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Future-Ready Workforce Strategies and Matching Skills Model: The Energy Transition Case

By Lin Al-Akkad

- This paper presents a Future-Ready Workforce Strategy, with a Matching Skills model to address mismatches and guide reskilling in times of major economic transitions. It shows that aligning labour market intelligence, training, and transition pathways to support displaced workers can promote lifelong learning and help position Canada as an industry leader following major shifts.
- In the case of the transition to a lower-carbon economy, studied here, most Canadian workers already possess many transferable skills, with minor gaps in technical knowledge, critical thinking, and problem-solving. Such occupational compatibility enables smoother transitions, especially in sectors like wind, nuclear, hydrogen energy, logistics, biomass processing, and metal refining.
- At the federal level, Employment and Social Development Canada (ESDC) should enhance intelligence gathering through its Occupational and Skills Information System (OaSIS) program to reflect emerging occupations, build a comprehensive skills database, and create tailored, sector-specific training programs through strong industry-academic partnerships.

This report unveils a new model for matching skills to jobs in Canada in periods of transition. It maps how workers can shift into emerging green industries – ensuring the best use of skills as the country's economy grows sustainably.

1. Introduction

At a time of considerable transformation in the Canadian economy, aligning workforce skills with evolving industry demands has never been more critical. However, there is a dearth of systematic information and analysis to compare demand for specific skills and competencies in current occupations with those that are forecast to emerge. This gap is especially relevant for emissions policy.

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A recent paper by Mahboubi (2019) shows that about 13 percent of Canadian workers have skills mismatched to their jobs.[1] Higher skills mismatches are associated with lower labour productivity. More recent data also suggest that skills mismatches remain a significant concern in Canada's labour market; according to a 2022 Statistics Canada report, 56.1 percent of businesses reported that their employees lacked full proficiency in performing their jobs at the required level (Fissuh et al. 2022).

In dynamic open economies, the skills needed by employers naturally evolve in relation to changes in trade, technology, public policy, or other factors. As a recent example of such dynamics, Canada's efforts to reduce greenhouse gas emissions and "decarbonize" the economy, launched in early 2022, have prompted a shift in required skill sets and activities for the labour force.

This study examines the workforce's capacity to adapt to changes in emissions policy. It also establishes a template for future analysis of other sudden shifts in skill demand. For example, it can help identify transferable skills, gaps, and training needs in implementing policies responding to evolving US tariffs and threats – such as increased defence spending and domestic infrastructure investments – as well as the tariffs' direct impacts.

A better understanding of future dynamics in skills demand and gaps will help policy makers and businesses implement strategies that support productivity and enhance Canadians' living standards. Regarding the lower-carbon economy, Pearson and Foxon (2012) highlighted the importance of retraining and upskilling to manage the economic and skills implications of transition. They advocated for proactive policies to ensure a smooth shift and maximize worker benefits.

This study develops a data-driven guide to addressing the challenges of upskilling and reskilling Canada's workforce to meet the demands of a lower-carbon economy. In doing so, it develops a universal template applicable to other important policy-driven changes. It introduces the Matching Skills model, designed to (i) identify transferable skills and competencies across occupations and (ii) help workers move into emerging roles within decarbonizing industries such as energy, manufacturing, and logistics. The study also includes a jurisdictional scan of sector-specific training and workforce transition programs in Canada and Europe, providing comparative insights into how other countries are preparing their labour forces for similar economic shifts.

1.1 From Mismatch to Momentum: Policy Solutions for Upskilling Canada's Workforce

The analysis reveals that many of the skills required for these transfers are already present among Canadian workers, though slight gaps remain in some areas, like technical knowledge, critical thinking, and problem-solving.

The findings highlight the importance of occupational compatibility to the success of workers and companies, where smaller skills gaps facilitate smoother transitions between roles. The study presents sector-specific case studies to demonstrate occupational opportunities for companies and workers in wind, nuclear, and hydrogen energy, as well as logistics workers with foundational or specialized skills, who can transition effectively into growing roles. The study also highlights pathways for workers with lower education levels to be successful in sub-sectors like biomass processing and metal refining.

1.2 Bridging the Skills Gap: A Model for a Future-Ready Workforce

Key policy recommendations to improve workforce adaptability include enhancing ESDC's

1 Overall, over-skilled workers are underutilized since they are unable to meet their optimal potential at work. Conversely, underqualified workers are overutilized since they lack the skills that make it possible to fulfill the requirements of their job.

OaSIS program to incorporate new occupations emerging from decarbonization and technological advancements.[2] As well, there is a need to develop a reliable skills database to improve training and employment mapping. Sector-specific training programs should be tailored to industries in the midst of change, with an emphasis on fostering partnerships between educational institutions and industry to develop relevant curricula.

Identifying and addressing the skills mismatch is critical to ensuring effective upskilling and reskilling. The Matching Skills model aims at doing just that. It leverages both quantitative and qualitative approaches to provide a deeper understanding of workforce dynamics during moments of shifting industrial priorities, helping to identify where the most pressing skills gaps and growth opportunities lie. By implementing targeted policies, such as improving access to labour market data, strengthening industry-academic collaboration, and encouraging lifelong learning, stakeholders can build a workforce that is both resilient and future-ready.

At the heart of this strategy is the integration of labour market intelligence (residing at OaSIS), sector-specific training, and transition pathways that include opportunities for both displaced workers and those with greater potential to contribute than is currently the case. When these components are strategically aligned, they form a coherent system that prepares workers for emerging jobs while reducing the risk of leaving economic opportunities on the table. Engaging Canada's technical workers and professionals in this process is important to governments at all levels. This coordinated, data-driven approach will foster a responsive training ecosystem, support inclusive economic growth, and solidify Canada's position as a global leader in sustainable industry. Together, these measures will align Canada's workforce with the demands of a changing economy.

2. Methodology: Mixed-Methods Research

This research uses a mixed-methods approach, combining quantitative and qualitative methodologies to collect, analyze, and integrate data to identify occupational transition pathways.

2.1 Quantitative Methodology

My quantitative analysis identifies skills, knowledge, and abilities gaps between occupations in related or comparable industries. The study relies on key data sources, including the 2023 industry vacancy rates in Canada, OaSIS, and the US Department of Labor's O*NET Database 28.3, which is built on the US Standard Occupation Classification (SOC) 2019 taxonomy structure. The SOC 2019 taxonomy structure is made up of 23 major groups and 98 minor groups, which provide comprehensive occupational descriptions. It includes 1,016 occupational titles, 923 of which represent O*NET data-level occupations (National Center for O*NET Development 2024). For an analysis focusing on sectors potentially sensitive to change driven by emissions reduction, I developed three subsets: one for the energy sector, another for manufacturing, and the third for supply chain occupations across sectors. Each subset includes 19 occupations that capture the diversity and variation within each sector, with different education requirements.

The Canadian government's OaSIS database builds on the SOC framework, offering expanded details for 900 occupational profiles and complementing the Canadian National Occupational Classification (NOC), which includes 516 unit groups (ESDC 2024). This paper compares the OaSIS and O*NET databases, as well as the NOC, to the US Standard Occupational Classification (SOC) structures to recommend improvements to the OaSIS database. These

2 See: Government of Canada. N.d. "Occupational and Skills Information System (OaSIS)." https://noc.esdc.gc.ca/Oasis/OasisWelcome.

distinctions highlight the need for detailed mapping crosswalks between classification systems to ensure accurate skill-matching and labour market analysis, which is particularly critical for industries with shared labour pools across Canada and the United States.[3] See Appendix A for a comparison between the NOC and SOC systems.

To analyze occupational compatibility and enable meaningful comparisons, descriptors from O*NET and OaSIS are each standardized to a 0-100 scale. Standardized scores for skills, knowledge, and abilities are used to calculate the "distance" between occupations. The closer the "distance" between occupations is (in terms of skill, education, and knowledge) to zero, the more compatible those occupations are for workers moving into new roles. A smaller distance – measured in standard deviations from the mean – indicates a smoother transition.[4]

O*NET and OaSIS offer different views of skill requirements in the fossil fuel and utilities industry; O*NET shows less variation, while OaSIS shows more. The choice of dataset can shape how we interpret the workforce needs of an industry. The analysis further examines the differences in the distribution of scores within selected occupations to evaluate the ease of transition between occupations in the fossil fuel, electricity, and manufacturing sectors, depending on the data source used (O*NET vs. OaSIS). For instance, in the fossil fuel and utilities industry, the O*NET database shows that the data points for selected occupations are tightly clustered around the mean of 5.04,[5] with a low standard deviation of 2.43, implying jobs within the industry require relatively similar skill sets, while OaSIS displays a higher mean of 15.49 and greater variability, with a standard deviation of 5.80 for fossil fuels and utilities. Percentage differences in skills and knowledge are calculated to identify critical gaps for effective transitions. See Appendix B for more details on the quantitative methodology used for this study.

The primary objective is to develop the Matching Skills model – a framework designed to assess the compatibility of occupations based on their skills, knowledge, and abilities – and hone its potential for upskilling and reskilling to address skills mismatches effectively. By evaluating the similarities and differences between occupational requirements, the Matching Skills model identifies pathways for workers to shift between roles with minimal retraining, providing a strategic tool for workforce development and labour market alignment.

2.2 Qualitative Analysis

The qualitative analysis examines case studies of various corporate and non-profit initiatives and projects across sectors, focusing on supply chain occupations. This approach is applied to occupations that – in order to transition to a lower emissions economy – require minor adjustments, such as additional skills and knowledge, but not fundamental changes. These occupations are typically found in industries like energy and manufacturing.

To characterize these changes, I collected occupation-specific qualitative information, work tasks, activities, and the associated skills and knowledge requirements of occupations such as industrial production managers and engineers, as presented on the O*NET US Department of Labor website.

Further, this paper's qualitative analysis includes a jurisdictional scan of sector-specific training programs and transition pathways to a low-carbon

3 In the labour market, crosswalks refer to mappings or conversion tools that connect different classification systems or taxonomies. These systems are often used to organize occupations, skills, industries, or education levels. Crosswalks help translate or align data across different systems for analysis, policy, or workforce planning.

4 A standard deviation from the mean indicates how spread-out data points are from the average value (mean) of a dataset.

5 A total of 452 occupations lie between the distances of 0 and 3.29, while 514 occupations lie between 3.29 and 7.99. The majority of the standardized scores are between 1.88 and 5.6.

Table 1: Summary of Statistical Results and Findings Across Sector

Industry	Mean	Median	Standard Deviation	Overall and Average Compatibility
Energy Sector	5.04	4.55	2.43	Broader spread of occupational distances: implies a less smooth transition compared to manufacturing sector and supply chain occupations across sectors.
Manufacturing Sector	5.26	4.87	2.34	Moderate cluster of low distance: suggest a more balanced transition compared to the energy sector and supply chain occupations.
Supply Chain Occupations Across Sectors	4.72	4.23	2.13	Tighter clustering of low distances: implies a smoother transition compared to the energy and manufacturing sectors.

Source: Author's calculations based on O*NET 28.3 Database.

economy in Canada and Europe. This scan reviews approaches to workforce development and labour market strategies to inform both the findings and the policy analysis (see Appendices E, F, and G).

3. Results and Findings

This section presents key findings from the qualitative and quantitative analysis of occupational transitioning opportunities in various energy and manufacturing sectors, focusing on the implications of decarbonization efforts. The results are structured around several core industries, including fossil fuels, electricity, wind energy, and nuclear energy, as well as emerging fields such as nanogeoscience, which is the study of matter at the nanoscale. I also examine the related topic of carbon capture and its applications in industries like cement manufacturing, and supply chain and logistics fields.

The analysis shows the importance of skill proximity in facilitating transitions, as closer alignment in skills, education, and knowledge reduces the retraining burden. Negative gap percentages signal skill shortages, while positive values indicate surpluses, providing insight for targeted interventions.

The distribution of occupational distances offers several insights into overall and average compatibility by examining the frequency of distances near zero, the mean or median of the distribution, and the range of compatibility levels based on whether the distribution is narrow or wide. Data from selected occupations across the energy and manufacturing sectors, as well as supply-chain occupations, yield the following findings (as summarized in Table 1 and shown in Figures 1, 2, and 3):

1 The energy sector shows a broader spread in occupational distances, suggesting a less smooth transition compared to the manufacturing sector and supply chain occupations across sectors. This implies that energy occupations are more diverse or require varying levels of skill adjustments.

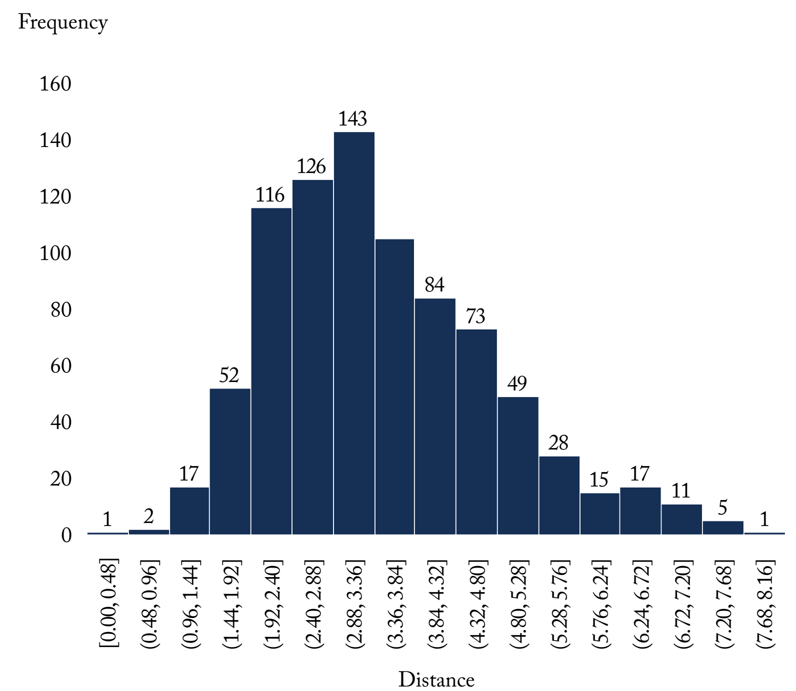
2 The manufacturing sector shows a moderate level of transition smoothness. While occupational distances still vary, the range of change from one occupation to another is narrower than in the energy sector, indicating a more manageable transition.

3 Supply chain occupations across sectors demonstrate a more gradual or moderate transition compared to the energy and manufacturing sectors. While not as tight as the low-distance clusters, it still allows for a more predictable career shift with some room for skill adjustments, making the transition smoother than in the energy sector.

3.1 Energy Decarbonization: Fossil Fuels, and Electricity

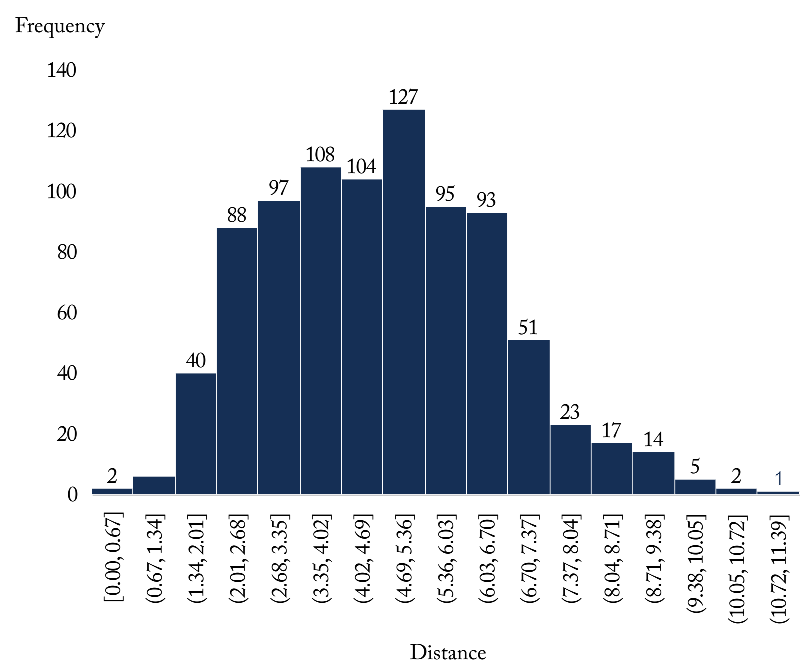
I examined different occupations in the oil and gas and electricity industries (energy sector). The findings reveal that transitioning these occupations to a lower-carbon economy will require employees

Figure 1: Distribution of Selected Occupations in the Fossil Fuel Indutry



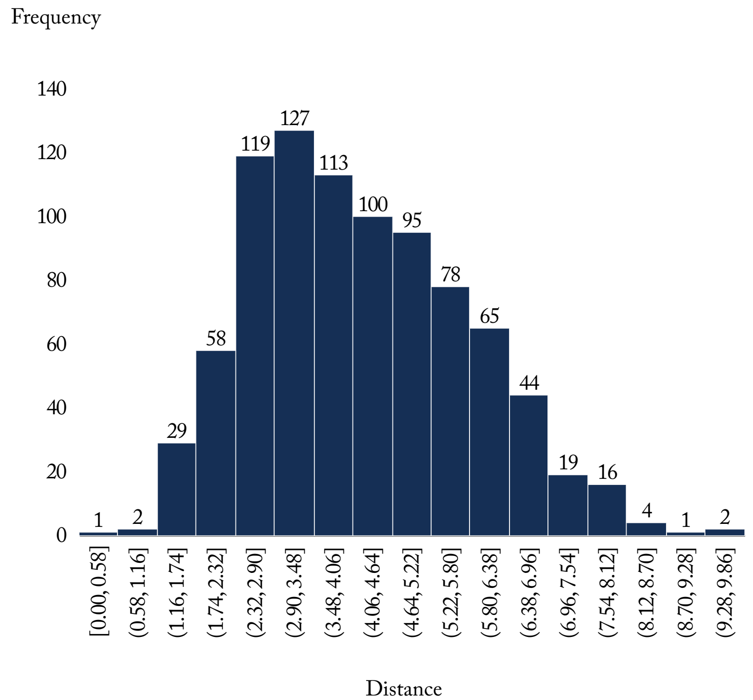
Source: Author's calculations based on O*NET 28.3 Database.

Figure 2: Distribution of Selected Manufacturing Sector



Source: Author's calculations based on O*NET 28.3 Database.

Figure 3: Distribution of Supply Chain Occupations Selected Across Industries



Source: Author's calculations based on O*NET 28.3 Database.

to have a combination of research, innovation, and critical thinking skills. These are fundamental in identifying cost-effective alternative technologies. In particular, research occupations that involve engineering and design skills will play an important role in developing clean energy solutions. Detailed descriptions of the occupations considered for this study are provided in Appendix C. Many of the skills required for this transition already exist among Canadian workers, which is a promising development for a low-carbon economy. Tables D1 and D2 in Appendix D show distances for selected occupations from O*NET and OaSIS databases, respectively. As examples, I select and describe the skills analysis for four subsectors: nanogeoscience and nanotechnology, wind energy, nuclear energy, and those subsectors requiring more general operator-type skills.

3.1.1 Nanogeoscience and Nanotechnology

Nanotechnology – the manipulation of matter at the atomic and molecular scale – has significant potential in Canada's heavy oil production, particularly for Enhanced Oil Recovery (EOR). Nanoparticles can modify fluid properties such as viscosity and thermal conductivity, improve efficiency and reduce costs. My analysis shows workers transitioning to these roles, such as geological technologists, will require additional training in chemistry and production processing (Figure 4).[6] Furthermore, geological technologists

6 The distance between geological technologists and nano-engineers and technologists is 1.16. This means geological technologists are four standard deviations closer to nano-engineers and technologists than the distribution mean of 5.04 (5.04/1.16 = 4.34). Please see Appendix B: Data Methodology in More Detail for more details regarding the calculations of the distance between two occupations.

can transition to roles as surveying and mapping technicians as well as environmental engineering technologists and technicians.[7]

Despite its potential, Canada's OaSIS database does not include entries for nano-focused occupations such as nanoengineering technologists, environmental engineering technologists, and technicians. This contrasts with the American O*NET database, which includes new technical and environmental occupations that are increasingly in demand due to advancements in decarbonization and computer technology. Therefore, my analysis of the OaSIS database indicates that geological and mineral technologists and technicians can transition to roles such as aerial survey and remote sensing technologists and land survey technologists, but those roles lack explicit pathways to nano-focused or environmental engineering roles. Addressing these omissions in the Canadian database is crucial for better workforce planning and adaptation in the context of decarbonization.

3.1.2 Wind Energy

Wind energy is the second-largest renewable energy source in Canada, accounting for 3.5 percent of the country's electricity generation. Alberta, Ontario, and Quebec lead the country in wind power capacity, and the sector has seen significant growth over the past decade (Terra 2024). Wind energy is also the fastest-growing and lowest-cost source of new electricity in Canada, with 39 projects worth $16 billion planned over the next decade.[8]

Industrial engineers (OaSIS) working in the fossil fuel and other sectors can transition to roles in wind energy, where they would contribute to the development and monitoring of wind turbine operations. Although industrial engineers have a deeper understanding of physics than wind energy engineers, they also outperform their wind energy counterparts in areas such as production and processing, operations analysis, and problem-solving to improve efficiency and profitability (see Figure 5).

3.1.3 Chemical to Nuclear Energy

Nuclear energy is a key power source in Canada, and its role is expanding. Ontario Power Generation (OPG) plays a significant role in the sector and is developing the country's first small modular reactor (SMR). In 2021, other provinces like Alberta, Saskatchewan, and New Brunswick joined Ontario in advancing nuclear energy. Nuclear reactors have diverse applications, including research and electricity generation (Johnson 2021).

As the shift to renewable energy progresses, demand for roles like nuclear monitoring technicians and reactor operators may rise. Chemical engineers and chemical technicians can specialize in roles as nuclear engineers and nuclear monitoring technicians, respectively, by focusing on designing and developing nuclear equipment, such as reactor cores, radiation shielding, or associated instrumentation or control mechanisms.[9] They can also monitor nuclear facility operations to identify any design, construction, or operation practices that violate safety regulations and laws, or could jeopardize safe operations. Chemical engineering programs offer foundational skills for this specialization. Research shows that chemical engineers often outperform nuclear engineers in production and processing by 34 percent (see Figure 6).

7 The distance between geological technologists and surveying and mapping technicians, and environmental engineering Technologists is 0.69 and 0.93, respectively. This means geological technologists are seven standard deviations closer to environmental engineering technologists than the distribution mean of 5.04. (5.04/0.69 = 7.31).

8 Terra, Nana. 2022. "Top 5 Wind Energy Projects in Canada." https://www.airswift.com/blog/wind-energy-canada.

9 The distance between chemical engineers and nuclear engineers is 0.68. This means chemical engineers are seven standard deviations closer to nuclear engineers than the distribution mean of 5.04 (5.04/0.68= 7.41).

Figure 4: Abilities, Skills, and Knowledge Differences between Geoscientists and Nanotechnology Engineering Technologists and Technicians

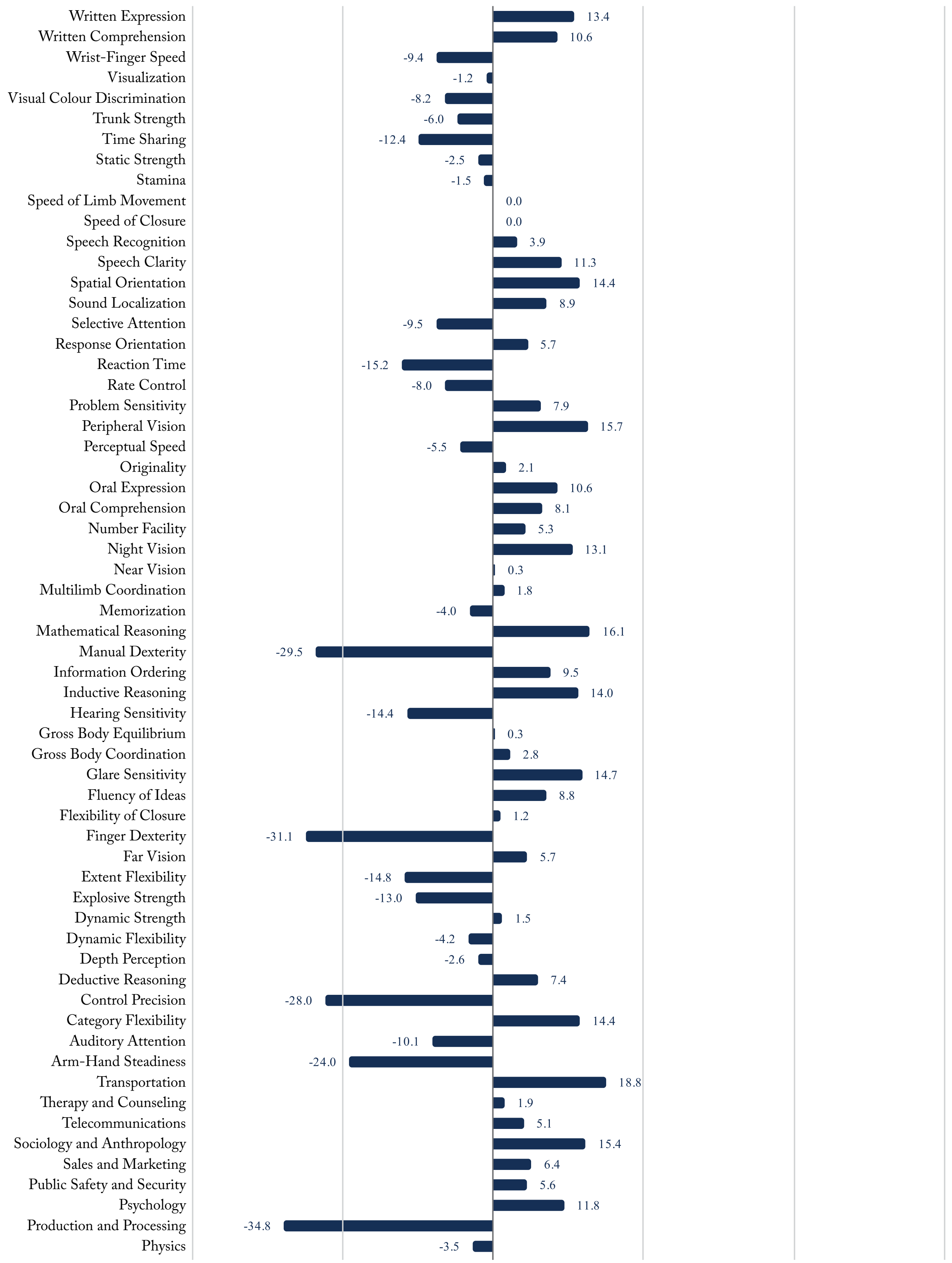
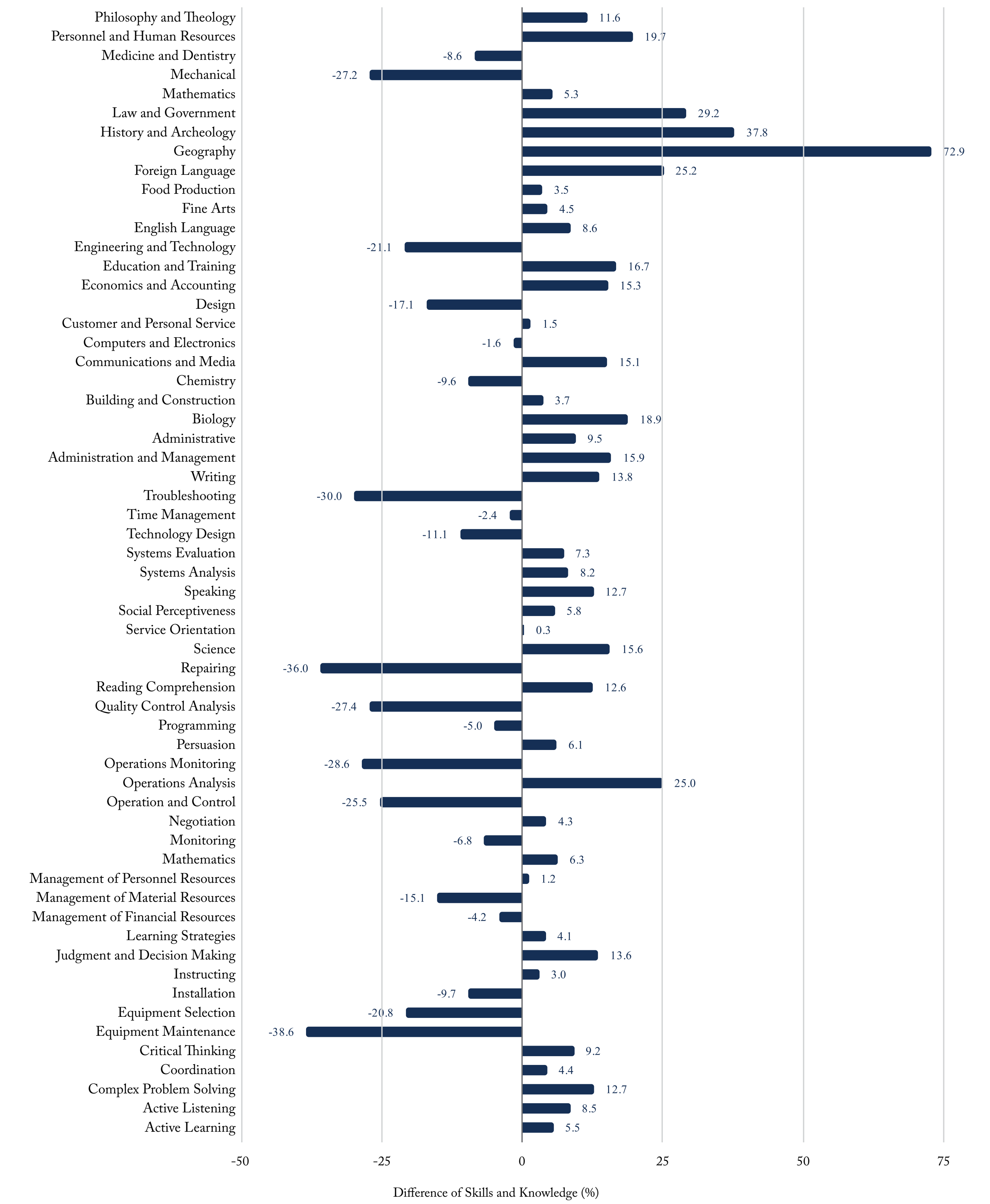


Figure 4: Continued



Note: The bars represent percentage-point differences in the relative level of skill or knowledge required between two occupations. A value of zero indicates equal importance of that skill or knowledge area in both occupations.

Source: Author's calculations based on O*NET 28.3 Database.

Figure 5: Abilities, Skills, and Knowledge Differences between Industrial Engineers and Wind Energy Engineers

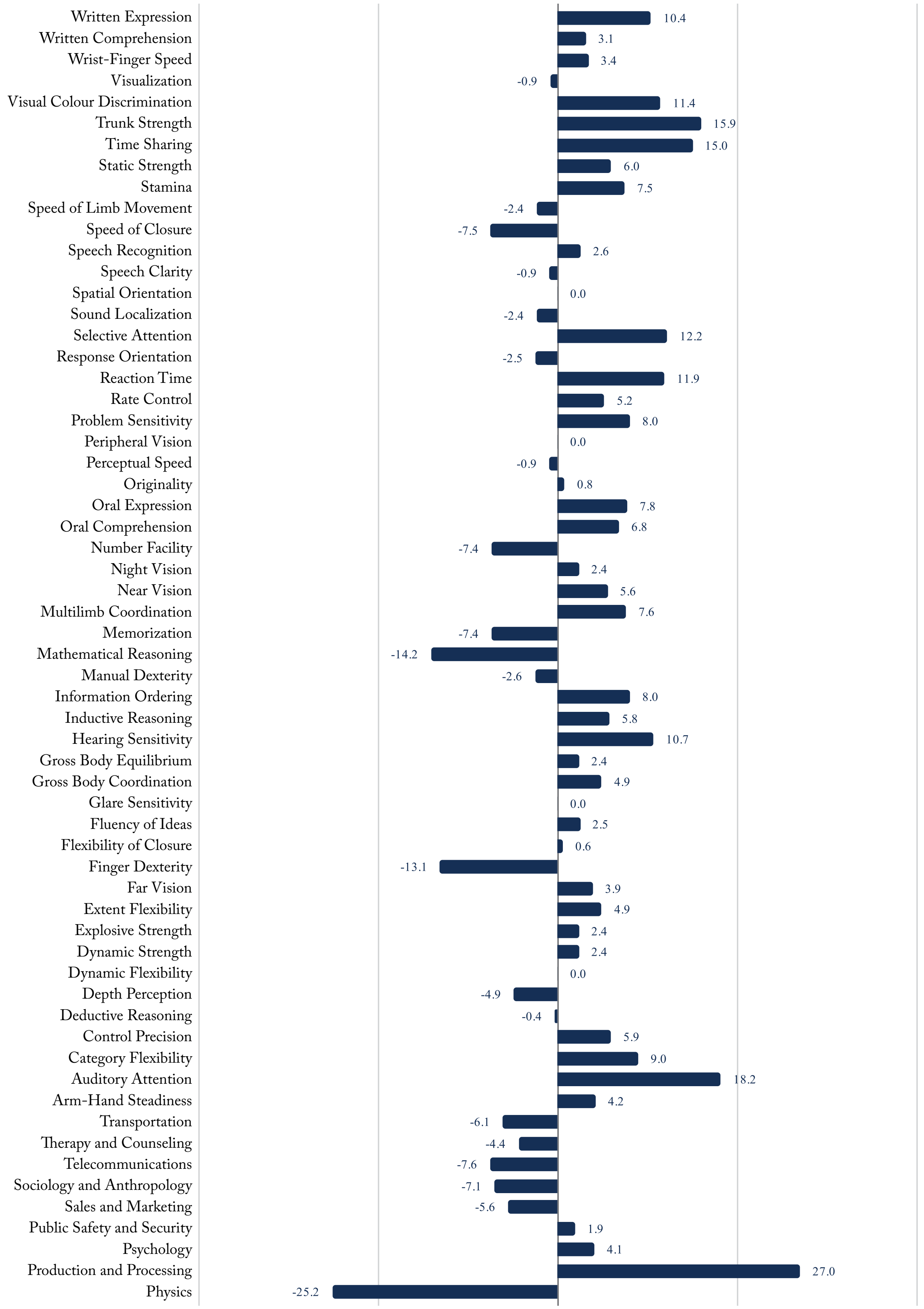
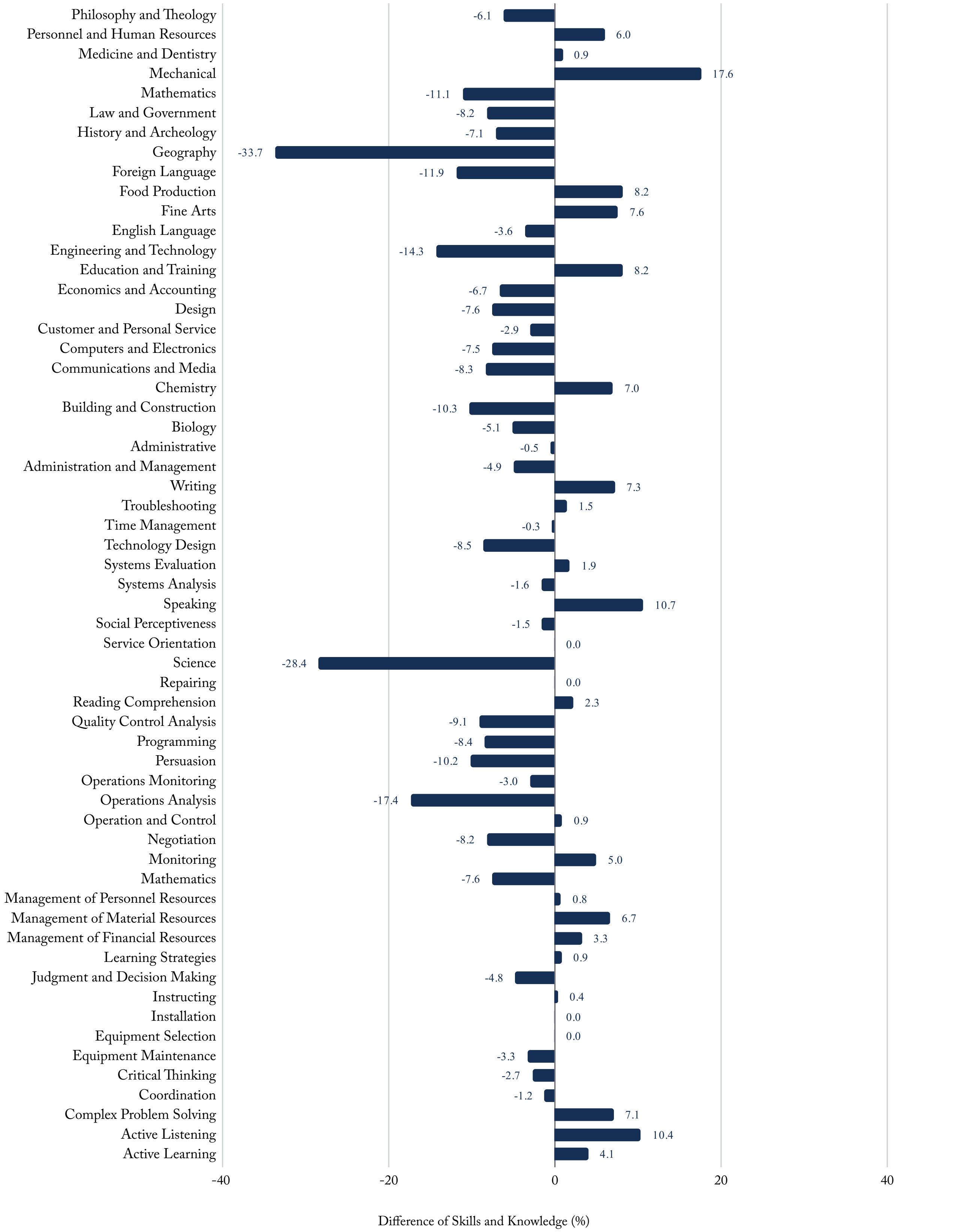


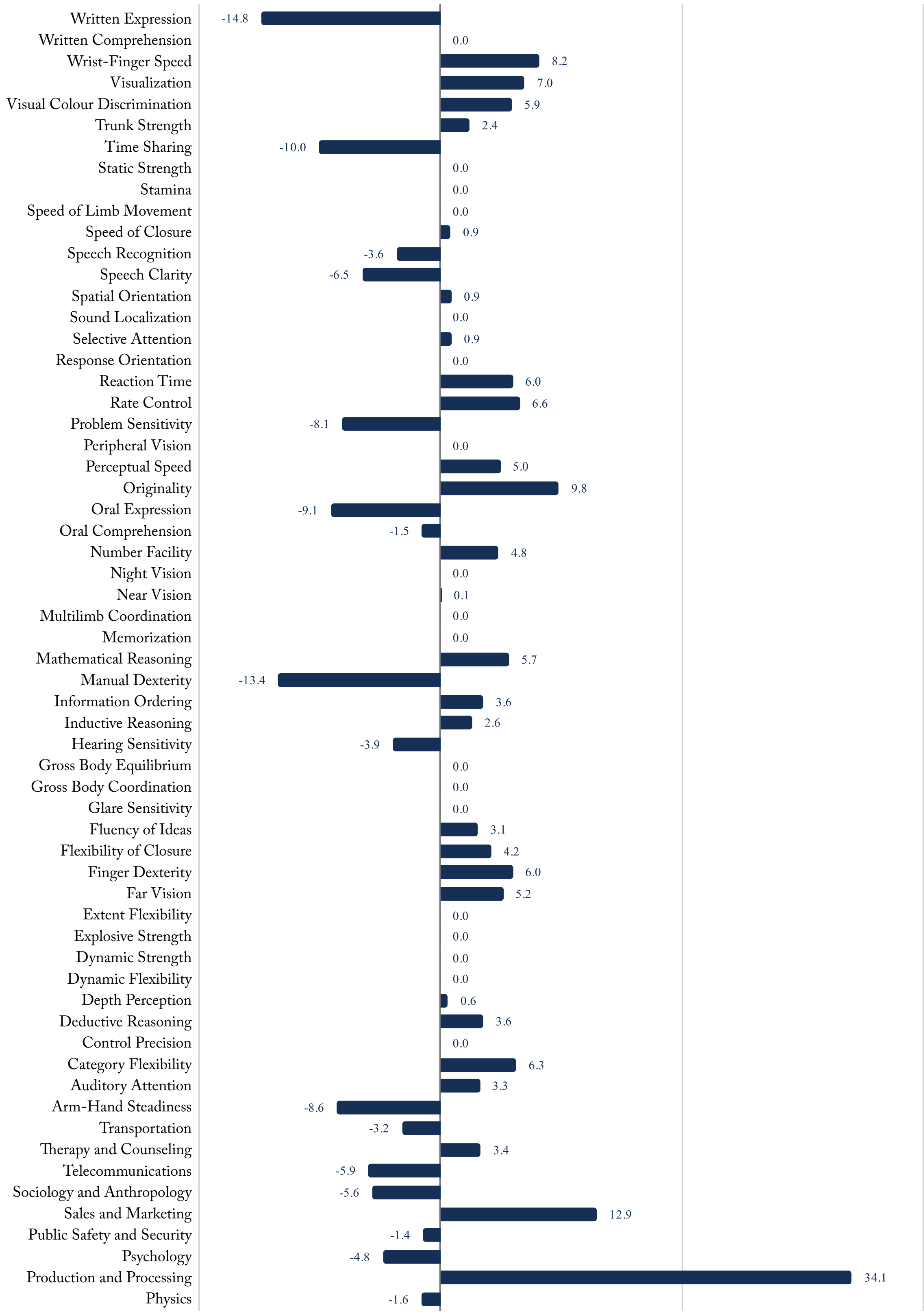
Figure 5: Continued



Note: The bars represent percentage-point differences in the relative level of skill or knowledge required between two occupations. A value of zero indicates equal importance of that skill or knowledge area in both occupations.

Source: Author's calculations based on O*NET 28.3 Database.

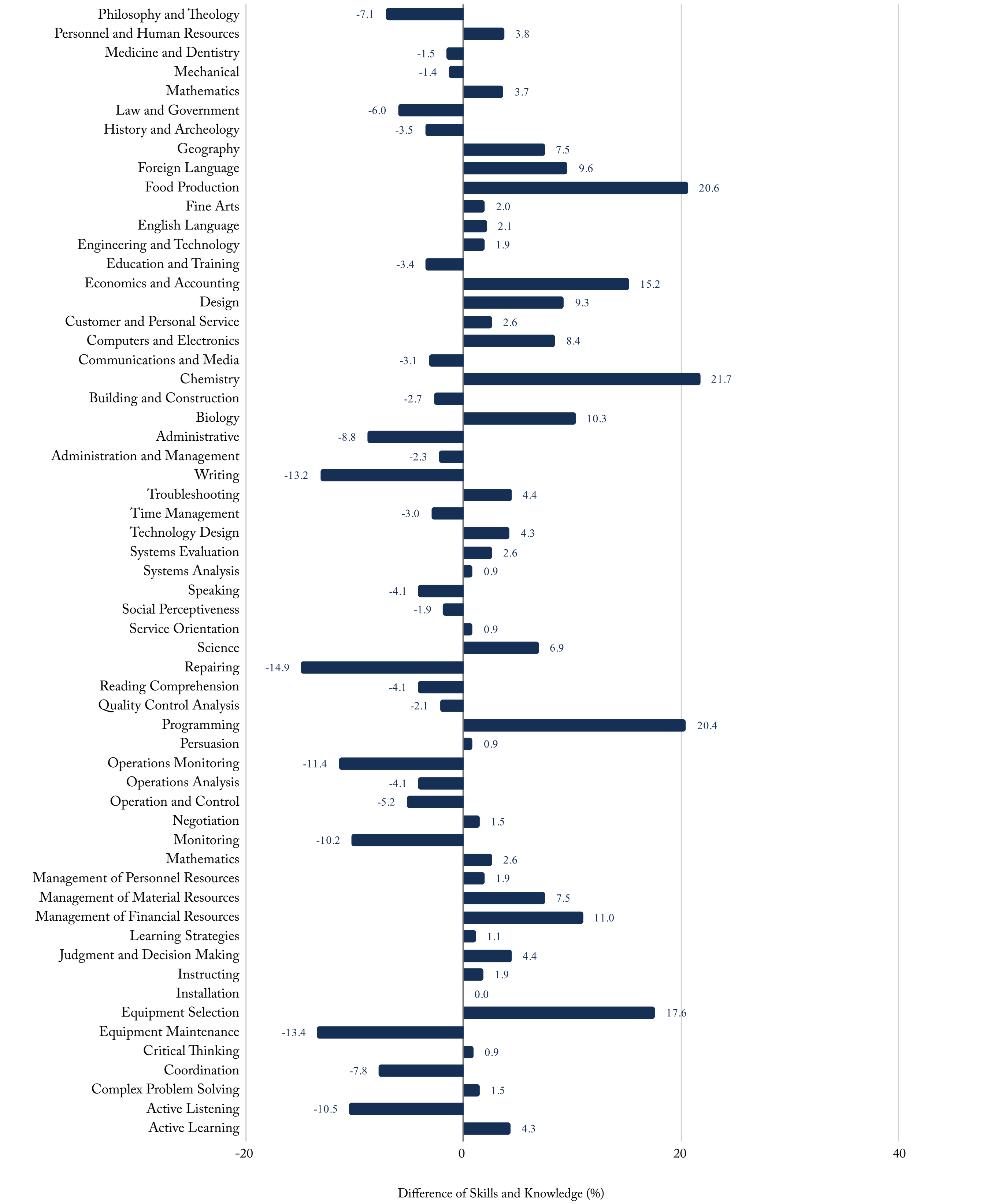
Figure 6: Abilities, Skills, and Knowledge Differences between Chemical Engineers and Nuclear Engineers



Note: The bars represent percentage-point differences in the relative level of skill or knowledge required between two occupations. A value of zero indicates equal importance of that skill or knowledge area in both occupations.

Source: Author's calculations based on O*NET 28.3 Database.

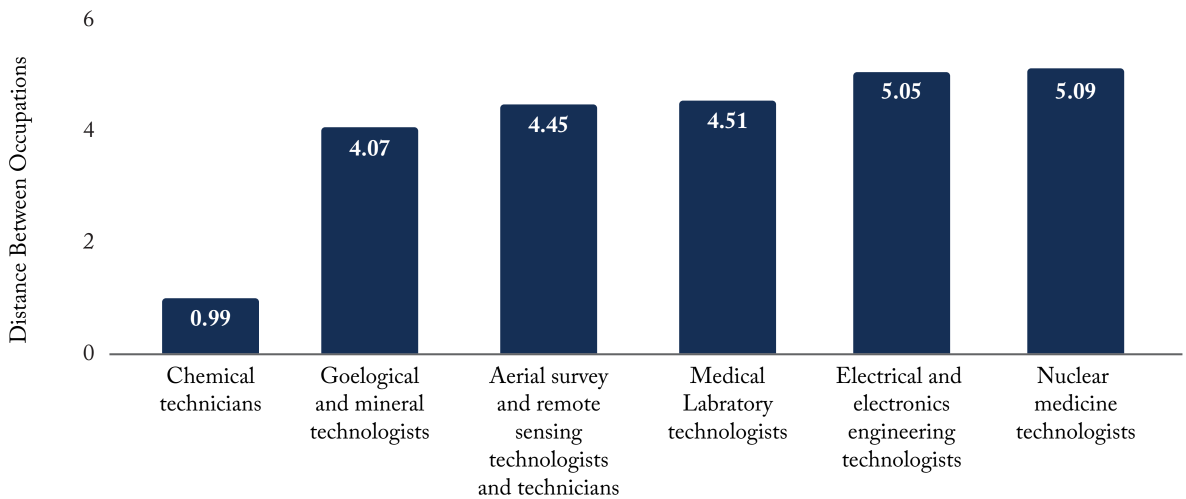
Figure 6: Continued



Note: The bars represent percentage-point differences in the relative level of skill or knowledge required between two occupations. A value of zero indicates equal importance of that skill or knowledge area in both occupations.

Source: Author's calculations based on O*NET 28.3 Database.

Table 7: Top Occupations for Chemical Technologists from the OaSIS Database



Source: Author's calculations based on the Canadian OaSIS Database.

The OaSIS database does not include the occupation of nuclear engineering, which limits its utility for workforce planning in this area. For example, my analysis of the OaSIS database shows that chemical engineers can work as industrial and manufacturing engineers and as metallurgical and materials engineers. Additionally, the growing focus on the conversion of carbon into usable products may increase the demand for chemical and materials engineers.

Chemical engineers, technologists, and technicians have the skills, knowledge, and abilities to work in different industries, including the healthcare sector. My analysis of both the O*NET and OaSIS databases shows that chemical technologists and technicians can easily work as medical and clinical laboratory technologists and technicians and as nuclear medicine technologists (see Figure 7 for an example of top occupations). Medical and clinical laboratory technologists perform complex medical laboratory tests essential for diagnosing, treating, and preventing disease, and may also train or supervise staff.

3.1.4 Careers Accessible to Lower Education Levels

For roles requiring a high-school diploma (Level 2 education) or a post-secondary certificate (Level 3 education), the most common occupational transition opportunities are shown in Table 2. The closer the "distance" between two occupations (in terms of skill, education, and knowledge) is to zero, the more compatible they are for transitioning workers. A smaller distance indicates a smoother transition. For example, petroleum pump system operators can transition to biomass plant technicians easily, with a small skills gap (a distance of 0.43) in the energy sector. They also have a relatively smooth path to becoming metal refining furnace operators in the manufacturing sector, with a slightly larger but still manageable gap (a distance of 0.74).

In statistical terms, these occupations are much closer in required skills compared to the average transition: the gap between petroleum pump system operators and biomass plant technicians is 11 standard deviations below the overall mean of 5.04, while the gap to metal refining furnace operators is six standard deviations below the mean. Metal refining furnace operators manage various types of furnaces, such as gas, oil, coal, electric-arc or electric induction, and open-hearth or oxygen furnaces, to melt and refine metal before casting or to produce specified types of steel.

3.2 Cement Manufacturing and Carbon Capture, Utilization, and Storage (CCUS)

Cement manufacturing is a carbon-intensive process that contributes significantly to greenhouse gas (GHG) emissions. The process starts with mining raw materials like limestone, clay, and marl, which are ground into a powder and heated in a kiln to create clinker. This clinker is then mixed with gypsum to make cement, which is used to produce concrete for construction.

Canada is emerging as a leader in carbon capture, utilization, and storage (CCUS) within the cement industry, driven by both industry innovation and government support. To reduce emissions, the Cement Association of Canada is promoting low-carbon alternatives such as Portland-limestone cement (PLC) and blended cements, which can cut greenhouse gas emissions by over 30 percent through reducing reliance on clinker, the most carbon-intensive component (Leetham 2015). In parallel, companies like Heidelberg Materials and Lafarge Canada are advancing CCUS technologies that aim to capture up to 95 percent of CO_2 emissions from cement production. These captured emissions can be stored in concrete or converted into carbonated aggregates that replace virgin materials and further reduce environmental impact materials.[10]

The government of Canada has been backing this transition through the Strategic Innovation Fund (SIF) managed by Innovation, Science and Economic Development Canada (ISED). From 2017 to 2023, over 108 direct-to-business agreements have been signed to provide support for activities in research and development (R&D) that lead to technology transfer and commercialization of new products, processes, and services (ISED 2022). SIF is set to provide up to $275 million in funding to Heidelberg Materials to support the development of North America's first full-scale CCUS system for the cement sector.[11] This shift toward cleaner production processes is expected to create demand for skilled workers in areas such as industrial ecology, chemical engineering, and production management. Industrial ecologists maximize the effective use of natural resources in the production of different commercial products such as cement and concrete. They examine the relationship between technical systems and the environment. These professionals must possess specialized knowledge of CCUS technologies to effectively manage and optimize low-carbon systems.[12]

As a result, workforce development initiatives and retraining programs supported by federal and provincial institutions will play a crucial role in preparing workers to transition from fossil fuel-related industries into emerging sectors like clean energy and sustainable construction. This growing demand suggests a pressing need for Employment and Social Development Canada (ESDC) and provincial governments to support targeted upskilling and retraining programs focused on carbon management and process integration, ensuring that professionals can adapt to the technological and regulatory demands of a low-carbon industrial economy.

10 Heidelberg Materials. 2022. "Largest CCUS Project Announced | Heidelberg Materials." September 1. https://www.heidelbergmaterials.com/en/pr-01-09-2022.

11 ISED. 2025. "Strategic Innovation Fund." April 15. https://ised-isde.canada.ca/site/strategic-innovation-fund/en/.

12 O*NET Online. "Industrial Ecologists 19-2041.03." US Department of Labor. https://www.onetonline.org/link/summary/19-2041.03.

Table 2: Occupational Transitional Opportunities for Occupations that Require a High-school Diploma in the Energy and Manufacturing Sectors

	Gas Compressor and Gas Pumping Station Operator	Petroleum Pump System Operators, Refinery Operators, and Gaugers	Stationary Engineers and Boiler Operators	Derrick Operators, Oil and Gas	Rotary Drill Operators, Oil and Gas	Roust-abouts, Oil and Gas	Boiler-makers	Riggers	Metal-Refining Furnace Operators and Tenders
Gas Plant Operators	0.76	0.64	0.8	n/a	1.24	n/a	n/a	n/a	n/a
Biomass Plant Technicians	0.66	0.43	0.49	1.4	0.93	n/a	1.1	n/a	0.76
Petroleum Pump System Operators, Refinery Operators, and Gaugers	0.7	0	0.77	1.25	0.94	n/a	n/a	n/a	0.74
Gas Compressor and Gas Pumping Station Operators	0	0.7	0.86	n/a	1.17	n/a	n/a	n/a	0.85
Stationary Engineers and Boiler Operators	0.86	0.77	0	n/a	1.23	n/a	1.19	n/a	n/a
Chemical Equipment Operators and Tenders	0.69	0.69	0.94	n/a	n/a	n/a	n/a	n/a	n/a
Water and Wastewater Treatment Plant and System Operators	0.94	1	0.85	n/a	n/a	n/a	n/a	n/a	n/a
Geothermal Technicians	1.19	1.15	0.69	n/a	n/a	n/a	n/a	n/a	n/a
Control and Valve Installers and Repairers, Except Mechanical Door	0.87	1.05	0.68	n/a	n/a	n/a	0.91	0.82	n/a
Biofuels Processing Technicians	0.96	0.71	0.82	n/a	n/a	n/a	n/a	n/a	n/a
Nuclear Technicians	n/a	1.15	0.95	n/a	n/a	n/a	n/a	n/a	n/a
Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	n/a	n/a	0.86	n/a	n/a	n/a	n/a	n/a	n/a
Septic Tank Servicers and Sewer Pipe Cleaners	1.13	1.05	n/a	0.84	1.01	0.91	1.05	0.78	0.84
Earth Drillers, Except Oil and Gas	1.08	0.99	1.07	1.18	0.96	n/a	1.16	1.15	0.97
Hazardous Materials Removal Workers	n/a	1.09	1.24	1.45	1.01	n/a	1.2	1.04	n/a
Wind Turbine Service Technicians	n/a	n/a	1.12	n/a	n/a	n/a	n/a	n/a	n/a

Table 2: Continued

	Gas Compressor and Gas Pumping Station Operator	Petroleum Pump System Operators, Refinery Operators, and Gaugers	Stationary Engineers and Boiler Operators	Derrick Operators, Oil and Gas	Rotary Drill Operators, Oil and Gas	Roust-abouts, Oil and Gas	Boiler-makers	Riggers	Metal-Refining Furnace Operators and Tenders
Automotive Engineering Technicians	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders	1.02	0.61	0.89	1.24	1.02	n/a	1.19	n/a	0.58
Electrical and Electronics Installers and Repairers, Transportation Equipment	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Outdoor Power Equipment and Other Small Engine Mechanics	1.15	n/a	1.09	n/a	n/a	n/a	n/a	1.03	n/a
Maintenance Workers, Machinery	0.99	1.05	0.58	1.49	1.19	n/a	0.8	0.87	n/a
Computer Numerically Controlled Tool Operators	1.11	0.83	1.15	n/a	1.3	n/a	1.02	n/a	0.99
Motorboat Mechanics and Service Technicians	1.07	n/a	1.09	n/a	n/a	n/a	1.18	1.06	n/a
Power Plant Operators	1.24	0.79	0.9	n/a	1.07	n/a	n/a	n/a	1.03
Metal-Refining Furnace Operators and Tenders	0.85	0.74	n/a	1.11	0.95	0.99	1.18	n/a	0
Rotary Drill Operators, Oil and Gas	1.17	0.94	1.23	0.84	0	n/a	n/a	n/a	0.95
Captains, Mates, and Pilots of Water Vessels	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Medical Equipment Repairers	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Farm Equipment Mechanics and Service Technicians	n/a	n/a	n/a	1.31	n/a	n/a	1.13	n/a	n/a
Electrical and Electronics Repairers, Commercial and Industrial Equipment	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Note: Colour gradients indicate transition ease, with red representing the smoothest transitions (distance = 0), followed by orange, yellow, light green, and dark green, which indicate increasing difficulty. "N/a" denotes no viable transition opportunities between two occupations.

Source: Author's calculations based on O*NET 28.3 Database.

As CCUS becomes more embedded in industrial strategy, the value of interdisciplinary expertise spanning engineering, environmental science, and data analytics will only grow. Companies demand a high level of technical proficiency from industrial ecologists, particularly in tools such as life cycle assessment (LCA) software, material flow analysis (MFA), and data management systems like Structured Query Language (SQL) and Systems, Applications, and Products in Data Processing (SAP). Industrial ecologists are expected to interpret large datasets, conduct simulations, and evaluate the unintended consequences of sustainability interventions. It also involves autonomy and decision-making, with over 50 percent of professionals reporting a high level of freedom in setting tasks and goals.[13] The findings from the O*NET database analysis show that this occupation requires knowledge of production processes, quality control, cost optimization, and manufacturing techniques (74 percent knowledge level). Skills such as judgment, decision-making, systems analysis, critical thinking, and problem-solving are essential, along with strong expertise in sciences (80 percent) and mathematics (71 percent).[14]

3.3 Logistics and Supply Chain Occupations

Logistics and supply chain management increasingly tie into sustainability, focusing on carbon accounting, renewable energy access, and reducing CO2 emissions. This sector emphasizes collaboration, operational efficiency, and environmental awareness across industries. Required competencies include problem-solving, communication, digital skills, and environmental awareness. While sectors like nanotechnology and wind energy demand specialized expertise, logistics remains accessible to those with less formal education and offers a wide range of roles that prioritize operational efficiency and sustainability over cutting-edge technological innovation.

Logistics spans multiple industries, optimizing the movement of goods while minimizing environmental impact. Key practices in sustainable supply chain management include carbon accounting and logistics tracking to quantify and maximize GHG emissions reductions. These roles emphasize collaboration with customers, supply networks, and industry groups.[15] However, stakeholder engagement remains a challenge, particularly in the long term.

Supply chain managers, buyers, transportation, distribution and storage managers, and logistics analysts require skills in:

- transportation system analysis, contract negotiations for green materials, and system evaluation;
- coordination and critical thinking;
- complex problem-solving;
- communication (speaking and reading comprehension);
- digital skills (such as artificial intelligence and blockchain); and,
- continuous enhancement of suppliers' environmental, safety, and social responsibility practices.

For instance, Schneider Electric's Zero Carbon Project and STRIVE program aim to reduce CO_2

13 O*NET Online. "Industrial Ecologists 19-2041.03." US Department of Labor. https://www.O*NETonline.org/link/summary/19-2041.03.

14 Ibid.

15 SCOR Digital Standard. https://www.ascm.org/corporate-solutions/standards-tools/scor-ds/.

emissions and achieve net-zero carbon operations across facilities.[16] Similarly, Walmart's Gigaton PPA Program, in partnership with Schneider Electric, helps suppliers access renewable energy, aiming to reduce one billion metric tons of emissions by 2030.

Supply chain professionals, including buyers, logistics analysts, and storage managers, play a crucial role in integrating sustainable practices by analyzing logistics data and negotiating contracts for green materials. These examples illustrate the shift in supply chain practices toward decarbonization goals and highlight the need for additional training in sustainability and environmental awareness.

Despite its accessibility relative to high-tech sectors, logistics still faces challenges, particularly in engaging diverse stakeholders over the long term and aligning supply networks with sustainability targets. This reinforces the importance of continuous training in sustainability, environmental regulation, and collaborative communication. As supply chain roles evolve, professionals such as buyers, analysts, and storage managers will increasingly need to integrate data-driven environmental analysis and supplier engagement into their core responsibilities.

The Sustainable Job Training Fund (SJTF), a federal Canadian initiative launched in 2024 with a $99.1 million budget over four years, aims to support workers transitioning to the low-carbon economy through training in areas like green building, low-carbon energy, and electric vehicles (EVs) (ISED 2025).

Since 2017, Canada's Strategic Innovation Fund networks have supported over 750 SMEs, created more than 1,200 jobs, and attracted $1.7 billion in investment, while directly strengthening supply chain development through innovation, productivity, and commercialization in clean energy and other key sectors. These targeted investments enhance the resilience and competitiveness of domestic supply chains. Complementing this, the Alberta Machine Intelligence Institute's AI Pathways project is equipping mid-career energy workers with AI skills to support the transition to a low-carbon economy, addressing talent shortages and preparing SMEs, industry associations, and unions for AI integration in the clean energy sector (ISED 2025).

4. Policy Discussion and Recommendations

This study applies a Matching Skills model to identify transitioning opportunities for occupations requiring significant skill shifts, particularly in specialized roles within the energy sector, including oil and gas, electricity, and manufacturing. It stresses the importance of skill compatibility and occupational mobility in facilitating a successful transition to a low-carbon economy. The findings indicate that occupations with lower skills and knowledge gaps (below 35 percent) are more compatible, enabling smoother transitions, while gaps above 65 percent significantly increase the difficulty of transitioning between roles.

Sector-specific insights reveal practical pathways for workforce adaptation. For instance, geological technologists can transition to nanotechnology roles with additional training, while industrial

16 Schneider Electric. 2021. "Schneider Electric Named as Best Global Sustainable Supply Chain Organization Spearheading Climate Action Throughout Its Ecosystem." June 15. https://www.se.com/us/en/about-us/newsroom/news/press-releases/schneider-electric-named-as-best-global-sustainable-supply-chain-organization-spearheading-climate-action-throughout-its-ecosystem-60c89c3ca7c2a547c66def73.

Note: Schneider Electric's fixed its carbon price at 130€/ton to guide investments with CO2 impact. Zero Carbon Project aims for a 50 percent reduction in operational CO2 emissions from top suppliers by 2025 (Eck 2021). STRIVE program targets 70 net-zero carbon plants and distribution centers by 2025 (Eck 2021). It focuses on energy and carbon efficiencies in 300 facilities.

engineers can leverage operations analysis expertise to enter wind energy positions. Chemical engineers demonstrate versatility, potentially transitioning effectively to nuclear energy, hydrogen fuel cells, and even healthcare roles with appropriate training. Additionally, logistics and supply chain professionals are increasingly focusing on sustainability and carbon accounting, highlighting the growing importance of complex problem-solving, digital skills, and environmental awareness. These findings reinforce the need for targeted upskilling initiatives and policies that support occupational mobility to meet the demands of a low-carbon economy.

This section also builds on the jurisdictional scan of workforce training and transition programs in Canada and Europe introduced earlier. The scan offers a comparative review of sector-specific training approaches, labour market strategies, and skills development systems, highlighting successful models that can inform Canadian policy design (see Appendices E-G).

Countries across Europe are actively aligning workforce development with the transition to green energy. For example, Denmark has invested significantly in cultivating a skilled workforce to support its leading wind energy sector.[17] Moreover, Germany, the UK, and other European nations, including the Netherlands and Belgium, have partnered with organizations like the International Labour Organization (ILO) and Cedefop to create strategic roadmaps that connect skills training with sustainable economic growth.[18]

Based on the findings, several key policy recommendations can be offered to help enhance workforce mobility and ensure a successful transition. These recommendations focus on improving skills mapping, sector-specific training, lifelong learning, and innovation in training approaches.

4.1. Improve the OaSIS Database to Build a Dynamic Skills Intelligence System

A comprehensive and reliable database is essential for tracking the evolving skill demands across industries. ESDC should consider updating the OaSIS database to include emerging occupations driven by decarbonization, digitization, and technological advancements. By improving this database to incorporate new skills and competencies, we can support a robust mapping of existing skills and avoid potential workforce disruptions. Accurate skills mapping can help ensure that the labour force is neither underemployed nor underutilized, providing a clear path to more targeted training and employment opportunities. Furthermore, ESDC should upgrade and expand the OaSIS database into a centralized labour market intelligence platform that:

- maps current and emerging green occupations by sector (energy, transport, manufacturing, construction, etc.);
- identifies skills adjacencies and transferable competencies, enabling the design of targeted retraining paths;
- links with training providers and employers to forecast demand and feed curriculum development; and,
- integrates international benchmarks from Cedefop, Centres of Vocational Excellence (CoVEs), and technical and vocational education and training (TVET) systems like Denmark's, to monitor skill needs in fast-evolving green industries.

Denmark's wind energy workforce success is rooted in proactive planning and the strategic use of labour-market intelligence to shape its TVET programs. By anticipating the needs of its growing renewable sector, Denmark aligned training with

17 Tisheva, Plamena. 2023. "Renewables Provided over 80% of Danish Power in 2022." December 1. https://renewablesnow.com/news/renewables-provided-over-80-percent-of-danish-power-in-2022-841970/.

18 European Commission. 2024. "Alliances for Innovation - Erasmus+." https://erasmus-plus.ec.europa.eu/programme-guide/part-b/key-action-2/alliances-innovation.

industry demands, creating a skilled workforce that supports its global leadership in wind energy. This model offers valuable lessons for Canada. Through its OaSIS database, Canada could similarly use real-time labour data to guide the development of targeted training, apprenticeship, and academic programs, ensuring its workforce is ready to meet the demands of a clean energy future.

4.2. Align Sector-Specific Training Programs with Decarbonization Goals and Integrate Innovative Training Solutions

To effectively support the transition to a low-carbon economy, sector-specific training programs must align closely with the needs of emerging green industries, including cement manufacturing, EV manufacturing, hydrogen production, and green construction. These sectors demand specialized competencies, adaptable delivery models, and strong partnerships between industry and educational institutions.

The jurisdictional scan reveals that several European countries have adopted highly integrated training ecosystems. They link labour market data with curriculum development, employer partnerships, and public investment in green skills. Scaling targeted programs like the Sustainable Jobs Training Fund (SJTF) is essential to reskill workers from high-carbon sectors – such as oil and gas, steel, and automotive manufacturing – into roles in renewable energy, EV maintenance, and hydrogen technologies. These programs should also offer comprehensive wraparound supports, from job readiness training and soft skills development to industry-recognized certifications and direct connections to employers.

Building strong industry-education partnerships is crucial for co-developing responsive curricula. Leading companies such as Siemens, Volkswagen, and ArcelorMittal are helping to shape training content that meets current and future workforce demands. Work-integrated learning opportunities like apprenticeships, co-op placements, and project-based learning should be embedded into training models. Additionally, increasing the capacity of training providers is vital, including funding for innovative delivery methods such as micro-credentials (short skill-focused digital certifications), blended and hybrid formats, and virtual labs.

The scan highlights CoVEs in countries like Denmark and the Netherlands that serve as regionally focused hubs for green skills development and facilitate collaboration between industry, government, and training institutions. Inclusive access is vital, such as Indigenous-led training programs that respect cultural contexts and local opportunities, and targeted outreach to underrepresented groups in trades. However, to maximize the impact of these programs, several challenges must be addressed: the high costs of training, complex regulatory environments (especially for small and medium-sized enterprises), a lack of national coordination, and significant gaps between current training curricula and the pace of technological change in green industries (European Training Foundation 2023).

Flexible online learning platforms and innovative training methods are key to preparing workers for low-carbon careers. Modular, self-paced courses in areas like sustainable energy and carbon accounting help workers upskill efficiently. Emerging tools such as virtual reality (VR) and simulation technologies offer immersive, hands-on learning that mirrors real-world job challenges. These methods also support the development of essential soft skills like problem-solving and critical thinking. Bluedrop Training & Simulation, an aerospace and defence e-learning company, is enhancing its VR training programs by integrating AI to create adaptive, personalized learning experiences. Supported by a $448,950 contribution from the Atlantic Canada Opportunities Agency, the initiative aims to tailor training content using real-time feedback, improve instruction and assessments, and strengthen mission training while ensuring data security.[19] Personalized, adaptive learning experiences hint at the great potential of technology in modern workforce development.

4.3. Improve the Structure of Transition Pathways

As industries decarbonize, it is critical to establish clear transition pathways that ensure workers are not left behind but are instead supported in shifting into sustainable roles within the green economy. This involves a coordinated national effort to map out viable career paths, strengthen training programs, align efforts with industrial investment, and prioritize equity and inclusion.

A key step is the development of national transition frameworks. These should include the creation of "transition maps," using data from OaSIS to identify pathways that require minimal upskilling. For example, a refinery technician could transition to a hydrogen plant operator or an HVAC energy auditor role with targeted training. These maps can serve as practical tools to guide workers and employers through the changing labour market landscape.

Strengthening the SJTF is essential to ensure that workers receive technical training and comprehensive wraparound supports. This includes sustained funding for income replacement during training periods, as well as subsidies for childcare, transportation, career coaching, and job placement services. It is also important to ensure coordination across provinces and territories to avoid fragmented or duplicative delivery of services.

Workforce transition efforts should be closely aligned with industrial investments supported by federal programs like the Net Zero Accelerator (NZA) and the SIF. Major projects such as Heidelberg Materials' cement production, Schneider Electric's Zero Carbon Project, and the STRIVE program present ideal opportunities to integrate workforce development, including co-op placements and guaranteed jobs for trainees from adjacent programs. Public funds should come with conditions requiring employers to offer green job placements and long-term career development opportunities for transitioning workers. Additionally, investing in community-based delivery models, especially in Indigenous and rural communities, helps make these programs more accessible and locally relevant.

Post-secondary institutions in Canada are offering specialized training programs to equip workers with skills for the clean energy transition. The Northern Alberta Institute of Technology (NAIT) delivers a 16-week subsidized Clean Energy Professional Upskilling Program focused on hydrogen production, carbon capture, sequestration, and lifecycle assessment. Graduates earn a certificate and nine micro-credentials, gaining hands-on experience through industry field placements. Similarly, the Southern Alberta Institute of Technology (SAIT) offers a Carbon Capture and Storage (CCS) Micro-Credential Series for professionals in engineering, geoscience, and trades.[20] The Engineering Institute of Technology (EIT) provides a comprehensive 12-module professional certificate in CCS, covering capture technologies, storage, transport, and economics.[21] These programs help build a technically skilled, low-carbon-ready workforce in Canada.

A leading global example of effective transition

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19 Atlantic Canada Opportunities Agency. 2024. "Smarter Simulations: Aerospace and Defence e-Learning Company Adopts AI." July 17. https://www.canada.ca/en/atlantic-canada-opportunities/news/2024/07/smarter-simulations-aerospace-and-defence-e-learning-company-adopts-ai.html.

20 SAIT. "Carbon Capture and Storage (CCS)." https://www.sait.ca/continuing-education/courses -and-certificates/certificates/carbon-capture-and-storage.

21 Engineering Institute of Technology. "Professional Certificates." https://www.eit.edu.au/course-types/professional-certificate/.

programming is Denmark. There, modular wind energy training is integrated into TVET systems. Public-private training centers are aligned with national clean energy strategies, resulting in the creation of over 30,000 wind energy jobs. These programs support domestic labour force transition and equip workers with skills that are in demand globally.[22]

4.4 Connect the System: A Unified Approach

These three components must be intentionally connected to form a seamless pathway from data to training to employment:

Component	Primary Role	Connection to Others
OaSIS Database	Tracks demand/supply of skills and occupations including green occupations.	Informs curriculum design and transition pathways
Sector-Specific Training Programs	Delivers the skills needed in priority sectors.	Designed using OaSIS data; linked to transition and job placement supports
Transition Pathways	Supports worker mobility and equity	Guided by real-time data; feeds workers into training aligned with growing sectors

Final Outcomes

Goal	Impact
Inclusive workforce transition to low-carbon economy.	Workers from high-carbon sectors are supported, not displaced
Responsive training ecosystem	Education systems adapt faster to labour market changes
Green industrial transformation	Clean growth is supported by a skilled, local workforce
Global competitiveness	Canada builds exportable skills and leadership in green sectors
Stronger local economies	Regional and Indigenous communities benefit from clean growth jobs

22 State of the Green. 2025. "The Economic Benefits of Wind Energy." Podcast. April 7. https://stateofgreen.com/en/news/the-economic-benefits-of-wind-energy/.

5. Conclusion

Addressing the skills mismatch through the Matching Skills model can help facilitate effective upskilling and reskilling in the face of significant policy and technological changes affecting industry, as demonstrated here in the case of a transition to a low-carbon economy. The integration of both quantitative and qualitative methodologies provides valuable insights into the current workforce, identifying gaps and opportunities for workers across various industries. By implementing policy recommendations like enhancing data accessibility, fostering industry partnerships, and promoting continuous professional development, stakeholders can create a robust framework that supports workforce adaptability.

A unified, data-driven system that connects labour market intelligence (collected by OaSIS), sector-specific training, and equitable transition pathways is essential for an effective and fair – that is, open to all – workforce strategy. When intentionally aligned, these components ensure that workers are not left behind in the policy shift but instead can thrive within it. It is important to involve Canada's technical workers and professionals in guidance at all levels of government in these transitions. By investing in this integrated approach, Canada can strengthen its local economies, support industrial transformation, and build a workforce equipped for the challenges and opportunities ahead.

Appendix A: Comparison of Canadian NOC and US SOC Structures

Both the US Standard Occupational Classification (SOC) and the Canadian National Occupational Classification (NOC) systems aim to categorize and organize occupations to facilitate analysis of labour markets, skills alignment, and workforce planning. However, differences in their structures and levels of detail present challenges in accurately mapping between the two systems.

Key Comparisons

1. Classification Numbers
   - SOC: Contains 867 occupational classifications at the 6-digit level.
   - NOC: Includes 500 occupational classifications at the 4-digit level.
2. Hierarchical Structure
   - Both the SOC and NOC use a four-level hierarchical structure to classify occupations systematically.
3. Level of Detail
   - NOC: Provides extensive details, including job titles, primary duties, employment requirements, and regulatory considerations (by province/territory).
   - SOC: Offers less detailed descriptions but emphasizes cross-sector applicability of occupational categories.
4. Enhanced Granularity
   - NOC: Extended by ESDC's Career Handbook, which expands the classifications to 939 categories at the 5-digit level. For example, broad occupations such as "Mathematicians, Statisticians, and Actuaries" are broken into more granular 5-digit categories.
   - SOC: Enhanced by O*NET's 8-digit classification (O*NET-SOC), which includes 974 categories, offering a more detailed description of job-worker characteristics, competencies, and skills.
5. Skills Concordance
   - The comparison highlights the necessity for a comprehensive concordance between Canada's 5-digit NOC classifications and O*NET's 8-digit classifications to accurately align occupational skills and related attributes.

Appendix B: Data Methodology in More Detail

This section describes in detail the methodologies used and the data employed in this research paper for finding accurate occupational transitioning opportunities during decarbonization in Canada. The expansion of existing industries usually involves both the creation of new occupations that could use existing technical skills and the requirements to acquire new technical skills. Therefore, it is appropriate to use a quantitative research methodology when analyzing the energy industry – from fossil fuels to the electrical sector – so as to determine the possibilities of future inter-occupational transitioning within the industry. This research uses quantitative research methods to measure and analyze data collected by the US Department of Labor. The quantitative research method analyzes the knowledge, skills, and education numerical data of 11 occupations in the oil and gas, electricity, and automotive industries to articulate the particular occupational transition opportunities for decarbonization in Canada.

B.1: Measuring Skills and Knowledge

Measuring knowledge and skills is important for this research, and they can be quantified in different ways. The database contains calculated standardized scores of skills and knowledge data associated with each O*NET occupation using Equation 1. Knowledge data denote what a worker learned through education or work experience – the theoretical and fundamental understanding of a subject that supports their thinking process above and beyond obvious solutions to a problem. Both skills and knowledge have two measures: "Importance" and "Level." The Importance rating indicates the degree of importance a particular descriptor holds for the occupation. The possible ratings range from "Not Important" (1) to "Extremely Important" (5). The Level rating indicates the degree, or point along a continuum, at which a particular descriptor is required or needed to perform the occupation. The minimum is zero and the maximum is 7. As we can see, the Level and Importance scales each have a different range of possible scores. Ratings on Level were collected on a 0-7 scale, and ratings on Importance were collected on a 1-5 scale. To make reports generated by O*NET Online more intuitively understandable to users, descriptor average ratings were standardized to a scale ranging from 0 to 100. The equation for conversion of original ratings to standardized scores is:

Equation 1:

$$S = ((O - L) / (H - L)) * 100$$

where S is the standardized score, O is the original rating score on one of the three scales, L is the lowest possible score on the rating scale used, and H is the highest possible score on the rating scale used. For example, an original Importance rating score of 2 is converted to a standardized score of 25 (25 = [[2 - 1] / [5 - 1]] * 100). For another example, an original Level rating score of 4 is converted to a standardized score of 57 (57 = [[4 - 0] / [7 - 0]] * 100). I calculated the average of the Level and Standardized Scores of Importance, and the Level ratings were calculated, and we called them AS. This reduces the complexity to one measure for every skill and knowledge type.

B.2: Education

Education strongly affects future upward or downward inter-occupational mobility, since it is related to knowledge in specific disciplines or sciences, and it determines the formal credentials of a worker. The level of education required is categorized or coded by numbers. For example, engineering technicians are required to complete an associate degree program (Category 5) at an accredited college, while most engineers are required to have a minimum of a bachelor's degree (Category 6). The credentials required are usually

Table B1: Education Categories and Descriptions

Year (Categories)	Description
1	Less than a High-school Diploma
2	High-school Diploma – or the equivalent (for example, GED)
3	Post-Secondary Certificate – awarded for training completed after high school (for example, in agriculture or natural resources, computer services, personal or culinary services, engineering technologies, healthcare, construction trades, mechanic and repair technologies, or precision production)
4	Some College Courses
5	Associate degree (or other 2-year degree)
6	Bachelor's Degree
7	Post-Baccalaureate Certificate – awarded for completion of an organized program of study; designed for people who have completed a Baccalaureate degree but do not meet the requirements of academic degrees carrying the title of Master.
8	Master's Degree
9	Post-master's Certificate – awarded for completion of an organized program of study; designed for people who have completed a Master's degree but do not meet the requirements of academic degrees at the doctoral level.
10	First Professional Degree – awarded for completion of a program that: requires at least 2 years of college work before entrance into the program, includes a total of at least 6 academic years of work to complete, and provides all remaining academic requirements to begin practice in a profession.
11	Doctoral Degree
12	Post-Doctoral Training

Source: 28.3 O*NET Database.

determined by a formal association that represents those occupations, such as the Association of Professional Engineers and Geoscientists of Alberta and the Association of Science and Engineering Technology Professionals of Alberta. The next step is to calculate the distance between the examined occupations and every other occupation to determine the closest 20 occupations for inter-occupational mobility using Equation 2.

B.3: Occupational Distance Scores

A more accurate understanding of the level and trends in occupational mobility requires an occupation distance measure that can be used to weight moves across various occupations. The distance measure is used to determine how close occupations are to each other in terms of knowledge, skill, and education required. Equation 2 measures the distance between the skills/knowledge of the occupation of interest and all the other occupations.

Equation 1:

The distance between two occupations =

$$\sum_{i=1}^{n}(ASx_i - ASy_i)^2$$

Where ASx_i is the Average Standard skill, knowledge, or education of the occupation of interest, and ASy_i is the average skill, knowledge, or education of another occupation. The distance indicates how close every occupation is to the occupation of interest. The smaller the distance between the occupation of interest and all other occupations, the easier it is to transition the displaced workers.

B.4: Skills and Knowledge Differences in Percentage

Determining the skills and knowledge that require the largest change when transitioning to other occupations is important for policy making and retraining efforts. Therefore, calculating the difference between the occupation of interest and other occupations, of each skill/knowledge in percentages, is a way to identify which skill/knowledge requires the biggest change to switch occupations. This means that having a better understanding of the specific skills and knowledge that requires upskilling and identifying the underutilized skills facilitate a smoother occupational transition.

Equation 2:

Skills/Knowledge Difference =

$$\sum_{i=1}^{n}(ASx_i - ASy_i) \text{ or } \sum_{i=1}^{n}(ASy_i - ASx_i)$$

Where ASxi is the skill, knowledge, or education of the occupation of interest, and ASyi is the skill, knowledge, or education of another occupation.

This contributes to determining every measure of every type of skill and knowledge of one occupation to another. The smaller the difference, the stronger the match for that skill or knowledge. This helps determine where those occupations are a good match and where they have gaps in the knowledge or skill type.

Appendix C: Occupation Description (O*NET Database)

Occupation	Description
Chemical Engineers	Design chemical plant equipment and devise processes for manufacturing chemicals and products, such as gasoline, synthetic rubber, plastics, detergents, cement, paper, and pulp, by applying principles and technology of chemistry, physics, and engineering.[23]
Energy engineers (except wind and solar)	Design, develop, or evaluate energy-related projects or programs to reduce energy costs or improve energy efficiency during the designing, building, or remodeling stages of construction. May specialize in electrical systems; heating, ventilation, and air-conditioning (HVAC) systems; green buildings; lighting; air quality; or energy procurement.[24]
Environmental Engineers	Research, design, plan, or perform engineering duties in the prevention, control, and remediation of environmental hazards using various engineering disciplines. Work may include waste treatment, site remediation, or pollution control technology.[25]
Environmental Engineering Technologists	Apply theory and principles of environmental engineering to modify, test, and operate equipment and devices used in the prevention, control, and remediation of environmental problems, including waste treatment and site remediation, under the direction of engineering staff or scientists. May assist in the development of environmental remediation devices.[26]
Fuel Cell Engineers	Design, evaluate, modify, or construct fuel cell components or systems for transportation, stationary, or portable applications.[27]
Geological Technicians	Assist scientists or engineers in the use of electronic, sonic, or nuclear measuring instruments in laboratory, exploration, and production activities to obtain data indicating resources such as metallic ore, minerals, gas, coal, or petroleum. Analyze mud and drill cuttings. Chart pressure, temperature, and other characteristics of wells or bore holes.[28]
Fuel Cell Engineers	Study the composition, structure, and other physical aspects of the Earth. May use geological, physics, and mathematics knowledge in exploration for oil, gas, minerals, or underground water; or in waste disposal, land reclamation, or other environmental problems. May study the Earth's internal composition, atmospheres, and oceans, and its magnetic, electrical, and gravitational forces. Includes mineralogists, paleontologists, stratigraphers, geodesists, and seismologists.[29]
Geological Technicians	Design, develop, test, and evaluate integrated systems for managing industrial production processes, including human work factors, quality control, inventory control, logistics and material flow, cost analysis, and production coordination.[30]
Geoscientists	Apply engineering theory and principles to problems of industrial layout or manufacturing production, usually under the direction of engineering staff. May perform time and motion studies on worker operations in a variety of industries for purposes such as establishing standard production rates or improving efficiency.[31]

23 O*NET Online. 2022. "Energy Engineers." June 7. https://www.O*NETonline.org/link/summary/47-4011.01.
24 O*NET Online. 2022. "Environmental Engineers 17-2081.00." June 7. https://www.O*NETonline.org/link/summary/17-2081.00.
25 O*NET Online. 2022. "Environmental Engineers 17-2081.00." June 7. https://www.O*NETonline.org/link/summary/17-2081.00.
26 O*NET Online. 2022. "Environmental Engineering Technologists and Technicians 17-3025.00" June 7. https://www.O*NETonline.org/link/summary/17-3025.
27 O*NET Online. 2022. "Fuel Cell Engineers 17-2141.01" June 7. https://www.O*NETonline.org/link/summary/17-2141.01.
28 O*NET Online. 2022. "Geological Technicians 19-4043.00." June 7. https://www.O*NETonline.org/link/summary/19-4043.00.
29 O*NET Online. 2022. "Geoscientists 19-2042.00" June 7. https://www.O*NETonline.org/link/summary/19-2042.00.
20 O*NET Online. 2022. "Industrial Engineers 17-2112.00."June 7. https://www.O*NETonline.org/link/summary/17-2112.00.
31 O*NET Online. 2022. "Industrial Engineering Technologists and Technicians 17-3026.00." June 7. https://www.O*NETonline.org/link/summary/17-3026.00.

Industrial/facilities Engineers	Design, develop, test, and evaluate integrated systems for managing industrial production processes, including human work factors, quality control, inventory control, logistics and material flow, cost analysis, and production coordination.[32]
Industrial/facilities Technologists and Technicians	Apply engineering theory and principles to problems of industrial layout or manufacturing production, usually under the direction of engineering staff. May perform time and motion studies on worker operations in a variety of industries for purposes such as establishing standard production rates or improving efficiency.[33]
Logistics Analysts	Analyze product delivery or supply chain processes to identify or recommend changes. May manage route activity including invoicing, electronic bills, and shipment tracing.[34]
Materials Engineers	Evaluate materials and develop machinery and processes to manufacture materials for use in products that must meet specialized design and performance specifications. Develop new uses for known materials. Includes those engineers working with composite materials or specializing in one type of material, such as graphite, metal and metal alloys, ceramics and glass, plastics and polymers, and naturally occurring materials. Includes metallurgists and metallurgical engineers, ceramic engineers, and welding engineers.[35]
Mining and Geological Engineers	Conduct subsurface surveys to identify the characteristics of potential land or mining development sites. May specify the ground support systems, processes, and equipment for safe, economical, and environmentally sound extraction or underground construction activities. May inspect areas for unsafe geological conditions, equipment, and working conditions. May design, implement, and coordinate mine safety programs.[36]
Nuclear Engineers	Conduct research on nuclear engineering projects or apply principles and theory of nuclear science to problems concerned with release, control, and use of nuclear energy and nuclear waste disposal.[37]
Nanogeoscience	Devise methods to improve oil and gas extraction and production and determine the need for new or modified tool designs. Oversee drilling and offer technical advice.
Nanotechnology Engineering Technologists and Technicians	Implement production processes and operate commercial-scale production equipment to produce, test, or modify materials, devices, or systems of unique molecular or macromolecular composition. Operate advanced microscopy equipment to manipulate nanoscale objects.[38]
Petroleum Engineers	Devise methods to improve oil and gas extraction and production and determine the need for new or modified tool designs. Oversee drilling and offer technical advice.[39]
Supply Chain Managers	Direct or coordinate production, purchasing, warehousing, distribution, or financial forecasting services or activities to limit costs and improve accuracy, customer service, or safety. Examine existing procedures or opportunities for streamlining activities to meet product distribution needs. Direct the movement, storage, or processing of inventory.[40]
Transportation, Storage and Distribution Managers	Plan, direct, or coordinate transportation, storage, or distribution activities in accordance with organizational policies and applicable government laws or regulations. Includes logistics managers.[41]

32 O*NET Online. 2022. "Logistics Analysts 13-1081.02. June 7. https://www.O*NETonline.org/link/summary/13-1081.02.
33 O*NET Online. 2022. "Materials Engineers 17-2131.00." June 7. https://www.O*NETonline.org/link/summary/17-2131.00.
34 O*NET Online. 2022. Mining and Geological Engineers, Including Mining Safety Engineers 17-2151.00." June 7. https://www.O*NETonline.org/link/summary/17-2151.00.
35 O*NET Online. 2022. "Materials Engineers 17-2131.00." June 7. https://www.O*NETonline.org/link/summary/17-2131.00.
36 O*NET Online. 2022. "17-2151.00 - Mining and Geological Engineers, Including Mining Safety Engineers." https://www.O*NETonline.org/link/summary/17-2151.00.
37 "O*NET Online. 2022. "17-2161.00 - Nuclear Engineers." https://www.O*NETonline.org/link/summary/17-2161.00.
38 O*NET Online. 2022. Nanotechnology Engineering Technologists and Technicians 17-3026.01." June 7. https://www.O*NETonline.org/link/summary/17-3026.01.
39 O*NET Online. 2022. "17-2171.00 - Petroleum Engineers." https://www.O*NETonline.org/link/summary/17-2171.00.
40 O*NET Online. 2022. "Supply Chain Managers 11-3071.04." June 7. https://www.O*NETonline.org/link/summary/11-3071.04
41 O*NET Online. 2022. "11-3071.00 - Transportation, Storage, and Distribution Managers." https://www.O*NETonline.org/link/summary/11-3071.00.

Appendix D: Quantitative Research Results

Table D1: Distance Measures for Possible Alternative Occupations based on O*NET Database

Occupation Name	Occupation Code	Possible Alternative Occupations (O*NET)	Distance
19-4043.00 Geological Technicians, Except Hydrologic Technicians *22101.01 Geological and Mineral technologists (OaSIS)* *22101.02 Geological and Mineral technicians (OaSIS)*	17-3031.00	Surveying and Mapping Technicians	0.69
	17-3025.00	Environmental Engineering Technologists and Technicians	0.93
	17-3026.01	Nanotechnology Engineering Technologists and Technicians	1.16
17-2199.03 Energy Engineers (Except wind and solar) *92100.01- Power Engineers (OaSIS)*	17-2051.02	Water/Wastewater Engineers	0.61
	17-2081.00	Environmental Engineers	0.69
	17-2199.10	Wind Energy Engineers	0.82
	11-9041.00	Architectural and Engineering Managers	0.93
	17-2051.01	Transportation Engineers	1
	17-2151.00	Mining and Geological Engineers, Including Mining Safety Engineers	1.13
19-2042.00 Geoscientists (Except Hydrologists and Geographers) *21102.01 Geoscientists (OaSIS)*	19-2043.00	Hydrologists	0.72
	19-2041.02	Environmental Restoration Planners	0.94
17-2171.00 Petroleum Engineers *21332.00 Petroleum Engineers (OaSIS)*	17-2081.00	Environmental Engineers	0.87
	17-2151.00	Mining and Geological Engineers, Including Mining Safety Engineers	0.88
	17-2199.03	Energy Engineers, Except Wind and Solar	0.9
17-2112.00 Industrial Engineers *22302.00 Industrial and Manufacturing Engineers (OaSIS)*	11-9199.09	Wind Energy Operations Managers	0.99
	11-3051.04	Biomass Power Plant Managers	1.03
	11-3051.01	Quality Control Systems Managers	1.09
	49-1011.00	First-Line Supervisors of Mechanics, Installers, and Repairers	1.09
	11-3051.03	Biofuels Production Managers	1.35
	11-3051.06	Hydroelectric Production Managers	1.38
	11-1021.00	General and Operations Managers	1.44
	11-3051.02	Geothermal Production Managers	1.49
17-3026.00 Industrial Engineering Technologists and Technicians *22302.00 Industrial and Manufacuturing Engineers (OaSIS)*	17-2199.10	Wind Energy Engineers	0.92
	17-3022.00	Civil Engineering Technologists and Technicians	1.01
	11-9041.00	Architectural and Engineering Managers	1.02
	17-2071.00	Electrical Engineers	1.08
	17-3026.00	Industrial Engineering Technologists and Technicians	1.16
17-2041.00 Chemical Engineers *21320.00 Chemical Engineers (OaSIS)*	17-2161.00	Nuclear Engineers	0.68
	17-2131.00	Materials Engineers	0.88
19-4031.00 Chemical Technicians *21320.01 Chemical Technicians (OaSIS)*	19-4099.01	Quality Control Analysts	0.99
	17-3026.01	Nanotechnology Engineering Technologists and Technicians	1.09
	19-4051.02	Nuclear Monitoring Technicians	1.14

17-2112.00 Industrial Engineering and Manufacturing Technologists *22302.00 Industrial and Manufacuturing Engineers (OaSIS)*	49-9098.00	Helpers – Installation, Maintenance, and Repair Workers	0.68
	47-4061.00	Rail-Track Laying and Maintenance Equipment Operators	0.74
	49-9012.00	Control and Valve Installers and Repairers, Except Mechanical Door	0.82
	49-9051.00	Electrical Power-Line Installers and Repairers	0.86
	51-4022.00	Forging Machine Setters, Operators, and Tenders, Metal and Plastic	0.87
	49-9043.00	Maintenance Workers, Machinery	0.87
	47-2011.00	Boilermakers	0.91
	51-2011.00	Aircraft Structure, Surfaces, Rigging, and Systems Assemblers	0.98
47-2011.00 Boilermakers *72103 Boilermakers (OaSIS)*	47-2211.00	Sheet Metal Workers	0.72
	51-2011.00	Aircraft Structure, Surfaces, Rigging, and Systems Assemblers	0.86
	47-2231.00	Solar Photovoltaic Installers	0.9
	49-9012.00	Control and Valve Installers and Repairers, Except Mechanical Door	0.91
47-5011.00 Derrick Operators, Oil and Gas *83101.01 Oil and gas well drillers and well servicers (OaSIS)*	47-4061.00	Rail-Track Laying and Maintenance Equipment Operators	0.71
	53-7021.00	Crane and Tower Operators	1
	53-4013.00	Rail Yard Engineers, Dinkey Operators, and Hostlers	1
	51-4051.00	Metal-Refining Furnace Operators and Tenders	1.11
	47-4051.00	Highway Maintenance Workers	1.13
	53-4022.00	Railroad Brake, Signal, and Switch Operators and Locomotive Firers	1.14
Rotary Drill Operators, Oil and Gas *83101.01 Oil and gas well drillers and well servicers (OaSIS)*	51-8013.03	Biomass Plant Technicians	0.93
	51-4051.00	Metal-Refining Furnace Operators and Tenders	0.95
	51-8013.00	Power Plant Operators	1.07
	47-4061.00	Rail-Track Laying and Maintenance Equipment Operators	1.07
	53-7021.00	Crane and Tower Operators	1.1
Service Unit Operator *84101.02 Oil and Gas Well Service Operators (OaSIS)*	49-3031.00	Bus and Truck Mechanics and Diesel Engine Specialists	1
	51-8092.00	Gas Plant Operators	1.03
	51-2011.00	Aircraft Structure, Surfaces, Rigging, and Systems Assemblers	1.04
	47-2011.00	Boilermakers	1.06
51-8093.00 Petroleum Pump System Operators, Refinery Operators, and Gaugers *N/A (OaSIS)*	51-8013.03	Biomass Plant Technicians	0.43
	53-7072.00	Pump Operators, Except Wellhead Pumpers	0.43
	51-8091.00	Chemical Plant and System Operators	0.6
	51-8092.00	Gas Plant Operators	0.64
	51-9011.00	Chemical Equipment Operators and Tenders	0.69
	53-7071.00	Gas Compressor and Gas Pumping Station Operators	0.7
	51-8099.01	Biofuels Processing Technicians	0.71

53-7071.00 Gas Compressor and Gas Pumping Station Operators *N/A (OaSIS)*	51-8013.03	Biomass Plant Technicians	0.66
	49-9012.00	Control and Valve Installers and Repairers, Except Mechanical Door	0.87
	17-2199.10	Wind Energy Engineers	0.92
	51-8099.01	Biofuels Processing Technicians	0.96

Source: Author's calculations based on O*NET 28.3 Database.

Note: The chart employs a colour coding system to indicate the distance measures between alternative occupations. Distances between 0.00 and 0.75 are represented in red, those between 0.76 and 1.25 are shown in orange, and distances greater than 1.26 are indicated in white. This colour scheme helps to visually highlight the relative proximity of alternative occupations, with white representing the greatest distance.

Table D2: Distance Measures for Possible Alternative Occupations based on OaSIS Database

Occupation	Code of Alternative Occupation	Possible Alternative Occupation (OaSIS)	Distance
21331 Geological Engineers	21330	Mining engineers	1.86
	21332	Petroleum engineers	2.87
22101.01 Geological and Mineral Technologists	22101.02	Geological and mineral technicians	0.91
	22214.03	Aerial survey and remote sensing technologists and technicians	3.78
	22213.01	Land survey technologists	3.99
	22100.01	Chemical technologists	4.07
22101.02 Geological and Mineral Technicians	22101.01	Geological and mineral technologists	0.91
	22214.03	Aerial survey and remote sensing technologists and technicians	4.15
	22213.01	Land survey technologists	4.36
	22100.02	Chemical technicians	4.47
	22213.02	Land survey technicians	4.47
21102.01 Geoscientists	21109.03	Soil scientists	4.48
	21102.02	Oceanographers	4.59
	21109.02	Materials scientists	4.81
21320 Chemical Engineers	21322	Metallurgical and materials engineers	3.58
	21399.02	Biomedical engineers	3.96
	21390	Aerospace engineers	4.19
21320.01 Chemical Technologists	22100.02	Chemical technicians	0.99
	32120	Medical laboratory technologists	4.51
	32121.02	Nuclear medicine technologists	5.09
	22110.01	Biological technologists	5.8
	32103.02	Clinical perfusionists	6
21332 Petroleum Engineers	21390	Aerospace engineers	5.47
	21321	Industrial and manufacturing engineers	5.49
	21399.01	Agricultural and bio-resource engineers	5.49
	21301	Mechanical engineers	6.76
	21399.02	Biomedical engineers	7.01
92100.01 Power Engineers	92100.02	Power systems operators	3.66
	22312	Industrial instrument technicians and mechanics	4.36
	92010	Supervisors, mineral and metal processing	5.8
22302 Industrial and Manufacturing Engineers	21301	Mechanical engineers	3.35
	21310	Electrical and electronics engineers	3.49
	21390	Aerospace engineers	4.39
	21300	Civil engineers	4.62
22302.01 Industrial Engineering and Manufacturing Technologists	22302.02	Industrial engineering and manufacturing technicians	1.78
	22310.01	Electrical and electronics engineering technologists	3.95
	22301.01	Mechanical engineering technologists	4.56
	22310.02	Electrical and electronics engineering technicians	4.67
	22300.02	Civil engineering technicians	4.91
	22300.01	Civil engineering technologists	5.07
	92100.02	Power systems operators	5.31

53111.05 Grips and Riggers	73110.01	Roofers	2.77
	74200.02	Railway track maintenance workers	2.77
	73200	Residential and commercial installers and servicers	2.94
	74201.02	Deck crew, water transport	3.01
	74205	Public works maintenance equipment operators and related workers	3.23
	94101.03	Foundry furnace operators	3.25
83101.01 Oil and Gas Well Drillers and Well Servicers	84100	Underground mine service and support workers	3.05
	84111	Silviculture and forestry workers	3.06
	83100	Underground production and development miners	3.08
	74200.01	Railway yard workers	3.22
	72501	Water well drillers	3.28
	73402.02	Blasters - surface mining, quarrying and construction	3.36
72103 Boilermakers	72102	Sheet metal workers	1.4
	72106.02	Welding, brazing and soldering machine operators	1.66
	72405	Machine fitters	1.75
	72104	Structural metal and platework fabricators and fitters	2.36
	72106.01	Welders	2.41
	72429	Other small engine and small equipment repairers	2.47
	72423.02	Recreation vehicle technicians	2.52
Oil and Gas Well Drillers and Well Servicers	74201.02	Deck crew, water transport	2.41
	94100	Machine operators, mineral and metal processing	2.42
	84100	Underground mine service and support workers	2.54

Source: Author's calculations based on OaSIS Database.

Note: The chart uses a colour-coding system to represent the distance measures between alternative occupations. Distances ranging from 0 to 2.49 are shown in red, indicating close matches. Distances between 2.5 and 4.99 are coloured orange, reflecting moderate matches, while distances greater than 5 are represented in white, highlighting significant differences. This system provides a clear visual indication of the degree of similarity between occupations.

Appendix E: Canadian Programs Supporting Sector-Specific Training

Table E1: Federal and Provincial Programs Supporting Sector-Specific Training and Upskilling

Jurisdiction	Program	Program Purpose and Funding	Key Outcomes and Impacts
Federal	Sustainable Job Training Fund (SJTF)	$99 million (2024–2028) to support workforce development for not-for-profits, Indigenous organizations, post-secondary institutions, training providers, provinces/territories, and businesses.[42] Target sectors include green construction, EV maintenance, and renewable energy.	• Reskilling/upskilling for workers moving from high-carbon to green sectors. • Job readiness: soft skills, safety, certifications. • Culturally relevant Indigenous-led training. • Innovation in delivery (micro-credentials, WIL). • Supports inclusion and regional/sector alignment.
	Canada Green Building Council (CAGBC) – Low Carbon Training Program	Upskilling professionals in architecture, engineering, construction, and real estate for low-carbon buildings, ESG practices, and energy/carbon competencies (ene+C2).	• 17,000+ job placements; $176M in wage subsidies.[43] • 71% intern retention; 76.6% hired in environment sector.[44] • High participant and employer satisfaction. Developed 35 competency profiles, 40+ career guides.[45] • Training includes AI, AR/VR, drone tech.
	Canadian Centre for Environmental Education (CCEE) – Certificate in Environmental Practice (CEP)	Online professional development program with 11 concentrations aligned with National Occupational Standards for Environmental Employment.	• Industry-recognized credentials for career changers and upskilling. • Flexible, modular learning. • Credits transferable to Royal Roads University programs.
	Mitacs	National nonprofit supporting research and innovation partnerships in low-carbon sectors.	• 99,000+ internships; 35,000+ projects; 11,000+ companies since 2018. • Increases in R&D (+37%), sales (+16%), productivity (+11%), employment (+18%).[46] • Strong intern retention (91% in Canada). Inclusive Innovation Plan promotes equity and diversity.[47]
Alberta	NAIT – Clean Energy Professional Upskilling Program	16-week subsidized program with certificates and micro-credentials in hydrogen, carbon capture, and LCA.	• Industry placements, high employer satisfaction. • Hydrogen Early Adopter Award nominee.
Alberta / Federal (NRC)	ENBIX – Low Carbon Built Environment Challenge	Supports R&D for decarbonizing construction, focusing on low-/zero-carbon materials.	• Developed carbon-accounting tools and datasets. • National LCI repository and procurement guidelines. • Released standards for whole-building LCA. • Supports Paris Agreement and Pan-Canadian goals.

42 ESDC. 2024. "Backgrounder: Government of Canada Launches Call for Proposals under the New Sustainable Jobs Training Fund." Backgrounders. March 8. https://www.canada.ca/en/employment-social-development/news/2024/03/backgrounder-government-of-canada-launches-call-for-proposals-under-the-new-sustainable-jobs-training-fund.html.

43 ECO Canada. 2023. "ECO Canada Provides Training and Funding for Young Professionals in the Environmental Sector." GlobeNewswire News Room. July 27. https://www.globenewswire.com/news-release/2023/07/27/2712618/0/en/ECO-Canada-Provides-Training-and-Funding-for-Young-Professionals-in-the-Environmental-Sector.html.

44 Ibid.

45 Ibid.

46 Mitacs. 2025. "Mitacs R&D Partnerships Fuel SME Innovation in Canada." *Mitacs*. June 20. https://www.mitacs.ca/our-innovation-insights/turning-business-challenges-into-innovation-opportunities/.

47 Mitacs. 2014. "Study of Mitacs Program Outcomes Reveals Significant Skills Development, Job Creation, and Retention of Highly Qualified Personnel in Canada." *Mitacs*. April 23. https://www.mitacs.ca/news/study-of-mitacs-program-outcomes-reveals-significant-skills-development-job-creation-and-retention-of-highly-qualified-personnel-in-canada/.

Appendix F: Programs Supporting Transition Pathways

Table F1: Federal and Provincial Programs Supporting Transition Pathways

Jurisdiction	Program	Program Purpose and Funding	Key Outcomes and Impacts
Federal	Strategic Innovation Fund – Net Zero Accelerator (NZA)	• Accelerates clean technology adoption in heavy industry, manufacturing, and transport. • Budget: $8B (NZA stream); $3.2B committed across 17 agreements as of May 2024.[48]	• **GHG Reductions**: Expected 7.2 Mt CO_2e by 2030; only 5.9 Mt CO_2e legally committed.[49] • **Notable Projects**: ArcelorMittal Dofasco (3 Mt CO_2e/year); Algoma Steel (6+ Mt CO_2e/year).[50] • **Green Innovation**: Major investments in EV batteries (VW), hydrogen (Air Products), DAC (Carbon Engineering). • **Jobs & Training**: 36,067 jobs and 14,570 co-ops tied to projects; $4.5B in green R&D.[51]
Federal	Canada Growth Fund (CGF)	• Launched 2022 with $15B mandate to crowd-in private capital. $3B invested in eight projects (Q1 2024).[52]	• **Major Investments**: $90M in geothermal (Eavor), $1B in CCUS (Strathcona), $137M in carbon-capture tech (Svante).[53] • **Innovation Tools**: Carbon Contracts for Difference (CCfDs); $7B earmarked to de-risk green projects.[54] • **Employment Potential**: Significant clean-tech job creation expected; supports long-term innovation reinvestment.
Alberta	Emissions Reduction Alberta (ERA)	• Since 2009: $855M in 245 projects (worth $7B).[55] • Key focus: industrial emissions reduction, energy efficiency, CCUS, hydrogen.	• **GHG Reductions**: 41 Mt CO_2e by 2030; 105 Mt by 2050.[56] • **Flagship Initiatives**: Methane Challenge, Natural Gas Challenge, Carbon Capture Kickstart, BEST Challenge. • **Workforce & Innovation**: New Innovator Support Services (2024) for commercialization; hosted BECCS Leadership Summit.

48 ISED. 2024. "Strategic Innovation Fund: Impact Report." March 21. https://ised-isde.canada.ca/site/strategic-innovation-fund/en/impact-report.

49 ISED. 2024. "Strategic Innovation Fund: Impact Report." March 21. https://ised-isde.canada.ca/site/strategic-innovation-fund/en/impact-report.

50 Reevely, David, Murad Hemmadi. 2024. "Flagship Federal Net-Zero Fund Isn't Capturing Heavy Emitters' Attention: Watchdog." The Logic. April 30. https://thelogic.co/news/flagship-federal-net-zero-fund-isnt-capturing-heavy-emitters-attention-commissioner/.

51 ISED. 2025. "Appearance before the Standing Committee on Environment and Sustainable Development (ENVI) by the ADM of Innovation, Science and Industry - Transparency." April 2. https://ised-isde.canada.ca/site/transparency/en/appearance-standing-committee-environment-and-sustainable-development-envi-adm-innovation-science.

52 Ibid.

53 Department of Finance Canada. "Chapter 2: Investing to Raise Wages | 2024 FES." https://www.budget.canada.ca/update-miseajour/2024/report-rapport/chap2-en.html.

54 CDEV. "Canada Growth Fund Inc." https://cdev.gc.ca/canada-growth-fund-inc/.

55 Emissions Reduction Alberta. "2024 Annual Report." https://www.eralberta.ca/2024-annual-report/.

56 Emissions Reduction Alberta. "$58 Million Announced for Natural Gas Innovations Worth $155 Million." https://www.eralberta.ca/media-releases/58-million-announced-for-natural-gas-innovations-worth-155-million/.

Alberta	Alberta Innovates	• Funds clean tech, hydrogen, digital energy, CCUS, carbon fibre R&D. • Co-invests with ERA and federal partners.	• **Hydrogen Projects**: $118.8M into 20 projects (April 2024); projected 493K t CO_2e cut by 2050.[57] • **Carbon Fibre Commercialization**: $10M for new test facility.[58] • **Job & GDP Growth**: 722 person-years, $210M GDP expected by 2027.[59] **Tech Commercialization**: 43 CCUS projects; DICE program supports clean hydrocarbon tech and digital twins.
Alberta / Federation of Canadian Municipalities (FCM)	Municipal Climate Change Action Centre (MCCAC)	• Partnership between Alberta and FCM. • $44M invested in clean energy across 401 orgs (156 communities).[60]	• **Clean Energy Impact**: 943 projects, 763K t CO_2e avoided; $171M saved in energy costs. • **EV & Efficiency**: Funded solar, EVs, and retrofits. • **Resilience Planning**: 66 communities developed 49 climate adaptation plans (2022–24). • **Case Studies**: Airdrie solar array, Medicine Hat EV equipment, Leduc energy manager savings.

57 Emissions Reduction Alberta. 2024.“Alberta Announces Almost $60 Million in Funding to 28 Projects Worth $280 Million That Will Advance the Hydrogen Economy in the Province.” https://www.eralberta.ca/media-releases/alberta-announces-almost-60-million-in-funding-to-28-projects-worth-280-million-that-will-advance-the-hydrogen-economy-in-the-province/.

58 Thomas Knowlton. 2025. “Alberta Innovates Garners $10M to Help Commercialize Carbon Fibre Innovation.” *Calgary. Tech*. July 5. https://calgary.tech/2024/07/05/alberta-innovates-commercialize-carbon-fibre-innovation/.

59 Ibid.

60 Energi. 2024. “Municipal Climate Change Action Centre.” Thoughtful Journalism About Energy’s Future. February 15. https://energi.media/news/municipal-climate-change-action-centre-helps-alberta-towns-save-millions-cut-emissions/.

Appendix G: Sector-Specific Training and Workforce Transitions

Table G1: International Programs Supporting Sector-Specific Training and Workforce Transitions

Jurisdiction	Program	Program Description and Initiatives	Outcomes
Denmark	Wind Energy Workforce Development	• Denmark is a global leader in wind energy, with over 50% of electricity from wind power.[61] Workforce development relies on vocational training, public-private partnerships, and research institutions. • Technical education integrated into Denmark's TVET system (e.g., Aarhus School of Marine and Technical Engineering offers wind turbine technician and offshore maintenance programs). • Partnerships between government, industry (Ørsted, Vestas), and academia align training with labour demand. • Flexible, modular, stackable training pathways support workers transitioning from shipping and fossil fuels. • Vocational education mandates 3+ months workplace training via strong links with employers. • Digital upskilling programs like DTU's DigiWind launched in 2024 for lifelong learning.	• Supports 33,000+ direct jobs in wind energy (2023), with industry employing over 31,000 people.[62] • Wind exports approximately €5.86 billion in 2023 (~half of energy-technology exports). • Green Future Fund promotes global dissemination of wind expertise and training. • Workforce resilience supported through lifelong learning, flexicurity labour market policies, and municipal initiatives like Esbjerg's Offshore Academy. • Strong emphasis on continuous upskilling and smooth transition from oil/gas to renewables. • Digital training increases accessibility and adaptability for technical workers and researchers.
Germany	Skills for Green Jobs (ILO / Federal Govt / Cedefop)	• Energiewende policy drives renewable energy expansion and workforce transition. • Collaboration between Federal Government, ILO, and Cedefop to align skills with green growth. • Federal training and reskilling for fossil fuel workers transitioning to green jobs. • Tripartite coordination with government, employers, unions. • Modernization of apprenticeship and vocational training with new green competencies. • Regional support for coal regions through structural development and retraining. • Occupational foresight, skills anticipation tools, and stakeholder dialogues. • Pilot upskilling programs in construction, energy, transport sectors.	• About 387,000 people employed in renewables in 2022 (highest since 2012).[63] • Targeted regional impacts: €150 million EU/EIB support to Lusatia coal region for transition.[64] • €40 billion allocated via Coal Exit Law to support coal region redevelopment.[65] • Strong federal coordination ensures aligned policy and funding. • Effective social dialogue and TVET system modernization recognized. • Coordinated initiatives like BuildUp Skills involving multiple stakeholders. • Structural funds and policies successfully manage regional workforce shifts.

61 Tisheva, Plamena. 2023. "Renewables Provided over 80% of Danish Power in 2022." Renewable Energy News. December 1. https://renewablesnow.com/news/renewables-provided-over-80-percent-of-danish-power-in-2022-841970/.

62 State of Green. 2025. "Testing and Perfecting the Turbines of Tomorrow." https://stateofgreen.com/en/news/testing-and-perfecting-the-turbines-of-tomorrow/.

63 Review Energy. "Employment opportunities in Germany's renewable energy sector surpassed 387,000 in 2022." https://www.review-energy.com/otras-fuentes/employment-opportunities-in-germany-s-renewable-energy-sector-surpassed-387-000-in-2022.

64 Williams, John. 2019. "Germany Invests €40 Billion to Transform Coal Regions." World Coal. September 5. https://www.worldcoal.com/power/05092019/germany-invests-40-billion-to-transform-coal-regions/.

65 Library of Congress. "Germany: Law on Phasing-Out Coal-Powered Energy by 2038 Enters into Force." https://www.loc.gov/item/global-legal-monitor/2020-08-31/germany-law-on-phasing-out-coal-powered-energy-by-2038-enters-into-force/

United Kingdom (UK)	National Skills Academy for Power (NSAP)	• Established under UK National Skills Academy network since 2010. • Funded by public-private partnerships, collaborating with industry bodies (EDF, National Grid, IET, Energy & Utility Skills). • Delivers tailored training to meet evolving power sector workforce needs. • Focus on transmission & distribution, SCADA, offshore wind, and nuclear skill shortages. • Power Generation Group formed to address offshore wind and nuclear workforce gaps. • Aligns workforce development with major projects like Dogger Bank wind farm. • Uses government skills heatmaps and workforce planning data.	• Significant recruitment challenges in T&D, SCADA, and technician roles. • Forecasts demand for 70,000 new offshore wind professionals by 2030.[66] • Addresses critical skill shortages across solar, nuclear, and power networks. • Strengthens pipeline for nuclear energy workforce in collaboration with EDF. • Enhances sector readiness for net-zero transition. • Provides evidence-based training aligned with government workforce assessments.
UK and Europe	Renewable Energy Institute (REI)	• Collaborates with Edinburgh Napier University, Heriot-Watt University, and others. • Offers specialized training in renewable energy technologies, energy efficiency, EVs, hydrogen. • Courses include Renewable Energy Management & Finance, Hydrogen Energy, and MSc in Renewable Energy Engineering. • Recognized since 1975 as Europe's first Renewable Energy Institute. • Provides face-to-face and online courses with global reach. • Partners with UNEP and European Energy Centre. • Focus on industry relevance and accredited certifications. • Programs led by experts with deep industry experience.	• Trains 5,000 professionals annually worldwide.[67] • Awarded Energy Institute Talent Development & Learning Award (2020). • High participant satisfaction (95%) across technical and career relevance. • Global reach with students in 150+ countries.[68] • Extensive portfolio of accredited courses covering diverse renewable technologies. • Strengthens workforce capacity in Europe and beyond. • Supports transitions in careers related to PV, wind, carbon finance, hydrogen, EVs, biomass, and energy efficiency.
Netherlands and Belgium	Carbon Connect Delta Program	• Joint CO_2 capture, transport, and storage initiative in the Scheldt-Delta industrial region. • Target to capture 1 million tonnes CO_2 annually by 2023, scaling to 6.5 million tonnes by 2030 (~30% of local emissions).[69] • Consortium includes Dutch and Belgian partners (Smart Delta Resources, North Sea Port, ArcelorMittal, Dow, PZEM, Yara, Zeeland Refinery). • Cross-border CO_2 transport infrastructure via pipelines. • Pre-FEED and FEED feasibility studies completed. • Permitting initiated under Dutch Multi-year Energy & Climate Infrastructure Program. • Supported by Dutch subsidy programs and EU funds. • Large investments by industry partners in CCS technology.	• Expected to reduce 30% of emissions in Scheldt Delta (~6.5 Mt CO_2/year) by 2030.[70] • Strengthens cross-border collaboration and infrastructure for carbon management. • Enables economic benefits including job creation and regional GDP growth. • Supports broader industrial transition pathways including hydrogen and electrification. • Demonstrates a replicable model for international CCS cooperation. • Enhances regulatory and commercial viability of carbon capture and storage projects.

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