon intensity of transportation fuels to drop by 20% (Low Carbon Fuel Standard) • Reduce GHG emissions 40% from B.C. government vehicles • Expand incentives for clean buses and heavy-duty vehicles • Develop a long-term Active Transportation Strategy • Promoting the use of clean fuel sources in transportation trade corridors and ports
Cleaner Industry	• Reduce industrial GHG emissions by 2.5 Mt per year (CleanBC Industry Fund) • Provide clean electricity to planned natural gas production in the Peace region • Reduce methane emissions from the natural gas sector by 45% by 2025 • 15% RNG in the natural gas pipeline by 2030
Waste-as-a-Resource	• 95% of organic waste diverted (including municipal, industrial, and agricultural) from landfills by 2030 • 75% of landfill methane captured by 2030
Others	• TBD (25% towards target)

Source: CleanBC Plan

Local Government Climate Action

Local Governments in BC have been driving climate action since before the Province's 2007 Climate Action Plan and continue to be an important part of the broader policy landscape. Recognition of local government efforts are exemplified through the Climate & Energy Action Awards that spotlights the leadership and innovation taking place of communities from across BC's rural and urban regions. Examples of projects that have received recognition include:

- **City of Kimberley's Sunmine Project (2016)**: Sunmine is a 1-megawatt peak production solar facility featuring 4,032 photovoltaic panels and 96 solar tracks that powers 200-300 homes, with the remainder of electricity sold to BC Hydro. The solar project was constructed on reclaimed mine land, and came to fruition through collaboration between the City, Teck Resources, Province of BC, Innovative Clean Energy Fund, Columbia Basin Trust, and the Southern Interior Development Trust Imitative. During its first year of production, the project generated 1,915 MWh of electricity and $195,730 in revenue and demonstrated valuable cooperation across several major industries in BC. [24]

[24] See: http://communityenergy.bc.ca/cea-2016-award-winners/

- **Terrace Area Integrated Solid Waste Management Program (2017**): The Regional District of Kitimat-Stikine won an award in the Corporate Operations category for the construction of its state-of-the-art waste management facility and transfer station. Combined with a three-stream residential curbside collection program, residential and commercial organics diversion, and solid waste material bans, the program prevented the release of nearly 1,500 tonnes of emissions in less than one year.[25]
- **Capital Regional District – Zero Emissions Fleet Initiative (2018)**: In partnership with Institute for Integrated Energy Systems at the University of Victoria (IES Vic), the Capital Regional District is working to reduce GHG emissions in its fleet over a three year period by: conducting a trial of fuel cell electric vehicles, undertaking a smart fleet analysis to develop tools to optimize the fleet, testing and comparing of the other zero emission alternatives (including battery electric vehicles), and testing of electric bikes. As part of the project, the Province of BC announced the opening of the region's first hydrogen fuelling station in the Fall of 2018.[26]
- **Regional District Central Kootenay (RDCK) – Regional Energy Efficiency Program – New Home and Home Renovation (2019)**: The Regional Energy and Efficiency Program (REEP) is a 2-year integrated, multi-sectoral approach to reducing GHGs in the regions' residential housing stock. Beginning in April of 2019, the project is supported by the Community Energy Association (CEA), Nelson EcoSave / Nelson Hydro, FortisBC, and BC Hydro, and is comprised of 2 programs. The first program is targeted at high performance / energy efficient construction training and education, integration with BC Energy Step Code, policy development and coordination, and region wide communication with member municipalities and rural areas. The second offers subsidized energy assessments, free energy efficiency equipment, and coaching / coordination for energy efficient improvements such as improving insulation (attic, basement / crawlspace, exterior walls), reducing air leakage / increasing air sealing, or converting to energy efficient space and water heating systems (e.g., ductless air source heat pumps). [27]

Major Projects

Based on data available through the BC Major Projects Inventory, there are currently 220 major clean economy projects at various stages of planning and development. These projects include clean energy projects such as the Site C dam, green building projects designed to a LEED gold standard such as the Royal Inland Hospital in Kamloops, clean transportation projects such as the Central Okanagan Multi-Modal Corridor in Kelowna, and a waste-to-energy facility near Surrey City Centre (see Table 4 below).

[25] See: http://communityenergy.bc.ca/2017-climate-energy-action-awards/
[26] See: http://communityenergy.bc.ca/wp-content/uploads/2018/09/2018-CEA-Award-Application-Summaries.pdf
[27] See: http://communityenergy.bc.ca/wp-content/uploads/2019/09/Award-Application-Summaries.pdf

Table 4: Major clean economy related projects in BC by region

Development Region	Total Projects	Total Value of All Projects ($ million)	Projects Proposed		Projects On Hold		Projects Construction Started		Projects Completed	
			Number	Value	Number	Value	Number	Value	Number	Value
1. Vancouver Island/ Coast	**36**	**13,653**	20	7,775	4	872	12	5,006		
2. Mainland/ Southwest	**108**	**25,060**	41	11,946	4	188	57	12,355	6	571
3. Thompson/ Okanagan	**34**	**3,595**	16	1,766	2	134	14	1,276	2	419
4. Kootenay	**5**	**992**	3	68	1	24	1	900		
5. Cariboo	**10**	**1,219**	8	975	1	200	1	44		
6. North Coast	**26**	**92,099**	20	53,526	4	2,491	2	36,082		
7. Nechako	**6**	**585**	5	445	1	140				
8. Northeast	**31**	**32,161**	15	8,595	7	6,084	9	17,482		
Total	**256**	**169,364**	**128**	**85,096**	**24**	**10,133**	**96**	**73,145**	**8**	**990**

Source: BC Major Projects Inventory Q2 2019

Technology Trends

The Fourth Industrial Revolution is characterized by the surge in technological innovation in artificial intelligence and robotics that is driving the digitization and automation of industrial operations.[28] Backed by policy signals and targets at multiple levels of government, these trends in innovation are impacting each sector in different ways as seen in Table 5 below.

Table 5: Sample of technology trends by clean economy sector

Sector	Technological Trends
Clean Power Supply and Storage	Renewable energy technologies, electrification, distributed energy systems, energy storage, digitalization of the energy grid
Green Building and Resilient Infrastructure	Envelope-first approach, high-performance commissioning and design, digitized project delivery, drones and remote sensing, prefabrication and modular construction, wood building construction, advanced building controls and technologies
Clean Transportation	Electrification, autonomous vehicles, smart mobility, last mile / multi-modal solutions, renewable fuels

[28] https://www.weforum.org/about/the-fourth-industrial-revolution-by-klaus-schwab

Materials Management and Waste-to-Resource	Bioeconomy, waste as a resource, extended producer responsibility / designing waste out of products, product-as-a-service, advanced materials
Industrial Energy and Process Efficiency	Precision sensors, blockchain, mechanization / machine learning, additive manufacturing, bioproducts

Source: The Delphi Group

Emerging Skills

Technological innovation is having a significant impact on the clean economy workforce, driving the demand for new and emerging technical skills. A high-level overview of some of the emerging skills are listed in Table 6 below by sector.

Table 6: Examples of emerging technical skills by sector

Sector	Emerging Technical Skills
Clean Power Supply and Storage	Electro-mechanical engineering, advanced manufacturing, design and prototyping, carbon accounting, energy storage
Green Building and Resilient Infrastructure	Integrated design / project delivery, energy modelling, software proficiency, 3D modelling and design (e.g., CAD, BIM), automated control systems, buildings as systems, life-cycle analysis (LCA) and environmental product declarations (EPDs)
Clean Transportation	Electrical and control systems, data science and analytics, 3D modelling, logistics planning, chemical engineering, carbon accounting, batteries and "smart" energy systems
Industrial Energy and Process Efficiency	Digital systems management, carbon capture, heat recovery, advanced chemistry, sensors, 3D modelling and data analysis, materials management
Materials Management and Waste-to-Resource	Material science, supply chain and logistics, GHG emissions modelling

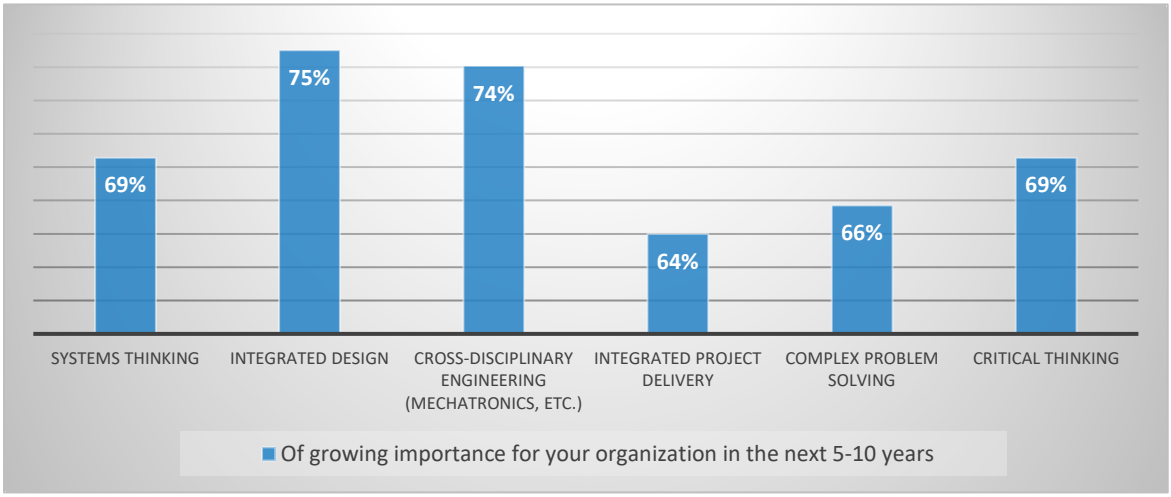
Source: The Delphi Group secondary research and consultation

Cross-functional Skills

In addition to the need for technical skills in the clean economy, there is also a growing need for cross-functional skills (also known as core or soft skills), including critical thinking and communications. Additional cross-functional skillsets were identified by stakeholders as important alongside technical ability in all types of occupations across the sector including:

- Project management
- Collaboration / teamwork
- Social interaction
- Critical thinking
- Diversity
- Multi-fold skillset
- Learning agility
- Leadership
- Problem solving
- Cultural awareness
- Social perceptiveness
- Systems thinking

All employers / business owners active in the clean economy that responded to the Clean Economy Workforce Readiness Project Industry Survey identified broad-based systems thinking as important to their organizations today, with 97% identifying complex problem solving and critical thinking as the most important. Further, respondents highlighted the growing importance of systems thinking across several areas to working in the clean economy, as shown in Figure 6.



Source: Clean Economy Workforce Readiness Project Industry Survey

Figure 6: Broad systems skillsets of growing importance over the next 5-10 years (n=41)

Further, an important set of skills in the workforce supports organizational needs in the changing political and regulatory landscape. These skills are particularly key for those with technical backgrounds who may be moving into management or senior roles.

3.1.3 EMPLOYMENT GROWTH PROJECTIONS

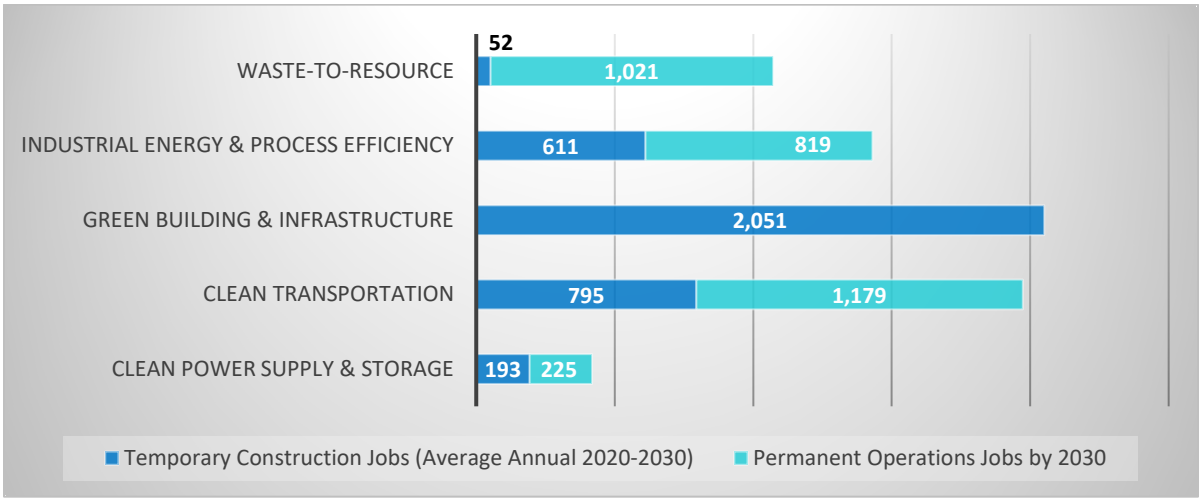
Job Creation

Economic and employment modelling undertaken as part of this LMI research, in line with the policy goals and targets outlined in the initial CleanBC Plan released in December 2018 (summarized in Table 3 above), suggests that approximately 3,700 temporary construction jobs on average per year (between 2020 and 2030) and 3,240 ongoing jobs in operations will be created by 2030. (see Figure 7 below). The Green Building and Infrastructure sector is projected to see more than half (55%) of the temporary construction jobs, followed by the Clean Transportation sector (22%), and the Industrial Energy and Process Efficiency sector (17%).

It has been assumed that the construction investments related to the CleanBC policies are evenly spread between 2020 and 2030. However, investments related to some policies are likely to be made prior to 2025 (e.g., reductions related to methane emissions from the natural gas industry) while others may come after 2025 (e.g., scale-up of larger biofuel production facilities).

In terms of ongoing jobs in operations, the Clean Transportation and Materials Management and Waste-to-Resource sectors are projected to see approximately 1,180 and 1,020 jobs created by 2030, respectively, equal to approximately two-thirds (67%) of the total operational jobs.

More details on these job creation impacts by sector are detailed in the Workforce Demand section of each sector profile chapter that follows, including breakouts and underlying assumptions by policy goal, as well as geographic and occupation-specific considerations.



Source: The Delphi Group

Figure 7: Projected job openings by sector based on modelling of initial CleanBC Plan policies

Job Transformation

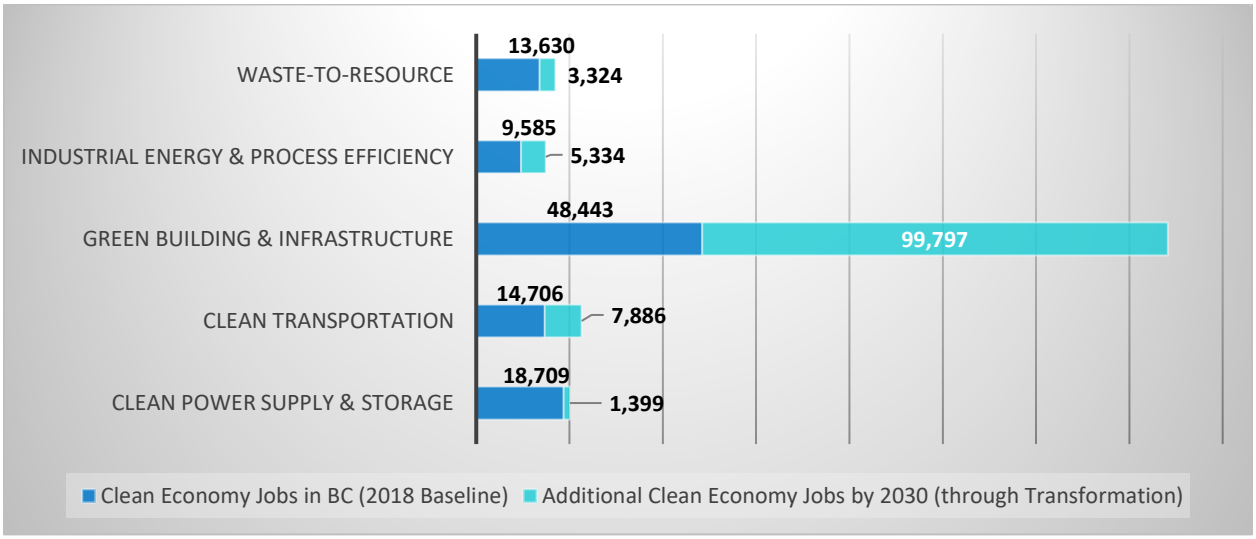
In addition to the new jobs created by CleanBC through expansion demand and new investments, the policy goals are expected to have an impact on job transformation within existing industries and occupations, as more people work on clean economy-related projects, as well as with related technologies, equipment, and/or processes – essentially greater market penetration within the existing labour pool.

While not affecting the total size of the labour pool, the impact of job transformation is important to consider as it relates to specific occupations and the need for retraining / upskilling to align supply with demand due to climate action. Examples include carpenters who need the skills to build to net zero energy performance standards in construction and automotive service technicians who may need retraining for electric and zero emission vehicles.

Figure 8 shows the projected growth of clean economy workers in BC over the next decade, from approximately 105,070 in 2018 to more than 222,800 in 2030. The greatest impact in terms of job transformation is expected for the Green Building and Infrastructure sector, due largely to the policy goal for all new construction in BC to be net zero energy ready by 2030, which has ripple effects across the broad building value chain. Based on the projected rate of market penetration for energy efficient and net zero buildings, the Green Building and Infrastructure sector is forecast to go from a total of 48,440 clean economy workers in 2018 to approximately 148,240 by 2030.

The Clean Transportation sector is also expected to see job transformation impacts as a result of a greater market penetration of lower-carbon fuels and zero emission vehicles (ZEVs) by 2030 in line with CleanBC policy goals, with the sector having more than 22,500 clean economy jobs by 2030. The Industrial Energy and Process Efficiency sector will also see more workers involved with clean economy projects and technologies, with a total of 14,910 clean economy workers by 2030.

Job transformation considerations are presented in more detail in the Workforce Supply section of each sector profile chapters that follow.



Source: The Delphi Group

Figure 8: Projected clean economy job transformation in BC by sector, 2018-2030

Job Displacement

Based on the economic and employment modelling undertaken as part of the LMI research in line with the policy goals and targets outlined in the initial CleanBC Plan, the risks for job displacement are relatively low. The shift toward more electrically heated buildings (e.g., to heat pumps and electric boilers) and away from natural gas equipment is expected to result in some job substitution and potential displacement within the HVAC sector as work shifts from gasfitters to refrigeration and air conditioning mechanics, plumbers, and electricians. Based on initial modelling for the Part 9 residential sector, electric heating is expected to generate approximately 147 temporary construction jobs per year on average for HVAC trades between 2020 and 2030, while potentially displacing on 73 temporary jobs in construction per year (the most at risk being residential gasfitters). The overall net result is a creation of 73 temporary construction jobs per year related to the residential HVAC sector. Given population and climate considerations in BC, retrofit activities and related job displacement impacts are largely expected to be felt in the Mainland / Southwest, on Vancouver Island / Coast, and the Thompson Okanagan within the 2030 timeframe.

Job displacement may also occur for traditional automotive mechanics working on internal combustion engine (ICE) vehicles given the need for less regular maintenance of EVs (i.e., no oil changes, spark plug changes, less brake servicing due to regenerative braking, etc.) and warranties that require going direct to dealerships and

manufacturers. The estimated displacement is approximately 1,460 permanent jobs by 2030. Given the adoption of EVs in the light-duty vehicle market is projected to be faster in the province's urban centres, and largely in Southwestern BC, job displacement is most likely to impact these regions within the 2030 timeframe. However, it is unlikely that sudden layoffs of mechanics would occur given existing vehicle market will still have considerable ICEs in 2030 and opportunities for retraining exist.

Finally, some additional job displacement may occur as demand for high-carbon products shift to low-carbon (e.g., from coke-fired cement kilns to biomass, from coal exported to Asia for metallurgic steel to carbon fibre alternatives, etc.), as well as due to broader macro-trends and disruptive technologies such as automation, pre-fabrication, modular construction, and additive manufacturing. These potential job displacement impact factors were not modelled as part of this LMI research given the challenge of isolating the impact from CleanBC as opposed to broader macro trends and forces.

While the net employment benefits outweigh the losses in the short-term from potential job displacement due to CleanBC, it will be important to consider potential risks for workers and develop strategies to address the risks through retraining and other actions.

3.2 CLEAN POWER SUPPLY & STORAGE SECTOR

3.2.1 SECTOR OVERVIEW

The Clean Power Supply and Storage sector includes electricity generation, transmission infrastructure, smart / microgrid solutions, and energy storage (see Table 7). There were approximately 18,710 jobs in BC's Clean Power Supply and Storage sector in 2018. Gross domestic product related to this sector is estimated to be $6.4 billion in 2018, with a gross output per job of $502 thousand.

Table 7: Employment and economic contribution of BC's Clean Power Supply and Storage Sector (2018)

Clean Power Sector Jobs	Clean Power Sector GDP ($ Millions)	Clean Power Sector Gross Output ($ Millions)	Clean Power Sector Gross Output per Job ($ Thousands)
18,709	$6,439	$9,390	$501.9

Source: The Delphi Group based on Statistics Canada data

Of the workers currently employed in the Clean Power Supply and Storage sector, 52% are between the ages of 25 and 64 (see Table 8). The median annual salary in 2018 was $72,411, while the workforce consisted of 80% men and 20% women.

Table 8: Socio-economic profile of BC's Clean Power Supply and Storage Sector (2018)

Remuneration	Employment by gender (%)		Employment by age group (%)			
Median Annual Salary	Men	Women	15-24	25-44	45-64	65+
$72,411	80%	20%	7%	52%	37%	3%

Source: Delphi's estimate from BC Labour Market Outlook (2018-2028) wage data by occupation

Electricity Generation

In British Columbia, this sector is characterized by a legacy of abundant clean power from hydroelectric dams across the province. According to the National Energy Board, non-hydro renewables reached 8% of total capacity in 2015, amounting to a 70% (563 MW) increase between 2005 and 2015.[2] A breakdown of renewable electric capacity and generation can be found in Table 9 below.

BC Hydro is a Crown corporation and the public power utility for British Columbia, providing power to 95% of the population (over 4 million customers). Within the area of electricity generation, BC Hydro operates 21 hydroelectric facilities, 3 thermal generation plants, and oversees electricity purchase agreements (EPAs) with independent power producers (IPPs) who operate small scale hydro, biomass, and wind projects that feed into the grid. Over the past decade, many small IPPs that were granted EPAs have been acquired or have merged with larger IPP companies such as AltaGas, Atlantic Power, Innergex, and Veresen.[29]

Table 9: Renewable electricity capacity and generation in BC

	Capacity in MW and %		Generation in GWh and %	
	2005	**2015**	**2005**	**2015**
Hydro	12,847	15,029	60,327	57,374
	85%	84%	89%	86%
Wind	0	488	0	1,206
	0%	3%	0%	2%
Biomass	811	886	3,254	3,711
	5%	5%	5%	6%
All Renewable Sources	13,658	16,405	63,581	62,292
	91%	92%	94%	94%
All Sources	15,030	17,913	67,774	66,565

Source: National Energy Board

FortisBC's electricity services provide electricity to the Southern Interior region of BC. This service area includes approximately 132,000 direct customers and approximately 36,000 indirect wholesale customers in Summerland, Penticton, Grand Forks, and Nelson.[30] These municipalities operate their own distribution systems and purchase electricity from FortisBC. The City of New Westminster also operates their own distribution system and purchases electricity from BC Hydro.[31]

Aside from BC Hydro and FortisBC, the province has a diverse network of clean energy producers connected through Clean Energy BC.[32] This network includes development and operating companies, suppliers, contractors, service providers, and many First Nations communities.

[29] See: http://globe.ca/wp-content/uploads/2012/10/GLOBE_BCCleanEnergyReport_FINAL.pdf
[30] See: https://www.fortisbc.com/about-us/regulatory-affairs/our-electricity-utility/electric-bcuc-submissions/resource-plans-for-electricity/2016-long-term-electric-resource-plan
[31] See: http://www.ampcbc.ca/energybc.html
[32] See: https://www.cleanenergybc.org

Smart Grid and Transmission Infrastructure

In terms of transmission and distribution, over 23,000 km of high-voltage electrical transmission lines run throughout the province.[33] Within this larger network, BC Hydro maintains over 18,000 km of transmission lines, connecting the major generating facilities in the northern and southern interior regions with the heavily populated region in southeast BC.[34]

Construction of new transmission infrastructure is required to connect clean energy projects to the distribution grid and to customers. Many projects are located in remote areas and require the construction of roads, transmission lines, and telecommunication infrastructure. Several of BC Hydro's planned major projects involve upgrading transmission and substation infrastructure to meet increasing demand and to optimize the delivery of renewable resources. The Major Projects Inventory Q2 2019 contains 9 clean energy projects with a transmission component, totalling $5.9 billion.[35]

Smart, modernized electricity grids and related transmission and distribution infrastructure allow for management of a more resilient and responsive digital electricity supply system capable of per-kilowatt pricing, selective conservation, renewable power integration, and the addition and storage of surplus power. Technologies that reduce voltage fluctuations result in less wasted energy and allow equipment to work properly through ensuring steady incoming power.

Smart grids have several applications in BC at various levels of deployment.[36] The application of Advanced Metering Infrastructure is broadly deployed across the province, while other applications are in the research and planning phase, including for:

- Distributed Energy Storage
- Self-Healing Grids
- Microgrids
- Voltage and Volt-Ampere Reactive Control

Table 10 below outlines differences between older 20th century grids and modern smart grid technology.[37]

Table 10: Benefits of 21st century smart grid technology

20th Century Grid	21st Century Smart Grid
No communications capability	Integrated two-way communications between the customer and utility
Customer cost / consumption feedback provided through bills only	Customer cost / consumption feedback provided near real-time and via multiple choices
No outage detection (customer must call in)	Automated outage detection and notification
Limited ability to support conservation rates and then, only simple rate structures	Full ability to support multiple types and complex conservation rates

[33] See: https://catalogue.data.gov.bc.ca/dataset/bc-transmission-lines
[34] See: https://www.bchydro.com/energy-in-bc/operations/transmission.html
[35] See: https://www2.gov.bc.ca/gov/content/employment-business/economic-development/industry/bc-major-projects-inventory
[36] See: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/canmetenergy/files/pubs/SmartGrid_e_acc.pdf
[37] See: https://www.bchydro.com/content/dam/hydro/medialib/internet/documents/news/press_releases/clean_energy_act/fact_sheet_smart_grid.pdf

No tamper detection capability	Automated meter tamper alarms, support for theft detection strategies
Built for centralized generation	Accommodates distributed generation
Few sensors to provide information on system status	Self-monitoring with sensors throughout
Manual restoration	Semi-automated restoration and eventually self-healing
Few consumer choices	Many consumer choices

Source: BC Hydro

The smart microgrid project at BCIT's Burnaby Campus is another facility that provides government and private sector partners with a test-bed for a variety of smart grid technologies.[38] Powertech Labs, a wholly-owned subsidiary of BC Hydro, operates facilities in Surrey capable of testing for a variety of applications, including:[39]

- EV data collection and analytics (from vehicles or infrastructure)
- EV communications pathways validation (AMI, IP based, HAN, FAN, SCADA, Open Standards and others)
- Use case development and simulation
- Interoperability testing and verification

Smart grid technologies are also being integrated with renewables into microgrid systems as an efficient way to produce, store, and distribute energy at the district scale. British Columbia is home to functioning microgrids in remote and First Nations communities, including Gitga'at Nation[40] in Hartley Bay and T'Sou-ke Nation on Vancouver Island.[41]

Energy Storage

Energy storage includes a variety of methods to harvest excess energy and store it until it is needed, either due to increasing demand or a dip in generation from intermittent sources like wind or solar. The most common form of energy storage in BC today is our large dams, which act as storage batteries and firm (i.e., provide backup support for) other types of renewables.

Energy storage is a rapidly growing component of the Clean Power Supply and Storage sector due to the falling cost of batteries and the growth of complementary renewable energy technologies like wind and solar, particularly for industry and remote communities in BC without direct grid access. It is also an evolving space for the 'prosumer', consumers that are able to generate power at home, store it through batteries and/or through a connection to their electric vehicles, and then sell it back to the utility through a grid-tied system. Combining energy storage with renewables provides a solution to peak demand, aging infrastructure, and low-carbon solutions, and system costs are expected to drop between 50-70% by 2025.[42]

[38] See: https://www.bcit.ca/files/appliedresearch/pdf/smart_microgrid_brochure.pdf
[39] See: https://www.powertechlabs.com/services-all/ev-smart-grid-integration
[40] See: https://www.nrcan.gc.ca/energy/offices-labs/canmet/publications/smart-grid/14421
[41] See: http://www.tsoukenation.com/first-nation-takes-lead-on-solar-power/
[42] See: https://www.airdberlis.com/insights/blogs/energyinsider/post/ei-item/2018-energy-storage-developments-in-the-last-twelve-months

BC-based companies are developing innovative energy storage solutions that can be used in specialized applications like the film industry and disaster relief,[43] while others are developing scalable zinc-air flow batteries to service a wide range of applications.[44] Other energy storage solutions are well-suited to remote communities either operating on diesel generation or prone to power outages.[45] For example, in 2013, BC Hydro completed a $13.5 million project to install a 1 MW battery energy storage system in the community of Field that provides clean back-up power and enhanced reliability.[46]

3.2.2 TECHNOLOGY TRENDS & MARKET SHIFTS

The business case for investment and development of clean power is stronger than ever as costs for renewable power generation and storage technologies have dropped at exponential rates in the last decade. This has resulted in job growth as more renewable projects are able to compete with conventional, carbon-based energy, increasing deployment at the global, national, and regional levels.[47]

The technology trends shaping this sector on a macro scale are described at a high level in Table 11 below. These trends are creating a demand for skilled professionals, particularly for those experienced in the areas of energy management and renewable power project development and deployment.

Table 11: Key technology trends impacting the Clean Power Supply and Storage Sector

Trend	Description
Renewable Technologies	Solar, wind, hydro technologies are seeing consistent annual increases in production as governments and business continue to channel significant investments to increase capacity.
Electrification	From individual sensors to entire cities, the shift toward electrification for communities and industry is a significant piece of the low-carbon transition which is also driving down the cost renewable technologies.
Distributed Energy Systems	Utility and grid operators are seeing new business models emerging, and disruptive energy technologies are expected to reach key milestones in the next decade.[48] Much of this is enabled by energy storage and the shift to smart grid technologies that allow better demand and supply of energy.
Energy Storage	The cost of energy storage systems is expected to fall 50-70% by 2025.[49] The costs of batteries have declined as much as 65% in the past five years, with the global battery market expected to hit US$250 Billion by 2040.[50]

[43] See: https://www.forbes.com/sites/eshachhabra/2018/10/30/how-a-canadian-startup-used-clean-tech-to-help-rebuild-the-carolinas-after-the-hurricanes/#7a4403953b2c
[44] See: https://www.mgxrenewables.com/technology/target-markets.html
[45] See: http://energystorageactivity.ca/region/british-columbia/projects/bc-remote-community-integrated-energy-bcrcie-project
[46] See: https://www.nrcan.gc.ca/energy/funding/current-funding-programs/cef/4981
[47] See: https://cleantechnica.com/2018/03/10/renewable-energy-economic-benefits-know/
[48] See: https://www.pwc.com/ca/en/industries/power-utilities/publications/gaining-momentum-energy-transformation.html
[49] See: https://www.airdberlis.com/insights/blogs/energyinsider/post/ei-item/2018-energy-storage-developments-in-the-last-twelve-months
[50] See: https://about.bnef.com/new-energy-outlook/

	BC-based cleantech companies focused on energy storage solutions are seeing growth in demand for their products and technologies in line with global markets.[51]
Digitalization of Energy Systems	Digitization can have significant impacts on energy grids and enables technical cascades like Blockchain and distributed generation[52]. Digitization of the energy market is forecast to hit US$45B by 2025.[53]

3.2.3 KEY INDUSTRIES

Industries and sub-sectors that make up the Clean Power Supply and Storage sector include services to plan and design new projects, maintain existing facilities and infrastructure, as well as companies involved in the manufacturing of equipment to generate, transmit, and store power, and the research and development of new technologies to improve the efficiency of the systems involved. The most relevant industries are listed below in Table 12 by North American Industry Classification System (NAICS) code and sub-sector.

Table 12: Sub-sectors and industries that make up BC's Clean Power Supply and Storage Sector

NAICS Code	Description	Sub-sector(s)
2211 Electric power generation, transmission and distribution	Generation of bulk electric power, transmission from generating facilities to distribution centers, and/or distribution to end users.	Electricity generation / Smart grid & transmission infrastructure
2371 Utility system construction	Construction of distribution lines and related buildings and structures that are integral parts of utility systems, including storage tanks, pumping stations, and power plants.	All sub-sectors
2379 Other heavy and civil engineering construction	Construction, rehabilitation, and repair of heavy and civil engineering works, specialized trade activities, construction projects.	Electricity generation / Smart grid & transmission infrastructure
2389 Other specialty trade contractors	New construction, maintenance, and repair related to site preparation and other specialized trade activities such as crane operation, solar panel installation, fence installation, sandblasting, steeplejack work.	Electricity generation / Smart grid & transmission infrastructure
3336 Engine, turbine and power transmission equipment manufacturing	Manufacturing of turbines and turbine generator sets, internal combustion engines, speed changers, and industrial high-speed drives and gears. Includes manufacturing wind- and solar-powered turbine generators and windmills for generating electric power.	Electricity generation / Smart grid & transmission infrastructure
3344 Semiconductor and other electronic component manufacturing	Manufacturing of semiconductors and other electronic components, production of circuit boards, loading components onto circuit boards.	Electricity generation
3345 Navigational, measuring, medical and control instruments manufacturing	Manufacturing of automatic environmental controls and regulators and industrial process control instruments.	Smart grid & transmission infrastructure
3353 Electrical equipment manufacturing	Manufacturing of equipment that generates and distributes electrical power. Includes power, distribution, and specialty transformers, motors, and generators.	Electricity generation / Smart grid & transmission infrastructure

[51] See: https://corvusenergy.com/corvus-energy-to-expand-production-in-response-to-high-demand-for-energy-storage/
[52] See: https://about.bnef.com/blog/digitalization-energy-systems/
[53] See: https://about.bnef.com/blog/market-digitalization-energy-sector-grow-64bn-2025/

3359 Other electrical equipment and component manufacturing	Manufacturing of electrical power storage and transmission devices, and accessories for carrying current.	Smart grid & transmission infrastructure / Energy storage
5413 Architectural, engineering and related services	Provision of architectural, engineering and related services, such as structure design, drafting, landscape design, surveying and mapping, laboratory and on-site testing, and other specialized design services.	Electricity generation / Smart grid & transmission infrastructure
5416 Management, scientific and technical consulting services	Provision of expert advice on management, environmental, scientific and technical issues.	All sub-sectors
5417 Scientific research and development services	Conducting research and applying findings to improved products or processes.	All sub-sectors

3.2.4 KEY OCCUPATIONS

Key occupations in the Clean Power Supply and Storage sector are listed in Table 13 by National Occupational Classification (NOC) code. These occupations were initially identified using statistical analysis. The key occupations (by NOC code) for industries relevant to this sector at the 3-digit NAICS code level (as published by Statistics Canada in its 2011 Census breakouts) were amalgamated across industries. The key occupations were then validated through additional secondary research and industry consultation as part of the LMI research.

Table 13: Key occupations in BC's Clean Power Supply and Storage Sector

NOC	Occupation
0912	Utilities managers
2131	Civil engineers
2133	Electrical and electronics engineers
2171	Information systems analysts and consultants
2173	Software engineers and designers
2174	Computer programmers and interactive media developers
2233	Industrial engineering and manufacturing technologists and technicians
2241	Electrical and electronics engineering technologists and technicians
5241	Graphic designers and illustrators
7243	Power system electricians
7244	Electrical power line and cable workers
7312	Heavy-duty equipment mechanics
9212	Supervisors, petroleum, gas and chemical processing and utilities
9241	Power engineers and power systems operators
9523	Electronics assemblers, fabricators, inspectors and testers

Source: Delphi Group

Key occupations within the Clean Power Supply and Storage sector include roles involved in the planning, design, construction, operation, and maintenance of facilities and infrastructure from the site of power generation to the customer. Many clean energy projects involve aspects also found in other capital infrastructure projects, including skilled trades and other professionals that are in demand at various stages of planning, construction, and operations.[54] Another important part of the value chain is people working to manufacture equipment and parts for power generation and distribution, including turbines, penstocks, energy storage solutions, switches and relays, and power transmission infrastructure components.[55]

3.2.5 WORKFORCE DEMAND

Demand-side Drivers

Workforce demand in the Clean Power Supply and Storage sector is driven by both the development of new projects and renewable energy sources, as well as the maintenance and modernization of existing assets. Under the *Clean Energy Act,* utilities and the BC Utilities Commission (BCUC) are required to meet a number of objectives including: [56]

- generating clean affordable electricity while working towards GHG reduction targets,
- creating jobs through clean electricity projects,
- developing renewable resources in rural and First Nation communities, and
- meeting at least 66% of the expected increase in demand through conservation and efficiency by 2020.

BC Hydro forecasts that demand for electricity is expected to grow almost 40% over the next 20 years due to the addition of over 1 million residents to BC, economic expansion (particularly in the Lower Mainland), the emerging LNG sector, and uptake of electric vehicles.[57] Expansion of generation capacity will be required to power LNG industry beyond initial 3,000 GWh load.[58] The current June 2019 load projection considers a mid-EV forecast that exceeds the targets set out in the *Zero-Emission Vehicles Act.* This forecast reflects the CleanBC Plan and expects annual load growth of approximately 1% over the next 20 years.[59]

It is important to note that in 2016, BC Hydro conducted a review of the 2013 Integrated Resource Plan (IRP) and updated their 20-year electricity demand and expected supply forecast. The next IRP is scheduled to be filed with BCUC by February 2021.[60] There are some industry experts that feel the forecast demand for power in BC will be greater than BC Hydro's latest projections, particularly in line with LNG project development and CleanBC. Opportunities exist to consider diversified pathways beyond electrification that may deliver similar GHG emissions reductions, including more use of renewable gas, such as RNG and hydrogen, in the energy mix.

[54] See: http://globe.ca/wp-content/uploads/2012/10/GLOBE_BCCleanEnergyReport_FINAL.pdf
[55] See: http://cleanenergycanada.org/report/missing-the-bigger-picture/
[56] See: https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/regulatory-planning-documents/integrated-resource-plans/current-plan/0000-nov-2013-irp-summary.pdf
[57] See: https://www.bchydro.com/news/conservation/2017/long-term-energy-capacity-needs.html
[58] See: https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/regulatory-planning-documents/integrated-resource-plans/current-plan/0000-nov-2013-irp-summary.pdf
[59] See: https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/regulatory-planning-documents/regulatory-filings/rra/00-2019-10-03-bchydro-f20-f21-rra-20-year-load-forecast.pdf
[60] See: https://archive.news.gov.bc.ca/releases/news_releases_2017-2021/2019EMPR0010-000539.htm

Major Projects

BC's Major Projects Inventory (Q2 2019) contains 95 clean energy projects at various stages of planning, approval, and construction (see Table 14 below).

Table 14: Clean Power Supply and Storage sector projects in the BC Major Projects Inventory

Development Region	Number of Projects[61]	Estimated Cost ($ millions)
1. Vancouver Island/Coast	10	5,605
2. Mainland/Southwest	29	2,156
3. Thompson/Okanagan	15	821
4. Kootenay	2	74
5. Cariboo	7	1,090
6. North Coast	10	3,887
7. Nechako	3	231
8. Northeast	19	16,470[62]
Total	**95**	**30,334**

Source: BC Major Projects Inventory Q2 2019

This includes over 50 hydroelectric projects, 16 wind projects, and several other renewable energy projects (e.g., tidal, geothermal, biomass). Note that of the projects listed in this table, 28 have started construction or been recently completed; these projects include Site C at $10.7 billion, and the Peace Region Electricity Supply project at $285 million.

In addition to Site C, BC Hydro is undertaking several major upgrades and expansion of existing generating facilities and related infrastructure. In total there are 13 major projects with capital costs exceeding $50 million to be completed between 2018 and 2024 (see Table 15).[63] [64]

With respect FortisBC, in its 2016 Long Term Electric Resource Plan submission to the BCUC, the company does not expect to require new supply-side resources for the next ten years based on current forecasts, existing contracts, and demand-side management activities.[65]

[61] Clean Power Supply and Storage projects in the MPI include hydroelectric, run-of-river, wind farms, biomass facilities, solar energy, geothermal plants, and tidal energy projects. Renewable energy by definition is an energy source that can be renewed naturally at a rate that exceeds its rate of consumption.
[62] The Site C Project accounts for $10.7 billion of this total value.
[63] See: https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/accountability-reports/financial-reports/annual-reports/BCHydro-Crown-Corporation-2017-18-Annual-Report.pdf
[64] Ibid.
[65] See: https://www.fortisbc.com/about-us/regulatory-affairs/our-electricity-utility/electric-bcuc-submissions/resource-plans-for-electricity/2016-long-term-electric-resource-plan

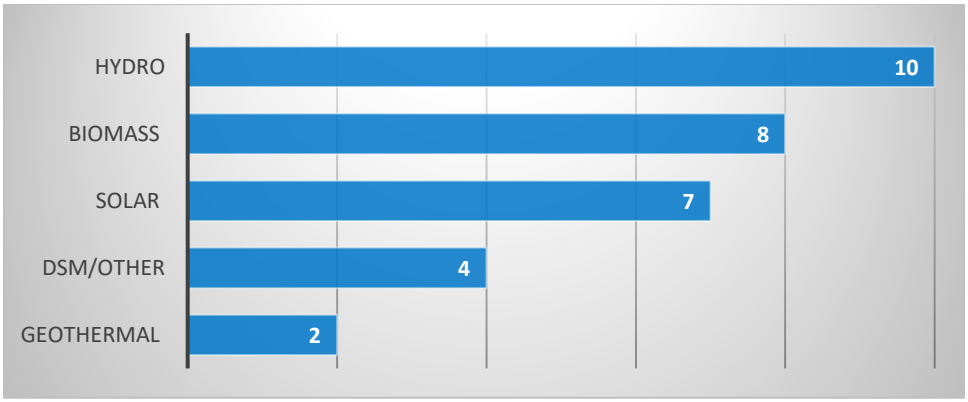
Table 15: Projected costs and completion dates of major clean electricity-related capital projects in BC

Major Capital Projects	Estimated Cost to Complete ($ millions)	Targeted Completion Date
Site C Project	2,354	2024
John Hart Generating Station Replacement	203	2019
W.A.C Bennett Dam Riprap Upgrade Project	61	2019
Cheakamus Unit 1 and Unit 2 Generator Replacement	40	2019
South Fraser Transmission Relocation Project	28	TBD
G.M. Shrum G1-G10 Control System Upgrade	24	2022
Bridge River 2 Units 5 and 6 Upgrade Project	23	2019
Fort St. John and Taylor Electric Supply	5	2020
UBC Load Increase Stage 2 Project	5	2021
Mica Replace Units 1-4 Transformers Project	3	2022

Source: BC Hydro

Considerations such as resiliency and self-sufficiency are driving the continued development of new clean energy projects and investments around the province on a smaller scale, particularly for more remote communities that have historically been dependent on diesel. First Nations in BC are leaders in renewable energy project development and deployment, with projects that include the T'Sou-ke First Nation's 75 kW solar project on southern Vancouver Island.[66]

Many First Nations communities have been historically reliant on electricity generation using diesel and other fossil fuels. The business case for moving to clean power has been identified by a number of First Nations communities and programs such as the BC Indigenous Clean Energy Initiative (BCICEI) exist to provide support and capacity building (see Figure 9), with more than 30 clean energy projects funded through the BCICEI program between 2016 and 2018 in all regions of the province – including in hydroelectricity, biomass, solar, geothermal, and energy efficiency measures (Demand-side Management or DSM).[67]



Source: Western Economic Diversification Canada

Figure 9: Number of projects funded through the BC Indigenous Clean Energy Initiative, 2016-2018

[66] See: http://www.tsoukenation.com/first-nation-takes-lead-on-solar-power/
[67] See: http://www.newrelationshiptrust.ca/initiatives/bcicei/

Employment Impacts from CleanBC

CleanBC does not set out specific overarching goals related to the Clean Power Supply and Storage sector. However, it does include two specific goals:

1. Provide investments to help remote communities move to cleaner sources of power by 2030, including:
    - Supporting communities to develop expertise and experience in energy efficiency and clean generation.
    - Implementing renewable energy projects to offset all or most remaining diesel generation, including rooftop solar photovoltaic, biofuels, and community-scale renewable systems. [68]
2. Provide clean electricity to planned natural gas production in the Peace region and increase access to clean electricity for large industrial operations.

Key Considerations by CleanBC Policy Goal

Employment considerations and assumptions for the policies outlined above are described below.

1. Increased renewable power for remote and Indigenous communities

Policy Details: Initial spending from BC's 2019 Budget provides $18 million in support of Indigenous and remote communities to move toward more renewable power solutions. Further, the CleanBC Remote Community Energy Strategy (RCES) looks to eliminate or significantly reduce diesel consumption in remote communities by targeting 22 diesel generating stations across BC (12 BC Hydro stations and 10 independently-owned stations supported by Indigenous Services Canada).

Assumptions: Approximately 10 small community energy projects are developed per year (between 2020-2030) with 3-year development cycles on average, and 2 larger community projects per year (with 4-year development cycles). The projects are largely solar PV and biomass (heat and/or power), with a smaller number of micro-hydro and geo-exchange. Equal to $82M in total capital expenditures between 2020-2030.

Timelines: Steady capital investments between 2020-2030.

Geographic: Rural and remote communities (Indigenous and/or diesel-dependent) outside of the Mainland / Southwest region.

Job Impacts: 24 temporary construction jobs on average per year (2020-2030), and approximately 167 ongoing jobs in operations / maintenance by 2030. There is no identified risk in terms of job displacement, apart from some minor impacts on those currently running diesel generators / generating stations with renewable power system and energy storage skill sets.

Employment impacts largely related to occupations in engineering, site planning / community engagement, construction trades, as well as system operations and maintenance for solar PV, biomass, small hydro, district heating, and micro-grid. While much of the employment opportunities in clean power projects are during the development stage, facility operators in BC require specific skillsets to operate and maintain equipment.

[68] See: CleanBC plan, page 33.

2. Increased electricity transmission infrastructure for powering industrial operations

Policy Details: A focus of the CleanBC Plan is to connect clean energy sources with large industrial operations to reduce GHG emissions from fossil fuels. A specific project is the $289 million Peace Region Electricity Supply project (800 MW) that will see the construction of two 230 kilovolt lines near Fort St. John to meet the growing electricity demand of the natural gas industry (meant for completion in 2021).[69] In addition, a recent memorandum of understanding between the Government of Canada and the Province of BC has earmarked funding for $680M in near-term electrification projects in the North.

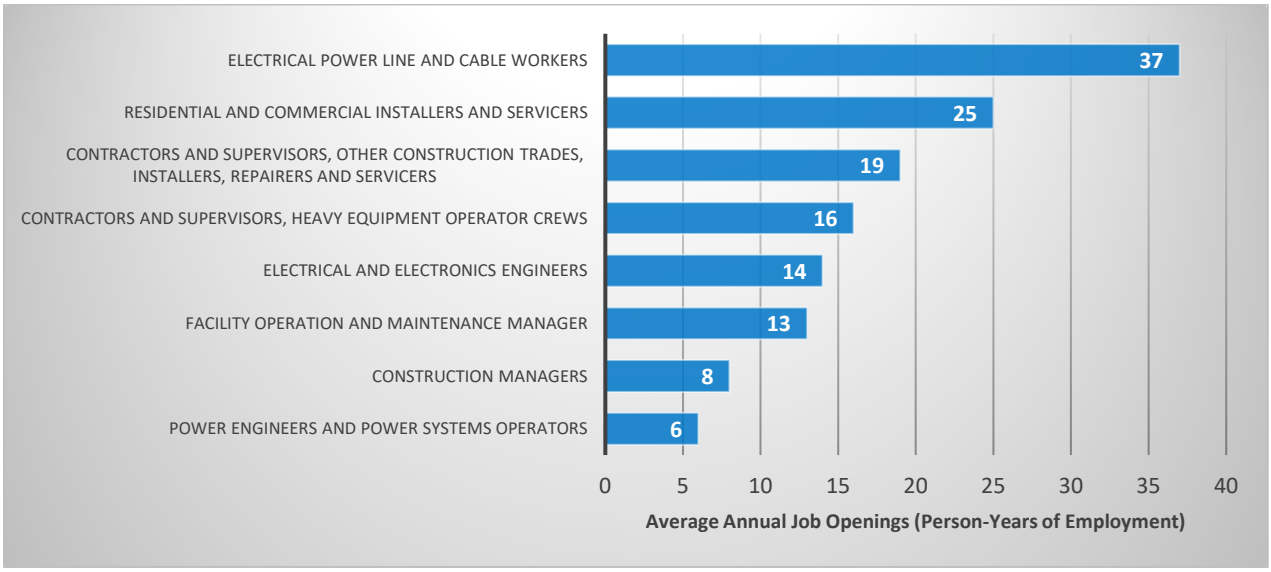
Timelines: Assumes steady construction project investments between 2020-2030.

Geographic: Northeast and North Coast / Nechako regions.

Job Impacts: Total job expansion is estimated at 169 temporary jobs on average per year between 2020-2030 for the construction of major transmission infrastructure and related interconnections and sub-stations, as well as 57 ongoing jobs in operations by 2030. There is no identified risk in terms of job displacement.

Employment Impacts by Occupation

The two CleanBC policy goals outlined above are expected to create a demand for approximately 193 temporary construction jobs on average per year between 2020-2030 and approximately 225 permanent direct jobs in operations by 2030. The top occupations relevant to this job creation are shown in Figure 10.



Source: The Delphi Group

Figure 10: Annual average number of job openings for key occupations in the Clean Power Supply and Storage Sector based on initial CleanBC policy targets (2020-2030)

[69] See: https://www.bchydro.com/energy-in-bc/projects/pres.html

Electrical power-line installers are projected to be in highest demand given investments for new transmission infrastructure and electrification of industry goals within CleanBC. Other important jobs created come from the RCES and renewable energy projects in communities, creating jobs for residential and commercial solar PV system installers and servicers, electrical and electronics engineers, facility operations and maintenance managers, construction managers, and power system operators and engineers.

Job transformation within this sector is expected to be minimal as workers in this sector are already focused on clean electricity supply and storage, with hydropower and a range of other sources (including solar PV, wind, and biomass-to-power) generating BC's power supply. Additional work with micro-grid and smart grid solutions will demand new skills in ICT system and network design, operations, and power management. In total, the sector is projected to see 1,400 jobs impacted through job transformation between 2018 and 2030. Table 16 provides a breakout of the top occupations by number.

Table 16: Key occupations projected to undergo job transformation within BC's Clean Power Supply and Storage Sector between 2018 and 2030

NOC - Occupation Title	Percent of Sector	Number of Jobs Undergoing Transformation (2018-2030)
0912 Utilities managers	4.1%	58
2133 Electrical and electronics engineers	2.9%	40
7244 Electrical power line and cable workers	2.8%	39
9241 Power engineers and power systems operators	2.8%	39
7611 Construction trades helpers and labourers	2.8%	39
7521 Heavy equipment operators (except crane)	2.7%	38
2241 Electrical and electronics engineering technologists and technicians	2.5%	34
7302 Contractors and supervisors, heavy equipment operator crews	2.1%	30
0711 Construction managers	1.7%	24
7243 Power system electricians	1.7%	24
2131 Civil engineers	1.7%	23

3.2.6 WORKFORCE SUPPLY

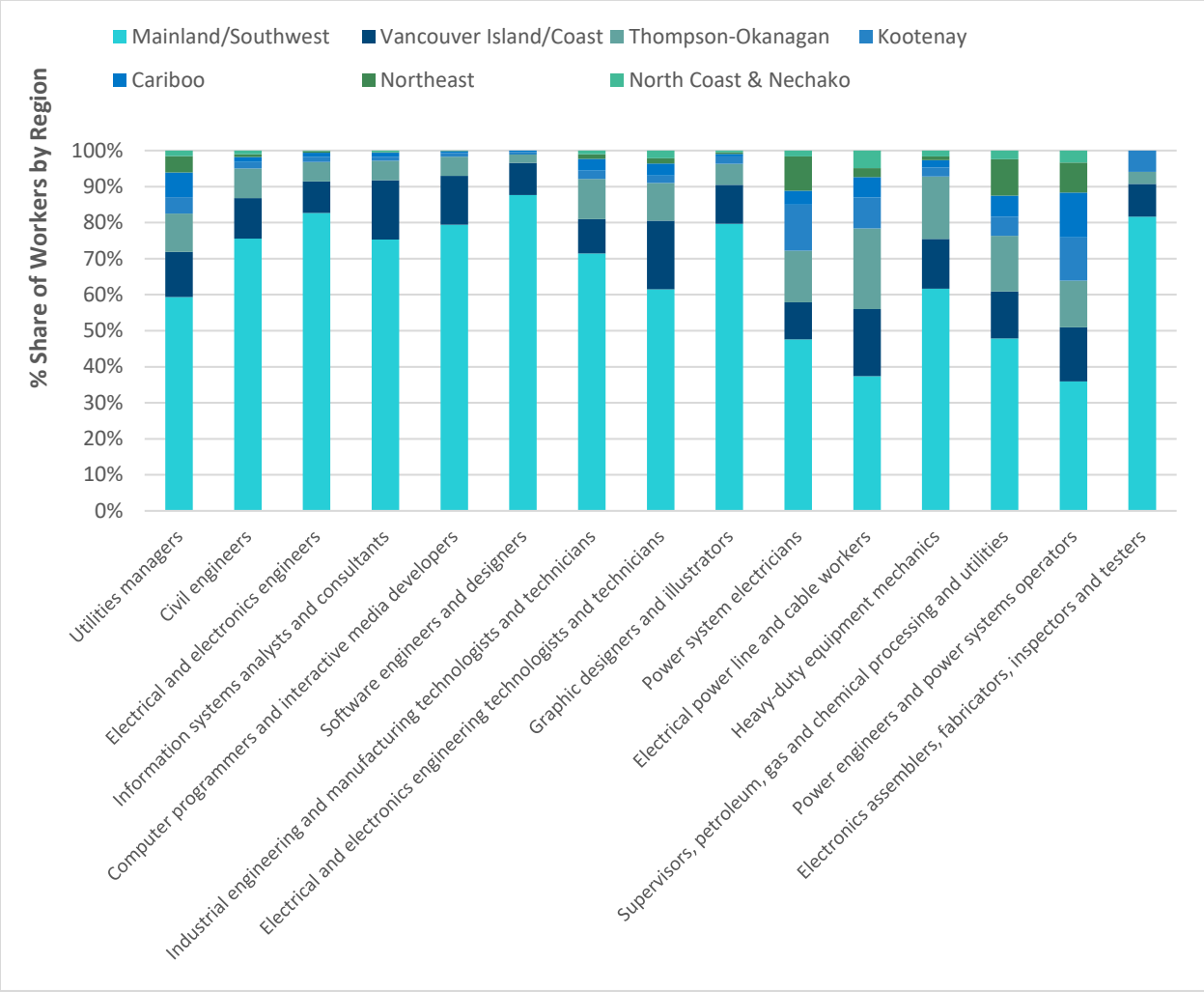
The supply of workers in the Clean Power Supply and Storage sector depends on a number of factors, including current population forecasts, labour force participation rates, attrition rates, migration and immigration flows, and trends in the number of students graduating from training institutions across BC.

The labour supply includes technicians working to build and maintain the electrical grid, electricians with a focus in power systems and industrial applications, specialized engineers, and software and information systems-related support roles. Technicians and engineers familiar with emerging renewable technologies, trends in digitization, and advanced manufacturing practices will be important to support the growth of the sector.

In addition to technical skills required for specific roles in the sector, the value of additional cross-functional skills has been identified through consultation with experts in BC's Clean Power Supply and Storage sector. They have highlighted a need for workers with skills in lean project management, stakeholder engagement, and an understanding of policy, permitting, and governance.

Regional Distribution

Key occupations concentrated in the Lower Mainland / Southwest region that are relevant to the Clean Power Supply and Storage sector include those that carry out project design, planning, and equipment / technology manufacturing (e.g., electrical and electronics engineers, electronics assemblers, and software engineers), while those more evenly distributed across the province include power engineers, power line workers, utilities managers, and power system electricians (see Figure 11).



Source: Statistics Canada, 2016 Census

Figure 11: Employment distribution by key occupation in BC's Clean Power Supply and Storage Sector (by Development Region)

In addition to the major projects related to hydro-electricity project refurbishments, CleanBC priorities for renewable power projects in rural and remote communities (Indigenous and/or diesel-dependent), as well as the major investments in power transmission and distribution projects in the Northeast and North Coast / Nechako regions, will result in the employment impacts largely taking place outside or the Lower Mainland and other urban centres.

3.2.7 EDUCATION & TRAINING

Education pathways within the sector are found through college diploma or trade certifications and university degrees focused on technical knowledge across environmental technologists, electronics, communications, engineering, and software design. The institutions offering these education resources are most concentrated in the Lower Mainland, followed by Vancouver Island and Thompson-Okanagan (see Table 18).

Table 17: Number of programs by location

	Lower Mainland	Vancouver Island	Thompson-Okanagan	Northern BC	Kootenay
Number of Programs	44	20	18	15	4

Source: EducationPlannerBC

Table 18, 19, and 20 1 below offer a high-level overview of common career pathways for select highly-relevant occupations in this sector.

Table 18: Common education pathway for power engineers

Secondary School	Certificate	Diploma	Internship	Red Seal	Continued Professional Development
Usually required	Power engineering certificate program[70]	Power and Process Engineering Diploma	Work-related practicum	Interprovincial Fourth-Class Power Engineer's Certificate of Competency	Exams and evaluation for higher (third, second, first) class power engineer certificates[71]

Source: EducationPlannerBC

[70] See: https://www.viu.ca/programs/trades-applied-technology/power-engineering/process-operator-4th-class
[71] See: https://www.technicalsafetybc.ca/certification/boiler-pv-and-refrigeration/power-engineer-third-class

Table 19: Common education pathway for electrical power line workers

Secondary School	Pre-Apprentice	Apprenticeship	Red Seal	Continued Professional Development
Usually required	One-year preparation program for apprenticeship training	ITA Certificate of Apprenticeship required (generally 3.5 years)[72]	Interprovincial Certificate of Qualification	Mentorship opportunities and progress to managerial or supervisory positions

Source: EducationPlannerBC

Table 20: Common education pathway for electrical and electronics engineers

Secondary School	Certificate	Bachelor's Degree	Master's Degree	Continued Professional Development
Required	One-year engineering foundations certificate	Electrical or electronics engineering program[73]	Required for some positions	Committee participation, workshops may soon be required for continued membership in the Association of Professional Engineers and Geoscientists of BC

Source: EducationPlannerBC

Post-secondary Institutions

Given that CleanBC is working towards low-carbon electrification of province's grid, there will be increased need for supply of workers with the skillsets to design, install, maintain, and operate electrical utility systems.

An example of partnerships between institutions to support these types of skillsets are the Nicola Valley Institute of Technology (NVIT) partnerships with Fanshawe College in Ontario to bring a Renewable Energies Technology (Co-op) program to BC. This program is unique to BC and Western Canada in that it is focused on the practical applications of multiple renewable energies such as wind, solar, geothermal, micro-hydro, and biomass. This program provides students with a foundation in science, design and installation techniques required to work with various renewable energy solutions. Graduates are taught how to integrate new utility-scale renewable technologies with existing energy sources, particularly important in rural, Indigenous, and remote communities as

[72] See: https://www.itabc.ca/sites/default/files/program-information/power-line-technician-profile-sept-2014_0.pdf
[73] See: https://www.uvic.ca/engineering/ece/current/undergraduate/electrical/index.php

they transition off fossil fuels. NVIT's program is also unique in that it brings an Indigenous perspective to renewable and clean energy concepts, conservation techniques, and climate change.[74]

In total, BC has 59 electrician programs.[75] Table 21 outlines the programs which are directly relevant to key occupations that will be needed as a result of CleanBC.

Table 21: Programs aligned with key occupations in Clean Power Supply and Storage sector

Institution	Program	Designation	Alignment with Key Occupation
BCIT	Electrical and Computer Engineering Technology	Diploma	Electrical and electronics engineers *Relevant to solar / renewables training
BCIT	Electrical Engineering	Bachelor	Electrical and electronics engineers *Relevant to solar / renewables training
BCIT	Renewable Energy Electrical Systems Installation & Maintenance Advanced Certificate	Certificate	Electrical and electronics engineering technologists
BCIT	Electronics: Bachelor of Technology *	Bachelor	Utilities managers Electrical and electronics engineering technologists *Relevant to solar / renewables training
Camosun College	Electronics and Computer Engineering Technology - Renewable Energy	Diploma	Utilities managers Electrical and electronics engineers Electrical and electronics engineering technologists
Camosun College	Electronics and Computer Engineering Technology Access Certificate	Certificate	Utilities managers Electrical and electronics engineers Electrical and electronics engineering technologists *Relevant to solar / renewables training

[74] CEWRP Industry Survey
[75] See: Education Planner BC https://www.educationplannerbc.ca/search?txtSearch=electrician

Simon Fraser University	Engineering Science	Bachelor of Applied Science Degree	Utilities managers Electrical and electronics engineers Electrical and electronics engineering technologists
Simon Fraser University	Sustainable Energy Engineering Program	Bachelor or Masters	Electrical and electronics engineers *Relevant to solar / renewables training
Simon Fraser University	Mechatronic Systems Engineering	Bachelor of Applied Science Degree	Utilities managers Electrical and electronics engineers Electrical and electronics engineering technologists
BCIT	Power Engineering	Certificate	Power systems electricians Power engineers and power systems operators *Relevant to solar / renewables training
BCIT	Power and process engineering	Diploma	Power engineers and power systems operators
Northern Lights College	Power Engineering	Certificate	Power systems electricians Power engineers and power systems operators *Relevant to solar / renewables training
Vancouver Island University	Power Engineering / Process Operation	Certificate	Power systems electricians Power engineers and power systems operators *Relevant to solar / renewables training
Okanagan College	Electronic Engineering Technology	Diploma	Power systems electricians Power engineers and power systems operators *Relevant to solar / renewables training
College of New Caledonia	Power Engineering (3rd and 4th class)	Certificate	Power engineers and power systems operators *Relevant to solar / renewables training

Industry-led Training

While the BC Industry Training Authority (ITA) is responsible for funding and overseeing programs which have standardized national or provincial apprenticeship trade curriculums, many other industry-based organizations, associations, and professional societies have developed their own certification and/or accreditation programs for their members or others in the same professional areas, either independently or in cooperation with apprenticeship and other post-secondary institutions. These can include standards that are recognized by governmental agencies or academic institutions.

The following training and education programs are examples of those that were identified through consultation as ones that provide specific support toward the development of skillsets and experience in line with Clean Power Supply and Storage sector.

- **BC Hydro's Community Energy Manager Program**: This program was offered by BC Hydro as a successful tool in incentivizing local workers to become trained in development of energy and emissions planning and implement clean energy projects with local partners.[76] It represents a valuable strategy to leverage in building clean energy project expertise across BC.[77]
- **BC Hydro / FortisBC Sustainable Energy Management Advanced Certificate**: This program is a partnership between BCIT, Natural Resources Canada, BC Hydro, and FortisBC, designed to support employment opportunities in the emerging field of sustainable energy management, with focus on the energy demands of commercial, institutional, industrial and community facilities.[78]
- **BC Hydro Engineer in Training Program**: The 2-year EIT program provides engineering graduates with the opportunity to build their on-the-job experience through three of BC Hydro's business groups: Engineering, Aboriginal Relation & Generation, Customer Care and Conservation, and Field Operations.[79]
- **BC Community Energy Association**: In partnership with BCIT, the Energy Manager Certificate offers an inter-disciplinary sequence of six online courses spanning energy emissions planning, renewable energy project development, local economic development, and financing for green energy systems.[80]
- **The North American Board of Certified Energy Practitioners (NABCEP)**: This organization offers certifications and credentials for skilled professionals in solar PV, solar heating, and small-scale wind technologies to support the growth of professionals in renewable energy and energy efficiency industries.[81]

There are smaller, regionally focused employment service businesses who are also active in providing employers with financial support to send employees for special or targeted training. For example, Kootenay Employment Services provides $1,500 subsidies that have been used by companies to send employees to solar PV installation training.[82]

[76] See: https://www.bchydro.com/powersmart/business/programs/sustainable-communities/cemp.html
[77] See: https://www.bchydro.com/powersmart/business/programs/sustainable-communities/cemp.html
https://www.bchydro.com/powersmart/business/programs/sustainable-communities/cemp.html
[78] See: https://www.bcit.ca/study/programs/5070adcert
[79] See: https://www.bchydro.com/content/dam/hydro/medialib/internet/documents/careers/eit_program_brochure.pdf
[80] See: https://commons.bcit.ca/energy/course-descriptions/community-energy-management/
[81] See: https://coursecatalog.nabcep.org/
[82] See: Kootenay Regional Workshop.

Labour Organizations

The following labour organizations are particularly relevant to BC's utilities workers and offer examples of training pathways. They offer training and support to employees and employers that will be instrumental in supporting the electrification of BC's grid alongside the change in worker demographic and skillsets.

- **IBEW 213:** Representing 6,000 members employed across several industries including utility workers in BC. They host an annual training conference that offers both technical training related to electrician specializations, as well as training in health and safety and mental wellness.
- **Electrical Joint Training Committee (EJTC):** Comprised of five union Directors from International Brotherhood of Electrical Workers, Electrical Contractors Association of BC offers entry level trades training programs for aspiring electricians, which can be used to enter apprenticeships. The Committee also offers a Mentorship Matters program in response to a report by Build Force Canada that pointed to mentorship as one of the most critical elements in workforce development for trades and the technical sector.[83] The Committee also offers a course (CSA Z463) which is Canada's first guideline on electrical systems maintenance that applies to utilities, as well as manufacturing, oil and gas and transportation. It is encouraged specifically for those who work as electrical and technical professional, power engineers, as well as senior and middle managers.[84]

3.2.8 EMERGING SKILLS

Electricity Generation

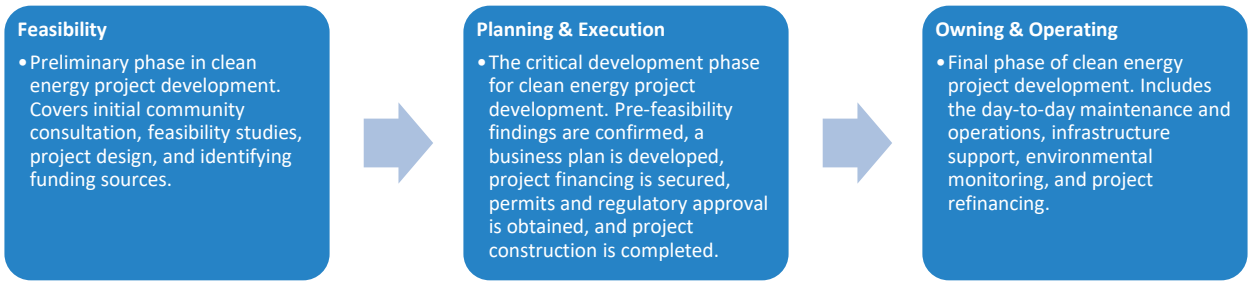
In a recent survey of Canadian cleantech companies, respondents emphasized the importance of keeping a global scope when training graduates in order to address large-scale problems in sustainability. The following technology-specific disciplines were cited as important areas of focus:[85]

1. Energy storage and smart grid applications;
2. A broad range of renewable energy technologies; and
3. Resource optimization and industrial efficiency applications.

Various business services and workforce considerations are required within each phase of clean power project development (see Figure 12). As BC builds out its capacity in the Clean Power Supply and Storage sector, both fundamental engineering skillsets and expertise will be required in the following areas:

- Engineering, energy, and interdisciplinary systems and integration;
- Mechanical engineering (e.g., fluids and thermodynamics);
- Electro-mechanical devices and IoT / software development (e.g., embedded systems engineering);
- Modelling and simulation;
- Engineering design and proto-typing;
- Understanding advanced instrumentation and controls; and
- Computer engineering and ICT systems (e.g., coding, wireless technologies, etc.)[86]

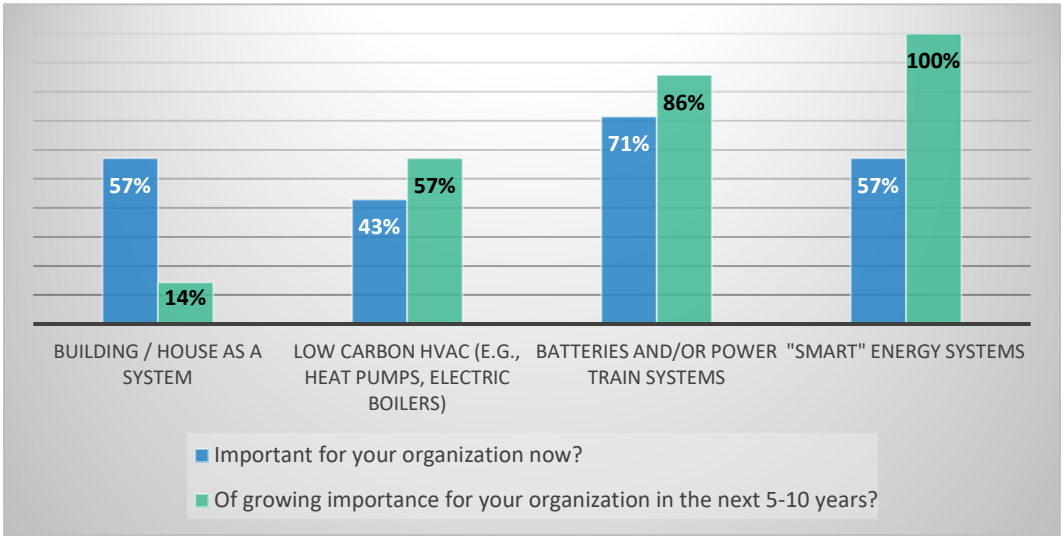
[83] See: https://ejtc.org/industry-training/mentorship-mentors.aspx
[84] See: https://ejtc.org/industry-training/csaz463.aspx
[85] Source: Delphi Group: Canadian Cleantech Industry Consultation Summary Report
[86] See: Canadian Cleantech Industry Consultation – Findings and Summary Report. Delphi Group. October 2016. http://delphi.ca/wp-content/uploads/2016/05/05-04-GLOBE-CCTI-Workshop-Report.pdf



Source: GLOBE Advisors[87]

Figure 12: Project development phases for a clean power

In a survey of local clean power supply and storage businesses in BC,[88] the top emerging skillsets were identified. For example, 100% of respondents identified 'smart' energy systems as a key technical skill over the next 5-10 years (see Figure 13 below). Several organizations identified the growing need for workers who can operate between multiple disciplines and understand the systems and processes that support integrated, automated, and low-carbon energy operations.[89]



Source: Clean Economy Workforce Readiness Project Industry Survey

Figure 13: Energy systems skillsets of growing importance over the next 5-10 years (n=7)

[87] GLOBE Advisors Powering our Province report. July 2012. https://globe.ca/wp-content/uploads/2012/10/GLOBE_BC_Clean_Energy_Business_Opportunities_AnalysisFINAL_July-30.pdf

[88] See: CEWRP Industry Survey

[89] See: CEWRP Industry Survey

Smart Grid and Transmission Infrastructure

Driven by energy-efficiency efforts and the trend towards electrification, the expansion of transmission infrastructure and smart grid technology will require skillsets in quality installation of system components as well as knowledge and expertise in the effective management and operation of smart grids. Effective energy management is underpinned by skills like project management and leadership, adaptability to change (particularly relating to changing technologies and standards), planning, budgeting, and reporting of carbon emissions.

Technical knowledge and understanding in general are in high demand within the Clean Power Supply and Storage sector. However, experience with building systems, software applications, and smart technology are particularly in demand with the increasingly digital trend of the energy sector. The emerging role of big data will also present an opportunity for those who are able to manage large amounts of information being produced by modern equipment and sensors in smart grid networks.

A recent study of specific smart grid skills requirements for future workforces identified 12 major categories,[90] shown in Table 22 below.

Table 22: Future skill requirements for smart grid sub-sector workers

Category	Skill
Technology	Advanced Components
	Advanced Control Technologies
	Sensing & Measuring Elements
System Integration and Communications	IT System, Networks and Architecture
	Integrated Communications Protocols and Technologies
	Cyber Security & Interoperability Standards
Organizational Management	Business Transformation Challenges
	Legal & Regulatory Issues
	Utility Decision Support Applications
Customer Management	Customer Communication & Relationships
	Energy Supply Side Management
	Customer Energy Management Systems

Source: Illinois Institute of Technology

Energy Storage

Technical skills in the rapidly growing field of energy storage include those suited to both industrial and consumer applications. Industries are looking to energy storage solutions to provide a source of backup power or a sink to absorb excess power when it exceeds demand. The applications include connecting to turbines and electric drivetrain mining equipment.[91] On the consumer side of energy storage, important skills include an understanding of battery storage products and technologies, how they interface with other systems in homes and electric vehicles, and the ability to explain these differences to the consumer.[92]

[90] See: http://www.iitmicrogrid.net/education/The%20Smart%20Grid%20Workforce%20of%20the%20Future.pdf
[91] See: https://www.macleanengineering.com/images/support/sectors/mining/EV-Brochure.pdf
[92] See: https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/the-new-rules-of-competition-in-energy-storage

3.3 GREEN BUILDING & RESILIENT INFRASTRUCTURE SECTOR

3.3.1 SECTOR OVERVIEW

The Green Building and Resilient Infrastructure sector consists of several multi-faceted segments, including architecture, design, engineering, and building management / operations; sustainable land use, community design and planning; construction and renovation; and building materials and energy-efficient product / technology design and manufacturing.

A total of 48,440 direct clean economy jobs existed in BC's Green Building and Resilient Infrastructure sector in 2018 (see Table 23). The GDP generated by this sector was estimated to be $4.47 billion in 2018, with a gross output per job of $196 thousand.

Table 23: Employment and economic contribution of BC's Green Building and Resilient Infrastructure sector (2018)

Green Building & Infrastructure Sector Jobs	Green Building & Infrastructure Sector GDP ($ Millions)	Green Building & Infrastructure Sector Gross Output ($ Millions)	Gross Output per Job ($ Thousands)
48,443	$4,470	$9,496	$196.0

Source: The Delphi Group based on Statistics Canada data

Of the workers currently employed in key occupations for BC's Green Building and Resilient Infrastructure sector, 43% are between the ages of 45 and 64 (see Table 24). The median annual salary in 2018 was $55,390, with the workforce being made up of 88% men and 12% women.

Table 24: Socio-economic profile of BC's Green Building and Infrastructure sector (2018)

Remuneration	Employment by gender (%)		Employment by age group (%)			
Median Annual Salary	Men	Women	15-24	25-44	45-64	65+
$55,390	88%	12%	9%	43%	43%	5%

Source: Delphi's estimate from BC Labour Market Outlook (2018-2028) wage data by occupation

The extensive value chain present across this sector and related segments holds some of the highest immediate potential for new investment and job creation in BC's clean economy (see Table 25). Across this supply chain, the Green Building and Resilient Infrastructure sector includes a number of employment opportunities in British Columbia, particularly related to the Building Design, Engineering, and Operations and Construction and Renovation sub-sectors or the provision of the following services:

- Sustainable design, architecture, community planning, and engineering;
- Skilled contractors, trades, and specialists in new high-performance, green building construction;
- Retrofits and renovations related to energy efficiency upgrades;
- Energy management and the operation and maintenance of buildings;
- Renewable energy, heating, and energy-efficient equipment installation and maintenance; and

- Engineers, technicians, and technologists in green building product design and manufacturing (including fenestration products (windows and doors), insulation, mechanical systems, and structural elements).

Table 25: Value chain segments for BC's Green Building and Resilient Infrastructure sector

Production	Provision	Consumption
Materials	**Distributors/Suppliers**	**Owners & Clients**
Wood Ferrous metals Stone, sand & gravel Cement Gypsum Glass Asphalt Non-ferrous metals Petrochemicals	Lumber Paint Fixtures Appliances Furnishings Other building materials Landscaping materials Equipment (elevators, etc.)	Private individuals Private companies Governments Non-profits Utilities Property managers
Manufacturers	**Architects/Designers/Engineers**	**Facilitation**
Concrete and masonry Metalwork Thermal and moisture protection (insulation, waterproofing) Millwork and cabinetry Roofing Cladding Equipment Doors and windows Fixtures and finishes Mechanical (HVAC, plumbing) Electrical	Architects Engineers Landscape artists Designers and consultants Planners Inspectors Specification writers Cost consultants and estimators	City of Vancouver Province of BC Metro Vancouver NRCan SFU, UBC, BCIT, Douglas, UFV, TRU, Camosun, Kwantlen Polytechnic Canada Green Building Council BC Housing BC Hydro FortisBC CMHC CHBA BC Trade Associations Unions
Reclamation	**Builders and Operators**	
Salvaged wood, fixtures, & other materials Harvested urban trees Soils and fill	General contractors Construction managers Sub-contractor & trades Operations & maintenance	
	Sellers	
	Real estate agents Lenders Title/escrow Inspectors Brokers	

Source: The Delphi Group

3.3.2 TECHNOLOGY TRENDS & MARKET SHIFTS

As market forces, technology trends, and policy drivers continue to encourage a shift toward more energy efficient buildings, transitioning the broader building sector to green practices represents a significant opportunity for BC's clean economy. Technology trends and market shifts are impacting the types of skills needed to support the growth of the Green Building and Resilient Infrastructure sector. These trends include current building practices favouring an "envelope-first" approach, the trend toward offsite construction and prefabrication, and advanced building controls and technologies. Table 26 outlines the key technological trends that are driving fundamental changes across this sector.

Table 26: Key technology trends impacting the Green Building and Resilient Infrastructure sector

TREND	DESCRIPTION
Envelope-First Approach	A growing best practice in constructing high-performance buildings involves applying increased insulation, high-performance windows, and updated thermal bridging technology to create a more energy efficient exterior. The benefits include reduced heating and cooling costs, as well as reduced GHG emissions.[93] Examples include Passive House and net zero energy construction practices.
Commissioning and Design of High-Performance Buildings	As buildings become more complex in compliance with energy efficient building codes, a greater level of knowledge of energy efficient design will be required in the pre-design stages to ensure the envelope, mechanical systems, and lighting are designed and integrated to deliver optimal energy savings.[94]
Digitalized Project Delivery	The construction industry is adopting digital platforms to increase productivity and efficiency across project delivery.[95] This includes innovative Building Information Modelling (BIM) software, Integrated Design Processes (IDP), and emerging Integrated Project Delivery (IPD) solutions.
Drones and Remote Sensing for Building Inspection	The inspection of tall buildings can be a time consuming and costly process alongside safety issues when projects are in remote areas or at great heights. This has led to the use of drones and remote sensing to efficiently inspect buildings with high resolution photos that can be analyzed in real time by project design and construction teams.[96]
Prefabrication and Modular Construction	The off-site construction of entire buildings or separate components is driving major efficiency gains and cost reductions in the construction industry. The process allows for mass production of specified elements and also reduces the amount of labour needed to complete a building on-site.[97]
Wood Building Construction	In addition to energy efficient mechanical systems and building envelopes, engineered wood products (e.g., cross-laminated timber or CLT) is increasingly being looked to as a low-carbon and reliable material that supports fire resistance, structural performance, and fast on-site construction.[98] Tall wood design and construction, for example, is a growing area of expertise for professionals in BC.

[93] See: https://www.certainteed.com/insulation/creating-energy-efficient-building-envelopes/
[94] See: https://www.wbdg.org/building-commissioning
[95] See: https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/imagining-constructions-digital-future
[96] See: https://www.buildings.com/news/industry-news/articleid/21477/title/deploy-drones-for-envelope-inspections
[97] See: https://www.forbes.com/sites/bisnow/2017/08/02/the-rise-of-the-prefabricated-building/#6d5319c1dd59
[98] See: https://www.thinkwood.com/building-better/taller-buildings

Advanced Building Controls and Technologies	Many buildings are now being equipped with digital platforms, some integrating sophisticated sensors, data analytics, and now artificial intelligence (AI), that allow building owners or managers to oversee energy use and control a building's heating, cooling, lighting, and security as one integrated system. This emerging area requires new skillsets or training for installers and operators to ensure the controls are integrated to deliver optimal comfort and building performance.

3.3.3 KEY INDUSTRIES

A list of the most relevant industries within the Green Building and Resilient Infrastructure sector are listed in Table 27 below by NAICS code.

Table 27: Sub-sectors and relevant industries (by NAICS code) for the Green Building and Resilient Infrastructure sector

Sub-sector	NAICS Codes
Building Design, Engineering, and Operations	5413 Architectural, engineering and related services
	5414 Specialized design services
	5415 Computer systems design and related services
	5416 Management, scientific and technical consulting services
	5417 Scientific research and development services
	5617 Services to buildings and dwellings
	8113 Commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance
	8114 Personal and household goods repair and maintenance
Construction and Renovation	2361 Residential Building Construction
	2362 Non-residential building construction
	2381 Foundation, structure, and building exterior contractors
	2382 Building equipment contractors
	2383 Building finishing contractors
	2389 Other speciality trade contractors
Building Materials and Product Manufacturing	3141 Textile furnishings mills
	3149 Other textile product mills
	3212 Veneer, plywood and engineered wood product manufacturing
	3219 Other wood product manufacturing
	3255 Paint, coating, and adhesive manufacturing
	3261 Plastic product manufacturing
	3273 Cement and concrete product manufacturing
	3274 Lime and gypsum product manufacturing
	3279 Other non-metallic mineral product manufacturing
	3323 Architectural and structural manufacturing
	3334 Ventilation, heating, air conditioning, and commercial refrigerant equipment manufacturing
	3345 Navigational, measuring, medical, and control instruments manufacturing

	3351 Electric lighting equipment manufacturing
	3352 Household appliance manufacturing
	3353 Electrical equipment manufacturing
	3359 Other electrical equipment and component manufacturing
Land Use and Planning	2372 Land subdivision
Resilient Infrastructure	2379 Other heavy and civil engineering construction

3.3.4 KEY OCCUPATIONS

Table 28 below lists the key occupations based on NOC codes that were identified as relevant to this sector. These occupations were initially identified using statistical analysis. The key occupations (by NOC code) for industries relevant to this sector at the 3-digit NAICS code level (as published by Statistics Canada in its 2011 Census breakouts) were amalgamated across industries. The key occupations were then validated through additional secondary research and industry consultation as part of the LMI research.

Table 28: Key occupations in BC's Green Building and Resilient Infrastructure sector

NOC	OCCUPATION
0711	Construction managers
0712	Home building and renovation managers
2132	Mechanical engineers
2151	Architects
2153	Urban and Land Use Planners
2225	Landscape and horticulture technicians and specialists
2251	Architectural technologists and technicians
5242	Interior designer and interior decorator
6733	Janitors, caretakers and building superintendents
7204	Contractors and supervisors, carpentry trades
7205	Contractors and supervisors, other construction trades, installers, repairers and servicers
7241	Electricians (except industrial and power system)
7251	Plumbers
7271	Carpenters
7291	Roofers and shinglers
7292	Glaziers
7293	Insulators
7313	Refrigeration and air conditioning mechanics
7441	Residential and commercial installers and servicers
7521	Heavy equipment operators (except crane)
7611	Construction trades helpers and labourers

3.3.5 WORKFORCE DEMAND

Workforce demand in the Green Building and Resilient Infrastructure sector is driven by investments in both new construction and renovation for residential and non-residential buildings across the province, impacting on the extensive supply chain from design, through to construction, product and equipment manufacturing and installation, as well as operations and maintenance. Projected employment impacts as they relate to the current CleanBC Plan and broader demand drivers are described below.

Demand-side Drivers

As British Columbia works toward the goal of reducing GHG emissions from buildings by 40% by 2030, the built environment provides a key area of opportunity and focus for reduction efforts. In 2016, GHG emissions from BC's buildings accounted for 22% of the province's overall emissions, totalling 13.5 Mt CO2e.[99] While these emissions have dropped 11% from 2007 levels, CleanBC has committed to reducing emissions by 2.0 Mt CO2e by 2030. One of the main tools in achieving this reduction goal is through adopting energy efficient building codes and focusing investments in public housing to use less energy.[100]

In the second quarter (Q2) of 2019, the estimated cost of major residential construction projects across BC's eight development regions totaled $50.4 billion, while commercial construction accounted for $34.1 billion.[101] Currently there are a total of 91 green building projects (both proposed and underway), totaling approximately $20.8 billion. Table 29 lists the green building projects identified as such in the BC Major Projects Inventory in Q2 2019.

Table 29: Green building projects by region listed in the BC Major Projects Inventory (Q2 2019)

Development Region	Number of Green Building Major Projects	Cost ($ millions)
1. Vancouver Island/Coast	18	4,903
2. Mainland/Southwest	55	13,271
3. Thompson/Okanagan	12	2,407
4. Kootenay	1	18
5. Cariboo	1	44
6. North Coast	0	0
7. Nechako	2	79
8. Northeast	2	81
Total	**91**	**20,803**

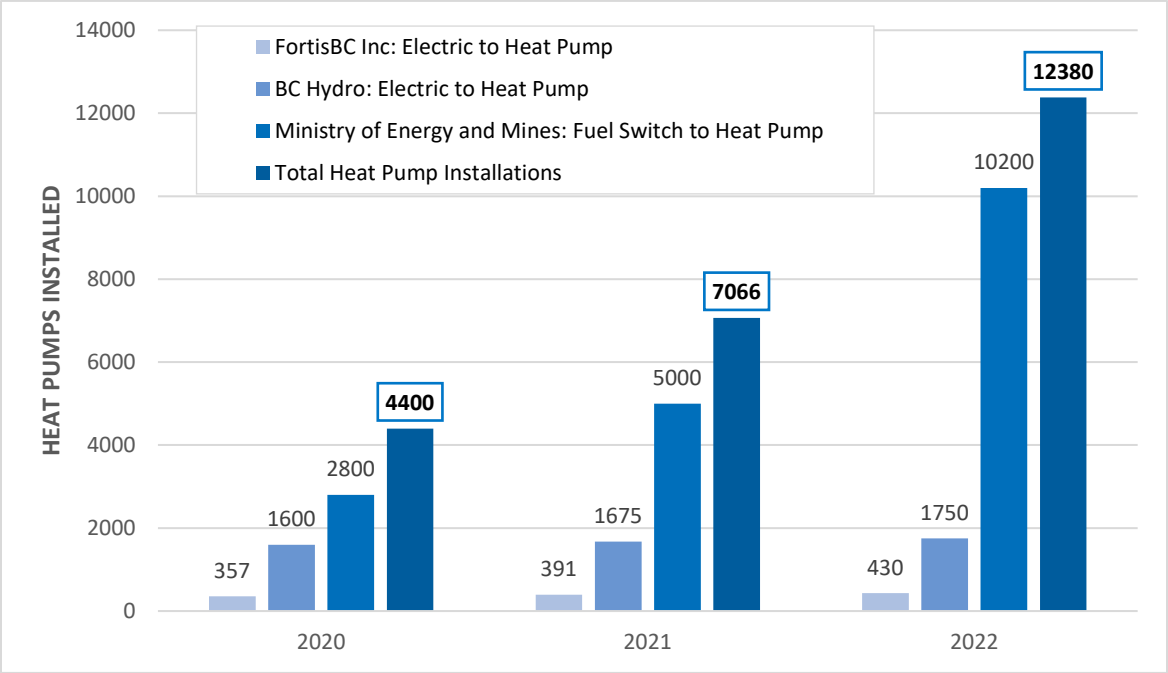
Source: BC Major Projects Inventory, Q2 2019

One of the key building code tools is the BC Energy Step Code: a policy tool available to local governments to take an incremental approach to achieve energy efficient construction. The Energy Step Code is focused on new construction and gives local governments the option of choosing which voluntary pathways to incentivize that will increase the energy efficiency of buildings as part of the broader goal of achieving a net-zero energy ready building

[99] See: https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/progress-to-targets/2018-progress-to-targets.pdf
[100] See: https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/cleanbc/cleanbc_2018-bc-climate-strategy.pdf
[101] See: Page 8 from https://www2.gov.bc.ca/assets/gov/employment-business-and-economic-development/economic-development/develop-economic-sectors/mpi/mpi-2019/mpi-report-2019q2.pdf

stock by 2032.[102] In Metro Vancouver alone, the construction of buildings to a net-zero energy standard by 2032 could drive a conservative $3.3 billion market for high-performance building products, not including the broader services supply chain.[103]

Building decarbonization is another key focus for CleanBC, as well as for other local governments and market players. This, in turn, is driving a push toward electrification and technologies such as heat pumps and electric boilers. Figure 14, for example, illustrates the expected demand for heat pumps between 2020 and 2022 in British Columbia. Given that current worker supply is unable to keep pace with demand, significant efforts will be required to incentivize training programs for this technology.



Source: City Green Solutions

Figure 14: BC provincial heat pump targets (all providers from 2020-2022)

In addition to the value generated by market demand, BC's Green Building sector generates a variety of jobs throughout the supply chain. Demand for key skills and occupations exists across the Green Building and Resilient Infrastructure sector and is especially high in the construction and renovation sub-sector. Specific demand drivers, targets, and expected growth are described in more detail in Table 30 below.

[102] See: https://www.vancouvereconomic.com/wp-content/uploads/2019/03/GreenBuildingsMarketResearch_WEBMarch7_Launch-compressed-compressed.pdf

[103] See: https://www.vancouvereconomic.com/wp-content/uploads/2019/03/GreenBuildingsMarketResearch_WEBMarch7_Launch-compressed-compressed.pdf

Table 30: Sub-sectors, targets and expected growth in BC's Green Building and Resilient Infrastructure sector

Sub-sector	CleanBC Targets	Expected Growth[104]
Building Design, Engineering, and Operations	**2030**: 60% of homes and 40% of commercial buildings will be heated with clean electricity. **2030**: Public buildings will reduce emissions by 50%. **2032**: All new buildings to be net zero ready by 2032 via BC Energy Step Code pathways.	**Medium** As the province and municipal governments work to decarbonize homes and buildings, labour demand will require a higher level of collaboration between architects, engineers, designers, builders, construction trades, building operators, and other professionals such as energy advisors and modellers, building commissioners, and the broader value chain.
Construction and Renovation	**2030**: 60% of homes and 40% of commercial buildings will be heated with clean electricity. **2030**: Public buildings will reduce emissions by 50%. **2032**: All new buildings to be net zero ready by 2032 via BC Energy Step Code pathways.	**Very High** Industrial and commercial sector growth coupled with the push toward better building envelopes and electrically heated homes and buildings will drive demand for both energy efficient new and retrofit construction activities across residential and non-residential sectors. In the residential sector, renovation demands are also expected to outpace new construction.[105]
Building Materials and Product Manufacturing	None specified in the CleanBC Plan apart from reference to more electrically-heated and cooled buildings and renewable energy technologies for community clean energy projects (such as solar photovoltaic).	**High** Energy efficient building products and materials, particularly building envelope products (fenestration, insulation, and air sealing) and high-efficiency space and water heating / cooling products, including HRVs, boilers, and heat pumps, will be required to meet federal and provincial energy efficient building targets.[106] A wide range of incentives targeting homeowners and building owners / managers are now available and expected to drive demand for certain products and equipment.[107]
Land Use and Planning	Densification targets and policies in certain communities favouring transit-oriented and mixed-used developments	**Medium** Continuing to drive the transition to compact, complete, energy efficient communities will require renewed skills for land use planners and related supporting services.
Resilient Infrastructure Development	None specified in the current CleanBC Plan, although many local governments and the Province of BC are working on climate adaptation related strategies.	**Medium** As with Land Use and Planning, a skills transition will be necessary in occupations that develop new and maintain and replace existing and aging infrastructure to incorporate climate resilience considerations.

[104] Note the terms used to describe the expected growth of sub-sectors (medium, high, very high) are relative and not based on specific quantifiable levels. Information used to inform the expected growth assessment includes key informant interviews, trends analysis, and secondary research.
[105] See: https://www.constructionforecasts.ca/sites/forecast/files/highlights/2018/2018_BC_Constr_Maint_Looking_Forward.pdf
[106] See: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/emmc/pdf/2018/en/18-00369-emmc-buildings-strategy-report-e.pdf
[107] See: https://betterhomesbc.ca/

Employment Impacts from CleanBC

CleanBC sets out an overarching goal of reducing GHG emissions from buildings by 40% by 2030. More specific targets / goals currently outlined in CleanBC include:

1. Improve the BC Building Code in phases leading up to all new construction being "net-zero energy ready" in the province by 2032.
2. Working to retrofit 70,000 homes and 10 million m2 of commercial buildings to use electricity in space heating by 2030 (i.e., 60% of homes and 40% of commercial buildings heated by electricity).
3. Investing $400 million to support retrofits and upgrades for BC's stock of publicly-funded housing to make energy performance improvements designed to lead to GHG emission reductions.

Key Considerations by CleanBC Policy Goal

Employment considerations and assumptions for the policies outlined above are described below.

1. All new buildings to be net-zero energy ready by 2032

Policy Details: New Part 9 and Part 3 buildings are moving toward net-zero energy ready construction in a series of updates to the BC Building Code (BCBC) over the next 13 years, with all new construction in BC expected to be net-zero energy ready by 2032. Local governments that have adopted the Energy Step Code may move to this target at an accelerated rate. Further, under the Energy Step Code, residential (Part 9) homes are required to use a building energy advisor (BEA) as part of their construction process.

Assumptions: Based on BC Hydro and other industry case studies, the additional costs for building to net-zero energy ready standards was estimated to range between 2%-8%, depending on the approach and geographic region. This additional capital cost for construction is assumed to largely go toward equipment / material costs and is largely due to increased costs for better building envelope design and construction (i.e., thicker walls, more insulation, air sealing, and high-performance windows and doors).

It is assumed that there will be an estimated 10,000 residential (Part 9) Energy Step Code files a year to 2030, with BEAs required for all new residential Energy Step Code files. There are currently 30 FTE BEAs with an estimated potential capacity to provide energy modelling and Energy Step Code compliance services for between 2,550 and 4,500 Energy Step Code homes per year.

Timelines: Steady growth between 2020-2030. Net-zero energy ready targets will likely be met starting in 2025 for aggressive BC Energy Step Code adopters (Step 5 residential, Step 4 MURBs, Step 3 commercial / institutional) and in 2030 for other regions in line with BCBC advancements.

Geographic: Based on current Energy Step Code implementation updates, movement toward net-zero energy ready construction is expected to be dispersed throughout the province, but will happen faster on Vancouver Island / Coast, Mainland Southwest, Thompson-Okanagan, and Kootenay regions.

Job Impacts: Based on the average additional costs / expenditures for residential, commercial, and institutional buildings to meet net-zero energy ready target, an estimated 1,641 temporary construction jobs on average per year will be created in BC between 2020-2030, largely in construction labour for building envelope trades and related product manufacturing in BC (fenestration, some insulation, thermal bridging products, and pre-fabrication). In addition, another 55-65 BEAs over the current capacity will be required to meet projected demand coming from existing Energy Step Code commitments.

2. 70,000 homes and 10 million square meters of commercial buildings retrofitted to use electricity in space heating by 2030

Policy Details: By 2030, 70,000 homes and 10 million square meters (m^2) of commercial buildings will be retrofitted to use clean electricity in space heating.

Assumptions: The average capital cost for heat pump and/or electric boiler retrofit install is assumed to be $10,000 for Part 9 residential buildings (50:50 equipment and labour) and $200,000 for large commercial (Part 3) buildings (50:50 equipment and labour), equal to $700 million and $800 million in investment respectively between 2020 and 2030.

Timelines: Steady growth between 2020-2030.

Geographic: 90% of activity in three regions based on population and climate considerations: Mainland / Southwest, Vancouver Island / Coast, and Thompson Okanagan.

Job Impacts: 316 temporary construction jobs on average per year between 2020-2030, largely for refrigeration and air conditioning mechanics (heat pumps / heat recovery chillers) and, to a lesser degree, plumbers (hydronics and electric boilers), electricians, and mechanical engineers (for commercial buildings). More job creation in BC is possible if the HVAC equipment manufacturing supply chain can be expanded in the province.

In addition, the shift toward more electrically-heated buildings (i.e., heat pumps, electric boilers) and away from natural gas equipment is expected to result in some job substitution and potential displacement within the HVAC sector from gasfitters to refrigeration and air conditioning mechanics, plumbers, and electricians. Based on initial modelling for the Part 9 residential sector, electric heating is expected to generate approximately 147 direct jobs on average per year for HVAC trades / installers, while potentially displacing 73 jobs on average per year between 2020 and 2030. The most negatively impacted are likely to be residential gasfitters, although the overall net difference is equal to 73 temporary construction jobs created on average per year, providing opportunities for retraining.

3. $400 million to support retrofits and upgrades for BC's publicly-funded housing

Policy Details: The Province has launched a $1.1 billion, 10-year Capital Renewal Fund to support the improvement and preservation of existing, aging public housing stock in BC. Of this, $400 million is targeted to energy performance improvements that will lead to GHG emission reductions.

Assumptions: $400 million is invested evenly over the 2020 to 2030 time period, impacting the entire renovation supply chain (for multi-unit residential buildings).

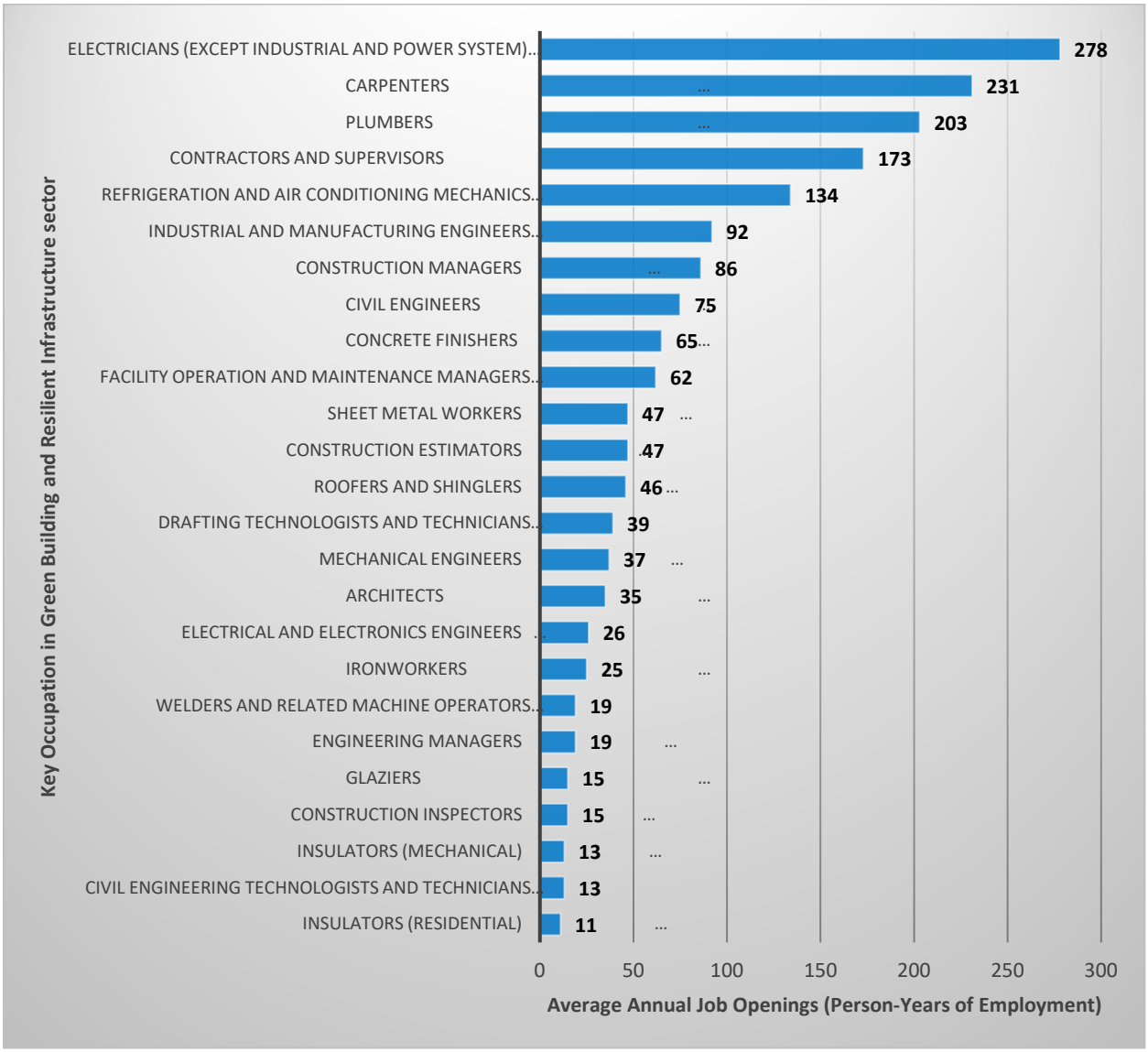
Timelines: Steady investment between 2020-2030.

Geographic: Evenly distributed across the province inline with the presence of public housing stock.

Job Impacts: An estimated 93 temporary construction jobs on average per year will be created in BC between 2020-2030, largely in construction labour for building envelope and HVAC sector retrofits, as well as related product manufacturing in BC (i.e., fenestration and some insulation).

Employment Impacts by Occupation

The three CleanBC policy goals outlined above are expected to create approximately 2,050 temporary construction jobs on average per year between 2020-2030. The top 25 occupations relevant to this job creation are shown in Figure 15.



Source: The Delphi Group

Figure 15: Annual average number of job openings for key occupations in the Green Building and Resilient Infrastructure sector based on initial CleanBC policy targets (2020-2030)

Job transformation within this sector is expected to be large as workers in this sector are impacted by both market trends and policy drivers toward more green buildings, including the Energy Step Code, the BC Building Code that is moving to net-zero energy ready new construction by 2032, and incentives that encourage low-carbon building and technology / equipment retrofits. In total, the sector is projected to see approximately 99,800 jobs impacted through transformation between 2018 and 2030. Table 31 provides a breakout of the key occupations by number.

Table 31: Key occupations projected to undergo job transformation within BC's Green Building and Resilient Infrastructure sector between 2018 and 2030

NOC - Occupation Title	Percent of Sector	Number of Jobs Undergoing Transformation (2018-2030)
7271 Carpenters	9.8%	9,793
7611 Construction trades helpers and labourers	5.8%	5,753
7241 Electricians (except industrial and power system)	4.3%	4,333
0711 Construction managers	3.2%	3,167
7294 Painters and decorators (except interior decorators)	3.0%	2,983
7251 Plumbers	2.8%	2,828
0712 Home building and renovation managers	2.1%	2,069
7284 Plasterers, drywall installers and finishers and lathers	2.0%	2,009
7521 Heavy equipment operators (except crane)	1.8%	1,796
7291 Roofers and shinglers	1.7%	1,648
7205 Contractors / supervisors, other construction trades, installers, repairers	1.4%	1,404
7441 Residential and commercial installers and servicers	1.4%	1,391
6733 Janitors, caretakers and building superintendents	1.1%	1,106
8612 Landscaping and grounds maintenance labourers	0.9%	905
7313 Refrigeration and air conditioning mechanics	0.8%	754
2171 Information systems analysts and consultants	0.6%	559
7292 Glaziers	0.5%	532
7302 Contractors and supervisors, heavy equipment operator crews	0.5%	486
2131 Civil engineers	0.4%	446
9614 Labourers in wood, pulp and paper processing	0.4%	442
7237 Welders and related machine operators	0.4%	427
7293 Insulators	0.4%	399
0911 Manufacturing managers	0.4%	356
7231 Machinists and machining and tooling inspectors	0.3%	345
2151 Architects	0.2%	243

Source: The Delphi Group

3.3.6 WORKFORCE SUPPLY

In order for BC to successfully decarbonize its building stock as part of the larger shift to a clean economy, industries and training organizations will be required to adopt a "building-as-a-system" approach, from conception and design through to construction, operations, and maintenance. This shift is having a large impact on all occupations and skill sets across the value chain. Both land use planning and the development of resilient infrastructure play important roles in the development of a low-carbon built environment but face less immediacy in terms of skills and job demand in relation to other segments of the Green Building sector supply chain.

Knowledge and expertise of low-carbon building techniques, processes, and technologies across the building design and construction supply chain will become an increasingly valuable asset for skilled workers. However, there will be a need for the entire labour force involved with the built environment to understand their role and those of others in order to effectively deliver high-performance buildings and infrastructure. This will require a certain level of cross-disciplinary knowledge that is less common in the industry today.

Within the skilled trades, there will be a significant demand for those who are specialized in building envelope and the electrification of heating and cooling systems, driven by GHG reduction targets and regulations like the BC Energy Step Code and BC Building Code. Given this, enhanced skills training and capacity building will be needed for occupations that include carpenters, electricians, insulators, window installers / glaziers, and heating, refrigeration, and air conditioning mechanics to name a few.

Regional Distribution

Figure 16 shows key occupations relevant to the Green Building and Resilient Infrastructure sector that are concentrated in the more urban centers of BC include architects and designers, while those more evenly distributed across the province include carpenters, public works maintenance equipment operators, and landscape and horticulture technicians and specialists.

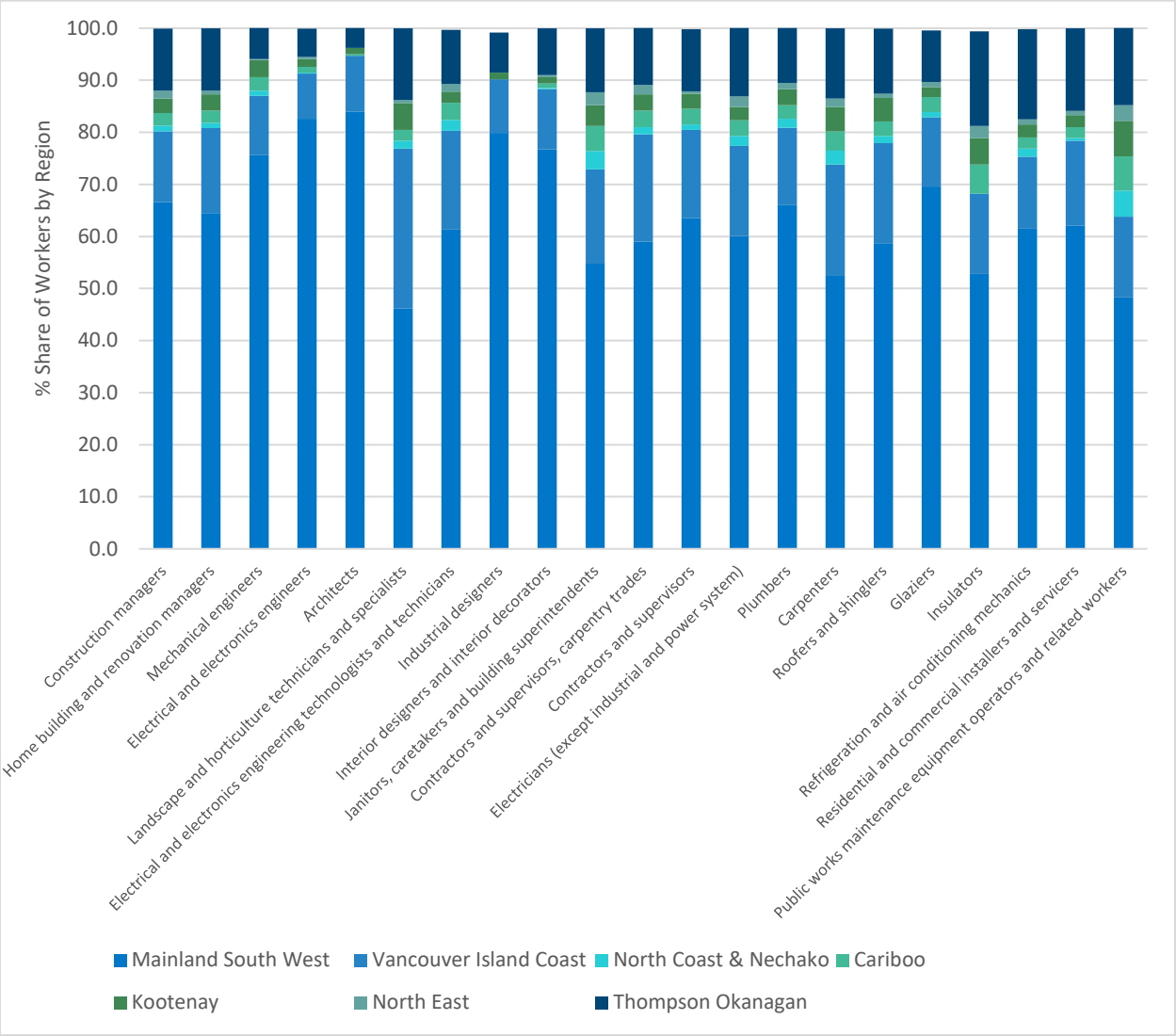
Data suggests that increasing land values around Metro Vancouver, Southern Vancouver Island, and the Okanagan regions are causing many BC residents to move to more affordable and sometimes rural areas, in turn driving growth and building activity in other regions.[108]

As referenced earlier, the supply of BEAs is another key consideration for the roll out of the BC Energy Step Code pathway. As of September 2019, it was estimated that fewer than 40 BEAs are servicing the new homes market in BC (see Figure 17).

In consultation with stakeholders from several regions across BC outside of the Lower Mainland, there is a current lack of access to qualified BEAs. Residents in Kelowna, for example, have had to pay additional costs to bring in energy advisors from the Lower Mainland.[109] This has the potential to create a significant barrier for the uptake of the BC Energy Step Code and has the potential to impact the standards of design and installation of energy efficient technologies and components.

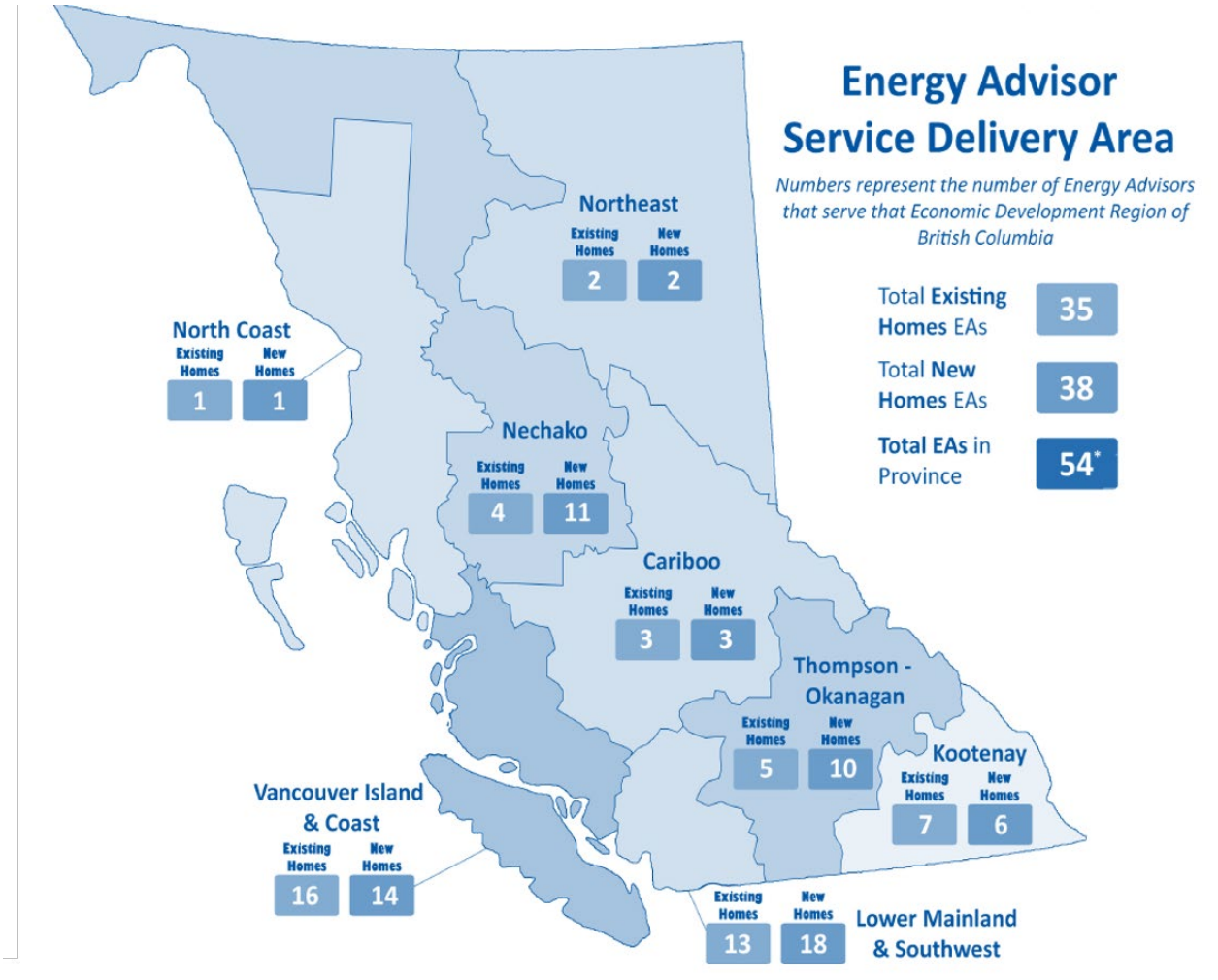
[108] See: https://business.financialpost.com/personal-finance/mortgages-real-estate/millennials-fleeing-vancouver-for-cities-with-more-affordable-housing-threatening-citys-tech-economy

[109] See: CleanBC WRP Thompson Okanagan Stakeholder Workshop



Source: Based on Statistics Canada 2016 Census

Figure 16: Employment distribution by key occupation in BC's Green Building and Resilient Infrastructure Sector (by Development Region)



Source: City Green Solutions

Figure 17: Number of active building energy advisors in BC as of September 2019

3.3.7 EDUCATION & TRAINING

As BC's Green Building and Resilient Infrastructure sector responds to the shift towards low-carbon, high-performance buildings, there will be increasing demand for resilient design, high-performance building components, and low-emission mechanical systems. These practices and technologies are important to meet the energy efficiency requirements of the evolving BC Building Code and BC Energy Step Code. While the BCBC lays out a set pathway and timeline for industry, it will require a new set of skills and knowledge across the building supply chain from commissioning to design to construction and operation.

Table 32 and Table 33 below offer a high-level overview of the common career pathways for these occupations and the institutions or organizations who offer relevant education and training. The pathway for skilled trades has been adapted by Canada Green Building Council's report on skilled trades education and training in Ontario.[110] While there is more required certification in Ontario, the education pathways, training, and certification reflect those in BC.

Table 32: Common education pathway for construction trades

Secondary School	Apprenticeship	Red Seal Exam	Red Seal Certification	Continued Professional Development
Secondary School Diploma	A combination of work experience and class time offered through Industry Training Authority, public or private training institutions and employers.	Journey Person	Mastership / Certificate of Qualification	Usually optional / voluntary training provided by colleges, manufacturers, unions, and industry associations.

Source: EducationPlannerBC

It is important to note that not all trades in the Green Building sector are Red Seal trades. The Industry Training Authority is responsible for over 100 trade programs in BC, 57 of which are in construction and, of those, 33 are designated Red Seal trades.[111] Additionally, BC does not require trades to achieve certain levels of certification to work in the sector (with the exception of a handful of occupations for primarily safety reasons, such as gasfitters and electricians), which presents a challenge or issue that is discussed further below.

Table 33: Common education pathways for engineers, architects and construction managers

Secondary School	Bachelor's degree	Master's Degree	Internship	Licensing Exam and Accreditation	Continued Professional Development
Secondary School Diploma		Sometimes required for architects and engineers.	3-4 years of supervised work experience	Relevant to architects and engineers	Training provided by colleges, manufacturers, unions, and industry associations.

Source: EducationPlannerBC

[110] See: https://www.cagbc.org/cagbcdocs/advocacy/CaGBC_Trading_Up_Skills_Analysis_Report_2019.pdf

[111] See: https://www.itabc.ca/discover-apprenticeship-programs/search-programs

Post-Secondary Institutions

Table 34 and Table 35 outline the number of programs and institutions that offer education and training that is aligned with the top skills and occupations that will be impacted by CleanBC.

Table 34: Education and training programs aligned with key construction trade occupations

Key Occupation	Number of Programs Offered in BC	Institutions Offering the Programs
Construction manager	8	BCIT, Nicola Valley Institute of Technology, Okanagan College, Thompson Rivers University, University of the Fraser Valley
Insulator	2	BCIT, Finishing Trades Institute of BC
Glazier	1	Finishing Trades Institute of BC
Refrigeration and HVAC mechanic	13	BCIT, Camosun College, Okanagan College, Selkirk College, Thompson Rivers University, Vancouver Island University
Carpenter	34	BCIT, Camosun College, Coast Mountain College, College of New Caledonia, College of the Rockies, Kwantlen Polytechnic University, Nicola Valley Institute of Technology, North Island College, Northern Lights College, Okanagan College, Selkirk College, Thompson Rivers University, University of the Fraser Valley, Vancouver Island University

Source: EducationPlannerBC

Table 35: Education and training programs aligned with ley green building design occupations

Key Occupation	Number of Programs Offered in BC	Institutions Offering the Programs
Architect and Architectural Technicians	11	BCIT, Okanagan College, Thompson Rivers University, University of British Columbia, University of Fraser Valley, Vancouver Community College
Mechanical Engineer (BSc)	19	BCIT, Camosun College, Okanagan College, University of British Columbia, University of Northern B.C., University of Victoria

Source: EducationPlannerBC

The BC Energy Step Code drives an envelope-first approach, which will drive the demand for glaziers, carpenters, insulators, as well as refrigeration mechanics and installers, heating and air conditioning mechanics and installers, and construction managers who oversee the build.

A leading program that is working to build skills and expertise in high performance building construction is BCIT's Zero Energy Buildings Learning Centre, part of the School of Construction and Environment, created to support the construction industry with transition to the new BC Energy Step Code. Courses focus on high performance residential buildings, and offer fundamentals in high performance building envelope, mechanical systems, and

electrical systems.[112] BCIT's School of Construction and Environment is also working with the City of Vancouver to offer a Passive House Tradesperson Course – Building Envelope Specialization in February of 2020.[113]

From the design perspective, mechanical engineers and architects who design high performance buildings and HVAC systems will also see an increase in demand as BC moves to decarbonize its new building stock.

Industry-led Training

Relevant continuing professional development and training is also offered by industry and is available to contractors, builders, and design professionals. A few examples of CleanBC-relevant training programs and initiatives by organization are listed in Table 36.[114] An overview of some of the key industry-led training organizations and associations is also provided below.

Table 36: Key training opportunities for professionals in BC's Green Building and Resilient Infrastructure sector

Organization	Focus Area
Community Energy Association	Full-day Workshops for Builders, Trades, Designers, and Building Officials on Building to Energy Step Code (various locations province-wide)
FortisBC	Trade Ally Network workshops
Passive House Canada	Cost-Effective Passive House Engineering for Larger Buildings Workshop
Fenestration Canada / FEN BC	Getting to Net Zero Energy Ready by 2030 – Lessons from BC's Energy Step Code
BC Housing	Building Smart with the BC Energy Step Code Workshops
Urban Development Institute	Seminar: Deciphering the BC Energy Step Code
CHBA BC & Regional Chapters	Energy Step Code presentations
Building Officials Association of British Columbia	Energy Step Code presentations
BCCA & Regional Chapters	Energy Step Code presentations
Architectural Institute of BC	Energy Step Code presentations
Planning Institute of British Columbia	Energy & Design: The Latest on BC's Step Code Adoption presentation
BCIT	Passive House Tradesperson courses

Industry Associations & Councils

A number of industry associations and organizations are active in providing support and training for trades and other professions in BC's high-performance building sector. For example, the BC Construction Association develops professional curriculum that is delivered through regional construction associations (Vancouver Island Construction Association, Vancouver Regional Construction Association, Southern Interior Construction Association, and the Northern Regional Construction Association). As part of their Strategic Plan for 2017-2020, working with employers to provide adequate training for construction trades is a key priority.[115] The organization currently offers the Skilled Trades Employment Program, which offers career coaching and support to prospective workers and connects employers with the skilled trades they are searching for.[116]

[112] See: https://commons.bcit.ca/zeroenergybuildings/energy-step-code-and-passive-house-courses/courses-at-bcit/

[113] See: https://bcbec.com/event/bcit-and-city-of-vancouver-present-cesa-1500-passive-house-tradesperson-course-building-envelope-specialization-feb2020/

[114] See: https://www2.gov.bc.ca/gov/content/industry/construction-industry/building-codes-standards/energy-efficiency#stepcode

[115] See: http://www.bccassn.com/media/BCCA%20Strategic%20Plan%202017-2020.pdf

[116] See: https://www.stepbc.ca/job-seeker/

Alongside these efforts, the Canadian Home Builders' Association (CHBA BC) and its regional chapters have been leaders in providing continuing education for residential construction professionals to stay up to date on industry changes. All training provided through formal courses not only help the current workforce update their knowledge and skillsets, but also earn Continuing Professional Development (CPD) Points (these are required to keep a contractor's licence in good standing).[117] [118] Most relevant to CleanBC, CHBA BC also provides net-zero and energy advisor courses for existing professionals and mentoring for students.[119]

Some of the other relevant industry-led associations and organizations involved in developing and supporting training in line with occupations and skills in high performance building design, construction, and operations include:

- Applied Science Technologists and Technicians of BC (ASTTBC)
- Architectural Institute of BC
- BC Home Performance Stakeholder Council (HPSC)
- BC Building Envelope Council
- BC Insulation Contractors Association
- BC Wall and Ceiling Association
- Building Officials' Association of BC (BOABC)
- Building Owners and Managers Association of BC
- Canadian Institute for Energy Training (CIET)
- Electrical Contractors Association of BC
- Engineers and Geoscientists BC (EGBC)
- Fenestration Association of BC
- Heating, Refrigeration, Air Conditioning Institute (HRAI)
- Independent Contractors and Businesses Association (ICBA)
- Mechanical Contractors Association of BC
- Refrigeration & Air Conditioning Contractors Association of BC
- Thermal Environmental Comfort Association of BC (TECA)

Labour Organizations

There are a number of labour organizations across BC that represent the interests of skilled trades and workers, and examples that are relevant to the skills / jobs in this sector include:

- BC Building Trades [120]
- BC Carpenter's Union
- BC Insulators Union – Local 118
- International Brotherhood of Electrical Workers (IBEW) - Local 213
- International Union of Painters and Allied Trades (known was District Council 38 in BC represents all finishing trades)
- International Association of Heat and Frost Insulators and Allied Workers Local 118
- United Association of Journeymen and Apprentices of the Plumbing and Pipefitting Industry of the United States and Canada - Locals 170 and 516

[117] See: https://www.bchousing.org/licensing-consumer-services/builder-licensing/CPD
[118] See: https://chbabc.org/education/continuing-professional-development/
[119] See: https://cpd.chbabc.org/#/public-dashboard
[120] Organization represents 25 local craft construction unions. They provide knowledge and expertise on issues ranging from labour codes, apprenticeships and training, and initiatives around women in trades

Other Organizations

The following organizations provide training support focused on Indigenous communities and are examples of efforts that can be replicated or scaled to address training gaps and build long-term, local expertise.

- **Construction Foundation:** The Construction Foundation of BC is a charitable organization focused on BC's trades and technology. Their program delivery takes place through three pillars: education and training, research, and community projects. Their Skills Ready[121] program focuses on engaging young people to enter the trades, connect with mentors in the industry, and gain work experience through apprenticeships and training programs. In recent years, the Foundation has partnered with BC's Industry Training Authority and First Nation Communities to develop residential insulation and training programs that reserve spaces for First Nation candidates to encourage participation in skills development.[122]
- **Ecotrust Canada:** Another workforce program focusing on developing local solutions to rural and remote communities that empower citizens to create resilient local economies, Ecotrust Canada works in and with communities to find solutions to environmental and economic challenges. There are successful examples of programs across Canada and more will be needed to adequately prepare the most affected communities in the transition to low-carbon economies and the adaptation to climate change effects.

3.3.8 EMERGING SKILLS

The required reskilling / upskilling of builders and trade contractors inline with energy performance and building / house-as-a-system best practices to build to net-zero energy ready by 2032 will be significant. Market penetration of net-zero energy ready new construction is expected to go from 10%-20% in 2019 to 80% by 2030 in line with BC Building Code timelines, with faster rates of change in urban centres in the Southern regions of the province. The renovation of buildings to be more energy efficient will also require an understanding of building systems and the coordination and sequencing of trades.

The shift will drive the demand for knowledge and expertise related to high-performance, energy efficient, and holistic building design and construction for both Part 3 and Part 9 buildings.[123]

Workforce skill shifts are expected to impact architects / designers, engineers (structural / mechanical), construction workers and trades (including carpenters, roofers, HVAC contractors, fenestration contractors, insulators, plumbers, and electricians), and building operators. The biggest gaps at the moment are identified in the Part 9 (residential sector).

[121] See: https://skillsready.ca/
[122] See: CleanBC WRP - Thompson Okanagan Regional Workshop
[123] See: GLOBE Advisors. 2012. BC's Green Building and Energy Efficient Sector. http://globe.ca/wp-content/uploads/2012/10/GLOBE_BCGreenBuildingReport_FINAL.pdf

Training will also be required for building officials / inspectors, as well as the products / material supply chains related to the focus on better building envelope design and construction (fenestration / glazing, insulation, air sealing) and HVAC system design.

In addition, a shift from low-performance fenestration products (windows and doors) to higher-performing products (e.g., triple-glazed windows) is expected from 2025 onward and may result in some job substitution and upskilling within the local manufacturing sector.

Building Design, Engineering and Operations

The inherent complexity of green building design, engineering, and operation will require additional knowledge and training among architects, engineers, and building operators. The most prominent emerging skills that will be demanded of the occupations within the sub-sector are:

- High performance / net-zero building commissioning and design;
- Energy advising (particularly important as a point of contact or expertise for homeowners and trade contractors and required as part of compliance with the BC Energy Step Code);
- Design and manufacturing of wood buildings (this is relevant to roles across carpentry, architecture, engineering, and industrial design);
- Operation and management of automated building control systems.

A survey of green building companies indicated that the skills associated with computer hardware and software that are expected to grow in importance over the next 5-10 years include 3D modelling and design, artificial intelligence, and robotics and automation (see Source: Clean Economy Workforce Readiness Project Industry Survey

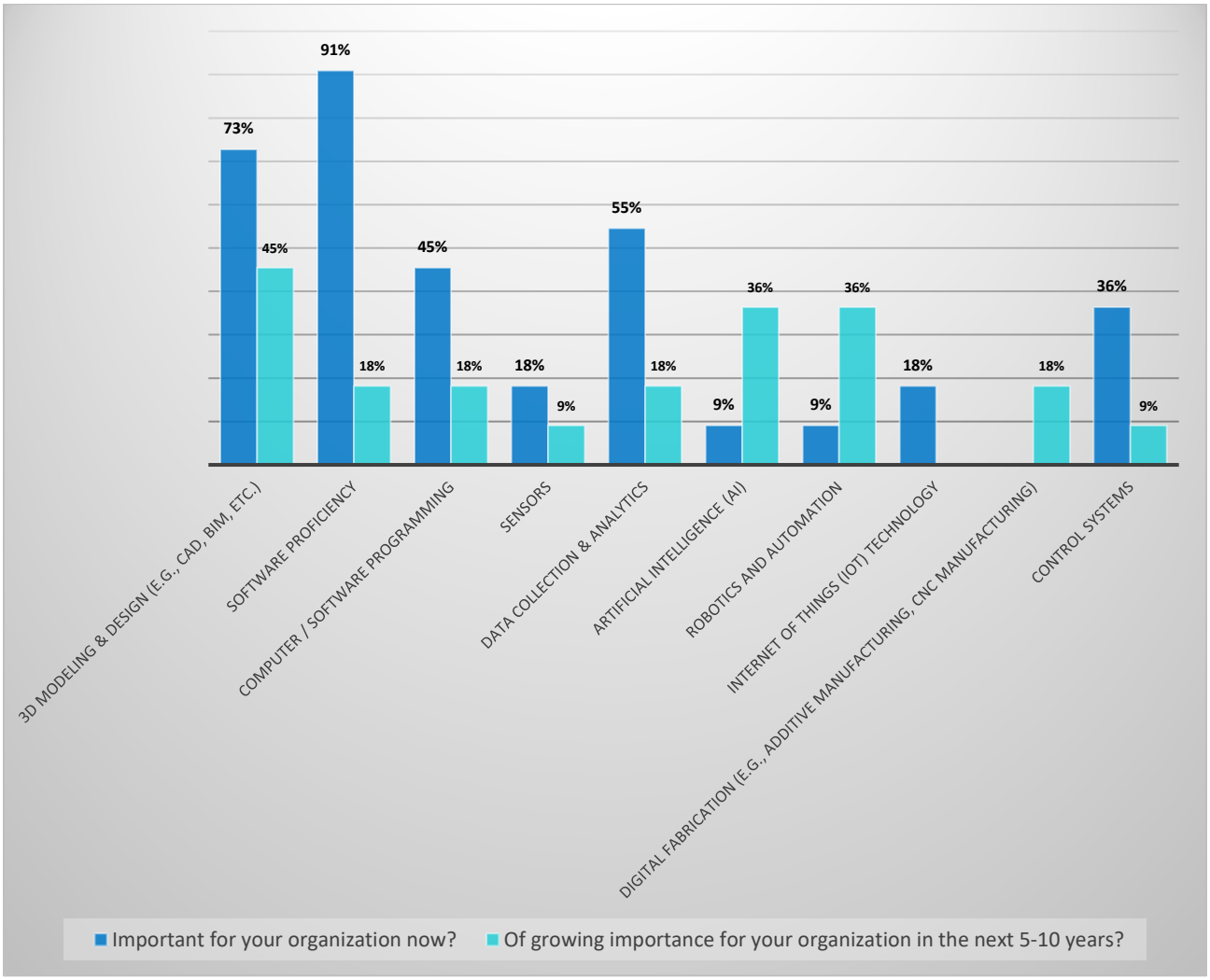
Figure 18). From a broad, systems-thinking perspective, survey respondents identified complex problem solving and critical thinking as skills of growing importance over the next 5-10 years.[124]

Construction and Renovation

For the most part, the skills required for the construction of green building projects are similar to those applied in traditional projects. However, additional education is critical to add a lens of sustainable building practices, systems-based thinking and application of new technologies. Companies involved in green building projects consider it essential that their staff and trades people understand the benefits behind green building practices and high performance building construction in the coming years.[125] For example, in a survey of BC's green building businesses, 63% identified "building / house as a system" as a key emerging skill in the next 5-10 years.[126]

> Having the technical understanding of building as a system as a skill will become an increasingly important part of credentials and for construction workers to understand why they are installing technologies and components a certain way.
>
> - BC High Performance Window Manufacturer

[124] CEWRP Industry Survey (2019).
[125] BC Green Building and Energy Efficiency Report. Globe Advisors. 2012
[126] CEWRP Industry Survey (2019).



Source: Clean Economy Workforce Readiness Project Industry Survey

Figure 18: Technology skills of growing importance to the Green Building and Resilient Infrastructure sector over next 5-10 years (n=11)

While companies will continue to seek contractors with general certifications in trades and well-rounded construction skills, attention to detail will be critical for trades in insulation, building envelope, electrical, and carpentry.

As BC adapts to the updated energy efficient building codes and pathways, emerging skills that will be key to the success of the construction and renovation sub-sector include:[127]

- Energy modelling
- Low-carbon HVAC (e.g., heat pump installation)
- Air sealing / air tightness testing
- Applying virtual and 3D tools to translate design and construction plans and techniques.

In addition to these emerging skills, the sequencing and coordination of qualified trades people and different trades with each other is increasingly important for the green building industry for ensuring that complex projects and systems are completed to code and inline with standards of best practice.[128]

Cross-functional Skills

In addition to the more technical skills list above, the following cross-functional skills were flagged as essential for the sector based on the LMI research and input through the sub-committee meetings (see Table 37).

Table 37: Cross-functional skill gaps in BC's construction trades

Gaps in Cross-functional Skills	Description
Communication and cooperation across trades	Trades have historically operated in silos with a singular focus on the system or component they are trained to install. More complex buildings will demand a change in this status quo to increase communication and cross disciplinary knowledge.
Allowing time for more complex projects	Design plans and construction timelines do not yet recognize the additional time and complexity that is demanded in delivering an energy efficient building. The ability to budget and manage time at the design and installation phase will be an increasingly valuable skill.
Holistic view of the building as a system in an integrated design process	Training and education of trades currently lacks a low-carbon, holistic building lens. This will be an important gap to address in order to establish an understanding among trades about how their role contributes to the broader success of a high-performing building.
Capacity building and lifelong learning	As more value is put on a worker's ability to adapt and develop new capacities or areas of expertise, the concept of lifelong learning and Continuing Professional Development (CPD) is not yet a common practice in the trades but will become increasingly valuable as the industry shifts to more complex, integrated building construction.

[127] CEWRP Industry Survey (2019).
[128] See: Green building key informant interview.

3.4 CLEAN TRANSPORTATION SECTOR

3.4.1 SECTOR OVERVIEW

Within BC's Clean Transportation sector, low-carbon and zero emission vehicles (e.g., electric and hydrogen) present opportunities for the movement of goods and people. Public transit and smart mobility include the bus and rapid transit systems that support urban and rural areas, as well as emerging mobility services such as ride-shares, bike-shares, and intelligent transportation system (ITS) solutions. Land use planning and transportation infrastructure includes planning decisions that shape the networks and influence the rate and form of transport development and activity. Renewable and low-carbon fuels include the institutions and businesses researching and producing low-carbon fuel alternatives that can be blended into the fuel mix and lower the GHG intensity of transport activities across a number of modes (land, air, sea).

A total of 14,700 direct clean economy jobs existed in BC's Clean Transportation sector in 2018 (see Table 38). The GDP generated by this sector was estimated to be $2.96 billion in 2018, with a gross output per job of $279 thousand.

Table 38: Employment and economic contribution of BC's Clean Transportation sector (2018)

Clean Transportation Sector Jobs	Clean Transportation Sector GDP ($ Millions)	Clean Transportation Sector Gross Output ($ Millions)	Gross Output per Job ($ Thousands)
14,706	$2,958	$4,106	$279.2

Source: The Delphi Group based on Statistics Canada data

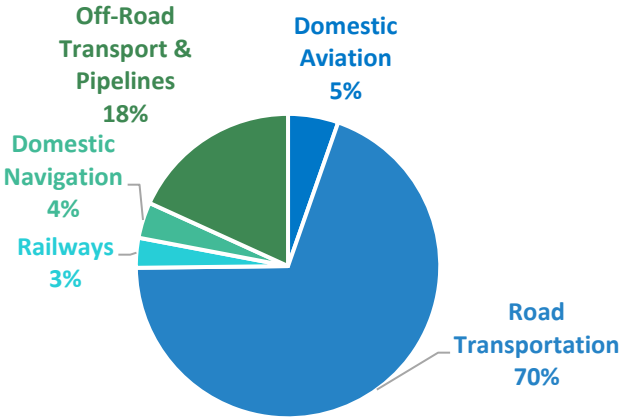
Of the workers currently employed in key occupations for BC's Clean Transportation sector, 45% are between the ages of 45 and 64 (see Table 39). The median annual salary in 2018 was $65,288, with the workforce being made up of 89% men and 11% women. Due to forecast attrition rates and the need for replacement of retiring workers, knowledge transfer and mentorship presents both a significant challenge and an opportunity for this sector.

Table 39: Socio-economic profile of BC's Clean Transportation sector (2018)

Remuneration	Employment by gender (%)		Employment by age group (%)			
Median Annual Salary	Men	Women	15-24	25-44	45-64	65+
$65,288	89%	11%	6%	45%	45%	5%

Source: Delphi's estimate from BC Labour Market Outlook (2018-2028) wage data by occupation

Much of the transportation activity in BC at present is fueled by gasoline, diesel, and other refined petroleum products. In 2016, total GHG emissions from transportation in BC were estimated to be 24,890 kt CO2e, 70% of which were from road transportation (see Figure 19).[129]



Source: BC Provincial GHG Emissions Inventory

Figure 19: GHG emissions from BC's transportation sector by source (2016)

Low-Carbon and Electric Vehicles

British Columbia has been a clean energy vehicle leader among Canadian provinces since the 2007 formation of the "Plug-In BC" stakeholder working group, a collaboration between government, industry, academic institutions, EV owners, NGOs, and utilities to advance the uptake of electric vehicles in British Columbia. This group has been responsible for market transformation, providing information to consumers on programs and initiatives, and studies on grid impacts and GHG emissions benefits.[130]

More recently, BC's Clean Energy Vehicle (CEV) program, CEVforBC, was first announced in 2011, renewed in 2015, and has received multiple funding additions since. The combination of federal and provincial incentives for electric vehicles and charging infrastructure has helped to spur a rapid increase in sales, and BC experienced a 100% increase in EV sales between Q1 2018 and Q1 2019 (from 1361 to 2718 vehicles sold).[131]

British Columbia currently offers a variety of incentives for EVs through CEVforBC, which provides up to $3,000 per eligible vehicle under $55,000. In addition to vehicle point-of-sale incentives, the CEV program also includes:[132]

- Charging infrastructure incentives / investments (Level 2 and DC Fast Charging)
- Hydrogen fuelling station investment (1 new public fuelling station)
- Fleet incentives for adopting CEVs
- Research, training, and public outreach

[129] See: https://www2.gov.bc.ca/gov/content/environment/climate-change/data/provincial-inventory
[130] See: https://pluginbc.ca/about-us/
[131] See: https://emc-mec.ca/wp-content/uploads/Sales-Report-Q1-2019.pdf
[132] See: https://www.cevforbc.ca/clean-energy-vehicle-program

Renewable and Low-Carbon Fuels

Provincial targets related to reducing GHG emissions from the transportation sector include the Low Carbon Fuel Standard which requires a minimum 20% cut in GHG emissions intensity by 2030. While this represents a significant increase in the volume of renewable fuel that will need to be produced, BC has a head start as the only province to have a Low Carbon Fuel Standard since the regulation was first passed in 2010.[133]

British Columbia has also been working together with the states of Washington, Oregon, and California through the Pacific Coast Collaborative Leaders' Forum. The Collaborative's Action Plan on Climate and Energy, signed in 2013, includes a commitment to adopt and maintain low-carbon fuel standards, with a focus on creating a uniform market for regional low-carbon fuel production.[134]

Companies in BC have also been showing leadership in low-carbon fuels by using patented technology for bio-refining ethanol and other co-products from biomass. British Columbia is the largest market in Canada for biodiesel and produced nearly half of the total volume in Canada in 2018.[135] Fuel can be purchased through bulk distribution suppliers and a retail card lock network in Metro Vancouver, Kelowna, Prince George, and on Vancouver Island.[136]

Parkland Fuels in Burnaby (one of only two large scale petroleum product refineries in BC) has been actively scaling its biofuel operations over the last couple of years (including plans to hire many more workers for its biofuel operation), working in collaboration with Metro Vancouver and West Coast Reductions.[137]

Consolidated Biofuels is another facility making biofuel in BC, although much of this is being sold to markets in California at present. At least one smaller organization is also active in BC; the Cowichan Biodiesel Co-op includes an integrated business model for the collection, refining, and distribution of approximately 10,000 liters / month of biodiesel from upcycled used cooking (canola) oil, operating 2 biodiesel pumps in Cowichan Valley on Vancouver Island. This model shows some potential for scaling across other communities in BC, along with the local employment benefits.

Next generation systems are also under development in BC. Chemical engineers and technicians in Prince George for example are working at a joint venture between Canfor and Licella looking to produce biocrude through a process invented in Australia that can be applied to wood residue streams from the pulp industry in BC.[138] Wastewater sludge from Metro Vancouver Wastewater Treatment plant is also being turned into biocrude as part of an innovative pilot project with funding support from the Pacific Northwest National Laboratory in the United States.[139]

Low-carbon fuels, such as liquefied natural gas (LNG) and biofuels, will also be important for powering heavy-duty vehicles (for long-haul trucking) and marine vessels, will be important in the near-term. CleanBC outlines goals to build on the province's global transportation hubs to lower fuel costs and air pollution while making its ports attractive to global shipping fleets transitioning to LNG as a lower cost, lower GHG transition fuel. FortisBC and

[133] See: https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/transportation-energies/renewable-low-carbon-fuels
[134] See: https://pacificcoastcollaborative.org/wp-content/uploads/2018/09/Pacific-Coast-Climate-Action-Plan.pdf
[135] See: https://www.naviusresearch.com/publications/2018-biofuels-in-canada/
[136] See: http://globe.ca/wp-content/uploads/2012/10/GLOBE_BCCleanTransportationReport_FINAL.pdf
[137] See: https://biv.com/article/2019/09/bc-fat-helping-beef-low-carbon-fuel-standards
[138] See: https://www.biofuelsdigest.com/bdigest/2017/03/14/the-wonder-from-down-under-and-canadall-fund-er-canfor-picks-up-13m-for-licella-biofuels-project/
[139] https://canada.constructconnect.com/joc/news/infrastructure/2016/09/metro-vancouver-looking-to-turn-sewage-sludge-to-bio-crude-1018316w

others that are part of the BC Clean Transportation Trade Corridors Advisory Council are working to develop cleaner trade corridors for BC, including the ports through solutions such as LNG bunkering for marine vessels.

BC is also partnering with the Vancouver Fraser Port Authority on a Clean Trucking pilot project to reduce emissions from drayage – the short-distance hauling of goods between terminals and other facilities such as distribution centres, which may be scaled to other freight vehicles in BC. The BC-Smart initiative involves a network of other key players.[140]

An emerging opportunity to help the transition to a low-carbon economy may exist in hydrogen-based energy. Hydrogen is applicable to CleanBC's reduction goals in Clean Transportation and other sectors, including the following:

- **Transportation:** Hydrogen fuel cell technology can be used to replace vehicles that use a traditional combustion engine.
- **Natural Gas and Methane:** As a potential replacement fuel, hydrogen will offset the need to extract natural gas and ultimately lower upstream methane emissions.
- **Industrial Electrification:** As a renewable resource, introducing hydrogen will expand the provincial portfolio of clean energy sources.
- **Cleaner Fuel:** The ability for hydrogen to be a replacement for natural gas across industry will lower the demand for natural gas products and reduce emissions.[141]

> The phase out of automobile-centric planning is creating space for smart mobility solutions that bring together multiple modes of transportation with technologies like sensor networks and smart phone applications.

Public Transit and Smart Mobility

Public Transit and Smart Mobility are drivers of BC's Clean Transportation sector in both rural and urban areas. The combined services provided by transit, smart mobility, and land use planning enable multi-modal options and provide citizens with an alternative to carbon-intensive patterns (e.g., single occupancy vehicle trips exacerbated by urban sprawl). Recent findings from Statistics Canada show that in 2016, nearly one-third of Canadians in census metropolitan areas used a mode of sustainable transportation as part of their primary mode of commuting, which includes cycling, walking, public transit, and carpooling.[142]

Public transit services in BC are provided by two large transit agencies: TransLink serving the Metro Vancouver region and BC Transit serving other communities across British Columbia.

BC Transit provides over 50 million rides to 1.5 million people through 80 transit systems in over 130 communities in the province.[143] As a Crown Agency, BC Transit is required to be carbon neutral and has been reporting and offsetting its GHG emissions since 2010. In addition to driving emission reductions in its fleet, BC Transit has been a leader in piloting emerging technologies such as such as hydrogen and electric / battery storage.

[140] http://www.bc-smart.ca/
[141] Fuel Cells and Hydrogen 2 Joint Undertaking. 2019. Hydrogen Roadmap Europe: A Sustainable Pathway for the European Energy Transition
[142] See: https://www12.statcan.gc.ca/census-recensement/2016/as-sa/98-200-x/2016029/98-200-x2016029-eng.cfm
[143] See: https://www.bctransit.com/about/sustainability

Within Metro Vancouver, TransLink (officially the South Coast British Columbia Transportation Authority) provides transit service to the 2.5 million people in the region through contracted services and subsidiaries that include Coast Mountain Bus Company, British Columbia Rapid Transit Company Ltd. (SkyTrain), and West Coast Express Ltd. (which also serves part of the Fraser Valley Regional District). TransLink operates a regional transit system serving 21 municipalities, as well as a variety of infrastructure assets including bridges, cycling paths, roads, the Seabus, and rail. In 2016, TransLink provided over 386 million rides, an increase of 6% over 2015.[144]

BC's new Active Transportation Strategy aims to double the percentage of trips taken with active transportation by 2030.

Smart mobility solutions include ride-sharing, car-sharing, public transit systems, and active transportation modes and related infrastructure, such as walking, cycling, scooters, and skateboards. As the negative environmental, social, and economic impacts of 20th century automobile-centric planning practices are phased out, space is being created for innovative mobility solutions that bring together multiple modes of transportation with technologies like sensor networks and smartphone apps.

There are a number of car-sharing platforms operating in BC communities, such as EVO, Modo, Zipcar, and Kootenay Carshare Cooperative. Bike share systems are also growing with services like Mobi and U-bicycle operating in Vancouver and Victoria.

The Province's Active Transportation Strategy released in June 2019 aims to double the percentage of trips taken with active transportation by 2030. Released with the strategy was an Active Transportation Design Guide to build on the success of the BikeBC infrastructure funding program and better equip communities to incorporate active transportation in land use planning efforts.[145]

Smart mobility solutions also include the sensors, information systems, and software platforms that bring together transportation options in our modern communities. BC companies, such as Urban Logiq, are using software tools to aggregate and analyze diverse data sets and provide intelligence to cities and fleets. In addition to providing improved mobility options for citizens, these software solutions have the potential to increase the safety and improve the efficiency of the wide range of vehicles on the road.[146]

Rail, Marine, Air, and Goods Movement

Shifting the movement of goods from trucks on the road to trains and ships has the potential to increase efficiencies and reduce fuel consumption and GHG emissions from the sector.[147] Shifting freight from trucks to rail can move goods using less fuel and also reduce congestion on highways, improving the fuel economy of other vehicles and reducing the need for expansion of highway infrastructure.[148]

Canadian National (CN) Railway is Canada's largest freight railroad, providing transportation and intermodal services throughout North America. The company currently employs approximately 2,400 workers in British

[144] See: https://www.translink.ca/-/media/Documents/about_translink/corporate_overview/corporate_reports/annual_reports/2016_TransLink_Annual_Report.pdf
[145] See: https://news.gov.bc.ca/releases/2019TRAN0099-001254
[146] See: https://blog.urbanlogiq.com/coding-the-curb-whats-next-for-smart-city-transportation/
[147] See: http://globe.ca/wp-content/uploads/2012/10/GLOBE_BCCleanTransportationReport_FINAL.pdf
[148] See: https://www.railcan.ca/resources/

Columbia and has made more than $1.1 billion in capital investments since 2013.[149] Current expansion projects include infrastructure on corridors between Prince Rupert and Jasper and between Vancouver and Edmonton.

Canadian Pacific Railway (CP) provides additional freight services in BC with a direct link to the Port of Vancouver, an intermodal terminal in Pitt Meadows, and lines connecting to the East and West Kootenays. Current CP projects include a track reconfiguration project in Field to accommodate longer trains and increase crossing efficiency.[150]

The Southern Railway of British Columbia (SRY) is based in New Westminster and provides connections throughout North America through interchanges with four other Class 1 railroads. The related company, Southern Railway of Vancouver Island, connects communities from Courtenay to Victoria to SRY's Annacis Rail Marine Terminal.[151]

In terms of marine vessels, Seaspan and BC Ferries have been operating LNG-diesel hybrids vessels for several years. In 2019, BC Ferries rolled out its first diesel / electric battery hybrid on two of its 80-meter Island Class vessels (which were new builds from Europe), servicing Northern Gulf Island routes, with four more similar ships ordered. These hybrid ships have been designed to be fully-electric in the future.

BC Ferries also has 5 larger vessels currently in the design phase for its Victoria-Vancouver routes. These will be LNG-battery hybrids with a 2023 delivery timeline, with potential to go to full battery or hydrogen fuel cell in the future (still 10 years out).

In terms of air travel, while larger airlines are likely a decade or more away from electrification, Harbour Air's smaller planes and short flight distances allowed it to become the first commercial airline in the world to fly a pure electric flight.[152] This innovation will have trickle down effects for workers, including marine engineers and aircraft maintenance engineers who will require experience working with high-voltage and battery management systems.

Land Use Planning and Transportation Infrastructure

Land use planning is led by local governments and involves technical and engagement processes to shape how urban and rural areas change over time.

The Planning Institute of British Columbia (PIBC) is the professional association of planners in British Columbia and represents over 1,500 members in nine chapters across the province.[153] PIBC works closely with planning schools like UBC's Collaborative for Advanced Landscape Planning (CALP) and SFU's School of Community and Regional Planning (SCARP) to connect professional planners and students with current research and applied research opportunities.

PIBC formed a climate action task force in 2016 and conducted a survey of 75 members to identify what action planners are taking on climate change. One of the top three topics for further support identified through the survey was "Walkable, sustainable, transit-oriented communities and the planning policies that support them".[154]

[149] See: https://www.cn.ca/en/news/2018/06/cn-investing-approximately-340-million-to-expand-and-strengthen/
[150] See: https://www.cpr.ca/en/community/living-near-the-railway/rail-projects-near-you
[151] See: https://www.sryraillink.com/about-us/overview/
[152] https://www.nationalobserver.com/2019/12/10/news/canadian-airline-makes-history-first-flight-world-all-electric-float-plane
[153] See: https://www.pibc.bc.ca/sites/default/files/PIBC%20FACT%20SHEET%20What%20is%20PIBC%20July%202.pdf
[154] See: https://www.pibc.bc.ca/sites/default/files/PIBC_Climate_Action_Member_Survey%20_March_2017.PDF

3.4.2 TECHNOLOGY TRENDS & MARKET SHIFTS

In addition to the policy drivers and major projects outlined above, technological trends and market shifts are impacting on the types of skills needed to support the growth of the Clean Transportation sector in areas such as electrification, smart mobility, autonomous vehicle technologies, and the sharing economy.

Table 40 outlines the key technological trends that are driving fundamental changes in the transportation sector and the energy efficient movement of goods and people.

Table 40: Key technology trends impacting the Clean Transportation sector

Trend	Description
Electrification of Transportation	Electrification of transportation is supported by the continued global trend of battery costs decreasing as much as 65% in the past five years[155]. E-buses are the fastest growing segment of the EV market at 100% growth since 2013[156], with China leading the way.
Autonomous Vehicles	Autonomous vehicles (AV) are being developed throughout the transportation sector. Self-driving transportation is already used in applications like the Skytrain, Seattle airport, and Toronto LINK Train, and 80% of top Original Equipment Manufacturers (OEMs) have announced highly autonomous road-ready technology by 2025.
Smart Mobility	Shared mobility has a significant growth opportunity with less than 1% of current passenger miles; in 2017 the market saw USD 32 Billion invested in ridesharing start-ups alone[157], and connected cars are emerging as key components of an intelligent transportation network. Intelligent mobility is becoming more prevalent in Smart Cities, by enabling users to make informed transportation choices based on real-time situation data[158]
Last Mile / Multi Modal Transportation	Logistics hubs are appearing more frequently due to the significant increase in e-retailing resulting in the need for local distribution points, and apps and other mobile technologies have enabled a proliferation of last-mile solutions[159].
Renewable Fuels	Biofuels comprised 2.8% of renewable fuels for transport as of 2015 and global ethanol production increased 2.5% in 2017[160]. Investment in hydrogen derived from water via electrolysis is growing around the world; if current projects come online in the next two years, cumulative capacity will rise from 55MW in 2017 to over 150MW in 2020[161].

[155] See: https://about.bnef.com/new-energy-outlook/
[156] See: https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/fast-transit-why-urban-e-buses-lead-electric-vehicle-growth
[157] See: https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/the-automotive-revolution-is-speeding-up
[158] See: https://www.researchandmarkets.com/research/5zx8ks/future_of_smart
[159] See: http://www.kennisdclogistiek.nl/nieuws/the-future-of-last-mile-delivery-10-most-important-trends
[160] See: http://www.ren21.net/gsr-2018/
[161] See: https://www.iea.org/tcep/energyintegration/hydrogen/

The trend toward more efficient modes of transportation is rooted in the rising and volatile price of high-carbon fossil fuels in addition to increasing challenges with congestion in urban areas.[162] For example, electric buses are the fastest growing segment of the EV market, at 100% growth since 2013.[163] Meanwhile, original equipment manufacturers (OEMs) have announced launches of >100 new battery EV models by 2024.[164]

Government rebates for zero emission or electric vehicles alongside improved charging station infrastructure is also pushing consumers towards adopting cleaner modes of transportation.[165] Demand also continues to increase for public transit across cities as local governments commit to reaching the GHG reduction targets and 100% renewable energy goals.[166]

3.4.3 KEY INDUSTRIES

British Columbia's Clean Transportation sector is made up of a vast network of road, rail, water, and air infrastructure connecting communities across the province and outward across the globe for the movement of both goods and people. For the purposes of the CleanBC LMI research, a framework of sub-sectors and corresponding industry NAICS codes is listed in Table 41 below.

Table 41: Sub-sectors and industries that make up BC's Clean Transportation sector

Sub-Sector	NAICS Codes	Description
Clean Transportation - General	5416 Management, scientific and technical consulting services	Establishments providing expert advice and assistance to other organizations on management, environmental, scientific and technical issues
	5417 Scientific research and development services	Original investigation, undertaken on a systematic basis to gain new knowledge, and in the application of research findings or other scientific knowledge for the creation of new or significantly improved products or processes
Low-Carbon and Electric Vehicles	3336 Engine, turbine and power transmission equipment manufacturing	Manufacturing of turbines and turbine generator sets; internal combustion engines (except automotive gasoline and aircraft); and speed changers, industrial high-speed drives and gears
	3359 Other electrical equipment and component manufacturing	Manufacturing of electrical power storage and transmission devices, and accessories for carrying current
	3361 Motor vehicle manufacturing	Manufacturing of motor vehicles
	3363 Motor vehicle parts manufacturing	Manufacturing of motor vehicle parts, including engines

[162] See: GLOBE Advisors. 2012. Market Report: BC's Clean Transportation Sector.
[163] See: https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/fast-transit-why-urban-e-buses-lead-electric-vehicle-growth
[164] See: https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/what-a-teardown-of-the-latest-electric-vehicles-reveals-about-the-future-of-mass-market-evs
[165] See: https://engage.gov.bc.ca/app/uploads/sites/391/2018/07/MoE-IntentionsPaper-Transportation.pdf
[166] See: GLOBE Advisors. 2012. Market Report: BC's Clean Transportation Sector.

	8111 Automotive repair and maintenance	Repairing and maintaining motor vehicles, such as cars, trucks, vans and commercial trailers
Renewable and Low-Carbon Fuels	3251 Basic chemical manufacturing	Manufacturing of chemicals, using basic processes such as thermal cracking and distillation
Public Transit and Smart Mobility	3353 Electrical equipment manufacturing	Manufacturing of equipment that generates and distributes electrical power
	3369 Other transportation equipment manufacturing	Manufacturing of equipment for transporting people and goods
	4851 Urban transit systems	Operation of local and suburban mass passenger transit systems
	4859 Other transit and ground passenger transportation	Establishments primarily engaged in providing shuttle services to airports and similar facilities, special needs transportation services, and other transit and ground passenger transport
Rail, Marine, Air, and Goods Movement	3365 Railroad rolling stock manufacturing	Manufacturing and rebuilding locomotives and railroad cars, of any type or gauge, including frames and parts
	4821 Rail transportation	Establishments primarily engaged in operating railways
	4882 Support activities for rail transportation	Establishments primarily engaged in providing specialized services to the rail transport industry, including the operation of railway terminals and stations, and the maintenance of railway rights-of-way and structures
	4831 Deep sea and coastal water transportation	Establishments primarily engaged in deep sea and coastal water transportation of freight and passengers
Land Use Planning and Transportation Infrastructure	9139 Other local, municipal and regional public administration	Local governments primarily engaged in activities of a governmental nature, such as legislative activities, taxation, public order and safety, and the administration of local government programs

3.4.4 KEY OCCUPATIONS

Key occupations found in BC's Clean Transportation sector are listed in Table 42 below. These occupations were initially identified using statistical analysis. The key occupations (by NOC code) for industries relevant to this sector at the 3-digit NAICS code level (as published by Statistics Canada in its 2011 Census breakouts) were amalgamated across industries. The key occupations were then validated through additional secondary research and industry consultation as part of the LMI research.

Key occupations include transit drivers and operators, railway workers, automotive service technicians, electricians, and engineers, among others. Another growing role in the transportation sector is related to the trends of digitization and automation of transportation; these occupations include information systems analysts and computer programmers.

Table 42: Key occupations in BC's Clean Transportation sector

NOC	Occupation
0731	Managers in transportation
1215	Supervisors, supply chain, tracking and scheduling co-ordination occupations
2131	Civil engineers
2132	Mechanical engineers
2133	Electrical and electronics engineers
2134	Chemical Engineers
2171	Information systems analysts and consultants
2174	Computer programmers and interactive media developers
2211	Chemical technologists and technicians
2241	Electrical and electronics engineering technologists and technicians
7242	Industrial electricians
7304	Supervisors, railway transport operations
7305	Supervisors, motor transport and other ground transit operators
7312	Heavy-duty equipment mechanics
7321	Automotive service technicians, truck and bus mechanics and mechanical repairers
7361	Railway and yard locomotive engineers
7362	Railway conductors and brakemen/women
7511	Transport truck drivers
7512	Bus drivers, subway operators and other transit operators
9421	Chemical plant machine operators
9522	Motor vehicle assemblers, inspectors and testers

3.4.5 WORKFORCE DEMAND

Demand-side Drivers

BC's Clean Transportation sector is a focus of the CleanBC Plan and is expected to undergo significant shifts in technology and required skills between now and 2030. Policy drivers in CleanBC include targets for zero emission vehicles (ZEVs) and low-carbon fuels, as well as incentive programs supporting transit and charging infrastructure.[167] Specific demand drivers, targets, and indicators of expected growth by sub-sector are described in more detail in Table 43.

[167] See: https://cleanbc.gov.bc.ca/

Table 43: Sub-sectors, targets, and expected growth for BC's Clean Transportation sector

Sub-sector	Targets and Indicators	Sub-sector Growth & Jobs Impact[168]
Low-carbon and Electric Vehicles	The CleanBC ZEV standard requires automakers to meet the following targets for ZEV's as a percentage of all new light-duty vehicle sales in BC: • 10% in 2025 • 30% in 2030 • 100% by 2040	**Medium**
Renewable and Low-carbon Fuels	CleanBC sets a production target of 650 million litres of low-carbon fuel by 2030 (current production is approximately 25 million litres).	**Very High**
Public Transit and Smart Mobility	• TransLink's Transport 2040 Plan forecasts a need to provide mobility for an additional 1 million people (2006-2040).[169] • TransLink's 2018-2027 Investment Plan includes an "unprecedented level of transit expansion for the Metro Vancouver Region" and forecasts an 8% increase in bus service and a 42% increase in rail service.[170] This plan also includes "$24 million from 2017 to 2026 to pilot, field test, and scale new mobility technologies and service concepts". • BC Transit's Plan for the Capital Region (2011) forecasts a 40% increase in daily trips by 2038.[171] • BC Transit's Plan for Prince George (2014) targets an increase in ridership from 2 million to 5.4 million passengers per year by 2038.[172] • BC Transit's Plan for the Central Okanagan (2011) targets an increase from 4.3 million rides to 16 million rides in 2035.[173] • BC's Active Transportation Strategy (2019) aims to double the proportion of trips taken using active transportation by 2030.[174]	**High**
Rail, Marine, Air, and Goods movement	• Significant conversion efforts underway, as well as the adoption of new buses, long-haul / heavy-duty trucks, marine vessels, and smaller aircraft in BC to electric and hybrid, as well as CNG and LNG powered vehicles / vessels • Demand for exported goods is linked to forecast growth of developing markets, including China (6.1%) and India (8.2%).	**High**

[168] Note the terms used to describe the expected growth of sub-sectors (medium, high, very high) are relative and not based on specific quantifiable levels. Information used to inform the expected growth assessment includes key informant interviews, trends analysis, and secondary research.
[169] See: https://www.translink.ca/-/media/Documents/plans_and_projects/regional_transportation_strategy/Transport-2040/Transport-2040.pdf
[170] See: https://tenyearvision.translink.ca/Documents/10-year_vision_phase_2_investment_plan.pdf
[171] See: https://www.bctransit.com/documents/1507213421003
[172] See: https://www.bctransit.com/documents/1507213420964
[173] See: https://www.bctransit.com/documents/1507213427841
[174] See: https://news.gov.bc.ca/releases/2019TRAN0099-001254

	• Demand for transportation of imported goods expected to grow by 4.1% per year in the short-term.[175]	
Land Use Planning and Transportation Infrastructure	Steady demand for planning services from local governments and related organizations.[176]	**Medium**

Transportation infrastructure projects of all sizes are planned across the province and include a variety of projects from electric charging stations to public transit infrastructure. A list of major projects related to the Clean Transportation sector is found in Table 44 and includes transit projects such as the South of Fraser Rapid Transit Construction project and the Millennium Line Extension Construction project along the Broadway Corridor in the City of Vancouver. Other major projects outside of the Mainland/Southwest region include the $75 million Central Okanagan Multi-Modal Corridor project and the restoration of the E&N rail track on Vancouver Island. Many of these projects present opportunities to include smart mobility solutions and technology, such as smart traffic lights, sensors, and camera installations.

Table 44: Clean transportation related major projects in BC

Development Region	Number of Projects	Estimated Cost ($ millions)
1. Vancouver Island/Coast	1	$70
2. Mainland/Southwest	13	$4,492
3. Thompson/Okanagan	2	$75
4. Kootenay	1	n/a
5. Cariboo	0	0
6. North Coast	0	0
7. Nechako	0	0
8. Northeast	0	0
Total	**17**	**$4,637**

Source: BC Major Projects Inventory Q2 2019

The demand for rail transportation is derived from the demand for other goods or services. Demand for imported goods in Canada is expected to continue growing by 4.1% per year in the short term. Conditions in natural resource markets (e.g., coal, potash, grain, oil, forest products) can significantly affect the capacity of rail and goods movement. China's GDP is expected to grow by an average of 6.1% to 2022, and India's GDP could reach 8.2% in the same time period. Other major Canadian trading partners in developed economies are expected to see relatively modest growth rates as a consequence of ageing populations and a lower labour force participation rate. Finally, demand for oil by rail in Canada grew in 2017 and future growth will depend largely on the status of current pipeline construction projects.[177]

[175] See: https://www.tc.gc.ca/eng/policy/transportation-canada-2017.html
[176] See: https://www.jobbank.gc.ca/marketreport/requirements/22469/39071
[177] See: https://www.tc.gc.ca/eng/policy/transportation-canada-2017.html

Employment Impacts from CleanBC

CleanBC sets out an overarching goal of reducing fossil fuel use for transportation by 20% by 2030. More specific targets / goals within the current CleanBC Plan to 2030 are outlined below as they relate to job creation potential, along with a discussion on projected employment impacts.

1. 30% of all new light-duty vehicle (LDV) and truck sales will be zero emission vehicles (ZEVs) by 2030.
2. Production of 650 million liters of renewable fuels per year by 2030.
3. Investments in active transportation infrastructure.

Key Considerations by CleanBC Policy Goal

Employment considerations and assumptions for the policies outlined above are described below.

1. 30% of all new LDV and truck sales to be ZEVs by 2030

Policy Details: By 2030, 30% of all sales of new light-duty cars and trucks will be zero-emission vehicles, rising to 100% by 2040.

Assumptions: The target will largely be met through growth of electric vehicles (EVs), with nominal market penetration of hydrogen passenger vehicles by 2030 given the technology is about a decade behind where EVs are today. Capital costs for residential EV charging infrastructure (Level 2) are estimated at $1,500 (50:50 equipment to labour) and commercial EV charging infrastructure installation equal to $3,000. Total capital investment is estimated at $675M between 2020-2030, with steady growth over the next decade.

Timelines: Steady growth of EV market, from 10% of new vehicle market sales today to 30% by 2030. Market penetration of EVs (pure and plug-in hybrid) as percentage of total LDV stock is estimated to go from 1% in 2019 (30,000) to approximately 18% by 2030 (350,000).

Geographic: Initial investments in EV charging infrastructure largely in southwestern and urban centres of BC, linked to the passenger vehicle market and some light duty trucks (e.g., delivery vehicles), including the retrofit of multi-unit residential and commercial buildings.

Job Impacts: 188 temporary construction jobs on average per year created between 2020 and 2030 for electricians, largely linked to new investments in the installation and maintenance EV charging infrastructure in order to meet the projected 350,000 ZEVs on BC roads by 2030.

Job transformation will largely be the reskilling of automotive mechanics and electricians to account for electric power train systems and more advanced computer and control systems in EVs. Long-term, there may be increased job creation opportunities for battery recycling and for cleantech companies across the power train supply chain.

Some job displacement may occur (estimated to be approximately 1,460 jobs by 2030) for traditional automotive mechanics working on internal combustion engine (ICE) vehicles, particularly those from non-dealership associated service stations, given the need for less regular maintenance of EVs (i.e., no oil changes, spark plug changes, less brake servicing due to regenerative braking, etc.) and warranties that require going direct to OEMs (e.g., Tesla). However, it is unlikely that sudden layoffs of mechanics would occur given existing vehicle market will still have considerable ICEs in 2030. Given the adoption of EVs in the light-duty vehicle market is projected to be faster in the province's urban centres, and largely in Southwestern BC, job displacement is most likely to impact these regions within the 2030 timeframe.

2. Production of 650 million liters of renewable fuels per year by 2030

Policy Details: Goal to produce 650 million liters of renewable fuel in BC per year by 2030, in line with Low Carbon and Renewable Fuel Standard targets.

Assumptions: At present, less than 15 million liters per year of renewable fuels is produced in BC. The following is assumed as pathways for reaching the 650 million liters per year of renewable fuels by 2030 in BC:

1. **450 million / year by 2030 from 1st generation sources** (e.g., from canola oil and tallow) converted to biodiesel (at sites such as Parkland Fuel refinery in Burnaby, BC).
2. **20 million / year by 2030 for 2nd generation non-cellulosic feedstock** processing form hydrothermal fractionation (e.g., scaling Metro Vancouver's wastewater treatment plant pilot to a $50M demonstration facility).
3. **180 million / year by 2030 for cellulosic (forestry-based) feedstock** to biocrude plant with major investment in the 2027-2030 timeline. Assumes the construction of one $1 billion project. Will likely locate near a pulp mill with excess waste pulp (instead of burning or gasifying it for electricity).

Timelines: Initial investments between 2020-2025, larger facility investments post 2025.

Geographic: Potential for all regions, linked to feedstock access.

Job Impacts: Job creation potential based on the assumptions above is 537 temporary construction jobs on average per year between 2020-2030 and approximately 1,179 permanent direct jobs in operations, including feedstock supply and transportation.

In addition to construction occupations, job creation includes work for: chemical engineers, technicians, and operators at oil processing (biodiesel) refineries; wastewater treatment plant facility engineers; research and development scientists, chemical engineers, and technicians; refinery facility design, construction and expansion; and transportation / logistics related occupations across the feedstock supply chain, including truck drivers (from agricultural waste, recycled cooking oils, tallow and lard from animal rendering, and forestry waste).

3. Investments in active transportation infrastructure

Policy Details: This CleanBC policy goal seeks to address transportation grid lock and help people get around, the province has developed a long-term strategy to increase active transportation and look at better commuting solutions.

Assumptions: The 2019 BC Budget earmarked $6 million annually for active transportation infrastructure investments. It is assumed this investment is matched for a total of $21 million annually in infrastructure such as bike lanes, pedestrian bridges, and improved walkability within communities. Total investment equal to $231 million between 2020-2030.

Timelines: Investments are equally distributed between 2020 and 2030.

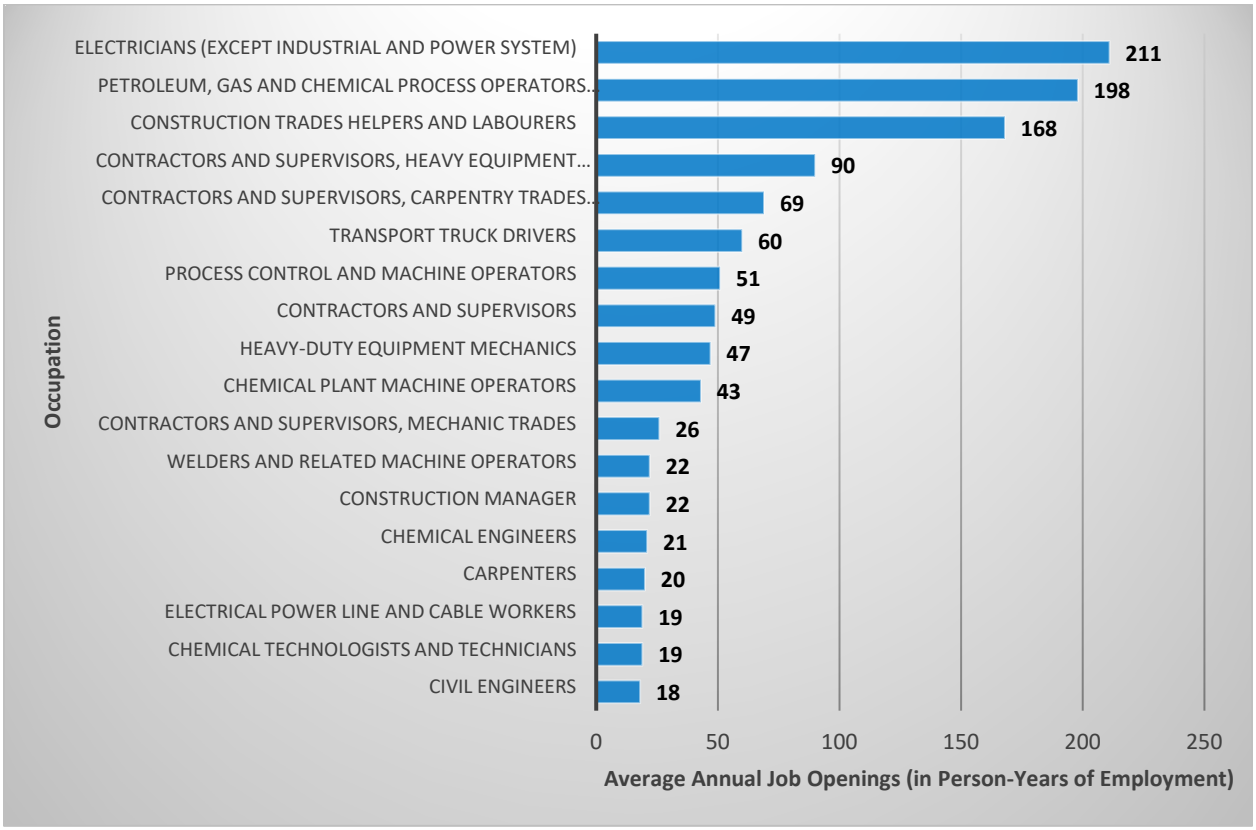
Geographic: Evenly distributed across the province.

Job Impacts: 70 temporary jobs on average per year related to planning, engineering, and construction between 2020-2030.

Employment Impacts by Occupation

The three CleanBC policy goals outlined above are expected to create demand for approximately 795 temporary construction jobs on average per year between 2020 and 2030 and approximately 1,180 permanent direct jobs in operations by 2030. Key occupations relevant to this job creation are shown in Figure 20.

Job transformation is expected to be linked to workers in this sector as they are impacted by both market trends and policy drivers related to the adoption of more zero emission vehicles and related technologies, including the impact on the supply chain from the electrification of light-duty passenger vehicles and trucks, buses, and fleet vehicles, as well as, to a lesser degree, within the rail, ocean vessel, and air (float plane) transportation segments. Conversion to natural gas (CNG, LNG) systems and biofuels, as well as "smart" mobility solutions, are expected to create additional skill requirements for vehicle operators and maintenance crews. In total, the sector is projected to see nearly 7,900 jobs impacted through transformation between 2018 and 2030. Table 45 provides a breakout of the key occupations by number.



Source: The Delphi Group

Figure 20: Annual average number of job openings for key occupations in the Clean Transportation sector based on modelling of initial CleanBC policy targets (2020-2030)

Table 45: Key occupations projected to undergo job transformation within BC's Clean Transportation sector between 2018 and 2030

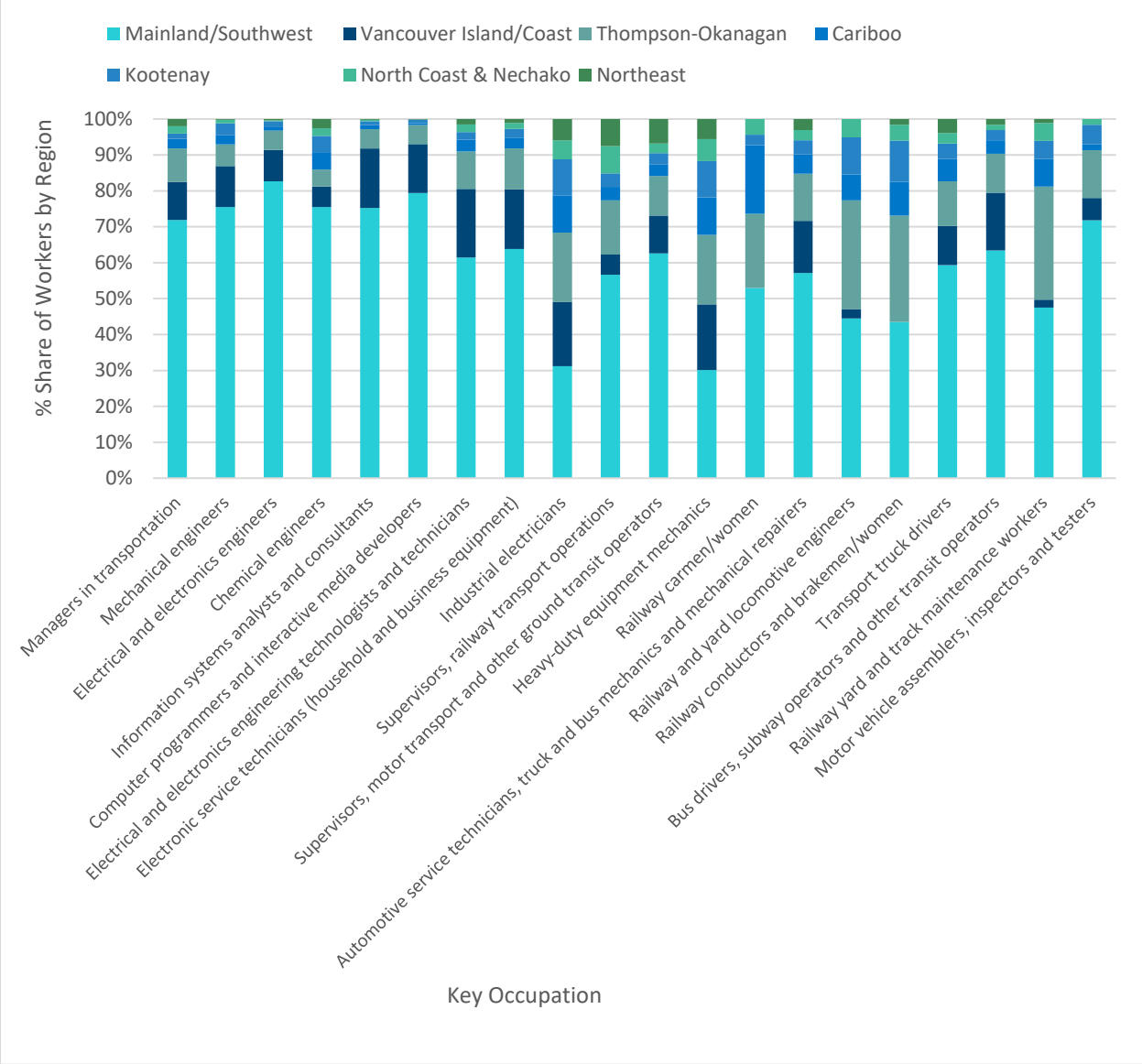
NOC - Occupation Title	Percent of Sector	Number of Jobs Undergoing Transformation (2018-2030)
7512 Bus drivers, subway operators and other transit operators	19.2%	1511
7513 Taxi and limousine drivers and chauffeurs	11.9%	938
7321 Automotive service technicians, truck and bus mechanics and mechanical repairers	6.8%	534
7362 Railway conductors and brakemen/women	5.8%	459
7511 Transport truck drivers	1.5%	121
7312 Heavy-duty equipment mechanics	1.5%	119
1525 Dispatchers	1.2%	97
0731 Managers in transportation	1.2%	95
7305 Supervisors, motor transport and other ground transit operators	1.0%	81
7304 Supervisors, railway transport operations	0.9%	70
7242 Industrial electricians	0.6%	51
2242 Electronic service technicians (household and business equipment)	0.6%	46
7535 Other automotive mechanical installers and servicers	0.4%	28
7315 Aircraft mechanics and aircraft inspectors	0.3%	24

Source: The Delphi Group

3.4.6 WORKFORCE SUPPLY

Regional Distribution

As shown in Figure 21 below, key occupations relevant to the Clean Transportation sector with the highest concentrations based in the Mainland/Southwest region include electrical and electronics engineers, computer programmers, and interactive media developers. Occupations that are more distributed across the province include rail engineers, track maintenance workers, industrial electricians, and heavy-duty equipment mechanics as examples.



Source: Based on Statistics Canada 2016 Census

Figure 21: Key occupations in the Clean Transportation sector by BC Development Region

3.4.7 EDUCATION & TRAINING

Based on consultation with industry stakeholders through this project, workers in the Clean Transportation sector include a mix of engineers and technicians, mechanics and operators, and increasingly people working in information systems, media, and software development and support.

Education and training for these workers depends on the specific occupation, and typically includes some post-secondary and on-the-job training. Due to the nature of the work and interface with the public, many workers require safety and first aid training in addition to the specifics of their trade.[178] Training pathways for some occupations include apprenticeships and certification through the Industry Training Authority. While this is not mandatory in BC, the Red Seal qualification typically increases employment opportunities as most employers will only hire certified mechanics.[179]

Heavy-duty equipment mechanic career pathways include specializing in specific types of machinery, advancing to management positions, and opening one's own business. While still a small piece of the broader industry, there is a growing opportunity for mechanics to specialize in natural gas, hydrogen fuel cell, and electric engines. Advancement into supervisory positions or progressing to heavier equipment and emerging technology are potential career pathways for drivers and operators.

The rail sector invests in their own training programs and partners with training institutions in BC and across Canada and the United States.[180] With only two primary railway operators in British Columbia, training for conductors and mechanics is limited and occurs in centralized training facilities such as the new CN Campus in Winnipeg.[181]

Table 46: Common education pathway for engineers

Secondary School	Bachelor's degree	Master's Degree	Internship	Licensing Exam and Accreditation	Continued Professional Development
Secondary School Diploma	Bachelor of Engineering	Sometimes required for engineers	3-4 years of supervised work experience	Relevant to engineers	Training provided by colleges, manufacturers, unions, and industry associations

Source: EducationPlannerBC

Table 47: Common education pathway for automotive service technicians

Secondary School	Apprenticeship	Red Seal Exam	Red Seal Certification	Continued Professional Development
Secondary School Diploma	A combination of work experience and class time offered through Industry Training Authority, public or private training institutions and employers.	Journey Person	Mastership / Certificate of Qualification	Usually optional / voluntary training provided by colleges, manufacturers, unions, and industry associations.

Source: EducationPlannerBC

[178] See: https://www.workbc.ca/Jobs-Careers/Explore-Careers/Browse-Career-Profile/7512
[179] See: https://www.itabc.ca/program/truck-and-transport-mechanic
[180] See: https://www.cpr.ca/en/careers/educational-partners
[181] See: https://www.cn.ca/en/customer-centre/safety-guidelines-and-regulations/cn-campus-customer-training/

Post-secondary Institutions

The drive towards renewable and low-carbon fuels, electric highways, zero emission vehicles, public transit, and smart mobility solutions will create demand for electricians, civil and mechanical engineers, EV mechanics and technicians, chemical engineers, transit drivers, and information systems analysts/computer programmers.

In response to this push toward EVs and related infrastructure, BCIT will be rolling out its EV Maintenance Training Program as a part-time studies course beginning in early 2020.[182] The program will be used to develop and grow subsequent training programs in clean transportation both at BCIT and other post secondary institutions across BC.

Table 48 outlines other programs and institutions who are offering programs and education relevant to key occupations listed above.

Table 48: Education and training programs aligned with key Clean Transportation sector occupations

Key Occupation	Number of Programs Offered in BC	Institutions Offering the Programs
Automotive Technician	33	BCIT, Camosun College, Coast Mountain College, College of New Caledonia, College of the Rockies, Kwantlen Polytechnic University, New Island College, Northern Lights College, Okanagan College, Thompson Rivers University, University of Fraser Valley, Vancouver Community College, Vancouver Island University
Electrician	59	BCIT, Camosun College, Coast Mountain College, College of New Caledonia, College of the Rockies, Kwantlen Polytechnic University, Nicola Valley Institute of Technology, North Island College, Northern Lights College, Okanagan College, Selkirk College, Simon Fraser University, Thompson Rivers University, University of British Columbia, University of Fraser Valley, University of Victoria, Vancouver Island University
Civil Engineer	13	BCIT, Camosun College, College of New Caledonia, Okanagan College, Thompson Rivers University, University of British Columbia, University of Northern B.C.
Mechanical Engineer	15	Camosun College, College of New Caledonia, Okanagan College, University of British Columbia, University of Victoria
Chemical Engineer	4	College of New Caledonia, Simon Fraser University, Thompson Rivers University, University of British Columbia
Heavy duty equipment mechanic	38	BCIT, Camosun College, Coast Mountain College, College of New Caledonia, College of the Rockies, North Island College, Northern Lights College, Okanagan College, Selkirk College, Thompson Rivers University, University of Fraser Valley, Vancouver Community College, Vancouver Island University

Source: EducationPlannerBC

[182] See: https://commons.bcit.ca/news/2019/12/ev-maintenance-training/

Industry-led Training

The Electric Vehicle Infrastructure Training Program (EVITP) is a leading example of industry-led training that was designed to address the need for installation and maintenance of the EV charging infrastructure across Canada. The course was developed through a voluntary collaboration of electrical industry organizations, which include but are not limited to General Motors, BMW, Pacific Gas and Electric, the National Electrical Contractors Association (NECA), and the University of California-Davis. It is offered through the Electrical Contractors Association of BC in the Lower Mainland.[183]

On a larger scale, Tesla Motors, Audi, and BMW provide examples of industry-led training. Tesla Motorsoffers its own training for its EV technicians called "Tesla START" .[184] More traditional auto manufacturers are also realizing the need to hire and train technicians to service EVs. Audi is offering two training courses, one for hybrid and one for electric vehicles to ensure technicians understand how to safely work with both types of vehicles. This includes training with the use of high-voltage insulated gloves and insulated tools.[185] Meanwhile, BMW will be investing $56 million in EV support centres to boost training capacity of EV technicians by 50%, producing approximately 12, 000 technicians.[186] BC can expect to see the same type of investment in training in dealerships across BC.

While dealerships and companies such as Tesla offer their own training, third-party service providers and repair shops will need to ensure they have the capacity to provide maintenance services to the EV market to stay relevant. Options to work with BCIT and other PSIs, as well as exploring private programs in BC exist, such as the ones offered by Sun Country Academy in Saskatchewan.[187]

Labour Organizations

Labour organizations who represent some of the key players to engage in the training and upskilling as part of BC's shift toward clean transportation include:

- **Unifor 333**: Represents Greater Victoria bus drivers, mechanics, and maintenance workers, as well as BC Transit workers.[188]
- **IAMAW Northwest District 250**: Represents skilled trades across commercial transport shops and automotive dealerships.[189]
- **Move UP**: In addition to BC Hydro, FortisBC, ICBC, and BCAA, Move UP also represents transit providers and their workers.

[183] See: https://eca.bc.ca/education/the-electric-vehicle-infrastructure-training-program-evitp__trashed-2/
[184] See: https://www.tesla.com/en_CA/careers/job/start-programtechnician-37373
[185] See: https://www.itabc.ca/overview/our-trades-training-system/technology-trades
[186] See: https://www.bmwblog.com/2019/08/15/bmw-to-invest-56-million-in-technician-support-centers-for-evs/
[187] An example of third-party program is the EV training offered by Sun Country Academy in Saskatchewan. See: http://suncountryacademy.com/
[188] See: https://www.unifor333bc.ca/
[189] See: http://iamdistrict250.ca/about-us/

3.4.8 EMERGING SKILLS

In general, there is an increasing need across the Clean Transportation sector for technical skills related to increasing the energy efficiency of transport, developing sources of renewable fuels, and the growing role of data, analytics, and software application support.

An understanding of tools and approaches to analyze and interpret data is an increasingly important skill within the Clean Transportation sector.

The growth of public transit ridership and app-enabled mobility solutions are creating a demand across the Clean Transportation sector for cross-functional skills such as story telling and effective communication with a variety of audiences. Gaps in cross-functional skills can be a barrier for employers, and the demand for these skills exists in technical and non-technical roles.

Employers / business owners that responded to the CEWRP Industry Survey from the Clean Transportation sector identified a number of emerging technologies that are expected to become increasingly important to their operations, as outlined in Figure 22. Eighty-nine percent (89%) of respondents indicated data collection and analytics as particularly important to their organizations today, with two-thirds (67%) suggesting data collection and analytics will become increasingly important in the next 5-10 years.

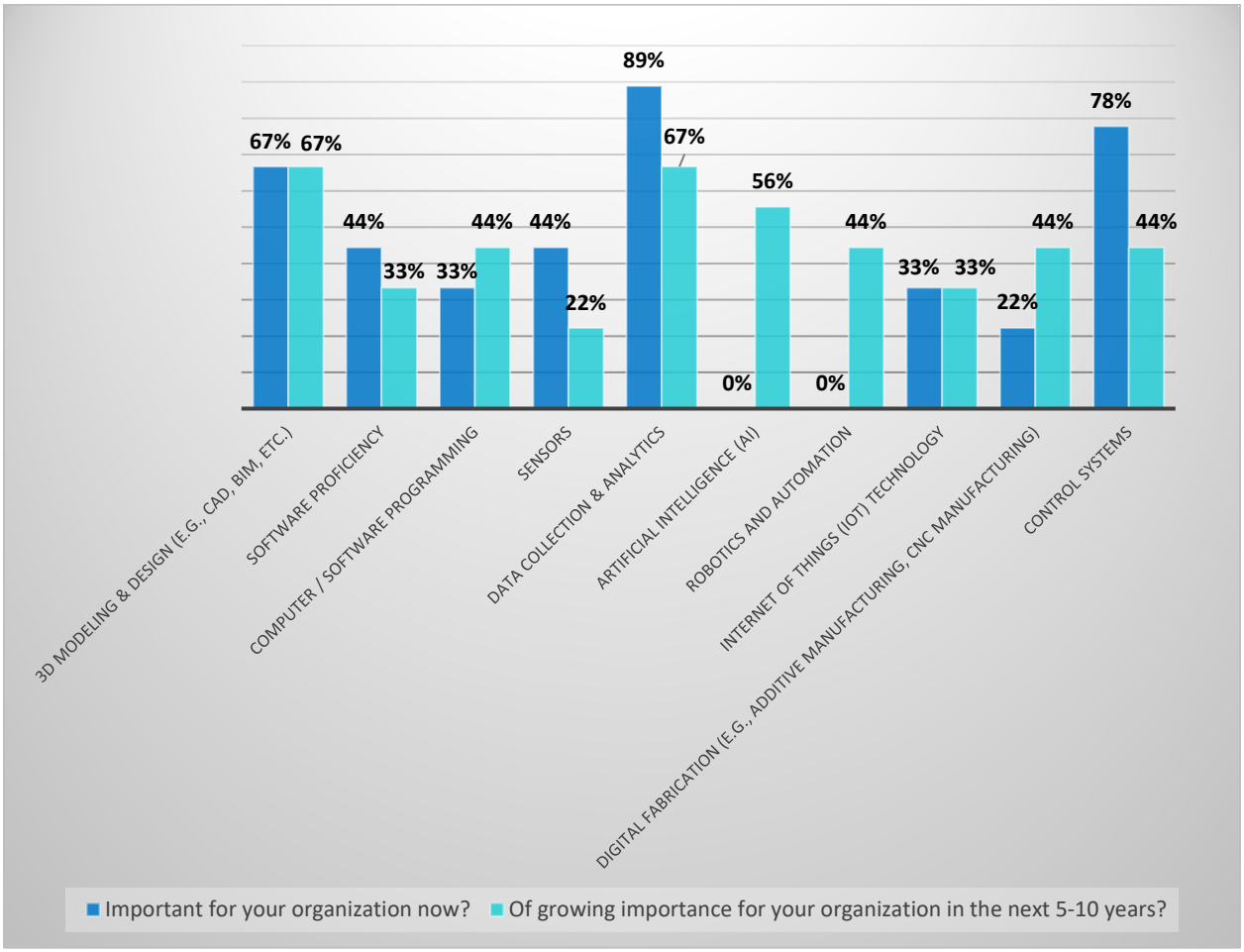
Safety considerations have been identified as a driver for change in the Clean Transportation sector. Workplace safety associated with electrical storage carries higher risks and dealing with electricity requires different safety standards and precautions. Electrification of the sector drives a need to focus on helping workers in various positions understand the risks associated with storing massive amounts of electricity.

Low-Carbon and Electric Vehicles (EVs)

As cars get cleaner and more technologically sophisticated, the mechanical and electrical skills of maintenance workers need to adapt quickly. Robotics engineers and electrician trades have the foundational skills and are currently helping to meet this need.

Technicians employed by auto dealerships tend to be well supported and up-to-date with training in new technologies, while there is a growing demand for EV-related skills and knowledge in independent repair shops as more EVs show up on the used market. Based on consultation with stakeholders, initiatives are underway between the Province and training institutions to address this demand by making EV-specific automotive training more mainstream and accessible.

Input received from stakeholders in BC's Clean Transportation sector highlighted the importance of having a comprehensive knowledge of the rapidly growing world of EVs in a variety of occupations. For example, fleet managers need to have a strong knowledge of the business case for EVs, and fleet technicians need the ability to manage use and state of charge.



Source: CEWRP Industry Survey

Figure 22: Computer hardware and software skillsets of growing importance for the Clean Transportation sector (n=9)

Because the subject of EVs is rapidly changing and widely-applicable, maintaining an understanding of currently relevant information and accurate facts is important for local government staff and other occupations that interface with the public. BC Hydro is supporting this communications effort by maintaining lists of currently available vehicles and incentives,[190] as well as dispelling myths around EVs in a 2018 report.[191]

[190] See: https://www.bchydro.com/powersmart/electric-vehicles/resources.html
[191] See: https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/news-and-features/Report-unplugged-myths-block-road-to-EV-dream_April%202018.pdf

The CleanBC target to undertake fuel efficiency improvements and driver education, as well as a goal to reduce GHG emissions by 40% from BC Government vehicles will require some reskilling. $1.4M per year for 3 years was set aside in the 2019 BC Budget to support these efficiency improvements and driver training, which will largely impact on heavy-duty vehicle and truck drivers undergoing driver education. In addition, the achieving the goal will require the reskilling of asset managers and light-duty vehicle and truck mechanics, vehicle technicians, and drivers, tied to the purchase of new, and the conversion of existing government fleet vehicles, to EVs, hybrids, CNG, and potentially hydrogen-powered vehicles in the future.

Initiatives are underway between the Province of BC and training institutions to make EV-specific automotive training more accessible.

While still relatively emerging and niche technologies, knowledge of hydrogen and natural gas transportation technology will be an important asset for workers in specialized areas of BC's Clean Transportation sector. A recent study on the opportunities associated with BC's Clean Energy Vehicle Program noted that the province is well positioned to produce a local source of clean hydrogen as a transportation fuel.[192]

Low-Carbon Fuels

The area of Low Carbon Fuels is already growing in BC due in part to the Province's Renewable and Low Carbon Fuel Standard and is expected to grow even more with the goal of a 20% reduction in the carbon intensity of gasoline and diesel by 2030. Meeting this target means the production of renewable fuel will have to increase significantly from 25 million litres currently, to 650 million litres by 2030.

A reskilling of chemical engineers and technicians for next generation renewable fuel production / processing pathways and technologies will be likely. Some job substitution potential also exists at refineries for petro-chemical engineers and plant facility operators focused on hydrocarbon-based processing to shift toward more biodiesel and renewable bio-oil processing and blending.

There is also some potential reskilling required of pulp mill, sawmill, and/or wastewater treatment plant engineers and operators with the deployment of advanced biofuel production technologies, although likely a decade away from fully commercial-ready deployment.

Other roles that will be required to support the growth of renewable fuel production are geographic information systems (GIS) analysts and managers in transportation logistics. Identifying appropriate sources of biomass feedstock and connecting them with production facilities across the province will be necessary to achieve the ambitious growth of renewable fuels signaled by CleanBC. Job substitution is likely related to transportation and logistics for occupations related to feedstock supply chains (e.g., truck drivers), collecting and cost-effectively transporting forestry and agricultural waste, recycled cooking oil, tallow, and lard from source to processing facilities.

[192] See: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/electricity-alternative-energy/transportation/cev_economic_opportunities_final_report.pdf

Public Transit and Smart Mobility

The plans to electrify bus fleets in BC (e.g., BC Transit, Translink, sightseeing buses, etc.) will bring with it a large demand for reskilling within both operator and maintenance related occupations in order to work safely with high-voltage.

Further, smart mobility solutions and Mobility as a Service (MaaS) are a growing piece of the Clean Transportation sector and are important to support other pieces like rapid transit and carsharing. Providing mobility solutions that do not require personal vehicle ownership are also very important from an equity perspective. A key component of the recent application to the Smart Cities Challenge by the South Island Prosperity Project, City of Vancouver and Surrey, and the City of Richmond, showcased many of the exciting opportunities and new technology solutions associated with smart mobility.[193]

An understanding of tools and approaches to analyze and interpret data is an increasingly significant skill in the Clean Transportation sector. Vast amounts of information are now being collected from vehicles and transportation systems and employers are seeking workers with the skills to manage and integrate this information. Roles that can benefit from this emerging skill are present in local governments, transit service providers, and original equipment manufacturers (OEMs). Some organizations such as Modo have made the commitment to make this data open so municipal and academic partners can use it.

Skills such as communication and user experience design are specifically important to support the growth of public transit. Making public transit options attractive to potential users is an ongoing challenge, and transit service providers need people to coordinate the many components of ensuring a positive user experience.[194]

Vehicle sharing cooperatives provide a growing number of mobility options for people that do not need to own a car (or second car) full-time. These services have similar needs to corporate fleets in terms of technical and IT support, and also require managers to have an understanding of cooperative business models. Degree programs and certificates such as those offered by Saint Mary's University in Nova Scotia are models that could be borrowed by business schools in BC to meet the gap in training for sharing economy businesses in the Clean Transportation sector.[195]

Rail, Marine, Air, and Goods Movement

Rail is an efficient and increasingly significant mode of goods movement. Locomotive engineers, conductors, mechanics, and maintenance workers are in high demand. The transition to low-carbon fuels will also affect rail operations, leading to a need for engineers, technicians, and others in the sector to understand the differences in operations and performance of equipment.

In addition, electrification (including hybrid electric) and the transition to low-carbon fuels such as LNG over the next decade for marine vessels (e.g., BC Ferries and Seaspan hybrid electric-diesel and hybrid electric-LNG), rail, and smaller aircraft (e.g., Harbour Air) will drive demand for reskilling of related asset managers, heavy-duty mechanics, industrial electricians, marine engineers, and aircraft maintenance engineers (AMEs) to deal with high voltage, battery and control systems (avionics), CNG / LNG systems, and related infrastructure.

[193] See: http://www.southislandprosperity.ca/wp-content/uploads/2019/03/smart-cities-challenge_south-island-prosperity-partnership_final.pdf
[194] See: https://www.vtpi.org/tdm/tdm112.htm
[195] See: https://www.smu.ca/academics/sobey/sobey-cooperative-management-education.html

3.5 MATERIALS MANAGEMENT & WASTE-TO-RESOURCE SECTOR

3.5.1 SECTOR OVERVIEW

British Columbia's Materials Management and Waste-to-Resource sector offers a range of technologies and services to measure, prevent, limit, or minimize waste, efficiently process materials and resources, and manage greenhouse gas (GHG) emissions.

A total of 13,630 direct clean economy jobs existed in BC's Materials Management and Waste-to-Resource sector in 2018 (see Table 49). The GDP generated by this sector was estimated to be $1.35 billion in 2018, with a gross output per job of $164 thousand.

Table 49: Employment and economic contribution of BC's Materials Management and Waste-to-Resource sector in 2018

Materials & Resource Management Sector Jobs	Materials & Resource Management Sector GDP ($ Millions)	Materials & Resource Management Sector Gross Output ($ Millions)	Materials & Resource Management Sector Gross Output per Job ($ Thousands)
13,630	$1,354	$2,231	$163.7

Source: The Delphi Group based on Statistics Canada

Of the workers currently employed in key occupations for BC's Materials Management and Waste-to-Resource sector, 42% are between the ages of 45 and 64 (see Table 50). The median annual salary in 2018 was $46,415, with the workforce being made up of 60% men and 40% women, which is the most gender-balanced of the five clean economy sectors.

Table 50: Socio-economic profile of BC's Materials Management and Waste-to-Resource Sector (2018)

Remuneration	Employment by gender (%)		Employment by age group (%)			
Median Annual Salary	**Men**	**Women**	**15-24**	**25-44**	**45-64**	**65+**
$46,415	60%	40%	14%	39%	42%	5%

Source: Delphi's estimate from BC Labour Market Outlook (2018-2028) wage data by occupation

BC's Materials Management and Waste-to-Resource sector forms a foundation for the transition to a more 'circular economy', where waste is considered a resource, materials circulate in the economy at their highest value for a longer period of time, and the entire system is powered by renewable energy. The circular economy presents enormous opportunities for investment, innovation, business and job creation, and GHG emission reductions as the traditional linear system of 'take-make-dispose' is reinvented through better design and management of valuable resources throughout their lifetime.[196]

Continued investment in materials and collection systems could push BC's economy to net-zero waste and reduce 6.2 million tonnes of GHGs by 2040.

[196] See: https://www.ellenmacarthurfoundation.org/circular-economy/concept

While BC's Materials Management and Waste-to-Resource sector is relatively small from a global perspective, the experience and innovation within BC companies demonstrates that the sector has key niche strengths that can be further scaled with the right combination of collaboration, financing, and market development support.[197]

BC's leading recycling system is built on an Extended Producer Responsibility model and active partnerships between industry, government, and the public.

The management of solid and organic waste, materials, and other waste-to-resource opportunities are key activities within this sector. British Columbia is home to a leading recycling system that has achieved the second highest diversion rate of organic and recyclable materials from landfills in the country.[198] This success is largely built on active partnerships between industry, government, and the public, through the implementation of a leading Extended Producer Responsibility (EPR) model, as well as progressive efforts to divert organic waste from landfill through incentives and regulation.

Organizations such as Recycle BC, the BC Product Stewardship Council, and the Recycling Council of BC are highly active in education and efforts to improve diversion, organics and resource management, and recycling programs across the province.[199] Within this ecosystem, companies such as Sybertech Waste Reduction, Machinex Recycling Services, Merlin Plastics, and Retriev Technologies are offering technical solutions to government, industry, and the public.

Organic waste, more specifically, emits methane, a GHG that is 25 times more potent than carbon dioxide.[200] In 2017, organics made up the largest component (40%) of BC's waste stream.[201] To address this waste stream, CleanBC has committed to the following strategies:

- Help communities to achieve 95% organic waste diversion for agricultural, industrial, and municipal waste – including systems in place to capture 75% of landfill gas.
- Waste less and make better use of it across all sectors of our economy, like forestry, agriculture, and residential areas, including renewing the B.C. Bioenergy Strategy and building out the bioenergy and biofuels cluster.

Projects such as Surrey's Biofuel facility are a key example of the type of initiatives that divert organics to create valuable resource streams to fuel other activities.[202] This project turns waste into biogas which is used to produce renewable natural gas (RNG) and into compost for local farms and gardens. The RNG is used to fuel garbage trucks and service trucks with plans to power the City Centre's District Energy System.[203]

It should be noted that this sector's activities contain some overlap with the Industrial Energy and Process Efficiency sector, specifically related to carbon capture and sequestration, and the reduction of methane emissions from organic waste. More specifically, GHG emissions management and carbon capture / sequestration as it relates to industrial sectors, such as oil and gas, agriculture, forestry, and cement production, is covered in the Industrial Energy and Process Efficiency sector profile while this sector focuses on carbon capture and utilization from municipal sources (landfills and sewage treatment facilities as examples).

[197] See: BC Green Economy. 2010. Globe Foundation.
[198] See: https://www.vancity.com/AboutVancity/News/MediaReleases/WasteAvoidanceReport_Feb2_2019/Vancity_Waste-Report_Updated.pdf
[199] See: https://www.cbc.ca/news/canada/british-columbia/b-c-reycling-explainer-1.5089661
[200] See: https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/progress-to-targets/2018-progress-to-targets.pdf
[201] See: https://www.rcbcconference.ca/the-circular-blog/factsheet-series-scope-and-regulations-of-organic-waste-in-bc
[202] See: https://www.surreybiofuel.ca/
[203] See: https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/cleanbc/cleanbc_2018-bc-climate-strategy.pdf

3.5.2 TECHNOLOGY TRENDS & MARKET SHIFTS

The circular economy concept is driving the acceleration of technologies and systems that enable both the reduction of waste and the transformation of waste into a resource. This includes reconceptualizing the design of products to increase their lifecycle and value or to track the materials within a product that can be disassembled to upcycle or recycle to other uses.[204]

The value drivers that are increasing the uptake and success of technologies can be categorized as: those which extend the use cycle; increase utilization; loops a product, material, or asset into additional use cycles; or regenerate natural capital.[205] Table 51 below outlines the trends and market shifts that are shaping both the management of materials and resources and associated skillsets, with potential for GHG emission reduction impacts across the supply chain.

Table 51: Technology trends impacting the Materials Management and Waste-to-Resource sector

TREND	DESCRIPTION
Bioeconomy	Several leading jurisdictions have bioeconomy or circular economy roadmaps to transform their economies. This includes BC,[206] the UK,[207] Germany,[208] and Finland.[209] Most recently, Canada launched a bioeconomy strategy earlier in 2019 with a focus on circular economy principles.[210]
Waste as a Resource	Industry drivers include China's import ban on contaminated recycling, new technologies that capture CO_2 to cultivate value-added biomass,[211] and significant opportunities in the remanufacturing sector.[212] Canada's National Industrial Symbiosis Program is active in this space, with a mission to redirect waste from one sector into inputs for other sectors.[213]
Designing Waste out of Products	Extended Producer Responsibility (EPR) is an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle. Industry is also driving innovative approaches to eliminating waste products by creating new markets for secondary materials,[214] increasing the use of repurposed fibres in textile industries,[215] and the use of "Biomimicry" design principles.[216] Canadian initiatives that are part of the global movement to mitigate plastics pollution include the Ocean Plastics Charter[217] and the CCME Strategy for Zero Plastic Waste.[218]
Product as a Service	The success of the SaaS (Software as a Service) business model has paved the way for PaaS (Product as a Service). This shifts the model from "buy-own-use-discard" to "plan-lease-repair-replace". [219]

[204] See: https://www.ellenmacarthurfoundation.org/assets/downloads/Cities-in-the-Circular-Economy-The-Role-of-Digital-Tech.pdf
[205] See: http://www3.weforum.org/docs/WEF_Intelligent_Assets_Unlocking_the_Circular_Economy.pdf
[206] See: https://www2.gov.bc.ca/gov/content/industry/forestry/supporting-innovation/bio-economy
[207] See: https://www.gov.uk/government/publications/bioeconomy-strategy-2018-to-2030
[208] See:https://ec.europa.eu/knowledge4policy/publication/national-research-strategy-bioeconomy-2030_en
[209] See: https://www.sitra.fi/en/projects/leading-the-cycle-finnish-road-map-to-a-circular-economy-2016-2025/
[210] See: https://www.bincanada.ca/biodesign
[211] See: https://www.pondtech.com/
[212] See: http://www.ourpositiveplanet.com/how-the-remanufacturing-industry-is-giving-new-life-to-old-products/
[213] See: https://nispcanada.ca/
[214] See: https://marketplacehub.org/
[215] See: https://www.ellenmacarthurfoundation.org/our-work/activities/make-fashion-circular
[216] See: https://www.wbdg.org/resources/biomimicry-designing-model-nature
[217] See: https://g7.gc.ca/en/official-documents/charlevoix-blueprint-healthy-oceans-seas-resilient-coastal-communities/
[218] See: https://www.ccme.ca/en/current_priorities/waste/waste/strategy-on-zero-plastic-waste.html
[219] See: https://circular-impacts.eu/library/1250

Advanced Materials	3D printing, nanoparticles, production automation, and advanced chemistry are driving the use of advanced materials and innovation with recycled products. Renewable materials like carbon fibre are replacing resource intensive materials like steel and aluminium. [220]

3.5.3 KEY INDUSTRIES

A description of the relevant industries, by NAICS code and sub-sector, for the Materials Management and Waste-to-Resource sector is listed in Table 52 below.

Table 52: Sub-sectors and industries in BC's Materials Management and Waste-to-Resource sector

Sub-sector	NAICS Codes	Definition
Carbon Capture, Utilization, and Storage (CCUS)	541 Professional, scientific, and technical services (including engineering)	The process of capturing waste carbon from various operations and storing or converting it into value-added product, such as cement, liquid fuels, carbon fibre, and other products and materials.
Advanced Chemistry	541 Professional, scientific, and technical services (including engineering) 5629 Remediation and other waste management	Comprises facilities and services that are engaged in treatment or disposal of non-hazardous and hazardous waste using advanced chemistry solutions.
Organics Management and Composting	2213 Water, sewage and other systems 5621 Waste collection 5622 Waste treatment and disposal	Includes establishments that integrate the collection, treatment, and disposal of organic waste / resources.
Waste Management and Recycling	4181 Recyclable material wholesale distribution 5621 Waste collection 5622 Waste treatment and disposal 5629 Remediation and other waste management 9139 Other local, municipal and regional public administration	Establishments engaged in collecting and hauling recyclable and landfill waste who may also be responsible for the treatment and packaging of waste for transport. Includes facilities and services that are engaged in treatment or disposal of non-hazardous and hazardous waste.

[220] See: https://3dfortify.com/composites-replace-traditional-materials/

3.5.4 KEY OCCUPATIONS

Key occupations for the Materials Management and Waste-to-Resource Sector are shown in Table 53. These occupations were initially identified using statistical analysis. The key occupations (by NOC code) for industries relevant to this sector at the 3-digit NAICS code level (as published by Statistics Canada in its 2011 Census breakouts) were amalgamated across industries. The key occupations were then validated through additional secondary research and industry consultation as part of the LMI research.

The labour force within this sector is largely characterized by workers with varied backgrounds and wide-ranging skillsets that can be categorized across management, professional, technical and skilled trades, and labourers such as drivers, material handlers, and heavy equipment operators.[221]

Table 53: Key occupations in BC's Materials Management and Waste-to-Resource sector

NOC	Occupation
0621	Retail and wholesale trade managers
0912	Utilities managers
1521	Shippers and receivers
7452	Material handlers
7511	Transport truck drivers
7521	Heavy equipment operators (except crane)
7522	Public works maintenance equipment operators and related workers
9243	Water and waste treatment plant operators

3.5.5 WORKFORCE DEMAND

Demand-side Drivers

Demand in the Materials Management and Waste-to-Resource sector is driven by global and local trends towards zero-waste solutions and attaching an increasing cost to pollution and materials disposal.[222] The value of waste as a resource is being accelerated by the growing influence of the circular economy approach. Specific demand drivers, targets, and indicators of expected growth by sub-sector are described in more detail in Table 54.

As demand builds in line with increased zero-waste, recycling / EPR programs, organics diversion, and waste-to-resource programs and targets, jobs in the sector are expected to grow and diversify over the next decade. The largest overarching driver in BC's Materials Management and Waste-to-Resource sector is the Province's focus on reducing emissions in both industrial activity and waste (e.g., diverting and reducing the amount of organic waste going to landfill). The reductions in these areas feed into the larger overarching target of reducing emissions by 40% below 2007 levels by 2030.

[221] See: ECO Canada. Careers in Waste Management. September 2017.
[222] See: https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work.html

Table 54: Targets and expected growth for BC's Materials Management and Waste-to-Resource sector

Sub-sector	Relevant Targets	Expected Growth[223]
Carbon Capture and Sequestration	Carbon Emissions: 40% reduction of GHG emissions by 2030 relative to 2007 levels.[224]	**Medium** Global carbon capture market is estimated to reach $800 billion by 2030.[14]
Advanced Chemistry	None specified.	**High** The global advanced materials market is expected to account for US $102.6 billion by 2024.[225]
Waste Management and Recycling	2020: Reduction in the municipal solid waste disposal rate from 570 to 350 kilograms per person.[226]	**High** Provincial extended producer responsibility initiatives are expected to decrease waste disposal rates.[227]
Organics and Composting Management	2020: 75% of BC's population is covered by organic waste disposal restrictions.[228] 2020: Metro Vancouver diversion rate target of 80% by 2020. (Currently 63 percent). 2030: Various CleanBC targets (discussed in more detail below)	**Very High** Despite strong economic cycles, provincial initiatives are expected to decrease waste disposal rates via organics diversion and food waste prevention programs.[229,230,231]

To reduce emissions from waste and reduce the overall amount of waste, there is a larger shift occurring around circular economy processes where waste materials from residential, commercial, and industrial sources are reused or 'upcycled' to extend the lifecycle of the materials.[232] The concept of a circular economy also encompasses industrial symbiosis, which seeks to engage traditionally separate industries in a collective approach where one's waste or by-product is another's resource.

[223] Note the terms used to describe the expected growth of sub-sectors (medium, high, very high) are relative and not based on specific quantifiable levels. Information used to inform the expected growth assessment includes key informant interviews, trends analysis, and secondary research.
[224] See: https://www.policynote.ca/clean-bc/
[225] See: https://www.marketwatch.com/press-release/global-advanced-materials-market-projected-to-worth-usd-1026-billion-by-the-end-of-2024-2019-04-08
[226] See: https://www2.gov.bc.ca/assets/gov/environment/waste-management/garbage/swmp-intentions-paper-final.pdf
[227] See: https://www2.gov.bc.ca/gov/content/environment/waste-management/recycling/product-stewardship
[228] See: https://www2.gov.bc.ca/assets/gov/environment/waste-management/garbage/swmp-intentions-paper-final.pdf
[229] See: https://www2.gov.bc.ca/gov/content/environment/waste-management/food-and-organic-waste/organic-waste-diversion
[230] See: https://www2.gov.bc.ca/gov/content/environment/waste-management/food-and-organic-waste/prevent-food-waste
[231] See: http://www.env.gov.bc.ca/soe/indicators/sustainability/municipal-solid-waste.html
[232] See: https://sustain.ubc.ca/sites/sustain.ubc.ca/files/Sustainability%20Scholars/2018_Sustainability_Scholars/Reports/2018-14%20Creating%20a%20circular%20economy%20in%20New%20West%20%20-%20%28NISP%29%20pilot_MacDonald.pdf

At the national level the Love Food Hate Waste initiative has been adopted, modelled after a UK campaign that addressed the immense amounts of food wasted, totalling 2.2 million tons annually in Canada alone.[233] The initiative offers resources and guidelines to help consumers better manage their food consumption. In addition to food waste, the federal government has committed to banning single use plastics by 2021.[234]

Municipal and regional governments across BC are already applying the concepts described above through targets, bans, and pilot programs to kickstart the use of circular economy principles and best practices. Examples include the City of Victoria's ban on plastic bags[235], the City of Vancouver's zero-waste goals by 2040, the Regional District of Nanaimo's waste diversion program, and other initiatives that have been in place since 2000.[236] Efforts are also being ramped up province-wide through the Recycling Council of B.C. and the National Zero Waste Council.[237]

According to a recent study by the Canadian Centre for Policy Alternatives, continued investment in changes in materials and source-separated collection systems could push BC's economy to net zero waste by 2040 and reduce an estimated 6.2 million tonnes of GHGs.[238] Additionally, the report found that employment opportunities arising from recycling materials can be 10 times higher per tonne than disposal, and the potential exists to create 12,341 green jobs through 100% recycling of BC's waste.

Major Projects

Landfill and wastewater / sewage treatment facilities are important projects given their potential role for reducing GHG emissions from organic sources (i.e., methane capture from waste and biosolids). In the BC Major Projects Inventory (Q2 2019), there are 22 waste-to-resource-related projects listed across 6 of the 8 economic development regions (see Table 55). In addition, there are 8 planned waste treatment-related major projects in BC, totalling approximately $2.6 billion (see Table 56).

Table 55: Materials Management and Waste-to-Resource sector related major projects by BC Development Region

Development Region	Number of Projects	Estimated Cost ($ millions)
1. Vancouver Island/Coast	5	1,075
2. Mainland/Southwest	8	3,016
3. Thompson/Okanagan	5	292
4. Kootenay	1	900
5. Cariboo	2	85
6. North Coast	1	30
7. Nechako	0	0
8. Northeast	0	0
Total	**22**	**5,398**

[233] See: https://lovefoodhatewaste.ca/about/food-waste/
[234] See: https://www.cbc.ca/news/politics/government-to-ban-single-use-plastics-by-2021-1.5168386
[235] See: https://vancouversun.com/news/local-news/zero-waste-feature
[236] See: https://www.rcbc.ca/resources/zero-waste#zero-waste-in-bc
[237] See: https://www2.gov.bc.ca/gov/content/environment/waste-management/zero-waste
[238] See: Lee, M. et al. Closing the Loop: Reducing Greenhouse Gas Emissions and Creating Green Jobs through Zero Waste in BC. Canadian Centre for Policy Solutions.

Source: BC Major Projects Inventory Q2 2019

Table 56: BC major projects relevant to the Materials Management and Waste-to-Resource sector (2018)

Project	Description	Project Status	Estimated Project Cost ($M)
Annacis Island Wastewater Treatment Plant Upgrades	Proposed upgrades to treatment plant secondary clarifier and associated infrastructure.	Proposed	50
Tofino Wastewater Treatment Plant	Proposed wastewater treatment plant, conveyance and residual solids system. Liquid Waste Management Plan Stage 3 adopted by council and public open house held in Summer 2018.	Proposed	15
Surrey Waste-to-Energy Incineration Facility	Proposed waste to energy plant to be located near Surrey town centre.	Proposed	
Iona Island Wastewater Treatment Plant Upgrades	Proposed upgrades to Iona Island wastewater treatment plant.	Proposed	1000
North Shore Wastewater Treatment Plant (formerly Lions Gate Sewerage)	(Description not provided)	Construction started	700
Highland Valley Centre for Sustainable Waste Management	Regional landfill proposed on a waste rock and overburden dump at the Highland Valley copper/molybdenum mine, located 20 km east of Logan Lake, with a capacity of 50 million tonnes of municipal solid waste (up to 600,000 tonnes/year) from throughout south-western BC.	On hold	119
Core Area Wastewater Management Project - Seaterra Program	Sewage treatment plans for Victoria and Core Area municipalities approved for McLoughlin Point have commenced construction on a treatment plant, upgrades to Clover Point Pump Station, and undersea forcemain from Ogden Point.	Construction started	765
Heartland Landfill Project	This project involves major upgrades to the Hartland Landfill including an anaerobic digester to process food scraps into biomass.	Proposed	23
Total			**2,607**

Source: BC Major Projects Inventory Q2 2019

Employment Impacts from CleanBC

CleanBC does not set out any specific overarching goals related to Materials Management and Waste-to-Resource sector. However, specific targets and goals are outlined below, along with a discussion on potential employment impacts.

1. 95% of organic waste diverted (including municipal, industrial, and agricultural) from landfills by 2030.
2. 75% of landfill methane captured by 2030.

NOTE: *Work is underway internal to the BC Government to apply circular economy principles, as well as develop a new Plastics Action Plan and Extended Producer Responsibility regulations, that may eventually impact on BC's workforce and employment demand. Additional jobs may be created in food waste prevention and connecting related organics waste to market / consumer demand are significant and include entrepreneurial business models leveraging digital technology platforms. These additional factors are not considered in this job forecasting.*

Key Considerations by CleanBC Policy Goal

Employment considerations and assumptions for the policies outlined above are described below.

1. 95% of organic waste diversion target by 2030

Policy Details: CleanBC sets a goal that, by 2030, 95% of organic waste (including municipal, industrial, and agricultural) will be diverted from landfills and turned into other products. The goal supports efforts to waste less and make better use of resources across all sectors of the economy, including forestry, agriculture, and residential areas. The goal ties in with the province's new Bioenergy Strategy and goals to build out BC's bioenergy and biofuels cluster.

Assumptions: In the municipal space, the BC Government's Organics Infrastructure Program is providing $30M to support more organics composting and anaerobic digestion facilities across the province. In addition, approximately 65% of the province is currently covered by regulatory bans on organics from entering the landfill. Investments in additional collection and processing infrastructure in additional communities may allow broader bans to be implemented, driving toward the higher diversion rate target of 95%.

Timelines: Steady investments between 2020 and 2030 in line with regulations.

Geographic: Province-wide, although largely rural and remote areas.

Job Impacts: 850 ongoing jobs in operations by 2030 related to new investments in organics waste collection services, including transportation, across municipal, agricultural, and industrial (mining and forestry-based) sectors and activities. In terms of job creation from increased diversion of organics waste in the agriculture and industrial sectors, this will likely be for collection and transportation of feedstocks (such as slash piles) to centralized processing locations.

2. 75% of landfill methane captured by 2030

Policy Details: By 2030, systems will be put in place to capture 75% of landfill gas / methane across the province.

Assumptions: Most of the larger landfills province-wide are already in compliance so incremental investments are assumed to be minimal.

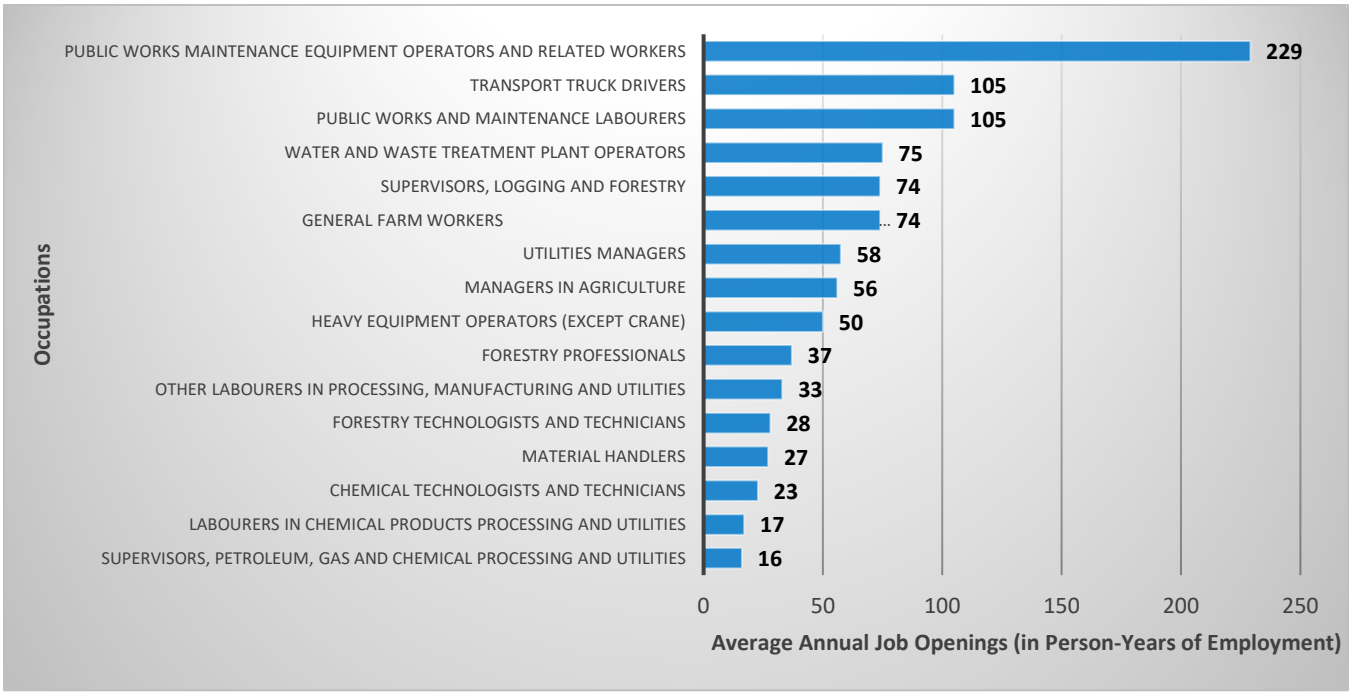
Timelines: Steady investments between 2020 and 2030.

Geographic: Province-wide, although largely rural areas.

Job Impacts: Job creation impacts include 52 temporary construction jobs on average per year between 2020 and 2030, as well as an estimated at 170 ongoing jobs in operations by 2030 (based on Navius Research modelling results). Job creation from this policy goal is expected to be minimal and largely related to engineering and construction jobs required for building new and expanding existing methane capture systems at landfills across the province, as well as operating jobs in facility management and maintenance.

Employment Impacts by Occupation

The two CleanBC policy goals outlined above are expected to create demand for approximately 52 temporary construction jobs on average per year between 2020 and 2030 and approximately 1,020 permanent direct jobs in operations by 2030. The key occupations relevant to this job creation are shown in Figure 23.



Source: The Delphi Group

Figure 23: Annual average number of job openings for key occupations in the Materials Management and Waste-to-Resource sector based on initial CleanBC policy targets (2020-2030)

Job transformation is expected to be linked to workers in this sector as they look to more effectively integrate supply chain management for resources and materials applying reverse logistics and circular economy principles. Additional reskilling will be required for affected landfill and wastewater treatment facility operators and engineers. In total, the sector is projected to see approximately 3,320 jobs impacted through transformation between 2018 and 2030. Table 57 provides a breakout of the key occupations by number.

Table 57: Key occupations projected to undergo job transformation within BC's Materials Management and Waste-to-Resource sector between 2018 and 2030

NOC - Occupation Title	Percent of Sector	Number of Jobs Undergoing Transformation (2018-2030)
7522 Public works maintenance equipment operators and related workers	6.4%	214
7511 Transport truck drivers	6.4%	211
7621 Public works and maintenance labourers	5.3%	177
0912 Utilities managers	3.2%	108
7452 Material handlers	2.9%	97
9243 Water and waste treatment plant operators	2.4%	81
7611 Construction trades helpers and labourers	2.2%	72
7521 Heavy equipment operators (except crane)	1.9%	64
0621 Retail and wholesale trade managers	1.7%	56
9619 Other labourers in processing, manufacturing and utilities	1.5%	51
9212 Supervisors, petroleum, gas and chemical processing and utilities	1.2%	38
2131 Civil engineers	0.6%	21
2171 Information systems analysts and consultants	0.6%	21
1521 Shippers and receivers	0.6%	20

Source: The Delphi Group

3.5.6 WORKFORCE SUPPLY

According to a recent study on waste management careers across Canada, the jobs in this sector tend to be broad and multi-disciplinary, categorized primarily across management positions, professional technical and skilled trades, and labourers.[239] This includes occupations with specialized waste management skills across engineering, clerical/financing, as well as legal and regulatory policy work. Of the occupations examined as part of the study, the largest labour force was found across transportation specialists, labourers, and equipment operators. Jobs in the Materials Management and Waste-to-Resource sector vary between unionized employers and contractors, and typically offer a living wage and opportunities for advancement. While there are a steady number of jobs in collection, greater growth potential exists in developing local solutions to resource recovery and recycling.

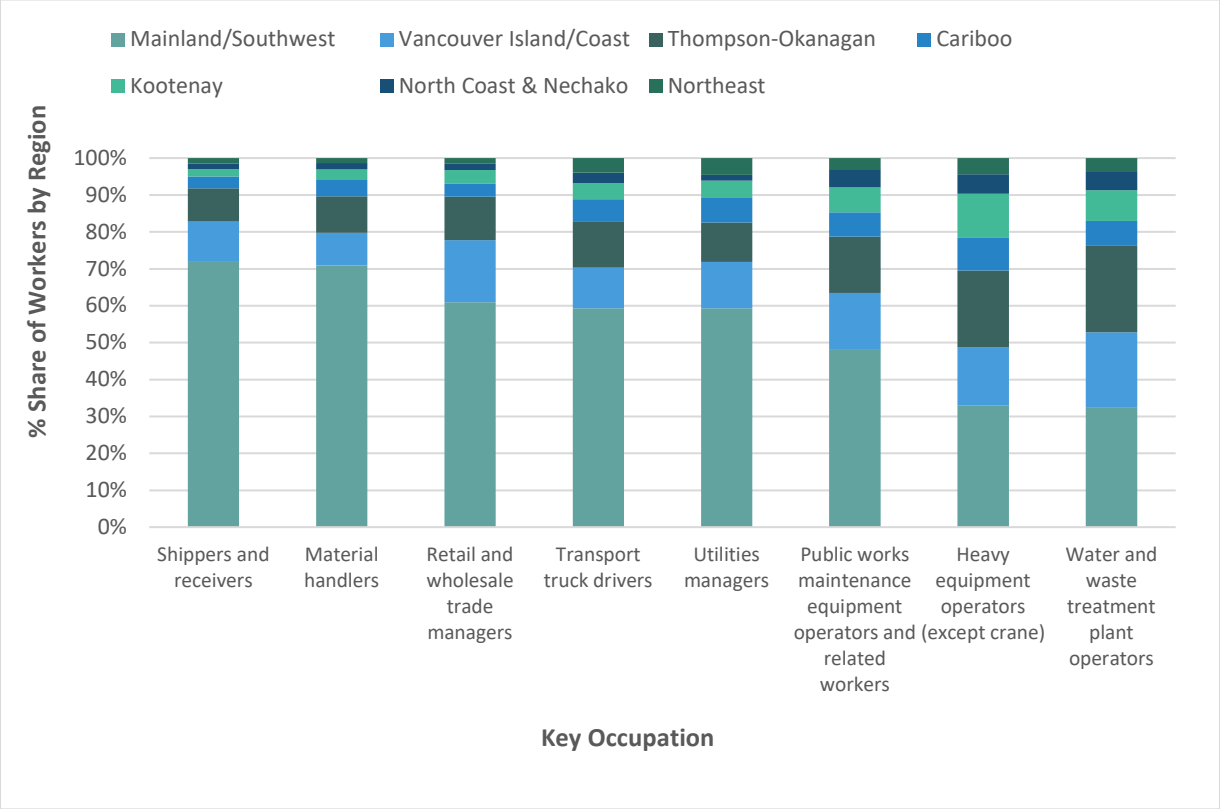
[239] See: ECO Canada. Careers in Waste Management. September 2017. https://www.eco.ca/wp-content/uploads/ECO-Canada-Careers-in-Waste-Management.pdf

Regional Distribution

As shown in Figure 24 below, key occupations relevant to the Materials Management and Waste-to-Resource sector and with the highest concentrations based in more urban centres include shippers / receivers and material handlers. Occupations that are more evenly distributed across BC and particularly more common in rural regions include heavy-duty equipment operators and water and waste treatment plant operators.

The most rural and remote regions of the province have a lower percentage share of employment, which is largely due to the lower population density. This creates some challenges with respect to offering effective recycling and organics collection and processing programs and related infrastructure.

As governments work towards zero-waste targets and increased diversion rates, there will be a need for a workforce with skillsets to move, handle, process, and manage new waste and resource streams in the context of a circular economy. New circular economy-related activities have the potential to drive skills development and project-based learning. For example, FoodMesh has been working with local governments in the Fraser Valley since 2018 to recover surplus food from retailers and divert it to charities and farmers for animal feed and expects to see over 100 new food recovery jobs over the next 5 years.[240]



Source: Based on Statistics Canada 2016 Census

Figure 24: Employment distribution by key occupation in BC's Materials Management and Waste-to-Resource Resource Sector (by Development Region)

[240] See: https://foodmesh.ca/services-regional/

For those operating in the management and handling of waste and organics, those who work as material handlers or supply chain managers will be required to have both an understanding of industry operations and familiarity with the concepts of circular economy and systems thinking. This includes skillsets across sciences, engineering, and business development involved in the transformation of organic waste streams into compost and other value-added products (such as organic fertilizers). However, it is important to note that demand for these skillsets and occupations will be shaped by the available supply and competition for organics feedstock waste streams.

The carbon capture, utilization, and storage / sequestration sub-sector will require more workers with skills in modelling insights and data analysis focused on GHG intensity, who can also communicate findings in line with industry challenges, policy context, and long-term goals. In addition to these skills, there will be a need for workers with skills specialized in RNG production. This includes knowledge and understanding across the RNG supply chain:

- Centralizing organic waste streams;
- Operation and maintenance of anaerobic digestion systems on local farms;
- Capturing methane / biogas from wastewater treatment plants and landfills;
- Upgrading, processing, compressing biogas into RNG that can be transported through pipelines.

3.5.7 EDUCATION & TRAINING

The most common educational backgrounds related to the Materials Management and Waste-to-Resource sector include environmental science, engineering, chemistry, as well as different technological, business, and communications backgrounds.[241] For jobs in professional, technical, or skilled trades, college-level education is typically required. These are largely concentrated in environmental studies/science and engineering as well as science-based areas such as chemistry, geology, and technological studies (see Table 58). Labourers and heavy equipment operators are not generally required to have any formal education, though a high school or college education is beneficial. However, workers in these occupations are generally required to have a valid driver's licence and may undertake on-the-job training that results in special certificates (e.g., Transportation of Dangerous Goods, WHMIS, Ground Disturbance Levels 1 and 2).[242]

Table 58: Educational pathways in BC's Materials Management and Waste-to-Resource sector

	Common Job Titles	Educational Background	Degree type
Management	Operations manager Director Retail and wholesale trade manager Utilities manager	Environmental Studies/Science Engineering Chemistry Business	Bachelor's degree Master's degree

[241] See: https://www.eco.ca/wp-content/uploads/ECO-Canada-Careers-in-Waste-Management.pdf
[242] See: https://www.eco.ca/wp-content/uploads/ECO-Canada-Careers-in-Waste-Management.pdf

Professional, Technical and Skilled Trades	Civil engineer	Environmental Studies/Science	Bachelor's degree
	Chemical engineer		
	Chemical technologist	Engineering	Diploma
	Material scientist		
	Plant operator	Chemistry	
Labour	Truck driver	On-the-job training	Certificate
			Highschool diploma
	Heavy equipment operator		
	Shippers and receivers		
	Material Handler		

Source: Adapted from ECO Canada, Careers in Waste Management (2017)

Post-secondary Institutions

While the relevant industries and occupations are somewhat varied and dynamic, BC's post-secondary institutions offer a number of programs providing foundational and specialized training related to the Materials Management and Waste-to-Resource sector. These programs exist for workers at all stages of career development and in many regions of the province. Some examples include:

- Thompson-Rivers University offers a Post-Baccalaureate Diploma in Supply Chain Management. This program includes courses focused on Information Systems, Procurement, Web-Enabled Business, Logistics and Transportation, and Business-to-Business Marketing.[243]
- BCIT offers two relevant certificate programs: the International Trade and Transportation Logistics Certificate, and the Operations Management Certificate (Materials Management Option).
- Selkirk College's Youth Train in Trades program offers foundation courses in Metal Fabrication and Millwright/Machinist. [244]
- Selkirk College's Community Education and Workforce Training department runs Growing Learning Opportunities with Science (GLOWS) summer camps. This program was originally started by the Kootenay Association of Science and Technology in 2007, and also includes after-school programs for youth between the ages of 6 and 13 with a focus on girls in engineering.[245]

[243] See: https://www.tru.ca/programs/catalogue/supply-chain-management-post-baccalaureate-diploma.html
[244] See: http://www.selkirk.ca/program/metal-fabricator-foundation
[245] See: http://selkirk.ca/news/glows-enjoys-successful-summer-science

Industry-led Training

The Pacific Chapter of the Solid Waste Association of North America is based in Vancouver offers regular training to solid waste professionals. This training includes workshops on Industrial Symbiosis and adding value to waste resources, a concept identified by stakeholders as needing more training and general understanding among industry.[246]

One example of a recent industry-led training initiative is the Cowichan Food Recovery Worker Placement program. This job creation project funded through WorkBC's Community and Employer Partnerships (CEP) program provided trainees with work experience in business, marketing social enterprise, and event planning while supporting the establishment of Cowichan Green Community's reFRESH Cowichan Marketplace. This training initiative builds on an existing food-waste recovery program that diverted over 63,500 kg of food from the landfill.[247]

Another example of industry-led training is the National Industrial Symbiosis Program (NISP). The NISP model focuses on transforming waste resources into value-added inputs for other business and is designed as a practical means for shifting businesses to a low-carbon, circular economy. NISP relies on dedicated practitioners to connect with businesses and identify and nurture circular economy opportunities. Part of the NISP project framework, recently piloted in Metro Vancouver, includes hands-on training for practitioners.[248]

Other relevant industry-led training are offered through:

- BC Trucking Association - Offers a Heavy-duty Vehicle Efficiency Program[249]
- Applied Scientists Technologists and Technicians of BC - Offers Onsite Water Certification Program[250]

Labour Organizations

The following represent examples of the labour organizations that support the interests, training, and development of workers in BC's Materials Management and Waste-to-Resource sector:

- The Operating Engineers Local 15 Training Association
- Unifor

[246] See: https://swanabc.org/invitation-to-industrial-symbiosis-workshop/
[247] See: https://news.gov.bc.ca/releases/2019SDPR0034-000667
[248] See: https://nispcanada.ca/wp-content/uploads/2019/08/NISPPerformanceReport-Pilot-FINAL.pdf
[249] See: https://www.bctrucking.com/training/cleanbc-heavy-duty-vehicle-efficiency-program-course
[250] See: https://owrp.asttbc.org/

3.5.8 EMERGING SKILLS

As the Materials Management and Waste-to-Resource sector shifts to respond to the public and political demand for reduced GHG emissions and waste pollution, there will be increased demand for the skills and jobs as outlined in Table 59 below. These skills were identified through consultation with stakeholders and review of relevant industry reports.

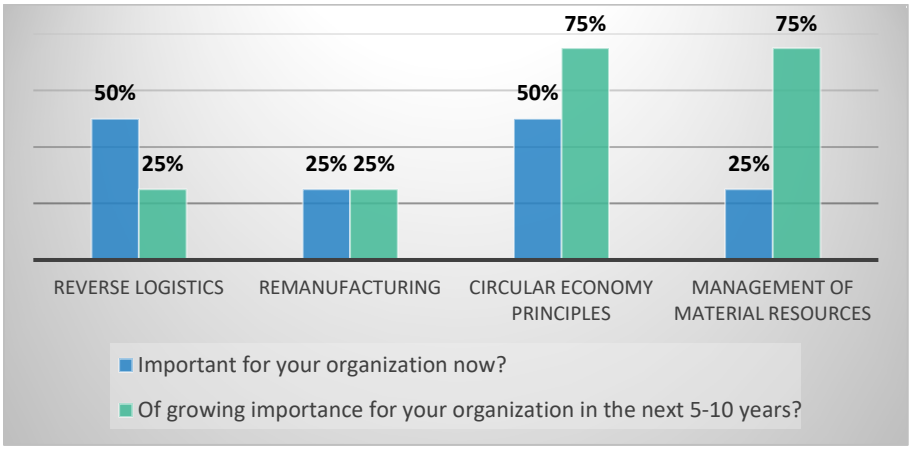
Table 59: Emerging skills by sub-sector

	Carbon Capture, Utilization and Storage / Sequestration	Advanced Chemistry	Organics and Composting Management	Waste Management and Recycling
Emerging Skills	• GHG modelling and data analysis • Management / operation of digital systems • Methane mitigation • Process engineering • Entrepreneurship / business development skills • Health and Safety Compliance • Compliance and Regulation	• Material science expertise • Entrepreneurship / business development skills	• Organic feedstock supply chain and logistics management • Landfill gas capture and utilization • Management / operation of digital systems • Entrepreneurship / business development skills	• Recycling / plastics materials / EPR supply chain and logistics management • Landfill gas capture and utilization • Management / operation of digital systems • Entrepreneurship / business development skills
Jobs in Increasing Demand	• Environmental scientists • Chemical engineers	• Material scientists • Chemical engineers	• Material handlers	• Material handlers • Civil engineers

In addition to the skills above, consultation with BC stakeholders from waste and resource industries revealed a strong consensus on the need for workers who understand the broader concept of the circular economy and understand the value of a "systems approach" to implementing solutions.

In a survey of companies active in material and waste management, 75% of respondents identified circular economy principles and management of material resources as top emerging skills in the next 5-10 years (see Figure 25).[251]

[251] CEWRP Industry Survey (2019).



Source: CEWRP Industry Survey (2019).

Figure 25: Skills of growing importance over the next 5-10 years for the Materials Management and Waste-to-Resource sector (n=4)

One example of this broad systems understanding may be the ability to connect a recovered product or recycled waste stream with the highest value end-use. Another example is understanding and communicating the shifting mindset focusing on preventing waste before resorting to reusing or recycling it.

This knowledge is further strengthened by a worker's ability to communicate across technical and policy realms, including maintaining current knowledge of various markets, evolving recycling regulations in different jurisdictions, and incentive programs for different materials and resources. This speaks to a larger trend across business and industry valuing multidisciplinary skillsets and the ability to apply skills that are both technical and policy-based.

3.6 INDUSTRIAL ENERGY & PROCESS EFFICIENCY SECTOR

3.6.1 SECTOR OVERVIEW

British Columbia's Industrial Energy and Process Efficiency sector is primarily composed of GHG emission-intensive industries including forestry, agriculture, oil and gas, cement production, smelting and refining, mining, and chemicals manufacturing. The sector is made up in large part of emissions-intensive, trade-exposed or 'EITE' industries. Nationally, EITE industries employ over one million Canadians and are a cornerstone of the economy.[252]

These industries are also reliant on a variety of specialized engineering and environmental consulting firms, as well as technology companies that offer services and products to help them reduce GHG emissions and improve their processes.[253] BC, for example, is home to innovative technology companies that specialize in carbon capture and utilization, such as Carbon Engineering and Inventys. These companies are providing solutions to traditional

[252] The Delphi Group research (2018).,
[253] See: https://bceia.com/membership-directory/

industries such as cement production to reduce their own carbon footprints, which feed into the larger goal of reducing BC's GHG emissions 40% by 2030.

A total of 9,585 direct clean economy jobs existed in BC's Industrial Energy and Process Efficiency sector in 2018 (see Table 60). The GDP generated by this sector was estimated to be $1.34 billion in 2018, with a gross output per job of $327 thousand.

Table 60: Employment and economic contribution of BC's Industrial Energy and Process Efficiency Sector (2018)

Industrial Energy & Process Efficiency Sector Jobs	Industrial Energy & Process Efficiency Sector GDP ($ Millions)	Industrial Energy & Process Efficiency Sector Gross Output ($ Millions)	Industrial Energy & Process Efficiency Sector Gross Output per Job ($ Thousands)
9,585	$1,336	$3,132	$326.8

Source: The Delphi Group based on Statistics Canada

Of the workers currently employed in key occupations for BC's Industrial Energy and Process Efficiency sector, 40% are between the ages of 45 and 64 (see Table 61). The median annual salary in 2018 was $62,006, with the workforce being made up of 82% men and 18% women.

Table 61: Socio-economic profile of BC's Industrial Energy and Process Efficiency sector (2018)

Remuneration	Employment by gender (%)		Employment by age group (%)			
Median Annual Salary	**Men**	**Women**	**15-24**	**25-44**	**45-64**	**65+**
$62,006	82%	18%	9%	45%	40%	6%

Source: Delphi's estimate from BC Labour Market Outlook (2018-2028) wage data by occupation

Based on discussion with key informants, these industries provide excellent opportunities for reducing GHG emissions and adopting more efficient technologies and processes, enhancing their overall competitiveness. At the same time, they are also vulnerable to GHG emission and energy reduction requirements, placing them at a disadvantage among foreign competitors that operate without similar restriction measures.

The focus of the Industrial Energy and Process Efficiency sector is unique from the other four "core" clean economy sectors examined as part of this LMI study in that it is primarily made up of EITE industries that are looking to transition to lower-carbon operations through the adoption or deployment of new processes and/or technologies as opposed to producing these technologies. These processes and associated jobs are concerned with deploying and adopting practices and/or technologies that have a favorable impact on the environment (e.g., a mining engineer who is working to lower energy consumption and the environmental impact of operations through the application of technologies or processes).

British Columbia's industrial GHG footprint can be attributed to five sectors: energy, waste, industrial processes and product use, afforestation and deforestation, and agriculture[254]. The largest amount of GHG emissions in British Columbia are a result of energy production.

[254] The Delphi Group. 2019. CleanBC Labour Readiness Plan Project Sub-committee Presentation

As such, the Industrial Energy and Process Efficiency sector for the purposes of the LMI research is made up of the following key sub-sectors, defined by the type of technologies required for reducing and/or sequestering GHG emissions across emissions-intensive industries:

- Energy and process efficiency technologies;
- Carbon capture, sequestration, and storage;
- Waste heat recovery; and
- Bio-products and low-carbon fuel.

3.6.2 TECHNOLOGY TRENDS & MARKET SHIFTS

The shift toward carbon and pollution pricing has been a key driver for industry to implement energy management systems and technologies that reduce GHG emissions and overall operational costs. Federal tax incentives offered by government to industrial firms to undertake clean energy projects or implement ISO 50001 Energy Management Systems are also key forces in pushing major industries towards greater energy efficiency.[255] Table 62 details a number of technology trends that are shaping the industrial energy and process efficiency sector.

Table 62: Technology trends impacting the Industrial Energy and Process Efficiency sector

TREND	DESCRIPTION
Precision Sensors	Used primarily in manufacturing and agriculture, the use of precision sensors allows operators to collect data and read real time info on the products and processes along the supply chain. It creates greater efficiencies and improve responsiveness to malfunctions or interruptions. The global sensor market was valued at $138 million in 2017, with projections to hit $287 million by 2025.[256]
Blockchain	Blockchain is a decentralized database that tracks and codifies data that allows for suppliers to track and account for their products and/or resources as it moves along the supply chain. It provides increased transparency and allows the collection of data from multiple sources. The global market for blockchain at $708 million in 2017 is anticipated to reach $60.7 billion in 2024.[257]
Mechanization (machine learning)	Mechanization (also known as AI or machine learning) is a key factor in easing the burden of processes or operations that would have traditionally demanded manual labour. Through a collection of software, sensors and AI, mechanization is able to dramatically increase output efficiencies and is predicted to create an additional $2 trillion in manufacturing and supply chain planning.[258]
Additive Manufacturing	The additive manufacturing (AM) (also known as 3D printing) uses computer aided design software that scans to direct hardware to precisely deposit material layer by layer to create an exact replica. This market is anticipated to reach US$20.5B by 2020, with the highest growth expected in tooling components and metal castings.[259]

[255] https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/oee/files/pdf/CIPEC%202017_e.pdf
[256] See: https://www.alliedmarketresearch.com/sensor-market
[257] See: https://www.marketwatch.com/press-release/blockchain-market-size-analytical-overview-demand-trends-and-forecast-to-2024-2019-04-05
[258] See: https://www.forbes.com/sites/louiscolumbus/2019/03/27/roundup-of-machine-learning-forecasts-and-market-estimates-2019/#6ad1d7827695
[259] See: https://www.statista.com/statistics/284863/additive-manufacturing-projected-global-market-size/

Bioproducts	Bioproducts are generally derived from agricultural, forestry or municipal waste streams. By applying chemical and mechanical technologies, materials can be separated from waste streams to be recycled or upcycled into new products. Bioplastics are type of biproduct that is poised for significant growth as plastic pollution legislation is taking hold worldwide. The global bioplastics market is set to reach $30 billion by 2020.[260]

Cross-industry technology investment opportunities for reducing GHG emissions within EITE sectors are shown in Table 63 below.[261]

Table 63: Opportunities for reducing GHG emissions within the Industrial Energy and Process Efficiency sector

Short to Medium-Term (0 – 10 years)	Long-term (10+ years)
Process Modelling and Optimization: Opportunity for governments to support process optimization through design and modelling. **Digital and Automation Technologies**: These technologies can enhance system performance and optimize process operations. **Waste Heat and Recycled Material Utilization**: Low-grade waste heat and/or energy recovery, as well as material recycling, is applicable to most EITE sectors. **Fuel Switching**: Focus on developing fuels that meet performance requirements. **Bio-Products**: Bio-products as substitutes for existing energy feedstocks and other material inputs.	**Electrification:** Electrification, including the integration of renewable energy and storage options, will be key across many EITE sectors for delivering GHG emission reductions on the pathway to decarbonization. **Carbon Capture, Utilization, and Sequestration (CCUS):** Developing a viable CCUS and carbon product market in Canada leveraging existing strengths in innovation.

Source: The Delphi Group

Based on previous research, four of the top cross-sector opportunities areas include: waste heat utilization, bio-based products and fuel, process modelling/optimization (efficiency technology), and carbon capture and storage. In a 2016 review of Canada's potential to decarbonize the nation's heavy industry economy, it was found that the technical potential exists to help decarbonize EITE sectors including those included in Figure 26 below. With additional studies into the capital and technology available, the 2016 study revealed that decarbonization of these sectors could be achieved within 1 to 2 economic cycles.[262]

[260] See: https://www.canadianbiomassmagazine.ca/global-bioplastics-market-to-reach-30-billion-by-2020-report-5435/
[261] The Delphi Group research (2019).
[262] Dr. Chris Bataille, N. Melton and S. Stiebert. 2016. The potential to decarbonize Canadian heavy industry.

Technology Segment	Mining	Cement	Smelting & Refining	Chemicals & Fertilizers	Forestry
Industrial carbon capture, storage, and utilization	Low	High*	High	High*	Low
Enhanced catalysts and separation systems	Medium	Low	High	High	Medium
Utilization of waste heat and recycled materials	High	High	High	High	High
Bio-based processes, refining, materials, products and fuel substitutions	Medium	High	High	High	High
Advanced chemistry and high efficiency combustion technologies	Low	High	High	High	Medium
Low intensity separation technologies	High	Low	Medium	Medium	Low
Process modelling/optimization	High	Medium	High	High	Medium
Digital, industrial internet of things (IIoT), and automation technologies	High	Low	Medium	Medium	High
Advances in energy efficiency of existing equipment (e.g., boilers, lightings, etc.)	High	Medium	Low	Low	High

Source: The Delphi Group

Figure 26: Cross-sector technology opportunities and priorities

** Sector with a particularly strong opportunity for carbon utilization into carbon-based products.*

3.6.3 KEY INDUSTRIES

The Industrial Energy and Process Efficiency sector represents companies and organizations that are transitioning to cleaner or "lower carbon" operations, with a specific focus on the industry NAICS codes framework provided in Table 64. The adoption of new processes and willingness to test and deploy new technologies within these traditional industries presents unique considerations with respect to workforce training and skills development.

Table 64: Industries that make up BC's Industrial Energy and Process Efficiency sector

NAICS Code	Description
111 - 112 Farms	Comprises establishments, such as farms, orchards, groves, greenhouses and nurseries, primarily engaged in growing crops, plants, vines, trees and their seeds (excluding those engaged in forestry operations).
113 Forestry and logging	Establishments primarily engaged in growing and harvesting timber on a long production cycle.
115 Support activities for agriculture and forestry	These support activities may be performed by the agriculture or forestry producing establishment or conducted independently as an alternative source of inputs required for the production process for a given crop, animal, or forestry industry.
211 Oil and gas extraction	Establishments primarily engaged in operating oil and gas field properties. Activities include exploration for crude petroleum and natural gas; drilling, completing and equipping wells; and all other activities in the preparation of oil and gas up to the point of shipment.

212 Mining and quarrying	Comprises establishments primarily engaged in mining or otherwise preparing metallic and non-metallic minerals, including coal.
2212 Natural gas distribution	Establishments primarily engaged in the distribution of natural or synthetic gas to the ultimate consumers through a system of mains.
321 Wood product manufacturing	Activities are primarily engaged in manufacturing products from wood. These include sawing logs into lumber and similar products, making products that improve the natural characteristics (i.e. engineered wood assemblies), and millwork.
322 Paper manufacturing	Consists of establishments primarily engaged in manufacturing pulp, paper and paper products.
324 Petroleum and coal product manufacturing	Includes establishments primarily engaged in transforming crude petroleum and coal into intermediate and end products.
325 Chemical manufacturing	Establishments primarily engaged in manufacturing chemicals and chemical preparations, from organic and inorganic raw materials.
326 Plastics and rubber products manufacturing	Establishments primarily engaged in making goods by processing raw rubber and plastics materials.
327 Non-metallic mineral product manufacturing	Establishments primarily engaged in manufacturing non-metallic mineral products. These establishments cut, grind, shape and finish granite, marble, limestone, slate and other stone; mix non-metallic minerals with chemicals and other additives; and heat non-metallic mineral preparations to make products, such as bricks, refractories, ceramic products, cement and glass.
331 Primary metal manufacturing	Establishments primarily engaged in smelting and refining ferrous and non-ferrous metals from ore, pig or scrap in blast or electric furnaces.
541 Professional, scientific, and technical services	This includes activities in which human capital is the major output and establishments make the knowledge and skills of their employees available as a service.

3.6.4 KEY OCCUPATIONS

Key occupations relevant to reducing GHG emissions within the Industrial Energy and Process Efficiency sector are listed in Table 65 by NOC code. These occupations were initially identified using statistical analysis. The key occupations (by NOC code) for industries relevant to this sector at the 3-digit NAICS code level (as published by Statistics Canada in its 2011 Census breakouts) were amalgamated across industries. The key occupations were then validated through additional secondary research and industry consultation as part of the LMI research to identify their relevance to BC's clean economy and to the potential for reducing GHG emissions.

Table 65: Key occupations in BC's Industrial Energy and Process Efficiency sector

NOC	Occupation
#0821	Managers in agriculture
#2132	Mechanical engineers
#2133	Electrical and electronics engineers
#2134	Chemical engineers
#2141	Industrial and manufacturing engineers
#2142	Metallurgical and materials engineers
#2143	Mining engineers
#2144	Geological engineers
#2145	Petroleum engineers
#2147	Computer engineers (except software engineers and designers)
#2173	Software engineers and designers
#2211	Chemical technologists and technicians
#2232	Mechanical engineering technologists and technicians
#2233	Industrial engineering and manufacturing technologists and technicians
#2241	Electrical and electronics engineering technologists and technicians
#7234	Boilermakers
#7241	Electricians (except industrial and power system)
#7242	Industrial electricians
#7243	Power system electricians
#7252	Steamfitters, pipefitters and sprinkler system installers
#7253	Gas fitters
#7311	Construction millwrights and industrial mechanics
#7312	Heavy-duty equipment mechanics
#7313	Refrigeration and air conditioning mechanics
#7333	Electrical mechanics
#7511	Transport truck drivers
#8431	General farm workers
#9232	Petroleum, gas and chemical process operators
#9243	Water and waste treatment plant operators
#9424	Plant and System Operators All Other
#9432	Pulp mill machine operators
#9434	Other wood processing machine operators

Source: The Delphi Group

3.6.5 WORKFORCE DEMAND

Demand-side Drivers

In the Industrial Energy and Process Efficiency sector, demand for clean economy jobs is largely shaped by policy drivers and technology trends that encourage reduced energy use and GHG emissions.

There are six main areas identified in the CleanBC Plan as opportunities to support cleaner industry and reduce GHG emissions. Table 66 provides a breakdown of the reduction potential of each opportunity area.

Table 66: GHG reduction opportunities identified in the CleanBC Plan likely to impact the Industrial Energy and Process Efficiency sector

CLEANER INDUSTRY		
INITIATIVE	**DESCRIPTION**	**GHG Mt in 2030**
Ramp up the clean growth program for industry	• Direct a portion of B.C.'s carbon tax paid by industry into incentives for cleaner operations	**2.5**
Improve air quality by cutting air pollution	• Clean up air pollution in the lower mainland with a pilot project to test options to switch 1,700 freight trucks to natural gas and low or zero-carbon fuel by 2030 • Make heavy-duty vehicles more efficient with fuel efficiency improvements, education on best driving practices	**N/A**
Reduce emissions from methane	• Reduce methane emissions from upstream oil and gas operations by 45%	**0.9**
Industrial electrification	• Provide clean electricity to planned natural gas production in the Peace region	**2.2**
	• Increase access to clean electricity for large operations with new transmission lines and interconnectivity to existing lines	**1.3**
Carbon capture and storage	• Ensure a regulatory framework for safe and effective underground CO_2 storage and direct air capture	**0.6**
Cleaner fuels for industry	• Make industrial natural gas consumption cleaner by putting in place a minimum requirement of 15% to come from renewable gas	**0.9**
	GHG Mt reduced by 2030	**8.4**

Source: CleanBC Plan

Expected growth and demand drivers in the Industrial Energy and Process Efficiency sector are described in Table 67 below. As the Province of BC further develops policies to encourage shifts in clean technology, related efforts to support the industrial workforce will be important for resource-dependent communities across the province.

Table 67: Sub-sectors, targets and expected growth in BC's Industrial Energy and Process Efficiency sector

Sub-sector	CleanBC Targets and Indicators	Expected Growth[263]
Energy and process efficiency technologies	The CleanBC program for industry is focused on reducing industrial GHG emissions by 2.5 Mt per year. **2025**: Methane emissions from the natural gas sector will drop by 45%.[264] **2030**: 60 large industrial operations using heat pumps instead of natural gas. **2030**: Over 55% of natural gas compressors in the oil and gas sector are electric.	High The clean technology sector, including renewable electricity, energy efficiency, transportation and industrial processes, has been growing steadily, worth $3 trillion per year globally.[265]
Carbon capture, utilization, and storage / sequestration	**2030**: Ensure a regulatory framework for safe and effective underground CO_2 storage and direct air capture. **2030**: Emissions from 580,000 tonnes of CO_2e are prevented because of innovative technology like carbon capture and storage.	Medium Global carbon capture market is estimated to reach $800 billion by 2030.[266]
Waste heat recovery	None.	Medium Global waste heat recovery market forecasted to reach $80 billion by 2025.[267]
Bio-products and low-carbon fuel switching	**2030**: Make industrial natural gas consumption cleaner by putting in place a minimum requirement of 15% to come from renewable gas. **2030**: Over 40% of diesel and 10% of gasoline comes from biofuels.[268]	**High** By 2022, the global biofuels market size will reach $218.7 billion. Nationally, annual avoided lifecycle GHG emissions resulting from biofuel consumption reached a record 5.5 million tonnes in 2017.[269] The substitution of non-renewable products / materials with bio-based products continues to grow within EITE sectors globally (e.g., carbon fibre in place of steel, biochar in place of coal combustion products for cement production).

[263] Note the terms used to describe the expected growth of sub-sectors (medium, high, very high) are relative and not based on specific quantifiable levels. Information used to inform the expected growth assessment includes key informant interviews, trends analysis, and secondary research.
[264] See: https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/cleanbc/cleanbc_2018-bc-climate-strategy.pdf
[265] See: https://www.britishcolumbia.ca/invest/industry-sectors/technology/clean-technology/
[266] See: Lee, M. et al. Closing the Loop: Reducing Greenhouse Gas Emissions and Creating Green Jobs through Zero Waste in BC. Canadian Centre for Policy Solutions.
[267] See: https://www.globenewswire.com/news-release/2019/02/20/1738074/0/en/Waste-Heat-Recovery-System-Market-to-hit-80-billion-by-2025-Global-Market-Insights-Inc.html
[268] See: https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/cleanbc/cleanbc_2018-bc-climate-strategy.pdf
[269] See: https://www.canadianbiomassmagazine.ca/canadas-ethanol-consumption-nearly-doubled-since-2010-report-7359/

Major Projects

Projects in the BC Major Projects inventory related to the Industrial Energy and Process Efficiency sector are primarily related to gas distribution and liquified natural gas facilities. There is currently a total of 31 of these major industrial projects proposed and underway, totaling approximately $108 billion. Table 68 lists the projects identified as such in the BC Major Projects Inventory in Q2 2019.

Table 68: Industrial Energy and Process Efficiency major projects by BC Development Region

Development Region	Number of Projects	Cost ($ millions)
1. Vancouver Island/Coast	2	$2,000
2. Mainland/Southwest	3	$2,125
3. Thompson/Okanagan	0	$0
4. Kootenay	0	$0
5. Cariboo	0	$0
6. North Coast	15	$88,182
7. Nechako	1	$275
8. Northeast	10	$15,610
Total	**31**	**$108,192**

Source: BC Major Projects Inventory, Q2 2019

Employment Impacts from CleanBC

CleanBC sets out an overarching goal of reducing industrial GHG emissions by 2.5 million tonnes (Mt) per year. More specific targets / goals are outlined below, along with a discussion on potential employment impacts.

1. Reduce industrial GHG emissions by 2.5 Mt per year by 2030.
2. 15% renewable gas in the natural gas pipeline by 2030.
3. Reduce methane emissions from the natural gas sector by 45% by 2025.

Key Considerations by CleanBC Policy Goal

Employment considerations and assumptions for the policies outlined above are described below.

1. Reduce industrial GHG emissions by 2.5 Mt per year

Policy Details: This policy includes a focus on ramping up the Clean Growth program for industry, including the Fund and Incentive programs by directing a portion of BC's carbon tax paid by industry into incentives for cleaner operations in order to reduce 2.5 million tonnes of GHG emission per year from 2020 to 2030.

Assumptions: Based on the CleanBC Industry Incentive program and Industry Fund (which has earmarked $168M over 3 years), it is assumed that more than $100 million per year will be invested into projects (50:50 leverage between government incentive and industry spend) – largely on equipment / technology upgrades with a 1 year deployment timeline, including some upfront design-engineering. Some job creation will occur through expenditures and investments in various technologies and capital projects to reduce GHG emissions – which will be highly sector-specific and varied based on emissions-intensive industries and company operations. Investments include technologies related to reducing GHG emissions from stationary combustion sources (e.g., high and low-grade process heat, waste heat recovery, co-generation), fuel switching, automation and sensor deployment, and

other industrial processes, as well as broader electrification of industry (including direct drive compressors for proposed future LNG facilities).

Timelines: Evenly distributed between 2020 and 2030.

Geographic: All regions of BC in line with GHG emissions intensive industrial activities (extraction, processing, and manufacturing).

Job Impacts: Job creation impacts are estimated at 264 temporary construction jobs on average per year between 2020 and 2030, as well as 264 jobs in operations by 2030 related to new system design, related engineering-construction, and operations and maintenance. Additional jobs may be created if the equipment can be sourced / manufactured locally. Employment in scientific and engineering occupations, as well as technicians (mechanical, environmental, chemical), industrial electricians, millwrights, and heavy-duty mechanic, as well as some opportunities for cleantech sector manufacturing, digital technology, and industrial systems design.

Some job displacement may occur as demand for high-carbon products shift to low-carbon (e.g., from coke-fired cement kilns to biomass, from coal exported to Asia for metallurgic steel to carbon fibre alternatives, etc.), as well as due to broader macro-trends and disruptive technologies such as automation, pre-fabrication, modular construction, and additive manufacturing. These potential job displacement impact factors have not been modelled as part of this LMI research.

2. 15% renewable gas in the natural gas pipeline by 2030

Policy Details: CleanBC has set a goal to make natural gas consumption cleaner province-wide by putting in place a minimum requirement of 15% to come from renewable gas by 2030.

Assumptions: To scale from BC's current renewable gas supply of 0.3% (equal to 5 projects producing 300,000 GigaJoules) to 15% (or 15M GJ / year) by 2030 will require significant innovation and capital investment in anaerobic digestion (AD) technology and related projects, including agriculture (approx. 2% of 15% target) and wastewater treatment (approx. 1%), as well as landfill biogas capture and upgrading to RNG (approx. 1%), and within the forestry sector through pyrolysis and gasification technology and/or closed loop gas systems and sawmills (approx. 5%). There are also opportunities for job creation related to investment in hydrogen production facilities into the pipeline (approx. 6%).

Timelines: Growth from 2020 onwards on a project-by-project basis.

Geographic: Geographic distribution will be largely based on farm activities and in line with suitable landfill locations, as well as access to natural gas pipeline infrastructure and customers. Forestry-based opportunities will largely be distributed for Vancouver Island / Coast and the Cariboo regions.

Job Impacts: Job creation impacts estimated to include 340 temporary construction jobs on average per year between 2020 and 2030, as well as 550 ongoing direct jobs in operations by 2030. Job creation potential from this policy target is considerable for renewable gas project developers, related construction trades, and facility operators and engineers related to anaerobic digestion facilities, hydrogen production facilities, and closed-loop syngas systems at sawmills.

3. Reduce methane emissions from the natural gas sector by 45% by 2025

Policy Details: The Province has been working in collaboration with the natural gas sector, environmental organizations, and the federal government to establish new rules to reduce methane emissions in the upstream production of natural gas by 45% by 2025. Provincial regulations have been developed by the BC Oil and Gas Commission and were released in 2019.

Assumptions: Estimated to be $35 million in investment until 2025, inline with assumptions developed by Navius Research. Some job creation will occur through expenditures and investments in various technologies and capital projects focused on reducing methane emissions from oil and gas operations and related pipeline transportation.

Timelines: Evenly distributed between 2020 and 2025 in line with regulations.

Geographic: Northern BC regions, as well as along natural gas pipeline routes.

Job Impacts: Job creation impacts are estimated at 9 temporary construction jobs on average per year between 2020 and 2025, as well as 9 ongoing jobs in operations by 2025 related to new system design and related engineering-construction, including for process engineers, oil and gas facility engineers and operators, natural gas pipeline operators, and specialized technicians, as well as some opportunities for cleantech product and equipment manufacturing and design (in areas such as leak detection technologies, LiDAR, sensors, etc.). Additional jobs may be created if the equipment can be sourced / manufactured locally.

Employment Impacts by Occupation

The three CleanBC policy goals outlined above are expected to create demand for approximately 610 temporary construction jobs on average per year between 2020 and 2030, as well as approximately 820 ongoing direct jobs in operations by 2030. Key occupations relevant to this job creation are shown in Figure 27.

Job transformation is this sector will impact workers as they look to increase energy and process efficiency within their existing operations, learn how to more effectively manage and sequester GHG emissions, including working with the related clean technologies (e.g., methane capture and storage). As market penetration of renewable gas enters the pipeline, this will have some minor impacts on the need for reskilling. In addition, consultants and engineering firms will require further upskilling related to supporting carbon reduction projects, energy and process efficiency, and carbon sequestration using evolving technologies and practices. In total, the sector is projected to see approximately 5,330 jobs impacted through transformation between 2018 and 2030. Table 69 provides a breakout of the key occupations by number.

Source: The Delphi Group

Figure 27: Annual average number of job openings for key occupations in the Industrial Energy and Process Efficiency sector based on initial CleanBC policy targets (2020-2030)

Table 69: Key occupations projected to undergo job transformation within BC's Industrial Energy and Process Efficiency sector between 2018 and 2030

NOC - Occupation Title	Percent of Sector	Number of Jobs Undergoing Transformation (2018-2030)
0821 Managers in agriculture	5.3%	284
8241 Logging machinery operators	3.7%	195
8431 General farm workers	3.4%	179
7511 Transport truck drivers	2.4%	129
8421 Chain saw and skidder operators	1.7%	93
7521 Heavy equipment operators (except crane)	1.7%	88
8432 Nursery and greenhouse workers	1.5%	78
7311 Construction millwrights and industrial mechanics	1.4%	74
0811 Managers in natural resources production and fishing	1.4%	74
8211 Supervisors, logging and forestry	1.4%	74
8616 Logging and forestry labourers	1.4%	73
7312 Heavy-duty equipment mechanics	1.2%	66
2171 Information systems analysts and consultants	1.2%	64
2223 Forestry technologists and technicians	1.1%	60
8611 Harvesting labourers	0.9%	51
2131 Civil engineers	0.9%	50
8231 Underground production and development miners	0.7%	37
8221 Supervisors, mining and quarrying	0.4%	23
0822 Managers in horticulture	0.4%	22
2122 Forestry professionals	0.4%	21
8252 Agricultural service contractors, farm supervisors and specialized livestock workers	0.3%	17
0911 Manufacturing managers	0.3%	14
8614 Mine labourers	0.3%	14
8422 Silviculture and forestry workers	0.2%	13
2212 Geological and mineral technologists and technicians	0.2%	13

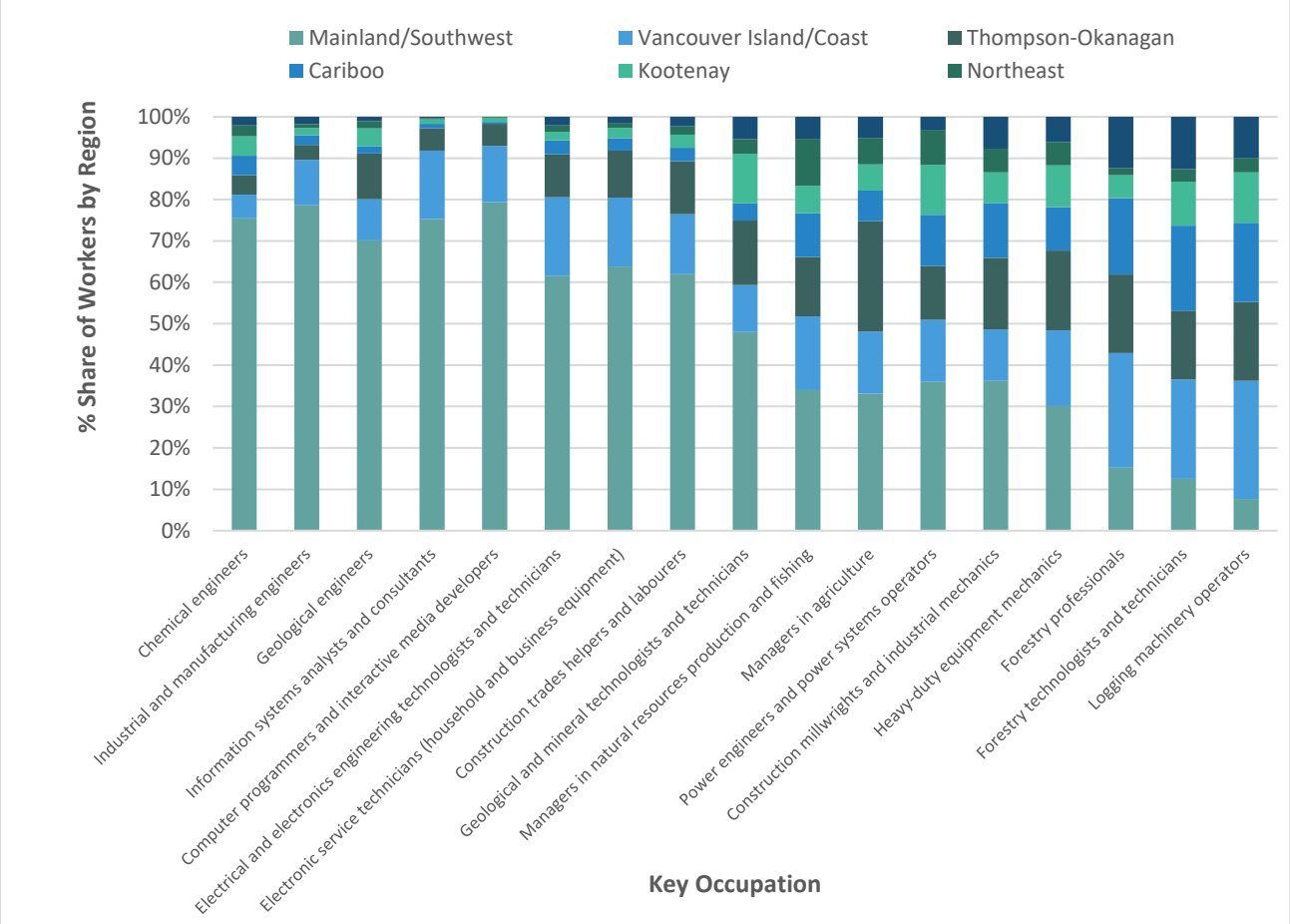
Source: The Delphi Group

3.6.6 WORKFORCE SUPPLY

The workforce supply in the Industrial Energy and Process Efficiency sector includes technicians working to build and maintain industrial equipment, electricians with a focus in power systems and industrial applications, specialized engineers, managers in natural resources production and agriculture, and software and information systems-related support roles, as examples.

Regional Distribution

Key occupations related to the Industrial Energy and Process Efficiency sector that are concentrated in the Lower Mainland / Southwest region include computer programmers and industrial engineers, while those more evenly distributed across the province include forestry professionals, heavy-duty mechanics, and managers in natural resource production (see Figure 28).



Source: Based on Statistics Canada 2016 Census

Figure 28: Key occupations in the Industrial Energy and Process Efficiency sector by BC Development Region

3.6.7 EDUCATION & TRAINING

The pathways for the occupations that comprise this sector vary widely. For occupations focused in engineering, mining, forestry, agriculture, and information systems, post secondary degrees are typically required (see Table 70).

Table 70: Educational pathways relevant to BC's Industrial Energy and Process Efficiency sector

	Common Job Titles	Educational Background	Degree type
Management	Manager (agriculture, aquaculture, natural resources production, petroleum, gas, and chemical processing)	Business	Bachelor's degree Master's degree
		Environmental Studies/Science	
Professional, Technical and Skilled Trades	Civil engineer or Chemical Engineer	Engineering	Bachelor's degree Diploma
	Mining engineer	Environmental Studies/Science	
	Forester	Forestry	
	Computer programmer	Computer Science	
	Systems analyst or consultant		
Labour	Heavy duty mechanic	Environmental Studies/Science	Certificate High School diploma
	Miner		
	Chain saw and skidder operators and Industrial millwrights	On the job training	

Source: Sourced from WorkBC

Post-secondary Institutions

As the province works to decarbonize industrial operations, there will be growing demand for workers in traditional sectors (e.g., forestry, cement mining) with skillsets in system design, supply chain logistics, carbon accounting, digital analytics, and the ability to translate the language between technical processes and policy analysis. In addition to these skillsets, proficiency with automated systems will also be of increasing importance.

Institutions in BC are beginning to offer programs targeting industrial automation operation, such as North Island College's diploma for industrial automation technicians[270], as well as BCIT's technician programs in Automated Controls Installation and Maintenance[271] or Industrial Instrumentation and Process Control.[272]

The following post secondary institutions offer programs relevant to the occupations that will be impacted by BC's shift to a cleaner, lower carbon industrial operations (see Table 71).

Table 71: Programs offered in BC aligned with select key occupations

Key Occupation	Number of programs offered in BC	Institutions offering programs
Industrial electrician	5[273]	BCIT, Okanagan College, Thompson Rivers University
Industrial and manufacturing engineers	19	BCIT, Simon Fraser University, Thompson Rivers University, University of British Columbia, University of Northern B.C., University of Victoria
Information systems analysts and consultants	96	BCIT, Camosun College, College of New Caledonia, Douglas College, Kwantlen Polytechnic, Langara College, Nicola Valley Institute of Technology, Okanagan College, Selkirk College, Simon Fraser University, Thompson Rivers University, University of British Columbia, University of Fraser Valley, University of Victoria, Vancouver Community College, Vancouver Island University
Forestry professionals	19	BCIT, College of New Caledonia, Nicola Valley Institute of Technology, North Island College, Selkirk College, Thompson Rivers University, University of British Columbia, University of Northern B.C., Vancouver Island University
Managers in agriculture	9	Kwantlen Polytechnic University, University of British Columbia, University of Fraser Valley

Source: EducationPlannerBC

Industry-led Training

There are several examples of industry led partnerships aimed at addressing the skills and knowledge needed to support low-carbon, efficient industrial operations in BC through a skilled workforce. The following examples have been provided through the CEWRP Industry survey, regional stakeholder workshops, and consultation with the Industrial Energy and Process Efficiency Sub-committee.

[270] See: https://www.nic.bc.ca/programs-courses/university-transfer/science-technology-engineering-math-programs-courses/electronics-technician-industrial-electronics-specialty/
[271] See: https://www.bcit.ca/study/programs/1320adcert
[272] See: https://www.bcit.ca/study/programs/2945dipma
[273] There is a total of 84 programs that offer training and education relevant to industrial electricians, of these programs 5 are specific to the skillsets of an industrial electrician.

- **BC Forest Safety Council**: The council collaborates with industry through advisory committees to collect insight on training and technology trends. There are 4 committees dedicated to wood manufacturing and 12 committees dedicated to wood harvesting.[274] Further, the Continuing Education and Training Association of BC (CETABC) works with BC Forest Safety Council and the Province of BC to develop entry level forest worker training and pilot new competency-based programs for other occupations.[275]
- **Carbon Footprint Reduction Project**: Prince George Chamber of Commerce coordinated a multi-year as part of a collaboration between the Chamber, UNBC, and CN.[276] Funded by CN, the initiative links local industry and business to university students from UNBC's Carbon and Energy Management courses to create carbon footprint analyses. The data is use d by students to better understand where efficiencies in operations can be made to reduce GHG emissions.
- **Canadian Institute for Energy Training (CIET):** CIET is an energy training centre founded in 1996 that offers a wide range of sustainable energy training programs across Canada, including British Columbia. The Institute specialises in high-quality energy management and energy efficiency training, as well as certification programs such as the Certified Energy Manager program and RETScreen training.[277]

Industry Associations

Table 72 highlights a sample of the industry associations and councils that represent the interests of workers and employers across BC's industrial operations and provide access to training and professional development.

Table 72: Industry relevant to BC's Industrial Energy and Process Efficiency sector

Sector	Organization
Oil and Gas	Canadian Association Petroleum Producers Canadian Energy Pipeline Association
Forestry	Council of Forest Industries The Forest Products Association of Canada Association of BC Forest Professionals Architectural Woodwork Manufacturers Association of BC BC Log and Timber Builders Vancouver Island Association of Wood Producers BC Wood
Mining	Mining Association of BC
Agriculture	BC Agriculture Council BC Young Farmers BC Dairy Council BC Cattlemen's Association BC Greenhouse Grower's Association
Cement	Concrete BC Cement Association of Canada

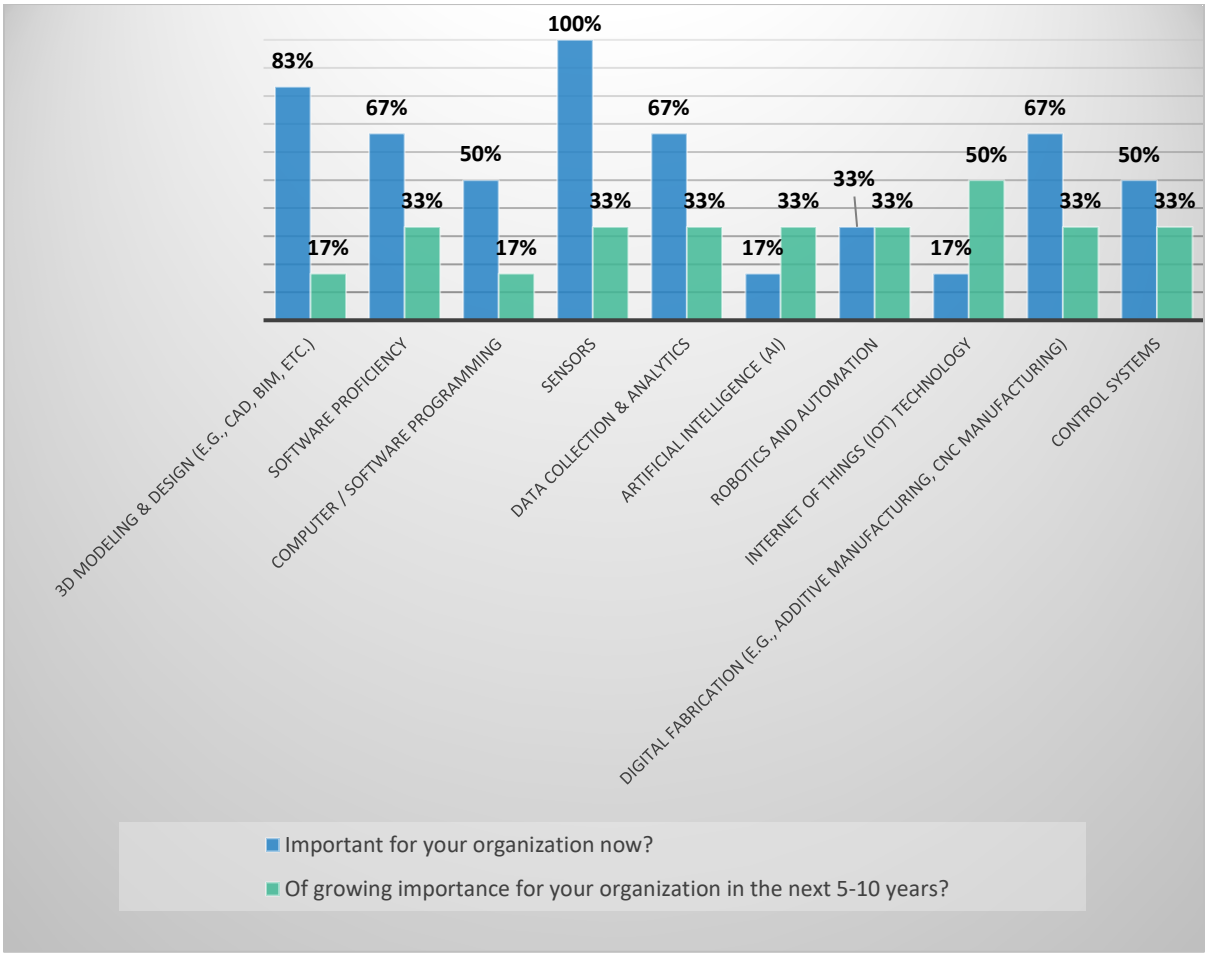
[274] See: http://www.bcforestsafe.org/about.html
[275] See: CleanBC Vancouver Island Region Stakeholder Workshop.
[276] See: http://www.pgchamber.bc.ca/projects/current-projects/carbon-reduction-project/
[277] See: https://cietcanada.com/about-ciet/

3.6.8 EMERGING SKILLS

The variation of organizations and activities within industrial sectors requires both specific and general skills to ensure operational success. Some skills are sector-specific while others are applicable across broader industries.

Cross-functional Skills

Digital systems management and operations are emerging trends where relevant skillsets are growing in demand. For example, half (50%) of the employers and business owners that responded to the CEWRP Industry Survey from the Industrial Energy and Process Efficiency sector ranked skills in operation and management of IoT (Internet of Things) technologies as growing in terms of future importance (see Figure 29). All respondents identified sensors as being relevant and important, while 83% flagged 3D modelling and design as important today for their organizations.



Source: CEWRP Industry Survey (2019)

Figure 29: Emerging computer software and hardware skills for the Industrial Energy and Process Efficiency sector (n=6)

Predictive analytics is needed where technology allows for people to work in a central location where equipment operates remotely. As autonomous technology grows, predictive analysis will be needed to operate. Autonomous shipping and navigation have been highlighted as a focus where individuals with naval backgrounds are being hired given their understanding with operating these systems.

Systems thinking requires people with broader circular economy and holistic/systematic thinking to identify integration between industry, policy and technology and determine the relevance and connectivity of different skillsets, both technical and non-technical. 80% of companies who operate in BC's Industrial Energy and Process Efficiency sector ranked integrated design as a top emerging skill, followed by systems thinking.

Policy and compliance analysis/interpretation, although not emerging skills were regularly identified as needed throughout industry. For example, 90% of companies surveyed through the CEWRP Industry Survey identified policy analysis as a current important skillset.[278] As new policies/regulations to advance the clean economy are introduced, they need to be identified, interpreted and integrated into operations to ensure a smooth transition and minimize risks of non-compliance.

Traditional skills training provides the foundation for professionals to succeed in the industrial sector. Additionally, this study revealed essential non-technical skills that will be key to the success of professionals in the clean economy. These non-technical, cross-functional skills include:

- Interpersonal skills
- Teamwork/collaboration
- Project management
- Communication/writing (people are strong technically, but cannot communicate well)
- Financial skills (how access to funding affects work)
- Sales (to sell innovative clean economy products)

Sector-specific Technical Skills

Within specific sectors of industrial operations, emerging skills were identified through input of industry stakeholders. Some of these emerging skills and areas include:

- **Material Science**: Chemical engineers and operators with skills in chemistry, electric chemistry and electrical engineering are needed to support the growing hydrogen technology market.
- **Forestry**: The greatest need is for operators to have an understanding and skills in carbon, climate change and the clean economy. More specifically, roles with expertise in carbon accounting and offsetting and lifecycle assessment were identified as limited people have the skills to complete tasks in these areas. Forestry management professionals will need skills found in the science and management of reforesting

Selkirk Technology Access Centre: Innovation in Action

The Selkirk Technology Access Centre (STAC) is a fabrication laboratory that provides access to students from Selkirk College to its digital fabrication lab, metal shop, wood shop, computer and training centre. It provides a leading example of public-private-PSI collaboration to kickstart economic development via applied research and skills training. It the result of contributions from Western Economic Diversification Canada, Selkirk College, Innovate BC, the National Research Council of Canada Research Assistance Program (NRC IRAP) and the Columbia Basin Trust.

Link: www.midaslab.ca

[278] CEWRP Industry Survey (2019).

climate resilient trees.[279] Forestry professionals will also need a greater focus on land management skills (e.g., silviculture, genetics, tree planting, climate change science / scenario modelling) as climate adaptation measures increase.[280]

- **Ag-Tech**: Agriculture and farm managers will become increasingly valuable as their skillsets relate to sustainable crop management technologies and best practices as well as sequestering carbon through soil management. There is also the potential for these managers to oversee organic waste management as it relates to methane capture and anaerobic digestion technology for biogas and RNG. Agronomists and individuals with expertise in plant and soil health are limited but in demand. Software developers are also in demand in the sector, however companies like Amazon and Microsoft are increasing competition and demanding talent that could be used in clean-tech.
- **Energy**: According to Energy Safety Canada's Petro LMI report there is demand for individuals with expertise in compliance and regulations, power-grids, methane mitigation, and reporting.[281]
- **Mining**: Skills in data analysis are key to the mining sector to effectively quantify and communicate information that is gathered from sensors across the extraction and processing supply chain.[282]

With respect to the three CleanBC goals, job transformation through reskilling / upskilling will be specific to the various technology pathways for achieving energy and process efficiency improvements in order to reduce GHG emissions, which will vary by sector / industry. Job transformation will impact on oil and gas facility operators, petro-chemical engineers, and pipeline operators who will require new skills related to working with technologies (such as sensors and control systems) that address venting and leak detection.

Reskilling / upskilling, depending on the industry, will need to consider a combination of the following GHG emission reduction equipment and technologies:

Surrey's Advanced Manufacturing and Innovation Economy partnership: The City of Surrey collaborated with Simon Fraser University, and Kwantlen Polytechnic University consulted industry to understand the competitive factors in the sector and trending skills. From the collaboration, the City developed a 3-phase Advanced Manufacturing Labour Market Strategy, that has produced several valuable outcomes, including the development of Siemens Mechatronic Systems Certification Program which provides graduates with an internationally recognized industrial certificate that supports a career in automation and manufacturing.

Link:
https://investsurrey.ca/sites/default/files/docs/amie_labour_market_development_strategy_final.pdf

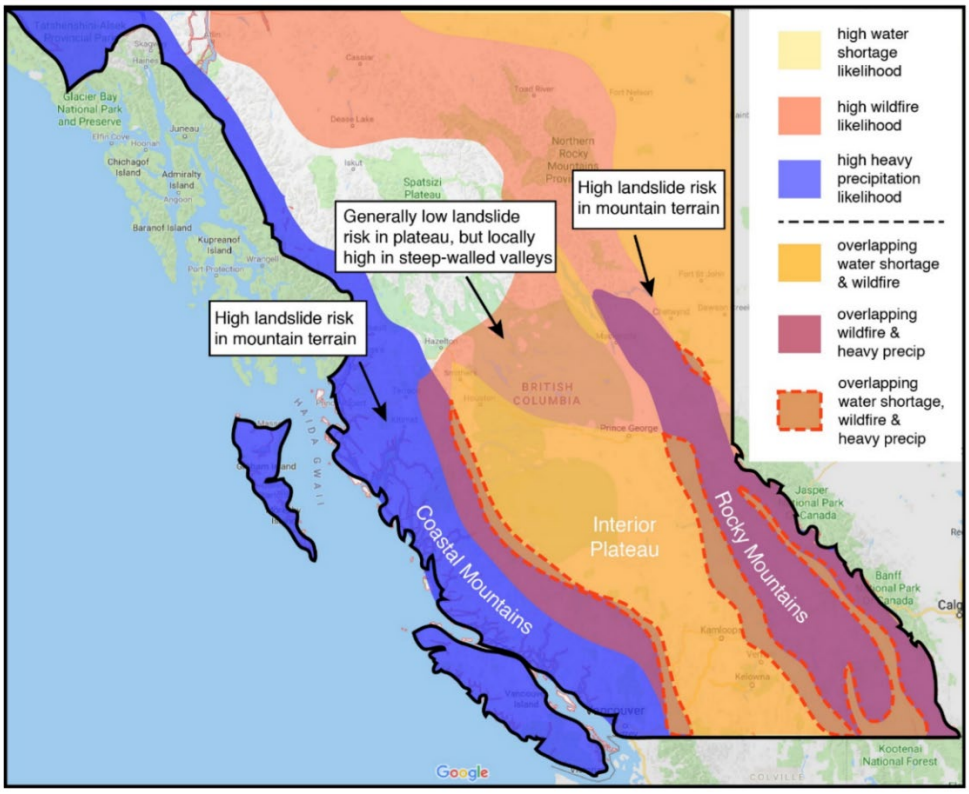
- Technologies to address GHG emissions from stationary combustion sources (e.g., high and low-grade process heat, waste heat recovery, co-generation)
- Fuel switching
- Electrification (including direct drive compressors for proposed future LNG facilities)
- Chemistry and bioeconomy focused pathways
- Carbon capture and utilization
- Advanced technologies (in areas such as automation, sensors, data visualization, data analytics, and Artificial Intelligence)

[279] See: https://www.bcbusiness.ca/can-bcs-forests-cope-with-climate-change
[280] Interview with Ministry of Forests, Lands, Natural Resource Operations and Rural Development Staff
[281] See: https://careers-oil-gas.s3.amazonaws.com/publications/33/en/Workforce_Insights_2019_FINAL.pdf
[282] See: CleanBC Industrial Energy and Process Efficiency Sub-committee

With respect to the 15% renewable gas target, job transformation will be largely related to the upskilling of farmers and landfill operators who will need to expand their knowledge of AD systems and upgraders, as well as sawmill operators working with pyrolysis and gasification technologies. It is likely that this will role out on a project-by-project basis over the next decade so developing specific training may be challenging, although opportunities exist to expose relevant individuals to functioning systems at existing sites where these technologies / equipment are in operation in BC and/or abroad. Knowledge in systems-thinking, circular economy principles, as well as new practices in carbon sequestration and better land use management, will be important.

3.7 CLIMATE ADAPTATION CONSIDERATIONS

With a recently published BC-focused climate risk report[283] revealing that catastrophic consequences are likely to occur in 73% of risks studied, the importance of adaptation to climate change is paramount (see Figure 30). Acknowledging that these changes are occurring, and adapting decision-making processes, behaviors, and activities to account for the impacts of climate change will not only increase BC's climate resiliency but will also enable the province to capitalize on emerging opportunities.



Source: Ministry of Environment and Climate Change Strategy

Figure 30: Risk map of climate-related hazards in BC

[283] Ministry of Environment and Climate Change Strategy, Preliminary Strategic Climate Risk Assessment for British Columbia (July 2019)

3.7.1 WORKFORCE IMPLICATIONS

For over a decade the Government of BC has acknowledged that climate change impacts present not only risk but also opportunities in BC's clean economy.[284] Planning and implementing adaptation measures can lead to new employment opportunities while mitigating potential job losses caused by climate change, and the broader transition to a clean economy is also estimated to lead to a net creation of jobs.[285]

Incorporating climate change considerations within existing occupations is an ongoing process, with many industry professionals reporting they lack the tools, information, resources, and client support necessary to make this shift.[286] The need to equip BC's current workforce with the knowledge and skills to support climate change adaptation has been recognized through a variety of initiatives, such as the *Inspiring Action: BC Professional's Adaptation Network,* led by Royal Roads University. This project focuses on training industry professionals including engineers, agrologists, biologists, planners, landscape architects, and technicians to protect our natural and built environment from climate disasters.[287] Engineers and Geoscientists BC has recognized the need to incorporate climate change adaptation strategies into current engineering and geoscience projects through the creation of a Climate Change Advisory Group, which provides extensive educational resources and tools to engineers and geoscientists.[288]

In addition to expanding the knowledge base of industry professionals, new skillsets are required by employees within industries endeavoring to adapt to climate change. These include skills in areas such as risk management, adaptive management, and scientific capacity.[289]

Modern day innovators have not shied away from the challenge of adapting to a changing climate. Innovation beyond physical infrastructure has taken the form of sophisticated evaluations of urban traffic flow,[290] the development of rating systems to evaluate environmental building attributes,[291] cost projection associated with infrastructure upgrades and maintenance, and proposed changes to building codes to ensure investments are resilient to climate change. [292] Climate projection is an emerging area of science which leaves no guarantees that innovation in the areas of design will be suitable for future climate scenarios. It is therefore important for engineering professionals and managers to develop and evaluate consequence management plans informed by multiple data streams.[293].

In addition to technical skills, companies are looking for employees to be capable of strategic planning, initiative and motivation, ability to learn quickly, innovate and think critically and creatively. Cross-functional skills including communication, language skills, conflict management, and negotiation are important for workers to collaboratively find solutions to industry problems.[294]

[284] BC Ministry of Environment, Preparing for Climate Change, British Columbia's Adaptation Strategy, (February 2010)
[285] International Labour Organization, The Employment Impact of Climate Change Adaptation, (February 2018)
[286] APEGBC CCAG, *Climate Change Survey, (2017)*
[287] Royal Roads University, Inspiring Climate Action: BC Professionals Adaptation Framework, (March 2019)
[288] Engineers and Scientists BC, *BC's Engineers and Geoscientists Are Helping Address Climate Change*, ACEC-BC Fall (2019)
[289] Simon Dale-Lace, Elise Pare WSP, *The Future of Stormwater Design in the Face of Uncertainty,* ACEC-BC Fall (2019)
[290] Alex Gray, Tech Innovations Save Us from Climate Change, World Economic Forum, (January 2017)
[291] Malcolm Shield, Jeremy Fyke, *Sound Business Decision-Making in a Changing Climate,* ACEC-BC Fall (2019)
[292] BC Ministry of Environment, Preparing for Climate Change, British Columbia's Adaptation Strategy, (February 2010)
[293] Kisters Environmental Data Analytics, Water Utilities Adapt to Climate Change, (July 2018)
[294] GLOBE Advisors, British Columbia's Clean Transportation Sector, (September 2012)

Clean Power Supply and Storage

The direct interaction of hydropower with the hydrological cycle presents a unique duality in which hydropower can both help mitigate climate change impacts while remaining vulnerable itself to a changing climate. Hydropower projects inherently control waterflow and can enable the storage of multipurpose dams, ease the pressures of increased flooding events, and enable effective management of water resources in altered weather patterns.[295] However, there is a limit to the resilience of hydropower facilities due to their dependency on precipitation, vulnerability to natural disasters, and inability to adapt to extreme weather. [296] [297]

The Canadian economy depends on electricity generation and transmission which are among the sectors most at risk in a changing climate.[298] The ways in which a changing climate can impact electricity generation and transmission are extensive and encompass risks from increased lightning strikes, ice buildup in extreme cold, increased frequency of heavy rainfall, natural disasters, fire events, higher mean temperatures, and high winds.

The exposed nature of various grid system components presents a challenge for climate adaptation strategies. While threats to electricity generation and transmission are extensive, they are generally all threats currently faced in present weather conditions and simply predicted to increase in orders of magnitude. This has resulted in the development of a wide array of adaptation strategies which are currently utilized to mitigate these risks, such as precautionary measures when planning long-range transmission routes. The prevention of high voltage electric short circuits, made through the air between conductors and trees (flashover), has been improved through insulator engineering designs.

Effective climate adaptation strategies require current industry workers, such as engineers, to expand their knowledge of climate change impacts and incorporate these into engineering designs. Engineers and Geoscientists BC has recognized the need for industry professionals to consider climate change in their work and has created extensive resources and tools to guide engineering and geoscience projects.[299]

Green Building and Resilient Infrastructure

Through time, the sophistication and ingenuity employed in the design of our built environment has enabled communities to adapt and thrive in various environmental conditions. The continual adaptation of our built environment in the face of climate change is imperative to maintain stability, human health, and economic security.[300]

Well poised to assist government agencies and regulators with changes to building practices are BC's consulting engineering companies. Responsible for the design and delivery of infrastructure, consulting engineering companies are trusted advisors and contribute to new codes, standards, and guidelines which encompass all aspects of our built environment. The development of the PIEVC (Public Infrastructure Engineering Vulnerability Committee) Engineering Protocol by Engineers Canada has provided a guideline for assessing infrastructure vulnerabilities in extreme weather events and a changing climate. This protocol is currently used in both private and public sectors. The evolution of infrastructure assessment guidelines has a cascading impact for all individuals

[295] Luis Bera, The Role Hydropower in Climate Change Mitigation and Adaptation: A Review, Engineering, (September 2016)
[296] International Hydropower Association, Hydropower Sector Climate Resilience Guide, (2019)
[297] International Atomic Energy Agency, Adapting the Energy Sector to Climate Change (September 2019)
[298] Laura Zizzo, Travis Allan, Joanna Kyrias, Understanding Canadian Electricity Generation and Transmission Sectors Action and Awareness on Climate change and Need to Adapt, Zizzo Allen Professional Corporation, (December 2014)
[299] Engineers and Scientists BC, *BC's Engineers and Geoscientists Are Helping Address Climate Change*, ACEC-BC Fall (2019)
[300] The Climate Atlas of Canada, Building a Climate-Resilient City, (2018)

working in this sector as these requirements must be taken into account by architects, designers, builders and building operators.[301]

Through effective land use planning strategies, communities are able to adapt to a changing climate while reaping additional secondary benefits in environment and human health. Nature-based Solutions (NBS) use services of nature in conjunction with conventional climate adaptation approaches and are gaining global recognition as a way of adapting to hazards while enhancing and restoring natural ecosystems. By using NBS in applications such as stormwater management through tidal wetlands, planners can not only address erosion and flood effects, but also improve water quality and provide habitat for aquatic flora and fauna.[302]

Local governments across Canada have started taking into account the value of natural features in asset management plans through the Municipal Natural Assets Initiative, which provides scientific, economic, and municipal expertise. With effective monitoring, maintenance, and rehabilitation, natural assets such as aquifers, forests, and streams can provide vital services equivalent to capital-intensive engineered assets.[303] Maximizing installations of green infrastructure in our built environment supports climate change adaptation through urban cooling, water storage, improved fire and drought resistance, and storm surge buffering, in addition to secondary benefits including carbon sequestration, increased biodiversity, improved air quality, boosts to mental health, and increasing recreational opportunities.[304]

In a survey of green building businesses in BC, the emerging skillsets in climate change knowledge that were ranked highest among respondents included:

- Lifecyle Assessment
- Climate Risk Assessment
- Using Climate Change Scenarios / Science for Decision-making

Clean Transportation

To maximize the development of and investment in clean transportation, BC must ensure transportation infrastructure is protected from climate threats. Due to its long operational life, exposure to irregular climate events and seasonal changes, transportation infrastructure is especially vulnerable to climate change impacts.[305] The Ministry of Transportation and Infrastructure requires that adequate protection strategies from climate change impacts are considered in engineering designs. The Province has developed best practice guidelines for BC's highway infrastructure to ensure a resilient transportation network in extreme weather and other climate change effects.[306]

Transit operators comprise the largest component of BC's public transit employees, accounting for 50% of total workers. Skilled trades, including commercial and heavy-duty mechanics, contribute significantly to the public and private transportation workforce through ensuring smooth operations of vehicles. While these workers will have

[301] Malcolm Shield, Jeremy Fyke, *Sound Business Decision-Making in a Changing Climate,* ACEC-BC Fall (2019)
[302] Association of Consulting Engineering Companies – British Columbia, Climate Shift (2019)
[303] Municipal Natural Assets Initiative, Municipal Natural Assets Initiative, (2018)
[304] Steve Winkelman, Edward Nichol, Deborah Harford, Taking Action on Green Resilience: Climate Change Adaptation and Mitigation Synergies, (November 2017)
[305] Ian Picketts, Jean Andrey, Lindsay Matthews, Stephen Dery, Susan Tighe, Climate Change Adaptation Strategies for Transportation Infrastructure in Prince George, Canada, Regional Environmental Change (July 2015)
[306] Government of BC, Adapting Transportation Infrastructure to Climate Change, (ND)

to understand how new technologies need to adapt to climate change, engineers and city planners will be the driving force behind transportation planning and infrastructure modification. Climate change adaptation in the transportation sector will require the application of climate science to decisions and climate science-informed risk governance and management. Current initiatives within BC to upskill engineers and planners in the context of climate change include *Inspiring Action: BC Professional's Adaptation Network,* led by Royal Roads University, and Engineers and Geoscientists BC's Climate Change Advisory Group.[307]

Materials Management and Waste-to-Resource

Vulnerabilities in Canada's municipal infrastructure have been exposed in severe rainfall events, with inadequate stormwater management facilities resulting in damage to several cities. Managing increased stormwater is one of many ways in which a changing climate may impact water and wastewater infrastructure. Permafrost degradation may result in ruptured sewage lines and storage tanks a hotter and drier climate may require new management strategies for water delivery and collection systems, and increased storm events may result in pipeline ruptures.[308] Engineering solutions to manage projected rainfall patterns is challenging because climate projection science is still evolving. Industry professionals who design and manage wastewater infrastructure must employ skills in the areas of risk assessment, adaptive management, and consequence management in the event that infrastructure is under-and-overdesigned until the accuracy of climate projection science improves.[309]

Through shifting from climate change adaptation to mitigation strategies, the waste industry has invested significant resources in transforming the sector with proven, practical and cost-effective technologies. Waste now offers a source of renewable energy through incineration, landfill gas recovery, and anaerobic biogas. Organic waste accounts for approximately 30-70% of municipal solid waste, such as garden waste, bio waste and food waste. Organic wastes are able to be recovered, known as organic recovery, through aerobic and anaerobic biological treatment technologies, and are utilized to improve physical and nutrient soil properties. Organic recovery is especially helpful where organic matter has been eroded due to climate change and other threats, such as deforestation. Through collaboration with other industry sectors, the waste sector is well poised to contribute real solutions to climate challenges faced across an array of industries.[310]

Industrial Energy and Process Efficiency

The dependency of the agriculture industry upon the natural environment presents both an opportunity for the advancement of the sector in a changing climate, as well exposing an inherent vulnerability to change. With temperatures predicted to continue warming, there is potential to expand the growing season in some areas, enable lower feed requirements of livestock and improve soil quality through carbon sequestration by shifting from annual to perennial crops. These opportunities may allow for increased productivity and expansion to more profitable crops. Conversely, extreme climate events such as floods, heat waves, and drought put the agriculture industry at risk to decreased yields, livestock deaths, reduced quality of products, and infestations of pests and disease.[311] Some of the tools used presently in the agriculture sector to safe guard against climate risks, such as sprinkler irrigation and crop insurance, rely upon the rarity of poor conditions to be sustainable.[312] Adaptive

[307] Royal Roads University, Inspiring Climate Action: BC Professionals Adaptation Framework, (March 2019)
[308] International Institute for Sustainable Development, Climate Change Adaptation and Canadian Infrastructure: A Review of the Literature, (November 2013)
[309] Simon Dale-Lace, Elise Pare WSP, *The Future of Stormwater Design in the Face of Uncertainty,* ACEC-BC Fall (2019)
[310] International Solid Waste Association, Waste and Climate Change, (December 2009)
[311] Government of Canada, Impact of Climate Change on Canadian Agriculture, (July 2015)
[312] Climate Atlas of Canada, Agriculture and Climate Change, (2018)

responses to climate change in agriculture include seasonal changes and sowing dates, changing varieties or species, water supply and irrigation, new crop varieties, altering inputs, and fire risk management.[313]

Canada's forests, and in turn the forestry industry, are suspectable to climate change through increased insect outbreaks, increased intensity and frequency of forest fires, and shifts in species distribution alongside shifts in climate zones.[314] Sustainable forest management strategies must take into account potential shifts in the distribution of optimal growing conditions, such as assisting with tree migration through seed dispersal when naturally occurring processes are insufficient, while ensuring ecosystems remain productive and functional for reliant species. The agile global forestry sector is capable of adapting to decreased outputs from BC, which provides an opportunity for other nations to gain stronger footholds in the global export market.[315]

Through improved land use management in the forestry sector, improvements in carbon sequestration of Canada's managed forests may be improved. While generally acting as carbon sinks, forests can also become sources of carbon through processes of decomposition following mass insect and disease infestations, and when burned in fire events. Both insect outbreaks and annual wildland fires have increased substantially in over the past decade, resulting in Canada's forests becoming net carbon sources.[316] Carbon sequestration can be improved through reforestation, afforestation, changes in harvest cycles on private lands, and restricting harvest on public lands.[317]

The research and development of tools, enabling the adaptation of forest and agriculture industries to climate change, will require investment in employees who possess creativity, innovation, technical skills and advanced scientific literacy. Scientific capacity is often variable between companies and management agencies, leaving some with limited advanced scientific capacity. Adequate scientific capacity is required to utilize climate change impact assessments as they often need to be downscaled to understand their impact at a scale appropriate to land managers. Without the scientific capacity to do this, large-scale climate change impact assessments are of little practical use. Investment in the development of climate data for levels suitable for land managers is critical if future risks are to be adequately assessed and adapted.[318]

[313] Food and Agricultural Organization of the United Nations, Adaptation to Climate Change in Agriculture, forestry and fisheries: Perspective framework and priorities, (2007)
[314] Climate Atlas of Canada, Forests and Climate Change, (2019)
[315] Forest Products Association of Canada, Climate Change and Canada's Forest Sector, (April 2015)
[316] Government of Canada, Forest Carbon, (December 2016)
[317] Beverly Law, Tara Hudiburg, Logan Berner, Jeffrey Kent, Polly Buotte, Mark Harmon, Land use strategies to mitigate climate change in carbon dense temperate forests, (April 2013)
[318] Sustainable Forest Management Network, Climate Change and Forest Management in Canada, (2010)

4. ANALYSIS & DISCUSSION

This section provides an analysis on the LMI research results, including a deeper socio-economic analysis (using a gender and equity or GBA+ lens) and specific insights gathered through the Indigenous consultation. This section also describes the workforce issues, gaps, and challenges that were highlighted through consultation with key informants, sub-committees, and the Steering Committee as part of this project's research and engagement activities. The range of key informants were selected to represent a broad cross section of the clean economy sectors, different types of organizations, demographics, and regional perspectives (a full list of organizations that were engaged can be found in Appendix B).

It is important to note that many of the issues and sub-issues identified in this report are not new and have been identified in previous LMI research efforts. For example, the disparity in access to training and education resources between rural and urban areas is a long-standing challenge felt across many sectors and should be considered as new training and education programs are developed to support the CleanBC plan.

4.1 SOCIO-ECONOMIC CONSIDERATIONS

This section looks at potential and existing barriers that need to be considered and addressed to ensure accessibility and inclusion of all workers in the clean economy. The primary and secondary research for this project takes into consideration First Nations experience, feedback, and recommendations, and identifies additional gaps and barriers that exist for other groups: women, youth, and people who live in rural and remote communities. In addition to input received through two youth-focused sessions and eight Indigenous-focused sessions, the overarching data, regional stakeholder workshops, and sector-specific sub-committees provide some insight on overlapping barriers and provide a basis for recommendations.

4.1.1 GENDER AND EQUITY

Overarching barriers created by poverty can affect access to training and employment across all sectors, including those in the clean economy. On March 18, 2019, BC released TogetherBC, its first Poverty Reduction Strategy, containing a number of actions related to training and employment opportunities.[319] These actions include:

- Skills training for workers 55 and older to transition into new work environments.
- Skills development programs for those who face extra barriers to success, including survivors of abuse, workers 55 and over, Indigenous workers, young adults, young adults at risk (including former youth in care), and people with multiple barriers.
- $3 million to the Industry Training Authority to provide more hands-on support for apprentices, employers and Indigenous communities.
- Changes to WorkBC to offer better services for people who need support to re-enter the workforce and access training opportunities.

[319] See: https://www2.gov.bc.ca/assets/gov/british-columbians-our-governments/initiatives-plans-strategies/poverty-reduction-strategy/togetherbc.pdf

- A partnership between the government, BC Chamber of Commerce, and business leaders to identify new ways to increase employment opportunities for people with disabilities and to reduce stigma around disabilities in the workplace.

Gender balance in the clean economy workforce is another very important consideration. Of the workers currently employed in the five clean economy sectors, there is a clear imbalance in the proportion of men and women employed. With the exception of the Materials Management and Waste-to-Resource sector, the workers in the top clean economy occupations in the sectors are 80% or greater men and 20% or fewer women. Table 73 below shows the median annual salary, gender split, and employment by age group in the five clean economy sectors.

Table 73: Socio-economic profile of BC's clean economy sectors

Sector	Remuneration	Employment by gender (%)		Employment by age group (%)			
	Median Annual Salary	Men	Women	15-24	25-44	45-64	65+
Clean Power Supply & Storage	$72,411	80%	20%	7%	52%	37%	3%
Green Building & Resilient Infrastructure	$55,390	88%	12%	9%	43%	43%	5%
Clean Transportation	$65,288	89%	11%	6%	45%	45%	5%
Materials Management & Waste-to-Resource	$46,415	60%	40%	14%	39%	42%	5%
Industrial Energy & Process Efficiency	$62,006	82%	18%	9%	45%	40%	6%

Source: Delphi's estimate from BC Labour Market Outlook (2018-2028) wage data by occupation

Affordability has been identified as a significant issue that will impact workers in entry level and lower paid positions. Women, youth, and people in rural communities are over-represented in entry level and lower paid roles and are more vulnerable to the impacts of higher housing and living costs. Although affordability and poverty reduction are complex issues that require a large system response, it becomes relevant when connecting clean economy workforce strategies to people who face affordability challenges. It goes without saying that income is directly related to poverty, and that one effective way to address affordability within CleanBC would be to focus on workforce pathways into living wage jobs, *especially* for people that are struggling with affordability.

"As CleanBC moves forward, there is an opportunity to increase participation by women, Indigenous peoples, and other historically under-represented groups."

-Sub-committee feedback

Women, youth, and people who live in rural and remote communities are under-represented in most of the industries important to the clean economy, and this trend could easily continue in the future if action is not taken. In the transition from carbon-intensive and polluting economies to the clean economy, there is a unique opportunity to include the marginalized groups and benefit from the unique knowledge and skills they bring.

"…women are…workers and producers and the potential of their participation in a green labour force should not be underestimated. Currently at least 80 percent of global green jobs are expected to be in the secondary sectors, such as construction, manufacturing and energy production — industries where women are currently under-represented. For example, women account for 9 percent of the workforce in construction, 12 percent in engineering, 15 percent in financial and business services, and 24 percent in manufacturing — all sectors critical to building a green economy."[320]

- Lakshmi Puri, former Deputy Executive Director of UN Women

Specifically, analysis on available labour market information reveals some key insights about women's participation in occupations and industries in the clean economy. Women's participation in the key occupations identified in the five clean economy sectors ranges from less than 1% to 45%, with the exception of one occupation (Interior designers and decorators) at 78%. Of the 23 identified key occupations, 14 jobs have very low (less than 20%) women participation. When focused on salaries, it is important to note that many of the higher paying positions ($65K and over) employ relatively lower numbers of women (see Figure 31). This indicates that women are being concentrated within lower paying jobs within the clean economy sectors.

In analyzing training and education attainment data, it is evident that women are on average a low percentage of trainees across the training spectrum. Apprenticeships, trade certificates, and diplomas consistently demonstrate a low rate of women participation.

High living costs and affordability is an issue that was repeatedly raised during engagement, and this issue tends to disproportionately impact women, youth, and other disadvantaged groups living on lower incomes. Affordable housing may be located farther from urban centres, compounding transportation issues, and cost of training is a barrier for some.[321]

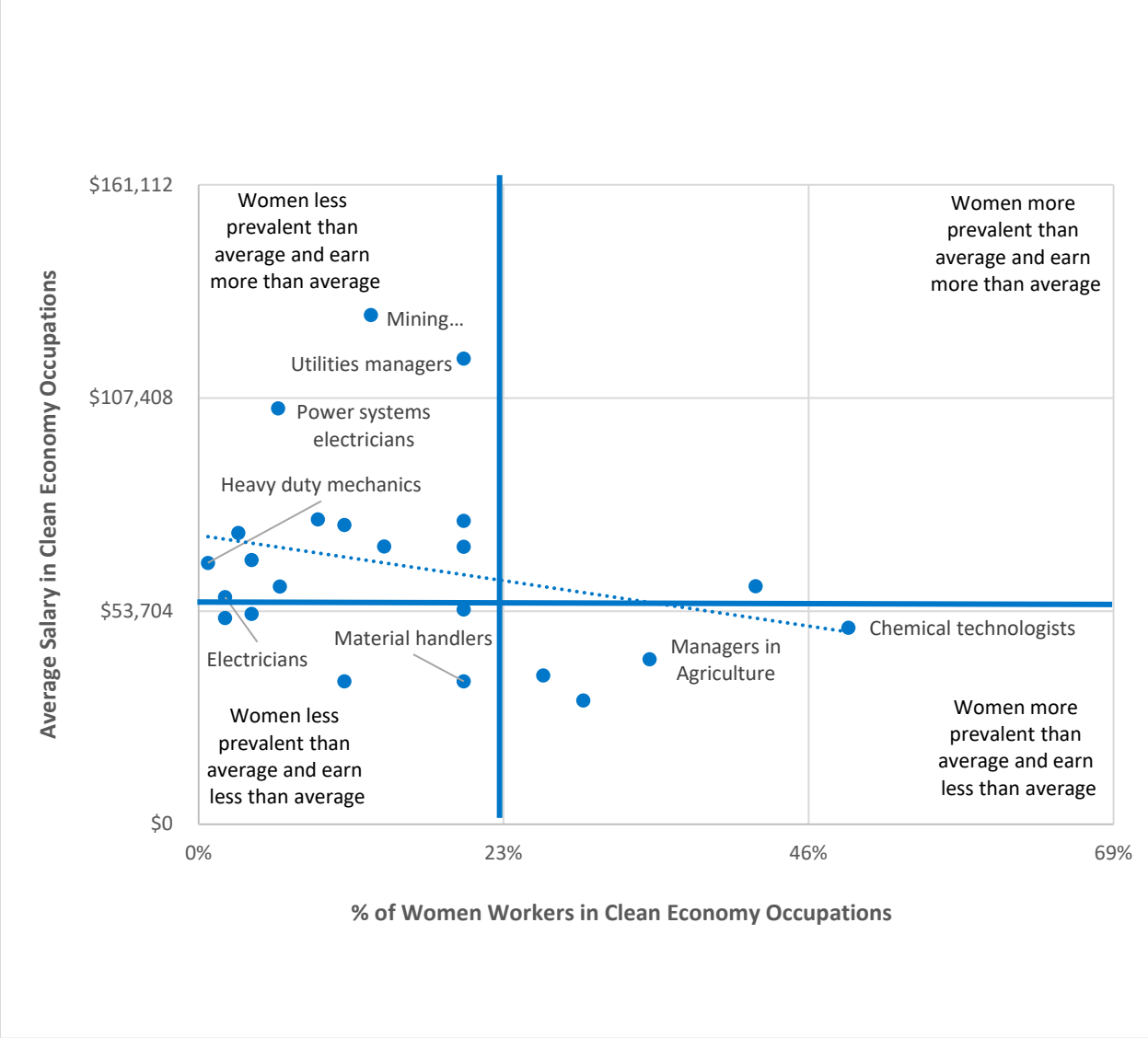
Other feedback received during engagement activities highlighted how pervasive bullying, harassment, and gender bias impacts women's ability to enter and stay employed in the trades. While B.C. is home to leading initiatives and organizations such as the BC Centre for Women in the Trades, it is evident that there needs to be a concerted effort to ensure that the transition to a clean economy does not simply carry over the exclusive cultures and conditions in many traditional industries.[322][323]

[320] 'Fast Forwarding Women's Leadership in the Green Economy; *UN Women's Deputy Executive Director Lakshmi Puri; June 19, 2012;* https://www.unwomen.org/en/news/stories/2012/6/fast-forwarding-women-s-leadership-in-the-green-economy

[321] Negotiating the Barriers to Employment for Vulnerable Youth in British Columbia; pgs 13 & 35; Cariboo and Williams Lake Focus Group meeting notes

[322] See: https://bccwitt-wevotebc.nationbuilder.com/what_we_do

[323] See: https://www.uottawa.ca/environment/blog/gender-and-clean-economy-moving-beyond-just-add-women-and-stir



Source: Scale Collaborative and Delphi Group based on Statistics Canada

Figure 31: Average salaries and participation by women in select key clean economy occupations

Table 74 below highlights the occupations in the clean economy with the highest and lowest proportions of women participation.

Table 74: Clean economy occupations with the highest and lowest participation by women

Occupation		Percent Women	Total Workers
Highest percentage women	5242 Interior designers and interior decorators	77.5%	4,185
	9523 Electronics assemblers, fabricators, inspectors and testers	49.6%	1,390
	2211 Chemical technologists and technicians	49.1%	2,260
	0822 Managers in horticulture	48.2%	1,130
	5241 Graphic designers and illustrators	48.1%	11,055
	8252 Agricultural service contractors, farm supervisors and specialized livestock workers	44.4%	1,240
	2153 Urban and land use planners	44.1%	1,850
	0621 Retail and wholesale trade managers	41.8%	58,155
	0821 Managers in agriculture	34.5%	11,970
	2225 Landscape and horticulture technicians and specialists	34.0%	3,790
Lowest percentage women	7291 Roofers and shinglers	2.3%	3,435
	7321 Automotive service technicians, truck and bus mechanics and mechanical repairers	2.3%	18,180
	7313 Heating, refrigeration and air conditioning mechanics	2.1%	2,670
	7271 Carpenters	2.1%	28,160
	8421 Chain saw and skidder operators	2.0%	2,525
	7251 Plumbers	1.8%	8,955
	8241 Logging machinery operators	1.8%	3,540
	7244 Electrical power line and cable workers	1.5%	1,330
	7311 Construction millwrights and industrial mechanics	1.2%	8,305
	7312 Heavy-duty equipment mechanics	0.7%	5,540

Source: Based on data from Statistics Canada 2016 Census

Relatively low representation of youth in the clean economy can be expected, as many professional roles require training and time to advance within, and youth are often at the start of their careers. The positions that demonstrate higher percentages of youth participation, such as material handlers, indicate important entry points and pathways into identified jobs and sectors. It is important to note that the age data was not segregated by gender nor ethnicity. However, by identifying these key entry point positions, it now becomes possible to ensure that these entry points are accessible to diverse youth.

Transportation is an oft-cited barrier for young people, in rural and remote areas especially.[324] Infrequent public transportation and/or cost of vehicle ownership, operations, and maintenance have a real impact on the ability to get to work on time, stay late as needed, or accommodate varying shifts.[325] The link between not having access to the right training, having little to no on-the-job experience and having few jobs related to that training is an

[324] Cranbrook, Nanaimo, Williams Lake, Thompson Okanagan Indigenous-focused Session notes
[325] Negotiating the Barriers to Employment for Vulnerable Youth in British Columbia; pg 15

overlapping combination of issues that impacts youth. The start-up cost to employment can also be a deterrent, including uniforms, equipment / tools, and initial pay delay.[326]

The knowledge of 'how to work' can be taken for granted, as there are a number of skills required to be successful in the workplace: communication, time management, initiative and motivation, problem solving, anger and frustration management, and knowledge of employment rights and responsibilities. A number of participants at Indigenous-focused sessions spoke to the need for 'soft skills' development (referred to throughout this report as cross-functional skills), and this need is similar for young people.

Trades and construction is a key employer of people with disabilities. *"Among men, 16% of those with a mild or moderate disability were in the industrial, construction or equipment operation trades - a proportion similar to those without a disability… In each group, transportation and construction workers and labourers also made up about 10% of the workforce."*[327] These statistics hold true regardless of the severity of the disability.

When gender is applied, significant differences become evident. Women with disabilities are not registering as participating in the sector in any statistically measurable way. These stats seem to demonstrate that the trades and construction sector incorporates workplace accommodations to meet the needs of disabled workers, yet women with disabilities face the same barriers experienced by women in trades.

The data highlights several gaps in the current systems of training and employment:

- **Safe working environments**: one of the biggest barriers to employing women of all ages is an environment where personal harassment, sexual harassment, and bullying are not only tolerated but, in many cases, encouraged.[328]
- **Discriminatory recruitment, hiring, and advancement practices**: bias and the tendency to hire familiar demographics leads to discriminatory practices and stops the unfamiliar with getting opportunities. This bias can prevent women from getting their foot in the door or obtaining the necessary skills and tools to advance.[329]
- **Income, wage gap, and affordability**: women and youth are often in the low paying jobs and have great difficulty in being able to meet living expenses, especially if they have dependents.
- **Training experiences, especially apprenticeships**: the apprenticeship period can be a painful period of training for women, and most women who leave the trades do so during this period.[330]
- **Lack of role models, mentors, and networks**: under-represented groups do not have the benefit of others to help them forge their way.

Throughout the data and analysis, there is mention of the need to transition culture away from polluting or carbon-intensive economies, and towards knowledge, skills, and progressive cultures related to the clean economy. This overarching cultural transition provides an opportunity to also shift current training and workplace processes and cultures that may exclude certain groups.

[326] Negotiating the Barriers to Employment for Vulnerable Youth in British Columbia; pg 24; Youth Jobs Better Future- Youth skilled trades employment strategy; pg 12
[327] Ibid, page 5
[328] Enhancing the Retention and Advancement of Women in Trades in British Columbia: Final Report
[329] Women in the Workforce- Canada: Quick Take; May 28, 2019; https://www.catalyst.org/research/women-in-the-workforce-canada/
[330] Enhancing the Retention and Advancement of Women in Trades in British Columbia: Final Report

<table>
<tr><td>Early experiences</td><td colspan="2">More likely to be first in family</td><td colspan="2">Less awareness / exposure to career choices in trades</td></tr>
<tr><td>Pre-apprenticeship</td><td>Relatively less prior exposure in construction</td><td colspan="2">Relatively less prior knowledge/skills</td><td>Relatively less access to networks in construction</td></tr>
<tr><td rowspan="3">Apprenticeship</td><td>Gender biases in recruiting</td><td colspan="2">Difficulty remaining steadily employed</td><td>Inflexible workplace policies/practices</td></tr>
<tr><td>Difficulty finding sponsors</td><td colspan="2">Workplace exclusion, harassment, discrimination</td><td rowspan="2">Early departure from apprenticeship programs</td></tr>
<tr><td>Ongoing lack of access to networks, mentoring</td><td colspan="2">Health and safety concerns</td></tr>
<tr><td rowspan="2">Journey</td><td colspan="2">Ongoing exclusion, harassment, discrimination</td><td colspan="2">Ongoing gender biases affecting advancement</td><td rowspan="2">Departure from trade</td></tr>
<tr><td colspan="2">Ongoing lack of access to networks, mentoring</td><td colspan="2">Ongoing health and safety concerns</td></tr>
</table>

Source: Social Research and Demonstration Corporation[331]

Figure 32: Experience of women throughout the trades journey

Based on the learning from other sectors such as humanitarian, social, education, sport, police, military, and faith, a systems approach to transition will allow the clean economy to not only adjust to cultural changes but to also develop a new way of working.

A clean economy systems approach will:

- Help overcome a fragmented approach which results in a homogeneous workforce rather than one that represents the diversity of BC.
- Build safe working environments so a diverse workforce can be productive and enjoy their work experience.
- Build capacity through inclusive training and employment practices.
- Build individual, business, and community capacity and sustainability while monitoring and holding the training institutions, employers, and governments accountable.
- Build on strengths and explore new ways of doing, while learning and evolving into inclusive safe training and working environments.
- Utilize a whole-systems approach that identifies and leverages opportunities to advance change.

There is a clear opportunity for industry, education and training providers, government, and other relevant institutions to utilize this transition to address systemic barriers that exist for women and other under-represented groups by leaving old and discriminatory workplace cultures behind.

[331] Enhancing the Retention and Advancement of Women in Trades in BC- Final Report; February 2017. See: http://www.srdc.org/media/199982/bc-women-in-trades-final-report-february-2017.pdf

4.1.2 INDIGENOUS PARTICIPATION IN THE CLEAN ECONOMY

Note: Parts of the following section are excerpts from a report on the Indigenous engagement for the BC Clean Economy Workforce Readiness Project, undertaken by Indigenuity Consulting. The full report can be found in Appendix G.

In a series of community workshops that were a part of this research, participants highlighted the important role of traditional Indigenous knowledge and values, as well as stewardship activities, into the CleanBC programs and this Clean Economy Workforce Readiness Project. Participants stressed that more information about CleanBC and opportunities associated with CleanBC initiatives needs to be shared with communities and said that government and industry need to work directly with communities to provide education on the emerging clean economy.

Several participants said that some of the CleanBC initiatives did not really apply to their community and suggested that it would be helpful to incorporate an Indigenous lens into the programs so that the initiatives were more relevant to their communities. Participants also discussed the importance of incorporating traditional Indigenous knowledge and values, as well as stewardship activities, into the CleanBC programs and Workforce Readiness Plan.

While a majority of participants were clear that there is an interest in pursuing economic, employment, and training opportunities related to a clean economy, they said that systemic barriers – such as socioeconomic issues and issues related to literacy and life skills – need to be addressed before Indigenous people can fully take advantage of those opportunities.

A number of participants also talked about the need to provide 'wraparound' support for many Indigenous students and said that funding for training programs need to be more flexible and more encouraging of partnerships between and among industry, educational institutions, and government.

Another key theme that was quite consistently raised in all of the sessions was that opportunities will be most successful if they are locally based. A key goal should be to train people locally for opportunities that are available locally, so that ultimately people can live with their families in their own communities. The related issue of transportation, and the fact that many people do not have driver's licenses and lack access to vehicles, was also raised in virtually every session.

Overall, participants expressed an interest in continuing to provide input into the BC Clean Economy Workforce Readiness Project, and stressed that values such as respect, cultural diversity, integrity, and flexibility need to be reflected in the Plan.

Themes from Indigenous-focused Sessions

In addition to general themes related to both CleanBC and training and employment in a clean economy, the comments received by participants have been grouped into four main categories:

- **Economic Opportunities** – interests that were shared around the types of opportunities communities and organizations may be interested in pursuing in a clean economy.
- **Education** – education required around green initiatives are outlined in this category.
- **Training** – broad feedback around how training can be most successful are outlined in this theme.
- **Engagement** – comments shared about engagement both around CleanBC and development of the Workforce Readiness Plan.

A number of challenges and barriers to training and economic opportunities were raised by participants in Indigenous-focused sessions as part of this research. These ranged from lack of sufficient wraparound supports for students, to barriers around transportation, to issues regarding cultural values. These barriers and challenges raised by participants have been grouped into eight broad categories:

- **Conflict of Values** – these comments focused on the challenges created by cultural differences and how those impact both participation and success levels of Indigenous students and employees.
- **Demand for Employment** – the fact that many communities lack access to long-term, sustainable jobs was cited as a barrier to developing successful training programs.
- **Funding Restrictions** – various issues associated with funding programs (lack of coordination among funders, inability to leverage dollars, and onerous reporting requirements) were cited by many participants.
- **Knowledge** – lack of knowledge about green-related economic and employment opportunities was cited as a major barrier to accessing training and employment.
- **Inaccessibility** – the apparent bias of CleanBC programs towards solutions for urban populations (particularly those in the lower mainland) was raised by many participants as an issue that prevented them from fully utilizing opportunities.
- **Social Issues** – issues such as addictions, poverty, residential school impacts, and literacy were raised as significant barriers.
- **Transportation** – transportation, or lack thereof, was cited as a major issue at virtually every session.
- **Wraparound Supports** – limited resources for supports such as child-care, housing costs, parking, and living allowances was cited as an issue by a majority of participants.

4.2 GAPS, BARRIERS & CHALLENGES BY SECTOR

4.2.1 CLEAN POWER SUPPLY & STORAGE

Challenges within this sector were identified by the project Steering Committee, sub-committees, and key informant interviews and are centered around four key challenge areas as detailed in Table 75 below.

Table 75: Challenge areas and issues identified for BC's Clean Power Supply and Storage sector

Challenge Area	Issue	Description
Workforce Supply	High employee turnover or lack of employee retention	This challenge is particularly relevant to the Lower Mainland where the cost of living can force employees to move to more affordable regions or prevent prospective employees from choosing to relocate to Lower Mainland.
	Lack of projects resulting in 'brain drain'	Recent changes to the province's Standing Offer Program and uncertainty around near to medium-term power surplus have created conditions where small projects are difficult, and skills and expertise associated with planning and establishing new projects are being redirected outside BC.
	Rural and remote communities lack local training opportunities	Rural or remote regions are underequipped to respond to the shift in energy systems and related skillsets. Many regions are not equipped to educate and train locally in a way that supports clean energy.
Workforce Culture	Negative stigma associated with some traditional occupations in the sector	Industry has struggled to break the "greasy" stigma of certain occupations, such as heavy-duty mechanics. This applies to the clean power sector, as well as transportation and other industries. New technology can help counter the stigma and may create an incentive for young people to explore new careers in the clean economy.
Specialized Skillsets	Need for skills related to the political and regulatory environment of project development	Increasingly complex regulatory landscape is creating a need for multi-faceted skillsets in the feasibility and planning stages of projects.
	Demand for a combination of power engineering and ICT skills	There is an increasing role for IT-related roles in companies to support the growth digitization and smart technologies. Hard to find IT professionals with knowledge of the technical side.
Education and Training	Outdated curriculum at the college and university levels	Education institutions at the both the college and university level lack the agility to update curriculum content to keep

		pace with the shifts happening at the technological and industry level.
	Capacity building and lifelong learning is not common practice	As more value is put on a worker's ability to adapt and develop new capacities or areas of expertise, the concept of lifelong learning and continuing professional development will become increasingly valuable.

Capacity Issues and Training

In consultation local employment associations, SMEs and utilities from across BC, the most common gaps that were identified in this sector exist in the lack of expertise in energy project development and management, specifically around solar and wind installation (i.e. having a program to train roofers and electricians on proper solar rooftop installation).[332] The cause of this gap largely stems from the provincial focus on large hydro projects, which in turn has reduced the demand for project development skills and experience in solar and wind energy installation. The lack of expertise is also due to a challenge among local businesses in the clean power sector to attract and retain experienced professionals, such as engineers at management to senior level, who bring experience and mentorship abilities to the sector.

Related to the gap in expertise, a consistent flag was raised around the lack of co-ops and apprenticeships (primarily focus on electrical trades) offered for the incoming workforce, which is also instrumental in building local capacity and expertise. The cause for the lack of co-ops is believed to be the disproportionate number of SMEs in BC's clean power sector, many of whom lack of time, financial, and personnel resources to bring in co-op students.[333]

In speaking with businesses and industry representatives as part of this project, there was a recurring flag raised around the lack of general mentorship resources for both the current and incoming workforce. This was identified as an area to focus on as mentorship or one-on-one coaching is considered a valuable tool in building expertise locally

Industry Challenges and Barriers

Based on a survey of BC-based cleantech firms active in the Clean Power Supply and Storage sector, challenges that exist across the sector are the relatively high operational costs of doing business in BC, a shortage of engineers with practical, hands on experience, and finding technically-proficient workers that also have an understanding of business fundamentals and finance.[334]

Another prominent challenge across the Clean Power Supply and Storage sector is the uncertainty concerning policies and responsibility governing clean power. This includes efforts and initiatives that span across several levels of government and utilities, ranging from provincial fuel standards, to federal incentives, to municipal projects. As a result, there is a general lack of understanding over who is accountable for policies and decisions when it comes to clean power within the province.

[332] See: CleanBC WRP Clean Energy Sub-committee
[333] See: CleanBC WRP Clean Energy Sub-committee
[334] Canadian Cleantech Industry Consultation – Findings and Summary Report. Delphi Group. October 2016.

Electricity Generation

A challenge related to clean energy projects in BC is the gap around skills and resources for the financing of clean power projects. Although the affordability of clean energy has improved significantly in recent years, the province's current electricity generation capacity and planned new facilities (e.g., Site C) provides little incentive for investment in smaller-scale clean or renewable energy projects. The estimated average installation cost per watt of solar power in BC in 2019 is $2.52 - $2.77.[335] As such, there is a significant gap between the financial resources currently deployed to these ventures and the resources required to increase capacity and scale. Additionally, financial management and planning specific to clean energy projects is a missing skillset highlighted by the industry.[336]

In addition to having to rely heavily on high-carbon energy sources like diesel to meet their energy needs, many regions are not equipped to educate and train locally in a way that supports clean energy.

Rural or remote regions, particularly northern and Indigenous communities, have been historically underserviced and underequipped to respond to the shift in energy systems and related skillsets. In addition to having to rely heavily on high-carbon energy sources like diesel to meet their energy needs, many regions are not equipped to educate and train locally in a way that supports clean energy.

Challenges around permitting retail access for small-scale power agreements is also a challenge that more of BC's rural and remote regions in particular face. This exists within a larger context of new industries coming to BC and creating more competition around retail access to power.[337]

This being said, there have been promising developments with a number of organizations and programs working to support the growth of clean energy projects in Indigenous communities in BC in recent years.[338]

Smart Grid and Transmission Infrastructure

Successful projects are dependent on the necessary clean energy infrastructure, which is another gap that was flagged in conversations with stakeholders. Clean power, like many large industrial projects, requires specific infrastructure to support its success, current gaps within infrastructure include storage and export capacity, connectivity to the grid, and supporting facilities (e.g., lodging).

Most relevant to the focus of this study however is the gap or barrier around the lack of skilled professionals that is creating a shortage of appropriate labour. According to organizations operating in BC's Clean Power Supply and Storage sector, this is especially relevant for engineers, technicians, and technologists who specialize in electrical systems and software.

The following section provides a snapshot of the labour demand and supply, regional profile, education and career pathways as well as emerging skills and gaps for key occupations.

4.2.2 GREEN BUILDING & RESILIENT INFRASTRUCTURE

The challenges within the Green Building and Resilient Infrastructure sector are centered around four key challenge areas, as described in Table 76 below.

[335] See: https://energyhub.org/cost-solar-power-canada/
[336] See: Clean BC WRP Regional Stakeholder Workshop – Kootenay Region
[337] See: Clean BC WRP Regional Stakeholder Workshop – Kootenay Region
[338] See: http://www.newrelationshiptrust.ca/wp-content/uploads/2018/02/GUI-BCICEI-Intake2-Alternatives-and-ResourcesPDF.pdf

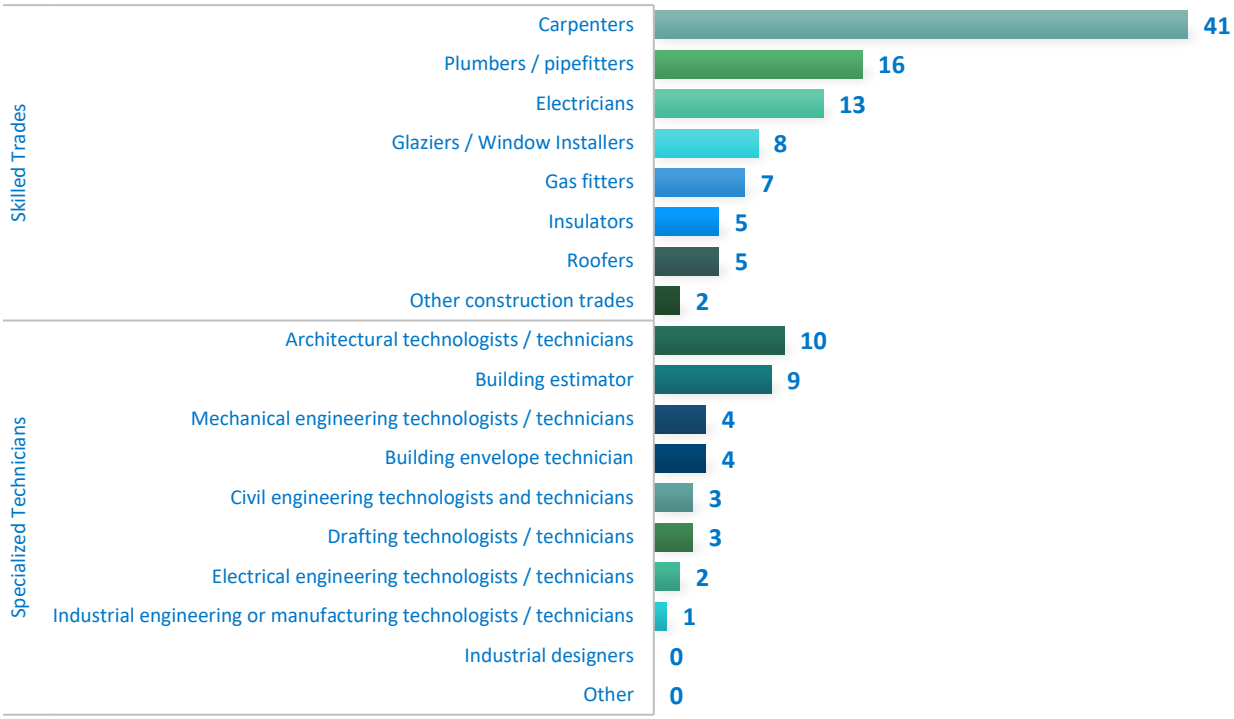
Table 76: Challenge areas and issues identified for BC's Green Building and Resilient Infrastructure sector

Challenge Area	Issue	Description
Specialized Skillsets	Lack of trades with the knowledge and expertise on the quality installation of heat pumps	At present, there is less of a demand for heat pump installations due to the cheaper cost of natural gas. As the province looks to ramp up electrically-heated and cooled homes and buildings in the province, a risk exists in terms of a shortage of qualified and available heat pump installers.
	Shortage of qualified energy advisors, building officials / inspectors, and high-performance building commissioners in certain regions	Evolving high-performance construction best practices along the pathway to net-zero energy ready buildings requires that building professionals, including building energy advisors (BEAs), inspectors, commissioning agents, and other building officials be trained up with best practice approaches and emerging technologies. In addition, the BC Energy Step Code requires BEAs as a first step to reaching compliance for new residential construction projects. at present, some gaps exist in certain regions of the province. Furthermore most of the building code compliance services currently being provided by BEAs is outside the scope of the EnerGuide license, training, and quality assurance program, creating a potential training and professional reliance gap between the BEA qualifications and the training / experience required for professionals providing BC Energy Step Code compliance services.
Workforce Supply	High employee turnover or lack of employee retention	This challenge is particularly relevant to the Lower Mainland and Southern Vancouver Island where the cost of living can force employees to move to more affordable regions or prevent prospective employees from choosing to relocate to Lower Mainland.
Education and Training	Outdated curriculum at the college and university levels	Education institutions at the both the college and university level lack the agility to update curriculum content to keep pace with the shifts happening at the technological and industry level.
	Lack of regulation and requirements for training or certification for trades	Many small to medium companies and their employees do not voluntarily undertake training or additional education because they cannot afford the lost wages and there is no regulatory requirement.
	Limited capacity for mentorship/training	Many builders and smaller contracting businesses in BC struggle to hire trainees or apprentices and provide appropriate mentorship or training.
Workforce Culture	Lack of quality installation with an eye for detail	Under supply of workers and increased demand for services has created a culture of tight timelines and rushed projects.
	Lack of collaboration across the design and construction phase	It is uncommon for those in the design and engineering phases of a project to communicate with the contractors and trades. As buildings become increasingly complex there will be a need for more communication across all phases of a project.

Capacity Issues & Training Gaps

In consulting with business, industries and post secondary institutions through one-on-one interviews and in person workshops, the most prominent gaps in workforce supply exist around lack of minimum training requirements for many trades, which impacts on the demand for apprenticeships and work-integrated learning opportunities for occupations including carpenters, insulators, and glaziers.[339] These occupations have been flagged as those that will face both increased demand due to energy efficient building code upgrades while also facing a supply shortage due to demographic shifts (i.e. retiring workforce).

According to a 2019 survey of business owners active in BC's renovation sector, the top five skilled trades where shortages have been felt over the past five years include carpenters, plumbers / pipefitters, electricians, glaziers and gas (see Figure 35).



Source: The Delphi Group (BC Retrofit Industry Survey, 2019)

Figure 33: Number of businesses reporting a shortage in supply of skilled trades (n=47)

Building Engineering, Design and Operations

In consulting with industry and business leaders as part of the LMI research, the challenges within this sub-sector are centered around lack of climate literacy and understanding of the "building-as-a-system" approach; this applies to many, if not all, of the sector's key occupations. The added level of complexity inherent in the design and

[339] See: Home Performance Stakeholder Council. Working Roadmap 2018.

construction of energy efficient buildings, from the building envelope to the mechanical systems, demands more holistic knowledge and foresight at the design stage.

These additional considerations also require greater responsibility and guidance from energy advisors and energy modellers who work with building officials (including inspectors and commissioners), architects, engineers, and trades people.

However, BC is not currently training or certifying enough energy advisors to meet the projected demand.[340] By 2025, for example, it has been estimated that more than 200 existing home energy advisors will be needed in BC – up from a total of 35 today.[341] In addition, a training gap has been identified between what is currently available to building energy advisors and energy modellers and what is needed to ensure the professional competency of the industry and the consistency and accuracy of BC Energy Step Code compliance services given that the majority of code compliance services fall outside of the scope of EnerGuide licensing agreements.[342]

There is a need to develop a core competencies framework outlining the knowledge and learning needs of the industry, develop specific training and professional development to address these needs, and regulate the standards of training and work experience required to deliver code compliance service.[343] Addressing these gaps will provide owners with valuable resources and lines of communication during the construction or renovation of homes and buildings in BC and ensure energy efficiency / net-zero energy goals for construction can be met.

Construction and Renovation

The most prominent barriers and challenges for the Green Building and Resilient Infrastructure sector exist within the construction and renovation sub-sector. Historical issues exist around compulsory training and certification in addition to access to continuous education funding and resources for employees and employers in the trades.[344] While the latter affects the supply of qualified skilled trades, there are also challenges around the demand for skilled trades, particularly when it comes to residential retrofits.[345] This is in part because homeowners are focused on aesthetic upgrades and have little information or awareness to distinguish between a qualified professional and low-quality contractor. Among other factors, this reality is influenced by the absence of compulsory training or requirements in BC for trades.[346]

Many of the challenges and gaps around skilled trades in the Green Building and Resilient Infrastructure sector are not unique to BC. The Canadian Green Building Council (CaGBC) recently released a report that highlights a gap in both technical and soft skills that will be critical to address the transition to low-carbon buildings and signals a need to support the skills transition for trades working across the built environment.[347]

The CaGBC report identified both technical and soft skillsets that will impact the success of the sector, many of which resonate in BC (see Table 77). The gaps outlined below were also echoed in a survey of BC builders and renovators.[348]

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[340] See: Home Performance Stakeholder Council Energy Advisor and Service Organization Sector Working Roadmap. February 2018.
[341] Ibid.
[342] City Green Solutions (March 2019). Energy Advisor and Energy Modeller Scope of Practice Report.
[343] Ibid.
[344] See: http://globe.ca/wp-content/uploads/2014/06/GLOBE_BC-Residential-Construction-Training-Consultation-Final-Report-FI....pdf
[345] See: http://homeperformance.ca/wp-content/uploads/2018/05/201803_HPSC_Roadmap_FINAL.pdf
[346] Ibid.
[347] See: https://www.cagbc.org/cagbcdocs/advocacy/CaGBC_Trading_Up_Skills_Analysis_Report_2019.pdf
[348] BC Retrofit Survey. Delphi Group. 2019.

Table 77: Identified capacity issues and technical skills gaps

Skills Gap	Occupation	Part 3 vs. Part 9	New vs. Existing
Airtightness and air barriers	• Home building and renovation managers • Insulators • Engineers • Building Envelope Consultants	Part 3 and Part 9	New and existing
Heat pump installation	• Refrigeration and air conditioning mechanics • Contractors and supervisors, other construction trades, installers, repairers and servicers	Part 3 and Part 9	Existing
Mechanical, electrical and automation systems	• Electricians • Residential and commercial installers and servicers • HVAC trades	Part 3	Existing
Insulation	• Insulators	Part 3 and Part 9	New and Existing
High performance building commissioning	• Building commissioners	Part 3	Existing
Integrated project delivery (systems-based building approach)	• General	Part 3 and Part 9	New and existing

Source: The Delphi Group

In addition to the gap in supply of skilled trades faced by many BC contractors and installers, there is also a looming gap in the supply of those skilled to install heat pumps relative to the demand that is anticipated through targets in CleanBC. Currently, contractors who install and service heat pumps are barely able to keep pace with demand and struggle with finding workers who are adequately trained. Based on the current heat pump targets set by CleanBC, there is likely insufficient numbers of heat pump professionals, from wholesalers, salespeople, installers and service technicians, to meet these targets.

Residential building energy advisors (BEAs) are another important job that will be in demand due to the Energy Step Code adoption, with an identified gap of approximately 55-65 workers. In addition, a potential shortage of BEAs available to service the existing home / renovation market has also been identified by the Home Performance Stakeholder Council should broader residential energy efficiency retrofit activities and rebate programs become a growing priority under CleanBC.

4.2.3 CLEAN TRANSPORTATION

The challenges within this sub-sector are centered around four key challenge areas as detailed in Table 78 below.

Table 78: Challenge areas and issues identified for BC's Clean Transportation sector

Challenge Area	Issue	Description
Workforce Supply	High employee turnover or lack of employee retention	This challenge is particularly relevant to the Lower Mainland where the cost of living can force employees to move to more affordable regions or prevent prospective employees from choosing to relocate to Lower Mainland.
	Competition for resources from other industries	Competition for resources within the broader transportation sector (e.g., trucking and rail) and from other industries makes it challenging to find workers.
Workforce Culture	Negative stigma associated with some traditional occupations in the sector	Industry has struggled to break the "greasy" stigma of certain occupations, such as heavy-duty mechanics. This applies to the Clean Transportation sector, as well as power supply and other industries. New technology can help counter the stigma and may create an incentive for young people to explore new careers in the clean economy.
Specialized Skillsets	Need for specialized skills related to EVs	New advances in technology means the whole skillset of maintenance crews is going to change. This is a significant transition happening soon.
	Demand for a combination of transportation and ICT	There is an increasing role for IT-related roles in transportation companies to support the growth of app-enabled integrated mobility solutions. Hard to find IT professionals with knowledge of transportation.
Education and Training	Outdated curriculum at the college and university levels	Education institutions at the both the college and university level lack the agility to update curriculum content to keep pace with the shifts happening at the technological and industry level.
	Capacity building and lifelong learning is not common practice	As more value is put on a worker's ability to adapt and develop new capacities or areas of expertise, the concept of lifelong learning and continuing professional development will become increasingly valuable.

Discussions with key informants in BC's Clean Transportation sector suggest that many of the challenges identified for the sector over the last decade are even more pronounced today. These challenges include:

- A shortage of qualified engineers and technicians across the whole Clean Transportation sector and visa delays limiting the ability to source talent from outside of Canada. A lack of experience in the design, manufacturing, and maintenance of vehicles and infrastructure is a barrier to growth for the sector.

- A shortage of heavy-duty mechanics, railroad engineers, and maintenance workers creates a barrier to expansion, particularly in remote regions of BC.
- A lack of well-established clean transportation-related technology clusters in BC being a barrier to the growth of BC companies. This limits the ability of companies to seize global market opportunities in sub-sectors like rail and marine technology. Limited adoption of new technologies among fleet operators and major service providers in BC means local companies are also faced with the challenge of trying to sell to the global marketplace without examples of domestic projects to showcase.
- Specialized trades working across municipal boundaries require separate permits and administration for each locale (e.g., to install EV charging infrastructure), creating challenges for workforce mobility.
- High costs and increased risk are associated with many clean transportation technologies and related infrastructure. Companies are working to increase efficiency and reliability of these technologies while reducing the costs, but this is a barrier to more people being employed in the sector.

While BC has many programs across post-secondary institutions relevant to the Clean Transportation sector, they require updating to keep pace with rapidly emerging and evolving technology (e.g., EVs, low-carbon fuels, first mile/last mile, and active transit planning). This includes giving students access to the newest technologies related to ZEVs and charging / fueling infrastructure, which is currently limited across BC. Another prominent gap related to the servicing of EVs in BC, is the lack of certification required of independent technicians working on EVs in the province.[349] This type of gap can create discrepancies in service standards and best practices as more EVs flow onto streets and highways.

While BCIT's EV Maintenance Training Program (based on the ITA's Automotive Service Technician program) offers training on electric and hybrid vehicles, retraining of automotive service technicians will be required, as well as training for commercial ZEV operators, and that training will need to be accessible for those outside of the Lower Mainland region.

4.2.4 MATERIALS MANAGEMENT & WASTE-TO-RESOURCE

In consulting with key informants in BC's Materials Management and Waste-to-Resource sector, there is a need for workers with multi-disciplinary skillsets with an emphasis on the ability to understand and operate digital / automated systems. At the management level, there will be a growing need for proficiency in the operation and management of digitalized systems, coupled with the ability to transfer data and analysis from a digital lens to an industry-specific lens to effectively inform policy and organizational goals.

Discussions with key informants in BC's Materials Management and Waste-to-Resource sector identified issues in several areas, described in Table 79 below.

Table 79: Challenge areas and issues identified for BC's Materials Management and Waste-to-Resource sector

Challenge Areas	Issue	Description
Specialized Skillsets	Limited access to workers with skillsets in policy	There is a lack of workers with skillsets in policy analysis and government relations who also understand business operations and challenges specific to this sector. This also includes the ability to

[349] See: BC Clean Economy WRP Project – Regional Workshop

	analysis and government relations	communicate between government and industry to clearly identify policy goals, desired impacts and how industry can best respond.
	Need to establish awareness and understanding of circular economy systems and best practices	From entry-level trades positions up to senior-level management positions, there will be a need to update skills training to meet the needs of new technologies and practices, such as carbon capture, industrial symbiosis, and closed-loop waste management systems. This knowledge is further strengthened by a worker's ability to communicate across technical and policy realms.
	Lack of skillsets in design and management of digitalized / automated systems	More employers are seeking out workers who are proficient in the management and operation of digitalized systems in industrial operations. This also extends in the design of new or updated automated systems as industry shifts towards technologies specific to the fourth industrial revolution (e.g., blockchain, AI, and software as a service).
	Lack of workers trained in reverse logistics, remanufacturing, repair and reuse	An integral piece of zero waste strategies is the ability to apply 'reverse logistics' thinking, as well as adopt remanufacturing, repair, and reuse business practices and related skillsets, which support expanded recycling, waste reduction, and extend product life cycles.
Industry Classification	Lack of industry classifications adequately representing the sector	Of the waste-related codes that currently shape the classification of the industry, only four are specific to recycling. However, as recycling becomes more complex and part of more multifaceted loop of materials, the lack of a relevant industry classification system is a major challenge and barrier to better differentiating sector development, increasing tax incentives, and enabling other funding mechanisms.[350]
Workforce Supply	Lack of guidance or strategy to oversee effective change management in traditional industries and adopting a 'systems' approach	One of the biggest challenges facing workforce supply in this sector is a change management piece that will be critical in adapting and retraining a diverse workforce that has operated in traditional industries.
	Lack of capacity and infrastructure in more rural and remote areas	Challenges exist for more rural communities as it relates to recycling and organics collection, processing, and related infrastructure given population density and dynamics. A barrier to more jobs in waste recovery/recycling is a lack of public infrastructure funding to establish and operate depots in communities.

Key considerations identified as gaps and opportunities by the sub-committee for this sector include:

- A need for specialized training (e.g., Industrial Symbiosis) across the province.
- A need across industry for workers who can interpret new policies, what they mean for companies, and how companies should navigate and respond.

[350] See: https://resource-recycling.com/recycling/2016/10/18/notes-from-the-nrc-a-mature-recycling-industry-needs-naics-codes/

- A need for skills related to logistics in the bioeconomy, design for safe operations (e.g., drone surveying vs. scaffolding), as well as disassembly and reuse (e.g., portable generators with batteries and how to manage batteries at the end of their lifespan).
- In addition, as materials management and recycling systems become more widespread and complex, there is a need for skillsets in health, safety, and compliance, especially in rural and remote areas.

A significant challenge facing workforce supply in this sector is a change management piece that will be critical in adapting and retraining a diverse workforce that has operated in traditional industries. From entry-level trades positions up to senior-level management positions, there will be a need to update skills training to reflect the shift toward industrial symbiosis and closed-loop waste management systems that reflect the larger global shift to circular economies.

The cross-sector challenge that was consistently flagged by stakeholders is the need for workers who are able to communicate across technical and policy disciplines. Employers flagged the difficulty they face in finding candidates who have both experience using digital systems coupled with knowledge of the industry's systems, challenges and broader industry objectives. In addition to this gap, another key historical challenge that could be addressed as CleanBC moves forward is the lack of women, Indigenous people, and other under-represented groups in the workforce.

Change management was identified as key piece for companies to address the shift to more digitalized and holistic operations and successfully transition workers from traditional operations to low-carbon, circular economy systems. More specifically, industry stakeholders flagged that effective change management strategies will require integrating a level of knowledge and understanding in personnel at management and operations levels on technological system upgrades, the value behind them, and being able to analyze and communicate the data being collected. Within the broader effort of updating the industry's knowledge base, there will also be a need to establish a common understanding of circular economy principles and the corresponding systems shift.

A key barrier identified in the research is the disconnect between industry and government on interpreting and responding to policy. This includes a lack of workers with skillsets in policy analysis and government relations who also understand business operations and challenges. This also includes the ability to communicate between government and industry to clearly identify policy goals, desired impacts and how industry can best respond.

Waste, Recycling, and Organics Management

Currently there is a gap in workers trained in repair and reuse, as well as those with experience in design and systems change. There is also a need for more chemical and civil engineers who can apply their fundamental skillsets to the concept of a circular economy, and specifically to organics and compost management activities.

One point that was highlighted in regional stakeholder workshops is that jobs associated with recycling are often considered entry-level. Industry stakeholders emphasized that these positions often require at least 6 months of training to develop an understanding of customer service, public education, local bylaws, and evolving provincial regulation related to Extended Producer Responsibility programs.

Another prominent challenge that is not unique to BC is the lack of NAICS codes related to recycling.[351] Of the waste-related codes that currently shape the classification of the industry, only four are specific to recycling. However, as recycling becomes more complex and part of more multifaceted loop of materials, the lack of a

[351] See: https://resource-recycling.com/recycling/2016/10/18/notes-from-the-nrc-a-mature-recycling-industry-needs-naics-codes/

relevant industry classification system is a major challenge and barrier to better differentiating sector development, increasing tax incentives, and enabling other funding mechanisms.[352]

4.2.5 INDUSTRIAL ENERGY & PROCESS EFFICIENCY

As British Columbia moves towards cleaner industrial operations, sectors such as oil and gas production, forest products, cement production, chemicals manufacturing, and mining will need to attract the talent necessary to make innovations in energy efficiency and GHG emission reductions. Based on secondary research and consultation with sector experts, the following barriers and gaps were identified across the sector.

Table 80: Challenge areas and issues identified for BC's Industrial Energy & Process Efficiency sector

Challenge Areas	Issue	Description
Education and Training	Location of education and training institutions and other facilities is a major barrier	Advancements in technology may require specialized education which may only be offered at specific institutions where access is limited to the larger population. Financial and geographical barriers present an upfront challenge to potential talent to enter jobs that contribute to the clean economy. When considering university training, most of the population does not live near a university or college which can be a barrier to access, both geographically and financial, for those who live in remote and rural regions. This type of barrier should be considered when developing programs to provide training in specialized skills.
Workforce Supply	Market mechanisms and competition for talent may limit the workforce for BC's clean industry goals	During times of economic downturn, skillsets for the clean economy are transferable where talent can easily leave and transition into a new role. Organizations like Amazon and Microsoft are looking for workers with a technology-based skill set and will compete for the talent pool needed for the cleantech sector to drive the clean economy.

[352] See: https://resource-recycling.com/recycling/2016/10/18/notes-from-the-nrc-a-mature-recycling-industry-needs-naics-codes/

		In boom and bust economies, like those that exist in traditional sectors (e.g., forestry, oil and gas), employers are likely to prioritize recruitment and are less likely to consider training and education for their employees. This can be a barrier to re-training or upskilling the current workforce in traditional industries.[353]
	High cost of living limits worker mobility	These challenges are especially present in the Lower Mainland and Vancouver Island where organizations are currently challenged to attract and retain talent. Affordability is a prohibiting factor for those wanting to move or live in Vancouver for work where work experience and compensation cannot support living expenses. Another challenge that is faced by those who live outside of city centers, specifically regions who depend on agriculture industries, is the shift from labour intensive operations to mechanized operations to automation. This shift has resulted in narrowed skillsets, lower paying jobs, which can limit employees' ability to afford both housing and a car in regions that are considered affordable relative to city centres in the Lower Mainland and Vancouver Island.[354]
Policy Barriers	Policy barriers in resource sectors preventing job creation opportunities	For the forest sector, a major challenge for local industries is the significant cost associated with burning wood waste because policy restricts third parties from sourcing the waste to create value-added waste streams.[355]
Workforce Culture	Lack of awareness of clean economy opportunities in traditional resource sectors	There is a gap in the awareness on the localized clean economy opportunities and benefits that exist across farming, ranching and forestry.

[353] See: CleanBC WRP Northeast Regional Stakeholder Workshop
[354] See: CleanBC WRP Fraser Valley Regional Stakeholder Workshop
[355] See: CleanBC WRP Northeast Regional Stakeholder Workshop

		It will be important to build more awareness with local business in these industries in rural and remote regions to foster uptake of the training and education around energy efficient operations.[356]

Capacity and Training Gaps

In conversations with provincial government staff, other identified training gaps exist in virtual reality systems to train on modern forestry equipment, remote sensing skills to operate drones and interpret LiDAR data, and researchers and scientists to support the continued growth of the Bioeconomy.[357] Feedback from consultation with industry groups, local businesses, and education institutions also identified the persisting gap in curriculum and industry training around systems thinking and design, carbon accounting, and supply chain logistics management. The reasons for these gaps are not unique to this sector; the education system and pace of industry differ where a multi-year time-lag exists in some instances (i.e. for every four-year degree program for example, it takes two years to modify the curriculum).

Training gaps in this sector also exist largely because of both time and money constraints. Again, while not unique to this sector, companies struggle with making time and money available to invest in new and existing employees to develop the skillsets required to adjust to changing roles and technology. Barriers to training also exist internally where workers may not have the resources to take time off and pay for the training required to adapt to a changing workspace.

[356] See: CleanBC WRP Fraser Valley Regional Stakeholder Workshop
[357] Interview with Ministry of Forests, Lands, Natural Resource Operations and Rural Development Staff

4.3 CROSS-SECTOR ISSUE AREAS

An objective of this project was to analyze existing and potential workforce challenges with a clean economy lens and identify opportunities for addressing these issues through the Workforce Readiness Industry Strategy.

The demand and supply for clean economy occupations based on the LMI forecasting for each sub-sector, as well as the common themes, challenges, and issues extracted from the key informant discussions were summarized and presented to each of the five sector-specific sub-committees for discussion and refinement. Sub-committee feedback was then used to develop four key issue areas that were presented to the Steering Committee for further refinement and validation. These issues were also discussed at regional workshops and used to gather further feedback through the CEWRP Industry Survey.

The four cross-cutting issue areas are presented below. It is important to note that the cross-sector issues highlighted below are broad in nature and relevant to BC's clean economy as a whole. That said, where specific workforce challenges linked to the LMI modeling of the CleanBC policies were identified, these are described under each issue area below.

4.3.1 ISSUE AREA #1: LACK OF FLEXIBLE & RESPONSIVE PROGRAMMING

Education and training programs need to be flexible and responsive to emerging industry trends and technology shifts. Without this flexibility, there is a risk that skill gaps will form or widen as graduates or trainees are not sufficiently equipped with the skillsets and knowledge that align with employers' needs.

Based on LMI modelling, several policy goals within the CleanBC Plan are expected to create demand for occupations that include heat pump installers, EV technicians, biofuel production engineers and technicians, and handlers and processors of organic materials as examples. Education and training programs for professional occupations and trades relevant to the clean economy will need to find ways to adapt faster in order to stay current and aligned with policy direction and needs of industry to ensure that the CleanBC goals can be met.

In order to improve responsive programming, there are challenges that need to be addressed around finding qualified instructors, maintaining valuable industry-academia partnerships, investing in the latest technologies, and ensuring programs and training are accessible to prospective students. Table 81 below offers further details on the sub-issues and examples that characterize this issue area.

Education and training programs need to be flexible and responsive to emerging industry trends and technology shifts. Without this flexibility, there is a risk that skill gaps will form or widen as graduates or trainees are not sufficiently equipped with the skillsets and knowledge that align with employers' needs. In order to improve responsive programming, there are challenges that need to be addressed around finding qualified instructors, maintaining valuable industry-academia partnerships, and ensuring programs and training are accessible to prospective students. Table 81 below offers further details on the sub-issues and examples that characterize this issue area.

Table 81: Flexible and responsive programming sub-issues and examples

Sub-issues	Examples
Regional programs struggle with minimum registration numbers and/or lack capacity and flexible delivery formats.	There are challenges with many rural areas not having the density required for economies of scale to deliver programs. This leads to a need to find innovative ways to developing education / training. *Source: Cariboo Region Stakeholder Workshop* Training for seasonal industries (i.e. eco tourism) should be designed to happen in the off season (i.e. in the Fall or Spring). *Source: Thompson Okanagan Region Stakeholder Workshop*
New education / training programs often take a long time to develop and go through the approvals process.	The speed of education system does not match the pace of industry change. It takes 2 years to modify curricula and 4-years to complete a degree program (resulting in a 6-year lag for qualified graduates from a new program). *Source: Informant interview*
Lack of partnerships between industry, government, and academia may create misaligned skills development and missed learning opportunities.	Trades and training programs do not always have access to the most current technologies needed by industry (e.g., additive manufacturing), creating a need for stronger industry-academia partnerships. *Source: Regional Workshop and key informant interview* Education and awareness across all stakeholders needs to happen. How extensively does the province understand the Clean BC Initiative and does the public know enough about its impacts to start looking at preparation and readiness? *Source: Steering Committee* Industry/PSI partnerships to create Program Advisory Committees are a good model, but the inner workings and inclusion of the right stakeholders could be improved and better coordinated to enable better information sharing among regions. PSIs in particular need to connect their work to local issues and needs. *Source: Cariboo Region Stakeholder Workshop*
Lack of support and demand for apprenticeships.	Many young trades are gravitating towards becoming heavy duty mechanics and getting into fixing battery-operated buses. Meanwhile there is limited success to get employers to hire apprentices, as it is not mandated. How do we require people to train if it is not mandated? *Source: Steering Committee* Employers will hire educated and more experienced workers from other provinces over hiring local apprentices. Young people have other unique skills that seasoned professionals may not have. *Source: Steering Committee*
Lack of clean economy lens on K-12 curriculum	Need to apply a green economy lends to K-12 through post-secondary programs (this includes technical studies such as GIS mapping to business and humanities). *Source: Kootenay Region Stakeholder Workshop*

4.3.2 ISSUE AREA #2: LACK OF LIFELONG LEARNING & DEMAND FOR TRAINING

Key occupations in the clean economy do not have effective incentives for continuous learning, which may impact factors such as safety, quality assurance, and accountability. This is in part due to a lack of clarity on which jobs are "clean" and thus require additional incentives, and also impacted by the willingness of employers to allow the necessary time away for training or skills development.

LMI modelling suggests that a large amount of job transformation is expected for a wide range of core clean economy occupations due to CleanBC policy goals, from carpenters to electricians, plumbers, heavy equipment mechanics, transit operators, truck drivers, engineers, farm managers, and many more. Broader trends and market shifts will further accelerate this skills transformation. As a result, it will be essential to address barriers and encourage a culture of continuous lifelong learning, support ongoing professional development, and regulate and incentivize training requirements and standards to ensure the skilled workforce evolves with best practices in their fields to support the clean economy transition.

Challenges in this area include providing the right incentives to different groups, having access to organizations or coaching resources to provide guidance on career pathways, and fostering an understanding and appreciation of the benefits of continuous learning (see Table 82).

Table 82: Lifelong learning and demand for training sub-issues and examples

Sub-issues	Examples
Unclear career pathways as it relates to clean economy occupations (from high school through to advanced degrees).	People are not always clear how to ladder from trades to master trades or professional occupations. Germany's vocational training is an example of a system with clear career pathways. *Source: Built Environment Sub-committee* There is a strong belief or perception that there is a misalignment of skills particularly for traditional industries. It will be important to make this alignment clear, especially for ranching and forestry industries. *Source: Northeast Regional Stakeholder Workshop* The strategy needs to have a plan for displaced workers whose skills fall outside the clean economy framework. *Source: Thompson Okanagan Region Stakeholder Workshop* There are no regional information hubs or local champions that provide job and skills training resources that are specific to the local values, culture and challenges. *Source: Thompson Okanagan Region Stakeholder Workshop* Need more awareness building around clean economy jobs. Consider bringing communities together for a weekend as part of a "jobs fair" and provide examples of occupations, new skills, training (recruitment) – trade show for green / clean economy jobs. *Source: Kootenay Region Stakeholder Workshop*

Lack of opportunities to develop 'hands-on' and experiential learning.	Having the technical understanding of a building-as-a-system is becoming an increasingly important part of credentials and for workers to understand why they are installing components a certain way. *Source: Informant interview* Applied learning and elements such as coop education is important and not integrated into many post-secondary programs. *Source: Informant interview*
Lack of options for employees to access training programs with minimal disruption to business owners.	Typically, the workers already in the field are resistant to re-training because it means missing work and giving up a day's pay. Some trades come back in for retraining because of stipulations in RFPs for qualified workers. Courses can cost up to $2000/week without a subsidy (because program is cost recovery). *Source: Informant interview* Small businesses struggle with time and financial resources to apply for grants to fund training for their employees. *Source: Northeast Region Stakeholder Workshop*
Need for more fostering of core "soft skills" and leadership / mentorship opportunities.	While co-op placements are valuable, most companies need students to come in with some form of experience or understanding of industry because many companies just do not have the time to fully train. This could be addressed through increased training / development of program for leadership around mentorship or through a Centre of Excellence. *Source: Clean Energy Sub-committee* Soft skills such as leadership, teamwork, and communication are of growing importance to all occupations. *Source: Sub-committees and key informant interview*
Lack of demand for training and continuing professional development due to lack of regulation and/or value place on training (e.g., construction trades).	One of the challenges in getting better-trained trades is that there is often no compelling reason for those who need the training to invest in taking it. There are some very good examples of training and certification programs which are unsubscribed due to lack of awareness and value put on lifelong learning. *Source: Built Environment Sub-committee* There is currently a lack of requirement for training and certification related to many trades in the construction sector (e.g., carpenters, window installers, heat pump installers) which can result in poor quality of work and impact on product performance. *Source: Built Environment Sub-committee*
Lack of understanding of specific skills gaps by sector and region.	There is a need to identify and understand specific skills gaps and assess the change management capacity of sectors and organizations. There is an opportunity to look at the balance of occupations in different regions and match up training programs in regions seeing or anticipating a decline. *Source: Steering Committee*

4.3.3 ISSUE AREA #3: RECRUITMENT & RETENTION CHALLENGES

Many employers in BC struggle to recruit and retain employees. Housing affordability and cost of living is one of the most commonly cited barriers to attracting or retaining new workers. This is especially relevant to the Southwest/Lower Mainland region of BC where a lack of affordable housing options prevents potential employees from moving to a new job. Based on the LMI forecasting analysis of relevant CleanBC policy goals, the *Green Building and Resilient Infrastructure* and *Clean Transportation* sectors are likely to be those most challenged with respect to recruitment and retention in urban centres, with a projected demand of more than 2,800 temporary construction jobs per year (on average) by 2030 between these two sectors.

The demographic shift is another challenge driving demand for new entrants in BC. This is a particular issue in trades as a large percentage of the workforce will be retiring in the coming decade creating a significant number of replacement job openings. Some of the key occupations for CleanBC (based on the LMI modelling) that are also expected to see significant attrition over the next decade are shown in Table 83 below. As noted in the Socio-economic Analysis section above, many traditionally under-represented groups face barriers related to workplace culture (e.g., unwelcoming work environments leading to apprentices aborting their trades training).

Alongside the historical challenges associated with worker recruitment, employers in BC will be competing with other sectors for workforce support of major project development over the next decade. Table 83 provides sub-issues and examples relevant to recruitment and retention.

Table 83: Recruitment and retention sub-issues and examples

Sub-issues	Examples
Demographic shifts such as attrition (i.e., retirement) are impacting on occupations important to the clean economy.	Several occupations important to the clean economy are expected to see significant attrition (retirements) over the next 10 years: • Motor transport supervisors • Transport truck drivers • Utilities managers • Managers in natural resource production • Rail operators and engineers • Carpenters • Construction managers • Heavy equipment operators *Source: Data analysis and consultation*
Competition from other industries / sectors or jurisdictions putting pressure on workforce recruitment.	Cleantech companies surveyed identified strong competition from international/multi-national firms in terms of retaining talent. *Source: Cleantech Survey* Major projects in the North (e.g., LNG, pipeline construction) may compete with clean economy sector projects for skilled construction trades and certain professional occupations (e.g., welders, pipefitters, land surveyors, civil engineers, etc.). *Source: Data analysis and consultation* There aren't enough graduates or qualified workers in emerging disciplines in BC. As an example, with hydrogen technology scaling up, one local company making fuel cells for trucks is hiring about 300 chemical engineers and is struggling to recruit. *Source: Clean Transportation Sub-committee*

Workers lack an accurate picture of their career options in the clean economy.	Industry has struggled to break the "greasy stigma" of being a mechanic, and many of these new technologies help with that. This also applies to the fuels industry. New technology creates an incentive for young people to explore a career as a technician. *Source: Clean Transportation Sub-committee*
Under-represented groups often have unequal access for participating in the clean economy workforce.	Indigenous people are under-represented in the post-secondary education system. There is an important link between skills development and infrastructure. There are still big gaps in basic levels of connectivity in many communities. *Source: Cleantech and Innovation Sub-committee* There is an unusually high gender pay gap in the construction sector in general and the trades in particular, which creates a major disincentive for women looking to enter that industry. *Source: Built Environment Sub-committee*
Resistance by employers to provide training or support co-op placements.	An example of a current initiative that is working to address this is the provincial government Indigenous Youth Internship Program. This could be replicated. *Source: Steering Committee* Resistance from businesses can also stem from a lack of clarity on timelines and incentives to adapt to the clean economy and shift their business to accommodate training. *Source: Thompson Okanagan Region Stakeholder Workshop*
Cost of living and housing affordability.	Where the majority of occupations are likely to be in future in BC (e.g., Vancouver Island, Okanagan and Lower Mainland), represent some of the highest cost of living options in Canada. This substantially impacts the ability to attract and retain the clean workforce of the future and needs to be addressed as part of recruitment efforts. *Source: Steering Committee* Attention needs to be given to the cost of living combined with the additional burden of student loans. In some cases, the younger generation cannot bear the burden of a student loan to get the education or training they need. *Source: Steering Committee*
Immigration policy barriers	Companies faces several challenges in hiring immigrant talent due to outdated policy in the Provincial Nomination Program. There are many emerging jobs and skillsets that are not reflected in the talent recruitment/immigration process, which causes delays or prevents companies from brining in talent from outside of BC. *Source: Cariboo Region Stakeholder Workshop*

4.3.4 ISSUE AREA #4: LACK OF ACCESS & CAPACITY IN RURAL & REMOTE AREAS

Many rural and remote areas of the province do not have adequate access to training and/or mechanisms to build workforce capacity in line with clean economy sector needs. The CleanBC policies analyzed through the LMI research are expected to drive demand in more rural and remote communities for expertise in renewable electricity projects (including generation and smart grid / microgrid solutions), biofuel production and organic feedstock and supply chain management, industrial GHG emission reduction projects, and the development of climate-resilient infrastructure.

However, smaller and more remote communities often struggle with a lack of skills to develop and implement projects, and developing and maintaining capacity can also be a challenge – particularly attracting workers to stay in the communities without a sufficient amount of continuous work and/or given competition from other locations or sectors that might provide better compensation.

One of the key barriers to accessing the training and mechanisms to build key skillsets is reliable infrastructure to enable connectivity. By focusing on establishing adequate broadband service in remote communities, online training and education resources can be accessed across the province in an equitable way (see Table 84).

Given more of the remote and rural communities in BC are in closer proximity to major industrial projects (e.g., LNG) that will be developed in the coming years, there is an opportunity to leverage the projects as platforms to build knowledge and skillsets in sustainability and clean technologies.

Table 84: Access and capacity for rural and remote areas sub-Issues and examples

Sub-issues	Examples
Access to training for rural and remote areas is limited due to lack of local program delivery and underlying infrastructure (e.g., broadband, access to transportation, access to qualified instructors / mentors, etc.).	Skilled labour and training relating to clean energy in rural areas is scarce, meaning the ability to source local talent is limited. It is common to have to hire professionals from other parts of the province and bring them in, or to "poach" employees from other provinces like Alberta. *Source: Key informant interview* It is often challenging to find staff in rural areas. Good jobs are posted with few applications received. *Source: Key informant interview* Public transportation can be a significant barrier to employment and prevent people from getting to their job or training. There needs to more agile transportation in more rural regions to enable better flow of workers and skills between communities. *Source: Fraser Valley Region Stakeholder Workshop*
Lack of opportunities for hands-on, project-based training in remote communities.	Many First Nations are off grid and powered by diesel. Developing more clean energy projects in local communities can provide more hands-on training opportunities. *Source: Cleantech and Innovation Sub-committee*

Challenge of providing communities with sustained workforce opportunities and managing through boom-bust resource cycles.	Some regions are experiencing 'brain drain' for certain skill types and occupations with a lack of clean power development projects at present. This happened with the energy advisor sector back in 2010 when incentives dropped off and energy advisors had no work. *Source: Clean Energy Sub-committee* Need to have policy or strategy in place to manage the positive and negative impacts that "fly in and fly out" camp work can have on communities. *Source: Steering Committee*

5. **CONCLUSION**

Job Growth and Transformation in BC's Clean Economy

British Columbia's clean economy is in a state of constant evolution, made up by a complex ecosystem and supply chain of interrelated sectors, industries, and key occupations. As the policies and targets in CleanBC are further developed and implemented, this broad and complex ecosystem will continue to evolve and grow as all industries look to transition to lower-carbon operations and more environmentally sustainable business practices.

Workforce development opportunities exist both in new jobs created through the CleanBC Plan, as well as for existing jobs that are undergoing transformation in terms of their core skillsets and competencies that are increasingly working with clean technologies and more energy and resource efficient processes. It is also important to consider the potential risks of job displacement in traditional industries undergoing economic shifts and/or resource cycles, and occupations that may be impacted by declines in demand for certain products or services due to policy, market, and/or technology shifts.

Some of the most significant growth for BC's clean economy workforce is projected to come from the *Green Building and Resilient Infrastructure* sector. This is partially driven by the policy certainty provided by the pathway for new construction to achieving net-zero energy ready buildings by 2032 in line with the BC Energy Step Code. Experts in other sectors have pointed to this example of policy certainty as a critical enabler for businesses in preparing transitioning to the low-carbon economy.

Underlying Barriers and Issue Areas

The clean economy is an exciting prospect for many people and presents new investment, business, and employment opportunities for BC. The transition to a clean economy is a unique opportunity to shift culture and practices that have traditionally excluded certain groups from the workforce. The prospect of an exciting and rewarding career, one that involves new technology and an opportunity to contribute to positive social and environmental impact, has the potential to attract and retain youth and under-represented groups.

To maximize the benefits coming for the transition to a clean economy, including successful outcomes for the CleanBC Plan, a number of underlying barriers and equity considerations must be addressed so that all BC residents have options (and see their place) in the clean economy. These underlying barriers are the focus of many existing coordinated efforts, including the eradication of poverty, diversity and inclusion initiatives for women and under-represented groups, improving environmental literacy and broader awareness of climate-related initiatives, and addressing infrastructure and mobility challenges.

In addition to the underlying barriers described in this Summary Report, common cross-sector challenges were identified by a range of businesses and organizations across the province. Maintaining relevance to global market, technology, and policy trends requires a system of flexible and responsive programming, without which there exists a risk that workers and trainees are not sufficiently equipped with the skillsets and knowledge required for the dynamic needs of the clean economy. Creating a culture of lifelong learning is beneficial to all sectors, but especially important to the clean economy where technology and practices are rapidly evolving. This culture is impacted by the ability for workers to see how their transferable skills are relevant to clean economy industries, and also by the willingness of employers to support the training and skills development of their employees.

Finally, communities and regions across the province do not have equal access to training and employment opportunities. People living in rural and northern rural and remote areas of the province, including Indigenous communities, have highlighted a disconnect with some of the policies in CleanBC that they feel are more 'urban' centric. If the CleanBC Plan is to be implemented successfully and equitably, innovative models and supports must be developed to provide opportunities that fit the many unique regional and community contexts across the province.

A Strategic Framework for Action

The information and key issues presented in this Summary Report are based on more than 12 months of LMI research, data analysis, and consultation, building on additional recent and sector-specific work. Based on the foundational research summarized in this document, a strategic framework for addressing the issues and barriers was developed, guided by the overall goals of the project and linked to specific outcome statements (see Figure 34 below). The strategic framework, referred to as BC's Clean Economy Workforce Readiness Model, includes five focus areas and 12 strategies designed to address the gaps and issues identified through this LMI research.

The Workforce Readiness Model forms the foundation to British Columbia's Workforce Readiness Industry Strategy for a Clean Economy Future (i.e., the "Industry Strategy") that was developed during Phase 3 of this project – a collaboration between the Delphi Group and Elevate Consulting, with input from a diverse project Steering Committee.

Implementing the recommendations found within the Industry Strategy will set BC up for success in terms of creating more resilient communities and sustainable employment province-wide, as well as generating new investments and enhanced strengths in cleantech and environment services domestically which can be exported in the future to meet growing global demand. Simultaneously, the Industry Strategy is designed to create a more diverse, inclusive, and skilled workforce that is effectively able to deliver on the GHG emission reduction goals outlined in the CleanBC Plan and ensure a sustainable and prosperous economy for future generations.

Source: The Delphi Group and Elevate Consulting

Figure 34: Framework for BC's Workforce Readiness Industry Strategy for the Clean Economy Future