Mapping the Junction of Digital-Green Skills for the Twin Transition

A COMPETENCY FRAMEWORK

ICTC CTIC

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PREFACE

The Information and Communications Technology Council (ICTC) is a not-for-profit, national centre of expertise for strengthening Canada's digital advantage in a global economy. Through trusted research, practical policy advice, and creative capacity-building programs, ICTC fosters globally competitive Canadian industries enabled by innovative and diverse digital talent. In partnership with an expansive network of industry leaders, academic partners, and policymakers from across Canada, ICTC has empowered a robust and inclusive digital economy for over 30 years.

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Executive Summary

Today's Canadian economy is rapidly and constantly evolving. According to Former Governor of the Bank of Canada, Stephen Poloz, we are living in a time of increased complexity, global interconnectedness, and uncertainty. This reality presents unique opportunities for innovation, but it also surfaces existing challenges and puts pressure on Canadians and the economy to evolve. While affordability and cost of living are at the top of many people's minds, the threat of climate change and its associated risks to quality of life also loom. In these uncertain times, the concept of a "twin transition"—where digitalization and sustainability go hand in hand—is increasingly viewed as key to a prosperous and secure future, both economically and environmentally.

Although a successful twin transition requires attention to many factors, a skilled labour force is essential to its very foundation. In this report, skills and competencies for the twin transition are referred to as "digital-green." The Canadian digital and green economies are growing, and in many ways, they are already intermingled. For example, the environmental and clean technology (ECT) industry is identified by Statistics Canada as producing and delivering environmental goods and services. This field already represents almost 2% of all Canadian jobs and is expected to grow in future. While workers in the ECT industry may require a unique blend of digital and green skill sets, often digital-green skills and competencies are layered onto existing roles, such as construction professionals who acquire skills related to sustainable retrofitting and smart energy management systems.

Because of the cross-sectoral nature of this transition, a digital-green competency framework for Canada's economy is necessary. This report offers such a framework, structuring essential skills and knowledge areas around five activity areas.

1. **Consulting and Analyzing:** The collection, assessment, analysis, reporting, and predictive modelling of environmental information and data services. Within this activity, skilled workers may rely on geospatial technologies, such as geographic information systems, to collect and analyze environmental data.

2. **Designing and Building:** Sustainable design and building processes related to the built environment, such as retrofitting the built environment to support climate change adaptation and mitigation. These activities commonly rely on the use of building information modelling and simulation software.

3. **Producing and Manufacturing:** Sustainably producing and manufacturing physical goods, leveraging automation, robotics, and additive manufacturing (3D printing) technologies.

4. **Managing, Regulating, and Accounting:** Activities guiding regulation of digital-green economic activity, natural resource management, and greenhouse gas emission accounting. Within this activity, workers may leverage environmental management systems or use smart meters to manage renewable energy across a virtual power grid.

5. **Transporting and Sustaining:** Activities required to ensure that transportation, logistics, and supply chain activities are environmentally sustainable. Increasingly, these activities rely on digital twinning technologies, cloud technologies, and 5G networks.

Each activity is linked with common occupations, industries, and explanatory case studies. The digital-green competency framework also includes two high-level transferable competency areas core to any activity that can be broadly considered to be part of the digital-green economy. These include an understanding of climate change and environmental sustainability, data analysis, management, and interpretation. Transferable skills cut across occupations and industries. Depending on where digital-green solutions are adopted, digital-green skills may be needed in the technology sector, manufacturing, skilled trades, public administration, architecture and design, business, procurement, and numerous other fields.

This reality implicates a wide range of stakeholders in digital-green workforce development, including educators, employers, industry organizations, and governments, who must work in coordination to develop and deliver timely and impactful training initiatives. ICTC's digital-green competency framework offers a standardized and coordinated approach to digital-green skills that can be leveraged by all stakeholders to build and support Canada's digital-green labour force.

Introduction

Many nations, including Canada, grapple with complex socioeconomic and ecological challenges, including climate change and economic well-being. Global leaders have identified "failure to mitigate climate change" as the biggest risk faced by humanity, closely followed by the related "failure of climate change adaptation," "natural disasters and extreme weather events," and "biodiversity loss and ecosystem collapse."[1] At the same time, leading Canadian economists are voicing concerns about economic and labour force challenges like declining domestic productivity or Canada's economic output per worker.[2] As noted in a recent article by the *Globe and Mail,* "2023 marked the third annual consecutive decline [in productivity] for the first time in at least 40 years."[3] This comes alongside a general decline in Canadian competitiveness, resulting from a loss of investor confidence, including fewer investments in Canadian securities and foreign investors selling off Canadian equities.[4]

The convergence of climate change with economic underperformance could mean declines in the quality of life for Canadians. In fact, recent research by National Bank of Canada Financial (NBF) shows that, like labour productivity, real GDP per capita in Canada lags behind the US; in 2023, GDP per capita purchasing power in Canada fell to just 76% of that of the US.[5] A recent poll by Leger also found that 72% of surveyed Canadians are heavily concerned about rising costs and inflation, 62% are concerned about a lack of adequate healthcare, and 49% are concerned about finding an affordable place to live.[6]

Moreover, despite intergovernmental climate targets, such as the Paris Agreement,[7] global annual greenhouse gas emissions continue to rise, triggering biophysical and ecologically cascading effects.[8] In 2023, Canada continued to feel the impacts of climate change; record-breaking heat waves, forest fires, droughts, torrential rainfalls, and extreme flooding events affected and displaced many people.[9]

1 The Global Risks Report 2023," *World Economic Forum,* 2023, https://www3.weforum.org/docs/WEF_Global_Risks_Report_2023.pdf.
2 See: Trevor Tombe, "As productivity plunges, Ontario and Alabama now have the same per capita GDP," The Hub, June 15, 2023, https://the-hub.ca/2023-06-15/trevor-tombe-most-provincial-economies-struggle-to-match-the-u-s/; Douglas Porter, "Canada's Perennial Productivity Puzzle," BMO Economics, November 3, 2023, https://economics.bmo.com/en/publications/detail/ac91d4fe-be13-4b37-874c-33713b6cc2f5/; Daniel Johnson, "Is lagging productivity more economically dangerous than inflation?" BNN Bloomberg, June 29, 2023, https://www.bnn-bloomberg.ca/is-lagging-productivity-more-economically-dangerous-than-inflation-1.1939595.
3 "More economists are getting deeply worried about Canada's future – and investors are taking notice," *The Globe and Mail,* March 11, 2024, https://www.theglobeandmail.com/investing/investment-ideas/article-more-economists-are-getting-deeply-worried-about-canadas-future-and/?login=true.
4 Ibid.
5 Stéfane Marion, "Attract private investment: Canada's only way out," National Bank of Canada, Financial Markets, March 11, 2024, https://www.nbc.ca/content/dam/bnc/taux-analyses/analyse-eco/etude-speciale/special-report_240311.pdf
6 "Is Canada Broken?" Leger, March 7, 2024, https://leger360.com/surveys/is-canada-broken-2/.
7 United Nations, "The Paris Agreement," United Nations Climate Change, accessed, March 18, 2024, https://unfccc.int/process-and-meetings/the-paris-agreement.
8 Rebecca Lindsey, "Climate change: atmospheric carbon dioxide," Climate.gov, May 2023, https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide; "Broken record: Atmospheric carbon dioxide levels jump again," Climate.gov, June 2023, https://www.climate.gov/news-features/feed/broken-record-atmospheric-carbon-dioxide-levels-jump-again.
9 Shuang-Ye Wu, "2023's extreme storms, heat and wildfires broke records – a scientist explains how global warming fuels climate disasters," The Conversation, December 2023, https://theconversation.com/2023s-extreme-storms-heat-and-wildfires-broke-records-a-scientist-explains-how-global-warming-fuels-climate-disasters-217500; Nicole Lulham et al., "Canada in a Changing Climate: Synthesis Report," Natural Resources Canada, December 07, 2023, https://doi.org/10.4095/332326.

Climate change also has impacts on human health, including declining air quality, increasing incidents of Lyme disease and other insect-borne infectious diseases such as malaria,[10] and increasing incidents of heat stroke.[11]

Left unaddressed, climate change will further perpetuate economic challenges. As detailed in a recent report by the Canadian Climate Institute, "A warming and increasingly volatile climate is a drag on sustained economic growth that erodes Canadians' income and prosperity by accelerating infrastructure decay, destroying assets, and causing avoidable illness and death."[12] The report included an economic impact analysis of climate change in Canada and found that by 2025, climate-related impacts could slow economic growth by $25 billion annually.[13]

While economic and climate analyses are concerning, there is reason for hope. The Canadian Climate Institute finds that investments in climate change adaptation and mitigation, such as clean technologies, could reduce the economic impacts of climate change by up to 75% while also having positive effects on quality of life.[14] Moreover, existing research points to the link between technological adoption and environmental and economic sustainability. For instance, McKinsey & Company notes that Industry 4.0 technologies can create "measurable improvements across key performance indicators, such as productivity, cost, agility, quality, and convenience," while simultaneously driving "eco-efficiencies."[15] Past research by ICTC also showcases a positive relationship between environmental sustainability efforts and profitability: by curtailing resource consumption, such as energy and water, businesses yield financial savings.[16]

The concept of simultaneous technological advancement and environmental sustainability is commonly referred to as the **"twin transition."**[17] The twin transition relies on digitalization and innovation to drive sustainability across the entire economy. It also relies on expertise in environmental sustainability and natural resource management to ensure there are few, if any, rebound effects to innovation and technology adoption.[18]

[10] Nooshin Mojahed, Mohammad Ali Mohammadkhani, and Ashraf Mohamadkhani, "Climate Crises and Developing Vector-Borne Diseases: A Narrative Review," *Iranian Journal of Public Health* vol. 51, no 12 (December 2022): 2664-2673, https://doi.org/10.18502/ijph.v51i12.11457.
[11] "The Health Cost of Climate Change: How Canada Can Adapt, Prepare, and Save Lives," Canadian Institute for Climate Choices, June 2021 https://climatechoices.ca/wp-content/uploads/2021/06/ClimateChoices_Health-report_Final_June2021.pdf.
[12] "Reducing the Costs of Climate Impacts in Canada," Canadian Climate Institute, September 2022, https://canadianclimat.wpenginepowered.com/wp-content/uploads/2022/09/Damage-Control_-EN_0927.pdf.
[13] "Canada's economy already hurt by climate change—households hit hardest," Canadian Climate Institute, September 28, 2022, https://climateinstitute.ca/news/canadas-economy-already-hurt-by-climate-change-households-hit-hardest/.
[14] Ibid.
[15] Francisco Betti, Enno de Boer, and Yves Giraud, "Lighthouses unlock sustainability through 4IR technologies," McKinsey & Company, September 27, 2021, https://www.mckinsey.com/capabilities/operations/our-insights/lighthouses-unlock-sustainability-through-4ir-technologies.
[16] Allison Clark and Mairead Matthews, "Canadian Agri-Food Sustainability: Skilled Talent Needed to Meet Food Demand and Reduce Environmental Impacts," Information and Communications Technology Council (ICTC), April 2023, https://ictc-ctic.ca/reports/canadian-agri-food-sustainability.
[17] Alexia Gonzalez Fanfalone and Celine Caira, "The twin transitions: are digital technologies the key to a clean energy future?" OECD AI Policy Observatory, November 9, 2022, https://oecd.ai/en/wonk/twin-transitions.
[18] Charlotte Freitag, et al., "The real climate and transformative impact of ICT: A critique of estimates, trends, and regulations," *Patterns*, 2, no. 9 (2021): https://doi.org/10.1016/j.patter.2021.100340; David Font Vivanco, René Kemp and Ester van der Voet, "How to deal with the rebound effect? A policy-oriented approach," *Energy Policy,* 84, (2016): 114-125, https://doi.org/10.1016/j.enpol.2016.03.054; "Aligning Policies for a Low-carbon Economy," 2015, OECD, https://www.oecd.org/environment/Aligning-Policies-fora-Low-carbon-Economy.pdf.

"Digital-green" is a near synonym for the twin transition. Unlike the narrower scope of "green IT," which emphasizes reducing the ecological and carbon footprint of information technologies (IT) and computing resources,[19] digital-green extends its focus beyond IT efficiency to include the use of digital tools to promote environmental sustainability. A smart meter, for instance, might both have a renewable energy power source and contribute to additional energy savings for other activities and devices, driving environmental sustainability in IT and beyond. Accordingly, Digital-Green entails a comprehensive approach that integrates digital technologies with environmental solutions to advance decarbonization and broader environmental sustainability.

As digital technologies converge with environmental solutions, new **"digital-green skills"** are emerging. These skills are increasingly important for occupations across Canada. Activities such as greenhouse gas accounting, environmental consulting, green IT adoption, sustainable software engineering, retrofitting the built environment, clean and renewable energy production and management, sustainable design, and clean transportation all rely on a combination of digital skills and green skills. Analysis by RBC suggests that over the next 10 years, Canada's transition to a net-zero economy will disrupt 3.1 million jobs, equal to 15% of Canada's total labour force.[20] In some sectors, RBC predicts that as much as 46% of new jobs will require an "enhanced skill set" aligned with environmental sustainability knowledge and skills.[21]

Recognizing the importance of digital-green skills in mitigating climate change while achieving socioeconomic prosperity, this paper provides a digital-green competency framework. The goals of this framework are twofold: 1) to support job seekers as they make important training and employment decisions related to the twin transition, and 2) to inform broader workforce development strategies to ensure a robust and inclusive twin transition in Canada.

This research unravels in-demand digital-green skills in Canada. First, it investigates employment opportunities and skills needs at the intersection of the digital-green economies and maps central components of the digital-green economy. Then, it disentangles the evolving labour market, including labour market shifts and transferable skills as digital-green skills become increasingly needed across all sectors. It concludes by highlighting emerging and future roles that will specialize in digital-green activities. Importantly, this analysis clarifies that the twin transition will impact the entire economy, requiring workers across occupations to upskill. As emphasized by research participants, including employers and subject matter experts, digital-green skills are already being layered onto existing jobs.

[19] Kaitlyn Carr, Allison Clark, and Mairead Matthews, "Building a Sustainable ICT Ecosystem: Strategies and Best Practices for Reducing Environmental Harms in a Digital World," Information and Communications Technology Council (ICTC), January 2024, https://ictc-ctic.ca/reports/building-a-sustainable-ict-ecosystem.

[20] "The skills revolution Canada needs to reach Net Zero," RBC Capital Markets, February 18, 2022, https://www.rbccm.com/en/insights/story.page?dcr=templatedata/article/insights/data/2022/02/green_collar_jobs_the_skills_revolution_canada_needs_to_reach_net_zero.

[21] Ibid.

To shape this analysis, ICTC conducted an employer survey (n=301), key informant interviews with employers and subject matter experts (n=25), and completed a literature review, including a comprehensive review of existing skills and competency frameworks for the digital and green economies.[22]

Section I begins by providing an overview of the digital-green labour market in Canada. It details employment demands for the digital economy, the green economy, and the new and emerging digital-green economy.

Section II provides an orientation to the purpose of skills and competency frameworks, as well as an illustrative overview of existing classification schemes for digital-green roles and skills. It ends by positioning this paper's contribution to ongoing efforts to understand digital-green skill development around the world.

Finally, **Section III** pulls from primary and secondary research to outline a competency framework built around five key activities: Consulting and Analyzing; Designing and Building; Producing and Manufacturing; Managing, Regulating, and Accounting; and Transporting and Sustaining. It closes by discussing transferable skills that cut across all activities.

[22] See Appendix A for details on research methods.

SECTION I

The Digital-Green Labour Market in Canada

A workforce equipped with digital-green skills is needed to enable the twin transition. This talent is essential to drive environmental sustainability and economic prosperity through digital technologies. Taking this into account, this section details the current state of the digital-green labour market in Canada and identifies labour market gaps.

HOW PREVALENT ARE DIGITAL TECHNOLOGY ROLES AND SKILLS ACROSS THE ECONOMY?

ICTC measures the **digital economy's** labour market footprint by examining all employment in technology-related roles, as well as all employment in the technology sector. Statistics Canada defines the information and communications technology (ICT) sector as industries primarily engaged in producing goods or services or supplying technologies used for processing, transmitting, or receiving information. By the end of 2023, over 1.18 million people were employed in Canada's ICT sector.[23]

The digital economy includes roles in the "technology sector" but also recognizes that technology roles are present across many industries. For example, an HR person at a software development company as well as a software developer at an HR firm both belong in the digital economy. By the end of 2023, over 2.6 million Canadians were employed in the digital economy.[24]

Increasingly, even firms without significant operations or involvement with technology require workers with some level of digital skills. For example, financial technology (fintech) applications for payment and accounting are used by companies across all sectors, and e-commerce solutions are now central to the average consumer's experience.

[23] "Canada's Digital Economy," etalent, Information and Communications Technology Council, November 2023, https://etalentcanada.ca/for-job-seekers/employment-data.
[24] Ibid.

HOW PREVALENT ARE GREEN ROLES AND SKILLS ACROSS THE ECONOMY?

There are various definitions for the **green economy.** Most explain that work performed in the green economy should revolve around objectives like improving human well-being and social equity, reducing environmental risks, managing ecological scarcities, and reducing greenhouse gas emissions. At the heart of the green economy's definition lies the fundamental concept of sustainability, which means meeting the needs of current generations without compromising the needs of future generations.[25]

Green jobs align with the principles of green economy, green growth, sustainable development, and circular economy. This definition evolves beyond tasks solely focused on environmental protection to encompass broader activities supporting the transition to a sustainable, net-zero future. According to the Environmental Careers Organization (ECO Canada), green jobs fall into two categories.[26] The first category is "core environmental workers," who, regardless of their industry, support environmental protection, resource management, and sustainability through environmental competencies. The second is environmental goods and service workers, who, regardless of their occupation, work for environmental goods and services firms, such as cleantech companies.[27] ECO Canada finds that there are environmental workers present in every Canadian region and industry, as well as nearly every occupation. In 2020, ECO Canada found that 689,000 workers in Canada were employed in green jobs.[28]

A study defining green employment in the European context found that while the EU's transition toward a green economy will come with drastic labour market disruptions like large-scale displacement, green and low-carbon sectors will see net positive employment in the long term.[29] ICTC's recent report, *Clean Energy and Pathways to Net-Zero: Jobs and Skills for Future Leaders,* similarly argues that there will be a net gain in employment during the transition to a net-zero economy.[30] This finding is corroborated in a 2021 study by Clean Energy Canada and Navius Research, which predicts that by 2030, a 9% drop in fossil fuel industry employment will be met by a 48% growth in clean energy jobs.[31]

[25] World Commission on Environment and Development, "Our Common Future (i.e., 'the Brundtland Report'),"United Nations, October 1987, available at: https://www.are.admin.ch/are/en/home/media/publications/sustainable-development/brundtland-report.html.
[26] Eco Canada, "From Recession to Recovery: Environmental Workforce Needs, Trends and Challenges," September 2020, https://esaa.org/wp-content/uploads/2021/05/ECO-Canada-Brochure.pdf.
[27] Ibid.
[28] Eco Canada, "Labour Market Research Report: Updated Labour Market Outlook (2025)," March 2021, https://eco.ca/new-reports/updated-environmental-labour-outlook-to-2025/#:~:text=Report%20Highlights,a%20green%20job%20in%202020.
[29] Marco Torregrossa, "Employment potential of the green economy," in Béla Galgóczi (ed.) Greening Industries and Creating Jobs, Brussels: European Trade Union Institute (2012): 137-162, available at: https://www.etui.org/publications/books/greening-industries-and-creating-jobs.
[30] Allison Clark and Mairead Matthews, "Clean Energy and Pathways to Net-Zero: Jobs and Skills for Future Leaders," ICTC, April 2023, https://ictc-ctic.ca/reports/clean-energy-and-pathways-to-netzero.
[31] Clean Energy Canada, "The New Reality," Morris J. Wosk Centre for Dialogue, Simon Fraser University, June 2021, available at: https://digital.library.yorku.ca/node/30013.

While labour market growth is expected in the green economy, the field is grappling with a talent crunch. LinkedIn's recent *Global Green Skills Report* found that green jobs on its platform are growing at an average rate of 8% per year, while the supply of talent to fill those jobs grows at 6% per year.[32] This suggests that the green economy could face a year-over-year compounding deficit of talent. Interestingly, the same LinkedIn research ranked Canada as having the fourth-best green skill intensity among its workforce in 2022, surpassed only by Australia, the United Kingdom, and the United States.[33]

AN INTERSECTION OF LABOUR MARKETS: DIGITAL-GREEN TALENT OUTLOOK

Certain activities, occupations, and even industries in today's economy occur at the nexus of digital technology and sustainability. For example, there is a growing ***environmental and clean technology (ECT) industry,*** defined by Statistics Canada as producing and delivering environmental goods and services, and clean technology goods and services. Together, these subsectors employed 322,972 workers in Canada in 2020, almost 2% of all Canadian jobs.[34] These subsectors enjoyed higher than average salaries: the average salary in the ECT sector was $80,834 in 2020, compared with that year's Canada-wide annual average of $68,678. Statistics Canada also found that men held 64% of ECT jobs and had higher average salaries in this industry ($86,413 compared with $71,099 for women).[35]

Figure 1 illustrates some of the major occupations employed by the environmental and clean technology industry. Many of the occupations are in the trades, transportation, business, finance, and sciences.

[32] LinkedIn Economic Graph, "Global Green Skills Report," 2022, https://economicgraph.linkedin.com/research/global-green-skills-report.
[33] Ibid.; LinkedIn calculates the green skills metric based on the average number of green skills held by industry workers, meaning that workers with zero green skills are averaged with workers boasting more than a dozen green skills.
[34] Statistics Canada "Environmental and clean technology jobs in Canada," StatsCAN Plus, August 30, 2022, https://www.statcan.gc.ca/o1/en/plus/1683-environmental-and-clean-technology-jobs-canada.
[35] "Environmental and Clean Technology Products Economic Account: Human Resource Module, 2020," The Daily, Statistics Canada, April 28, 2022, https://www150.statcan.gc.ca/n1/daily-quotidien/220428/dq220428f-eng.htm.

Major Occupations in the Canadian Environmental and Clean Technology Sector

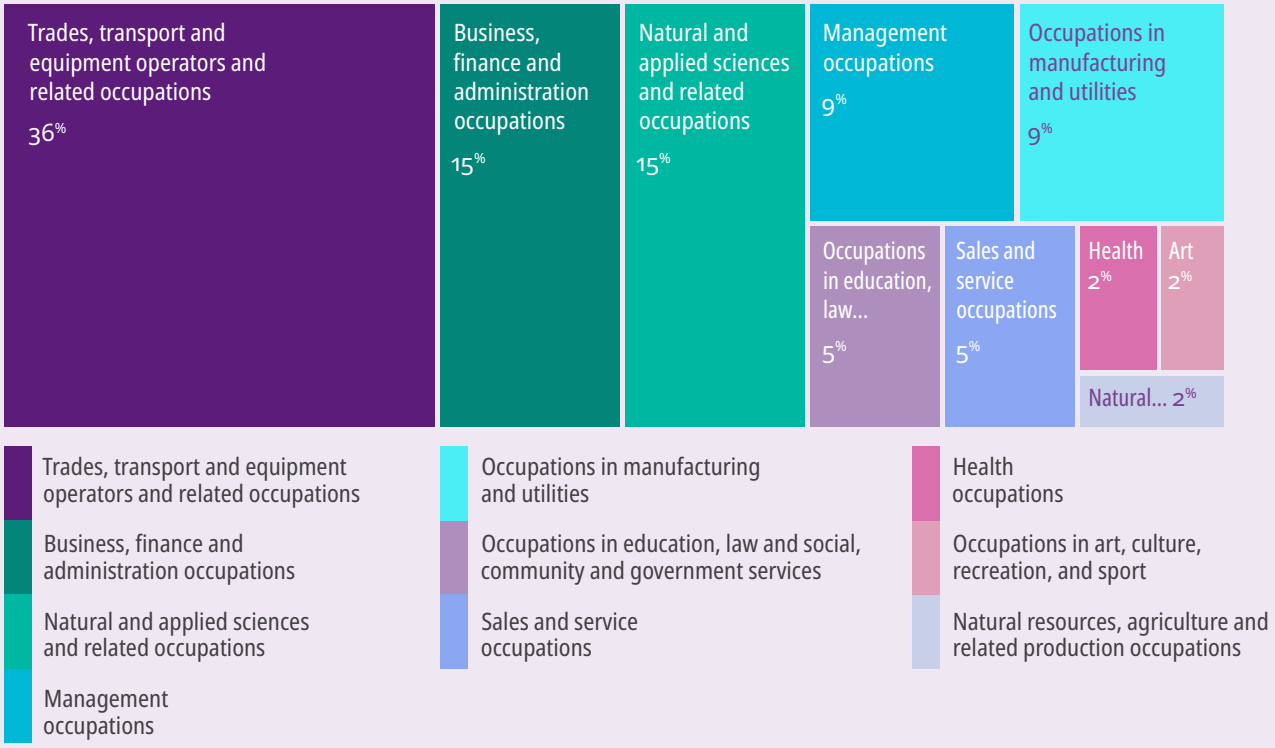

Figure 1: *Major occupations in the Canadian Environmental and Clean Technology Sector. Data Source: Statistics Canada. Table 36-10-0694-01, Employment per occupation in the environmental and clean technology products sector by demographic characteristic. 2019 data is used here for best data quality.*

To further investigate the types of roles the digital-green market needs, ICTC ran a survey that engaged over 300 Canadian employers. To qualify for the survey, employers were asked to self-select into the pool by choosing one of the following:

> **" My organization is part of the digital economy, meaning digital technology is a core part of how we operate and/or our products and services. Some examples of digital technology are software programs, data, artificial intelligence, ICT hardware, and IoT equipment.**

> **“ My organization is part of the green economy, meaning environmental solutions are a core part of how we operate and/or our products and services. Some examples of environmental solutions are clean energy, carbon credits, carbon capture and storage, circular economy, nature-based solutions, and electric vehicles.**

> **“ My organization is part of both the digital and green economies.[36]**

Figure 2 shows in-demand roles for each of these three self-selected groups. Digital-green employers seek a wide variety of skilled hires. Some of these occupations require specialized technology skills, and others require strong environmental competencies. That said, both types of skills are likely required for many roles in a digital-green organization. For example, an administrative or operations role may require knowledge of sustainable ICT practices or environmental data analysis for environmental, social, and corporate governance (ESG) reporting. Accordingly, while the traditional skills of an administrator or sales professional still apply, workers in these roles may require layered skill sets specific to the digital-green economy. One digital-green employer participating in this study described their anticipated hiring plan for their sales department in the following way:

> **“ We’re going to require more digitally competent salespeople… bringing awareness to the world around what it is that we do and why so that our customers take notice. It’s not a traditional sales role. We have to be much more compelling, much more technical, and you have to be able to speak from the boardroom right down to an operator.**
>
> — Sustainability Manager at a Technology Firm

[36] Additional information about the employer survey is available in Appendix A.

Roles that Employers Are Planning to Fill

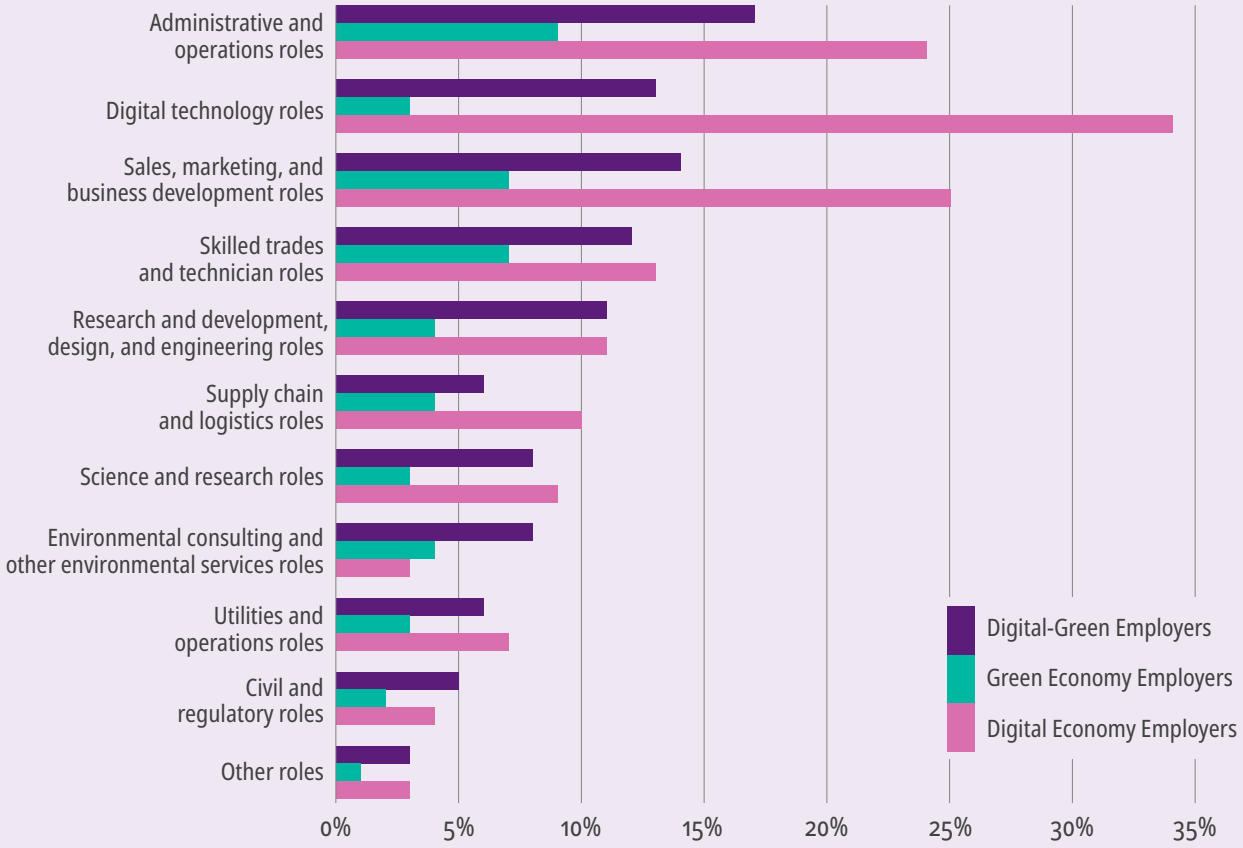

Figure 2: *Hiring Plans, ICTC Digital-Green Employer Survey, n = 301.*

Employer demand for multidisciplinary skills also meant that many of their roles were hard to fill. Digital-green economy employers described difficulties finding workers with strong domain knowledge in their field, paired with digital literacy and an understanding of environmental sustainability. For example, one interviewee whose work centres around retrofitting the built environment commented that it was difficult to find construction workers who had specific knowledge of retrofitting for environmental sustainability. This employer said, "There is a significant shortage of specialized skills to decarbonize the building stock."

Even outside of clear-cut digital-green occupations and industries, many businesses and workers increasingly require some degree of competency with both digital technology and sustainability, and digital adoption and sustainability monitoring are driving some of these changes. In 2022, a national survey of advanced technology adoption found that 62.1% of Canadian businesses had adopted at least one domain of advanced tech. Domains in the survey included design and information control technologies, clean technologies, business intelligence technologies, supply chain tech, IoT, AI, robotics, and others.[37] Clean technologies were the second most commonly adopted by 33.4% of businesses.[38]

[37] Statistics Canada, "Survey of Advanced Technology, 2022," The Daily, July 28, 2023, https://www150.statcan.gc.ca/n1/daily-quotidien/230728/dq230728b-eng.htm.
[38] Ibid.

However, it isn’t just advanced technology that has implications for sustainability; even relatively simple tools like “off-the-shelf” e-commerce solutions are now built with sustainability in mind. In addition to tracking sales, these solutions can help a business better understand and manage an organization’s carbon footprint. Along with digitalization and digital adoption, more businesses will seek and implement solutions that help keep their carbon footprints low and manage their resources sustainably.

SECTION II

Competency Frameworks, Occupational Databases, Skills Taxonomies, Typologies, and Ontologies—Oh My!

Why classify skills and jobs? Labour market information (LMI) is a crucial part of many public processes, from estimating how many seats a jurisdiction needs to offer in its medical programs to streamlining immigration processes to ensure that internationally educated professionals can see where their experience and skills are most needed. Typically, LMI at a high level requires a structured breakdown of occupations, training requirements, and skill sets. Standardized skills and definitions can allow governments to compare their standings internationally. For example, an internationally agreed-upon definition of numeracy or basic mathematical skills can help countries identify where updates to primary education are necessary. However, some roles and skills shift quickly—in particular, in the technology sector.

Standardized frameworks of skills and occupations are already challenging to create across industries and countries. Adding new technology into the mix means that structuring LMI effectively is no easy task. Section II of this report, therefore, provides different tools commonly used to classify skills and occupations before turning to existing examples of tools for the intersection of digital and green domains. It then outlines existing gaps in these frameworks and presents important steps forward for Canadian LMI.

SKILLS AND COMPETENCY FRAMEWORKS

We all have skills and competencies, and the two terms are nearly synonymous. Many organizations consider "skills" to be specific prerequisites to more holistic "competencies," which might include "knowledge, skills, attitudes, and values."[39] A 2020 study published by the Public Policy Forum defines competency

[39] OECD, "OECD Learning Compass 2030 frequently asked questions," OECD Future of Education and Skills 2030, accessed March 10, 2024, https://www.oecd.org/education/2030-project/teaching-and-learning/learning/faq/.

frameworks as "a tool used to develop, classify and recognize skills, knowledge and competencies."[40] Such competency frameworks can be developed by human resource professionals within an individual company or organization,[41] but they can also be developed for specific industries or entire economies.

The Government of Canada's Skills for Success program offers a framework of nine foundational skills or competencies that all Canadian workers need "to participate and thrive in learning, work, and life."[42] The Skills for Success competency framework has been reproduced as an illustrative example in Table 1 below.

Table 1: *Government of Canada Skills for Success Competency Framework*

Skill	Definition
Reading	"Reading is your ability to find, understand, and use information presented through words, symbols, and images."
Writing	"Writing is your ability to share information using written words, symbols, and images."
Numeracy	"Numeracy is your ability to find, understand, use, and report mathematical information presented through words, numbers, symbols, and graphics."
Digital	"Digital is your ability to use digital technology and tools to find, manage, apply, create and share information and content."
Problem solving	"Problem solving is your ability to identify, analyze, propose solutions, and make decisions. Problem solving helps you to address issues, monitor success, and learn from the experience."
Communication	"Communication is your ability to receive, understand, consider, and share information and ideas through speaking, listening, and interacting with others."
Collaboration	"Collaboration is your ability to contribute and support others to achieve a common goal."
Adaptability	"Adaptability is your ability to achieve or adjust goals and behaviours when expected or unexpected change occurs. Adaptability is shown by planning, staying focused, persisting, and overcoming setbacks."
Creativity and Innovation	"Creativity and innovation is your ability to imagine, develop, express, encourage, and apply ideas in ways that are novel, unexpected, or challenge existing methods and norms."

Data Source: *adapted from Boris Palameta, et al., "Research Report to Support the Launch of Skills for Success: Structure, Evidence, and Recommendations: Final Report," Social Research and Demonstration Corporation, May 2021, 14-32. https://srdc.org/project/Research-report-to-support-the-launch-of-Skills-for-Success-Structure-evidence-and-recommendations-Final-report/.*

[40] David Gyarmati, Janet Lane, and Scott Murray, "Competency Frameworks and Canada's Essential Skills," Public Policy Forum, November 2020, https://ppforum.ca/publications/skills-next-competency-frameworks-and-canadas-essential-skills/, viii.
[41] McLean & Company, "Develop a Comprehensive Competency Framework," https://hr.mcleanco.com/research/ss/develop-a-comprehensive-competency-framework.
[42] Government of Canada, "Skills for Success," last update: January 23, 2024, https://www.canada.ca/en/services/jobs/training/initiatives/skills-success.html.

Competency frameworks can include both technical and soft or human skills. They can also include both generalized knowledge and specific domain knowledge. Like the Government of Canada's Skills for Success program, they can cover general competencies at a high level, or they can be more granular and specified and include a detailed, hierarchical breakdown of skill groupings and knowledge areas. At their most specific, competency frameworks can seek to qualify framework elements by attributes such as requisite level of mastery of skill and knowledge areas.

However—irrespective of the theme, how general or specific, or the intended end-user of a competency framework—to be of most use, competency frameworks should be closely aligned with strategic goals.[43] Creating alignment between competency framework and organizational strategy is a critical consideration, whether developed at a sectoral or economy-wide level. Stakeholders such as individual workers, employers, post-secondary institutions, government, and civil society utilize sectoral or economy-wide competency frameworks to influence their own decision-making processes.

SKILLS AND COMPETENCY TAXONOMIES

The term "skills taxonomy" is often used synonymously with competency framework, though, in some cases, the term "taxonomy" may suggest an effort to standardize language and terminology, and develop a systematized understanding of roles and skills. However, in practice, competency frameworks will also standardize and systematize language and terminology. According to a 2020 research note published by the Inter-American Development Bank, skills and competency taxonomies are "structures developed to help provide this common language and set of standards for understanding and comparing skills."[44] Like competency frameworks, taxonomies will often take the form of multilevel datasets documenting skills and competencies across sectors or broad parts of the economy.

Employment and Social Development Canada (ESDC) maintains a *Skills and Competencies Taxonomy* for the Canadian labour market. This database contains over 250 skills and competencies, including detailed definitions, for more than 900 occupations.[45] The taxonomy is based on internal government data, the US O*NET system, and other international sources of LMI.[46]

In an effort to capture a set of universal and globally relevant occupational competencies, the World Economic Forum has produced a global taxonomy of work-related skills.[47] The taxonomy frames competencies as a "Collection of

[43] Gregory W. Stevens, "A Critical Review of the Science and Practice of Competency Modeling," *Human Resource Development Review,* vol. 12 no. 1, August 2012, https://journals.sagepub.com/doi/abs/10.1177/1534484312456690?journalCode=hrda.
[44] Álvaro Altamirano and Nicole Amaral, "A Skills Taxonomy for LAC: Lessons Learned and a Roadmap for Future Users," Inter-American Development Bank, November 2020, 1 https://publications.iadb.org/en/skills-taxonomy-lac-lessons-learned-and-roadmap-future-users.
[45] Employment and Social Development Canada, "Skills and Competencies Taxonomy," last update: June 2, 2023, https://noc.esdc.gc.ca/SkillsTaxonomy/SkillsTaxonomyWelcome.
[46] Ibid.
[47] World Economic Forum, "Building a Common Language for Skills at Work A Global Taxonomy," January 2021, https://www.weforum.org/publications/building-a-common-language-for-skills-at-work-a-global-taxonomy/.

skills, knowledge, attitudes and abilities that enable an individual to perform job roles."[48] It uses five nested levels, with Level 1 being high-level skills, abilities, and attitudes, with each following level becoming more specific. For each competency, the taxonomy also provides definitions for three levels of mastery: "foundational," "experienced," and "advanced."[49]

The World Economic Forum intends its taxonomy to help workers accurately map their skills and make them more translatable to different industries and employment contexts. The taxonomy may also help employers find new pools of talent across sectors that they may have never considered in the past.[50] Providing such an extensive international taxonomy of occupational competencies also provides essential data for employers to adopt skills-based hiring and career development practices.[51]

Occupational Databases with Green Job Subsets: O*NET, ESCO, SkillsFuture Singapore

Governments worldwide develop comprehensive occupational databases consisting of taxonomies of occupations, skills and competencies, and career qualification, education, and training pathways. Occupational databases provide helpful labour market information to individual job seekers, employers, and post-secondary education and workforce development organizations. Such occupational databases have increasingly begun tracking green jobs and green skills. Three relevant examples are presented here.

I. O*NET Green Occupations (United States)

The Occupational Information Network (O*NET) is a comprehensive occupational database sponsored by the United States government. O*NET was originally deployed in 1998 and has since undergone numerous updates to reflect new occupations and skills produced by the dynamic and ever-changing United States economy.[52] Today, O*NET contains a taxonomy of nearly 1,000 different occupations reflecting the entirety of the United States economy.[53] Of particular interest to the digital-green economy, O*NET includes a dataset of "Green Occupations," which

[48] Ibid., 7.
[49] Ibid., 15.
[50] Ibid., 7.
[51] See: World Economic Forum, "Putting Skills First: A Framework for Action," May 2023, World Economic Forum & PricewaterhouseCoopers, https://www3.weforum.org/docs/WEF_CNES_Putting_Skills_First_2023.pdf.
[52] National Research Council, "A Database for a Changing Economy: Review of the Occupational Information Network (O*NET)," National Academies of Sciences, Engineering, and Medicine, United States Government, 2010, https://doi.org/10.17226/12814.
[53] O*NET Resource Center, National Center for O*NET Development, "About O*NET," accessed March 2, 2024, https://www.onetcenter.org/overview.html.

includes information on emerging green occupations, green occupations enjoying increasing demand, and changes to existing occupations and skills needed in green industries.[54] O*NET's Green Occupations database was launched in 2013.[55]

II. ESCO Green Skills and Knowledge Concepts (European Union)

The European Skills, Competences, Qualifications and Occupations (ESCO) occupational database was developed and funded by the European Commission of the European Union (EU).[56] ESCO contains a taxonomy of 3,007 occupations and 14,295 competencies and skills that cover the entire European economy.[57] It also covers information on occupational qualifications, education, and training. To support the EU's 2050 goal of climate neutrality, ESCO has labelled 571 of its skills and knowledge areas as "green."[58]

III. MySkillsFuture (Singapore)

MySkillsFuture is an education and training portal and a key component of the Government of Singapore's SkillsFuture Singapore initiative.[59] The portal includes comprehensive information on education and training options available throughout Singapore, as well as a list of relevant industries and job roles for learners who successfully complete the recommended programs. The SkillsFuture Series is a training program series based on four "economic pillars" deemed by the Government of Singapore to be of strategic importance to the country's economic future. These pillars include: "Digital Economy," "Green Economy," "Care Economy," and "Industry 4.0."[60]

[54] O*NET Resource Center, National Center for O*NET Development, "Green Occupations, " accessed March 2, 2024, https://www.onetcenter.org/dictionary/22.0/excel/green_occupations.html.
[55] National Centre for O*NET Development, "Greening of the World of Work: O*NET Project's Book of References," December 2013, https://www.onetcenter.org/dl_files/GreenRef.pdf
[56] Directorate-General for Employment, Social Affairs and Inclusion, "What is ESCO," European Commission, accessed March 2, 2024, https://esco.ec.europa.eu/en.
[57] See: ESCO Occupations: https://esco.ec.europa.eu/en/classification/occupation_main; and ESCO Skills & Competences: https://esco.ec.europa.eu/en/classification/skill_main.
[58] Directorate-General for Employment, Social Affairs and Inclusion, "Green Skills and Knowledge Concepts: Labelling the ESCO classification - Technical Report," European Commission, January 2022, https://esco.ec.europa.eu/en/about-esco/publications/publication/green-skills-and-knowledge-concepts-labelling-esco, 5.
[59] SkillsFuture Singapore, "MySkillsFuture: SkillsFuture Series," last update: March 2, 2024, https://www.myskillsfuture.gov.sg/content/portal/en/career-resources/career-resources/education-career-personal-development/skillsfuture-series.html.
[60] Ibid.

Emerging Technology: Skills Ontologies

The Association for Talent Development defines skills ontologies as "a set of skills and their relationships between one another."[61] For example, an analysis of job descriptions could investigate which skills most commonly co-occur in job posts across industries. Advancements in digital technology such as machine learning and artificial intelligence have enabled researchers and early-adopter organizations to begin experimenting with skills ontologies as part of their human resource management.[62] Using data science concepts, the data from these skills ontologies can be self-generating over time as the system learns from new skills data inputs and finds new relationships between the data.[63]

Skills ontologies seek to understand deep relationships between different skills categories and occupations dynamically over time. While a skills taxonomy may associate a static list of skills under a single occupational heading, the skills ontology would seek to map skill relationships across categories or occupational fields in a non-hierarchical manner.[64] For example, a skills ontology developed by HR technology company Phenom captures "skill-to-skill," "role-to-role," and "skill-to-role" relationships, allowing skills to be mapped in association with seemingly unrelated jobs or between seemingly unrelated skills (see Figure 3 below).[65] Such ontological mapping provides deep insight into the workforce and labour market.

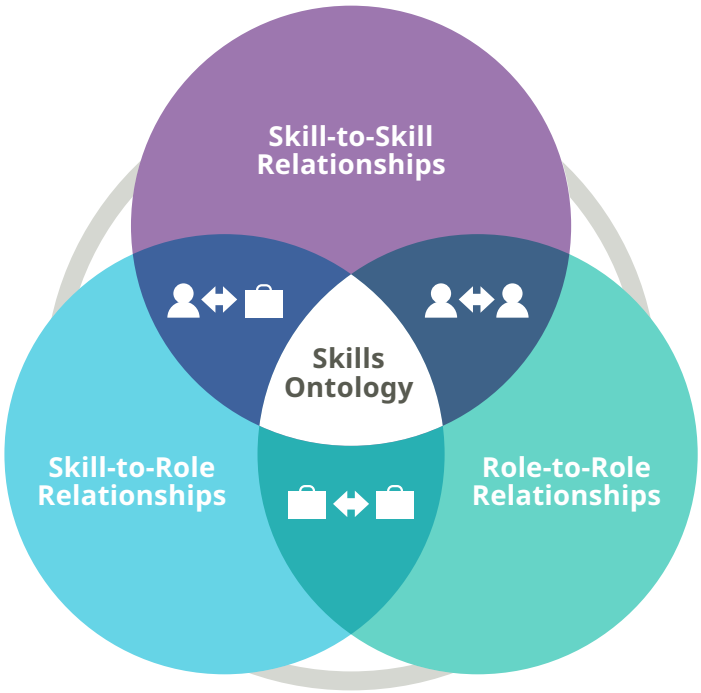

Figure 3: *Skill Ontology Relationship Diagram; Source: Adapted with permission from Kasey Lynch, "Demystifying Skill Ontologies: Your Roadmap to Clarity," November 13, 2023, Phenom.*

[61] Isabella Lazzareschi, "Skill Data Dictionary, Part 2: Taxonomies, Ontologies, and More," Association for Talent Development, March 12, 2021, https://www.td.org/atd-blog/skill-data-dictionary-part-2-taxonomies-ontologies-and-more.

[62] See: KPMG International, "The Future of HR: Lessons from the Pathfinders," 2021, https://assets.kpmg.com/content/dam/kpmg/xx/pdf/2021/09/future-of-hr-lessons-from-the-pathfinders.pdf; Thorsten Lau & York Sure, "Introducing Ontology-based Skills Management at a large Insurance Company," Modellierung in der Praxis, 2002, https://www.aifb.kit.edu/web/Inproceedings27; Maryam Fazel-Zarandi and Mark S. Fox, "An Ontology for Skill and Competency Management," Proceedings of the 7th International Conference on Formal Ontologies in Information Systems, Graz, Austria, 2012, http://eil.utoronto.ca/wp-content/uploads/km/papers/MFZ_Fox_FOIS_2012_CR.pdf.

[63] KPMG International, "The Future of HR: Lessons from the Pathfinders," 13.

[64] Nathaniel Plamondon, "Skills ontology 101," Cornerstone, accessed March 1, 2024, https://www.cornerstoneondemand.com/mx/resources/article/skills-ontology-101/.

[65] See: Kasey Lynch, "Demystifying Skill Ontologies: Your Roadmap to Clarity," November 13, 2023, Phenom, https://www.phenom.com/blog/demystifying-skill-ontologies.

Skills ontologies have exciting possible applications in future research on digital-green skills and competencies. As the green and digital economies evolve and integrate in Canada and internationally, robust and dynamic digital-green skills ontologies can provide timely and multifaceted labour market information to job seekers, employers, and policymakers.

CLASSIFYING SKILLS AND ROLES FOR THE DIGITAL-GREEN ECONOMY: EXISTING MECHANISMS

There are several existing tools for classifying roles and skills in the digital-green economy, each for different regions and purposes. As a 2023 report on green jobs by the Centre for European Policy Studies (CEPS) notes, "A variety of definitions and classification frameworks have been produced by international organizations and academics, with most of them assessing the greenness of jobs either from a firm-level or a worker-level perspective."[66] According to the CEPS analysis, these differing definitions of green work are framed at different levels of analysis. For example, skills, skill clusters, or occupations, rely on differing normative lenses to conceptualize green occupations or green industries (detailed below) and vary in terms of they are used to analyze labour market data.[67]

Bohnenberger's Taxonomy of Sustainable Employment

Frameworks and taxonomies can be deployed in labour market analysis to better understand other aspects of occupations, such as how sustainable or green individual occupations are throughout an entire industry or sector. University of Duisburg-Essen researcher Katharina Bohnenberger proposes a taxonomy of sustainable employment, which classifies occupations and employment sectors as "green," "mixed," or "brown" jobs.[68]

Under Bohnenberger's taxonomy, for a job to be considered fully green, it must produce "sustainable work outputs," be carried out in the context of a "sustainable occupation," support workers to live a "sustainable work lifestyle," and create "sustainable outcome efficiency." Jobs that fail to meet all these criteria are considered mixed jobs—or, if they actively cause environmental harm, brown jobs.[69] Bohnenberger's sustainable employment taxonomy provides a useful way to think about the sustainability of occupations in a fuller context. The taxonomy looks at the sustainability of the outputs and tasks associated with an occupation, as well as the efficiency of outcomes and support for individual workers to adopt sustainable work lifestyles. (See Figure 4 below.)

[66] Patricia Urban, et al., "Jobs for the Green Transition: Definitions, Classifications and Emerging Trends," Centre for European Policy Studies, September 2023, 34, https://esco.ec.europa.eu/en/about-esco/publications/publication/jobs-green-transition-definitions-classifications-and-emerging.
[67] Ibid., 1-7.
[68] Katharina Bohnenberger, "Is it a green or brown job? A Taxonomy of Sustainable Employment," Ecological Economics no. 200, 2022, https://www.sciencedirect.com/science/article/pii/S0921800922001318?via%3Dihub.
[69] Ibid., 7.

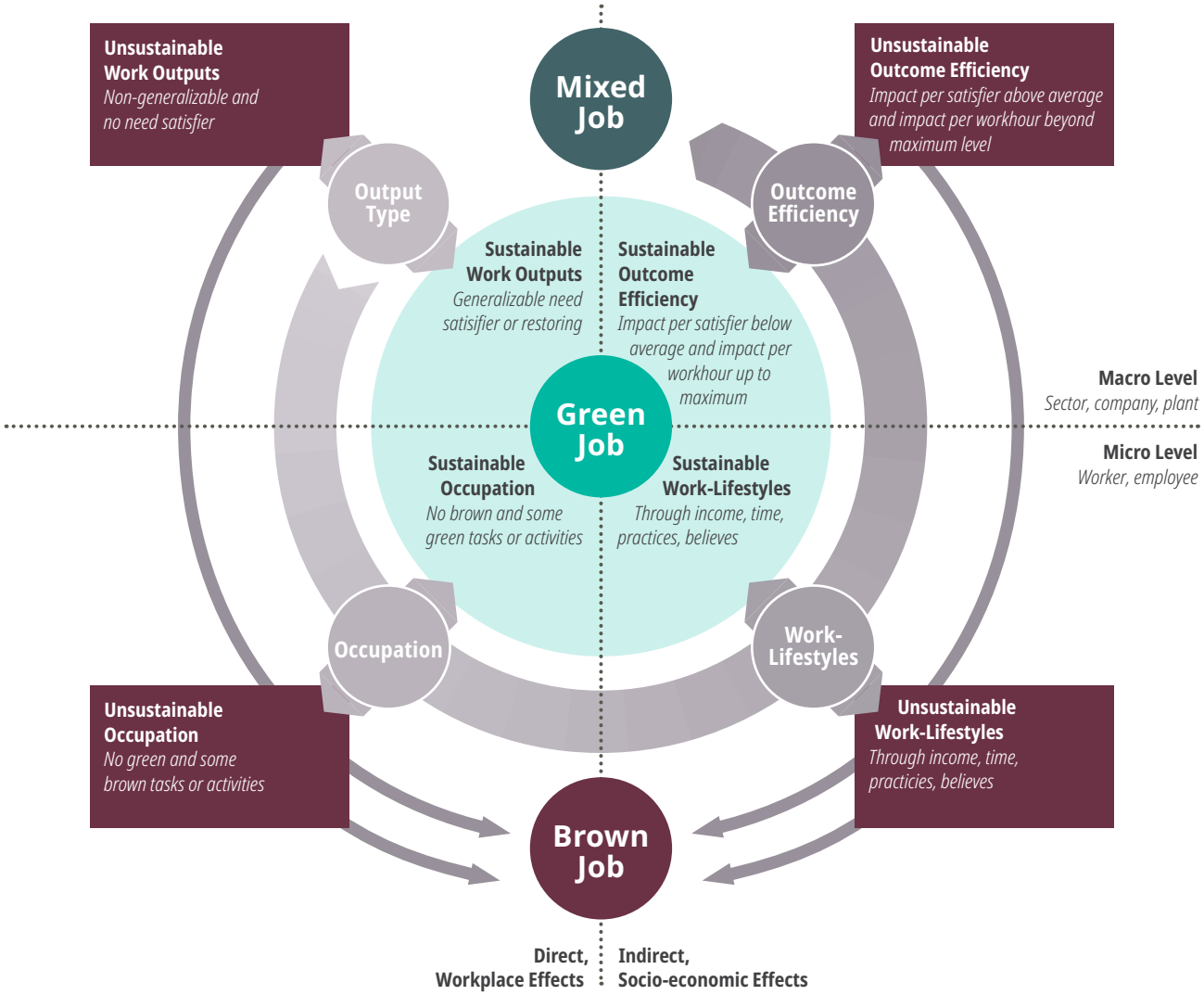

Figure 4: *Bohnenberger's Taxonomy of Sustainable Employment. Source: Adapted with permission from Katharina Bohnenberger, "Is it a green or brown job? A Taxonomy of Sustainable Employment," Ecological Economics no. 200, 2022, 7.*

Green Skills Typology for Technical and Technology-Based College Programs

Skills typologies cluster skills into meaningful groups that attempt to convey the common attributes groups of skills share beyond being part of the same occupation or industry. These skills typologies provide a useful analytical framework to understand skills and other competencies in a broad sense. For example, distinguishing between "soft," human, or interpersonal skills vs. hard/technical skills comprises a rough typology. Typologies have many applications, but in higher education, they can provide post-secondary education and training institutions with a framework and a point of reference for developing new training programs and academic curricula.

Canadian higher education researchers Helen Knibb and Chris Paci have produced a typology of green skills for technical and vocational education and training (TVET) institutions, such as community colleges and institutes of technology.[70] The typology seeks to classify occupational skills by level of specificity, starting with narrow technical skills relevant to a single job or occupation and then broadening to technical skills relevant to multiple fields or industries. They also identify "transitioning skills" that are in a period of change as occupations and industries become greener, and finally, "transversal skills" critical for the green transition and of universal applicability throughout the economy.[71]

One strength of this approach is its nod to specialization. By breaking down technical, human, and green skills and domain knowledge into specialist or generalist levels, Knibb and Paci highlight that even though few people need to be trained in job or occupation-related green specialist technical skills, the entire workforce can benefit from training and education in generalist transversal skills. They also emphasize transitory skills that will remain relevant as they evolve with the green transition taking place in society and the economy. Table 2 below provides an adaptation of the typology.

Table 2: *Green Skills Typology for TVET Programs (adapted from Knibb & Paci, 2016)*

Skill Levels	Attributes and Workplace Application
I Specialist technical skills	• Job/occupation specific • Emergent/new • Scarce supply • Short shelf-life • Proprietary technologies may be involved
II Broad-based technical skills	• Covers a range of technical/technology competencies • Includes new and adapted legacy competencies • Common skills across multiple jobs/occupations • Adaptable to different workplaces/industries
III Transitioning skills	• Adapts existing workplace skills to green/sustainable practices • Incremental modifications to existing occupational skills
IV Skills for sustainability *i.e.,"transversal skills"*	• Future-oriented • General in nature • Common or universal throughout the workforce • Highly transferable across sectors/industries *(i.e., soft skills)* • Complimentary to more specific skills • Long shelf-life

Adapted from: *Helen Knibb & Chris Paci, "The Greening of Canada's College Curriculum: A Pan-Canadian Survey," TVET@Asia, January 2016, https://tvet-online.asia/issue/6/knibb-paci/, 13-14.*

[70] Helen Knibb and Chris Paci, "The Greening of Canada's College Curriculum: A Pan-Canadian Survey," TVET@Asia, January 2016, 13-14 https://tvet-online.asia/issue/6/knibb-paci/.
[71] Ibid.

POSITIONING A DIGITAL-GREEN COMPETENCY FRAMEWORK FOR CANADA

As discussed above, numerous publicly available competency frameworks, occupational databases, skills taxonomies, and typologies currently exist. Some cover the entire economy, while others take a narrower approach to cover green and sustainable jobs and skills. Yet, there is no current competency framework that focuses on the intersection of the digital and green economies available for Canada. Job seekers, employers, and policymakers do not currently have access to a contemporary digital-green competency framework to be used in individual career planning, labour market analysis, and policy development.

ICTC seeks to remedy this gap in the Canadian labour market information ecosystem by developing a digital-green competency framework for Canada. ICTC's digital-green competency framework seeks to provide a platform upon which LMI-generating organizations can build future data and LMI products, such as digital-green skills competency frameworks and taxonomies, typologies, occupational databases, and eventually digital-green skills ontologies. ICTC's digital-green competency framework is presented in Section III of this report.

SECTION III

A Digital-Green Competency Framework

The twin transition is having widespread impacts on the labour market. The skills requirements for traditional occupations are constantly evolving as new digital technologies emerge and new environmental and climate-related legislation and targets are set. While traditional roles are becoming increasingly "digital-green," new digital specialist and sustainability specialist roles are also emerging. As the twin transition changes labour markets, it is critical that job seekers, employers, educational institutions, and policymakers have a clear understanding of in-demand digital-green competencies, skills, and knowledge areas.

Building upon key informant interviews, ICTC's Digital-Green Employer Survey, and secondary data such as labour market research and databases, this competency framework presents a first iteration at classifying digital-green competencies, skills, and knowledge areas. Given that this is the first study examining the intersection of the green economy and digital economy labour markets in Canada, this framework is broad in nature. It serves as a stepping stone for future digital-green labour market research in Canada.

This competency framework seeks to help those seeking careers that interface with digital technologies and environmental sustainability solutions. It provides relevant and empirical data on career paths and industries of interest. This framework also seeks to inform employers and policymakers about the current attributes of Canada's digital-green job market. Post-secondary institutions and workforce development organizations can leverage this framework when developing new and/or updated programming and curricula aimed at addressing digital-green skills gaps.

This competency framework is organized into five core activities that transcend the digital and green economies in Canada. The activities outlined in ICTC's digital-green framework include:

1. Consulting and Analyzing
2. Designing and Building
3. Producing and Manufacturing
4. Managing, Regulating, and Accounting
5. Transporting and Sustaining

For each activity, ICTC presents a list of the most common digital-green skills and knowledge areas required to carry out each activity (Table 3). Activity 1 (Consulting and Analyzing) includes digital-green skills and knowledge areas related to the collection, assessment, analysis, and reporting of environmental information and data services. Activity 2 (Designing and Building) includes digital-green skills and knowledge areas related to sustainable design and building processes, such as retrofitting the built environment to support climate change adaptation and mitigation. For Activity 3 (Producing and Manufacturing), digital-green skills and knowledge areas for sustainable production and manufacturing goods are discussed. For example, this includes skill sets related to renewable energy production, sustainable agriculture, and advanced manufacturing. For Activity 4 (Managing, Regulating, and Accounting), digital-green skills and knowledge areas needed to ensure economic activities (both digital and green) are well regulated, natural resources are properly managed, and greenhouse gas emissions are effectively quantified and controlled. Finally, Activity 5 (Transporting and Sustaining) presents digital-green skills and knowledge areas required to ensure that transportation, logistics, and supply chain activities are environmentally sustainable.

ICTC's digital-green competency framework is outlined at a high level in Table 3. The nuances of each activity are expanded upon in the following subsections, which unpack common digital-green skills and knowledge areas and present relevant occupations characterized by each activity. Each subsection also includes case studies, which detail how industries, skills, and occupations are evolving in Canada to include more digital and green skill sets. Lastly, ICTC presents a section on transferable competencies, which transcends across all activity areas outlined in this framework.

Importantly, ICTC uses the term "digital-green" as a catch-all term for skill sets, knowledge areas, and competencies required in the twin transition. Some of the skills and knowledge areas discussed throughout this report are more digital in nature, while others are greener in nature. What is most important is the convergence between digital skills and green skills and how they complement one another to unlock operation efficiencies, mitigate climate change, protect natural resources, and enhance economic prosperity. Workers with the digital and green skills outlined in this framework can be deemed well-equipped to participate meaningfully in the twin transition.

Table 3: *ICTC Digital-Green Competency Framework: Common Digital-Green Skills for Core Activities Characterized by the Twin Transition.*

Activity	Common Digital-Green Skills	Common Digital-Green Knowledge	Example Industries/Sectors
Consulting and Analyzing *Includes skills and knowledge areas related to collecting, assessing, analyzing, processing, and reporting environmental information and data services.*	• Data analysis • Data visualization • Data modelling and database design • Analytical software • Energy modelling • Environmental impact assessments • Stakeholder engagement • Geospatial technologies • Business intelligence platforms • Programming and coding • Generative AI • Risk analysis/management • Financial analysis • Scientific writing/communication	• Environmental monitoring • Environmental legislation and regulations • Environmental Management • Regulatory compliance • Environmental auditing • Environmental governance • Natural systems • Environmental science • Environmental sustainability • Nature-based solutions • Climate change and global environmental trends • Environmental conservation	• Environmental consulting • ESG advisory and information services • Research services • Environmental information services
Designing and Building *Includes skills and knowledge areas required to sustainably design, construct, and retrofit infrastructure across the built environment.*	• Programming and coding • Digital literacy • Data analysis • Building information modelling • Energy modelling • Project management • Equipment operation • Computer-aided drafting • Immersive technologies • 3D printing	• Renewable energy • Climate change adaptation • Nature-based solutions • Environmental sustainability • Energy efficiency • Regulatory compliance • Environmental legislation and regulations • Building codes	• Architecture & design • Construction & skilled trades • Engineering • Utilities • Urban planning and development
Producing and Manufacturing *Includes skills and knowledge areas involved in the sustainable production and manufacturing of physical products and outputs.*	• Robotics and automation • Energy modelling Optimization • Data analysis • Environmental remediation • Digital literacy • Cybersecurity • 3D printing • Computer programming and coding • Cloud computing • Equipment operation • Installation and maintenance	• Environmental legislation and regulations • Environmental sustainability • Natural resource management • Sustainable procurement • Climate change and global environmental trends • Climate change mitigation	• Agri-Food • Advanced manufacturing • Biotechnology • Renewable energy (production) • Mining • Utilities

Activity	Common Digital-Green Skills	Common Digital-Green Knowledge	Example Industries/Sectors
Managing, Regulating and Accounting *Includes skills and knowledge areas related to managing, regulating, and accounting economic activities and humanity's numerous interfaces with the natural environment.*	• Policy analysis and development • Data analysis • GHG accounting • Project management • Risk assessments • Change management • Human and resource management • Natural resource management • Stakeholder management	• Digital governance • Environmental science • Regulatory compliance • Environmental regulations, legislation and policy • Climate change and global environmental trends • Environmental sustainability • Cybersecurity • Privacy regulation	• Regulatory services • Planning and policy • Waste management • Water and resource management • Renewable energy • Environmental law
Transporting and Sustaining *All industries/sectors whose primary focus interfaces with transporting, distributing, logistics and the supply chain.*	• Computer programming and coding • Digital literacy • Data analysis • Navigation and route optimization • Fleet maintenance monitoring • Fleet dispatch strategy • Energy modelling • Lifecycle assessments • Project management • Heavy equipment operation • Immersive technologies *(e.g., augmented reality, virtual reality)*	• Urban planning • Port management • Climate change adaptation • Trade corridors • Environmental sustainability • Energy systems modelling • Regulatory compliance • Environmental legislation and regulations • Traffic/fleet flow management • Asset management • Logistics and freight distribution	• Supply chain and logistics • Shipping and marine transport • Aviation transport • Rail transport • Trucking and freight • Passenger vehicle transport

ACTIVITY 1: CONSULTING AND ANALYZING

With the rapid adoption of digital technologies—and a likewise increasing understanding of environmental sustainability, concern for climate change, and adoption of green business practices—there is a demand for digital-green skills focused on gathering and analyzing environmental and sustainability data and consulting with different clients and stakeholder groups to advise on digital and green approaches to sustainability. These activities constitute Activity 1 (Consulting and Analyzing) of ICTC's digital-green competency framework.

Activity 1 encompasses digital-green jobs and industries whose primary focus and day-to-day activity consists of collecting and analyzing data and consulting on the digital-green economy. This includes all industries and sectors whose primary focus is collecting, managing, processing, analyzing, assessing, and reporting environmental information.

While analyzing data and information is a common activity across the digital-green economy, some industries have information services, consulting, and analysis as their primary value offering. These firms would include those offering environmental consulting, impact assessments, environmental monitoring, environmental and sustainability information services, ESG data and advisory services, as well as education and research institutions focusing on environmental sustainability and the digital economy. While firms in these industries may vary, what they have in common is that their main value offering is in providing information and analysis on environmental and sustainability issues. In doing so, these firms make heavy use of digital skills and platforms.

Digital-green competencies that commonly fall into Activity 1 include skills such as collecting environmental data and using digital technologies such as databases and analytical software packages to manage, process, and analyze the data. Those working in Activity 1 industries require well-developed research and analytical skills to successfully carry out their work, as well as superior written, verbal, and visual communication skills to communicate their findings to clients, decision makers, and the public. Common domain knowledge needed by Activity 1 workers includes environmental science, sustainability principles, environmental regulations and compliance, and governance and ESG concepts. See Table 4 below.

Table 4: Activity 1 – Consulting and Analyzing, Common Digital-Green Skills and Knowledge

Common Digital-Green Skills	Common Digital-Green Knowledge Areas
• Data analysis • Data visualization *(e.g., Tableau)* • Data modelling and database design • Analytical software *(e.g., STATA, SPSS)* • Energy modelling • Environmental impact assessments • Stakeholder engagement • Business intelligence platforms *(e.g., Power BI)* • Geospatial technologies *(GIS software, GPS, and remote sensing)* • Scientific writing/communication • Programming and coding *(e.g., JavaScript, Python)* • Generative AI • Risk analysis/management • Financial analysis	• Environmental monitoring • Environmental regulations • Environmental management • Regulatory compliance • Environmental auditing • Environmental governance • Natural systems • Environmental sustainability • Environmental science • Nature-based solutions • Climate science/climate change

Based on green occupations data provided by O*NET and complimented by information collected during ICTC's Digital-Green Employer Survey and interviews with experts, key digital-green roles involved in the activity of consulting and analyzing are listed in Table 5 below.

Table 5: *Roles Most Associated with Activity 1: Consulting and Analyzing*

Digital-Green Role	O*NET SOC 2010 Code
Carbon Trading Analyst	13-2051.00
Climate Change Analyst	19-2041.01
Environmental Consultant	13-1199.05
Environmental Economist	19-3011.01
Environmental Scientists and Specialists	19-2041.00
ESG Data Analyst/Data Scientist	15-2051.00
Financial Quantitative Analyst	13-2099.01
Geographic Information Systems Technician	15-1199.05
Geospatial Information Scientists and Technologists	15-1199.04
Industrial Ecologist	19-2041.03
Remote Sensing Scientists and Technologists	19-2099.01
Remote Sensing Technician	19-4099.03
Risk Management Specialist	13-2099.02
Sustainability Specialist	13-1199.05

*Data sources: O*NET Occupational Listings: Green New and Emerging Occupations, Green Increased Demand Occupations, and Green Enhanced Skills Databases: https://www.onetcenter.org/reports/Green.html. ICTC Analysis.*

To better specify the digital-green skills, knowledge areas and occupations that fall under activity 1 (consulting and analyzing) of ICTC's digital-green competency framework, three short case studies on the environmental consulting industry, the use of geospatial technologies in digital-green industries, and the ESG information and advisory services industry are presented below.

Digital-Green Industry of Focus: Environmental Consulting

The environmental consulting industry provides clients with professional advice regarding issues such as regulatory compliance, sustainability, environmental management, and impact assessment. Environmental consulting firms work across Canada. Their services are used by industries such as real estate and construction, infrastructure and transportation, energy, manufacturing, and more.

Environmental consulting firms operate in urban, rural, and remote field settings, collecting samples and data on ecosystem health and human impacts on the natural environment. Data collected in the field typically includes chemical, biological, and geological indicators of air, water, and soil quality. By processing, compiling, and analyzing this data, environmental consultants can draw inferences about ecosystem health—for instance, by informing contaminant levels and risks to ecological and human health.

Through field, laboratory, and data collection workflows, environmental consultants make heavy use of digital technologies to log field measurements. They may also use drones and aircraft to capture remote sensing data, such as aerial photographs and LiDAR scans. Satellite photography is also commonly used as a data source in environmental consulting projects.

In the laboratory, environmental consultants may leverage digital technologies to engage in biogeochemical analytics, such as spectroscopy (e.g., X-ray fluorescence to determine the elemental composition of soil and water samples or isotope-ratio mass spectrometry to measure the relative abundance of isotopes in field samples). In addition to field and laboratory data collection and analysis, environmental consultants also rely on vast masses of data and literature from secondary sources. One environmental consultant interviewed for this study explained that consulting firms are beginning to experiment with AI technology to pull and summarize useful information from written information sources, such as regulatory reports and scientific literature.

Following field and laboratory work, environmental consultants must synthesize all collected information into client deliverables, such as reports and data dashboards. This requires a high level of data analysis, including skills in statistical analysis, data management, and interpretation. This process relies again on digital technologies, such as business intelligence, geographic information systems, and computer-aided design software packages. More and more, environmental consulting firms supplement traditional written reports with data dashboards and 3D visualizations

with data overlays of study sites. Information outputs and recommendations from environmental consulting projects are key information sources for environmental compliance and decision-making activities.

For its heavy use of digital-green skills and its important role in providing information, analysis, and expert advice for regulatory compliance and environmental decision-making, the environmental consulting industry provides a useful example of Activity 1 digital-green industry in Canada.

Geospatial Technologies: The Digital-Green Macroscope

For firms such as environmental consultancies, environmental and sustainability information service providers, environmental research institutes, and ESG advisory—all of which engage heavily in collecting, assessing, analyzing, processing, and reporting environmental information—the use of geospatial technologies, such as geographic information systems (GIS), remote sensing (RS), and global positioning systems (GPS), is very common. Among employers interviewed for this study, geospatial technology often formed critical components of their business activities. For digital-green workers tasked with collecting and analyzing environmental and sustainability data, knowledge of geospatial technologies is an invaluable skill set.

Like other digital technologies, geospatial technologies have rapidly advanced in recent years, taking advantage of more computing power and geographic data. As one digital-green employer interviewed for this study remarked, "Geographic information systems have existed for decades, but I think what's happening right now is we have more access to high-quality data, the methods we use to collect data have become more scalable, and things like satellite imagery have also become a higher resolution."

For example, in environmental consulting, a biologist's GPS field measurements of sensitive flora and fauna can be combined with aerial photography from a manned aircraft or a drone and overlayed over satellite data on vegetation stress in a region of study. These spatial data collected from different sources can be fused in a GIS database and then mapped and visualized for reports and presentations. This geospatial information can be integrated with plans created in computer-aided design (CAD) software to understand how building a new industrial project might affect the natural environment.

As University of Kansas geography professor Jerome E. Dobson observes, "Collectively, GIS, GPS, satellite remote sensing, and popular geographics constitute a macroscope that allows scientists, practitioners, and the public alike to view the earth as never before."[72] This geospatial macroscope enables a newfound level of data fusion and data-driven decision-making and is immensely useful in digital-

[72] Jerome Dobson, "Through the Macroscope: Geography's View of the World," Esri, N.D., https://www.esri.com/news/arcnews/winter1112articles/through-the-macroscope-geographys-view-of-the-world.html.

green industries, enabling data-informed decision-making and planning like never before. The ability to measure, analyze, process, compare, map, and visualize our natural and built environments presents a powerful tool for digital-green workers.

Digital-Green Industry of Focus: ESG Information and Advisory Services

Environmental, social, and corporate governance (ESG) is a concept that helps business leaders, investors, and the public understand corporate performance and business health in a more nuanced way than just relying on financial metrics alone.[73] The Corporate Finance Institute describes ESG as a "framework" to help organizations and their stakeholders "understand how an organization is managing risks and opportunities related to environmental, social, and governance criteria."[74] From an environmental or sustainability perspective, ESG measures companies on performance criteria such as energy use, pollution and waste management, greenhouse gas emissions, and land use and natural resource stewardship.

Consumers of ESG information, such as banks and financial institutions, government regulators, and individual investors,[75] turn to ESG information and advisory services to understand, benchmark, and compare corporate and industry performance across the environmental, social, and corporate governance spheres. Specific ESG metrics, measurement methodologies, and reporting frameworks vary by company and industry, but what is common across ESG advisory and information services is the significant number of digital technologies used in the collection and reporting of data.

Those working for ESG information and advisory firms use financial and environmental concepts alongside data science methods to collect, manage, analyze, and disseminate complex and up-to-date ESG datasets to clients.

These data are collected from a variety of sources, including corporate annual reports, regulatory filings, third-party reports, and other publicly available information, as well as more esoteric sources, such as satellite imagery. As one analyst interviewed for this study stated, "There are a lot of data points that we extract from company documents and from third-party resources."

Collected data is analyzed by data scientists and financial analysis and applied to different proprietary ESG frameworks and financial risk management concepts, such as Value at Risk (VaR). To deal with this deluge of data, scripting languages such as JavaScript, Python, and R are commonly used in the industry, according to interviewees. Firms working in the ESG information and advisory industry have also begun experimenting with generative AI tools to manage, analyze, and forecast ESG

[73] See: BDC, "What is ESG and what does it mean for your business?" accessed February 28, 2024, https://www.bdc.ca/en/articles-tools/sustainability/environment/what-esg-and-what-does-mean-business.
[74] Kyle Peterdy, "ESG (Environmental, Social, & Governance)," Corporate Finance Institute, accessed February 28, 2024, https://corporatefinanceinstitute.com/resources/esg/esg-environmental-social-governance/.
[75] Fabrizio Tocchini and Grazia Cafagna, "Who is looking at your ESG performance data?" Wolters Kluwer, December 12, 2022, https://www.wolterskluwer.com/en/expert-insights/who-is-looking-at-your-esg-performance-data.

data. The resulting ESG information, analysis, and predictive modelling are shared with clients using custom data dashboards, common financial industry information platforms such as Bloomberg Terminal, and business intelligence software such as Microsoft Power BI.

With successive new governments, ESG reporting regulations in jurisdictions such as Canada and the European Union, ESG information and advisory service firms will undoubtedly continue to be in demand. For example, under its Corporate Sustainability Reporting Directive (CSRD), the European Union now requires companies to report "risks and opportunities arising from social and environmental issues," as well as how their business activities affect "people and the environment."[76] In Canada, more and more voluntary guidelines related to corporate ESG reporting, such as the Climate Investment Taxonomy, are becoming involuntary requirements under Canadian legislation.[77] Changes in public policy, as it relates to ESG reporting, means a wave of digital-green talent skilled in ESG data collection, reporting, and strategizing will be needed to ensure compliance with new legislation.

ACTIVITY 2: DESIGNING AND BUILDING

Humans have been designing and building infrastructure, such as homes, roads, bridges, and communities, for millenniums. While this activity is not new, modern-day design and building practices differ greatly from practices held decades to centuries ago. Through the adoption of industrial and technological tools, the processes for designing and building have been greatly enhanced, allowing humans to scale the built environment.

In the past, environmental sustainability was not always top of mind in design and building processes. Much of the built environment in Canada today, especially in residential areas, relies heavily on oil and gas for home heating.[78] Other infrastructure may lack proper insulation and modern windows and roofs, resulting in energy losses and increased reliance on oil and gas for temperature regulation.[79] As a result, the built environment is responsible for 13% or 88 megatons (Mt) of Canada's greenhouse gas emissions.[80] Much of these emissions (78%) stem from the use of fossil fuels, such as natural gas for water and space heating.[81]

[76] European Commission (European Union), "Corporate sustainability reporting," https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en.
[77] Noah Miller, ESG Regulation in Canada, Corporate Finance Institute, accessed March 13, 2024, https://corporatefinanceinstitute.com/resources/esg/esg-regulation-in-canada/.
[78] Nichole Dusyk, and Lasse Toft Christensen, "Why Canada's Energy Security Hinges on Renewables," International Institute for Sustainable Development, October 2022, https://www.iisd.org/system/files/2022-10/bottom-line-canada-energy-security.pdf.
[79] Ted Kesik, Liam O'Brien, and Aylin Ozkan, "Thermal Resilience Design Guide," University of Toronto, May 2019, https://pbs.daniels.utoronto.ca/faculty/kesik_t/PBS/Kesik-Resources/Thermal-Resilience-Guide-v1.0-May2019.pdf.
[80] Natural Resources Canada, "The Canada Green Buildings Strategy - Discussion Paper," July 2022, https://natural-resources.canada.ca/sites/nrcan/files/public-consultation/CGBS_Discussion_Paper_EN_1.pdf.
[81] Natural Resources Canada, "Comprehensive Energy Use Database," 2018, https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/menus/trends/comprehensive_tables/list.cfm.

Additionally, much of Canada's built environment lacks resiliency to climate change. According to estimates by the Canadian Institute for Climate Choices, 14% of Canadian homes are in regions with high flood risks.[82] As climate change accelerates sea level rise and alters precipitation norms (e.g., increased rainfall), "flood damage to homes and buildings across Canada could increase fivefold in the next few decades and by a factor of 10 by the end of the century, costing as much as $13.6 billion annually."[83] Moreover, public infrastructure, such as roads, bridges, airports, electricity grids, and water systems, lack resiliency to climate change. As temperatures rise, electricity distribution systems will be stressed, and highways and roads will be more likely to crack and degrade.[84]

Canada's buildings sector must undergo transformational changes to mitigate climate change and enhance infrastructural resiliency. Canada's 2030 Emissions Reductions Plan has the ambitious target of reducing direct residential, commercial, and institutional building emissions by 53 Mt by 2030—a 37% reduction from 2005 levels. A reduction in GHG emissions of this scale will require concerted and cross-industry efforts in decarbonization, including electrifying space and water heating and retrofitting current buildings with new materials and smart technologies that drive energy efficiency.[85] In addition to this, nature-based solutions, such as green infrastructure (e.g., urban forests, green roofs, and permeable surfaces) and blue infrastructure (e.g., constructed wetlands and flood line buffer zones) will be needed to enhance the absorption and proper drainage of rainwater, reduce the urban heat island effect, build resiliency to coastal erosion, and sequester carbon.[86]

As the built environment works to reduce GHG emissions and adapt to climate change, a new wave of digital-green skills and knowledge is needed (see Table 6). Industries directly involved in designing and building activities, such as architecture and design, construction and the skilled trades, engineering (e.g., civil, structural, electrical and industrial), utilities, and urban planning and development will require skilled personnel who have basic to advanced levels of digital literacy and knowledge of environmental sustainability.

[82] The Canadian Institute for Climate Choices, "Under Water: The Costs of Climate Change for Canada's Infrastructure," September 2021, https://climatechoices.ca/wp-content/uploads/2021/09/Infrastructure-English-FINAL-Sep29.pdf.
[83] Ibid.
[84] United States Environmental Protection Agency (United States Government), "Climate Change in the United States: Benefits of Global Action," March 2021, https://www.epa.gov/sites/default/files/2021-03/documents/cirareport.pdf.
[85] Vancouver Economic commission and Building to Electrification Coalition, "BC Heat Pump Technology Attraction Strategy," November 2021, https://vancouvereconomic.com/programs/bc-heat-pump-strategy/; Natural Resources Canada, "The Canada Green Buildings Strategy - Discussion Paper," July 2022.
[86] Nanco Dolman and Mily O'Donnell, "5 lessons learned from blue-green infrastructure delivery," Institution of Civil Engineers, July 6, 2021, https://www.ice.org.uk/news-and-insight/the-civil-engineer/july-2021/theory-and-practice-of-blue-green-infrastructure.

Table 6: Activity 2 (Designing and Building) Common Digital-Green Skills and Knowledge Areas

Common Digital-Green Skills	Common Digital-Green Knowledge Areas
• Computer programming and coding • Digital literacy • Data analysis • Building information modelling • Energy modelling • Engineering • Project management • Equipment operation • Computer-aided drafting • Immersive technologies (e.g., augmented reality, virtual reality) • 3D printing	• Renewable energy • Climate change adaptation • Nature-based solutions • Environmental sustainability • Energy efficiency • Regulatory compliance • Environmental legislation and regulations • Building codes

Interviewees engaged in this study noted that traditional skills in design and building will not become obsolete; instead, additional digit-green skills will be added. Key digital-green roles involved in the activity of designing and building are listed in Table 7 below.

Table 7: Roles Most Associated with Activity 2: Designing and Building

Digital-Green Role	O*NET SOC 2010 Code
Architectural Drafters	17-3011.01
Computer Software Engineers, Systems Software	15-1032.00
Electricians	47-2111.00
Installation, Maintenance, and Repair Workers	49-9098.00
Carpenters	47-3012.00
Industrial Engineers	17-2112.00
Insulation Workers, Floor, Ceiling, and Wall	47-2131.00
Architects, Except Landscape and Naval	17-1011.00
Construction and Building Inspectors	47-4011.00
Electrical Engineers	17-2071.00
Heating and Air Conditioning Mechanics and Installers	49-9021.01
Nuclear Power Reactor Operators	51-8011.00
Power Plant Operators	51-8013.00
Urban and Regional Planners	19-3051.00

Urban and Regional Planners	19-3051.00
Biofuels/Biodiesel Technology and Product Development Managers	11-9041.01
Energy Engineers	17-2199.03
Geothermal Technicians	49-9099.01
Hydroelectric Production Managers	11-3051.06
Industrial Ecologists	19-2041.03
Solar Energy Systems Engineers	17-2199.11
Sustainability Specialists	13-1199.05
Wind Energy Engineers	17-2199.10

Data sources: *O*NET Occupational Listings: Green New and Emerging Occupations, Green Increased Demand Occupations, and Green Enhanced Skills Databases: https://www.onetcenter.org/reports/Green.html. ICTC Analysis.*

Common digital-green skills and knowledge areas required by workers in Activity 2 (Designing and Building) are expanded upon in the following case studies. One case study looks at the broad array of digital-green skills needed to retrofit the built environment, while the other looks at specific skill sets required for sustainable design.

From Assessment to Design to Installation: Digital-Green Skills for Retrofitting

Widespread retrofitting is needed to enhance energy efficiency and reduce greenhouse gas emissions across Canada's built environment. Given the growing demand for retrofits, Canada's energy-efficiency labour market is poised for growth. In 2018, energy efficiency employment across Canada comprised 435,994 permanent employees, much of whom were in construction (286,703 people, or 66% of total employment).[87] Key tasks included in retrofitting the built environment are:

- Updating or installing insulation
- Sealing infrastructure with caulking or spray
- Switching to energy-efficient lighting fixtures
- Replacing windows and doors
- Updating heating and cooling systems
- Installing submetering systems to monitor water and electricity usage

[87] Eco Canada, "Energy Efficiency Employment in Canada," 2019, https://eco.ca/new-reports/energy-efficiency-canada/.

- Replacing roofs to change how much solar energy is either absorbed or reflected
- Adding windows to increase sunlight exposure
- Updating ventilation systems, such as installing geothermal heat pumps[88]

The above tasks rely on talent who possess a mix of digital skills, green skills, traditional technical skills, and know-how in the skilled trades, engineering, and construction sectors. Some workers involved in retrofitting will have specialist digital-green skills as a core part of their role, while others have generalized digital-green skills added to their traditional knowledge.

To ensure optimal results, retrofits should be data-informed. This requires a thorough assessment to understand the current state of energy efficiency in a building and identify retrofit opportunities to create long-term energy and cost savings. Individuals involved in retrofit assessments must have strong digital skills and environmental knowledge. In some instances, individuals with the right mix of specialist skill sets—including data collection, analysis, knowledge of environmental regulations and building codes, and the ability to develop operating plans and procedures—can lead a retrofit assessment and design process. Referred to as "retrofit assessors," these individuals are highly skilled in both the digital and green domains. In other instances, retrofit assessments may be performed by a group of individuals, such as engineers, data scientists, and environmental professionals, who have complementary skills in environmental assessment, data analysis, and sustainable design.

Following proper assessment, building information modelling processes can be leveraged in the retrofit design process. This may include collecting data on the natural environment, such as solar exposure and solar angle and wind and weathering exposure paired with building information, to model the most efficient retrofit. Some individuals working in architecture and engineering may rely on data science skills, software programming, and 3D printing skills to model the most sustainable design. As detailed by one interviewee, considering environmental and structural factors in the design process is critical to designing efficient homes and building improvements. Building information modelling is equally helpful to new builds as it is to buildings that are being retrofitted. Another interviewee working in a skilled trades support organization noted that building information modelling can help alleviate stress from workers in the skilled trades: "Building modelling takes so much of the pressure away from the trades part of it… If you properly engineer buildings to start with, you remove work down the line… I think that's a huge opportunity there."

[88] Natural Resources Canada, "Smarter Energy Use in Canada: Report to Parliament Under the Energy Efficiency Act," 2019, https://oee.nrcan.gc.ca/publications/statistics/parliament/2018-2019/pdf/2018-19-ReportToParliament-EEAct-EN.pdf; also see: Energy Efficiency, Natural Resources Canada, last update December 21, 2023, https://natural-resources.canada.ca/energy-efficiency/10832.

Following assessment and modelling, the installation, repair, and construction processes of retrofitting take place. This relies heavily on hands-on knowledge in the skilled trades who can demolish and remove old, weathered, and inefficient systems and replace them with new and efficient systems and materials. More specifically, these individuals are responsible for installing energy-efficiency technologies and materials, such as efficient lighting, insulation, HVAC systems, ENERGY STAR or other high-efficiency and/or renewable energy-powered heating and cooling equipment, water efficiency products and appliances, and other building materials.[89]

Retrofitting buildings with energy-efficient equipment requires enhanced knowledge as compared to traditional trade activities. This is creating challenges for employers in hiring qualified candidates to carry out such tasks.[90] According to an employer survey by ECO Canada, 85% of employers cite difficulties hiring individuals able to install ENERGY STAR appliances; 91% cite having difficulties hiring individuals able to install ENERGY STAR and other high efficiencies; 82% have difficulties hiring individuals able to install HVAC goods, control systems and services; and 81% cite difficulties hiring individuals qualified to install reduced water consumption products and appliances. Labour market challenges differ by region, with some regions having a higher demand for certain skill sets. Nova Scotian clean economy employers who met with ICTC at a roundtable event on in-demand digital-green skills noted that HVAC technicians were particularly challenging to come by in the province. As noted by one attendee, "I think there is only one qualified HVAC technician in Cape Breton [Nova Scotia]."

Interviewees engaged in this study also noted that construction and skilled trades workers engaging in retrofits require a new awareness of environmental sustainability and climate change. These workers must understand the value-add (e.g., cost savings, energy savings) of retrofits and the broader importance of retrofits in mitigating climate change. Additionally, there is a growing demand for individuals working in the skilled trades to understand and engage in recycling programs to drive proper disposal and reuse of metals and other materials used in the retrofit process.

Skills for Sustainable Design

Individuals involved in designing new builds must have a breadth and depth of digital-green knowledge. Individuals working in sustainable design must know how to use unique software tools and understand specific aspects of environmental science, environmental regulations, and building codes while also having the required professional designations. Drawing upon findings from ICTC's Digital-Green Employer Survey (n=301) and insights from key informant interviews, this case study highlights the interdisciplinarity of workers engaging in the activity of sustainable design.

[89] Eco Canada, "Energy Efficiency Employment in Canada," 2019.
[90] Ibid.

A subset of these employers surveyed by ICTC self-identified as belonging to the Design, Planning, and Engineering Services industry (n=20). These employers were asked to identify the most important software skills, environmental skills, and environmental knowledge areas they desire in current and future employees. Of these skills, the Design, Planning, and Engineering Services employers detailed the following as most important:

- Industrial Design and Control Software (60%)
- Image Processing, Graphical, and Design Software (50%)
- Understanding of environmental legislation and agreements (45%)
- Understanding of global environmental trends, challenges, concerns, and solutions (40%)

These software skills, environmental skills, and environmental knowledge areas converge to create digital-green talent capable of mapping out design solutions that comply with environmental regulations and address environmental challenges. Interviewees engaged in this study noted that workers engaged in sustainable design are not specialists in any one area. Instead, they must be well-equipped with digital skills, environmental knowledge, and domain knowledge related to architecture, building codes, and design processes. Most engineering and architecture firms also require employees working in sustainable design to hold professional designations or certifications, such as:

- Leadership in Energy and Environmental Design (LEED) designation[91]
- The Canadian Green Building Council's Zero Carbon Building (ZCB) standards[92]
- Total Resource Use and Efficiency (TRUE) certification[93]
- Investor Ready Energy Efficiency (IREE) certification[94]

Of the above certifications and designations, LEED is perhaps the most prevalent requirement for sustainable design professions in Canada today. One-quarter of employers surveyed by ICTC stated that the LEED designation was important for current and future employees to possess. This was higher for employers who identified as belonging to the digital-green economy (27%) than those who identified as just belonging to the green economy (19%). This difference is likely due to the digital-green nature of sustainable design, which is leveraging digital tools and data to inform sustainable design plans and decisions.

[91] See: "Leading Green," accessed March 19, 2024, https://leadinggreen.com/.
[92] "Zero Carbon Building Standards: A made-in-Canada solution," Canada Green Building Council, accessed March 19, 2024, https://www.cagbc.org/our-work/certification/zero-carbon-building-standard/.
[93] "TRUE: A certification for zero waste performance," Canada Green Building Council, accessed March 19, 2024, https://www.cagbc.org/our-work/certification/true/.
[94] "Investor Ready Energy Efficiency," Canada Green Building Council, accessed March 19, 2024, https://www.cagbc.org/our-work/certification/investor-ready-energy-efficiency/.

ACTIVITY 3: PRODUCING AND MANUFACTURING

Canada's race to net-zero has resulted in a growing demand for resources and products that are environmentally sustainable. Consumers are demanding that their products be carbon neutral or upcycled, and companies are seeking to lower and/or eliminate their scope 2 and 3 emissions.[95] As climate mitigation moves up the social, corporate, and government agendas, there is an increased demand for products that support a transition to net-zero. This includes increases in the production of clean and renewable energy, clean technologies, sustainable agri-food, electric vehicles (EVs), energy-efficient appliances and systems, and sustainable consumer goods. This is creating operational and labour market shifts in industries heavily involved in production and manufacturing, such as agri-food, advanced manufacturing, biological and chemical technology, clean and renewable energy, and mining.

Many industries involved in producing and manufacturing are undergoing digitalization, which is driving efficiency and sustainability gains. This includes integrating and leveraging Industry 4.0 technologies, such as artificial intelligence (AI), the internet of things (IoT), big data, and machine learning (ML), into operational processes and flows to yield sustainable outcomes. As a result, skill sets required for producing and manufacturing are evolving to include a greater focus on basic to advanced digital skills (Table 8). At the same time, individuals involved in this activity must leverage principles of environmental sustainability such as resource efficiency and climate change mitigation in their work.

Table 8: *Activity 3 (Producing and Manufacturing): Common Digital-Green Skills and Knowledge Areas*

Common Digital-Green Skills	Common Digital-Green Knowledge Areas
• Robotics and automation • Energy modelling optimization • Data analysis • Environmental remediation • Digital literacy • Cybersecurity • 3D printing • Computer programming and coding • Cloud computing • Equipment operation • Installation and maintenance	• Environmental legislation and regulations • Environmental sustainability • Natural resource management • Sustainable procurement • Climate change and global environmental trends • Climate change mitigation

[95] "Building sustainability into operations," McKinsey & Company, October 19, 2022, https://www.mckinsey.com/capabilities/operations/our-insights/building-sustainability-into-operations.

While specific digital-green skills differ from industry to industry, the skill sets characterized by the following roles are increasingly incorporating the digital-green skills and knowledge areas outlined in Activity 3 (producing and manufacturing) of ICTC's competency framework (Table 9).

Table 9: *Roles Most Associated with Activity 3: Producing and Manufacturing*

Digital-Green Role	O*NET SOC 2010 Code
Precision Agriculture Technician	17-2199.07
Robotics Engineer	13-2099.02
Robotics Technicians	17-2199.08
Validation Engineers	17-2199.02
Biochemical Engineers	17-2199.01
Electromechanical Engineering Technologists	17-3029.03
Electronics Engineering Technologists	17-3029.03
Manufacturing Engineering Technologists	17-3029.06
Manufacturing Engineers	17-2199.04
Manufacturing Production Technicians	17-3029.09
Mechanical Engineering Technologists	17-3029.07
Mechatronics Engineers	17-2199.05
Installation, Maintenance, and Repair Workers	49-9098.00
Industrial Production Managers	11-3051.00
Computer Software Engineers, Systems Software	15-1032.00
Computer-Controlled Machine Tool Operators, Metal and Plastic	51-4011.00
Agricultural Technicians	19-4011.01

Data sources: *O*NET Occupational Listings: Green New and Emerging Occupations, Green Increased Demand Occupations, and Green Enhanced Skills Databases: https://www.onetcenter.org/reports/Green.html. ICTC Analysis.*

In-demand digital-green skills used in production and manufacturing are expanded upon below in the following case studies. One case study details the digital-green skill in advanced manufacturing, while the other touches on the increasing need for electronics, hardware, and robotics skills in various industries involved in production and manufacturing.

Industry of Focus: Advanced Manufacturing

Advanced manufacturing makes use of innovative technologies such as Industry 4.0 technologies to optimize production methods and processes.[96] The integration of Industry 4.0 technologies in manufacturing has provided increased data, information, and insights into all aspects of manufacturing processes, including their environmental impacts.[97] This has created a new wave of manufacturers who are leveraging digital technologies and tools to provide data-informed decision-making and drive efficiencies that enhance business sustainability (e.g., reducing production costs, improving product quality, and enhancing business agility) and environmental sustainability (e.g., reducing waste, consumption, and greenhouse gas emissions).[98]

Skills required in sustainable advanced manufacturing span software skills, data science and data management skills, mechanical engineering skills, and environmental skills and knowledge areas.[99] These skills are applied to varying degrees across key Industry 4.0 technologies used in advanced manufacturing, such as cyber-physical systems, big data and analytics, cloud computing, IT security systems, autonomous robots, additive manufacturing, and immersive technologies.[100]

Cyber-physical systems include sensors, actuators, and intelligent software that connect the virtual environment to the physical environment. Leveraging these systems requires skilled personnel with hardware and software skills who can install, maintain, and make use of cyber-physical technologies in day-to-day operations. Big data and analytics are then used to make sense of information gathered from sensors, actuators, and intelligent software. Complimentary to this, skills in cloud computing are required to ensure data is properly stored and computed. Big data, analytics, and cloud computing require personnel skilled in storing, processing, and computing data through algorithms, programming, and coding to provide a real-time analysis of information gathered throughout a manufacturing process. This information may include information related to environmental sustainability key performance metrics, including water consumption, energy consumption, greenhouse gas emissions, and/or environmental toxicity. By pairing IoT devices with data analytics, strategic planning, and in some instances, process simulation technologies, advanced manufacturing companies can optimize resource efficiency and sustainability.

[96] Christian Cavallo, "What is Advanced Manufacturing?" Thomas, May 29, 2023, https://www.thomasnet.com/articles/services/what-is-advanced-manufacturing/.
[97] Francisco Betti, Enno de Boer, and Yves Giraud, "Lighthouses unlock sustainability through 4IR technologies," McKinsey & Company, September 27, 2021, https://www.mckinsey.com/capabilities/operations/our-insights/lighthouses-unlock-sustainability-through-4ir-technologies; "Building sustainability into operations," McKinsey & Company, October 19, 2022.
[98] Ibid.
[99] Elizabeth Moore, et al., "Preparing the Advanced Manufacturing Workforce: A Study of Occupation and Skills Demand in the Advanced Robotics Industry," Massachusetts Institute of Technology, August 2021, https://cam.masstech.org/sites/default/files/2022-06/Robotics-Roadmap-Report-Nov2021.pdf.
[100] Florian Ernst and Patrick Frische, "Industry 4.0/Industrial Internet of Things - Related Technologies and Requirements for a Successful Digital Transformation: An Investigation of Manufacturing Businesses Worldwide," Department of Strategy & Organisation, University of Strathclyde, 2015, available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2698137.

In addition to IoT devices, advanced manufacturing relies on applied technologies that help build more efficient and precise manufacturing processes. Automation and robotics are increasingly utilized in manufacturing processes, while additive manufacturing, or 3D printing, is increasingly used to produce rapid prototyping and, in some instances, is used in mass production.[101] Automation, robotics, and 3D printing are increasing the demand for mechanical engineers, machine operators, and service technicians who have strong hardware, electronic, and robotics skills.[102] Moreover, immersive technologies, such as augmented reality (AR), can be used in the manufacturing process to enhance worker precision. This is especially important for manufacturing processes that cannot be automated, such as aerospace manufacturing, which is done predominantly by hand; using immersive technologies can reduce human errors, increase safety, and drive efficiencies.[103]

Moreover, IT security systems underpin Industry 4.0 technologies across the entire advanced manufacturing process. These IT security systems are used to support the optimal functioning of software and digital devices while also protecting against cybersecurity risks. As manufacturing processes become increasingly digital in nature, it will be critical to have individuals who can understand and regulate the complex inner workings of IT networks and safeguard them against security risks. Key cybersecurity skills and specializations are Network Administration, General Cybersecurity Analytics, Incident Response, and Digital Forensics.[104]

In-Demand Electronics, Hardware, and Robotics Skills for Producing and Manufacturing

ICTC surveyed digital economy employers (n=163) and digital-green employers (n=86) on their skills demands.[105] In this survey, ICTC asked employers to select the importance of specific electronics, robotics, and hardware skills for current and future employees to have (Figure 6). Approximately 80% of these employers noted that electronics, hardware, and robotics skills were not applicable to their organization. This finding is not surprising, as most Information and Communications Technology (ICT) companies (91.6%) in Canada operate in the subsector of software and computer services and prioritize software skills over hardware skills.[106]

[101] Chris Herron, Maryna Ivus, and Akshay Kotak, "Just Press 'Print': Canada's Additive Manufacturing Ecosystem," ICTC, May 2021, https://ictc-ctic.ca/reports/just-press-print.
[102] Elizabeth Moore, Frank Field, Richard Roth, and Randolph Kirchain, "Preparing the Advanced Manufacturing Workforce: A Study of Occupation and Skills Demand in the Advanced Robotics Industry," Massachusetts Institute of Technology, August 2021, https://dspace.mit.edu/bitstream/handle/1721.1/143869/Robotics%20Roadmap%20Report%20Nov%202021.pdf?sequence=1&isAllowed=y; "Role of 3D Printing in Manufacturing Industry," Zeal 3D, November 08, 2022, https://www.zeal3dprinting.com.au/how-3d-printing-is-changing-the-manufacturing-industry/.
[103] "How to Adopt Augmented Reality for Quality Control In Aerospace Manufacturing," LightGuide Systems, June 20, 2022, https://www.lightguidesys.com/resource-center/blog/how-to-adopt-augmented-reality-for-quality-control-in-aerospace-manufacturing/; "How Lockheed Martin is Using Augmented Reality in Aerospace Manufacturing," engineering.com, August 13, 2019, https://www.engineering.com/story/how-lockheed-martin-is-using-augmented-reality-in-aerospace-manufacturing; "How Augmented Reality Can Modernize Aerospace And Defense Manufacturing," SAE International, December 1, 2019, https://www.mobilityengineeringtech.com/component/content/article/35685-how-augmented-reality-can-modernize-aerospace-and-defense-manufacturing.
[104] Chris Herron and Trevor Quan, "Cybersecurity Talent Development: Protecting Canada's Digital Economy," ICTC, March 2022, https://ictc-ctic.ca/reports/cybersecurity-talent-development.
[105] See Appendix for primary research methods.
[106] "Canadian ICT Sector Profile 2021," Innovation, Science and Economic Development Canada, last update August 17, 2022, https://ised-isde.canada.ca/site/digital-technologies-ict/en/canadian-ict-sector-profile.

However, some digital-green industries rely more heavily on electronics, hardware, and robotics skills. Survey respondents who selected that these skills were important self-selected into the following industries: natural resources (e.g., agriculture, forestry, fishing, and mining), industrial manufacturing, and clean technology (e.g., energy storage, smart grid, precision agriculture tech, and clean transportation tech), all of which partake in production and manufacturing.

Of the employers who noted electronics, hardware, and robotics skills to be in demand, about one-quarter (26% of digital economy employers and 22% of digital-green employers) placed importance on employees who could "install or program computer hardware, machines, or instrumentation software." Similarly, employers placed importance on employees who could "inspect, maintain, and repair electrical, electronic, or mechanical components, equipment, or systems to ensure proper functioning," with 20% of digital economy and 24% of digital-green economy respondents noting these capabilities to be important. Moreover, employers noted a demand for employees who could "read blueprints, schematic diagrams, or technical engineering orders for assembling electronic units," with 12% of the digital economy and 30% of digital-green economy employers noting these skills as in demand. See Figure 5 for more information.

Reflecting on your organization's skils needs, which of the following electronics, robotics, and hardware skills are important for current and future employees to possess?

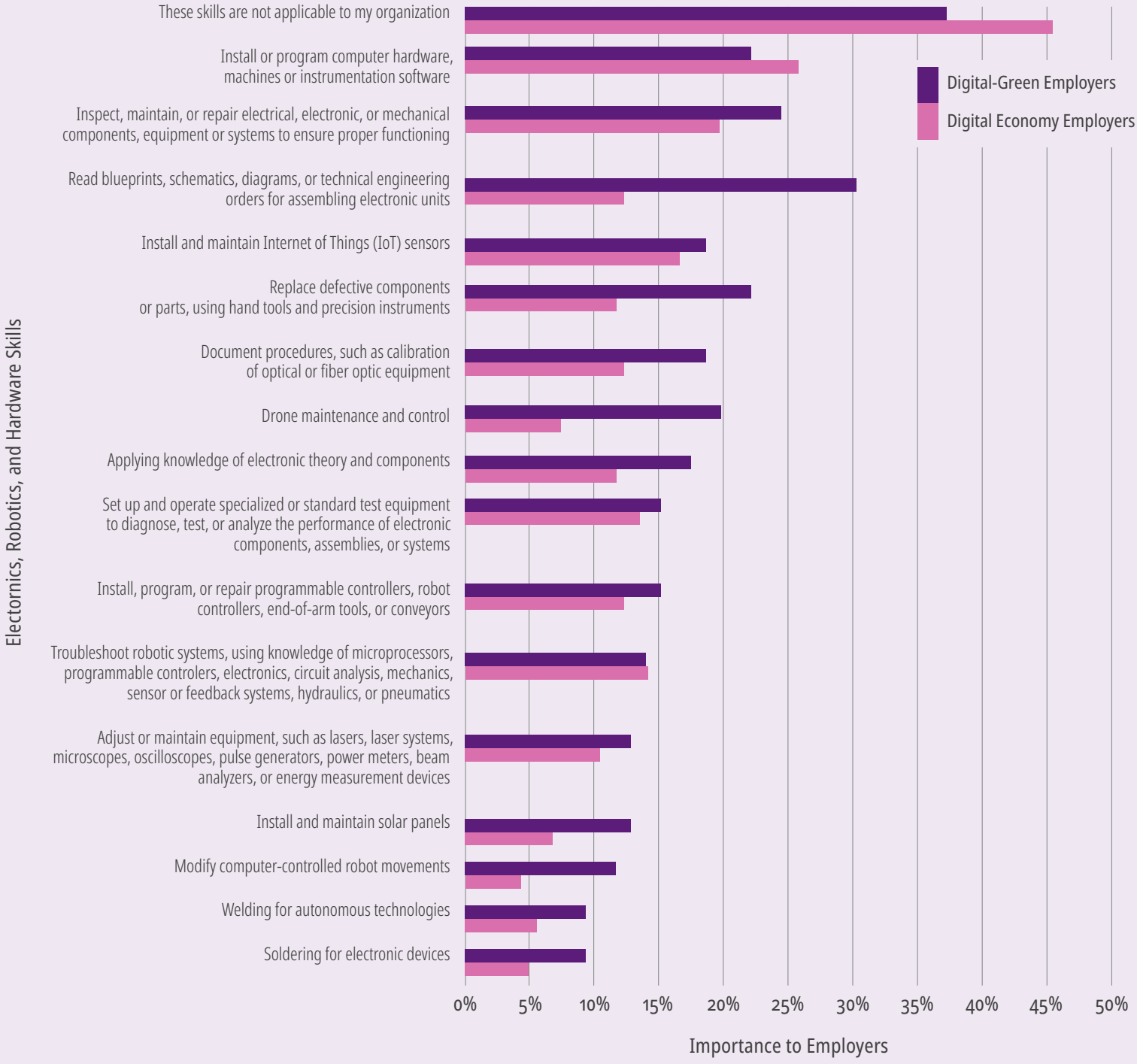

Figure 5: *The importance of electronics, robotics, and hardware skills to Canadian employers that operate in the digital economy (n=163) and to employers that operate in both the digital and green economies (n=86). A total of 249 employers responded to this question.*

These electronics, robotics, and hardware skills are applied differently in various industries. In agriculture, an agricultural engineer or an agricultural technician may be tasked with installing sensors that monitor animal health and nutrition or programming precision agriculture technologies to eliminate pesticide and herbicide spray in regions that border waterways to reduce contaminated runoff in surrounding freshwater ecosystems. In the energy sector, individuals in the skilled trades may use hardware, robotics, and electronic skills to ensure nuclear energy and/or bioenergy plants operate in a safe and efficient manner. Regardless of industry, workers engaging in production and manufacturing require a strong level of technical know-how related to installing, monitoring, and maintaining technologies that enable environmental sustainability gains.

ACTIVITY 4: MANAGING, REGULATING, AND ACCOUNTING

Management's significance in today's world cannot be overstated. Whether it's coordinating natural and human resources, managing economic activities concerning the environment, or harnessing talents and skills to achieve key objectives, its importance is key and multifaceted. Organizations and systems rely on management for their functioning, making it indispensable. In the environmental context, management serves as the cornerstone around which all other organizational elements orbit. Its pervasive influence shapes how organizations navigate, comprehend, and respond to various challenges and opportunities. Effective management is a crucial skill for guiding organizations toward sustainability and enabling them to adapt to the ever-evolving landscape of digital-green skills.

Regulations serve as important safeguards to protect the environment from pollution and harm. Regulatory laws and frameworks play a crucial role in ensuring the effective management of resources and providing environmental protection. Canada has various regulations in place, including the Canadian Environmental Protection Act, to safeguard the environment from pollution.[107] Regulatory frameworks such as the renewable energy targets and proposed framework for air emissions[108] offer essential guidance for businesses and industries, influencing their practices toward more sustainable approaches.

GHG accounting, also referred to as carbon accounting, involves measuring the total emissions of GHG gases produced and released into the atmosphere by companies.[109] It enables companies to trade carbon credits fairly in the market and gain insight into the primary sources of their emissions. Furthermore, it allows for the quantification of GHG generated, assigning them a value for fair trade in the carbon market.[110] This promotes transparency among investors, employees, and customers while also empowering individuals or companies responsible for emissions to adopt new habits aimed at reducing emissions.

[107] "Canadian Environmental Protection Act," Environment and Climate Change Canada, February 08, 2024, https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry.html.
[108] "Regulatory Framework for Air Emissions," Government of Canada, 2007, https://www.ec.gc.ca/doc/media/m_124/report_eng.pdf.
[109] Michael Gillenwater, "Examining the impact of GHG accounting principles" Carbon Management, vol 13, October 2022, 550-553, https://www.tandfonline.com/doi/full/10.1080/17583004.2022.2135238.
[110] Ibid.

Primary research participants underscored the critical role of managing, regulating, and accounting activities in shaping the digital-green future. Some interviewees felt that without effective management practices and effective regulatory frameworks, the potential of digital technologies to drive environmental sustainability may be untenable. Others stressed the need for proactive management approaches to foster innovation and drive organizational change toward sustainable practices.

Activity 4 encompasses skills, roles, and industries within the digital-green economy that are primarily dedicated to managing or regulating sustainable economic activities and interactions with the natural environment. This includes all sectors involved in overseeing, regulating, and accounting for human and economic activities that impact the natural environment. Digital-green competencies that commonly fall into Activity 4 include environmental management skills, risk management and stakeholder management, project management, cybersecurity, and knowledge of digital governance, digital ethics, and environmental regulations (Table 10). The specialized skill sets and knowledge areas required for managing, regulating, and accounting are expanded upon below.

Table 10: *Activity 4 (Managing, Regulating and Accounting) Common Digital-Green Skills and Knowledge*

Common Digital-Green Skills	Common Digital-Green Knowledge Areas
• Environmental management • Policy analysis and development • Data analysis • GHG/Environmental accounting • GHG Emissions Management • Project Management • Risk Management • Change Management • Human and Resource Management • Natural Resource Management • Stakeholder Management	• Digital governance • Environmental science • Regulatory compliance • Data governance and management • Environmental regulations, legislation and policy • Digital ethics • Environmental management and monitoring • Climate change • Environmental conservation • Sustainability • Cybersecurity • Privacy regulation

Commonly cited as in-demand by interviewed employers, the ability to understand and comply with environmental and digital regulations is critical, especially for those directly involved in the activities of managing, regulating, and accounting. This includes the ability to navigate the complex regulatory landscapes related to environmental standards, data protection laws, and industry-specific regulations. This is critical to environmental management professionals and digital governance professionals.

An understanding of environmental legislation and regulations is increasingly important across all industries and in the digital-green economy. "Understand, enforce, and comply with environmental regulations and standards and communicate standards to industry workers" was one of the most important environmental skill sets selected by employers surveyed for this study, with 33% of green economy employers and 38% of digital-green employers listing this skill as important (see Figure 8 below). Similarly, 38% of green economy employers and 37% of digital-green employers reported that an understanding of "environmental legislation and agreements" is important for current and future employees to possess (see Figure 7 below). Skills and knowledge related to environmental legislation and regulations are needed to ensure public and private sector operations adhere to established government policies, industry standards, and regulatory frameworks. This is needed to foster a well-regulated business environment that supports ecological and socioeconomic sustainability.

Broadly speaking, the skill sets of environmental management, regulatory compliance, and risk management go hand in hand. Environmental management includes the sustainable management of resources, such as energy, water, minerals and elements, flora, and fauna. Managing these resources sustainably requires a keen understanding of environmental regulations, legislation, standards, and best practices. At the same time, resource management relies on a thorough understanding of environmental risks such as land use change, aquatic and terrestrial contamination, greenhouse gas emissions, and biodiversity loss. Professionals working in environmental management must have an in-depth knowledge of environmental science, ecological systems, environmental contaminants, and remediation techniques. The specificity of this knowledge differs depending on the industry or organization in which environmental management is being performed.

In the corporate world, there is a growing need for individuals who can perform greenhouse gas emissions accounting to track and report on emissions reduction progress. An interviewee engaged in this study noted that greenhouse gas emissions accounting has similar skill sets to that of a financial analyst or accountant, paired with a keen understanding of climate change, greenhouse gases, and climate mitigation. Greenhouse gas accounting involves analysis, management, and interpretation of large datasets. Oftentimes, individuals involved in greenhouse gas emissions must also possess software skills to leverage emissions accounting software. Microsoft Cloud, for instance, has an emissions impact dashboard for Azure and Office 365, which validates greenhouse gas accounting of digital operations (that is the emissions arising from digital activities, such as using digital devices, or from storing data in the cloud).[111] Similarly, the Microsoft Sustainability Manager is a tool that can be used in corporate management and accounting of GHG emissions and other environmental sustainability metrics, such as energy consumption and the carbon intensity per dollar of revenue.[112]

[111] "Emissions Impact Dashboard," Microsoft, 2024, https://www.microsoft.com/en-ca/sustainability/emissions-impact-dashboard?ef_id=_k_292dadb984d7145696a3cbf6c7a8bcbb_k_&OCID=AIDcmm0eoh9uxh_SEM__k_292dadb984d7145696a3cbf6c7a8bcbb_k_&msclkid=-292dadb984d7145696a3cbf6c7a8bcbb.

[112] "Microsoft Sustainability Manager," Microsoft, 2024, https://www.microsoft.com/en-us/sustainability/microsoft-sustainability-manager.

Also core to managing, regulating, and accounting is digital governance knowledge. This includes an understanding of the principles, practices, and frameworks governing digital technologies and their integration into green initiatives. Relevant tasks may include overseeing digital infrastructure, data management systems, and decision-making processes. Knowledge of privacy regulations is also crucial for safeguarding individual privacy rights and maintaining trust in digital platforms. This may include an understanding of privacy laws and regulations such as the General Data Protection Regulation (GDPR) and the Personal Information Protection and Electronic Documents Act (PIPEDA), which regulate how organizations can collect, use, and disclose personal information in different jurisdictions. Proficiency in data governance and management requires managing and safeguarding digital data assets, including ensuring data integrity, privacy, and security. Related to this is cybersecurity skills, including best practices to protect digital assets and infrastructure from unauthorized access, data breaches, and cyberattacks.

Furthermore, project management skills are critical for planning, executing, and monitoring projects within the digital-green economy. Project management skills ensure efficient resource allocation, timely delivery, and effective collaboration among stakeholders in the digital-green domain. Research participants noted that project managers need multidisciplinary skills, including digital, green, domain knowledge, interpersonal skills, and management skills. Given the broad nature of project managers, employers across the digital-green economy report difficulties finding skilled project managers. Similar findings were observed in ICTC's recent study, *Clean Energy and Pathways to Net-Zero: Jobs and Skills for Future Leaders.*[113]

Based on green occupations data provided by O*NET and complimented by information collected during ICTC's Digital-Green Employer Survey and key informant interviews, digital-green roles commonly involved in managing, regulating, and accounting activities are listed in Table 11 below.

Table 11: *Roles Most Associated with Activity 4: Managing, Regulating, and Accounting*

Digital-Green Role	O*NET SOC 2010 Code
Climate Change Analysts	19-2041.01
Investment Underwriters	13-2099.03
Risk Management Specialists	13-2099.02
Sustainability Specialists	13-1199.05
Energy Auditors	13-1199.01
Regulatory Affairs Specialists	13-1041.07
Regulatory Affairs Managers	11-9199.01
General and Operations Managers	11-1021.00
Chief Sustainability Officers	11-1011.03
Compliance Managers	11-9199.02

Data sources: *O*NET Occupational Listings: Green New and Emerging Occupations, Green Increased Demand Occupations, and Green Enhanced Skills Databases: https://www.onetcenter.org/reports/Green.html. ICTC Analysis.*

[113] Allison Clark and Mairead Matthews, "Clean Energy and Pathways to Net-Zero: Jobs and Skills for Future Leaders," ICTC, April 2023, https://ictc-ctic.ca/reports/clean-energy-and-pathways-to-netzero.

A specific form of management commonly discussed by interviewees and roundtable attendees engaged in this study was energy management. This broad skill set is expanded upon in the following case study.

Managing Energy in a Digital Age: In-Demand Digital-Green Skills

Producing and managing energy sustainably is an essential priority for countries around the world, including Canada. Increasingly, digital technologies are a central part of energy systems.[114] ICTC's employer survey found that 34% digital economy employers and 23% of green economy employers placed importance on the skill of "implementing energy management initiatives and projects."

Integrating digital solutions into energy systems not only enhances efficiency but also presents new challenges and opportunities in energy management and modelling. An aspect discussed in ICTC interviews was the intersection of management in the transition toward the adoption of smart energy tools and networks facilitated by advancements in IoT devices. For example, smart energy tools and networks that automatically implement energy-saving measures are made possible by advances in IoT devices. These technologies enable automated energy-saving measures, exemplified by the implementation of smart controls in the construction sector.

According to interviewees engaged in this study, "smart controls are going to be a big area where digital skills are required." These include smart thermostats, which necessitate expertise in software engineering and electrical engineering. The interconnection of smart homes with the grid further underscores the need for digital proficiency, requiring the integration of various digital tools with software solutions.

Adopting digital technologies enhances energy efficiency and lays the foundation for advanced energy management strategies. As the grid evolves to become smarter, the demand for digital skills is expected to surge with the development of digitalized platforms for energy trading and managing fluctuations in energy demand and supply. The management of grids with sophisticated software systems plays a crucial role in achieving optimal energy production during peak and off-peak demand periods. Energy management is essentially the fulcrum enabling a meaningful and sustainable transition to net-zero.

Moreover, amid the digital transformation of energy systems, the management of cybersecurity assets emerges as a critical concern, especially at the regional level, where smart grids are vulnerable to cyberattacks. As assets become increasingly digitalized, grid operations are increasingly susceptible to cyberattacks, which could cause widespread blackouts. Interviewees engaged in this study noted that the need for strong cybersecurity cannot be overstated. Beyond energy management, virtual power grids must be designed securely.

[114] Alexia Gonzalez Fanfalone, and Celine Caira, "The twin transitions: are digital technologies the key to a clean energy future?" OECD AI Policy Observatory, November 9, 2022, https://oecd.ai/en/wonk/twin-transitions.

Looking ahead, the digitalization of energy systems presents both challenges and opportunities for stakeholders across various sectors. On one hand, there is a growing demand for skilled professionals with expertise in software engineering, data analytics, and cybersecurity to support the development and maintenance of digital energy infrastructure. On the other hand, the integration of digital technologies opens new avenues for innovation and collaboration, offering opportunities to optimize energy efficiency, reduce carbon emissions, and enhance grid resilience. Furthermore, it underscores the saliency of effective management in achieving desired outcomes in the energy management value chain.

ACTIVITY 5: TRANSPORTING AND SUSTAINING

As Canada seeks to decarbonize its economy, the transportation sector (a traditionally high greenhouse gas emitter) is changing.[115] In an effort to reduce greenhouse gas emissions, a new wave of clean transportation is emerging, defined by electrification and alternative fuels. For passenger vehicles, the shift to clean transportation has been driven by federal incentives, such as the iZEV Program for light-duty vehicles, which is helping to advance the adoption of electric passenger vehicles.[116] In short, the transportation sector, including all vehicles and fleets across marine, aviation and rail, is working to reduce and/or eliminate their greenhouse gas emissions. The methods by which decarbonization is occurring vary across transport subsectors, which are each facing nuanced challenges.[117]

Decarbonizing the transportation sector relies heavily on the innovation and development of clean technologies, paired with a keen understanding of greenhouse gas emissions and climate change mitigation. The development of such technologies requires multidisciplinary knowledge. As such, a coordinated and collaborative approach will be imperative to ensure the transportation sector sees a successful clean transition.

As the transportation sector evolves, so too does its workforce. A new emergence of digital-green workers with strong software skills, hardware skills, environmental sustainability skills, and domain knowledge of the transportation sector is required.[118] These skills are reflected in Activity 5 (Transporting and Sustaining) of ICTC's digital-green competency framework (see Table 12).

[115] Canadian Centre For Energy Information, "Greenhouse gas emissions – National Inventory Report (NIR)," Government of Canada, July 04, 2023, https://energy-information.canada.ca/en/subjects/greenhouse-gas-emissions-national-inventory-report-nir.
[116] For a full overview of provincial and federal vehicle incentives, see: "Zero-emission vehicles - Incentives," Government of Canada, February 22, 2024 https://www.canada.ca/en/services/transport/zero-emission-vehicles/zero-emission-vehicles-incentives.html.
[117] Fuels Institute, "The Easiest and Hardest Commercial Vehicles to Decarbonize," April 2022, https://www.transportationenergy.org/wp-content/uploads/2022/10/FI_Report_Med-Heavy-Duty_FINAL.pdf; Faissal Jelti, Amine Allouhi, and Kheira Anissa Tabet Aoul, "Transition Paths towards a Sustainable Transportation System: A Literature Review," *Sustainability* vol. 15, no 21 (October 2023), https://www.mdpi.com/2071-1050/15/21/15457.
[118] Transport Canada, "Transport Canada's Climate Change Adaptation Plan 2021/22 to 2025/26," April 2021, https://publications.gc.ca/collections/collection_2022/tc/T40-4-2021-eng.pdf.

Table 12: Activity 5 (Transporting and Sustaining) Common Digital-Green Skills and Knowledge Areas

Common Digital-Green Skills	Common Digital-Green Knowledge Areas
• Computer programming and coding • Digital literacy • Data analysis • Navigation and route optimization • Fleet maintenance monitoring • Fleet dispatch strategy • Energy modelling • Lifecycle assessments • Project management • Heavy equipment operation • Generative AI • Immersive technologies (e.g., augmented reality, virtual reality)	• Urban planning • Port management • Climate change adaptation • Trade corridors • Environmental sustainability • Energy systems modelling • Regulatory compliance • Environmental legislation and regulations • Traffic/fleet flow management • Asset management • Logistics and freight distribution

Activity 5 encompasses digital-green jobs and industries whose primary focus interfaces with transporting, distributing, logistics and the supply chain. This includes all industries and sectors whose primary focus is the transportation of goods, including personal mobility, while services include all companies involved in managing, tracking, analyzing, and maintaining transportation methods. Digital-green roles most associated with the activity of transporting and sustaining are detailed in Table 13 below.

Table 13: Roles Most Associated with Activity 5: Transporting and Sustaining

Digital-Green Role	O*NET SOC 2010 Code
Electrical Engineering Technologists	17-3029.02
Electromechanical Engineering Technologists	17-3029.03
Sustainability Specialists	13-1199.05
Transportation Planners	19-3099.01
Transportation Engineers	17-2051.01
Supply Chain Managers	11-9199.04
Remote Sensing Technicians	19-4099.03
Mechanical Engineering Technologists	17-3029.07
Logistics Managers	11-3071.03
Fuel Cell Engineers	17-2141.01
Automotive Engineers	17-2141.02
Maintenance and Repair Workers, General	49-9042.00
Engineering Managers	11-9041.00
Urban and Regional Planners	19-3051.00

***Data sources:** O*NET Occupational Listings: Green New and Emerging Occupations, Green Increased Demand Occupations, and Green Enhanced Skills Databases: https://www.onetcenter.org/reports/Green.html. ICTC Analysis.*

Digitalization of the transportation industry is the major transformative force facilitating the transition to clean transportation. As alternative fuels and technology applications advance, digital twinning, cloud technologies, and 5G networks will become increasingly intertwined with logistic and fleet management strategies.

As digital twinning technologies provide the basis to integrate machinery, networks, and control systems, the skill sets of engineers, mechanics, and electricians will remain paramount for the clean transport industry. Interviewees noted the significant need to expand "high-voltage training" while developing new training to better understand and minimize the risks associated with alternative fuels and new technologies. With these changing dynamics, individuals with systems thinking that understand the relationship between clean transportation and energy systems will be key to advancing the digital-green future.

Lastly, interviewees noted that partnerships and multi-sector collaboration that leverage specialized skills and advancements in clean technologies will be key for the decarbonization of the clean transportation sector, as the sector is nascent and largely evolving with environmental regulations.

Digital Transformation of Marine Transport

With an estimated 70 to 80% of daily goods used by Canadians transported by ship,[119] the marine transport industry is deeply intertwined with the daily lives of Canadians. The marine transportation sector is going through a period of tremendous change between the adoption of technology and workforce dynamics. With 43% of the marine transportation workforce set to retire over the next 10 years, there is a need to hire 19,000 new workers to meet projected demands, representing 68% of the current workforce.[120] The skill needs of the marine transport sector have also changed as digitalization impacts all domains of maritime transport and logistics.[121]

As ports evolve from load and offload points to information-rich, intermodal logistical service hubs, the importance of efficient information capture has increased around four key players: vessels, cargo, workers, and ports.[122] The most immediate opportunities for the marine industry at large lie within data IoT devices, geolocation technology, AI and machine learning, and cloud solutions.[123] While technologies like blockchain, automation, robotics and digital twins provide great promise, further development of technologies and personnel is required to leverage these technologies.[124]

[119] Transport Canada, "Minister of Transport marks International Day of Seafarers and announces agreements to certify foreign seafarers in Canada (Press Release)," Government of Canada, June 25, 2023, https://www.canada.ca/en/transport-canada/news/2023/06/minister-of-transport-marks-international-day-of-seafarers-and-announces-agreements-to-certify-foreign-seafarers-in-canada.html.
[120] Transport Canada "Let's talk: Labour shortages in Canada's marine transportation sector," May 18, 2022, https://letstalktransportation.ca/lets-talk-labour-shortages-canadas-marine-transportation-sector.
[121] Olli-Pekka Brunila, Vappu Kunnaala-Hyrkki, and Tommu Inkinen, "Hindrances in port digitalization? Identifying problems in adoption and implementation," *European Transport Research Review* no. 62, 2021, https://etrr.springeropen.com/articles/10.1186/s12544-021-00523-0.
[122] Ibid.
[123] Zeeshan Raza, et al., "Digital transformation of maritime logistics: Exploring trends in the liner shipping segment," Computers in Industry, February 2023, https://doi.org/10.1016/j.compind.2022.103811.
[124] Ibid.

With a growing number of functions being transferred from ships to shore-based control centres, maritime professionals require a better understanding of the challenges and issues that seagoing maritime professionals face. Operations are increasingly integrated through ship-to-shore computer operations on board, while cloud service engineers and remote onshore support with advanced skills in analytics are becoming increasingly needed.[125]

A growing gap looms between shore-based maritime and seagoing professionals, and more transferable skills between occupations are needed. To enable reality-based training, leveraging the use of simulators that use VR, AR, and IoT devices to train high-risk operations and enable team performance for maritime professionals will be paramount. Interviewees noted that this will be increasingly important for the maintenance and operations associated with the new technologies of alternative fuel vessels as the maritime industry aims to decarbonize. Additionally, ongoing technology development will cause challenging interactions between complex autonomous systems and maritime professionals, ensuring that access to lifelong learning that mimics fleet operation will be critical for the absorption of technologies.

Primary research participants highlighted the critical role of maritime clusters and partnerships in enabling innovations that align with maritime needs. Digitalizing the port ecosystem provides tangible value for all participants. As such, this requires a collaborative approach in the development of a joint platform that shares information across various actors. Interviewees noted that the increased digitalization of assets in the maritime transportation industry will require a strong cybersecurity network and more individuals skilled in cybersecurity analysis software and tools.

TRANSFERABLE DIGITAL-GREEN COMPETENCIES

Grouping digital-green skills into key activities helps shed light on how digital skills and green skills intersect and complement one another across the labour market. While it is important to understand the most common digital-green skills and knowledge areas across core activities, it is also important to understand which skills and knowledge areas transcend activities, industries, tasks, and roles. The skills and knowledge areas that transcend activities are also known as transferable, as they can be applied in various roles and industries.

Upon synthesizing primary and secondary data, ICTC identified two transferable digital-green competencies. Competencies encapsulate a combination of skills, knowledge areas, and technical abilities and are, therefore, broader in nature.[126] Transferable digital-green competencies outlined in this research include (1) an understanding of climate change and environmental sustainability and (2) data analysis, management, and interpretation. This section details these transferable competencies while also detailing some of the transferable soft skills required by digital-green workers.

[125] Arnfinn Oksavik, Hans Petter Hildre, and Yushan Pan, "Future Skills and Competence Needs," Skillsea, March 23, 2020, https://www.skillsea.eu/images/Public_deliverables/D1.1.3%20Future%20Skills%20and%20competence%20needs_final%20version(1).pdf.
[126] Sheila Fournier-Bonilla, "What's The Difference Between Skills and Competencies?" Nexford University, March 17, 2024, https://www.nexford.edu/insights/whats-the-difference-between-skills-and-competencies.

Transferable Competency 1: Knowledge of Climate Change and Environmental Sustainability

General knowledge of climate change and environmental sustainability is important for all digital-green workers to possess. Understanding climate change includes awareness of anthropogenic impacts on the environment, such as how human activities have amplified the greenhouse gas effect and warmed the earth's surface. Meanwhile, an understanding of environmental sustainability is more solutions-oriented and relates to best practices for optimizing environmental well-being without compromising socioeconomic well-being. Knowledge of climate change and environmental sustainability are complimentary: one must first understand climate change to build sustainable solutions.

Green economy employers and digital-green economy employers surveyed for this study placed high levels of importance on knowledge of climate change (Figure 6). More specifically, nearly half of the surveyed respondents placed importance on an understanding of "how human activities impact the environment," while half of the green economy employers and one-third of digital-green employers placed importance on an understanding of "environmental concerns among the public." Meanwhile, 38% of green economy employers and 31% of digital-green employers placed importance on employees who understand "the value of protecting, conserving, and restoring natural resources and biodiversity." All these knowledge areas are interconnected to the broader issue of climate change. Without this baseline understanding, it is difficult for workers to participate meaningfully in the green economy or the digital-green economy.

Related to environmental sustainability, employers noted a high degree of importance on knowledge related to climate change mitigation, adaptation, and environmental management. Half of green economy employers and 42% of digital-green employers listed "climate change mitigation and adaptation strategies" as important. Meanwhile, 37% of green economy employers and 34% of digital-green employers noted "environmental management systems" as important. A knowledge area related to both climate change awareness and environmental sustainability solutions was an understanding of "global environmental trends, challenges, concerns, and solutions," which was noted to be important by 27% of green economy employers and 41% of digital-green employers (Figure 6).

Reflecting on your organization's skills needs, which of the following environmental knowledge areas are important for current employees and/or future hires to possess?

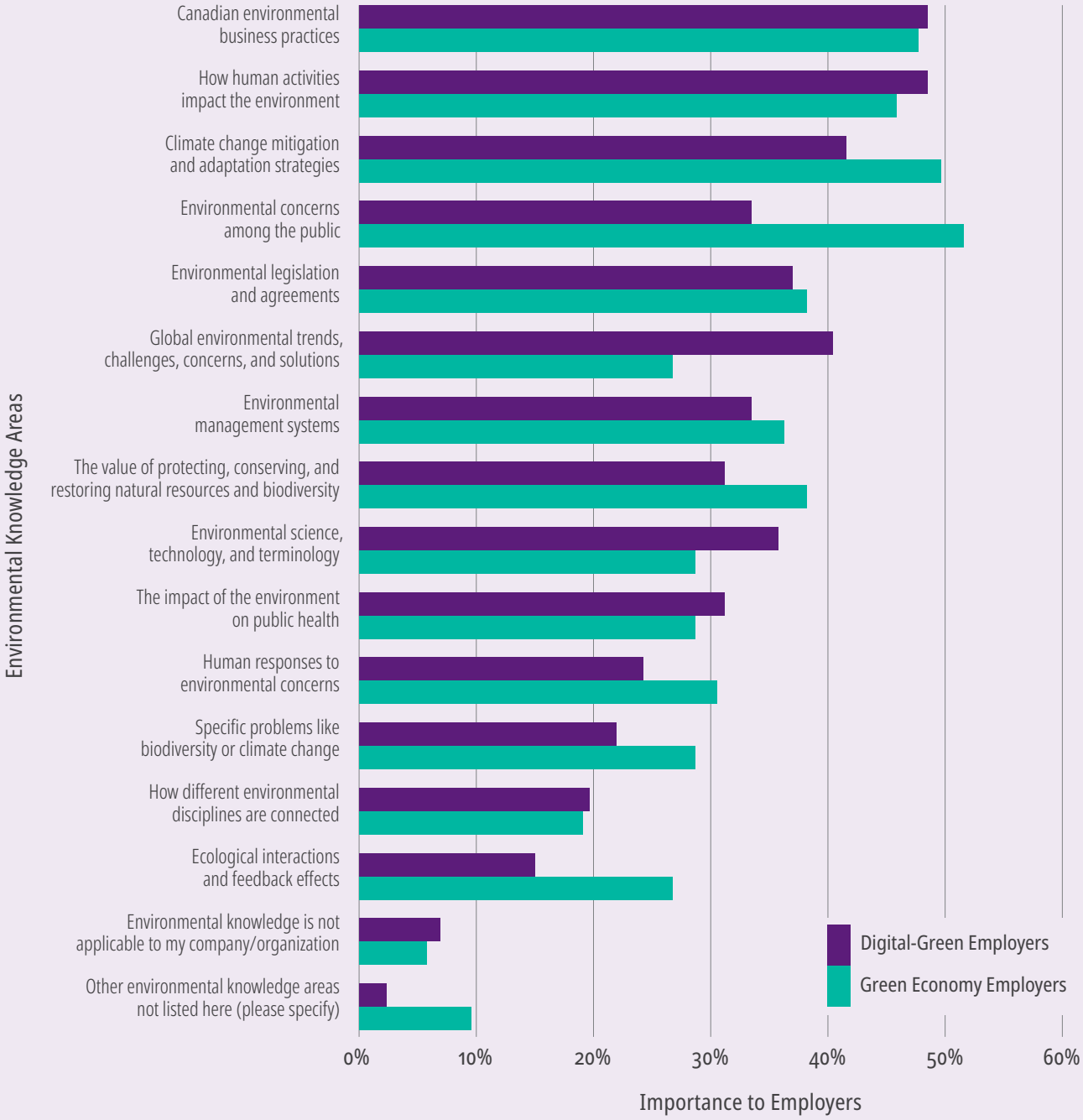

Figure 6: *The importance of environmental knowledge areas to Canadian employers that operate in the green economy (n=52) and to employers that operate in both the digital and green economies (n=86). A total of 138 employers responded to this question.*

In addition to environmental knowledge areas, surveyed employers were asked to report on the importance of environmental skills (Figure 7). The results from this question yielded insights into some of the environmental sustainability skills required by green economy and digital-green economy employers. The top five most important environmental sustainability skills reported by surveyed employers (green economy and digital-green economy inclusive) include:

- Develop and implement corporate sustainability programs and indicators (34%)
- Implement renewable energy initiatives and projects (34%)
- Carry out awareness/educative programs and present information on environmental matters (33%)
- Implement energy management initiatives and projects (30%)
- Implement and monitor waste management programs (31%)

All of the above skills are specific applications of environmental sustainability knowledge. These skills can be used to reduce pollution, waste, and greenhouse gas emissions, and mitigate climate change. These skills are not necessarily transferable, but the common knowledge underlying them is an understanding of climate change and environmental sustainability, thus highlighting the transferable nature of this competency.

Reflecting on your organization's skills needs, which of the following core environmental skills are important for current and future employees to possess?

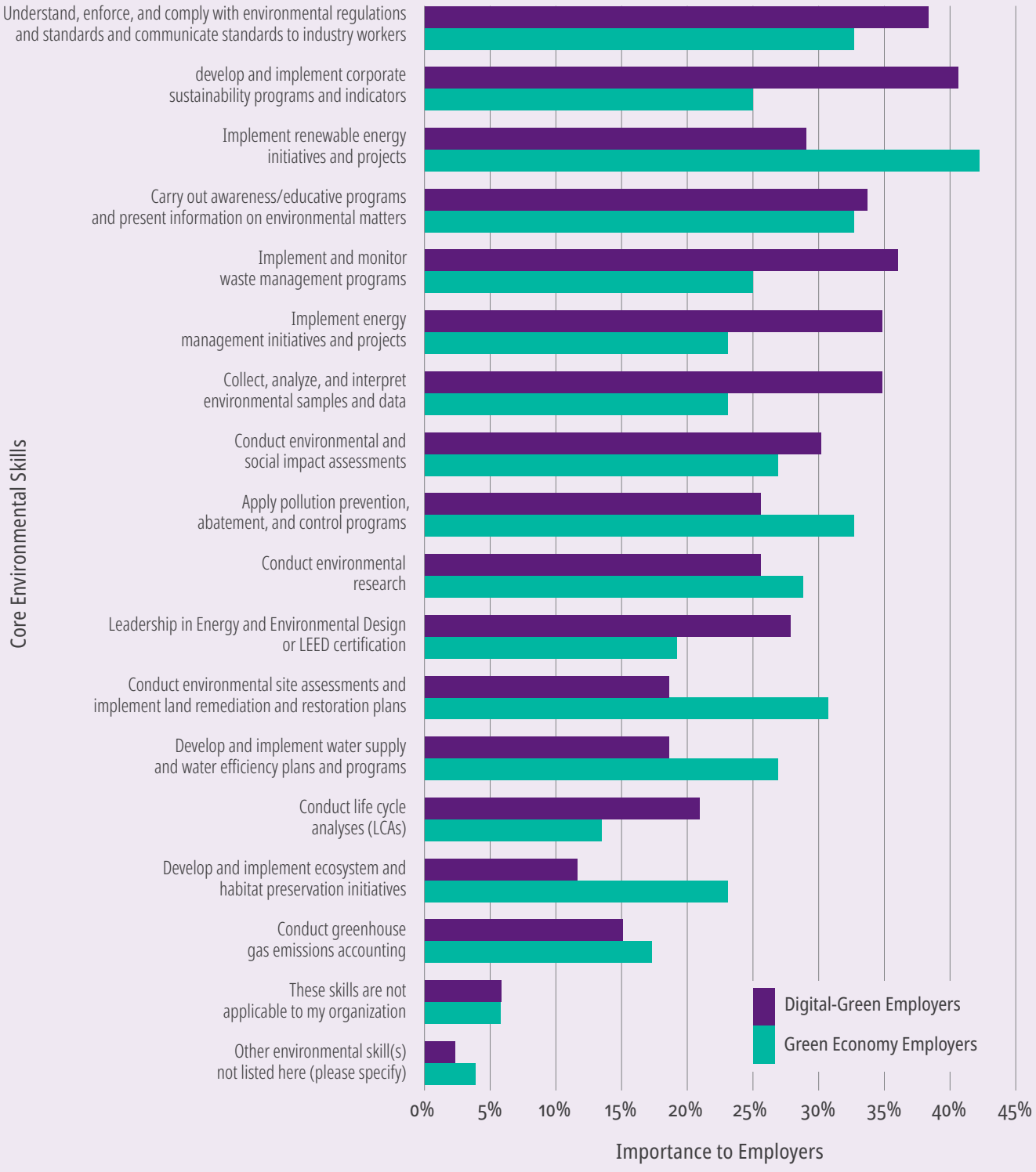

Figure 7: *The importance of core environmental skills to Canadian employers that operate in the green economy (n=52) and to employers that operate in both the digital and green economies (n=86). A total of 138 employers responded to this question.*

Interviewees engaged in this study similarly emphasized the importance of all digital-green workers having a baseline understanding of climate change and environmental sustainability best practices. One interviewee who works in the skilled trades said that this is especially important for skilled trades workers who are transitioning from legacy industries (e.g., oil and gas) to green economy adjacent roles. The interviewee said that a general "environmental conscientiousness" is critical in the skilled trades. For people involved in retrofitting the built environment, this could include a strong understanding of recycling complex construction materials such as insulation, metals, plastics, and wood to reduce environmental impacts. Meanwhile, a general understanding of climate change and environmental sustainability translates differently in the corporate world. Interviewees expressed that for corporate executives, this competency is critical to ensuring that environmental sustainability key performance indicators (KPIs) are included in business processes and planning.

Regardless of industry or role, interviewees noted that an understanding of climate change and environmental sustainability was a critical transferable competency that all digital-green workers should possess.

Transferable Competency 2: Data Analysis, Management, and Interpretation

Through the adoption of digital technologies, such as sensors, smart meters, geospatial technologies, and information services, organizations now have access to a large volume of data and information. Datasets may help to inform or track operational efficiencies, energy demands, greenhouse gas emissions, financial records, customer information, and much more. As detailed by one interviewee involved in vocational training, "Data is the foundation of the digital-green transition."

However, for data to inform meaningful improvements to environmental and/or economic performance, datasets must be analyzed, managed, and interpreted accurately and efficiently. The skill sets of data analysis, management, and interpretation were found to be vital to all five activities outlined in ICTC's competency framework. As Industry 4.0 technologies continue to be adopted, competencies in understanding and making use of large datasets will be increasingly important. Interviewees engaged in this study felt strongly that all digital-green workers should have a baseline understanding of data analysis, management, and/or interpretation:

> **" Data literacy is the ability to analyze data and make sense of data… I think it's a really underserved skill set.**
>
> — Green Transition Training Provider

> **“ Every person should understand how to interpret a graph.**
>
> — Work-Integrated Learning Provider

> **“ Data interpretation is key.**
>
> — Cybersecurity Employer

Employers surveyed for this study similarly reported placing a high level of importance on skills related to data analysis, management, and interpretation. Data management was listed as an important skill set by 46% of digital economy employers and 37% of digital-green employers (Figure 8). Also highly in demand, an understanding and competency in data analysis and visualization software, such as MATLAB, R Studio, and Stata, was listed as important by 25% of digital economy employers and 37% of digital-green employers. Similarly, 23% of green economy and 34% of digital-green economy employers noted that it was important for current and future employees to be able to “collect, analyze, and interpret environmental samples and data.”

Some employers engaged in this study reported that more advanced data management skills are also required. Many employers seek individuals who understand programming languages, such as Python, JavaScript, Java, and C++, with 48% of digital economy employers and 28% of digital-green employers noting this skill set as important (Figure 8). Computer programming and coding may extend to more complex data analysis and management processes, such as the development of machine learning and artificial intelligence algorithms, as well as cloud computing.

From basic to advanced, data analysis, management, and interpretation are important across various digital-green roles and activities, making it an imperative transferable skill for job seekers to possess.

Reflecting on your organization's skills needs, which of the following software skills are important for current and future employees to possess?

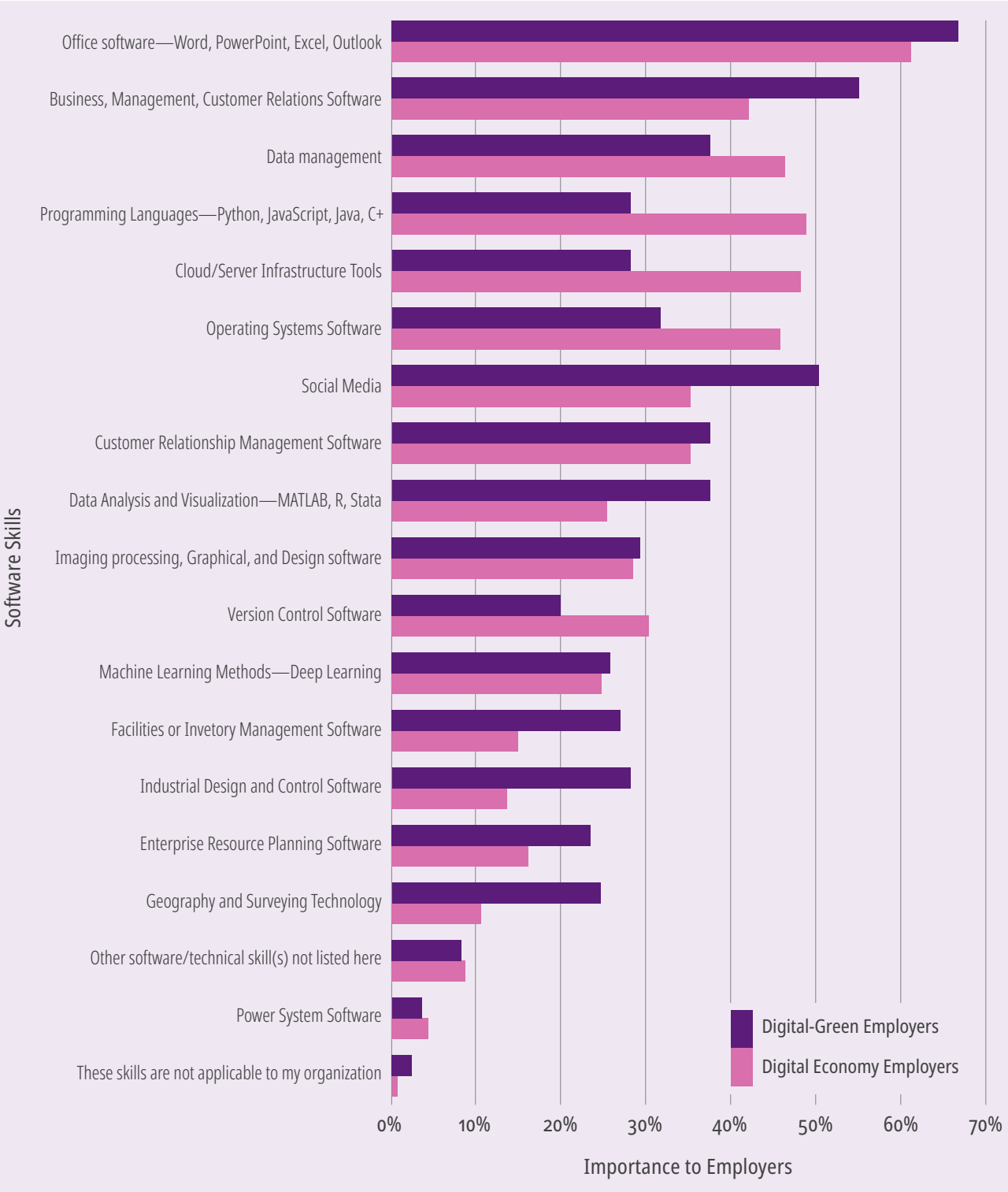

Figure 8: *The importance of software skills to Canadian employers that operate in the digital economy (n=163) and to employers that operate in both the digital and green economies (n=86). A total of 249 employers responded to this question.*

In-Demand Soft Skills for Digital-Green Workers

ICTC's first iteration of a digital-green competency framework sought only to classify technical skill sets, not "soft" or human skill sets. Employer surveys, interviews, and roundtable questions therefore centred around technical skills. Despite this, interviewees and roundtable attendees could not help but comment on the need for digital-green talent who possess strong human skills. Core human skills that emerged as both important and in demand were critical thinking, problem solving, systems thinking, communication, resiliency, and interpersonal skills.

Some interviewees explained that, without these human skills, meaningful advances in the twin transition would be difficult to achieve. This is because a digital-green transition requires innovative and solutions-oriented individuals capable of analyzing complex and addressing complex socioeconomic, ecological, and technical problems. Interviewees noted that these individuals must be capable of thinking in systems—that is, ecosystems, business systems, and economic systems—to avoid rebound effects or other unforeseen consequences.

Moreover, interviewees noted resiliency as a critically important human skill for digital-green workers. While the twin transition is promising, it also presents continuous change and uncertainty. Digital-green workers must be flexible and easily adaptable in the face of digital-green changes. Similar findings were observed in a recent study, *High Value Skills for a Net-Zero Economy: Skills Assessment for the Ports, Supply Chain, and Maritime Sector,* which details high-demand socio-cognitive skills needed in the transition to net-zero.[127] This study finds that resilience, perseverance, resourcefulness, and grit are important soft skills that enable workers to remain positive and motivated in the face of change – whether that be change by way of digital adoption, green economy principles, or both.

Moreover, strong communication skills were detailed by several interviewees as high demand soft skills for digital-green workers. Written communication skills, including technical writing, are needed to ensure that all data collected on environmental matters is interpreted and clearly summarized in a written format. Moreover, oral communication skills are needed to present key findings to relevant stakeholders. Related to this are stakeholder engagement skills, which include strong interpersonal skills, relationship management skills, and teamwork skills.

Workers who possess strong soft or human skills paired with transferable digital-green competencies can expect a promising career ahead. These competencies and soft skills are likely to stand the test of time, regardless of digital-green shifts.

[127] Sherry Scully and May Young, "High Value Skills for a Net-Zero Economy: A Skills Assessment for the Ports, Supply Chain and Maritime Sector," The Halifax Port Authority and The PIER, August 2023, https://www.thepierhfx.com/wp-content/uploads/2023/10/High-Value-Skills-for-a-Net-Zero-Economy.pdf.

Conclusion

Canada is already witnessing labour market disruptions as a consequence of the twin transition: over the coming decades, its impact will only increase. At the same time, digitalization and technology adoption are transforming the Canadian economy, rapidly increasing demand for new skills related to data, software, and ICT hardware solutions. Whether Canada's workforce is sufficiently trained in this emerging class of "digital-green skills" has significant implications: it will impact the ability of Canadian organizations to develop and adopt clean technology solutions and, in turn, Canada's ability to meet its environmental sustainability goals.

Because digital-green skills can be layered on top of a broad range of existing careers, there is no single training pathway to a digital-green career. Nearly all digital-green careers are built by combining traditional skills and experience in a given profession—such as finance, construction, or procurement—with new knowledge and skills related to information and communications technologies, environmental sustainability, or both. Depending on where technology solutions are adopted, digital-green skills may be needed in the skilled trades, policy and planning, architecture and design, business, or numerous other fields. This reality implicates a wide range of stakeholders in digital-green workforce development, including kindergarten to Grade 12 educators, post-secondary institutions, employers, industry organizations, and governments, but also increases the risk of uncoordinated and misaligned training initiatives.

ICTC's digital-green competency framework responds to this challenge by creating a standardized and coordinated approach to digital-green skills. It defines digital-green skills and classifies these skills into core activities: *Consulting and Analyzing; Designing and Building; Producing and Manufacturing; Managing, Regulating, and Accounting;* and *Transporting and Sustaining.* It details common digital-green skills and knowledge areas needed to carry out each activity, lists in-demand roles, provides industry case studies, and details transferable digital-green competencies that transcend all activities.

In doing so, this competency framework lays the groundwork for far-reaching organizations to help develop Canada's digital-green labour force. It clarifies employer demand for digital-green skills and builds awareness of digital-green career pathways and skill requirements among students and early- to mid-career professionals. Lastly, it provides governments, educators, and industry with a standardized way to describe digital-green skills, facilitating their incorporation into educational curricula, work-integrated learning programs, and other training and workforce development initiatives.

Research Methods and Limitations

RESEARCH METHODS

ICTC has utilized a mixed methods approach to gathering information and insights into Canada's emerging digital-green workforce. This includes secondary and primary research methods as described below.

Secondary Research

ICTC researchers undertook a comprehensive literature review of skills taxonomies and sustainable, clean, and green employment frameworks and typologies. To align its digital-green framework to international best practices and validate primary data, ICTC researchers conducted an automated data scrape of the US Department of Labor's *Occupational Information Network* (O*NET) database,[128] the *European Commission's European Skills, Competences, Qualifications and Occupations* (ESCO) database,[129] and the Government of Singapore's *MySkillsFuture* job information portal.[130]

Primary Research

Primary research consisted of an employer survey, a series of key informant interviews, and a roundtable of clean economy employers and experts held in Halifax, Nova Scotia, in January 2024.

For the employer survey, ICTC contracted a survey firm to produce an employer survey on Canada's digital-green employment landscape. The survey took place between July and August 2023. The survey was conducted in both French and English.

The survey received a total of 301 qualified respondents. Of the 301 respondents, 163 (54%) were from the digital economy, while 52 (17%) were from the green economy. Eighty-six respondents (29%) represented employers that bridged the green and digital economies. The majority of respondents (83%) represented private sector businesses, while government and non-profit organizations represented a combined 17% of respondents.

[128] See: O*NET OnLine, https://www.onetonline.org/.
[129] See: ESCO portal, https://esco.ec.europa.eu/en.
[130] See: MySkillsFuture portal, https://www.myskillsfuture.gov.sg/content/portal/en/index.html.

Table A1: ICT Digital-Green Employer Survey, Employer Type

Employer Type	Responses	Percentage
Privately owned business	188	62.5%
Public company	61	20.3%
Non-profit organization	26	8.6%
Government organization	25	8.3%
Other	1	0.3%

Data Source: *ICTC Digital-Green Employer Survey, 2023*

Survey respondents represented firms both large and small, with 75% of respondents representing small and medium-sized enterprises with less than 500 employees, while 25% represented employers with over 500 employees.

Table A2: *ICT Digital-Green Employer Survey, Employer Size*

Company/Organization Size	Responses	Percentage
Micro *2–4 employees*	188	13%
Small *5–99 employees*	61	37%
Medium *100–499 employees*	26	25%
Large *500–9,999 employees*	25	16%
Very Large *10,000+ employees*	1	9%

Data Source: *ICTC Digital-Green Employer Survey, 2023*

The employer survey received responses from employers headquartered in all but one Canadian province, Prince Edward Island. It also received a response from an employer in Nunavut, alongside 21 companies headquartered outside of Canada. Nearly half of the survey respondents (45.51%) were employers headquartered in Ontario, while other significant clusters of respondents were headquartered in British Columbia (18.27%) and Alberta (11.96%).

Table A3: ICT Digital-Green Employer Survey, Geographical Breakdown of Respondents

Provinces	Responses	Percentage
British Columbia	55	18.27%
Alberta	36	11.96%
Saskatchewan	13	4.32%
Manitoba	10	3.32%
Ontario	137	45.51%
Quebec	19	6.31%
New Brunswick	2	0.66%
Nova Scotia	5	1.66%
Newfoundland and Labrador	2	0.66%
Nunavut	1	0.33%
Outside of Canada	21	6.98%

Data Source: *ICTC Digital-Green Employer Survey, 2023*

Key Informant Interviews ICTC researchers carried out a series of 25 key informant interviews (KIIs) with employers in the digital and green economies, as well as with Canadian and international experts on green/clean jobs. These KIIs were carried out virtually in an open, semi-structured format. Interviewees represented private sector companies from a variety of green and digital industries, as well as government, civil society and non-profits, and academia.

Employer/Expert Roundtable ICTC hosted an employer roundtable held in Halifax, Nova Scotia, on January 10, 2024. A total of 14 clean economy employers and workforce experts participated. The roundtable consisted of a framing presentation on renewable electricity and North American utilities providers followed by a facilitated, semi-structured conversation between workshop participants regarding digitization in the clean economy, emerging and in-demand skill sets, labour market challenges, and policy recommendations for capacity development for clean economy jobs. Detailed results from the roundtable have also been published separately by ICTC in the policy brief, *Strengthening Nova Scotia's Clean Energy Economy* (2024).[131]

[131] Allison Clark and Todd Legere, "Strengthening Nova Scotia's Clean Economy: An ICTC Policy Brief," Information and Communications Technology Council (ICTC), May 2024, https://ictc-ctic.ca/reports/strengthening-nova-scotias-clean-energy-economy.

RESEARCH LIMITATIONS

This research and the resulting digital-green competency framework are not intended to be exhaustive and do not reflect the totality of the digital or green economies in Canada. The digital-green skills and knowledge sets listed in the framework and throughout the body of the report should not be thought of as a comprehensive inventory but instead as a partial catalogue of digital-green competencies. These competencies will undoubtedly evolve over time. Like the digital-green competencies listed in this report, the digital-green industries covered should be thought of as examples rather than a comprehensive list. More research is required to better understand how other sectors and industries in Canada participate in the digital-green economy.

ICTC researchers made significant efforts to interview experts and employers throughout the digital-green economy. The employer survey deployed as part of this study sought to gather information from organizations both large and small throughout Canada—however, Quebec, the provinces of Atlantic Canada, and the Northern territories of Yukon, Northwest Territories, and Nunavut were underrepresented in the survey. There are undoubtedly regional variations in Canada's digital-green economy that this research was unable to uncover.

This research, by intention and design, is exploratory in nature. There is still much to learn about Canada's digital-green economy.