CLEAN ENERGY AND PATHWAYS TO NET-ZERO

Jobs and Skills for Future Leaders

ICTC CTIC

Research by

ICTC CTIC

Information and
Communications
Technology Council

Conseil des technologies
de l'information
et des communications

Canada

This project is funded in part by the Government of
Canada's Student Work Placement Program

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.

To cite this report:

Clark, A. and Matthews, M., April 2023. *Clean Energy and Pathways to Net-Zero: Jobs and Skills for Future Leaders.* Information and Communications Technology Council (ICTC). Ottawa, Canada.

Researched and written by Mairead Matthews and Allison Clark, with generous support from Alexandra Cutean, Rosina Hamoni, Chris Herron, and the ICTC Research and Policy team.

Disclaimer:

The opinions and interpretations in this publication are those of the authors and do not necessarily reflect those of the Government of Canada.

Abstract:

To mitigate climate change, Canada seeks to decarbonize its economy and reach net-zero by 2050. In response, the clean energy sector is experiencing rapid growth. This will include growth in clean energy production, including hydropower, nuclear, wind, solar, tidal, and geothermal, as well as low-emitting energy sources like bioenergy and green hydrogen. Achieving net-zero will also require electrifying supply chains, modernizing grid infrastructure, increasing transmission capabilities, and adopting carbon capture, utilization, and storage (CCUS) technologies. In addition to emissions reduction policies, the clean energy economy is being driven by carbon pricing programs, a need for global energy security, public sector investments, and private sector investments. That said, some barriers are preventing Canada from scaling its clean energy economy, including strict permitting processes, capital costs and scaling private sector investments, the global supply chain, technological immaturity, lagging technology adoption, political and cultural backlash, and the need for community buy-in. Above all, one of the largest barriers that could prevent the clean energy sector from scaling is the lack of skilled labour. This study provides an in-depth overview of the clean energy sector in Canada, the pathways needed to achieve net-zero, the labour market impacts of transitioning to net-zero, and recommendations for filling skills and employment gaps. It is found that there are ample career opportunities in the clean energy sector, with the most in-demand roles found in skilled trades, construction, utilities, engineering, and project management. The skill sets needed for the clean energy economy are similarly diverse and include soft skills like communication, domain knowledge like understanding energy markets, environmental sustainability skills, digital technology skills, technical skills, and multidisciplinary knowledge. While there are more entry-level job openings, employers engaged in this study expressed that they struggled most to fill mid to senior-level roles because very few people have extensive experience in the clean energy sector. To address labour shortages, efforts will be needed to pivot oil and gas workers with transferable skills to the clean energy sector and enrich educational, training, and mentorship opportunities for post-secondary students. Despite barriers, this study highlights that if key stakeholders work together in a collaborative and proactive manner, Canada will be able to transition to net-zero while strengthening its economy.

Key Words:

Clean Energy

Net-Zero

Clean Economy

Labour Market

Future Jobs

Future Skills

Canada

Acknowledgements:

The contributions made to this report by our key informant interviewees, advisory committee, and other subject-matter experts are greatly appreciated. We would like to acknowledge all the contributors to this report, along with the following specific individuals and organizations:

Afshan Basaria, Co-operative Education Coordinator, Simon Fraser University

Canadian Renewable Energy Association

David Adams, Manager, Energy Programs, University of Victoria

Foresight Cleantech Accelerator Centre

Geoff de Ruiter, Head of Carbon Business Development, BC Biocarbon

Jeanette Jackson, CEO, Foresight Canada

Jodie Hon, Innovation & STEM Manager, Iron & Earth

Matthew Klippenstein, Regional Director, Western Canada, Canadian Hydrogen and Fuel Cell Association

Miranda Fuller, Renewable Energy and Sustainability Management Professional

Nicholas B. Rajkovich, Associate Professor and Associate Dean for Research and Creative Practice, University at Buffalo School of Architecture and Planning

Phil De Luna, Adjunct Professor, Department of Material Science & Engineering, University of Toronto

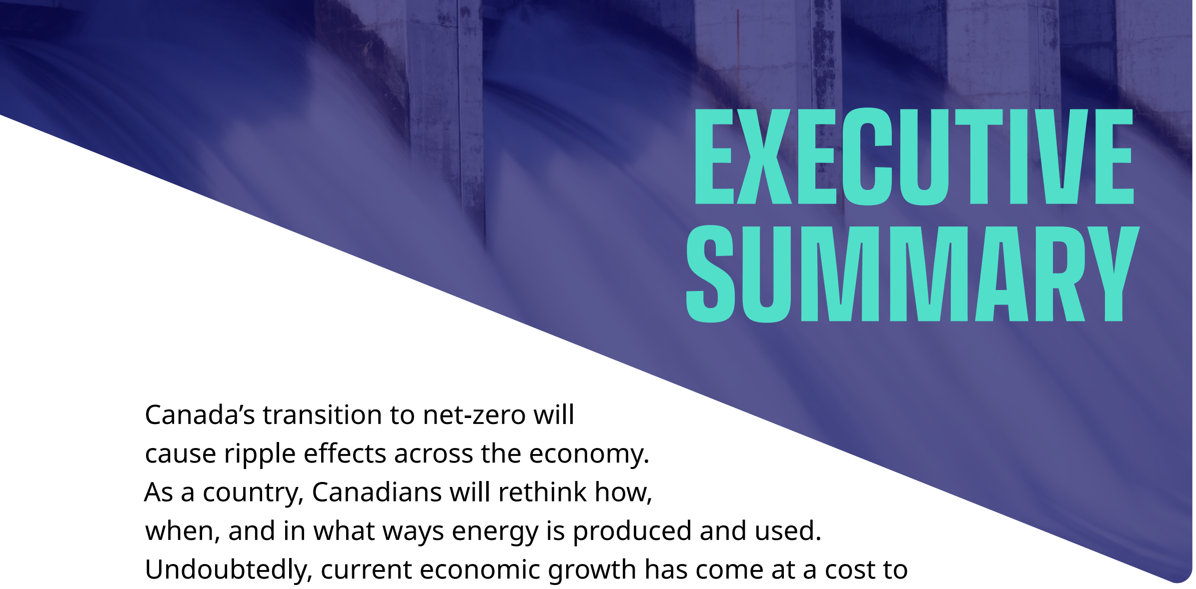
Rob Andrews, CEO, Heliolytics

UGE International Ltd.

Victor Becerra, Professor of Power Systems Engineering, University of Portsmouth, UK

Zafar Adeel, Executive Director, Pacific Water Research Centre, Simon Fraser University

TABLE OF CONTENTS



EXECUTIVE SUMMARY

Canada's transition to net-zero will cause ripple effects across the economy. As a country, Canadians will rethink how, when, and in what ways energy is produced and used. Undoubtedly, current economic growth has come at a cost to environmental well-being; greenhouse gas (GHG) emissions have scaled as planetary boundaries have been transgressed. A sustainable economic future requires decoupling these concepts, at once safeguarding our collective prosperity while reducing—eventually eliminating—our carbon footprint. On this path, Canada will need to produce cleaner sources of energy, and use it more efficiently.

Yet, both domestic and international demand for energy grows. Recent climate events and geopolitical developments put further pressure on Canada as a producer and exporter of different types of energy. Meeting this demand while adhering to net-zero commitments is essential, and skilled talent is key.

As the market evolves, energy roles will also evolve, and new employment pathways will emerge. Current estimates point to a Canadian energy labour force that will total nearly 640,000 by 2030.[1] As Canada decarbonizes its energy supply, workers will be needed in areas, including research and development, design, engineering, technology, the trades, business and marketing, and environmental services; important will be soft skills, domain knowledge, environmental sustainability expertise, core digital skills, and technical know-how.

Technical roles often require a deep understanding of environmental remediation, sustainability best practices, climate change mitigation, sustainable development, and environmental science. Digital roles at the intersection of clean energy require workers that are proficient with a variety of programming languages, have knowledge of cloud infrastructure tools and operating systems, and possess expertise with geography and surveying technology. Business and consulting roles are also in demand in the clean energy ecosystem, and employers seek talent with data analysis skills, project management capabilities, customer relationship management skills, and knowledge of energy regulation and policy.

---

[1] "Tracking the Energy Transition 2021," 2021, *Clean Energy Canada,* https://cleanenergycanada.org/wp-content/uploads/2021/06/Report_CEC_CleanJobs2021.pdf

The clean energy landscape is vast, and a variety of roles are needed across the board. Like many other sectors, acute shortages exist at mid and senior levels. Canada's existing energy workers possess critical skills and experience gained in the sector; retaining this knowledge base is essential to fill labour market gaps while ensuring a just transition for geographic regions that will be impacted by the shift to clean energy.

At the entry level, however, some gaps exist. First is an awareness gap: while nearly half of the students surveyed in this study were interested in a career in clean energy, approximately one-fifth reported a lack of interest, largely due to the belief that they would not be able to find entry-level employment. Yet, surveyed energy employers note high demand for workers at all levels, including the entry level. Moreover, many interviewed employers report offering training and other mechanisms that help junior talent grow in their careers and take on progressive leadership roles. Second, skill mismatches are also present. Although approximately 70% of current students surveyed in this study note proficiency with geography and surveying technology, nearly 75% were not confident about their knowledge of and proficiency with cloud infrastructure and tools. Students also reported low confidence in their knowledge of environmental science, environmental technology, awareness of environmental legislation and agreements, and Canadian environmental business practices. Yet, clean energy employers highlight all these skills as both important and in demand. Pairing post-secondary training with work-integrated learning experience, like co-ops and internships, can help bridge the labour market gap, allowing students to better understand the clean energy landscape, build practical experience in the field, and grow their knowledge base and confidence.

Labour shortages and high competition for talent are likely to persist, if not intensify, as the global demand for energy persists and Canada transitions to net-zero. Steady upward pressure on the labour market requires a robust and continuous stream of talent. While current in-career workers can be upskilled or reskilled to fill mid and senior roles, there is clear demand at the entry level as well. Effectively engaging today's youth is critical to building and supporting the next generation of leaders that will drive the decarbonization of the Canadian economy.

INTRODUCTION

Economic growth over the past 250 years has relied on a massive increase in energy use.[2] Energy is used throughout the global economy—to extract and refine natural resources, power manufacturing facilities, transport goods and people, and heat and cool buildings. Because many of the world's energy sources are emissions intensive, such as oil, gas, and coal,[3] economic growth has also hinged on an unprecedented increase in global greenhouse gas (GHG) emissions. In 2016, energy use, including electricity, heat, and transport, accounted for 73.2% of GHG emissions globally.[4] Natural Resources Canada meanwhile estimates that in 2021, energy accounted for about 78% of global GHG emissions, compared to 81% of Canada's GHG emissions.[5] Notably, because of Canada's extreme temperatures, expansive landscape, and dispersed population, Canadians tend to use more energy than their international counterparts.[6] Canada is also highly reliant on fossil fuels, which "provide much of the energy used to heat homes and businesses, transport goods and people, and power industrial equipment."[7]

Cumulative GHG emissions to date have already caused us to transgress the earth's planetary boundaries for climate change, according to the Stockholm Resilience Centre, increasing the severity and frequency of extreme weather events and rendering some regions of the world inhabitable.[8] The Government of Canada passed the Canadian Net-Zero Emissions Accountability Act in June 2021, which affirms in legislation Canada's commitment to achieving net-zero emissions by 2050.[9] Notably, to prevent global temperatures from rising 2°C above pre-industrial levels—as is required to stave off catastrophic climate change—global carbon intensity would need to be reduced by 6.3% every year until 2100, "much faster than the modest annual decline of 1.3% achieved between 2000 and 2014."[10]

---

[2] Steffen, Will et al., "The trajectory of the Anthropocene: The Great Acceleration," January 16, 2015, Stockholm University, the Australia National University, and International Geosphere-Biosphere Programme, https://journals.sagepub.com/doi/abs/10.1177/2053019614564785?journalCode=anra

[3] Smil, Vaclav, "Global Primary Energy Consumption By Source," 2017, *Our World in Data,* https://ourworldindata.org/grapher/global-energy-consumption-source

[4] Ritchie, Hannah and Roser, Max, "Emissions by Sector," *Our World in Data,* https://ourworldindata.org/emissions-by-sector#energy-electricity-heat-and-transport-73-2

[5] "Energy Fact Book 2021-2022," 2021, *Natural Resources Canada,* https://natural-resources.canada.ca/sites/nrcan/files/energy/energy_fact/2021-2022/PDF/2021_Energy-factbook_december23_EN_accessible.pdf

[6] "Energy Fact Book 2021-2022," 2021, *Natural Resources Canada,* https://natural-resources.canada.ca/sites/nrcan/files/energy/energy_fact/2021-2022/PDF/2021_Energy-factbook_december23_EN_accessible.pdf

[7] "Canada's Energy Future 2021, 2021, *Canada Energy Regulator,* https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/canada-energy-futures-2021.pdf

[8] "Planetary Boundaries," 2021, *Stockholm Resilience Centre,* https://www.stockholmresilience.org/research/planetary-boundaries.html

[9] "Net-Zero Emissions by 2050," January 2023, *Government of Canada,* https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/net-zero-emissions-2050.html

[10] "Green Industrial Policy: Concept, Policies, Country Experiences," February 2018, UN Environmental Programme, https://www.unep.org/resources/report/green-industrial-policy-concept-policies-country-experiences

Despite an urgent need to reduce emissions, continued economic growth is also necessary to improve quality of life, reduce poverty, uphold government funds, and maintain political and economic stability. Since economic growth has to date relied on emissions-intensive energy use, there is an urgent need to reduce the emissions intensity of global energy consumption, both through further advances in energy efficiency and carbon capture, utilization, and storage (CCUS) technologies, and by rapidly introducing clean energy sources. These profound changes to our energy system are already impacting the energy sector's labour market needs and introducing a variety of new roles and skill sets, which will need to be filled for Canada's energy transition to be successful;

> "In the long term, global and Canadian ambition to reduce GHG emissions will be a critical factor in how energy systems evolve." — **CANADA ENERGY REGULATOR**[11]

The global energy market was more diversified than ever before in 2021, with no single energy source surpassing 30% of global energy consumption.[12] Nonetheless, emissions-intensive energy sources like natural gas, oil, and coal still accounted for 77% of global energy consumption. Meanwhile, clean energy sources like hydropower, solar, wind, nuclear, and other renewables accounted for 23% of energy consumption. That said, over the past 20 years, global consumption of clean energy has grown at an outstanding pace.[13] Global consumption of solar energy, for example, has grown by 86,179%, from 3.13 terawatt-hours (TWh) in 2000 to 2,698.51 TWh in 2021. Likewise, global consumption of wind energy has grown by 5,146%, from 92.87 TWh in 2000 to 4,779.22 TWh in 2021.[14]

Amid a phasing out of emissions-intensive energy sources, the International Energy Agency expects global consumption of clean energy to grow further.[15] The degree to which these changes take place will depend on policy and industry decisions, in addition to technological progress, infrastructure, global energy markets, and consumer behaviour and preferences.[16]

Recognizing the importance of clean energy for sustainable economic growth, *Clean Energy and Pathways to Net-Zero: Jobs and Skills for Future Leaders* assesses the impact of clean energy initiatives on labour market needs in Canada's energy sector. The study used a mixed-methods research approach, including:

---

[11] "Canada's Energy Future 2021, 2021, *Canada Energy Regulator,* https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/canada-energy-futures-2021.pdf

[12] "Global primary energy consumption by source," 2023, *Our World in Data,* https://ourworldindata.org/grapher/global-energy-consumption-source

[13] "Global primary energy consumption by source," 2023, *Our World in Data,* https://ourworldindata.org/grapher/global-energy-consumption-source

[14] "Global primary energy consumption by source," 2023, *Our World in Data,* https://ourworldindata.org/grapher/global-energy-consumption-source

[15] "World Energy Outlook 2022," 2022, *International Energy Agency,* https://iea.blob.core.windows.net/assets/830fe099-5530-48f2-a7c1-11f35d510983/WorldEnergyOutlook2022.pdf

[16] "Canada's Energy Future 2021, 2021, Canada Energy Regulator, https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/canada-energy-futures-2021.pdf; "World Energy Outlook 2022," 2022, *International Energy Agency,* https://iea.blob.core.windows.net/assets/830fe099-5530-48f2-a7c1-11f35d510983/WorldEnergyOutlook2022.pdf

- A secondary literature review and analysis of secondary data acquired through web scraping
- Primary qualitative research consisting of 23 key informant interviews (KIIs) with experts in clean energy
- An employer survey of 74 energy companies
- A student survey of 312 students

In addition, over the course of the project, an advisory committee met to contribute to and validate the research findings.

Section I of the report provides an overview of current and future trends in Canada’s clean energy economy. It discusses the relationship between Canada’s energy sector and GHG emissions, looking at both the GHG intensity of energy consumption and total GHG emissions from energy consumption over time. These indicators are explored in more detail for each of Canada’s energy sources, including electricity, natural gas, oil products, and other fuels. The second half of Section I looks at regional differences in Canada’s electricity mix and assesses which provinces and territories are most likely to be impacted by clean energy technologies in the future, such as wind, solar, and battery electric storage.

Section II of the report assesses what impact Canada’s clean energy transition will have on the Canadian labour market. It highlights which occupations and skills are associated with different sources of clean energy, as well as which jobs can be categorized as entry-level, high growth, and in demand. It also discusses present and future potential for clean energy labour shortages and the possibility of transitioning oil and gas workers into clean energy roles in some geographic regions. Finally, building on the comments of key informant interviewees and advisory committee members in this study, Section II concludes by addressing how educational institutions, government, and industry must work together to build and prepare the future energy workforce.

DEFINING CLEAN ENERGY AND PATHWAYS TO NET-ZERO

There are a number of ways to classify different kinds of energy sources based on their environmental benefits. **Renewable energy,** which is perhaps the most commonly used term, is defined by Natural Resources Canada as "energy derived from natural processes that are replenished at a rate that is equal to or faster than the rate at which they are consumed."[17] In terms of environmental benefits, renewable energy sources help to reduce resource depletion by replacing finite energy sources with ones that do not run out as a result of human consumption.

Clean energy instead refers to the GHG emissions intensity of the energy source. Clean energy is energy that does not emit GHGs during its production. In comparison to green energy, clean energy includes a broader range of energy sources, such as nuclear, which despite having other environmental risks, is GHG emissions-free.

Finally, **green energy** is energy that has the least environmental impact overall, not only in relation to resource depletion and GHG emissions but also across a holistic set of environmental indicators, including land-system change, biodiversity loss, freshwater use, and more. Notably, large-scale hydroelectric dams are not considered a green energy source because of the resulting land use change, the impact on natural waterways, and potential biodiversity risks. Similarly, nuclear is not considered a source of green energy because of its environmental risks.

This paper intentionally adopts a **clean energy** lens, and there are several reasons for this. For one, climate change is the most urgent environmental threat facing the planet today, making GHG emissions an important environmental indicator to focus on. This is compounded by the immense impact that the energy sector has on global GHG emissions, which reinforces the need to reduce energy-related emissions, even at the expense of other environmental impacts. Finally, a clean energy lens is well-suited to the Canadian context. Canada is the third-largest hydroelectricity producer in the world (behind the People's Republic of China and Brazil), and hydro and nuclear account for 12% and 9% of Canada's total energy supply, respectively, making them important sources of emissions-free energy.

In addition to nuclear and hydro, interviewees and advisory committee members in this study highlighted the importance of including green hydrogen and bioenergy (including biomass, biofuels, and biogas) in the

---

[17] "About Renewable Energy," December 2017, *Government of Canada*, https://www.nrcan.gc.ca/our-natural-resources/energy-sources-distribution/renewable-energy/about-renewable-energy/7295

scope of the study. Canada has the potential to be a large supplier of green hydrogen energy and bioenergy due to its large deposits of organic waste from agriculture, forestry, and residential and industrial biowaste. While green hydrogen and bioenergy are not entirely emissions-free, they are significantly cleaner than fossil fuel alternatives and have potential for development in Canada.[18] Accordingly, this paper looks at the labour market impacts of the following energy sources: solar, wind, geothermal, hydropower, tidal energy, bioenergy, nuclear, and green hydrogen.

Renewable	Clean	Green
Energy derived from natural processes that are replenished at a rate that is equal to or faster than the rate at which they are consumed.	Energy that does not emit GHGs during its production.	Energy that has the least environmental impact, not just in relation to resource depletion and GHGs, but across a holistic set of environmental indicators, including land-system change, biodiversity loss, and freshwater use.
Environmental Benefit Prevents resource depletion	**Environmental Benefit** Emits zero GHG emissions	**Environmental Benefit** Prevents resource depletion Emits zero GHG emissions Prevents land-system change Prevents biodiversity loss Prevents other environmental impacts
Examples Solar Wind Geothermal Hydropower Tidal energy Bioenergy that is replenished as quickly as consumed	**Examples** Solar Wind Geothermal Hydropower Tidal energy Nuclear	**Examples** Solar Wind Geothermal Low-impact and small-scale hydropower Tidal energy Some forms of bioenergy Green hydrogen

Table 1. *Summary of the different approaches to defining environmentally friendly energy sources.*

---

[18] "Canada's Energy Future 2021, 2021, *Canada Energy Regulator,* https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/canada-energy-futures-2021.pdf

SECTION 1

CANADA'S CLEAN ENERGY ECONOMY

CANADIAN ENERGY PRODUCTION AND USE

To understand the impact of clean energy trends on Canada's labour market, it is important to first understand current and future trends in energy production and demand. Accordingly, this section looks at Canadian energy production and exports, domestic energy supply and consumption, and the relationship between Canadian energy consumption, energy sources, and GHGs. It also discusses the need to reduce GHGs from Canadian energy use by increasing energy efficiency, replacing fossil fuel consumption with clean energy sources, and increasing the proportion of clean electricity sources in Canada's electricity supply. Finally, this section looks at regional trends in electricity generation and speculates on what Canada's clean energy economy is likely to look like in the years to come.

DOMESTIC ENERGY PRODUCTION AND EXPORTS

Emissions-intensive energy sources have dominated Canadian energy production to date, accounting for 85.8% of Canada's energy production in 2020 (oil accounted for 51%, natural gas 30%, and coal 4.8%).[19] Clean energy sources made up the remaining 14.2% that year, including hydro, nuclear, biofuels and waste, and other renewables.[20] Canada produces much more energy than it needs, and so a significant portion of Canada's energy is produced for export, which it mainly exports in the form of fossil fuels. In 2020, Canada exported 44% of its domestic energy production, mainly in the form of natural gas, oil, and coal (see Figure 1).[21] Globally, Canada is the fourth-largest producer of crude oil, fifth-largest producer of natural gas, and seventh-largest exporter of coal.[22] Oil production has grown the most in Canada over time, increasing by 55% in just 10 years, from 167 Mtoe in 2010 to 260 Mtoe in 2020.[23]

---

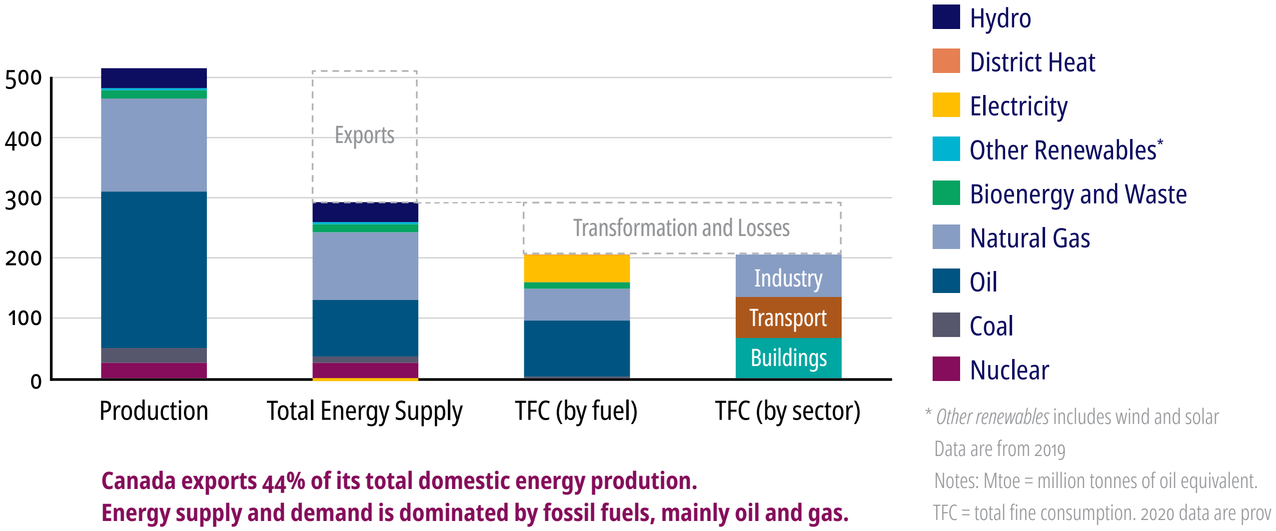
[19] "Canada 2022 Energy Policy Review," 2022, *International Energy Agency,* https://iea.blob.core.windows.net/assets/7ec2467c-78b4-4c0c-a966-a42b8861ec5a/Canada2022.pdf

[20] "Canada 2022 Energy Policy Review," 2022, *International Energy Agency,* https://iea.blob.core.windows.net/assets/7ec2467c-78b4-4c0c-a966-a42b8861ec5a/Canada2022.pdf

[21] "Canada 2022 Energy Policy Review," 2022, *International Energy Agency,* https://iea.blob.core.windows.net/assets/7ec2467c-78b4-4c0c-a966-a42b8861ec5a/Canada2022.pdf

[22] "Canada 2022 Energy Policy Review," 2022, *International Energy Agency,* https://iea.blob.core.windows.net/assets/7ec2467c-78b4-4c0c-a966-a42b8861ec5a/Canada2022.pdf

[23] "Canada 2022 Energy Policy Review," 2022, *International Energy Agency,* https://iea.blob.core.windows.net/assets/7ec2467c-78b4-4c0c-a966-a42b8861ec5a/Canada2022.pdf



Canada exports 44% of its total domestic energy prodution.
Energy supply and demand is dominated by fossil fuels, mainly oil and gas.

* *Other renewables* includes wind and solar
Data are from 2019
Notes: Mtoe = million tonnes of oil equivalent.
TFC = total fine consumption. 2020 data are prov

Figure 1. *Overview of Canada's energy production, supply, and demand in 2020. Data Source: IEA, 2021, IEA World Energy Statistics and Balances Database, "Canada 2022 Energy Policy Review," 2022,* International Energy Agency, *https://iea.blob.core.windows.net/assets/7ec2467c-78b4-4c0c-a966-a42b8861ec5a/Canada2022.pdf*

Despite continued efforts to reduce GHGs, Canada's energy regulator expects crude oil production to increase over the near term. Crude oil production is projected to expand by an additional 16% above 2021 levels, reaching a peak of 5.8 million barrels per day in 2032 and then declining slowly until 2050.[24] Natural gas production is meanwhile expected to fluctuate over the next few years before declining 17% below 2021 levels by 2050.[25] Despite a decrease in natural gas production from now until 2050, natural gas exports are projected to grow, with exports accounting for nearly 40% of Canada's natural gas production by 2050. Importantly, these projections assume that global and domestic efforts to reduce GHG emissions will continue at the current pace, which may or may not happen. Long-term projections for oil production remain uncertain and will be significantly impacted by future oil prices and the realization of domestic and global climate policy.

At the same time, the global energy market is changing, giving Canada an opportunity to examine its role as a supplier of clean energy and materials for the clean energy transition.[26] Around the world, advanced economies have an urgent need to diversify their energy production and imports to meet net-zero targets. Simultaneously, geopolitical events are threatening the stability of existing energy supplies. Together, these trends provide Canada with an opportunity to green its

---

[24] "Canada's Energy Future 2021, 2021, *Canada Energy Regulator,* https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/canada-energy-futures-2021.pdf

[25] "Canada's Energy Future 2021, 2021, *Canada Energy Regulator,* https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/canada-energy-futures-2021.pdf

[26] Legere, Todd et al., "How Three Recent Trade Developments Could Shape Canada's Green Energy Exports," November 2022, *Digital Think Tank by ICTC,* https://www.digitalthinktankictc.com/articles/how-three-recent-trade-developments-could-shape-canadas-green-energy-exports

energy trade: Canada can leverage its natural resources, past strengths in existing energy industries, and international relationships to become a global supplier of clean energy sources and material inputs, including clean fuels like hydrogen, advanced biofuels, renewable natural gas, inputs for electric vehicles, and more.

Already, we are starting to see signs of Canada's greening energy trade. Canada is engaged in a growing number of international partnerships focused on clean energy research and development and adoption. Examples include Canada's recent agreement with Germany to enhance Germany's energy security with clean Canadian hydrogen,[27] Canada and South Korea's comprehensive strategic partnership to promote energy security, sustainable energy sources, and critical minerals,[28] and opportunities for Canada to supply electric vehicles and electric vehicle components under the United States Inflation Reduction Act.[29] In 2023, a clean energy project in Point Tupper, Nova Scotia, became the first independent green hydrogen and green ammonia project in North America to receive environmental approval.[30] The project is on track to begin construction in 2023 and begin delivering green ammonia for export to Germany by 2025. As more opportunities for clean energy trade emerge, and as more "firsts" like the project in Point Tupper, Nova Scotia, are accomplished, clean energy will become an increasingly important component of Canada's energy trade.

DOMESTIC ENERGY SUPPLY

Since a large portion of Canada's fossil fuels is exported, Canada's total energy supply (e.g., the overall energy supply available for use in the country) is considerably cleaner than its production. In 2020, emissions-intensive energy sources accounted for approximately 76% of Canada's energy supply (e.g., natural gas, oil, and coal), while clean energy sources accounted for the remaining 24% (e.g., nuclear, renewables, and waste).[31] Interestingly, the supply of wind and solar energy increased by 11% and 4%, respectively in 2020, whereas coal and oil decreased by 24% and 9% (however, the latter trend was likely due to the impact of the COVID-19 pandemic on fossil fuel demand). While wind and solar energy are growing, the supply of natural gas in Canada is increasing at the fastest rate, growing by 41% in just one decade from 2009 to 2019.[32]

---

[27] "Canada and Germany Sign Agreement to Enhance German Energy Security with Clean Canadian Hydrogen," August 2022, *Government of Canada,* https://www.canada.ca/en/natural-resources-canada/news/2022/08/canada-and-germany-sign-agreement-to-enhance-german-energy-security-with-clean-canadian-hydrogen.html

[28] "The Republic of Korea and Canada: Stronger Together - Joint Leaders' Statement," September 2022, *Office of the Prime Minister of Canada,* https://pm.gc.ca/en/news/statements/2022/09/23/republic-korea-and-canada-stronger-together-joint-leaders-statement

[29] "FACT SHEET: The Inflation Reduction Act Supports Workers and Families," August 2022, *The White House,* https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/19/fact-sheet-the-inflation-reduction-act-supports-workers-and-families/

[30] "EverWind Fuels Receives Environmental Approval for First Industrial-Scale Green Hydrogen and Green Ammonia Project in North America." February 2023, *Cision,* https://www.prnewswire.com/news-releases/everwind-fuels-receives-environmental-approval-for-first-industrial-scale-green-hydrogen-and-green-ammonia-project-in-north-america-301741136.html

[31] "World Energy Balances Highlights," October 2022, *International Energy Agency*, https://www.iea.org/data-and-statistics/data-product/world-energy-balances-highlights#highlights

[32] "Canada 2022 Energy Policy Review," 2022, *International Energy Agency,* https://iea.blob.core.windows.net/assets/7ec2467c-78b4-4c0c-a966-a42b8861ec5a/Canada2022.pdf

DOMESTIC ENERGY USE

Domestic energy use is again different from supply. While total energy supply is a measure of the overall energy supply *available* for use in a given country, energy use, or consumption, is a measure of how much energy is actually consumed. Several organizations provide data about Canada's energy use. Despite using slightly different indicators and methodologies, the data sources yield similar results.

Total Final Consumption

The International Energy Agency publishes data about country-level total final consumption (TFC) for a collection of countries around the world. TFC is a measure of how much energy is consumed by end users across the economy. It includes household energy consumption and energy consumption by industry but excludes the energy consumed by the energy sector itself, such as to transport or transform energy.[33] In 2020, oil accounted for 43% of Canada's TFC (See Figure 2).[34] This was slightly less than in 2019, when oil accounted for 46%, once again likely due to the impact of the COVID-19 pandemic on oil demand. Natural gas accounted for the second-highest percentage of Canada's TFC in 2020 (26%), followed by electricity (24%), renewables and waste (5%), and finally, coal (1%).[35]

As seen in Figure 2, oil accounts for the largest share of TFC in the transport sector, where it accounted for 90% of TFC in 2020 (in comparison, oil accounted for just 12% and 4% of industrial and residential TFC). Use of natural gas and electricity is meanwhile more balanced across sectors: natural gas and electricity each accounted for nearly half of residential TFC in 2020 (42% and 46%, respectively) and just over a third of industry TFC (34% and 36% respectively). Renewables and waste accounted for the largest share of industrial TFC at 12%, followed by residential at 8%, and transport at 3%. Finally, coal, peat, and oil shale were only used in industry, where they accounted for 6% of TFC.

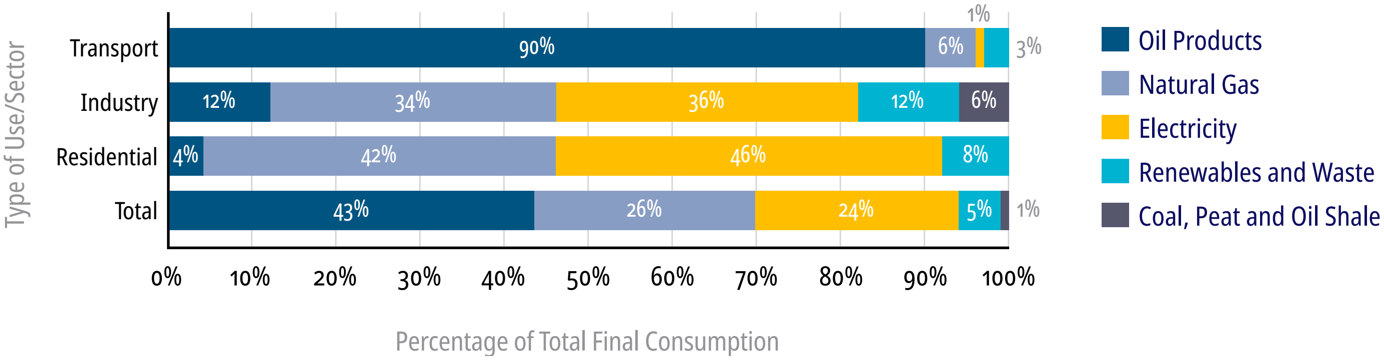


Figure 2. *Canada's total final consumption by sector and energy source. Data Source: "World Energy Balances Highlights," October 2022,* International Energy Agency, *https://www.iea.org/data-and-statistics/data-product/world-energy-balances-highlights#highlights*

---

[33] "World Energy Balances Highlights," October 2022, *International Energy Agency,* https://www.iea.org/data-and-statistics/data-product/world-energy-balances-highlights#highlights

[34] "World Energy Balances Highlights," October 2022, *International Energy Agency,* https://www.iea.org/data-and-statistics/data-product/world-energy-balances-highlights#highlights

[35] "World Energy Balances Highlights," October 2022, *International Energy Agency,* https://www.iea.org/data-and-statistics/data-product/world-energy-balances-highlights#highlights

Total Energy Use

Natural Resources Canada also publishes data about Canada's energy use. According to this data, energy use in Canada has grown by 20% over the past two decades, from 8,042 PJ in 2000 to 9,683 PJ in 2019. During this time, the use of natural gas grew the fastest (by 40%), followed by residential wood (22%), oil products (19%), and electricity (5%). Meanwhile, the use of wood waste and pulping liquor and other fuels declined by 21% and 5%, respectively. In 2019, oil accounted for two-fifths (40%) of Canada's total energy use, followed by natural gas (31%), electricity (20%), wood waste and pulping liquor (4%), other fuels (3%), and residential wood (1%).

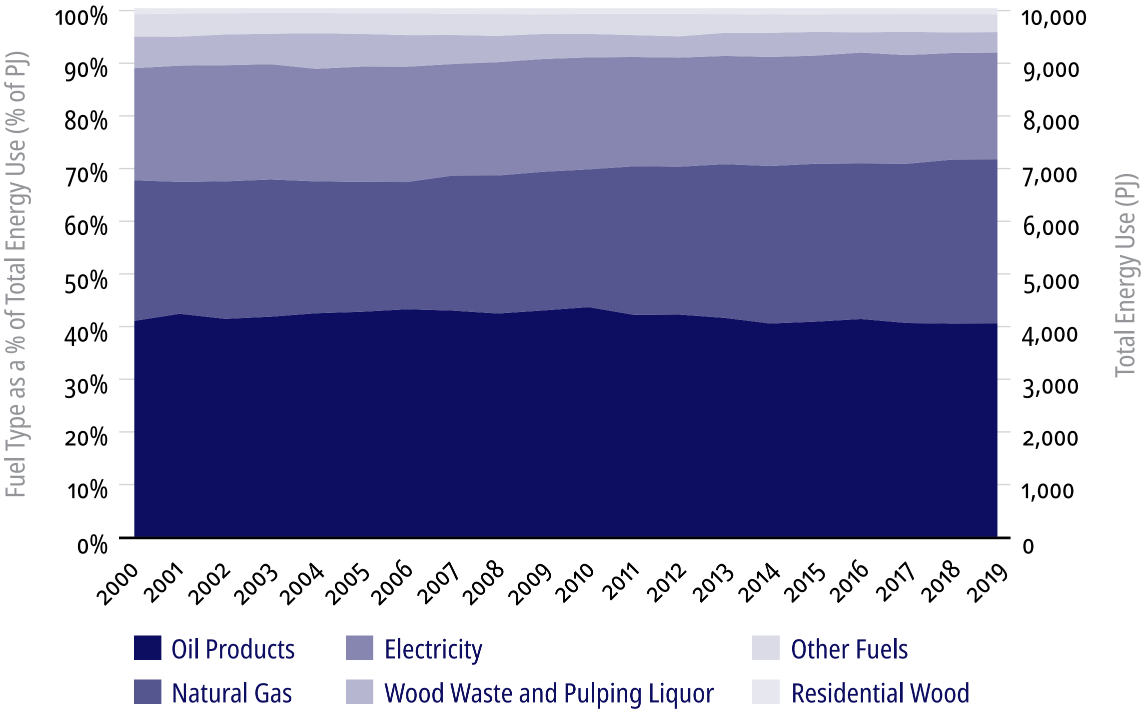


Figure 3. *Total Energy Use in Canada and energy use by source from 2000 to 2019. Data source: "Total End-Use Sector – Energy Use Analysis," 2023,* Natural Resources Canada, *oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=AN&sector=aaa&juris=ca&rn=1&page=0*

ENERGY USE AND GHG EMISSIONS

Natural Resources Canada publishes data about the **GHG intensity** of Canada's energy use (e.g., the amount of Mt of CO2e emitted per unit of energy consumed) and **total GHG emissions** from Canadian energy use (e.g., the total amount of GHG emissions from energy use per year). Used together, this data can help determine whether Canada's energy use has become more sustainable. Figure 3 shows that while the GHG intensity of Canadian energy use has decreased over time, falling by nearly 9% from 2000 to 2019, steady growth in the consumption of fossil fuels has caused total emissions to outpace carbon efficiency gains. As seen in Figure 4, total GHG emissions from Canadian energy use have grown by at least 10%, from 466 Mt of CO2e in 2000 to 511 Mt of CO2e in 2019.

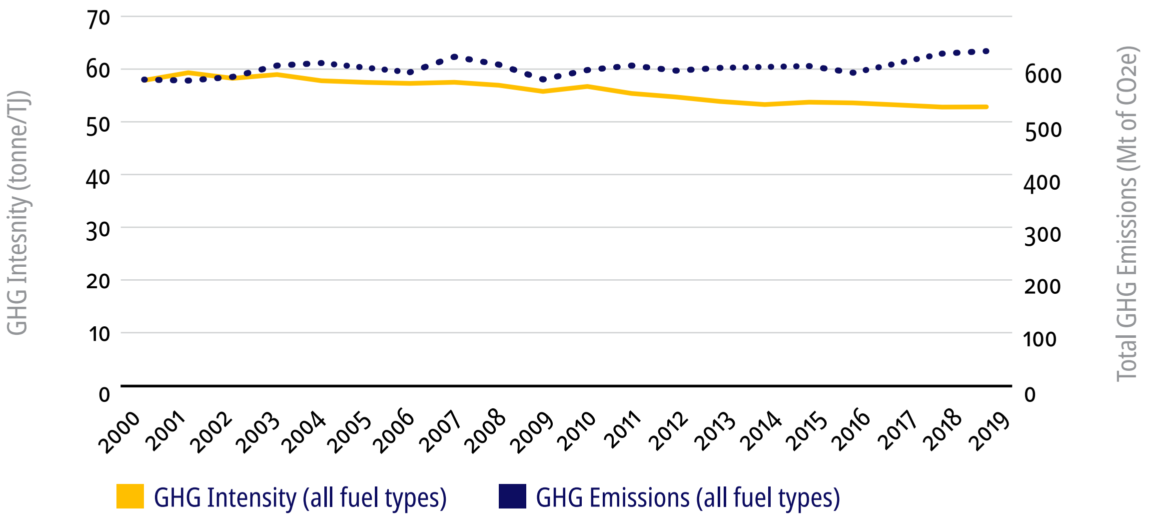


Figure 4. *The GHG Intensity of Canada's Energy Sources and Total GHG Emissions from Canadian Energy Use Over Time. Data Source: "Total End-Use Sector – GHG Emissions Base Year 2000," 2023,* Natural Resources Canada, *oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=AN&sector=aaa&juris=00&rn=1&page=0*

When looking at GHG intensity by fuel type, we see that nearly all of the carbon efficiency gains from 2000 to 2019 are from electricity. From 2000 to 2019, the GHG intensity of Canada's electricity use declined by 45%, from 59.56 to 32.55 tonnes per TJ of energy. There was also a slight reduction in the GHG intensity of oil products (-2%), alongside an increase in the GHG intensity of natural gas (+2%) and other fuels (+5%).

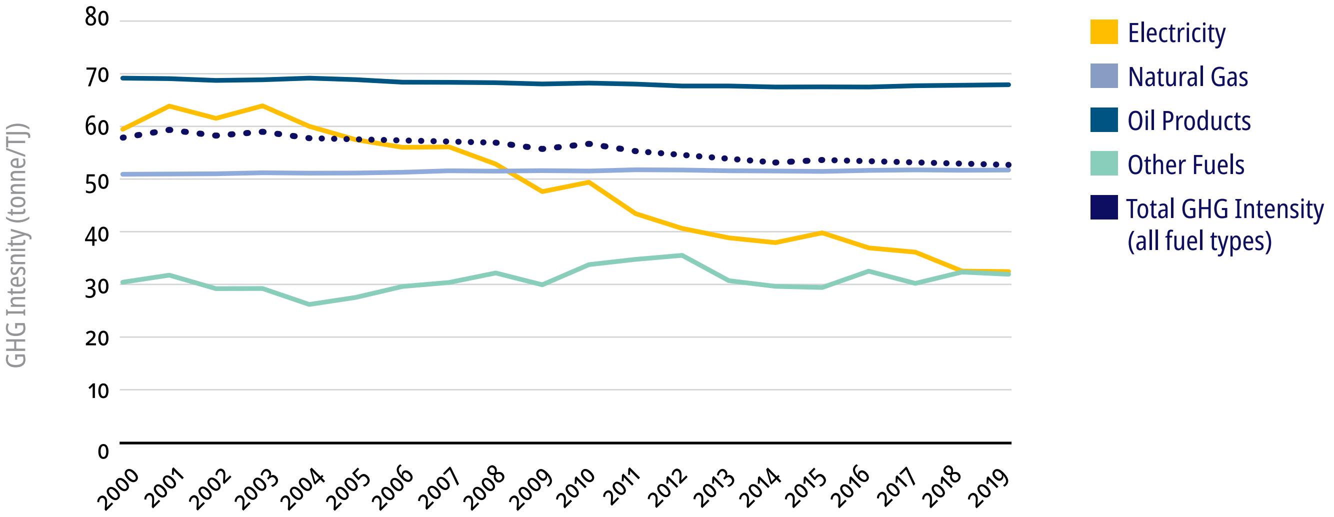


Figure 5. *The GHG Intensity of Canada's Energy Sources Over Time. Data Source: "Total End-Use Sector – GHG Emissions Base Year 2000," 2023,* Natural Resources Canada, *oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=AN&sector=aaa&juris=00&rn=1&page=0*

Electricity is also the only fuel type for which GHG emissions have declined (see Figure 6). From 2000 to 2019, GHG emissions from electricity use fell by 37%, while emissions from natural gas and oil products increased by 43% and 17%, and emissions from other fuels remained the same.

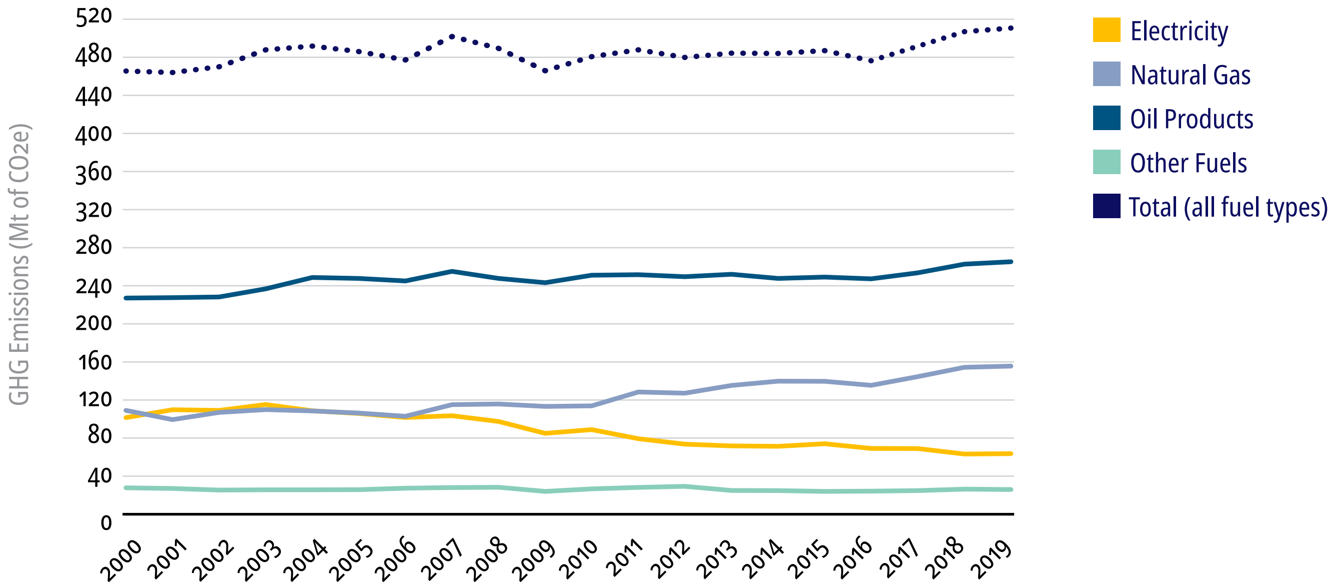


Figure 6. *GHG Emission from Canada's Energy Sources Over Time. Data Source: "Total End-Use Sector – GHG Emissions Base Year 2000," 2023,* Natural Resources Canada, *oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=AN&sector=aaa&juris=00&rn=1&page=0*

FUTURE PROGRESS

The above data highlights that Canada must (1) reduce energy intensity (e.g., the amount of energy consumed per dollar of GDP) across the Canadian economy by making energy use more efficient, (2) replace fossil fuel consumption with clean energy sources, such as clean fuels and clean electricity, and (3) increase the proportion of clean electricity sources in Canada's electricity supply—and make the necessary grid and interregional transmission upgrades to make this supply usable. These initiatives are explored in more detail in the section below.

IMPROVING ENERGY EFFICIENCY

While the impact of energy efficiency is limited, energy efficiency is expected to contribute to Canada's 2030 and 2050 net-zero goals. Indeed, Canada's energy regulator expects energy efficiency to reduce primary energy use by more than a fifth (21%) from 2021 to 2050, in turn reducing upward pressure on GHGs.[36] This work will include a range of energy efficiency measures, including those that promote energy efficiency in buildings; encourage the use of industry standards, such as ISO 500001, Superior Energy Performance, and ENERGY STAR; incentivize the introduction and use of energy management systems; and nudge businesses and consumers toward more fuel-efficient transport options.[37] While energy efficiency is an important mechanism to reduce energy use in the Canadian

[36] "Canada's Energy Future 2021, 2021, *Canada Energy Regulator,* https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/canada-energy-futures-2021.pdf

[37] "Canada 2022 Energy Policy Review," 2022, *International Energy Agency,* https://iea.blob.core.windows.net/assets/7ec2467c-78b4-4c0c-a966-a42b8861ec5a/Canada2022.pdf

economy, energy efficiency gains are subject to rebound effects, whereby increased energy efficiency in one area of the economy leads to greater consumption of energy in other areas of the economy. Without concurrent efforts to phase-out fossil fuels and expand Canada's clean electricity supply, a strong rebound effect could threaten Canada's ability to achieve net-zero goals.

PHASING OUT FOSSIL FUELS

Energy efficiency measures can only achieve so much, making the phase-out of fossil fuels a high-priority goal. While there is unlikely to be a complete reduction in fossil fuels,[38] it will be important for Canada to reduce its fossil fuel consumption to the greatest extent possible over the next 30 years.

For the transport sector, this means electrifying industry and consumer transport options and, where possible, replacing gasoline and diesel consumption with cleaner fuels. As discussed, oil products account for 43% of Canada's total final consumption, with transport alone accounting for 88% of Canada's oil demand. Clean fuels (including hydrogen, advanced biofuels, renewable natural gas, sustainable aviation fuel, and synthetic fuels) meanwhile make up less than 6% of Canada's total energy supply.[39] For Canada to meet its net-zero goals by 2050, clean fuels will need to account for 10% to 51% of domestic energy demand.[40]

In comparison to oil, natural gas consumption is more evenly split between industry and residential use. Natural gas is used in Canada to heat buildings and power appliances and equipment such as lights, water heaters, fridges, and cooking ranges. To reduce its consumption of natural gas, Canada will need to opt for electricity-based infrastructure and appliances in new buildings and electrify existing infrastructure and appliances where possible. Where it is not possible to reduce the consumption of natural gas, CCUS will need to be utilized to reduce its GHG intensity.

EXPANDING CANADA'S CLEAN ELECTRICITY SUPPLY

Thanks to an abundance of hydropower and nuclear, Canada is home to "one of the cleanest electricity systems in the world."[41] Yet, nearly one-fifth (18%) of Canada's electricity supply still comes from high-emissions sources, such as coal, petroleum, and natural gas.[42] In order to meet its 2030 and 2050 net-zero goals, Canada will need to decarbonize its electricity grid by expanding the supply

---

[38] "Canada's Energy Future 2021, 2021, *Canada Energy Regulator,* https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/canada-energy-futures-2021.pdf

[39] "Canada 2022 Energy Policy Review," 2022, *International Energy Agency,* https://iea.blob.core.windows.net/assets/7ec2467c-78b4-4c0c-a966-a42b8861ec5a/Canada2022.pdf

[40] "Canada 2022 Energy Policy Review," 2022, *International Energy Agency,* https://iea.blob.core.windows.net/assets/7ec2467c-78b4-4c0c-a966-a42b8861ec5a/Canada2022.pdf

[41] "Canada 2022 Energy Policy Review," 2022, *International Energy Agency,* https://iea.blob.core.windows.net/assets/7ec2467c-78b4-4c0c-a966-a42b8861ec5a/Canada2022.pdf

[42] "Energy Fact Book 2021-2022," 2021, *Natural Resources Canada,* https://natural-resources.canada.ca/sites/nrcan/files/energy/energy_fact/2021-2022/PDF/2021_Energy-factbook_december23_EN_accessible.pdf; "Canada 2022 Energy Policy Review," 2022, *International Energy Agency,* https://iea.blob.core.windows.net/assets/7ec2467c-78b4-4c0c-a966-a42b8861ec5a/Canada2022.pdf

of clean electricity sources and make related upgrades to Canada's grid and transmission infrastructure. In 2021, the Canada Energy Regulator projected that electricity demand will increase by 47% from 2021 to 2050, partly due to increased electrification in Canada's industrial, residential, and commercial sectors; increased adoption of electric vehicles; and the production of hydrogen.[43]

In terms of the overall electricity mix, Canada's electricity system is projected to become cleaner, with the proportion of low and non-emitting sources reaching 95% by 2050.[44] These trends will be driven by a decrease in the use of coal, oil, and unabated natural gas and a large increase in wind and solar electricity production and natural gas electricity generation combined with CCUS.[45] Finally, to assist with the integration of wind and solar generation, Canada's energy regulator projects a large increase in the use of electricity storage technologies, alongside a small increase in the use of hydro and nuclear.[46]

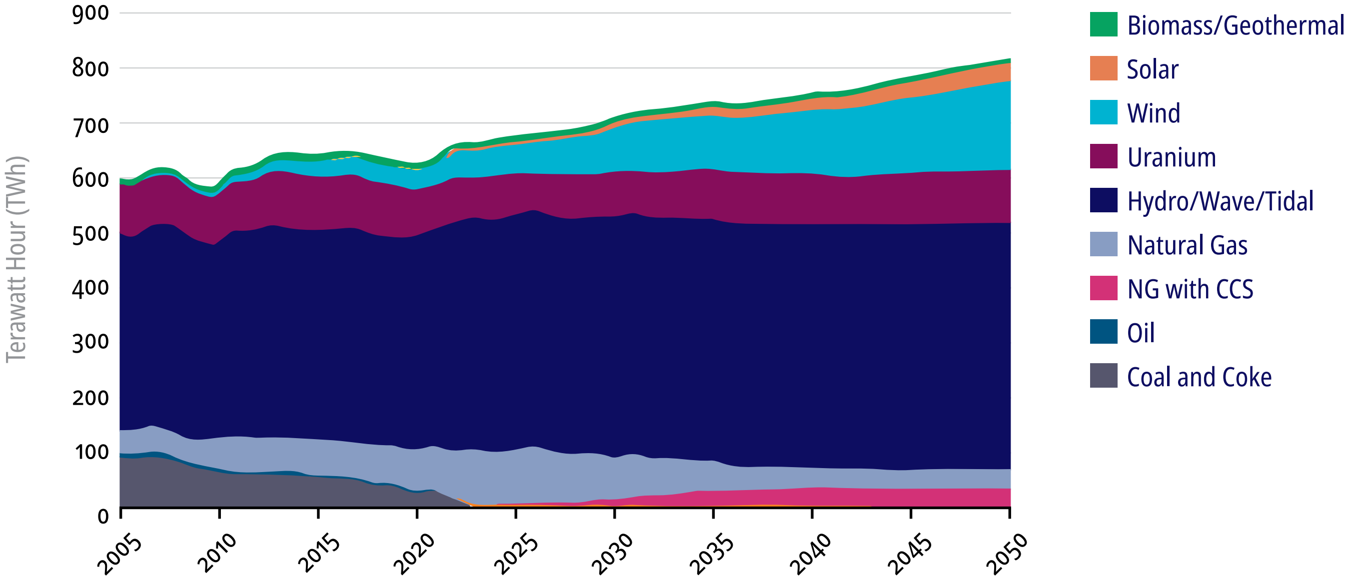


Figure 7. *Projected electricity generation in Canada by source from 2005 to 2050. Data source: "Canada's Energy Future 2021," 2021,* Canada Energy Regulator, *https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/key-findings.html#kf2*

Regional Opportunities for Clean Electricity

Canada has a vast and diverse geography. Natural resource availability, such as water reservoirs, wind, and sun, varies extensively by region, and because of this, so do opportunities for clean electricity generation. In 2019, many provinces and territories used a unique combination of clean electricity sources, while in some

---

[43] "Canada's Energy Future 2021, 2021, *Canada Energy Regulator,* https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/canada-energy-futures-2021.pdf

[44] "Canada's Energy Future 2021, 2021, *Canada Energy Regulator,* https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/canada-energy-futures-2021.pdf

[45] "Canada's Energy Future 2021, 2021, *Canada Energy Regulator,* https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/canada-energy-futures-2021.pdf

[46] "Canada's Energy Future 2021, 2021, *Canada Energy Regulator,* https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/canada-energy-futures-2021.pdf

regions, no clean electricity was produced at all. This is important because the types of electricity sources that provinces and territories use today can tell us a lot about these regions' present and future labour market needs. They can also tell us about what clean electricity opportunities might be available in future years.

As seen in Figure 8, hydro accounts for the vast majority of electricity generation in Manitoba (96.9%), Newfoundland and Labrador (95.6%), Quebec (93.7%), British Columbia (86.3%), and Yukon (79.7%), and is a significant source of clean electricity in Northwest Territories (36.6%), New Brunswick (23.4%), and Ontario (22.8%).[47] Meanwhile, nuclear is an important source of clean electricity in Ontario and New Brunswick, where it accounts for 58.4% and 38.2% of provincial electricity generation.[48] While this tells us that there is a need for hydro and nuclear-related jobs and skills in these regions, it also tells us about these regions' future capacity to integrate variable sources of clean electricity.

Variable sources of clean electricity, such as wind and solar, can only generate electricity in specific weather conditions. Hydro and nuclear can assist with this challenge by providing a cost effective and constant source of back-up power generation when weather conditions are unsuitable.[49] Regions that do not have access to hydro or nuclear may need to build out other solutions, such as demand flexibility, electricity storage, natural gas with CCUS, and other options for clean back-up generation.[50] Finally, while Canada's electricity grid is currently quite siloed, future efforts to connect neighbouring grids will enable more regions to integrate variable generation into their electricity mix. Today, variable sources account for the largest share of electricity generation in Prince Edward Island (99%), Nova Scotia (11.2%), Ontario (9.6%), New Brunswick (6.8%), Alberta (5.6%), and Quebec (5.2%).[51] Wind is the main source of variable electricity in all of these regions.

Regions that rely extensively on fossil fuels today are likely to experience the most disruptive labour market changes in a net-zero world. As seen in Figure 8, Nunavut relies on petroleum for 100% of its electricity generation. Alberta and Saskatchewan also rely on fossil fuels for 89% and 81% of their electricity generation, most of which is produced using a mix of natural gas and coal. Nova Scotia produces just over three-quarters (76%) of its electricity using fossil fuels: mostly coal, followed by natural gas, and then petroleum. Finally, New Brunswick and Yukon rely on fossil fuels for 28% and 19% of their electricity generation. In New Brunswick, there is a mix of coal, natural gas, petroleum, and natural gas-based electricity generation, whereas in Yukon, it is primarily natural gas, with petroleum making up the remaining amount.

---

[47] "Energy Fact Book 2021-2022," 2021, *Natural Resources Canada,* https://natural-resources.canada.ca/sites/nrcan/files/energy/energy_fact/2021-2022/PDF/2021_Energy-factbook_december23_EN_accessible.pdf

[48] "Energy Fact Book 2021-2022," 2021, *Natural Resources Canada*, https://natural-resources.canada.ca/sites/nrcan/files/energy/energy_fact/2021-2022/PDF/2021_Energy-factbook_december23_EN_accessible.pdf

[49] "Canada 2022 Energy Policy Review," 2022, *International Energy Agency,* https://iea.blob.core.windows.net/assets/7ec2467c-78b4-4c0c-a966-a42b8861ec5a/Canada2022.pdf

[50] "Canada's Energy Future 2021, 2021, *Canada Energy Regulator,* https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/canada-energy-futures-2021.pdf

[51] "Energy Fact Book 2021-2022," 2021, *Natural Resources Canada,* https://natural-resources.canada.ca/sites/nrcan/files/energy/energy_fact/2021-2022/PDF/2021_Energy-factbook_december23_EN_accessible.pdf

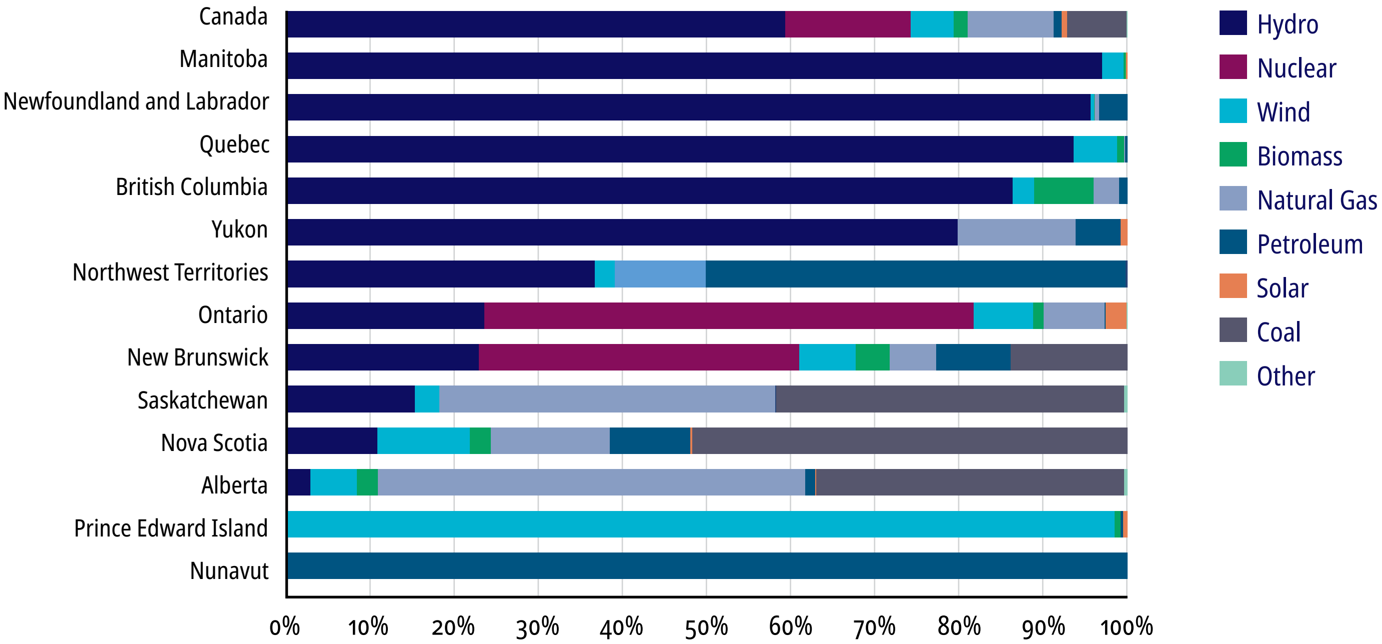


Figure 8. *Provincial electricity generation by source, 2019. Data source: "Energy Fact Book 2021-2022," 2021,* Natural Resources Canada, *https://natural-resources.canada.ca/sites/nrcan/files/energy/energy_fact/2021-2022/PDF/2021_Energy-factbook_december23_EN_accessible.pdf*

Future Projections for Canada's Electricity Mix in a Net-Zero World

In 2021, the Canada Energy Regulator (CER) modelled what Canada's electricity mix might look like in a net-zero world. The 2021 projections are the most recently available, however, the CER plans to update these projections in 2023. While the 2021 projections were calculated several years ago, the 2023 projections will be based on more recent data, trends, and technology advances, and will therefore paint a more accurate picture of Canada's future energy sector. Nonetheless, the goal for the 2021 projects was to "select the optimal set of power generation technologies that minimize the total cost while satisfying future power demand."[52] Projections were provided for six net-zero scenarios, each with a different set of assumptions and simplifications. In all six scenarios, power systems across Canada continue to be very regionally distinct, with a unique electricity mix in each of the provinces. Moreover, "wind, solar, and battery storage dominate electric capacity additions," "making up between 82% and 85% of added capacity" from now until 2050.[53]

Figure 9 demonstrates what the energy mix could look like under the Canada Energy Regulator's "main net-zero scenario."[54] Importantly, to assist with modelling,

---

[52] "Canada's Energy Future 2021, 2021, *Canada Energy Regulator,* https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/canada-energy-futures-2021.pdf
[53] "Canada's Energy Future 2021, 2021, *Canada Energy Regulator,* https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/canada-energy-futures-2021.pdf
[54] "Canada's Energy Future 2021, 2021, *Canada Energy Regulator,* https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/canada-energy-futures-2021.pdf

this scenario makes several assumptions about Canada's energy system. For one, it excludes hydrogen and biomass with CCUS, given that at the time of writing, these technologies were not as well understood, in addition to geothermal, tidal, conventional biomass, and offshore wind. It also assumes that new inter-provincial transmission will become available and that there will be significant capital investment in a variety of technologies from now until 2050. It also only accounts for grid-connected generation, meaning isolated wind or solar generation is not accounted for. Finally, it does not account for future breakthroughs in electricity storage, the introduction of demand-side management solutions and distributed electricity resources, nor the impact of electricity trade with the United States.

As seen in Figure 9, regions that rely extensively on fossil fuels would experience disruptive changes to their electricity mix. In Alberta, Nova Scotia, and New Brunswick, unabated fossil fuel consumption would be phased out, while wind and/or natural gas with CCUS would provide additional capacity in the near term, and solar would provide additional capacity by 2050. In Saskatchewan, wind and solar generation would both increase substantially in the near term, with natural gas with CCUS providing additional capacity by 2050.

British Columbia, Manitoba, Quebec, and Newfoundland and Labrador generate nearly all of their electricity using hydro today. In British Columbia and Quebec, new capacity for wind generation would help reduce the consumption of fossil fuel in the near term, while in the long term, new wind and solar capacity would help meet new demand. In Newfoundland and Labrador, fossil fuel consumption would instead be offset by increased hydro capacity, and finally, new wind and solar capacity would help Manitoba meet additional demand.

Prince Edward Island already generates nearly all of its electricity using wind. In the near term, its negligible use of petroleum for electricity would be offset by increased wind generation and brand-new capacity for solar. In the long term, both wind and solar would help meet additional demand.

Ontario and New Brunswick both use a diverse combination of electricity sources to meet current electricity demand, including nuclear, hydro, wind, and fossil fuels. In Ontario, a small portion of current electricity demand is also met using solar. While both Ontario and New Brunswick would continue to generate electricity using natural gas in the short and long term, fossil fuel consumption would be phased out in the near term while wind's role in the energy mix would grow. By 2050, nearly all of Ontario and New Brunswick's energy needs is expected to be met using a mix of nuclear, wind, solar, and hydro.

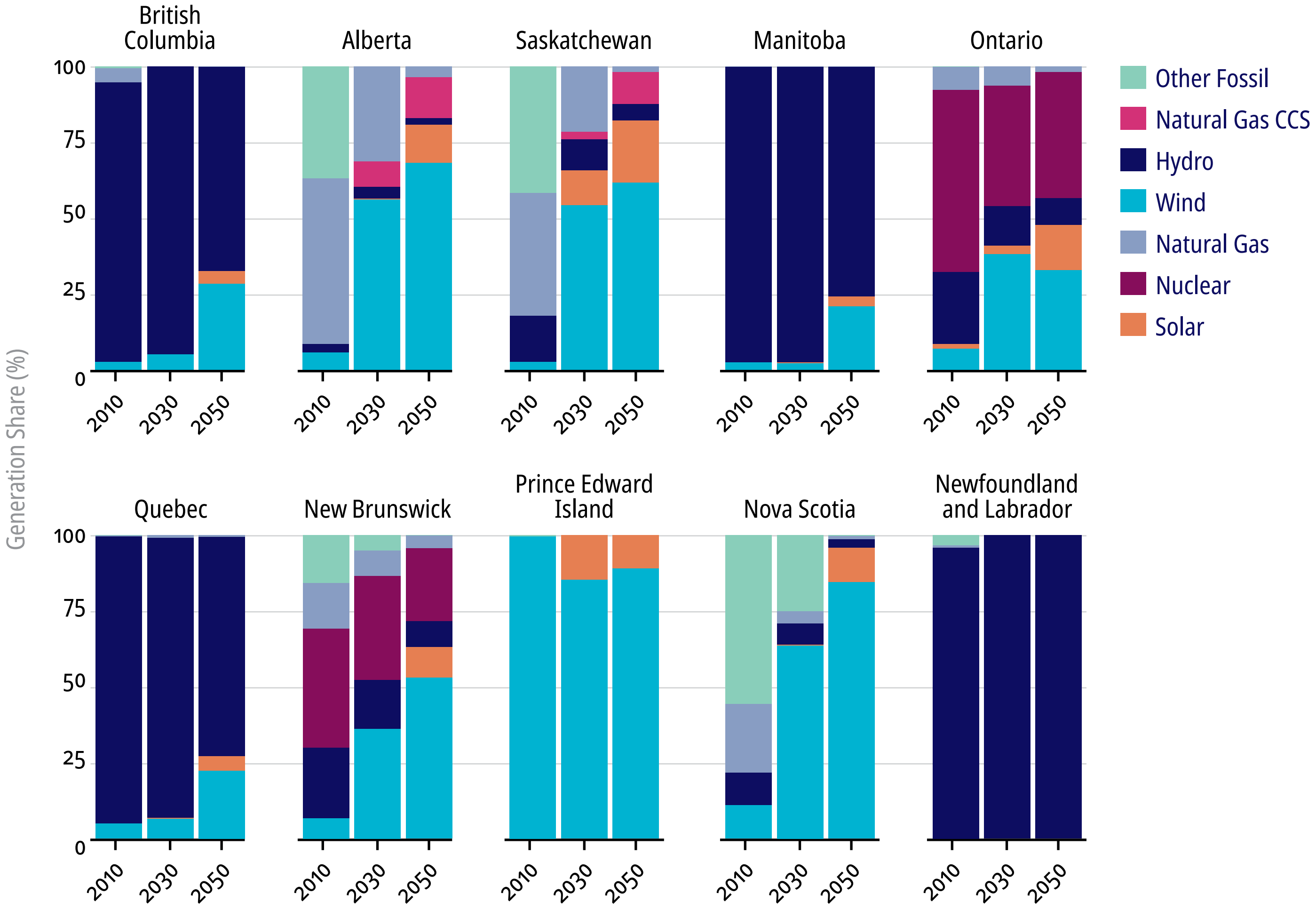


Figure 9. *Electricity generation share by technology, main net-zero electricity scenario. Data source: "Canada's Energy Future 2021," 2021,* Canada Energy Regulator, *https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/key-findings.html#kf2*

While an updated version of these projections is expected in 2023, the 2021 projects provide some insight into which regions will see the greatest adoption of wind, solar, and additional hydro capacity. As we explore the impact of transitioning to net-zero on labour market needs, it is important to keep in mind that the transition to net-zero will have regional differences. Similarly, it is important to note that future trends in clean energy are subject to change, for instance, due to future changes in the price and availability of clean energy technologies, updates to domestic and international clean energy policy, progress in inter-provincial transmission, and changes in electricity demand. Interviewees in this study discussed a variety of drivers and barriers to clean energy adoption and growth, all of which will have a profound impact on clean energy adoption. These are summarized below.

Clean Energy and Clean Electricity Drivers

Climate Change

Climate change is a core driver of clean energy technology development and clean energy policy. Climate change provides the clean energy sector with its raison d'être: reducing carbon emissions and preventing catastrophic changes to the earth's climate. In addition to climate change, some clean energy solutions have other environmental benefits. Wind power, for instance, is said to have the lowest water consumption among energy sources.

Carbon Pricing

While GHG emissions have many inherent, externalized costs, governments around the world are putting a financial price on pollution through carbon taxes and cap and trade programs. These policies have a very direct impact on the clean energy sector as they drive up the cost of fossil fuels.

Declining Technology Costs

Over the last 10 years, the cost of clean energy technologies has fallen steadily, some by up to 90%. Falling costs have made solar and wind projects more affordable, thereby driving up demand.

Co-ops and Other Forms of Community Ownership

Co-ops and other innovative approaches to community ownership can be a driving force in clean energy projects. When communities are involved in the planning process and are given ownership of the outcomes, they become more motivated to make projects successful. Similarly, when communities financially benefit from a project, they become more likely to adopt it. That said, in order for communities to have the greatest impact on clean energy adoption, there will need to be adequate support for community-based clean energy training opportunities.

Global Energy Security

Over the past few years, countries around the world have had their energy security threatened by supply chain issues, geopolitical conflicts, and volatility in the price of fossil fuels. As a result, many countries are turning to new sources of clean energy, such as hydrogen, in an effort to improve their energy security and diversify their energy supply.

Public Sector Investment

Many governments, including the Government of Canada, recognize the importance of clean energy to the world's future and are making significant investments in clean energy in the form of funding programs, tax credits, and rebates. These investments help reduce the costs and risks associated with technology development and adoption.

Private Sector Investment

Private sector companies, too, recognize the role that climate change (and the global response to climate change) will play in reshaping global markets. To get ahead of this trend, many companies are investing in and/or adopting clean energy solutions.

Ability to Attract Workers

While it can sometimes be difficult to fill growing clean energy roles, interviewees noted that clean energy is an attractive sector to work in, particularly among students and young people. Clean energy workers come from diverse backgrounds and often "have a passion for making the world a better place," creating a unique and valuable dynamic for clean energy employers.

Barriers to Clean Energy and Clean Electricity

Capital Costs and the Scale of Private Sector Investment

Transforming Canada's energy sector will require significant capital investments to develop the necessary technologies and infrastructure. As noted by the International Energy Agency and Canada's energy regulator, the sheer cost of these investments could be a significant barrier to the growth of clean energy. In regions where the electricity grid is already very clean, the potential return on investment may be smaller, creating a need for investment incentives.

Technological Maturity

Many clean energy technologies are in the early stages of development, meaning their supply chains, use cases, and business models are not fully established. In this study, interviewees brought up several examples of technologies that have yet to be "proven," including hydrogen, bioenergy, tidal, and large-scale batteries.

Global Supply Chains

The global energy transition will require a robust supply of the critical minerals, natural resources, and components that are required to make electric batteries, wind turbines, solar panels, and more. The supply of some technology inputs is dominated by a select few countries, which has, in the past, impacted global supply chains. If global supply chains for these inputs remain constrained, it could impact the sector's ability to grow.

Labour Market Shortages and Competing for Talent with Other Industries

While clean energy is an attractive industry to work in, there remains an ongoing labour shortage for many clean energy roles. This challenge is compounded by the reality that many of the workers who are well-suited to clean energy roles also have the right skill sets to work in other industries, such as manufacturing, construction, or oil and gas. In order to compete, clean energy employers will need to provide work opportunities with competitive pay, hours, flexibility, and quality of life.

The Need for Community Buy-In

Many clean energy projects take place at the community level. Either community "buy-in" is needed to get projects past regulatory and social hurdles, or community-wide adoption is needed to make solutions functional and/or cost effective. While not impossible to overcome, the need for community-level change introduces unique challenges, such as competing interests or coordination costs. Community buy-in are particularly important for interregional transmission projects, which will need to travel through many communities in order to be successful.

Culture

Culture may be a barrier to change. One interviewee noted that the adoption of clean energy solutions will require Canadians to integrate clean energy "into their cultural fabric." They noted that Canada has a low population density and an abundance of natural resources, potentially making it harder for Canada to integrate resource preservation than a country like the Netherlands, which has a high population density and limited internal resources.

Barriers to Clean Energy and Clean Electricity

Political Barriers

The clean energy transition will not impact all regions or industries equally. While some regions stand to benefit from the clean energy transition, others may be negatively impacted by a reduction in GDP, jobs, and growth. Because of this, clean energy can be a divisive and political topic. Many interest groups lobby the government to draft clean energy policies, such as carbon pricing, in their favour. In a worst-case scenario, political pressure prevents governments from taking decisive action.

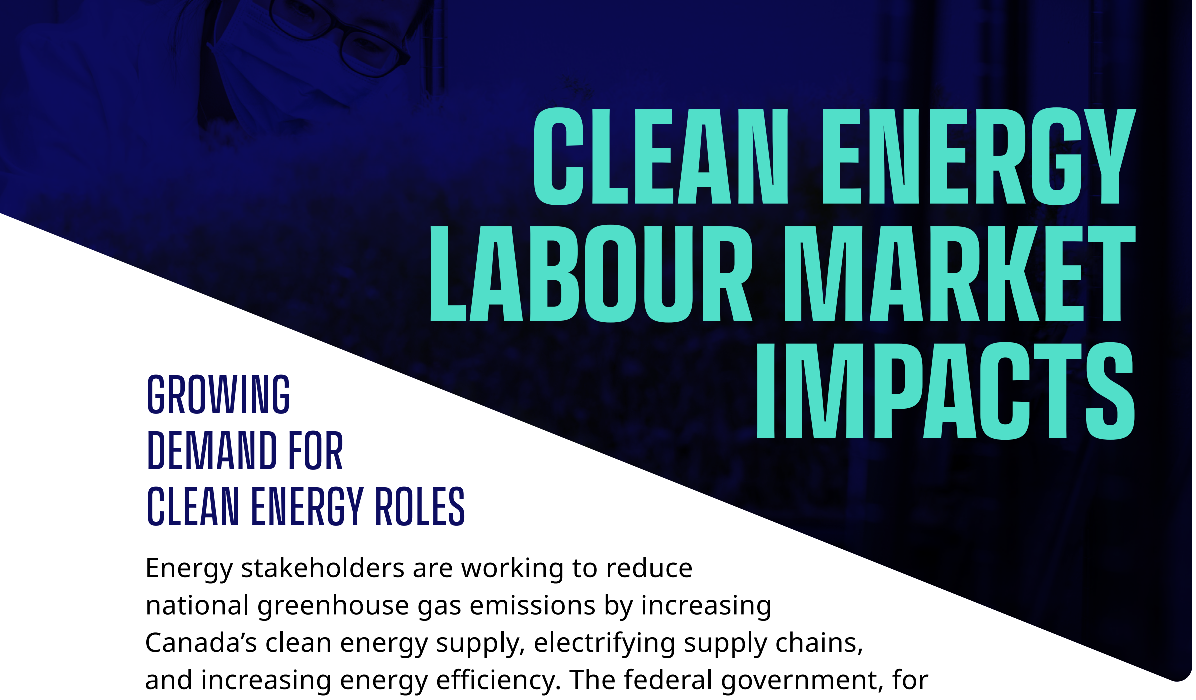
Red Tape

Depending on the region, the regulatory approvals required for clean energy projects can be strict. In some provinces, energy is completely regulated, meaning there is no way to build independent power production without approval from utility regulators. Other jurisdictions are unregulated, making it easier for clean energy projects to get started. Environmental assessments and permits are also required at the federal and provincial levels, which can add additional time and financial costs to projects.

The Pace of Adoption

Utilities can be slow to adopt and/or enable the adoption of clean energy solutions. Interviewees discussed a variety of factors that can cause this, including risk aversion, competing interests, centralized power and resources, and constrained budgets. However, it is worth noting that not all utilities are slow to adopt: Canada is home to many utilities that are pushing the boundaries of clean energy.

Figure 10. *Driver and barriers to clean energy and clean electricity in Canada and around the world. Data source: based on comments by key informant interviewees and advisory committee members in this study.*



CLEAN ENERGY LABOUR MARKET IMPACTS

GROWING DEMAND FOR CLEAN ENERGY ROLES

Energy stakeholders are working to reduce national greenhouse gas emissions by increasing Canada's clean energy supply, electrifying supply chains, and increasing energy efficiency. The federal government, for instance, has plans to reduce emissions 40% below 2005 levels by 2030 and hopes to achieve net-zero by 2050.[55] Many Canadian provinces and cities have their own emissions reduction targets and/or are working to improve the adoption of clean energy within their borders. To achieve federal emissions reductions targets, Canada's clean energy production will need to increase by 90% by 2030.[56] As pathways to net-zero take root and grow, the demand for skilled labour will also grow.

Existing research suggests that clean energy roles are poised for growth. According to a 2021 study by Clean Energy Canada and Navius Research, the clean energy sector already employs approximately 430,500 people, and this is expected to grow to 639,200 people by 2030.[57] The clean energy sector is also growing at a rate faster than the Canadian economy: from 2010–2017, Canada's clean energy labour force grew by 4.8% per year, whereas the labour force at large only grew by 3.6%.[58] Over the next decade, the clean energy labour force is expected to continue to grow by about 4% annually.[59]

Of the clean energy subsectors, clean buildings are expected to experience the highest growth. From 2017 to 2030, the clean buildings subsector is expected to see a 14.2% compound annual growth in labour needed to design, install, and operate heating, ventilation, and air conditioning (HVAC) systems and energy-efficient appliances. Other subsectors experiencing growth are clean transportation,

---

[55] "2030 Emissions Reduction Plan: Canada's next steps to clean air and a strong economy," June 2, 2022, *Environment and Climate Change Canada,* https://publications.gc.ca/site/eng/9.909338/publication.html

[56] "A Healthy Environment and a Healthy Economy," 2020, *Environment and Climate Change Canada,* https://www.canada.ca/content/dam/eccc/documents/pdf/climate-change/climate-plan/healthy_environment_healthy_economy_plan.pdf

[57] "A Renewables Powerhouse," February 2023, *Clean Energy Canada,* https://cleanenergycanada.org/wp-content/uploads/2023/01/RenewableCost_Report_CleaEnergyCanada_Feb2023.pdf

[58] "A Renewables Powerhouse," February 2023, *Clean Energy Canada,* https://cleanenergycanada.org/wp-content/uploads/2023/01/RenewableCost_Report_CleaEnergyCanada_Feb2023.pdf

[59] "Tracking the Energy Transition 2021: The New Reality," June 2021, *Clean Energy Canada,* https://cleanenergycanada.org/wp-content/uploads/2021/06/Report_CEC_CleanJobs2021.pdf

including the labour needed to design and maintain hybrid and electric vehicles and operate public transit and clean energy supply, which encompasses labour focused on wind, solar, and hydro projects. While no employment data was provided for industry-related jobs for 2017, Clean Energy Canada notes that industry-focused technologies like low-carbon machinery and emissions detection and control technologies are likely to generate 24,000 new jobs by 2030.[60]

Clean Energy Subsector	Employment in 2017	Employment in 2030	Compound Annual Growth Rate
Clean Buildings	19,600	110,600	14.2%
Clean Transportation	171,350	363,700	6%
Clean Energy Supply	59,800	111,100	4.9%
Grid Infrastructure	47,000	29,900	-3.4%
Total	298,000	639,300	6%

Table 2. *Canadian 2030 labour force projections for the clean energy economy for key clean energy subsectors. Data source: Clean Energy Canada 2019 and 2021 economic outlook reports.*[61]

Building on existing research, this section unpacks the labour market complexities and nuances related to Canada's net-zero transition. First, the clean energy labour shortage is discussed, followed by potential pathways to increase Canada's skilled clean energy talent. Next, this section dives into the specific in-demand roles, skills, and competencies desired by energy employers before outlining labour supply information. The findings in this section are informed by quantitative and qualitative research, including job postings data, key informant interviews, advisory committee meetings, an employer survey, and a student survey.

CLEAN ENERGY POLICY IS DRIVING DEMAND

Rapid changes to clean energy policy and legislation are partially responsible for growing labour demand. In the United States, for instance, the Inflation Reduction Act (IRA) is set to provide US $370 billion in subsidies for solar, wind, and electric vehicles.[62] One United States-based interviewee described the IRA as "the biggest climate bill any country has ever signed into law," while another commented that the IRA is an exciting new turn in the United States' energy policy, which will accelerate the adoption of solar and wind. Notably, the IRA is projected to create 537,000 new

---

[60] "Tracking the Energy Transition 2021: The New Reality," June 2021, *Clean Energy Canada,* https://cleanenergycanada.org/wp-content/uploads/2021/06/Report_CEC_CleanJobs2021.pdf

[61] "Tracking the Energy Revolution 2019: Missing the Bigger Picture," 2019, *Clean Energy Canada,* https://cleanenergycanada.org/wp-content/uploads/2019/05/Report_TER2019_CleanJobs_20190516_v3_ForWeb_FINAL.pdf; "Tracking the Energy Revolution 2021," 2021, *Clean Energy Canada,* https://cleanenergycanada.org/wp-content/uploads/2021/06/Report_CEC_CleanJobs2021.pdf

[62] "Biden's climate agenda has a problem: Not enough workers," January 2023, *Reuters,* https://www.reuters.com/business/energy/bidens-climate-agenda-has-problem-not-enough-workers-2023-01-11/

jobs in the United States every year over the next decade.[63] Given that the United States is Canada's largest energy trading partner and the only country with which Canada conducts electricity trade,[64] these developments are likely to have a trickle-down effect in Canada as well. As explained by the Canadian Climate Institute, the IRA puts pressure on Canada to "catch up,"[65] spurring Canada to strengthen its investment tax credits, carbon taxes, clean fuel standards, and subsidies.[66]

In Canada, the 2022 federal budget proposed to launch a $15 billion Canada Growth Fund, which will attract private sector investment in projects that reduce GHG emissions and accelerate the clean economy.[67] Budget 2022 also announced the government's intention to introduce two new tax credits to drive clean tech and clean energy adoption.[68] Tax credits and incentives are good catalysts to increase clean energy supply and adoption of clean energy technologies, however, interviewees in this study noted that without scaled-up training efforts, they are also likely to perpetuate Canada's clean energy labour shortage. Clean energy companies in the United States have similarly commented that finding skilled labour to fill clean energy roles will be challenging[69] and could potentially cause "plans to transition away from fossil fuels to stall out."[70] Rapid growth in the clean energy sector has already resulted in significant labour shortages to date. In this study, interviewees cited the tight labour market as one of the biggest challenges facing clean energy employers.

> "We're growing quite quickly, which means that virtually everything is in demand."
> **— CLEAN ENERGY PROJECT MANAGER**

> "We're honestly looking for everything."
> **— CLEAN ENERGY EMPLOYER, BIOFUELS SECTOR**

> "They [employers] have more jobs right now than they have people to do these jobs." **— CLEAN ENERGY NGO**

[63] BW Research, "The Inflation Reduction Act's green jobs promise," 2023, *Reuters,* https://www.reuters.com/graphics/USA-LABOR/CLEANENERGY/zjvqjjxaepx/index.html

[64] "Provincial and Territorial Energy Profiles – Canada," March 2023, *Canada Energy Regulator,* https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/provincial-territorial-energy-profiles/provincial-territorial-energy-profiles-canada.html

[65] Beck, Marisa, "Responding to the Inflation Reduction Act: What are Canada's options?," February 2022, Canadian Climate Institute, https://climateinstitute.ca/inflation-reduction-act-what-are-canadas-options/

[66] "Additional Design Features of the Investment Tax Credit for Carbon Capture, Utilization and Storage: Recovery Mechanism, Climate Risk Disclosure, and Knowledge Sharing," August 2022, *Department of Finance of Canada,* https://www.canada.ca/en/department-finance/news/2022/08/additional-design-features-of-the-investment-tax-credit-for-carbon-capture-utilization-and-storage-recovery-mechanism-climate-risk-disclosure-and-k.html; Ding, Juan Antonio, "Building on Success: B.C.'s Low Carbon Fuel Standard," June 2022, Canadian Climate institute, https://climateinstitute.ca/british-columbias-low-carbon-fuel-standard/

[67] Clark, Allison et al., "What the Fall Economic Update Means for Canada's Digital Economy," November 2022, https://www.digitalthinktankictc.com/articles/what-the-fall-economic-update-means-for-canadas-digital-economy

[68] Clark, Allison et al., "What the Fall Economic Update Means for Canada's Digital Economy," November 2022, https://www.digitalthinktankictc.com/articles/what-the-fall-economic-update-means-for-canadas-digital-economy

[69] Groom, Nichola and Volcovici, Valerie, "Biden's climate agenda has a problem: Not enough workers," January 2023, *Reuters,* https://www.reuters.com/business/energy/bidens-climate-agenda-has-problem-not-enough-workers-2023-01-11/

[70] Groom, Nichola and Volcovici, Valerie, "Biden's climate agenda has a problem: Not enough workers," January 2023, *Reuters,* https://www.reuters.com/business/energy/bidens-climate-agenda-has-problem-not-enough-workers-2023-01-11/

The growing labour shortage faced by clean energy employers is also increasing competition for skilled talent. Interviewees described this as being particularly challenging for younger and smaller companies that cannot afford to compete with larger corporations' salaries. As one solar start-up noted:

> "Recruiters from much larger companies, for example, large utilities companies, billion-dollar companies, are offering developers on LinkedIn salaries that we historically might have offered to [developers with] six to eight years of experience. And so that leaves us in a position of needing to pay the developers that we have more to keep "hem." **— CLEAN ENERGY PROFESSIONAL, SOLAR SECTOR**

Another clean energy employer explained that the shift to remote work has further increased competition for in-demand talent, such as software developers:

> "There are plenty of software developer'. It's just that there is a lot of competition. You have Amazon, Microsoft, Hootsuite, Shopify. And now the world is pretty remote, so our staff could likely go to any of [the big tech companies] or even an American firm and get a higher wage."
>
> **— CLEAN ENERGY PROFESSIONAL, BIOFUELS SECTOR**

To address the labour shortage, clean energy employers will need to work on integrating workers from all walks of life into the clean energy economy. This will include oil and gas workers as well as workers from non-energy sectors looking to transition careers. As one employer put it:

> "For entry-level technicians, we prefer to hire out of college programs, but there just'aren't enough graduates. So, we do take people from different walks of life, different backgrounds—somebody'that's working in the oil field and wants to make a career transion...or, depending on the time of year, somebody with no experience. We'll train them as well."
>
> **— TECHNICAL AND ENGINEERING SERVICES, NUCLEAR ENERGY**

Other employers discussed how offering flexible work environments, providing work-from-home opportunities, and employing skilled immigrants and newcomers can help close the labour gap for certain roles.

OPPORTUNITIES FOR OIL AND GAS WORKERS IN CLEAN ENERGY

The clean energy transition will not only increase demand for clean energy workers but will also change the types of roles that are needed across the energy sector. While demand for clean energy roles is likely to grow, demand for occupations associated with Canada's oil and gas sector will likely decrease. Clean Energy Canada estimates that by 2030, employment in Canada's fossil fuel sector could fall by as much as 9%.[71] TD Bank meanwhile projects that by 2050, 50% to 75% of oil and gas workers (or approximately 312,000 to 450,000 people) could be displaced.[72] Due to the concentration of Canada's fossil fuel sector in specific geographic regions, job displacement will not be felt equally across Canada, with the largest impacts taking place in Alberta, Saskatchewan, and Newfoundland and Labrador.[73] For Canada's energy transition to be just, efforts will need to be made to transition workers from oil and gas into new energy roles and to further support workers who find themselves displaced.

While employment in oil and gas is likely to fall, total employment in Canada's energy sector is projected to grow. Clean Energy Canada estimates that the 9% drop in fossil fuel employment will be met by a 48% increase in clean energy roles, resulting in a net increase of 82,900 roles.[74] Similar projections have been made for the United States, where even accounting for the clean energy transition, the energy sector's share of total employment is expected to grow.[75] In Canada, Alberta and Saskatchewan are expected to see the largest influx of clean energy employment opportunities, mostly related to renewable energy production, hydrogen production, and growth in the energy efficiency sector.[76] From 2020 to 2030, clean energy employment is projected to increase by 164.4% (71,700 jobs) in Alberta and 43.3% (220,700 jobs) in Saskatchewan.[77]

While the transition to net-zero is multi-faceted and complex, measures can be taken to reduce geographical inequity and ensure the transition occurs more justly across Canada. For instance, government and industry can work to concentrate clean energy infrastructure in communities that are heavily populated by fossil fuel workers, provide income protection to displaced workers, and invest in training and reskilling programs.[78] Moreover, it will be

---

[71] "Tracking the Energy Transition 2021: The New Reality," June 2021, *Clean Energy Canada,* https://cleanenergycanada.org/wp-content/uploads/2021/06/Report_CEC_CleanJobs2021.pdf

[72] Caranci, Beata et al., "Don't Let History Repeat: Canada's Energy Sector Transition and the Potential Impact on Workers," April 2021, *TD Economics,* https://economics.td.com/esg-energy-sector

[73] Caranci, Beata et al., "Don't Let History Repeat: Canada's Energy Sector Transition and the Potential Impact on Workers," April 2021, *TD Economics,* https://economics.td.com/esg-energy-sector

[74] "Tracking the Energy Transition 2021: The New Reality," June 2021, *Clean Energy Canada,* https://cleanenergycanada.org/wp-content/uploads/2021/06/Report_CEC_CleanJobs2021.pdf

[75] Caranci, Beata et al., "Don't Let History Repeat: Canada's Energy Sector Transition and the Potential Impact on Workers," April 2021, *TD Economics,* https://economics.td.com/esg-energy-sector

[76] "Tracking the Energy Transition 2021: The New Reality," June 2021, *Clean Energy Canada,* https://cleanenergycanada.org/wp-content/uploads/2021/06/Report_CEC_CleanJobs2021.pdf

[77] "Tracking the Energy Transition 2021: The New Reality," June 2021, *Clean Energy Canada,* https://cleanenergycanada.org/wp-content/uploads/2021/06/Report_CEC_CleanJobs2021.pdf

[78] Caranci, Beata et al., "Don't Let History Repeat: Canada's Energy Sector Transition and the Potential Impact on Workers," April 2021, *TD Economics,* https://economics.td.com/esg-energy-sector; Stanford, Jim, "Employment Transitions and the Phase-Out of Fossil Fuels," January 2021, *The Centre for the Future of Work,* https://www.centreforfuturework.ca/wp-content/uploads/2021/01/Employment-Transi-

critical for fossil fuel workers to "participate meaningfully in the development and implementation of these plans."[79] With strong policies, programs, and engagement strategies in place, transitioning oil and gas workers to the clean energy sector will be possible.[80]

Importantly, many of the skills possessed by oil and gas workers are also needed in clean energy, meaning many oil and gas workers will be able to pivot into clean energy without abandoning their prior skills and experience. Organizations like Iron and Earth, which is a non-profit led by former Canadian oilsands workers, recognize this and are committed to empowering fossil fuel and Indigenous workers to leverage their existing skill sets, reskill, and transition into clean energy.[81] Similarly, EDGE UP (Energy to Digital Growth Education and Upskilling Project), led by Calgary Economic Development (CED) and ICTC, recognize that as the oil and gas sector is shrinking, the digital economy is growing.[82] EDGE UP provides six months of innovative and experiential training for displaced mid-career oil and gas professionals, including training pathways in data analytics for clean technology. With government incentives, strategic planning, and help from organizations like Iron and Earth, and initiatives like EDGE UP, oil and gas workers should be able to transition smoothly while also helping clean energy companies meet their labour market needs.

Given that oil and gas workers possess transferable skills, research participants engaged in this study suggested that the transition to net-zero will present oil and gas workers with ample career opportunities. Several advisory committee members suggested that, with the proper supports in place, oil and gas workers will experience a prosperous pivot to the clean energy sector.

IN-DEMAND ROLES IN THE CLEAN ENERGY SECTOR

As discussed, employment in the clean energy sector is projected to grow overall, however, not all roles will be impacted equally. To determine which types of clean energy roles will be most in demand, ICTC conducted a survey of 74 clean energy employers. In terms of geography, approximately two-thirds (68%) of the respondents were based in Canada, while roughly one-third (32%) were based

---

[79] Stanford, Jim, "Employment Transitions and the Phase-Out of Fossil Fuels," January 2021, *The Centre for the Future of Work,* https://www.centreforfuturework.ca/wp-content/uploads/2021/01/Employment-Transitions-Report-Final.pdf

[80] Stanford, Jim, "Employment Transitions and the Phase-Out of Fossil Fuels," January 2021, *The Centre for the Future of Work,* https://www.centreforfuturework.ca/wp-content/uploads/2021/01/Employment-Transitions-Report-Final.pdf

[81] "Net Zerio Pathways," 2023, *Iron and Earth,* https://www.ironandearth.org/net_zero_pathways

[82] "Applicants," 2023, *EdgeUp,* https://edgeupyyc.com/applicants/

in the United States. Employers were asked to consider which broad categories of entry-level roles they foresee their company hiring over the next few years. Research and development, design, engineering, and business roles were selected by the greatest percentage of respondents, at 49% and 46%, respectively. This is likely because of how new the clean energy sector is: for businesses operating in very new and innovative technology areas, core activities are often centred on research and development activities and go-to-market and business expansion plans. Trades roles, utilities and operations roles, environmental consulting and other environmental services roles, and digital technology roles were all selected by approximately two-fifths of respondents (38% to 42%), highlighting how diverse hiring needs are in the clean energy sector. Finally, civil and regulatory roles were selected by the least percentage of respondents, at 27%, and just 9% of respondents indicated that they would not need to hire entry-level employees at all.

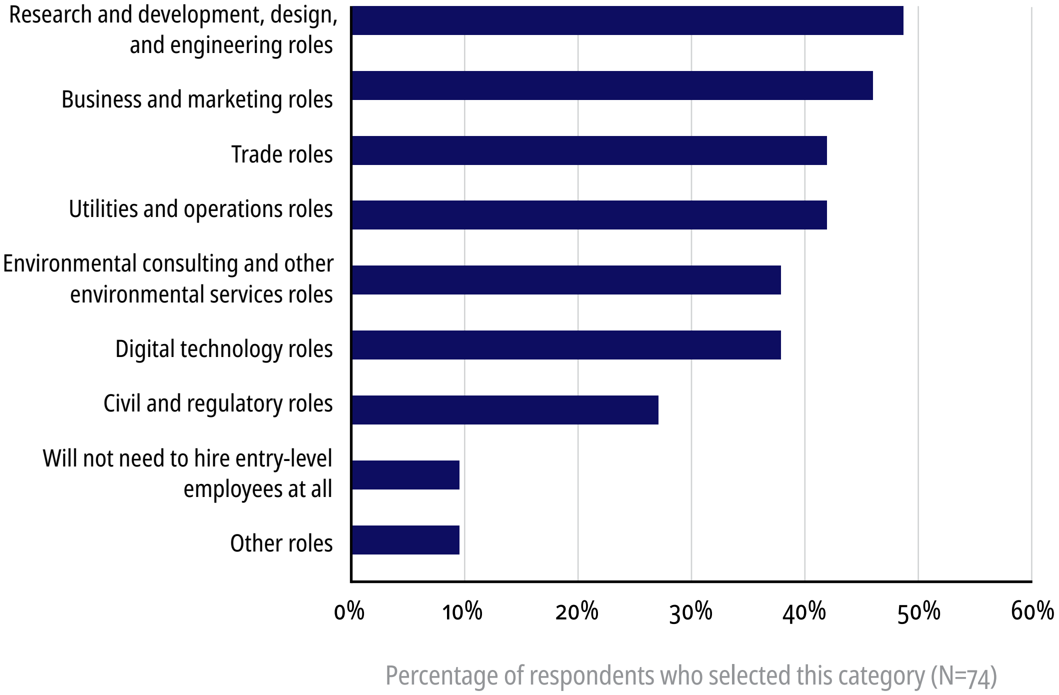


Figure 11. *Thinking about entry-level positions only, which of the following roles do you foresee your company or organization hiring in the next few years?*

In addition to the employer survey, ICTC conducted key informant interviews with individuals from clean energy companies, held advisory committee meetings with clean energy stakeholders, and conducted web scraping. While the survey focused on broad categories of roles so as to not overburden survey respondents, the interviews, advisory committee meetings, and web scraping went more in-depth to identify which specific occupations are in demand. Table 3 provides a summary of the in-demand roles identified by interviewees, advisory committee members, and web scraping techniques. The roles are notably diverse and span multiple occupational categories and levels of seniority. Apart from consulting, advisory, engineering, and managerial roles, all of which require significant career experience, many of the roles in the table could be entry level, mid level, or senior level, depending on the specific context. For example, one could progress through their career from being a junior software developer to a senior software developer to a manager of software development.

Correspondence to Survey Categories	Roles	Seniority Level	Data Source(s)
Research Development, Design, and Engineering Roles	Chemists	Entry to senior	Interviews
	Renewable Energy Specialists	Entry to senior	Interviews
	Renewable Energy Analysts	Entry to senior	Interviews
	Energy Management Specialists	Entry to senior	Interviews
	(General) Engineers	Mid to senior	Web Scraping
	Chemical Engineers	Mid to senior	Interviews
	Civil Engineers	Mid to senior	Interviews
	Electrical Engineers	Mid to senior	Interviews
	Fuel Cell Engineers	Mid to senior	Interviews
	Geotechnical Engineers	Mid to senior	Web Scraping
	Mechanical Engineers	Mid to senior	Web Scraping, Interviews
	Power Semiconductor Engineers	Mid to senior	Interviews
	Interfacial Engineers	Mid to senior	Interviews
	Materials Engineers	Mid to senior	Interviews
	(General) Project Engineers	Mid to senior	Web Scraping
	(General) Manager of Engineering	Senior	Web Scraping
	Energy Managers	Senior	Interviews
Business and Marketing Roles	Solar Sales Representatives	Entry to senior	Interviews
	Customer Success Managers	Senior	Interviews
Skilled Trades and Technician Roles	Wind Technicians	Entry to senior	Interviews
	(General) Technicians	Entry to senior	Web Scraping
	Mechanics	Entry to senior	Web Scraping, Interviews
	HVAC Installers	Entry to senior	KIIs, Advisory Committee
	Electrical Power-Line Installers and Repairers	Entry to senior	Interviews

Correspondence to Survey Categories	Roles	Seniority Level	Data Source(s)
Digital Technology Roles	Data Analysts	Entry to senior	Web Scraping, Interviews
	Technologists	Entry to senior	Web Scraping
	Programmers	Entry to senior	Interviews
	Machine Learning Developers	Entry to senior	Interviews
	Software Developers	Entry to senior	Interviews
	Building Automation Specialists	Entry to senior	Interviews
	Programmers	Entry to senior	Interviews
Utilities and Operations Roles	Control and Valve Installers and Repairers	Entry to senior	Interviews
	Originators for Solar Projects	Entry to senior	Interviews
	Estimator	Entry to senior	Web Scraping, Interviews
	(General) Operators	Entry to senior	Web Scraping
	Financial Analysts	Entry to senior	Interviews
	Energy Auditors	Entry to senior	Interviews
	Accountants	Mid to senior	Interviews
	(General) Planners	Mid to senior	Web Scraping
	Solar Project Developers	Mid to senior	Interviews
	(General) Project Managers	Senior	Web Scraping, Interviews
	(General) Managers	Senior	Web Scraping
	Operations Manager	Senior	Web Scraping
Environmental Consulting and Other Environmental Service Roles	Environmental Scientist	Entry to senior	Web Scraping
	Hydrogeologist	Entry to senior	Web Scraping
	Sustainable Urban Designers	Entry to senior	Interviews
Civil and Regulatory Roles	Inspectors	Entry to senior	Web Scraping
	Safety Personnel	Entry to senior	Interviews
	Policy Analysts	Entry to senior	Interviews
	Legal and Regulatory Affairs Professionals	Mid to senior	Interviews

Table 3. *Aggregate list of clean energy roles identified as "in demand" by key informant interviewees, advisory committee members, and through web scraping.*

While all of the above roles were cited as being in demand, some were emphasized more frequently by clean energy employers. In terms of frequency, the top three roles cited by interviewees in this study as in demand were project manager roles, engineering roles, and skilled trades, construction, and utilities roles. Given their importance to research participants, these roles are explored in more detail below.

ENTRY-LEVEL ROLES: CONSTRUCTION, UTILITIES, MANUFACTURING, AND SKILLED TRADES

An overwhelming number of interviewees highlighted the need for skilled trades, utilities, and construction workers. As explained by one interviewee, skilled trades and construction professionals are vital to the clean energy economy, as they are the ones who will make research and development progress "usable" in society. Another interviewee stated that "technical roles [like skilled trades] are responsible for real-world industrial decarbonization…actually building the infrastructure that enables decarbonization." This finding is corroborated by previous studies: according to the Columbia Institute, the labour needed to meet Canada's climate targets could amount to a demand for "3.3 million direct jobs in the building trades by 2050."[83] Notably, trades and construction roles can be entry, mid, or senior level, depending on whether the trade requires an apprenticeship or other work experience. In terms of entry-level trades, utilities, and construction roles, research participants frequently mentioned HVAC installers, technicians, and install and repair personnel.

Advisory committee members also stressed that the clean energy economy will require the manufacturing of specific inputs and building materials. Rather than importing what is needed, Canada has an opportunity to develop its manufacturing capacity in the clean energy sector. If Canadian manufacturers shift to producing inputs for the clean energy sector, new roles in manufacturing will be generated.[84] For example, Elysis Technologies, a Quebec-based clean technology company working to remove GHG emissions from aluminum production, recently received $10 billion in capital investment, leading to roughly 1000 new jobs, many of which are in manufacturing.[85] While minor reskilling may be needed, advisory committee members expressed that manufacturing roles will largely remain the same. A recent study by the Royal Bank of Canada suggests that by 2030, demand for manufacturing roles across the United States and Canada will grow to include 282,500 new jobs, 127,200 of which will include enhanced skills required for clean energy manufacturing.[86]

---

[83] "Jobs for Tomorrow: Canada's Building Trades and Net Zero Emissions," July 2017, *Columbia Institute,* https://columbiainstitute.eco/wp-content/uploads/2017/09/Columbia-Jobs-for-Tomorrow-web-revised-Oct-26-2017-dft-1.pdf

[84] "Supporting renewable energy manufacturing in Quebec to create jobs and build a cleaner future," July 2021, *The Office of the Prime Minister of Canada,* https://pm.gc.ca/en/news/news-releases/2021/07/14/supporting-renewable-energy-manufacturing-quebec-create-jobs-and

[85] "Canada's Economic Strategy Tables: Clean Technology," 2020, *ISED,* https://ised-isde.canada.ca/site/economic-strategy-tables/sites/default/files/attachments/ISEDC_CleanTechnologies.pdf

[86] Guildimann, Colin and Powell, Naomi, "Green Collar Jobs: The skills revolution Canada needs to reach net zero," February 2022, *RBC Special Reports,* https://thoughtleadership.rbc.com/green-collar-jobs-the-skills-revolution-canada-needs-to-reach-net-zero/

MID TO SENIOR-LEVEL ROLES:
PROJECT MANAGERS, ENGINEERS, AND SKILLED TRADES

Employers stressed that project managers were lacking in all facets of the energy sector—whether it be in the field or in the office. Project managers require a multidisciplinary background, including practical experience in the energy sector, an understanding of energy markets, and managerial capabilities. As one interviewee explained: “I think project management is the number one thing we need for all sustainability roles. If you are a project manager, you are wearing the hats of so many different things. It’s not just one project.” Energy employers interviewed by ICTC explained that project managers were lacking in engineering, ICT, and operations across all subsectors of clean energy (e.g., energy supply, energy efficiency, etc.). Interviewees also explained that the increase in demand for project managers has been caused by the fast-paced growth of the clean energy sector, whereby companies are quickly scaling up and expanding the number of projects they have under management.

Given how technical and innovative clean energy is, it is unsurprising that many interviewees and advisory committee members listed engineering roles as being very high in demand. As one interviewee explained, “Obviously engineers [are in demand], like materials engineering, but really any engineering.” Some engineering roles mentioned include electrical, mechanical, civil, and materials engineers that have been involved in the traditional energy sector (e.g., working in oil and gas) for many years. Other engineering roles such as fuel cell, geotechnical, power semiconductor, and interfacial engineers are only growing in demand now due to clean energy initiatives.

Finally, in terms of mid to senior-level trades and utilities roles, research participants frequently mentioned mechanics and electricians. Without filling the demand for these roles, Canada will have trouble mobilizing clean energy initiatives.

ENERGY EFFICIENCY AND THE LABOUR MARKET

While not necessarily related to clean energy, a large part of Canada's net-zero transition will centre on energy efficiency. Enhancing energy efficiency will have significant environmental and economic benefits, including, saving Canadians money, reducing Canada's emissions, increasing asset values, and reducing strain on our existing energy infrastructure.[87] Energy efficiency solutions are diverse and will implicate a large number of occupations. Retrofits alone can include:

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

In 2018, there were 436,000 energy efficiency-related jobs in Canada, and this number is projected to grow at an average growth rate of 8.3% per year.[89] According to ECO Canada, energy efficiency will create permanent employment opportunities in construction, manufacturing, wholesale and trade, professional and business services, utilities, and other services.[90] In terms of specific occupations, installation and repair, and management and professional roles were the most in demand (see Figure 12). Among technical roles in the sector, ECO Canada reports high demand for workers who understand LED, CFL, and other efficient lighting; HVAC goods, control systems, and services; and ENERGY STAR®/high efficiency heating and cooling equipment.

---

[87] "Smarter Energy Use in Canada: Report to Parliament Under the Energy Efficiency Act," 2019, *Natural Resources Canada,* https://oee.nrcan.gc.ca/publications/statistics/parliament/2018-2019/pdf/2018-19-ReportToParliament-EEAct-EN.pdf; "Energy Efficiency," March 2023, Natural Resources Canada, https://www.nrcan.gc.ca/energy-efficiency/10832

[88] "Smarter Energy Use in Canada: Report to Parliament Under the Energy Efficiency Act," 2019, *Natural Resources Canada,* https://oee.nrcan.gc.ca/publications/statistics/parliament/2018-2019/pdf/2018-19-ReportToParliament-EEAct-EN.pdf; "Energy Efficiency," March 2023, Natural Resources Canada, https://www.nrcan.gc.ca/energy-efficiency/10832

[89] "Energy Efficiency Employment in Canada," April 2019, *ECO Canada,* https://eco.ca/new-reports/energy-efficiency-canada/

[90] "Energy Efficiency Employment in Canada," April 2019, *ECO Canada,* https://eco.ca/new-reports/energy-efficiency-canada/

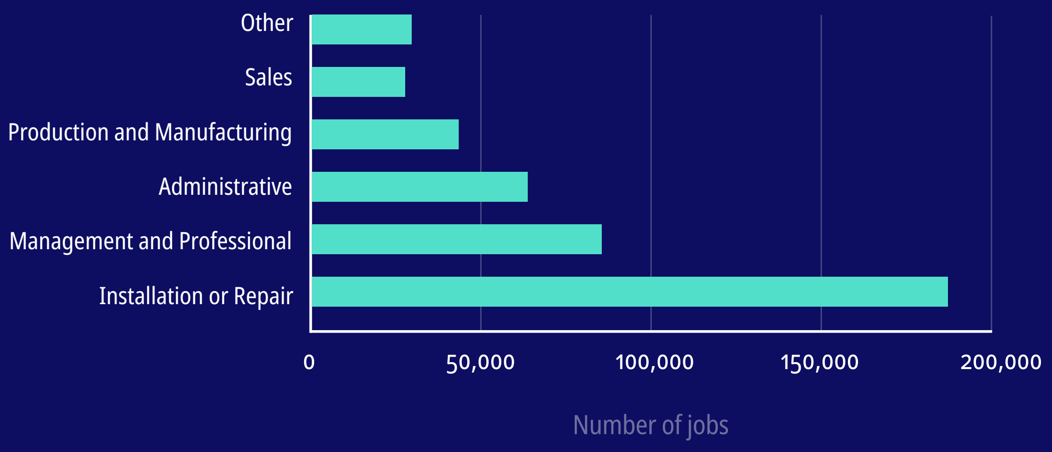


Figure 12. *Energy Efficiency Jobs by Occupational Category, 2018. Data source: ECO Canada's Energy Efficiency Employment in Canada report.*[91]

Interviewees in this study similarly cited energy efficiency as a growing field that is important to Canada's net-zero transition. In terms of retrofit-related roles, employers stressed a need for electricians, install and repair personnel, and general contractors. Other interviewees stressed the importance of roles in energy management, such as energy managers (who are responsible for planning energy efficient infrastructure), energy specialists (who establishd best practices focused on energy conservation), and "building automation system specialists" or "building scientists" (who are responsible for understanding new, efficiency-related technologies and integrating them into existing infrastructure). According to interviewees, energy management roles, in general, are highly multidisciplinary, involving "a combination of engineering, operations, maintenance, planning, and project management" skills.

While the economic outlook for the energy efficiency sector looks promising, government support via programs and policies will be crucial to support growth. As noted by interviewees, government support can reduce the cost of retrofits for individuals and small businesses, incentivize the adoption of energy management solutions, encourage the use of ENERGY STAR®, EnerGuide, and FleetSmart-certified products, and ensure buildings meet the National Building Codes.[92] Moreover, consistent reviews of the *Energy Efficiency Act* can help ensure new programs and policies continue to enhance Canada's energy efficiency potential.

---

[91] "Energy Efficiency Employment in Canada, April 2019, *ECO Canada,* https://info.eco.ca/acton/attachment/42902/f-84cf2d68-0ecd-44de-a24a-a347ccd110cd/1/-/-/-/-/ECO-Canada-Energy-Efficiency-Employment-in-Canada.pdf

[92] "Smarter Energy Use in Canada: Report to Parliament Under the Energy Efficiency Act," 2019, *Natural Resources Canada,* https://oee.nrcan.gc.ca/publications/statistics/parliament/2018-2019/pdf/2018-19-ReportToParliament-EEAct-EN.pdf

CLEAN ENERGY ROLES BY ENERGY SOURCE

Another way of looking at clean energy roles is by energy source. While this information is not readily available for Canada, the United States Department of Labour publishes data about clean energy roles on its online labour market platform, O*NET.[93] When it comes to clean energy innovation and adoption, Canada lags the United States. This is due to a number of reasons, including differences in energy regulation, access to capital for research and development, differences in the overall supply of skilled labour, and increased solar availability in Southern regions.[94] Since the United States is ahead of Canada in clean energy adoption, U.S. labour market data can help paint a picture of what future labour market demand might look like in Canada once clean energy is more heavily adopted. Accordingly, Table 4 summarizes the occupations that are important for clean energy adoption, along with their growth prospects.

Energy Source	Seniority Level	Role	Rate of Growth	Projected Job Openings 2021–2031
Applicable to all	Entry	Meter Readers, Utilities	▼	1,600
		Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	▼	1,900
		Energy Auditors	▼	14,800
		Power Plant Operators	▼	2,100
		Power Distributors and Dispatchers	▬	800
		Control and Valve Installers and Repairers	▬	3,600
		Electrical and Electronics Drafters	▬	2,000
		Electrical Power-Line Installers and Repairers	▾	11,100
		Weatherization Installers and Technicians	△	3,800
		Sustainability Specialists	△	114,200
	Mid to Senior	Chief Sustainability Officer	▼	17,700
		Electrical Engineers	▾	12,300
		Fuel Cell Engineers	▾	17,900
		Environmental Economists	△	1,400
		Industrial Ecologists	△	7,800
		Civil Engineers	△	24,200
		Construction Managers	▴	41,500

- ▲ Much faster than average
- ▴ Faster than average
- △ Average
- ▬ Little or no change
- ▾ Slower than average
- ▼ Decline

---

[93] "O*NET Online," 2023, *O*NET,* https://www.onetonline.org/

[94] Richards, Garrett et al., "Barriers to renewable energy development: A case study of large-scale wind energy in Saskatchewan, Canada," March 2012, *ScienceDirect,* https://www.sciencedirect.com/science/article/abs/pii/S030142151101055X; Mousa, Ola, "BIPV/BAPV Barriers to Adoption: Architects' Perspectives from Canada and the United States," 2014, *University of Waterloo,* https://uwspace.uwaterloo.ca/bitstream/handle/10012/8364/Mousa_Ola.pdf?sequence=3&isAllowed=y; Karakaya, Emrah and Sriwannawit, Pranpreya,"Barriers to the adoption of photovoltaic systems: The state of the art," September 2015, *ScienceDirect,* https://www.sciencedirect.com/science/article/abs/pii/S1364032115003287

Bioenergy	Entry	Biomass Plant Technicians	▼	2,100
		Biofuels Processing Technicians	▬	1,700
	Mid to Senior	Biofuels/Biodiesel Technology and Product Development Managers	▾	14,000
		Biofuels Production Managers	△	15,400
Hydro	Entry	Hydroelectric Plant Technicians	▼	2,100
Nuclear	Entry	Nuclear Monitoring Technicians	▼	400
		Nuclear Power Reactor Operators	▼	300
		Nuclear Technicians	▼	400
	Mid to Senior	Nuclear Engineers	▼	700
Solar	Entry	Solar Thermal Installers and Technicians	▾	48,600
		Solar Sales Representatives and Assessors	△	304,000
	Mid to Senior	Solar Energy Systems Engineers	▬	10,800
		Solar Energy Installation Managers	△	72,700
Wind	Entry	Wind Turbine Service Technicians	▲	1,900
	Mid to Senior	Wind Energy Engineers	▬	10,800
		Wind Energy Development Managers	△	113,100
		Wind Energy Operations Managers	△	113,100

▲	Much faster than average
▴	Faster than average
△	Average
▬	Little or no change
▾	Slower than average
▼	Decline

*Table 4. In-demand roles for the clean energy sector by energy source, seniority level, and projected rate of growth. Source: O*NET labour market data.*

In terms of entry-level roles, the United States is projected to experience the greatest demand (e.g., number of job openings from 2021 to 2031) for solar-related roles, including sales representatives and assessors, sustainability specialists, and solar thermal installers and technicians. On the contrary, entry-level roles with the fewest projected job openings from 2021 to 2031 are all in nuclear energy. These include nuclear monitoring technicians, nuclear technicians, and nuclear power reactor operators. Notably, nuclear is listed by O*NET as one of the only clean energy sources with a shrinking labour force.

In terms of mid to senior-level roles, the United States is projected to experience the greatest demand for roles in wind energy, including wind energy systems engineers and wind energy development managers. As with entry-level roles, many mid to senior-level job openings in the solar sector will see increased demand (for example, solar energy installers). Other mid to senior-level roles that are projected to be in high demand include construction managers and civil engineers.

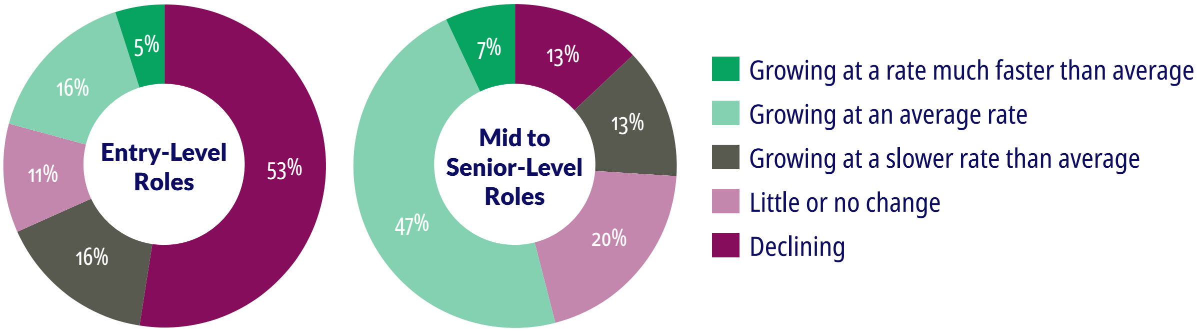


__Figure 13.__ Projected growth rate of entry versus mid- to senior-level clean energy roles from 2021 to 2031. Data source: ONET data, ICTC analysis.

As seen in Figure 13, employment in mid to senior-level roles is projected to grow at a faster rate than employment in entry-level roles in the United States over the next eight years. Employment is projected to grow in the United States for nearly three-quarters (74%) of mid to senior-level roles, whereas this is the case for only one-third (32%) of entry-level roles. The demand growth in mid to senior-level roles was also confirmed by interviewees for this study. Clean energy employers expressed that it is more difficult to find mid to senior-level talent than it is to find entry-level talent. This is likely because the clean energy sector is relatively new (except for hydropower and nuclear), meaning few people have worked in the industry long enough to earn the practical experience required for senior-level positions. This trend appears to be especially true in the solar energy sector:

> "We know where to find engineers, but we're growing fast. So we need help with project management. We'd love to find people with five to eight years of solar experience, but in many cases, that this is hard to find or doesn't exist."
> **— CLEAN ENERGY PROFESSIONAL, SOLAR SECTOR**

> "There is an infinite number of engineers coming out of the universities. What we're missing are people who have actually done and completed projects that we could rely on." **— CLEAN TECHNOLOGY EMPLOYER, SOLAR SECTOR**

> "When we're trying to hire a seasoned person, there's a lot of competition—you know, for people with five to 10 years of experience. There's a lack of knowledge among new grads or people from other industries.... So that is the most challenging for us." **— CLEAN ENERGY PROFESSIONAL, SOLAR SECTOR**

To address the short supply of mid to senior-level talent and talent with practical experience in the clean energy sector, post-secondary education institutions, employers, governments, and ecosystem organizations will need to work together to provide the following:

1. Students with practical experience in the clean energy sector prior to graduation, such as through work-integrated learning programs or internships;
2. Entry-level talent with mentorship and professional development opportunities to more quickly advance into senior management roles.

IN-DEMAND SKILLS AND COMPETENCIES

GENERAL SKILLS FOR THE CLEAN ENERGY SECTOR

Participants in this study (key informant interviewees, survey respondents, and advisory committee members) provided insight into the general skills and competencies that are required by clean energy workers. While the skills needed for specific occupations vary (and these are outlined in the next section), six general skills for the clean energy sector are outlined below.

Soft Skills

Soft skills are critical to all clean energy roles. In fact, some interviewees in this study placed a higher degree of importance on soft skills than technical skills. From their perspective, technical skills are easier for employees to improve or learn on the job when they already have strong soft skills like work ethic, interest, and teachability. In terms of specific skills, interviewees identified communication, organization, creativity, teamwork, adaptability, and problem solving as most important. Further, interviewees felt that these soft skills are what sets apart good from great employees. If a candidate possesses strong soft skills, like communication and an ability to learn, they possess some of the most important foundational skills needed in the clean energy sector. Pairing these soft skills with technical, business, and/or environmental sustainability skill sets further strengthens one’s employability.

Domain Knowledge

Several interviewees in this study identified domain knowledge as being in high demand for all roles. For instance, employers indicated that business and management employees require a strong understanding of energy markets, energy supply chains, and input prices. As one interviewee commented, understanding current trends in the energy sector is important, and this can include everything from knowing the fair cost of solar panels to understanding the current demand for wind energy services to knowing which materials need to come from overseas. Another interviewee similarly highlighted the importance of understanding clean energy project forecasts—"looking at a wind report and understanding what wind output will look like for the next eight months," or "understanding what a 500-kilowatt solar project looks like in terms of square footage." Overall, "understanding the energy market and its intricacies is really important because it does impact project viability and timelines."

Environmental Sustainability Skills

All clean energy projects are built on a foundation of environmental sustainability, seeking to reduce GHG emissions and limit ecological damage. Nonetheless, some roles are more heavily related to environmental sustainability than others. In this study, interviewees highlighted a number of roles that require sustainability skills, including management and consulting roles, sustainable finance roles, sustainable design and planning roles, resource conservation roles, and research and development roles. Across roles, common sustainability-related skills include environmental literacy, resource conservation, knowledge of regulatory and legal systems, and knowledge of energy efficiency strategies and standards (e.g., building standards and building codes like Passive House[95] or LEED[96]). Together, these skills help clean energy workers increase the environmental and economic sustainability of their projects while complying with industry standards and government legislation.

ICTC's employer survey also asked about environmental sustainability skills. When provided a list of sustainability-related skills, employers ranked the following as being most in demand (listed in order of importance):

1. Understanding energy regulations and standards and communicating standards to energy researchers
2. Implementing renewable energy initiatives and projects
3. Conducting environmental site assessments
4. Conducting environmental and social impact assessments
5. Carrying out awareness programs and presenting information on environmental and energy matters
6. Liaising and partnering with energy stakeholders
7. Developing and implementing sustainability strategies, programs, plans, and indicators
8. Implementing energy management initiatives and projects

---

[95] "Passive House Canada," 2023, *Passive House Canada,* https://www.passivehousecanada.com/

[96] "LEED Canada," 2023, *Canada Green Building Council,* https://www.cagbc.org/our-work/certification/leed/leed-canada/

Participants in this study noted that it can be difficult to find workers with a deep knowledge of sustainability, in part because it is a relatively new field. This also holds true for recently developed standards or concepts, such as GHG accounting, which was only developed quite recently in response to carbon taxes and credits.

Multidisciplinary Skills

Given the complexity of clean energy markets, it is unsurprising that employers seek candidates with multidisciplinary knowledge and skills. According to interviewees, multidisciplinary knowledge and skills enable workers to think holistically about their work, engage in systems thinking, collaborate with other departments and teams, and wear multiple hats on projects. Often, the most desirable candidates are those who can apply systems thinking and integrate technical, sustainability, and business-related concepts into clean energy solutions. As expressed by one interviewee from a clean energy nongovernmental organization, “Systems thinking and the ability to approach problems holistically has become more in demand as we’ve realized the interconnectedness of the energy transition’s impacts.”

According to interviewees, multidisciplinary skills are particularly important for workers in engineering and project management roles. As one interviewee said, “On our team, everyone has a combination of skill sets: on the energy manager side, it’s a combination of engineering first principles and engineering thinking, project management and planning, business case development, building automation, a technical understanding of network infrastructure, and different programming languages.” Another interviewee—this time a co-op coordinator for an energy engineering faculty—echoed this point, commenting that “one of the major transformations has been the realization that, in addition to engineering and technological skills, you need the policy and sustainability components and software skills that allow you to work well in teams and be able to integrate with other disciplines.” These comments demonstrate that training initiatives in the clean energy sector cannot be siloed and that disciplines should instead be integrated with one another, as the strongest candidates possess an understanding of multiple domains.

Digital Skills

The clean energy sector is highly innovative and involves a vast number of technology solutions. To better understand which “digital” or technology-related skill sets are in demand across the clean energy sector, ICTC provided surveyed employers with a list of digital technologies and asked them to rank the technologies by order of importance to their organization. Business, management, and customer relations software, such as Excel or Salesforce, were ranked as the most important technologies for candidates to be familiar with, followed by geography and surveying technologies (e.g., GPS, ArcGIS, 3D surveying, drones and other remote sensing data), cloud infrastructure tools (e.g., AWS, Azure, Kubernetes, Docker, Jenkins), operating systems software (e.g., Linux, Windows, Bash), and facilities or inventory management software.

Interviewees and advisory committee members also identified in-demand technology-related skills. One interviewee expressed the value of understanding the RETScreen Clean Energy Management Software platform, a package developed by Natural Resources Canada to enable "low-carbon planning, implementation, monitoring, and reporting."[97] Other interviewees stressed the need for programmers and analysts that can navigate programming software and languages like Python, R, and Julia. Finally, interviewees stressed that ICT solutions are increasingly integrated into the energy and utilities sector, so technicians, engineers, installers, and maintenance workers need to have a base-level knowledge of and comfort with ICT. As expressed by one interviewee who works as a project manager of utilities, "[Candidates] need a better understanding of information technology now more than ever."

Technical Skills

ICTC asked clean energy employers about in-demand technical skills in a broad categories of roles as part of its clean energy employer survey. Employers were provided with a list of technical skills and asked to rank the most in-demand skills for certain types of workers within their organization. For research and development, design, and engineering roles, respondents ranked "adhering to laboratory safety procedures and complying with standards" as most important, followed by "observing manufacturing, installation, and operations processes to ensure conformance to specifications and compliance with standards," "conducting scientific and applied research projects and compiling and analyze data," "preparing technical drawings, specifications, or maps to ensure manufacturing, installation, and operations processes conform to standards and customer requirements," "conducting engineering site audits to collect geographical, structural, electrical, and related site information," and "coordinating with and advising departments outside of research and development or engineering, such as manufacturing." For utilities and operations roles, on the other hand, respondents ranked "adhering to safety practices and procedures" as the most in-demand skill, followed by "understanding and complying with industry regulations and standards," "consulting engineering personnel to troubleshoot and solve equipment problems and determine optimum equipment functioning," and "recording or reporting operational data, such as readings on meters, instruments, and gauges, and maintain logs."

In terms of their ability to find candidates with these skills, employers reported that research and development, design, and engineering candidates who can adhere to safety procedures and comply with standards are relatively easy to find. Conversely, it is more difficult to find candidates who can conduct engineering site audits to collect geographical, structural, electrical, and related site information. For utilities and operations roles, employers noted that all of the in-demand skill sets were difficult to find, except for one: that is, the ability to read and interpret instruction manuals, technical drawings, schematics, and diagrams related to equipment or processes.

---

[97] "RETScreen," 2023, *Natural Resources Canada,* https://natural-resources.canada.ca/maps-tools-and-publications/tools/modelling-tools/retscreen/7465

Notably, technical skills vary more substantially by role in comparison to soft skills, domain skills, and sustainability-related skills, making it difficult to pinpoint a general set of technical skills needed across the clean energy sector. In the next section, job postings data is used to provide a list of the most in-demand technical skills and competencies for some of the most in-demand clean energy roles. While it is likely that technical skill sets will continue to evolve as new technologies are developed and adopted in the clean energy sector, many of the above skills will be crucial to the clean energy sector for years to come.

OCCUPATION-SPECIFIC IN-DEMAND SKILLS

This section expands on the general skills needed for the clean energy sector by providing a list of in-demand skills for specific clean energy roles. ICTC used job postings data to identify the top 22 most in-demand roles in Canada's clean energy sector, as well as the most in-demand technical and human skills for these roles. While this data represents an aggregation of multiple job postings, the skills needed for a specific role would vary, depending on the size and subsector of the hiring company. For example, the skills required for a technician working on a solar operation would differ from those required by a technician working in hydropower. Nonetheless, the below data helps clarify the common skill sets that would be required by technicians and other workers across the clean energy sector, including in wind, hydropower, and more.

Furthermore, it is worth noting that web scraped data may not be reflective of all in-demand roles due to sectoral differences in how job opportunities are shared and how employers find suitable candidates. For example, trades and union roles tend to be posted in-house and are typically not publicly available, which could be a factor contributing to their absence in the below list.

Engineer

In-Demand Role

Top Technical Skills and Competencies

- Project Management
- Civil Engineering
- P.Eng. Designation
- AutoCAD
- Environmental Remediation
- Excel
- Electrical Engineering
- Civil 3D
- Clean Energy Generation Technologies (nuclear, hydroelectric, biomass, and solar)
- Electrical Transient Analyzer Program (ETAP)

Top Soft Skills

- Design Thinking
- General Communication
- Planning
- Leadership
- Flexibility
- Written Communication
- Responsibility
- Working Independently
- Time Management
- Problem Solving

Data Analyst

In-Demand Role

Top Technical Skills and Competencies

- Excel
- Project Management
- ArcGIS
- SQL
- SAP
- Python
- Sustainability Best Practices
- Environmental Remediation
- Renewable Energy Industry Knowledge
- Primavera

Top Soft Skills

- General Communication
- Planning
- Design Thinking
- Leadership
- Responsibility
- Problem Solving
- Written Communication
- Flexibility
- Working Independently
- Time Management

Project Manager

In-Demand Role

Top Technical Skills and Competencies

- Project Management
- Business Development
- Construction Management
- Civil Engineering
- Cost Control
- Risk Management
- Contract Management
- Environmental Remediation
- Urban Planning
- Excel

Top Soft Skills

- Design Thinking
- Planning
- General Communication
- Leadership
- Responsibility
- Flexibility
- Negotiation
- Problem Solving
- Teamwork
- Written Communication

Coordinator

In-Demand Role

Top Technical Skills and Competencies

- Excel
- Project Management
- Microsoft Project
- Human Resource Management System (HRMS)
- Renewable Energy Industry Knowledge
- Occupational Health and Safety
- Environmental Remediation
- Primavera
- Sustainability Best Practices
- SAP

Top Soft Skills

- General Communication
- Planning
- Design Thinking
- Leadership
- Time Management
- Working Independently
- Responsibility
- Problem Solving
- Written Communication
- Flexibility

People Manager (General)

In-Demand Role

Top Technical Skills and Competencies

- Project Management
- Business Development
- Change Management
- Risk Management
- Construction Management
- Excel
- Public Relations
- Employee Performance Management
- Renewable Energy Industry Knowledge
- Talent Management

Top Soft Skills

- Leadership
- General Communication
- Planning
- Design Thinking
- Responsibility
- Written Communications
- Flexibility
- Negotiation
- Time Management
- Problem Solving

Technician

In-Demand Role

Top Technical Skills and Competencies

- Project Management
- Excel
- Civil Engineering
- Environmental Remediation
- Troubleshooting
- Microsoft Office
- Clean Energy Generation Technologies (Nuclear, Hydroelectric, Biomass, and Solar)
- Climate Change Mitigation
- Sustainable Development
- Renewable Energy Industry Knowledge

Top Soft Skills

- General Communication
- Design Thinking
- Planning
- Leadership
- Problem Solving
- Creativity
- Flexibility
- Teamwork
- Working Independently
- Responsibility

Consultant

In-Demand Role

Top Technical Skills and Competencies

- Project Management
- Employee Engagement
- Health and Safety Regulations
- Business Administration
- Business Development
- Sustainability Best Practices
- Human Resources Information System (HRIS)
- Construction Management
- Climate Change Mitigation
- Environmental Remediation

Top Soft Skills

- Planning
- General Communication
- Leadership
- Design Thinking
- Guiding Others
- Written Communication
- Negotiation
- Confidence
- Conflict Resolution
- Decision Making

Software Developer

In-Demand Role

Top Technical Skills and Competencies

- Java
- Azure
- SQL
- Agile
- JavaScript
- Angular
- Scrum
- C#
- CSS
- Python

Top Soft Skills

- Design Thinking
- General Communication
- Planning
- Responsibility
- Problem Solving
- Working Independently
- Leadership
- Time Management
- Flexibility
- Ability To Learn

Technologist

In-Demand Role

Top Technical Skills and Competencies

- Civil Engineering
- Excel
- Civil 3D
- Microsoft Office
- REVIT
- Environmental Remediation
- MicroStation
- ArcGIS
- Environmental Science Degree
- Clean Energy

Top Soft Skills

- Design Thinking
- General Communication
- Planning
- Leadership
- Time Management
- Creativity
- Problem Solving
- Working Independently
- Written Communication
- Flexibility

Advisor

In-Demand Role

Top Technical Skills and Competencies

- Project Management
- Health and Safety Regulations
- Human Resources Management
- Sustainable Development Advocacy
- Urban Planning
- Environmental Remediation
- Climate Change Mitigation
- Clean Energy Generation Technologies (Nuclear, Hydroelectric, Biomass, and Solar)
- Sustainability Best Practices
- Renewable Energy Industry Knowledge

Top Soft Skills

- Planning
- General Communication
- Leadership
- Design Thinking
- Responsibility
- Working Independently
- Written Communication
- Flexibility
- Teamwork
- Time Management

Planner

In-Demand Role

Top Technical Skills and Competencies

- Project Management
- Urban Design
- Excel
- Primavera
- Demand Modelling
- Civil Engineering
- GIS
- Sustainable Design
- Environmental Science Degree
- Environmental Remediation

Top Soft Skills

- Planning
- General Communication
- Design Thinking
- Time Management
- Flexibility
- Oral Communication
- Guide Others
- Leadership
- Problem Solving
- Listening

Mechanic

In-Demand Role

Top Technical Skills and Competencies

- Repairing Vehicles
- Sustainability Best Practices
- Environmental Stewardship
- Pneumatic Systems
- Project Management
- Mechanical Engineering
- Troubleshooting
- Hydraulics
- Clean Energy Generation Technologies (Nuclear, Hydroelectric, Biomass, and Solar)

Top Soft Skills

- General Communication
- Teamwork
- Responsibility
- Working Independently
- Design Thinking
- Planning
- Leadership
- Written Communication
- Time Management
- Flexibility

Mechanical Engineer

In-Demand Role

Top Technical Skills and Competencies

- Mechanical Engineering
- ASHRAE Standards
- NFPA Tool
- Microsoft Office
- P.Eng. Designation
- Excel
- Environmental Remediation
- Hourly Analysis Program (HAP)
- SolidWorks
- Sustainability Standards

Top Soft Skills

- Design Thinking
- General Communication
- Leadership
- Planning
- Written Communication
- Working Independently
- Flexibility
- Creativity
- Responsibility
- Time Management

Operator

In-Demand Role

Top Technical Skills and Competencies

- Process Control
- Mechanical Aptitude
- First Aid
- Microsoft Office
- Environmental Stewardship
- SCADA
- HVAC
- Workplace Hazardous Materials Information System (WHMIS)
- Pipeline Construction Safety Training (PCST)
- Renewable Energy Industry Knowledge

Top Soft Skills

- General Communication
- Design Thinking
- Leadership
- Planning
- Responsibility
- Flexibility
- Written Communication
- Creativity
- Effective Communication
- Teamwork

Inspector

In-Demand Role

Top Technical Skills and Competencies

- Inspection and Test Plan (ITP)
- Excel
- Health and Safety Regulations
- Quality Assurance/Quality Control (QA/QC)
- Civil Engineering Technology Diploma
- Renewable Energy Industry Knowledge
- Transportation of Dangerous Goods (TDG)
- Workplace Hazardous Materials Information System (WHMIS)
- Environmental Remediation
- Certified Inspector of Sediment and Erosion Control (CISEC)

Top Soft Skills

- Leadership
- Written Communication
- Planning
- General Communication
- Design Thinking
- Flexibility
- Creativity
- Time Management
- Problem Solving
- Responsibility

Estimator

In-Demand Role

Top Technical Skills and Competencies

- Project Management
- Excel
- Construction Management
- Civil Engineering
- Primavera
- LEAN Construction Estimation
- LEED Accredited
- Cost Management
- Environmental Remediation
- Wind Power

Top Soft Skills

- Design Thinking
- Planning
- Leadership
- General Communication
- Responsibility
- Written Communication
- Flexibility
- Problem Solving
- Teamwork
- Creativity

Project Engineer

In-Demand Role

Top Technical Skills and Competencies

- Project Management
- Civil Engineering
- P. Eng. Designation
- Land Development Report Writing
- Environmental Protection
- Renewable Energy Industry Knowledge
- Clean Energy Generation Technologies (Nuclear, Hydroelectric, Biomass, and Solar)
- Occupation Health and Safety Rules and Regulations
- WorkPLAN
- Environmental Compliance

Top Soft Skills

- Design Thinking
- Planning
- General Communication
- Written Communication
- Leadership
- Problem Solving
- Working Independently
- Flexibility
- Responsibility
- Teamwork

Operations Manager

In-Demand Role

Top Technical Skills and Competencies

- Operations Management
- Project Management
- Budget Management
- Project Finance
- Occupational Health and Safety
- Excel
- Construction Management
- Water Treatment
- Talent Management
- Renewable Energy Industry Knowledge

Top Soft Skills

- Leadership
- General Communication
- Design Thinking
- Responsibility
- Planning
- Written Communication
- Time Management
- Flexibility
- Negotiation
- Problem Solving

Engineering Manager

In-Demand Role

Top Technical Skills and Competencies

- Project Management
- Structural Engineering
- Project Engineering
- Construction Management
- Business Development
- Civil Engineering
- Water Resources Management
- Design Management
- Research and Development
- Environmental Remediation

Top Soft Skills

- Leadership
- Design Thinking
- General Communication
- Planning
- Responsibility
- Flexibility
- Time Management
- Working Independently
- Creativity
- Written Communication

Environmental Scientist

In-Demand Role

Top Technical Skills and Competencies

- Environmental Field Work
- Microsoft Office
- Environmental Compliance
- Sustainable Development Advocacy
- Climate Change Mitigation
- Excel
- Remedial Option Analysis
- Site Investigation

Top Soft Skills

- General Communication
- Planning
- Design Thinking
- Creativity
- Guide Others
- Leadership
- Time Management
- Written Communication
- Flexibility
- Responsibility

Hydrogeologist

In-Demand Role

Top Technical Skills and Competencies

- Environmental Remediation
- Hydrogeology
- Ethics
- Excel
- Environmental Science Degree
- AQTESOLV
- Geo-Environmental Engineering
- EQuIS
- Earth Sciences Diploma or Degree
- Sustainability Best Practices

Top Soft Skills

- Planning
- General Communication
- Leadership
- Design Thinking
- Flexibility
- Oral Communication
- Responsibility
- Working Independently
- Guide Others
- Time Management

Geotechnical Engineer

In-Demand Role

Top Technical Skills and Competencies

- Excel
- Geotechnical Engineering
- Clean Energy Generation Technologies (Nuclear, Hydroelectric, Biomass, and Solar)
- Settle 3D
- GeoStudio
- Quality Assurance/Quality Control (QA/QC)
- Apile
- Sustainable Development Advocacy
- Environmental Remediation
- Climate Change Mitigation

Top Soft Skills

- Time Management
- Flexibility
- Written Communication
- Design
- Guide Others
- Leadership
- General Communication
- Planning

Figure 14. *In-demand occupation-specific skills for Canada's top 22 most in-demand clean energy roles. Data source: job postings data web scraped and aggregated by ICTC.*

Technical Skills

Environmental and sustainability-related skills are commonly featured across roles. An understanding of environmental remediation was mentioned in 77% of job postings, implying that many positions across the clean energy economy have some relation to environmental remediation. This could include positions with tasks related to the remediation of land polluted by toxins from oilsands. Similarly, environmental remediation skills could be applied to nuclear energy projects or biofuel projects, helping to minimize environmental damages. That said, it is somewhat surprising that environmental remediation was mentioned so frequently, as it is not a skill directly associated with the production of clean energy and is instead related to environmental services.

Other competencies related to the environment were sustainability best practices, which were featured in 41% of job postings, and knowledge of climate change mitigation, sustainable development, and environmental science, which were each featured in 18% of job postings. Renewable energy industry knowledge, which was featured in 9% of job postings, and environmental stewardship were also desired competencies. It is no surprise that environmental skills and competencies are in demand as they are vital to the development and production of clean energy.

In addition to environmental skills, several roles included programming skills, such as Java, which was featured in 64% of job postings and SQL, which was featured in 21% of job postings, implying that many employers seek candidates with strong technology-related skills.

Soft Skills

The need for strong communication was mentioned across all job postings, highlighting the importance of this skill. Strong communication is needed for environmental stewardship initiatives, client relations, internal productivity, and more. Other important soft skills were teamwork, responsibility, creativity, and design thinking. As discussed in the previous section, many of the above soft skills were echoed by interviewees and advisory committee members.

STUDENT PERSPECTIVES ON CLEAN ENERGY CAREER PATHWAYS AND SKILLS

To understand how students feel about clean energy career pathways and in-demand skills, ICTC surveyed 312 post-secondary students in programs related to the clean energy sector. Survey respondents were primarily enrolled in programs related to environmental sustainability, energy, engineering, digital technologies, and agriculture. Approximately 20% of students were enrolled in engineering faculties, 19% were enrolled in business or management faculties, and 16% were enrolled in computer science faculties.

When asked about their immediate career plans, 33% of students stated they hoped to find entry-level employment, while 27% stated they planned to pursue further education. Nearly half (43%) of students expressed interest in pursuing a career in Canada's green economy, such as in renewable energy production, environmental services, or sustainable agriculture or food production. Among students who were not interested in pursuing a career in the green economy, nearly one-fifth (17.5%) indicated that they were not interested in pursuing a career in the green economy because they did not think they would be able to find entry-level employment. This is surprising given that there is no shortage of entry-level clean energy roles. In fact, employers interviewed by ICTC stressed that they had a hard time filling entry-level roles.

Students were also asked to report their familiarity with technology-related skills and core environmental topics.

Technology-Related Skills

In terms of technology-related skills, students reported the highest degree of confidence in their ability to use operating systems software like Linux, Windows, and Bash, followed by business management and customer relations software, and then programming languages like Python, JavaScript, Java, and SQL. These three skills were similarly listed by clean energy employers as the most in-demand technology-related skills, suggesting a suitable match between employers and candidates for these skills. Conversely, students indicated that they were the least familiar with geography and surveying technology and cloud infrastructure tools, which were ranked as highly important by surveyed employers.

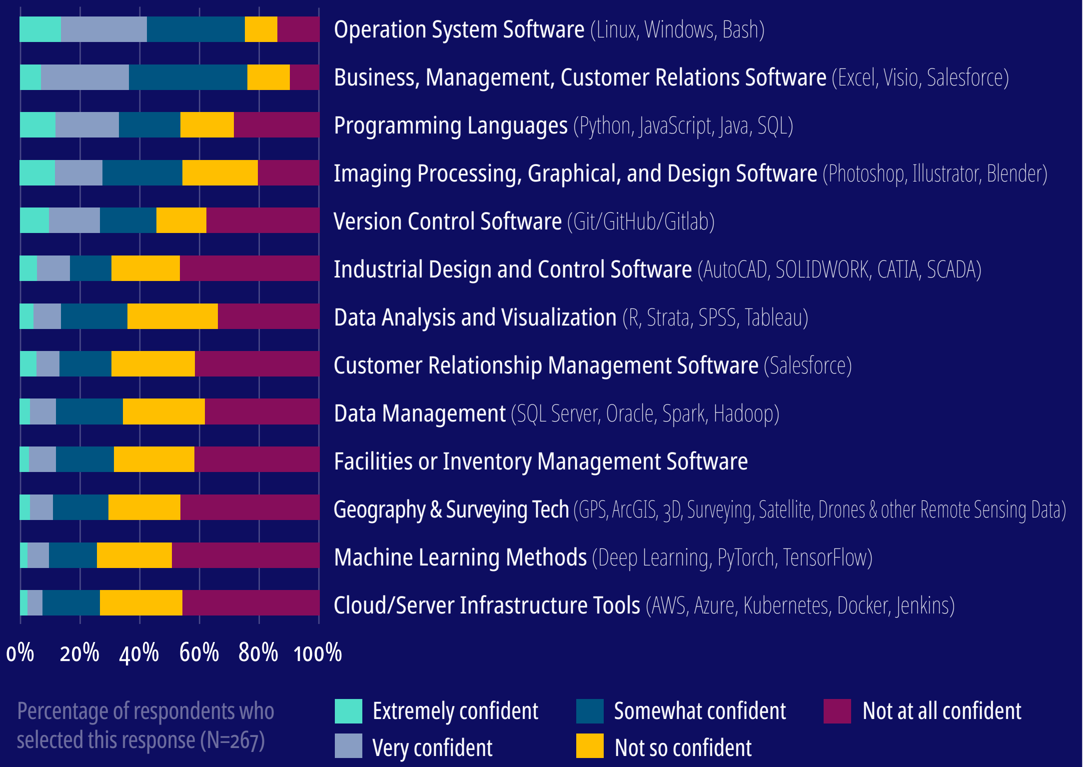


Figure 15. Student familiarity with technology-related skills. Distribution of survey responses to the question, "How confident are you in your ability to use the following tools?"

Core Environmental Knowledge

To gauge student familiarity with environmental topics, ICTC asked students to indicate their familiarity with a list of core knowledge areas. These core knowledge areas were adapted from ECO Canada's list of core knowledge areas for environmental workers, published in 2016.[98] ECO Canada is a Canadian labour market research organization that conducts labour market research on Canada's environmental sector.

As seen in Figure 16, students were overall more confident in their knowledge of general environmental literacy than they were in their technology-related skills. Nearly all respondents indicated that they were "somewhat," "very," or "extremely confident" in their understanding of how human activities impact the environment and the value of protecting, conserving, and restoring natural resources. Meanwhile, approximately 80% of respondents indicated that they were confident in their knowledge of global environmental trends, concerns, and challenges, the impact of the environment on public health, specific problems like biodiversity or climate change, environmental concerns among the public, and human responses to environmental concerns.

---

[98] "Competencies for Environmental Professionals in Canada," August 2016, *ECO Canada,* https://info.eco.ca/acton/attachment/42902/f-65f916cd-d7be-432b-9bce-6f8bcbb92dce/1/-/-/-/-/NOS-for-Environmental-Professionals-ECO-Canada.pdf

Respondents meanwhile indicated that they were less confident in more technical environmental knowledge areas, such as how different environmental disciplines are connected, environmental science, technology, and terminology, environmental management systems, environmental legislation and agreements, and Canadian environmental business practices.

Approximately two-thirds of respondents indicated that they were “not so confident” or “not at all confident” in their understanding of environmental legislation and agreements, and in their knowledge of Canadian environmental business practices. While employers interviewed by ICTC stressed the importance of general environmental literacy, they also emphasized that there is a large skills gap related to the regulatory and legal side of sustainability. The legal and regulatory skills gap mentioned by employers is apparent among surveyed post-secondary students, implying that post-secondary education institutions may need to increase their capacity to educate students on the practical, business, and legal intricacies of environmental sustainability.

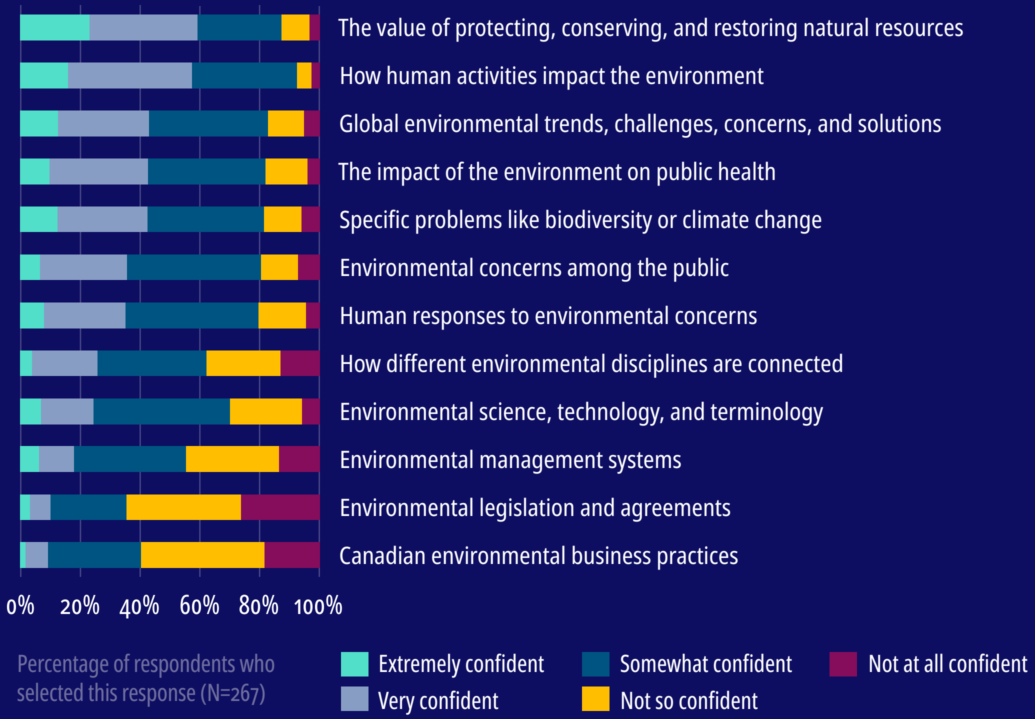


Figure 16. *Student familiarity with environmental topics. Distribution of survey responses to the question, “How familiar are you with the following environmental topics?”*

ADDRESSING LABOUR SHORTAGES: EDUCATION, TRAINING, AND MENTORSHIP

The clean energy economy is experiencing rapid growth, resulting in high demand for skilled labour across many occupational categories. Unfortunately, Canada's clean energy sector is also facing a labour shortage. To ensure federal GHG emissions targets can be met, Canada's energy labour shortage will need to be addressed, including through enhanced education, training, and mentorship programs.

Post-secondary institutions have a large role to play in addressing labour shortages. Several clean energy employers engaged in this study expressed that Canadian universities are not adequately preparing students for the clean energy sector—in part because their teachings do not align with industry needs. As one employer expressed: "Our main concern is… the risk of a widening skills gap caused by the continued use of traditional models of education, many of which are not appropriate for preparing young people to enter the workforce of a transitioning energy sector." To address this gap, post-secondary institutions can begin by reviewing in-demand roles and skills to ensure that students are acquiring the skills that will set them up for success. This may require enriching existing curricula or developing new curricula altogether.

While the theoretical and technical skills taught in university are valued by employers, interviewees expressed that one of the best ways to prepare students for the workforce is through experiential learning, such as co-op and internship programs. One interviewee with experience in industry and in post-secondary instruction said that co-op placements provide "a good, basic, flexible skill set" that better prepares students for the clean energy sector. Another interviewee explained that "[students] learn so much more when actually working in a company than you do in school." Some employers indicated that while they would like to take on co-op students, they lack the funding to do so, highlighting the importance of subsidies and incentives for experiential learning opportunities.

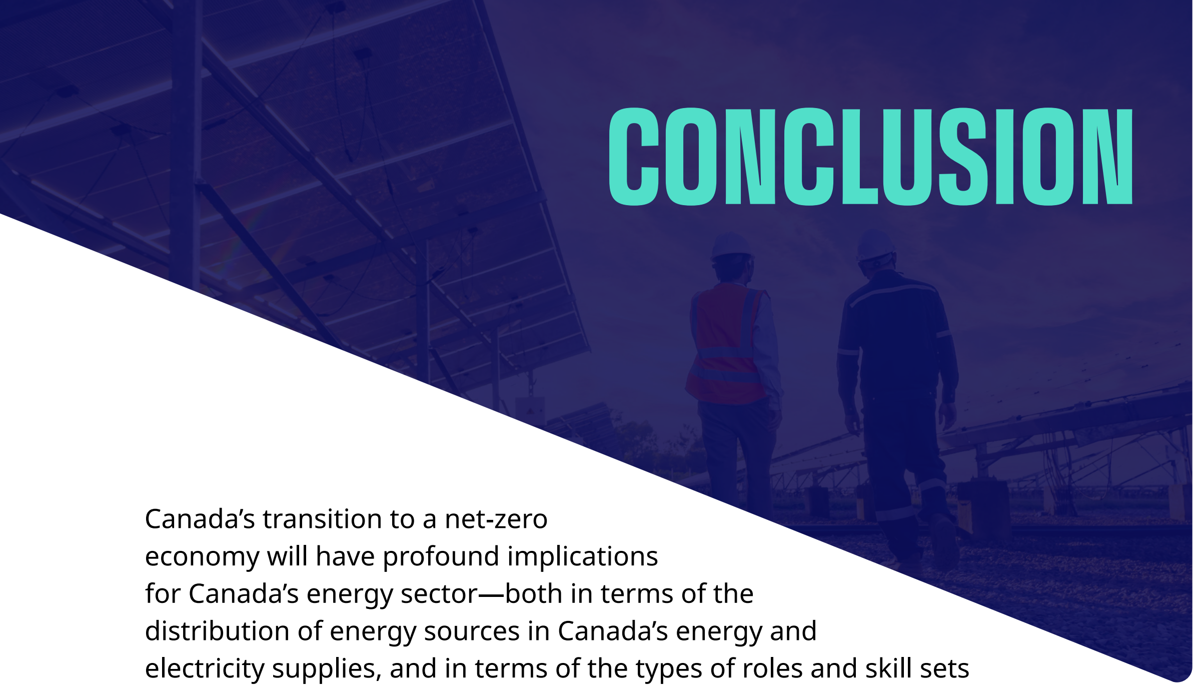
Programs like the Government of Canada's Student Work Placement Program can help employers provide students with work-integrated learning (WIL) opportunities while helping post-secondary students acquire on-the-job training. WIL programs typically include a combination of coursework (e.g., micro-credentials) and work placements. ICTC's WIL Digital program focuses on developing digital technology skills among students,[99] while other programs, such as ECO Canada's Student Work Placement Program, help students develop other types of skills, such as environmental knowledge and skills.[100] All of the above programs may be beneficial in helping students attain practical experience required by industry.

---

[99] "Work Integrated Learning (WIL) Digital," 2023, *eTalent Canada*, https://www.wil-ait.digital/en/

[100] https://eco.ca/environmental-students/student-work-placement-program/

Given the shortage of mid to senior-level talent, additional efforts will be needed to ensure students are industry-ready upon graduation and that junior-level talent can advance quickly through their careers to fill upper-level and managerial-level roles. Given the clean energy sector's strong project focus and a high demand for project managers, several interviewees said that project management credentials, courses, and degrees would benefit students seeking to advance in the clean energy sector. In addition to this, informal and formal mentorship programs will be critical to addressing current and future demand for mid to senior-level roles. This will require employers and managers to work closely with junior talent to transfer knowledge and expertise.



CONCLUSION

Canada's transition to a net-zero economy will have profound implications for Canada's energy sector—both in terms of the distribution of energy sources in Canada's energy and electricity supplies, and in terms of the types of roles and skill sets that will be needed by energy employers. Economic growth in Canada and around the world has, to date, depended on massive increases in global energy use and GHG emissions. For future economic growth to be sustainable, Canada and the world will need to decouple the economy from GHG-intensive energy use. Going forward, it will be important for Canada to not only reduce the energy intensity of the Canadian economy by making energy use more efficient but also to replace fossil fuel consumption with clean energy sources, such as clean fuels and clean electricity, and increase the proportion of clean electricity sources in Canada's electricity grid. This will mean relying less on oil products, natural gas, and coal and introducing more biofuels, clean hydrogen, hydro, wind, and solar.

All of these initiatives will require rapid changes in Canada's energy sector, and indeed, many of these changes are already taking place today. Clean Energy Canada estimates that Canada's energy labour force is growing at a steady rate of 4% annually and is expected to employ 639,200 people by 2030.[101] As Canada decarbonizes its energy supply, the proportion of clean energy roles in the sector will grow. Clean energy companies require a wide array of talent, including research and development, design, and engineering roles, digital technology roles, trades and construction roles, business and marketing roles, and environmental services roles. While entry-level roles are vital to the clean energy sector, mid to senior-level talent with practical and applied experience in the sector is lacking most.

All of these roles require a unique combination of soft skills, domain knowledge, environmental sustainability skills, multidisciplinary skills, digital skills, and technical skills. Many occupations require robust knowledge of environmental remediation, sustainability best practices, climate change mitigation, sustainable development, and environmental science. In terms of digital technology,

---

[101] "Tracking the Energy Transition 2021," 2021, *Clean Energy Canada,* https://cleanenergycanada.org/wp-content/uploads/2021/06/Report_CEC_CleanJobs2021.pdf

programming skills are also important, as is proficiency with business, management, and customer relations software, geography and surveying technology, cloud infrastructure tools, operating systems software, and facilities or inventory management software. Finally, in terms of soft skills, employers indicate a strong need for communication, teamwork, responsibility, creativity, and design thinking.

The employer and student surveys completed for this study highlighted several gaps between the skills clean energy students feel confident they have and the skills clean energy employers need. As was highlighted in Section II, more than two-thirds (70%) of surveyed students indicated that they were not so confident or not at all confident with geography and surveying technology, while three-quarters (74%) indicated that they were not confident with cloud infrastructure tools. Furthermore, students indicated that they were less confident in their knowledge of more technical environmental disciplines such as environmental science, technology, and terminology, environmental legislation and agreements, and Canadian environmental business practices. Meanwhile, all of these skills were identified by clean energy employers as both important and in demand.

Interviewees in this study were routinely concerned that potential labour shortages and high competition for labour could stall Canada’s plans to transition from fossil fuels and to cleaner energy. In Canada and in the United States, market forces and government policy and programs are driving demand for clean energy solutions, but without the necessary talent, clean energy companies may face challenges meeting demand. Training and reskilling programs will be critical to meeting labour needs. Canadian universities will play a large role in training students for entry-level roles in the sector, addressing the identified skills gaps, and helping students see a role for themselves in clean energy. Co-op, internship, and mentorship programs will need to be introduced so that students are acquiring practical experience and the shortage of mid to senior-level talent is addressed. On this point, it will also be critical to onboard oil and gas workers into the clean energy sector—both to retain their Canadian energy sector knowledge and experience and to ensure a just transition for geographic regions that will be negatively impacted by the clean energy transition. Failing to transfer skilled talent from the oil and gas sector will not only hamper the growth of the clean energy economy but will also have implications for the nation’s broader economic well-being. Aligning post-secondary curricula with industry needs, leveraging and enhancing experiential learning opportunities, and making the sector an inclusive space for people from all walks of life will collectively contribute to addressing the clean energy sector’s potential labour shortages while meeting clean energy demand and decarbonizing the Canadian economy.

APPENDIX: RESEARCH METHODOLOGY AND STUDY LIMITATIONS

RESEARCH METHODOLOGY

SECONDARY SOURCES

Existing Literature

The qualitative and quantitative portions of this project were supported by a thorough review of the available literature. The literature review helped shape research methods and questions, and provided information to help further validate the findings in the report. The initial literature review helped identify interviewees and advisory committee participations and form a methodology for the quantitative portion of the research.

Web Scraping

ICTC's data science team used web scraping and machine learning techniques to web scrape jobs and skills-related data from online job posting sites. The scraped data was parsed and analyzed to assess the most in-demand jobs and skills in Canada's clean energy sector. While job postings provide valuable data for jobs and skills analysis, it is worth noting that web scraped data may not be reflective of all in-demand roles due to sectoral differences in how job opportunities are shared and how employers find suitable candidates. For example, trades and union roles tend to be posted in-house and are typically not publicly available.

PRIMARY RESEARCH METHODOLOGY

Key Informant Interviews

ICTC conducted 23 key informant interviews with diverse experts in the clean energy sector. Interviews were conducted from August to December 2022. Interviewees held influential positions within their organizations, including founders, CEOs, directors, and owners. The interview questions were tailored to collect information about the interviewees' experiences within their companies and within the clean energy sector, such as their opinions about clean energy technology development and adoption and clean energy labour market trends. The interviewees were coded in NVIVO, a software program for qualitative data analysis, using a combined inductive and deductive approach.

Employer Survey

ICTC contracted a vendor to conduct a survey of 74 energy employers located in North America: 68% of the employers were located in Canada, while 32% were located in the United States. The survey was conducted in August 2022. In order to be included in the survey, respondents had to, at the time of responding, (1) be employed in the clean energy sector and (2) be involved in or be familiar with their companies hiring and skills assessment processes. Respondents were asked about their recent entry-level hiring activity, entry-level hiring plans for the next few years, training and education preferences, and entry-level skills needs.

In developing the survey questions, ICTC utilized data from O*NET OnLine, which is hosted by the Occupational Information Network and the United States Department of Labour, Employment, and Training. In addition to this, ICTC utilized ECO Canada's list of core knowledge areas for environmental workers, published in 2016.[102] The employer survey questions were aligned with the questions posed in the student survey in order to allow for comparability between the survey responses.

Student Survey

ICTC conducted a survey of 312 students across Canada who are registered in post-secondary and college programs relevant to the clean energy sector. To deliver the survey, ICTC partnered with a number of college and university faculties and departments across Canada, in addition to utilizing its own repositories of student contacts. Students were asked about their plans for future employment and education, which industries they want to work in and why, and how comfortable they are with a variety of clean energy skill sets.

In developing the survey questions, ICTC utilized data from O*NET OnLine, which is hosted by the Occupational Information Network and the United States Department of Labour, Employment, and Training. In addition to this, ICTC utilized ECO Canada's list of core knowledge areas for environmental workers, published in 2016.[103] The student survey questions were aligned with the questions posed in the employer survey in order to allow for comparability between the survey responses.

LIMITATIONS OF RESEARCH

While efforts were made to mitigate potential biases, there are certain limitations that may be inevitably embedded in this study. While ICTC made a concerted effort to speak with a diverse range of clean energy stakeholders, the trends identified through key informant interviews and advisory committee meetings should be interpreted only as the experiences of those interviewed. In total, ICTC conducted 23 interviews, a sample that is too small to be considered representative of the entire industry. Similarly, while ICTC made a concerted effort to reach a comprehensive survey sample, there may be inherent biases in the data provided by survey respondents.

---

[102] "Competencies for Environmental Professionals in Canada," August 2016, *ECO Canada,* https://info.eco.ca/acton/attachment/42902/f-65f916cd-d7be-432b-9bce-6f8bcbb92dce/1/-/-/-/-/NOS-for-Environmental-Professionals-ECO-Canada.pdf

[103] "Competencies for Environmental Professionals in Canada," August 2016, *ECO Canada,* https://info.eco.ca/acton/attachment/42902/f-65f916cd-d7be-432b-9bce-6f8bcbb92dce/1/-/-/-/-/NOS-for-Environmental-Professionals-ECO-Canada.pdf