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Projected Electricity Sector Labour Implications of Net-Zero Transitions in Canada

Report Prepared for CICC

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Jason Dion
Mitigation Research Director
Canadian Institute for Climate Choices

Dear Mr. Dion,

Re: Projected Electricity Sector Labour Implications of Net-Zero Transitions in Canada

I am pleased to provide this brief report and methodology of labour implications of Net-Zero Electricity Transitions. The labour implications provided in this report and supporting excel spreadsheets relates to the average total capital and fixed operating costs for different generation, distribution and transmission technologies within the electricity sector identified in three different low carbon investment modelling scenarios that were provided to Stiebert Consulting.

Sincerely,

Seton Stiebert
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Executive Summary

The average total electricity sector spending (three scenarios modelled) in electricity generation, transmission and distribution results in an estimate of 68,000 direct fulltime equivalent (FTE) jobs in 2020, rising to 150,000 by 2050. Indirect jobs account for roughly an additional 40%, such that total (direct and indirect) FTE jobs rises from 120,000 in 2022 to 262,000 in 2050.

Five technologies account for more than three quarters of the job projections. Wind, Transmission and Distribution, Hydro-including Tidal Power, Solar and Storage. Eight technologies account for more than 90% of the jobs projection, with the addition of Nuclear, Natural Gas with CCS and Biomass.

Direct and Indirect jobs are primarily located in the largest provinces, where six provinces account for 90% of the projected jobs in Ontario, Quebec, Alberta, British Columbia, Saskatchewan and Manitoba.

Total wages and salaries that are associated with the projected direct and indirect jobs rise from $8 billion in 2020 to more than $18 billion in 2022.

1 Introduction

The Canadian Institute for Climate Choices is undertaking a project focused on policy for preparing Canadian electricity systems to play a key role in the country's transition to net zero. The goal of this project is to develop specific policy recommendations that can help drive systemic transformations in Canada's electricity sector necessary to support net zero.

As part of this goal, the Institute is interested in understanding the regional increases in labour demand associated with transitioning electricity systems to align with the net zero goals. Stiebert Consulting is providing expertise on macroeconomic impacts to examine the labour implications of the associated investment in electricity systems in Canada out to 2050 that are estimated from three different models that examine net-zero scenarios.

This report first provides a brief description of labour implications from investments in different electricity generation, transmission and distribution technologies in Section 2, then outlines the model methodology and structure that we used in Section 3, before summarizing the labour implications (Direct and Indirect Jobs and Wages) covering provincial and territorial, technology and temporal distributions in Section 4. Finally, Section 5 discusses a few important points for consideration of the data.

2 Labour Requirements Related to Electricity Generation, Transmission and Distribution Investment

The transition of Canada's electricity grid to enable net-zero will require significant new investments in generation, transmission and distribution. Additional investments will also be needed to build climate resiliency and ensure that electricity infrastructure is climate proofed.

To consider the implications of a net-zero transition for the Canadian electricity sector we start with projected capital and fixed operating cost investments from three separate models.

1. IET Net-Zero: Scenario from the Canadian Energy Outlook 2021 published by the Institut de l'énergie Trottier that imposes a net-zero emissions target on total CO2-eq by 2050, and a 40% reduction target by 2030, with respect to 2005.
2. CER – HD: High demand scenario from Canada's Energy Future 2021 published by Canadian Energy Regulator that assumes a higher level of electrification due to climate action and technology development.
3. EPRI – Net-Zero: Scenario from Canadian National Electrification Assessment 2021 published by Electric Power Research Institute. The scenario assumes net-zero economy-wide CO2 emissions are achieved by 2050 for each province. The scenario includes accelerated carbon pricing (rising 10% per year after 2030), accelerated equipment turnover in transport and industry, as well as proposed zero-emissions standards for light-duty vehicles.

Investment in these models cover both capital and fixed operating costs from 2020 to 2050 and are expressed in CDN$2022 dollars. In addition to the investments indicated by these three models, we include in each scenario investments that are necessary for climate resilience of these systems that were independently produced from CICC modelling. These additional climate resilience investments represent nearly $15 billion from 2022 to 2050 and between 1% and 5% of total investment depending upon the scenario.

These investments in a net-zero transition electricity sector create economic activity that in turns creates jobs in both the local labour market where the infrastructure is built and indirectly in the labour market across Canada. Employment activity can be related to capital and fixed operating costs investment or spending using input-output multipliers developed by Statistics Canada, which measure how investment spending filters through the total economy. The total impact attributable to the spending is a combination of two impact areas:

- **Direct effects** measure the initial requirements for an extra dollar's worth of output of a given industry. The direct effect on the output of an industry is a one dollar change in output to meet the change of one dollar in final demand. Associated with this change, there are direct effects on GDP, jobs, and wages and salary and indirect taxes (municipal taxes). Direct jobs are the jobs that are related directly to the investments. They are the construction manufacturing and service jobs that occur within the province or territory where the project is located.

- **Indirect effects** measure the changes due to inter-industry purchases as they respond to the new demands of the directly affected industries. This includes all the chain reaction of output up the production stream since each of the products purchased will require, in turn, the production of various inputs. Indirect effects can be both within the province where the project occurs or out of the province. Indirect jobs are indirectly related to the investment. They are manufacturing and service jobs that are related to the production of inputs for the project. For example, a turbine manufacturer will need to acquire steel to build turbines and therefore indirect jobs at producer steel mills are included.

Labour requirements are assessed by developing an ***Electricity Sector Labour Model*** that is based on the economic structure of Canada's economy from Statistics Canada. More specifically, the model uses Statistics Canada input-output accounts that detail Canadian production and consumption, with the focus on goods and the services produced and the industries that produce and use them. The input-output accounts provide a detailed framework of the economy and all the economic activities that take place within it, for each province and territory, where the input-output tables include estimates of total production for each product, and use by industry.

The input-output information that forms the basis of the ***Electricity Sector Labour Model*** has the potential to provide two basic indicators associated with electricity sector spending, namely; full time equivalent jobs and wages and salaries.

According to Statistics Canada,[1] the indicators can be interpreted as follows:

- **Full time equivalent jobs** are calculated as the total hours worked divided by average annual hours worked in full-time jobs. This can also be described as full-time-equivalent work-years where actual hours worked are during normal periods of work, including overtime but excluding paid leave (e.g., holidays, sick leave. It is a less precise alternative to expressing labour input in terms of total hours worked.
- **Wages and salaries** include monetary compensation and payments-in-kind (for example, board and lodging), to wage earners and salaried persons employed in Canada. Includes other forms of compensation, namely commissions, tips, bonuses, directors' fees and allowances. It is recorded on a gross basis, before any deduction for income taxes, pensions, unemployment insurance and other social insurance schemes. It also excludes mandatory and non-mandatory employer contributions on behalf of employees to social insurance plans, which are treated as supplementary labour income.

[1] Glossary of Terms from Statistics Canada found here: http://www.statcan.gc.ca/eng/nea/gloss/index

3 Methodology and Model Structure

The model for estimating labour requirements that can be traced to investment in the electricity generation, transmission and distribution sector is based on national and provincial employment multipliers **from Statistics Canada**.[2] These multipliers are used to map the capital and fixed operating costs of electricity sector investments in different technologies to job and wages and salaries multipliers that reflect the structure of the Canadian economy. Multipliers essentially take the investment spending from three different forecast models (IET Net-Zero, CER-HD and EPRI Net-Zero) and determine on a per dollar basis, full time equivalent jobs and labor income that can be traced direct or indirect impacts to the spending.

The model is a simple accounting model, it is not a CGE model that allows for feed-back effects of different macroeconomic variables. For example it does not consider competition for labour and skills to estimate net employment effects.

Given data limitations, expenditure information does not include the impacts of variable operation costs. The model assumes that all spending occurred in the year indicated by the models, and that there are no continued economic impacts resulting from operation.

With investment spending identified from the output of the three models for 25 distinct electricity generation, transmission and distribution technologies, from the 13 provinces and territories, the second step in the model is to map them to the structure of Canada's economic accounts. To do this, we relied on a number of different sources that break down typical capital and fixed operating costs for utility scale electric generation technologies (***Archetypes***). The primary source of information is a report from the U.S. Energy Information Administration[3]. This comprehensive and up to date report characterizes detailed capital and operating costs for 22 different ***archetype*** facilities that are covered by the various models. The costs are specific for typical capacity sizes and technology configurations and are developed using a top-down capital cost methodology derived from parametric evaluations of costs from actual or planned projects. For a few additional technologies we rely on some additional sources of information including, the Jobs and Economic Development Impact (JEDI) model developed by the National Renewable Energy Laboratory[4].

Table 1 identifies how technologies identified in the investment model were mapped to capital and fixed operating costs of ***archetype*** technologies. In addition, the last column of the table indicates how the technology may be aggregated for reporting purposes.

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2 Statistics Canada, 2014, National and Provincial Multipliers (15F0046X). http://www5.statcan.gc.ca/olc-cel/olc.action?objId=15F0046X&objType=2&lang=en&limit=0

3 U.S. Energy Information Administration (2020). Capital Cost and Performance Characteristic Estimates for Utility Scale Electric Power Generation Technologies. February 2020. U.S. Department of Energy. https://www.eia.gov/analysis/studies/powerplants/capitalcost/pdf/capital_cost_AEO2020.pdf

4 National Renewable Energy Laboratory. Jobs and Economic Development impact (JEDI) model. https://www.nrel.gov/analysis/jedi/about.html

Table 1: Mapping of Investment Model Technologies to Archetype Technology Data used for Costing and Mapping to NAICS Industry Sectors

Major Category	Investment Model Tech	Archetype Tech Mapped for Costs	Archetype Cost Data Source	Final Aggregated Reporting
Fossil Generation	Natural Gas Steam	Internal Combustion 22 MW	US IEA (2020)	Natural Gas w/o CCS
	Natural Gas Turbine	NG Combustion Turbine 237 MW	US IEA (2020)	
	Natural Gas (and RNG) Combined Cycle	Natural Gas Combined Cycle 430 MW	US IEA (2020)	
	Heavy Fuel Oil	Internal Combustion 22 MW	US IEA (2020)	Oil
	Petroleum Steam Gas Turbine or Internal Combustion	Internal Combustion 22 MW	US IEA (2020)	
Fossil Generation with CCS	Coal	Ultra-Critical Coal 650 MW	US IEA (2020)	Coal w/o CCS
	Natural Gas Combined Cycle with CCS	Natural Gas Combined Cycle 430 MW with CCS	US IEA (2020)	Natural Gas w/o CCS
	Coal with 50% CCS capture (new IGCC only)	Ultra-Critical Coal 650 MW with 30% CCS	US IEA (2020)	Coal - CCS
	Coal with 90% CCS Capture	Ultra-Critical Coal 650 MW with 90% CCS	US IEA (2020)	
Renewable Generation	Solar	Solar 150 MW	US IEA (2020)	Solar
	Rooftop Solar PV	Solar 150 MW	US IEA (2020)	
	Utility Fixed Tilt PV	Solar 150 MW	US IEA (2020)	
	Wind (on-shore)	Onshore Wind 200 MW	US IEA (2020)	Wind
	Wind (off-shore)	Offshore Wind 400 MW	US IEA (2020)	
	Conventional Hydro	Hydro Plant 100 MW	US IEA (2020)	Hydro, including Tidal
	Tidal	Tidal 100 MW	US IEA (2020)	
	Nuclear	Nuclear 2156 MW	US IEA (2020)	Nuclear
	Nuclear-SMR	Nuclear SMR 600 MW	US IEA (2020)	
	Biomass Generation	Biomass Plant 50 MW	US IEA (2020)	Biomass
	Biogas	Biogas LFG Plant 36 MW	US IEA (2020)	Biogas
	Geothermal	Geothermal 50 MW	US IEA (2020)	Geothermal
	Hydrogen or syngas combined cycle	Fuel Cell 10 MW	US IEA (2020)	Hydrogen
Electricity infrastructure	Transmission and Distribution	Transmission and Distribution	JEDI Model (2018)	T&D
	Adaptation Investment	Transmission and Distribution	JEDI Model (2018)	Adaptation Investment
	Storage	Battery Storage 50 MW	US IEA (2020)	Storage

The capital costs and fixed operating costs for the archetype technologies were mapped to 254 detailed NAICS industry categories or 32 summary (i.e., higher level) NAICS industry categories that are identified in Statistic Canada’s most recent National and Provincial Multipliers

+accounts[5]. The fraction of net present value of capital and fixed operating costs is used to apportion the investment indicated in the models to the NAICS industry categories. Net present value of fixed operating costs is based on a social discount rate of 5% and reported operating lifetimes for the different technologies.

Figure 1 highlights the four steps to estimating labour implications using the model providing a specific example for Transmission and Distribution Investment indicated in the IET Net-Zero scenario for Alberta in 2022.

Figure 1: Model Steps to Calculating Labour Implications of Electricity Sector Spending

STEP	Inputs	Outputs	Example
Specify Electricity Sector Investment	Annual Model Investment ($CDN 2022) Technology Type (20 Archetype Technologies representing 25 Technologies identified in Models) Province		IET - NZ scenario. Investment in Transmission and Distribution in Alberta in 2022: $8,524,284
Map Investment to Multipliers	Ratio of Investment mapped to 254 detailed NAICS industry categories or 32 summary NAICS industry categories		See NAICS mapping table below
	Mapping of NAICS Industry investment to Multipliers by Province	Jobs	Full time Equivalent Jobs / $ Spent in 2022
		Wages and Salaries	$ Wages and Salaries / $ Spent in 2022
Adjust to $2022 CDN dollars	2018 Multiplier to 2022 Multiplier using CPI Index	$2022 dollars	CPI Index of 1.079 to convert $2018 to $2022
Estimate Labour Requirements		Jobs / Wages & Salaries Direct / Indirect In Province / Out of Province	See results table below

NAICS Industry Category	Fraction	Archetype Project Capital and Fixed Cost Category
Electrical equipment manufacturing	30.6%	Overhead wires (conductor and insulators and shield wire) Positions (new bays/circuits) New and upgrades to Substation Facilities Transformers, Series Compensation
Electric power engineering construction	29.7%	Installation (grading, roads, site prep, foundations, fencing) Installation tower Erection, conductor Stringing Transmission Line Services Infrastructure Services Associated Labour
Electric power generation, transmission and distribution	15.0%	Replacement Parts and Substation Labour
Steel product manufacturing from purchased steel	14.2%	Steel structures and poles
Architectural, engineering and related services	2.6%	Engineering/Surveying/Geotechnical Consulting Services
Finance, insurance, real estate, rental and leasing and holding companies	2.1%	Land Acquisition
Insurance carriers	2.1%	Construction and other insurance
Other professional, scientific and technical services	1.9%	Environmental & Permitting Services
Cement and concrete product manufacturing	1.7%	Concrete, gravel, asphalt

	Direct	Indirect (In Province)	(Out of Province)
Jobs	20	11	7
Wages and Salaries (million $2022)	1.8	1.7	0.42

[5] Statistics Canada. Table 36-10-0595-01 Input-output multipliers, provincial and territorial, detail level. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3610059501

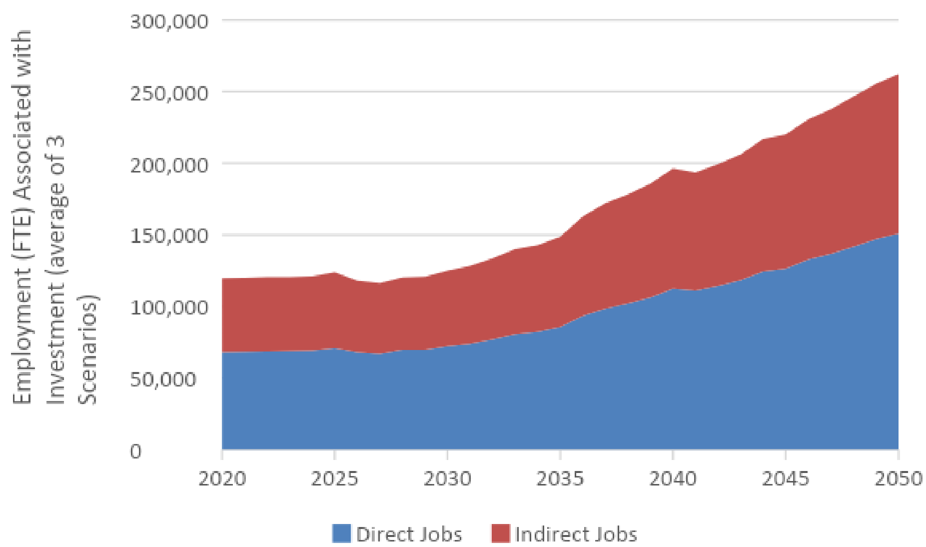
4 Estimating Labour Requirements

The section presents a high level summary of results from the ***Electricity Sector Labour Model***. The accompanying excel spreadsheet provides exact figures and additional detail.

4.1 National Direct and Indirect Jobs

The average of the total electricity sector spending of the three models and the associated output activity of the varied investments in electricity generation, transmission and distribution results in an estimate of 68,000 direct fulltime equivalent (FTE) jobs in 2020, rising to 150,000 by 2050. Indirect jobs account for roughly an additional 40%, such that total (direct and indirect) FTE jobs rises from 120,000 in 2022 to 262,000 in 2050. Figure 2 summarizes in a stacked area chart the total direct and indirect jobs from 2020 to 2050. For context the total number of jobs in the Electric power generation, transmission and distribution sector (NAICS 2211) in 2020 is reported by Statistics Canada as 96,910[6,7].

Figure 2: Jobs by Electricity Sector Spending (Total Direct and Indirect FTE)



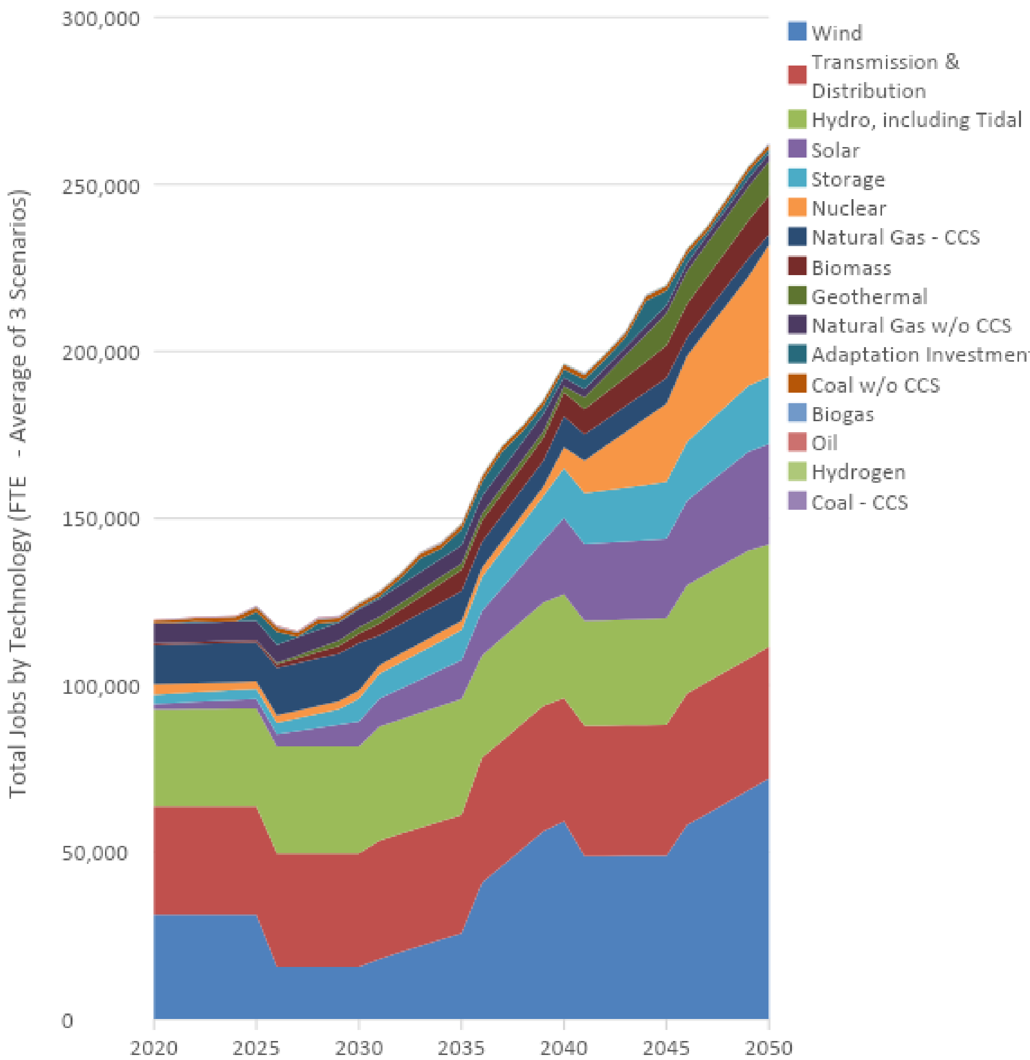
[6] Statistics Canada. Table 14-10-0202-01 Employment by industry, annual
DOI: https://doi.org/10.25318/1410020201-eng

[7] Note that employment in the sector cannot be directly equated to the direct employment related to capital and fixed cost investments shown in Figure 2. Sector employment also include jobs associated with variable costs and non-project related costs (e.g., marketing).

Total indirect and direct jobs disaggregated by electricity generation, distribution and transmission technology are provided in Figure 3.

Five technologies account for more than three quarters of the job projections. Wind, Transmission and Distribution, Hydro-including Tidal Power, Solar and Storage. Eight technologies account for more than 90% of the jobs projection, with the addition of Nuclear, Natural Gas with CCS and Biomass.

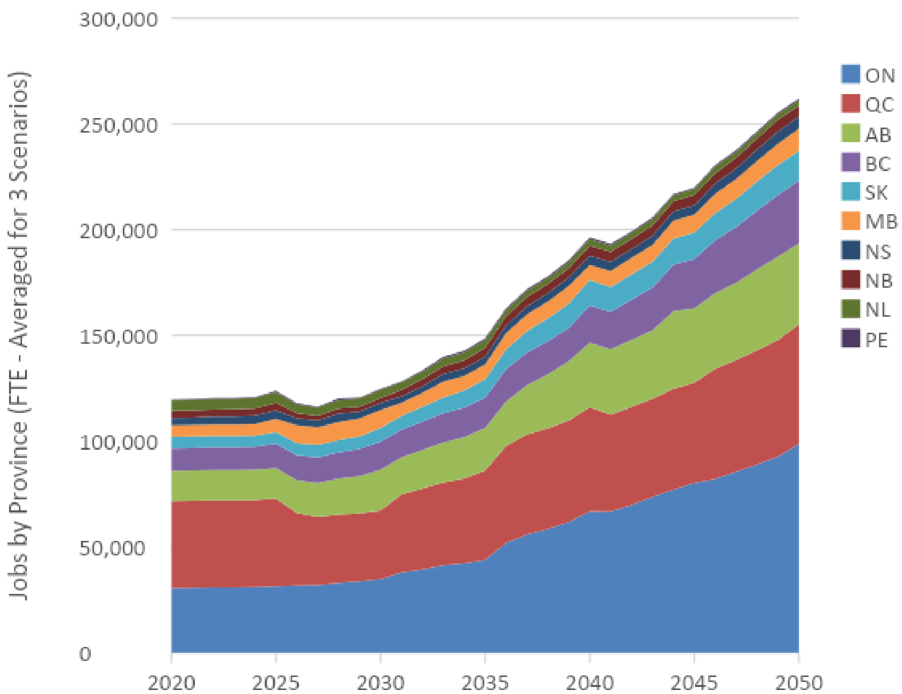
Figure 3: Jobs by Electricity Generation, Transmission and Distribution Technology (Total Direct and Indirect FTE)



4.2 Direct and Indirect Jobs by Province

Figure 4 identifies the projected total jobs by Province. Six provinces account for 90% of the projected jobs: Ontario, Quebec, Alberta, British Columbia, Saskatchewan and Manitoba.

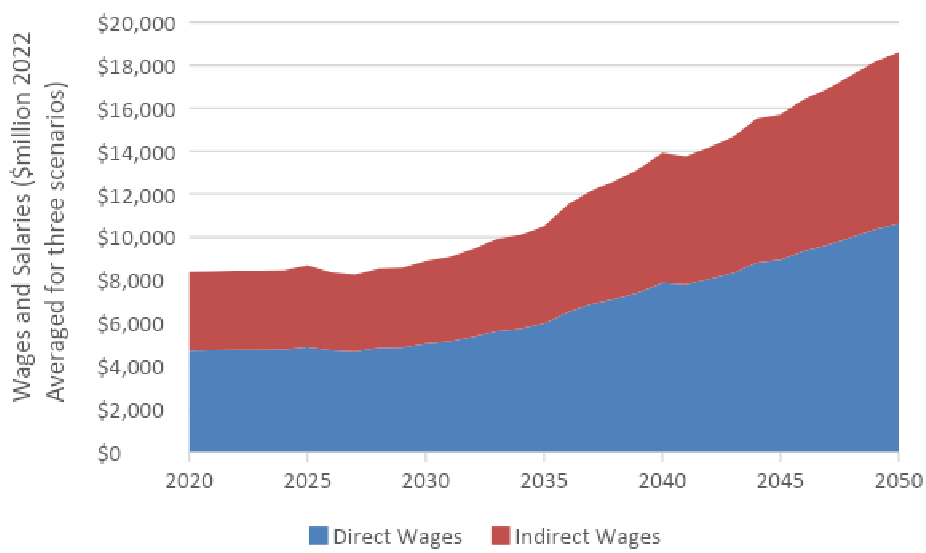
Figure 4: Jobs by Province (Total Direct and Indirect FTE)



4.3 Wages

Wages and salaries that are associated with the projected direct and indirect jobs are indicated in Figure 5. Total wages and salaries rise from $8 billion in 2020 to more than $18 billion in 2022.

Figure 5: Wages and Salaries of Electricity Sector Investment



5 Caveats

The report results are representative of the average annual capital and fixed operating costs for the technologies indicated in each of the three models. These sources provide estimates of investment based on different modelling assumptions and the employment results should therefore be understood to be indicative rather than a precise prediction.

The multipliers used for associating capital and fixed operating cost spending to jobs and wages are based on the most recent Statistics Canada Multipliers. These are likely to change in time with changes in the structure in the economy. Because of the long thirty-year time frame of the analysis it is possible that labour productivity which has historically improved by about 1% per year should be considered. In any case, a similar improvement in labour productivity in the electricity sector, could mean that the number of jobs is being overestimated by as much as 30% by 2050.

Technologies with relatively low penetration today that are expected to grow rapidly (e.g., Solar, Storage) are likely to have significantly changing capital and fixed operating costs over time. This is driven not only by potential new forms of production and inputs but also by significantly declining costs of generation as improvements are made. The three separate net-zero transition models capture declining overall costs of generation, but potential changing relative capital and fixed operating cost fractions for individual technologies is based on fixed current project estimates. So for example, storage battery and inverter costs may fall much faster than the civil/structural and architectural costs for building a project. This in turn could impact the overall jobs project multiplier for the technology.

The archetype technology capital and fixed operating costs used to determine the mapping of spending in different NAICS industry categories is also likely to be sensitive to a number of factors; including geography, size or capacity of projects, advancements in technology (different technology cost components may fall relative to others for some technologies overtime). To limit this uncertainty, we focused on North American data only and aligned archetype projects to match as close as possible the technology description from the investment models and to consider likely average capacities for Canadian installations.