Sustainable Jobs Blueprint

Modeling annex

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1. Introduction

This technical memo provides an overview of the methodology used and key insights gained from an analysis of labour market outcomes during Canada's energy transition, completed by Navius Research for the Canadian Labour Congress (CLC). CLC commissioned Navius to assess how the transition to net zero emissions will impact employment and interprovincial labour force growth in Canada, and the role of proposed labour policy interventions in supporting communities and occupations most at-risk.

Navius built a customized version of gTech to undertake this analysis, which includes disaggregation of the labour supply into occupations, interprovincial mobility, and inter-occupational retraining. The model did not incorporate potential economic impacts due to extreme weather or other climate-related disasters.

The scenarios below were modeled using the oil price from the IEA's "Net-Zero Energy" scenario, intended to represent a scenario where the future sees limited international demand for crude oil exports. The IEA Net-Zero Energy scenario shows the global demand for crude oil peaking before the end of this decade and prices declining to $30USD per barrel by 2030.

1. "Legislated Policy" is a reference case that reflects all currently legislated provincial and federal policies in Canada, including the Clean Fuels Regulation and a federal carbon price of $65 per tonne.
2. "Announced Policy" includes all existing federal and provincial policies and policies announced in the federal 2030 Emissions Reduction Plan (ERP), including a carbon price that rises to $170 per tonne in 2030.
3. "Net Zero" implements at cap on emissions at Canada's 2030 emissions target and net zero emissions in 2050. This scenario also assumes that the US implements equally stringent climate policy, which affects the future costs of low-carbon technologies.

This analysis provides the following key insights:

- Canada's clean economy supports two million jobs in Canada under a net zero by 2050 scenario. Alberta gains more or a similar number of clean economy jobs than are lost in conventional sectors as innovative new technologies, like direct air capture, are deployed.

- Proposed retraining subsidies, Employment Insurance (EI) for retraining, and retirement bridging policies improve outcomes for the workers identified as most at-risk of negative outcomes under net-zero, with higher wages and lower unemployment rates in response to these proposed policies. These improvements to outcomes for at-risk workers happen despite a short-term negative GDP effect due to workers retraining and no change (either increase or decrease) to the economy-wide average wage.

- Implementation of the suite of modeled labour policies results in higher GDP in Canada in the long run by reducing labour market frictions and resulting in a more productive labour force by 2050. Modeled GDP under net-zero was $7B (2015 CAD) higher by 2050 when public subsidies for retraining and regional economic development were provided. This reflects about a 0.2% increase to Canada's GDP in the net-zero scenario relative to when these policies are not implemented. In 2030, the GDP effect is negative due to a smaller labour force as workers retrain.

- Modeled retraining subsidies (EI and tuition fees) did not reduce population changes in fossil fuel producing regions. However, regionally targeted economic development policies which subsidized trade-exposed clean economy industries helped alleviate this change to population growth and created employment opportunities for workers in their home provinces.

- Labour force growth in oil-producing regions was found to be more sensitive to international prices for oil (simulated via the oil price assumption) than domestic policy measures to reduce Canada's emissions. In the low oil price scenario, modeled employment declines in the oil and gas sector were similar regardless of the stringency of domestic climate policy.

- Across many economic analyses of net zero scenarios with low oil prices, we have found that economy-wide employment, GDP, and wages are lower compared to a scenario where net-zero is not achieved in Canada and oil prices remain high, especially for oil-producing regions in Canada. The labour market policies simulated in this project were found to bridge some of the gap between winners and losers, resulting in improved outcomes for workers who are most at-risk during the transition.

The remainder of this technical memo includes:

- Navius' modeling methodology (Section 2)

- Key results (Section 3)

- Limitations (Section 4)

2. Methodology

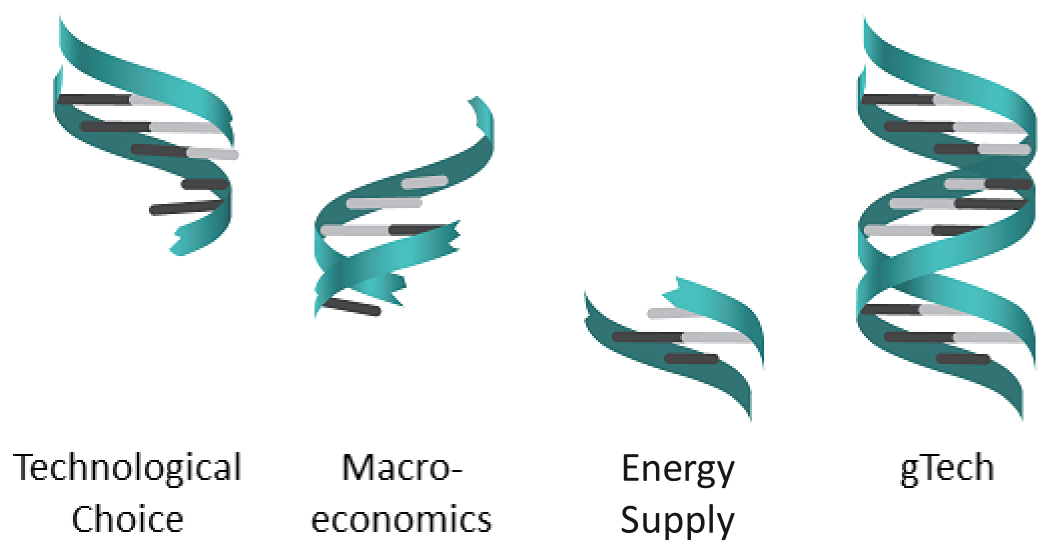
This section discusses the modeling framework used for this analysis, including custom model features designed to capture occupational granularity, labour mobility and unemployment.

2.1. gTech

2.1.1. About the gTech model

Navius maintains and operates an in-house computable general equilibrium (CGE) model of Canada and the United States called gTech. By virtue of being an energy-economy model that treats all actions as happening simultaneously, gTech performs well at capturing policy interactions. However, unlike other energy-economy models, gTech incorporates a sophisticated representation of technological change and technological choice within a full equilibrium framework that links all major macroeconomic feedbacks. The three key elements that were brought together to create gTech are illustrated in Figure 1.

Figure 1: The gTech model



gTech builds on three of Navius' previous models (CIMS, GEEM and OILTRANS/IESD), combining their best elements into a comprehensive integrated framework.

CGE models represent the economy through a series of simultaneous equations linking economic inputs with outputs. Their parameters capture aggregate relationships between the relative costs and market shares of energy and other inputs to the economy, and may be estimated econometrically from time-series data. CGE models represent all economic activity and capture all the major macroeconomic feedbacks that balance supply and demand through price signals. They do so in a full equilibrium framework, solving for a set of prices that results in supply being equal to demand in every market.

gTech is unique among energy-economy models because it combines features that are typically only found in separate models:

- A realistic representation of how households and firms select technologies and processes that affect their energy consumption and greenhouse gas emissions;
- An exhaustive accounting of the economy at large, including how provinces and territories interact with each other and the rest of the world; and
- A detailed representation of energy supply, including liquid fuel (crude oil and biofuel), gaseous fuel (natural gas and renewable natural gas) and electricity.

gTech accounts for all economic activity in Canada and the United States, as measured by national accounts. Specifically, it captures all sector activity, all GDP, all trade of goods and services, and the transactions that occur among households, firms, and government. As such, the model provides a forecast of how government policy affects many different economic indicators including GDP, investment, trade, household income, and employment. The key macroeconomic feedbacks captured by gTech are summarized in Table 1.

The key macroeconomic inputs to gTech are: (1) a social accounting matrix (SAM) used to characterize the structure of the economy in the model base year (currently 2015) and (2) forecasts of growth in labour supply and productivity. The SAM is based on Statistics Canada supply and use tables[1] and IMPLAN supply and use tables[2] for the United States. The expected rates of growth in labour supply and labour productivity are based on Canada Energy Regulator's Canada Energy Future 2021 report[3] for

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[1] Statistics Canada (annual). *Supply and Use Tables*. Available from: www150.statcan.gc.ca/n1/en/catalogue/15-602-X

[2] IMPLAN, 2021, Customized supply-use tables.

[3] Canada Energy Regulatory (2021). *Canada's Energy Future 2021.* Available at: https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/

Canada and the U.S. Energy Information Administration's Annual Energy Outlook[4]. gTech generates an internal forecast of economic growth from these growth rates, subject to policy and other conditions, such as the price of oil.

gTech is customizable in terms of the way North America is divided into regions. The version used for this analysis represents all the Canadian provinces separately and one aggregate region for the United States.

The model offers a high degree of sectoral disaggregation, representing over 80 economic sectors. Each sector represented by gTech produces a unique good or service (e.g., the mining sector produces ore, while the trucking sector produces transportation services) and requires specific inputs to production. Of these inputs, some are not directly related to energy consumption or GHG emissions (e.g., the demand by a sector for services), while other inputs are classified as "energy end-uses" and are related to energy consumption or GHG emissions.

To categorize the low-carbon economy in gTech, we assign economic activity to one of three categories:

- low-carbon energy: *The technologies, services and resources that increase renewable energy supply, enhance energy productivity, improve the infrastructure and systems that transmit, store and use energy while reducing carbon pollution*
- conventional energy: most activities related to fossil energy supply and use, other than those considered low carbon such as emissions control efforts
- and non-energy: (e.g., insurance services, education)

Appendix C defines these categories and details which sectors are considered part of the low-carbon energy category.

gTech normally solves in 5-year increments. While Navius has developed versions that solve in smaller time increments, 5-years is the default because the model simulates full equilibrium in all markets and is intended to capture long-term trends, as opposed to the short-term effects of business-cycles in which markets may be out of equilibrium. Solving in 5-year increments also reduces the amount of time required to complete analyses (relative to annual or biannual increments).

[4] U.S. Energy Information Administration, 2021, Annual Energy Outlook 2021. Available from: https://www.eia.gov/outlooks/archive/aeo21

GHG emissions are calibrated in the model base year (currently 2015) to align with historical emissions. Between the base year and the most recent year for which data are available, modeled emissions are also calibrated to align with historical trends. The ability of gTech to replicate these trends improves confidence in its projections.

Table 1: Macroeconomic feedbacks captured by gTech

Model feature	Description
Full equilibrium	gTech ensures that all markets in the model return to equilibrium (i.e., that the supply of each good or service is equal to its demand). This means a shift that occurs in one sector is likely to have ripple effects throughout the entire economy. For example, greater demand for electricity due to GHG policy initiatives will require greater electricity production. In turn, greater production is expected to necessitate greater investment in and consumption of goods and services by the electricity sector. An increase in demand for labour in construction services could ultimately lead to higher wages. The model also accounts for price responses. In the above example, the price of electricity may increase, as more expensive generation resources are brought online to meet the increased demand. Households can adjust to this price increase by making changes that reduce their electricity consumption, such as switching to technologies that are more energy efficient, switching to technologies that use alternative forms of energy, and reducing their consumption of services that use electricity.
Energy supply markets	gTech accounts for all the major energy supply markets, such as electricity, refined petroleum products, and natural gas. Each market is characterized by resource availability and production costs by region, as well as costs and constraints related to transporting energy between regions (e.g., pipeline capacity) and associated GHG emissions. Low carbon energy sources can be introduced within each market in response to policy, including renewable electricity and bioenergy. The model accounts for the availability and cost of bioenergy feedstocks, allowing it to provide insight about the economic effects of emissions reduction policy, biofuels policy, and the approval of pipelines. Oil price is an exogenous input to the model (i.e., based on an assumed global price). The price for other energy commodities is determined by the model based on demand and the cost of production.
Labour and capital markets	Like other markets, labour and capital markets must achieve equilibrium in the model. The availability of labour can change with the real wage rate (i.e., the wage rate relative to the price for consumption). If the real wage increases, the availability of labour increases. The model also accounts for involuntary unemployment. A more detailed description of changes made to the labour market in gTech is presented below.
Interactions between regions	Economic activity in each region represented in gTech is highly influenced by interactions with other modeled regions. These interactions are based on: (1) the trade of goods and services, (2) capital movements, (3) government taxation, and (4) various types of “transfers” between regions (e.g., the federal government provides transfers to provincial and territorial governments).

Model feature	Description
Representation of households	Households receive income from businesses in exchange for their labour and investment of savings. They use this income to consume various goods and services. gTech accounts for these interactions. Households are disaggregated into 5 different income groups within the model to provide greater insight into how policies might affect different households.

2.1.2. Model customization

As noted, the model created for CLC had four customizations:

1) Occupational disaggregation: the model is able to examine specific occupations that will be more affected by a reduction in emissions.

2) Interprovincial mobility: the model allows workers to move from province to province, depending on the availability of jobs.

3) Inter-occupational retraining: the model allows for a worker in one occupation to retrain to work in a different occupation of the same level.

4) A revised approach to simulating involuntary unemployment.

These customizations are discussed in detail, below.

Occupational disaggregation

Workers in Canada's oil and gas industry and supporting sectors will be unevenly able to transition to jobs in other sectors of the economy – some workers have skills that are primarily used in other sectors, whereas some workers' skills have limited transferability to other industries. In most CGE models, the labour supply is aggregated into one or a few categories of labour. Previously, the labour supply in gTech was allocated between low-, medium-, high-, and very high-skilled labour, with the composition of employment in each sector based on that sector's average wage. While these four classes provides some rigidity between classes of labour supply at large, it does not include certain details of the sector-specific nature of certain workers' skills.

To better reflect the occupational distribution of wage and employment impacts of the transition to net-zero, and be able to simulate the macroeconomic effects of retraining policies, census data was used to disaggregate the labour supply into 38 unique occupations in gTech based on Canada's National Occupation Classification code system. The following sources were used:

- Statistics Canada (2018), Table 98-400-X2016298: *National Occupational Classification (NOC) 2016 (693A), Industry - North American Industry Classification System (NAICS) 2012 (23A), Labour Force Status (3), Age (5) and Sex (3) for the Labour Force Aged 15 Years and Over in Private Households of Canada, Provinces and Territories, Census Metropolitan Areas and Census Agglomerations, 2016 Census - 25% Sample Data*. (used for occupational composition by two-digit NAICS code and province).
- Statistics Canada (2018), *Table 98-400-X2016306: Total Income Groups (17), Occupation - National Occupational Classification (NOC) 2016 (13A) and Work Activity During the Reference Year (9) for the Population Aged 15 Years and Over in Private Households of Canada, Provinces and Territories and Census Metropolitan Areas, 2016 Census - 25% Sample Data*. (used for allocating occupation-specific supply of labour into income quintiles of representative households).
- Statistics Canada (2023), *Table: 14-10-0340-01: Employee wages by occupation, annual, 1997 to 2022.*
- Statistics Canada (2023), *Table: 14-10-0299-01: Usual hours worked by occupation, annual, inactive.*

The level of detail in the occupational disaggregation was completed based on relevance to the occupational composition of the oil and gas industry. By default, the 2-digit NOC code was used. For many service-sector occupations with little to no presence in the oil and gas sector, only the 1-digit NOC code was used. For trades, natural sciences, and natural resources occupations, selected 3-digit NOC codes were disaggregated for occupations disproportionately employed in the oil and gas sector. The final list of occupations included in the model is shown below, along with those identified as “at-risk”, which were targeted for retraining policy supports.

About 40% of the workers in the oil, gas, and mining industry are in an occupation disproportionately employed in this industry. The remaining 60% of workers are in occupations that are more transferrable to other industries without re-training (e.g., electrical and construction trades, office support occupations, professional occupations in business and finance), though sectoral wage differentials within the occupation are still likely to exist.

Table 2: Occupations used in the gTech model, national employment, and share of occupation in mining, quarrying, and oil and gas extraction

Occupation	Employment (2016 census)	Share of this occupation in NAICS 21 (Mining, quarrying, and oil and gas extraction)	Eligible for targeted training supports (in this analysis)
0 Management occupations other than 06	1,326,100	2%	
06 Middle management occupations in retail and wholesale trade and customer services	632,800	0%	
11 Professional occupations in business and finance	615,000	2%	
12 Administrative and financial supervisors and administrative occupations	931,300	1%	
13 Finance, insurance and related business administrative occupations	187,400	1%	
14 Office support occupations	687,700	1%	
15 Distribution, tracking and scheduling co-ordination occupations	323,000	1%	
21 Professional occupations in natural and applied sciences	436,000	1%	
211 Physical science professionals	28,800	17%	Yes
213 Civil, mechanical, electrical and chemical engineers	163,200	4%	Yes
214 Other engineers	66,100	12%	Yes
22 Technical occupations related to natural and applied sciences other than 211-214	324,900	1%	
221 Technical occupations in physical sciences	30,200	14%	Yes
224 Technical occupations in electronics and electrical engineering	104,600	3%	
226 Other technical inspectors and regulatory officers	57,800	7%	Yes
3 Health occupations	1,217,900	0%	
4 Occupations in education, law and social, community and government services	2,062,000	0%	
5 Occupations in art, culture, recreation and sport	515,800	0%	
6 Sales and service occupations	3,979,600	0%	

72 Industrial, electrical and construction trades	838,100	2%	
73 Maintenance and equipment operation trades other than 730, 731, and 737	243,400	1%	
730 Contractors and supervisors, maintenance trades and heavy equipment and transport operators	71,400	3%	
731 Machinery and transportation equipment mechanics (except motor vehicles)	157,400	8%	Yes
737 Crane operators, drillers and blasters	16,700	9%	
74 Other installers, repairers and servicers and material handlers	245,200	1%	
75 Transport and heavy equipment operation and related maintenance occupations other than 752	559,900	2%	
752 Heavy equipment operators	96,400	13%	Yes
76 Trades helpers, construction labourers and related occupations	204,100	1%	
82 Supervisors and technical occupations in natural resources, agriculture and related production other than 822 and 823	57,800	0%	
822 Contractors and supervisors, mining, oil and gas	18,500	78%	Yes
823 Underground miners, oil and gas drillers and related occupations	22,400	84%	Yes
84 Workers in natural resources, agriculture and related production other than 841	125,600	0%	
841 Mine service workers and operators in oil and gas drilling	9,000	68%	Yes
86 Harvesting, landscaping and natural resources labourers	120,900	6%	
92 Processing, manufacturing and utilities supervisors and central control operators	131,500	12%	
94 Processing and manufacturing machine operators and related production workers	225,100	1%	
95 Assemblers in manufacturing	180,500	0%	
96 Labourers in processing, manufacturing and utilities	216,100	1%	
Total	**17,230,100**	**1.4%**	

Interprovincial mobility

In the past, Navius has relied on an exogenous labour force growth forecast derived from the supplementary data tables of the Canada Energy Regulator's Canada's Energy Future report[5]. When simulating net-zero emissions with low oil price scenarios (~$30/bbl WTI) which result in a substantial reduction in Canada's oil production by 2050, the population and wage growth in fossil-fuel producing regions is likely to be different. Workers and the distribution of new migrants to Canada was previously fixed (i.e. the same number would always enter the Alberta labour market regardless of relative wages or employment growth).

To allow for interprovincial mobility in the gTech, we chose to use a constant elasticity of supply (CES) function which re-allocates labour supply within a given occupation between the provinces based on the relative change in the wage rate of this type of labour. This represents a similar model employed in the STAGE_DEV model or (D. Flaig et. al., 2013)[6][7]. The following process is used in the recursive gTech model:

4. An exogenous level of in-migration is applied to each region in each 5-year model period, based on the CER's forecast labour supply growth.

5. Within the 5-year model period, the labour supply is re-allocated based on the relative wage rate of each occupation in each Canadian region of the model using the conditional demand function:

$$Q_{r,occ} = \left[\sum_{rr} \alpha_{rr,occ} \left(\frac{PL_{rr,occ}}{\alpha_{rr,occ}}\right)^{\frac{\rho}{\rho-1}}\right]^{-\frac{1}{\rho}} * \left(\frac{PL_{r,occ}}{\alpha_{r,occ}}\right)^{\frac{\rho}{\rho-1}} * Y_{occ}$$

Where $Q_{r,occ}$ is the quantity of workers in occupation *occ* in province *r*, $PL_{r,occ}$ is the wage rate for occupation *occ* in province *r*, α is the calibrated share parameter based on the previous model period, Y is a calibrated constant scale adjustment factor, and ρ is equal to 1-(1/σ), where σ is the constant elasticity of substitution. An elasticity of -2 was used for this analysis, intended to reflect a long-run model in

[5] Canada Energy Regulatory (2021). *Canada's Energy Future 2021.* Available at: https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/

[6] E. Aragie et. al. (2017). *STAGE_DEV: A variant of the STAGE model to analyse developing countries*. JRC Technical reports. Available online at: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC104686/kj-na-28627-en-n_.pdf

[7] D. Flaig, H. Grethe, S. McDonald. *Imperfect labour mobility in a CGE model: Does factor specific productivity matter?.* 16th Annual Conference on Global Economic Analysis, Shanghai, China, June 12-14, 2013. Available online at: https://www.gtap.agecon.purdue.edu/uploads/resources/download/6565.pdf

which the provincial labour supply is relatively elastic with respect to inter-provincial wage differentials. Using a lower elasticity would result in a high level of alignment with the exogenous CER forecast. For the first model period, share parameters were calibrated based on provincial-level data for employment and income from the census and labour force survey for 2015[8] [9].

6. The share parameters and constant scale adjustment factor are updated in each subsequent model period based on the simulation result of the previous model period. Non-labour income for the representative households and federal-provincial transfers are assumed to change 1:1 with labour force size.

This results in the following model assumptions and behavioural results:

- Within one occupation (e.g., "Sales and service occupations"), workers and new migrants to Canada will distribute themselves to the provinces with the highest real wages for their line of work.
- The baseline 2015 wage differential between provinces for a given occupation is assumed to reflect the compensating differential for non-financial aspects of that line of work in that region. If the relative wage difference remains constant, no re-allocation will take place.
- Non-workers (e.g., children, students, stay-at-home spouses, retirees) are assumed to move with workers (i.e., a 1% change in the labour force size in Alberta would also reduce the non-working population by 1%).
- Household capital income is assumed to move with the working population.
- Transfers to the provincial governments from the federal government scale with the province's population.

A discussion of how this model structure affects results in presented in Section 3.

Inter-occupational retraining

The model allows for workers to re-train from one occupational class to another if the difference in wage rate becomes large enough to overcome the estimated re-training

[8] Statistics Canada (2018), Table 98-400-X2016298: National Occupational Classification (NOC) 2016 (693A), Industry - North American Industry Classification System (NAICS) 2012 (23A), Labour Force Status (3), Age (5) and Sex (3) for the Labour Force Aged 15 Years and Over in Private Households of Canada, Provinces and Territories, Census Metropolitan Areas and Census Agglomerations, 2016 Census - 25% Sample Data.

[9] Statistics Canada (2023), Table: 14-10-0340-01: Employee wages by occupation, annual, 1997 to 2022.

costs and time commitment. Within one occupational class, workers are able to transition between industries of employment without an investment in retraining (e.g., a crane operator in the oil and gas sector does not need retraining to be a crane operator in the construction industry).

Following the disaggregation of the labour force into occupations based on census data, retraining pathways were enabled in the model based on the 15-year net-present value (NPV) of a career choice based on wages, hours of work, and estimated retraining costs. For each possible transition between the 38 NOC code occupations in the model, Canadian Labour Congress staff estimated a retraining level-of-effort in the categories shown in Table 3 below. The "Private tuition cost" is the portion of the education cost paid by the worker and incorporated into the evaluation of any occupational transitions. The "Public cost" portion is paid for by the provincial government, intended to reflect an approximate per-student funding to higher education institutions that is paid for with government funding.

Table 3: Retraining cost categories for occupational transitions

Retraining cost level	Time (weeks)	Private tuition cost ($)	Public cost ($)	Example
Zero (no training needed)	0	0	0	Office support occupations -> Sales and service occupations
Low (two-week course)	2	$2k	0	Mine service workers and operators in oil and gas drilling -> Other workers in natural resources, agriculture and related production
Medium (two semesters of college or similar)	23	$8k	$10k	Heavy equipment operator -> Industrial, electrical, and construction trades
High (4-year university degree)	139	$24k	$60k	Industrial, electrical, and construction trades -> Professional occupations in natural and applied sciences

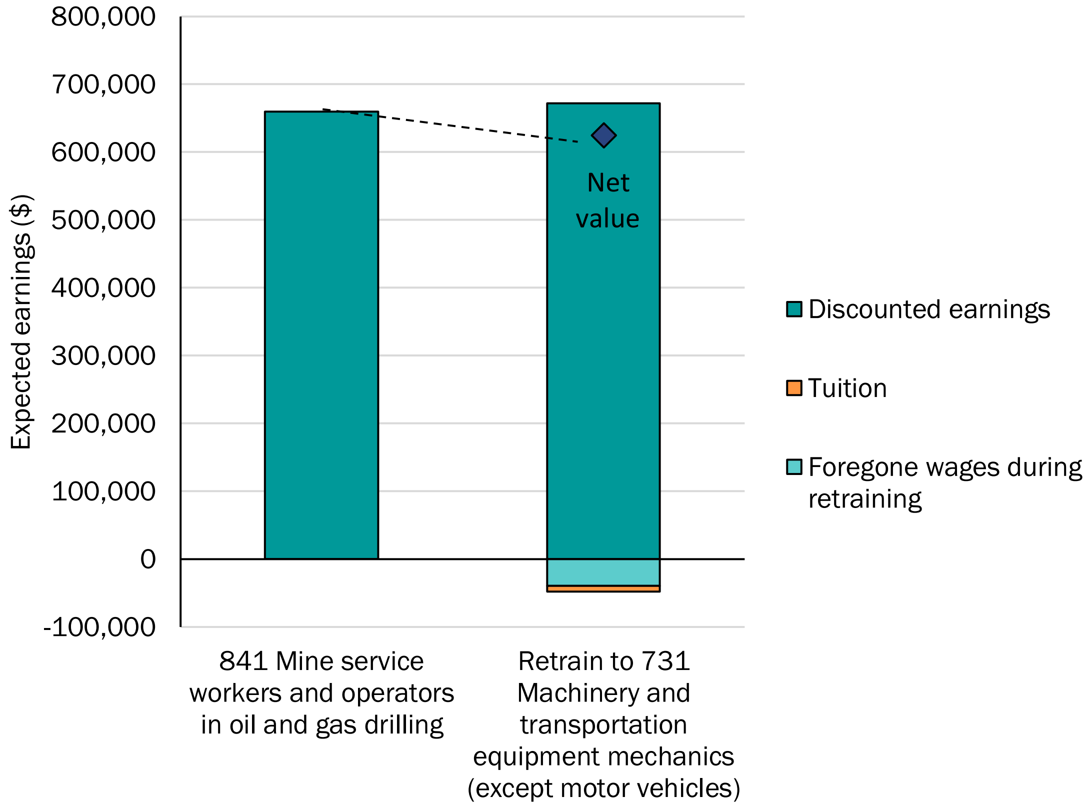
A subset of the model input for training costs is shown below to illustrate the approach. Occupational transitions were categorized by CLC into one of the four tiers, with some transitions being asymmetric (e.g., occupation 737 can transition into 74 without formal retraining, but not vice-versa).

Figure 2: Illustrative subset of CLC's training cost estimates

Starting occupation				Ending occupation				
	...	737 Crane operators, drillers and blasters	74 Other installers, repairers and servicers and material handlers	75 Transport and heavy equipment operation and related maintenance occupations other than 752	752 Heavy equipment operators	76 Trades helpers, construction labourers and related occupations	82 Supervisors and technical occupations in natural resources, agriculture and related production other than 822 and 823	...
...	...	...	...	...	...	...	...	...
737 Crane operators, drillers and blasters	...		Zero	Medium	Low	Zero	Medium	Low
74 Other installers, repairers and servicers and material handlers	...	Medium		Medium	Medium	Zero	Medium	Medium
75 Transport and heavy equipment operation and related maintenance occupations other than 752	...	Medium	Zero		Medium	Zero	Medium	Medium
752 Heavy equipment operators	...	Low	Zero	Medium		Zero	Medium	Low
76 Trades helpers, construction labourers and related occupations	...	Medium	Zero	Medium	Medium		Medium	Medium
82 Supervisors and technical occupations in natural resources, agriculture and related production other than 822 and 823	...	Medium	Zero	Medium	Medium	Zero		Medium
822 Contractors and supervisors, mining, oil and gas	...	Low	Zero	Medium	Low	Zero	Medium	
823 Underground miners, oil and gas drillers and related occupations	...	Medium	Zero	Medium	Medium	Zero	Medium	Low
...	...	...	...	...	...	...	...	...

For each potential transition from one occupation to another, the model calculates the NPV of a) staying in one's current job with one's current wage and hours of work or b) transitioning to a new job with some estimated training cost. To limit unrealistic transitions due to ability or preferences, re-training pathways that are "profitable" at benchmark wages and the assessed training time/cost are turned off (e.g., retail worker -> lawyer, teacher -> mine labourer), along with certain other pathways that were deemed unlikely. Workers will then re-train from occupation to occupation if it makes sense to do so because a) the wage rate in their starting occupation declines or b) policies subsize retraining. An example of this is shown in Figure 3 below.

Figure 3: Example of retraining cost approach used in gTech: net-present value of retraining pathway over 15-year time horizon[10]



In this case, at the baseline 2015 wages, the expected earnings from occupation 841, a high-earning occupation which generally requires only a high school degree of job-specific training, and occupation 731, which typically requires a trades certificate, are similar, but the opportunity cost associated with the time spent training results in it not being "profitable" to transition. However, in scenarios in which the marginal product of labour for occupation 841 declines, resulting in a lower wage rate, or the government subsidizes retraining via the provision of EI, workers would transition until the wage rates equilibrate.

Voluntary and involuntary unemployment

gTech incorporates both a representation of voluntary unemployment (labour-leisure trade-off based on wages) and involuntary unemployment (based on observed empirical relationships between wages and unemployment rates).

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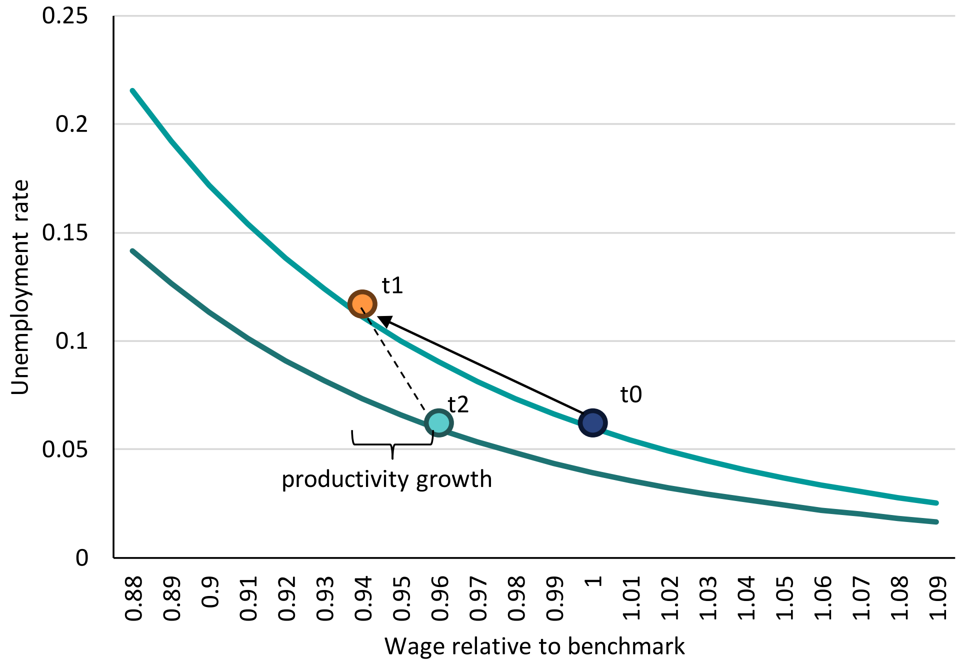
[10] "Discounted earnings" refers to the total earnings over the time period, discounted at 12% per year.

gTech previously used a static model for unemployment based on the estimated empirical relationship between wages and involuntary unemployment: a 10% increase to unemployment is associated with a 1% decrease in the wage rate[11]. This results in reasonable outcomes for small deviations from the benchmark wage in a static model (which was the origin of this approach at Navius). In a long-term model where wages differ from the benchmark by ~10%, this can result in sustained periods of high unemployment which do not dissipate, because modeled workers never revise expectations for wage growth.

To resolve this, we implemented a revised unemployment-wage curve that is dynamic, being updated in each model period based on wage changes in the prior model period, as opposed to being static with respect to the reference case. An illustration of the new approach is shown in the figure below. If wage growth from one five-year model period to the next is proportional to the exogenous rate of productivity growth, unemployment remains at the equilibrium level (t0 on the chart). If wages within an occupation decline, or are stationary under growing productivity, above equilibrium unemployment arises (shift to t1 at end of model period). The wage cure is then revised such that unemployment returns to the equilibrium level at the lower wage rate in the following model period (t2). This is intended to reflect that expectations of wages for the following model period are updated past on the past model period (i.e., if one became unemployed, you would accept a lower wage in the next 5-year period to find work).

[11] S. Boeters, L. Savard (2011). The Labour Market in CGE Models. S 5.6. Available at: https://www.gtap.agecon.purdue.edu/uploads/resources/download/5694.pdf

Figure 4: Revised approach to involuntary unemployment



This change has a material impact on the model results for the unemployment rate, as well as more broadly, the economic cost of achieving net-zero in Canada. With a static wage curve, the unemployment rate has the potential to steadily increases over time in some scenarios, as workers in the model never revise their expectations for wages. With the dynamic wage curve, unemployment eventually returns to the equilibrium level, unless a new shock is applied.

2.2. Scenario design

Three climate policy scenarios were simulated in this analysis:

1. "Legislated Policy" is a reference case that reflects all currently legislated provincial and federal policies in Canada, including the Clean Fuels Regulation and a federal carbon price of $65 per tonne.

2. "Announced Policy" includes all existing federal and provincial policies and policies announced in the federal 2030 Emissions Reduction Plan (ERP), including a carbon price that rises to $170 per tonne in 2030.

3. "Net Zero" implements at cap on emissions at Canada's 2030 emissions target and net zero emissions in 2050. This scenario assumes that a certain amount of offsets are available via land-use, land-use change and forestry (30 Mt in 2030 and 103 Mt in 2050) based on the ERP and a recent report by Nature United[12] [13]. This scenario also assumes that the US implements equally stringent climate policy, which affects the future costs of low-carbon technologies.

Within each climate policy scenario, four "buckets" of labour market supports were modeled. Buckets were modeled on their own, and in combination all together:

Bucket 1: "Training and skills" includes a series of retraining subsidies, employer government cost sharing programs and targeted funding for at-risk occupations. Subsidies are available between 2025 and 2050. This included:

- For all workers: up to $17,400 in funding for workers undergoing re-training to a new occupation, intended to reflect a combination of federal funding for worker retraining and employer-government cost sharing programs.
- For at-risk occupations: up to an additional $12,000 in tuition vouchers for workers transitioning out of an occupation disproportionately employed in the oil and gas sector. Assistance is capped at 100% of the estimated training cost.

Bucket 2: "EI and income support" allows for workers that are retraining to access EI without requiring them to be looking for or available for work. Subsidies are available between 2025 and 2050, for the entire duration of the retraining from one occupation to another.

Bucket 3: "Pension bridging" allows for workers approaching the age of retirement to opt to take early retirement via a bridging program that provides 75% of weekly wages for 72 weeks. This applies to 2% of workers in the at-risk NOC codes every 5 years. Bridging is available between 2025 and 2035.

Bucket 4: "Economic development" includes a series of funds for supporting sectors and regions affected by the energy transition. These funds include the proposed

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[12] Environment and Climate Change Canada (2022). 2030 Emissions Reduction Plan. Available at: https://publications.gc.ca/collections/collection_2022/eccc/En4-460-2022-eng.pdf

[13] C. Drever et. al. (2021) *Natural climate solutions for Canada.* Science Advances Vol. 7 No. 23. Available at: https://www.science.org/doi/10.1126/sciadv.abd6034

Futures Fund[14] and other targeted regional economic development interventions. These are funded via incrementally higher value-added taxes by the federal government. This was modeled as an additional $12B (nominal) of federal spending on investment tax credits, spread over 10 years between 2025 and 2035, divided as follows:

- $2B on low-carbon technologies in Alberta, Saskatchewan, and Newfoundland, intended to represent the proposed Futures Fund.
- $5B on low-carbon technologies with no regional restrictions, intended to represent an expanded version of the Futures Fund.
- $5B of subsidies for manufacturing or low-carbon sectors, available only in Alberta, Saskatchewan, and Newfoundland. This was modeled as an output subsidy for these sectors, only in these regions, intended to improve the competitiveness and spur investment in non-fossil fuel industries.

A sensitivity analysis was also conducted to evaluate how assumptions for CCS and DAC costs affect model results. Direct air capture was assumed to be commercially available in all the scenarios. The model was calibrated with the reference case oil price (shown below), but unless otherwise noted in this report, results are presented from the IEA's net-zero oil price scenario (shown in the table below).

Economic Growth

The model reference case was calibrated to assumptions for macroeconomic growth, oil prices, and oil production were derived CER's 2021 Canada's Energy Futures report[15]. Reference case productivity growth was calibrated from the CER's "Current Policy" results for GDP, provincial population, and the baseline oil price and production values (as opposed to those from a net-zero scenario). These values are shown below.

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[14] Liberal Party of Canada (2021). *Ensuring Workers and Communities Prosper as We Move to Net-Zero.* Available at: https://liberal.ca/our-platform/ensuring-workers-and-communities-prosper-as-we-move-to-net-zero/

[15] Canada Energy Regulatory (2021). *Canada's Energy Future 2021.* Available at: https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/

Table 4: Reference case productivity growth (calibrated from CER GDP and population data)

	2021-2025	2026-2030	2031-3035	2036-2040	2041-2045	2046-2050
British Columbia	0.2%	1.5%	2.0%	1.1%	1.1%	0.6%
Alberta	0.1%	0.9%	0.8%	0.4%	0.4%	0.4%
Saskatchewan	-0.8%	0.8%	1.4%	0.4%	0.5%	0.1%
Manitoba	-0.8%	0.6%	0.9%	0.3%	0.5%	0.4%
Ontario	-0.3%	0.9%	1.4%	0.9%	1.0%	1.0%
Quebec	0.2%	1.2%	1.7%	0.8%	1.0%	0.9%
New Brunswick	-0.1%	0.8%	0.9%	0.4%	0.4%	0.3%
Prince Edward Island	0.0%	0.5%	1.7%	0.6%	0.6%	0.6%
Nova Scotia	0.4%	0.9%	1.5%	0.8%	0.7%	0.7%
Newfoundland	-0.4%	-1.7%	2.6%	-0.2%	-0.7%	-0.3%

Table 5: National population growth

	2025	2030	2035	2040	2045	2050
Population (M)	40.1	42.1	43.8	45.3	46.6	48.0

The model was run with a reference case and low oil price scenario, with the low oil price scenario intended to represent a net-zero future where there is little international demand for Canadian oil. In the low oil price scenario taken from the net zero scenario in the IEA's 2021 World Energy Outlook, most of the price shock takes place beginning in the 2026-2030 model period.

Table 6: WTI oil price assumptions (2015 USD/barrel)

	2021-2025	2026-2030	2031-3035	2036-2040	2041-2045	2046-2050
Reference case[16]	62	61	60	59	59	58
Low oil price[17]	40	31	28	26	23	21

[16] Canada Energy Regulatory (2021). *Canada's Energy Future 2021.* Available at: https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/

[17] International Energy Agency (2021). World Energy Outlook. Table 2.2 (Net Zero Emissions by 2050 scenario). Available at: https://iea.blob.core.windows.net/assets/4ed140c1-c3f3-4fd9-acae-789a4e14a23c/WorldEnergyOutlook2021.pdf

3. Key results

This section explores the key results of this analysis, including how a net zero future affects employment and population change within Canada, as well as the impact that proposed labour policies could have on macroeconomic and occupational outcomes.

Labour policy impacts

This analysis assessed a suite of labour policies, including:

- Bucket 1: Training and skills – an aggregation of retraining subsidies, including proposed federal programs, employer-government cost sharing schemes, and targeted funding for high-emitting occupations.
- Bucket 2: EI and income support – full access to EI for workers who choose to retrain into another occupation, to offset the opportunity cost of lost wages while retraining, without the requirement to search for work while retraining on EI.
- Bucket 3: Pension bridging – a bridge to retirement for workers in 'at risk' occupations, which covers 75% of wages over 72 weeks, intended to support late-stage career workers.
- Bucket 4: Economic development – a series of funding schemes designed to accelerate clean industry, particularly in fossil fuel dependent communities.

This section presents key results of these policies.

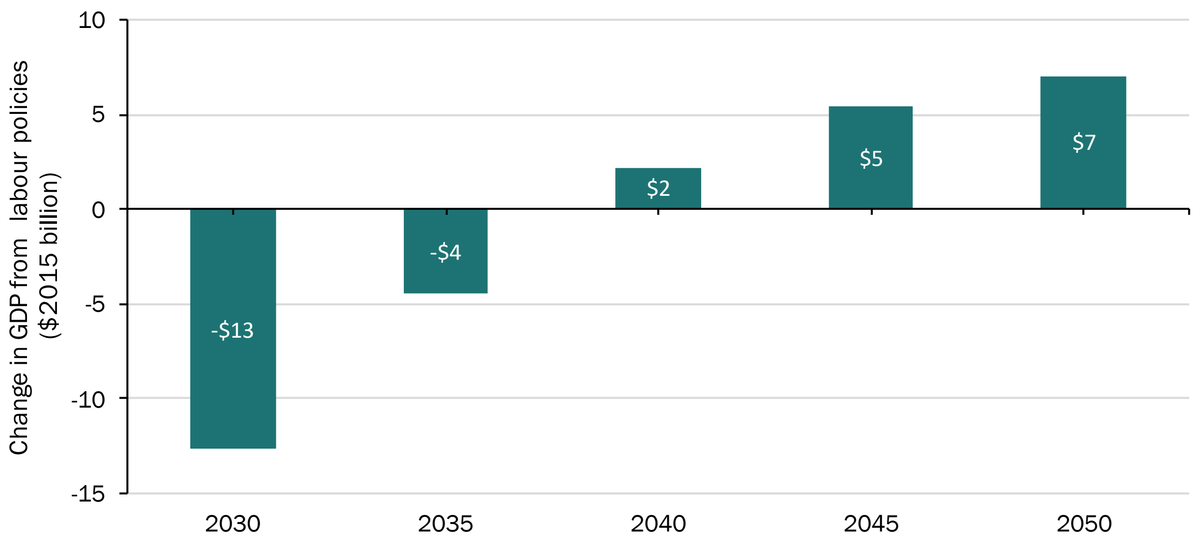
Macroeconomy

All labour policies (all buckets together)

Implementing the full suite of labour policies leads to sustained increases in Canada-wide GDP in the long run. Figure 5 emphasizes the importance of implementing all four labour policy buckets relative to a net zero scenario with no labour policies. Policies that result in retrained workers re-entering the workforce and a more efficient allocation of labour throughout the economy results in higher GDP from 2040 onwards. The near-term reduction in labour force is primarily associated with the policy to provide EI for retraining for any worker making an occupational transition. Removing barriers to retraining helps spur growth across most sectors of the economy in the long term, with the highest growth in construction and transportation sectors.

Early investments in worker retraining and economic development result in an initial decline in GDP of 0.5% ($13B) but pay dividends in later decades where those retrained workers are able to contribute annually to GDP in the order of between $5B by 2045 and $7B by 2050.

Figure 5: Change in GDP from implementing all labour policies relative to net zero by 2050 scenario with no labour polices



The set of labour policies result in a long-term benefit to Canada's GDP by reducing labour market frictions. The cumulative increase in annual GDP between 2040 and 2050 is $55 billion (2015 CAD) relative to a cumulative public expenditure of about $30 billion on the policy package from 2026-2050. However, as the labour policies are implemented in 2026, there is 10–20-year lag between implementation and positive returns to economic growth.

Retraining and EI support (buckets 1 & 2)

Buckets 1 and 2 reflect tuition fee subsidies for occupational transitions and expanding the eligibility for EI to cover workers undergoing retraining without a requirement to search for work. While some of the tuition supports were targeted only to occupations deemed to be at-risk, the EI policy was available to all workers undergoing occupational transitions irrespective of their starting industry or occupation.

Implementation of retraining and EI support increase wages and reduce unemployment for at-risk occupations in natural resources and trades in a net zero scenario. This is shown in Figure 6 and Figure 7 below. Figure 6 presents the change in average hourly wage for all trades and natural resource occupations as a result of the EI and training supports. Figure 7 presents the unemployment rate under Net Zero with and without the supports. In 2035, the EI and training supports lead to a real wage rate increase of $1.02 per hour for trades occupations and $1.21 per hour for natural resource occupations. Further, the unemployment rate is lower by 1.2% for trades and 2.0% for natural resource professions. By 2050, wage rates remain higher when EI and training supports are available, while unemployment rates return to a similar level due to a lower overall worker base.

Figure 6: Impact of EI and training supports on wages

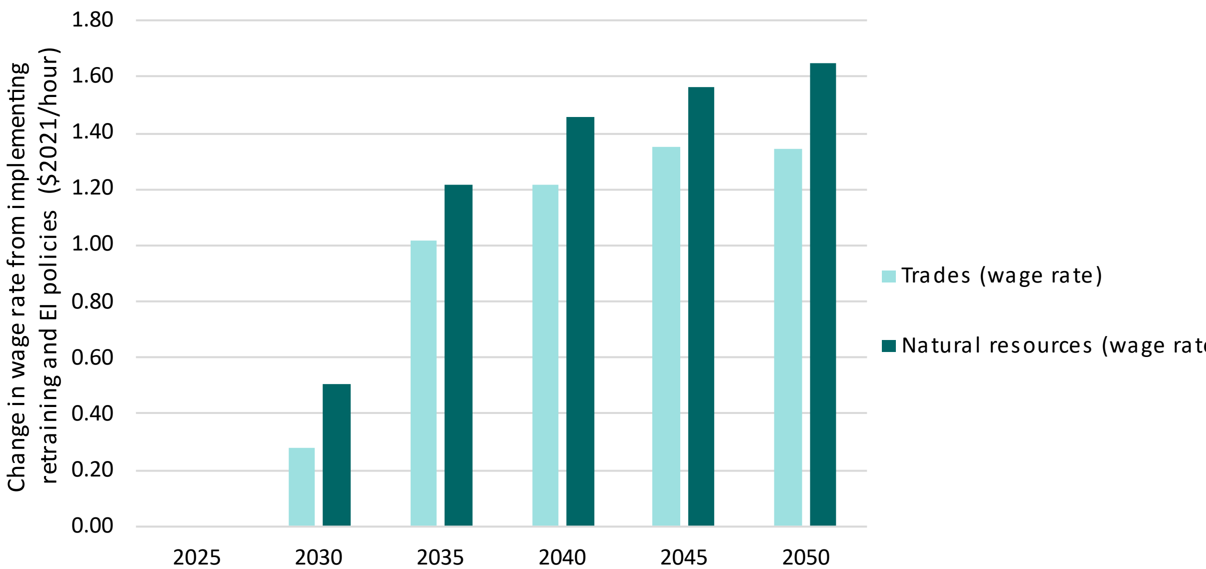
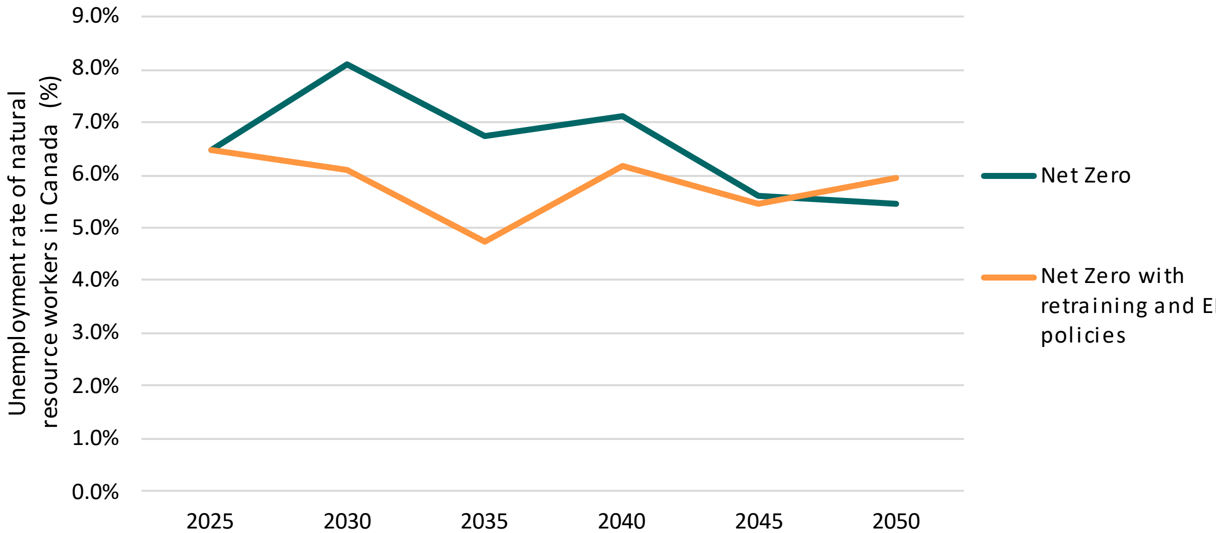


Figure 7: Impact of EI and training support on unemployment rate in natural resources



However, these policies do not have a material effect on economy-wide average wages and employment rates due to an offsetting change in the occupations into which workers were retraining. As workers receive subsidized training, this increases the supply of labour in the destination occupation, which puts downwards pressure on wage growth for existing and new workers in that occupation.

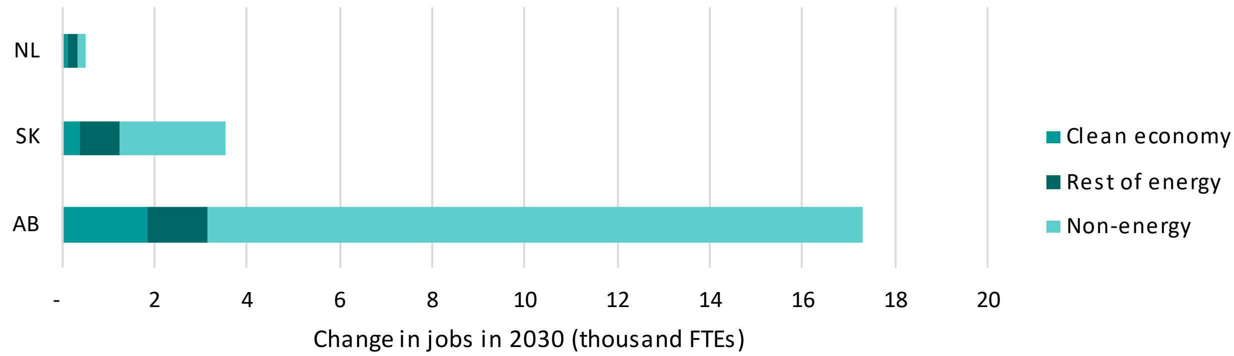
Implementation of retraining and EI policies also did not alleviate the population changes identified above. These policies improve outcomes for at-risk workers but do not create vacancies for these workers to fill. In fact, the modeled population in Alberta and Saskatchewan was incrementally lower when these policies were not implemented as employment growth took place in other regions. However, this may overlook non-financial aspects associated with worker's decisions to remain in their communities or relocate in exchange for a lower wage rate.

Economic development policies (bucket 4)

Implementation of the economic development policy bucket leads to increases in economic activity and job opportunities for Alberta, Saskatchewan and Newfoundland and Labrador while the programs are active. The largest benefits are seen from 2026-2030, which is when most funding is allocated. In this scenario, investment tax credits for trade-exposed, low-carbon industries are provided for these three regions by the federal government, funded by incrementally higher national tax revenue.

Figure 8 below presents the additional job opportunities in each province as a result of economic development policies. While these policies increase growth in clean economy jobs, most increased economic activity and subsequent employment is non-energy related. Non-energy related jobs include those in the services, manufacturing and construction sectors. This outcome is due to the secondary effect of increased industrial growth on the wider economy.

Figure 8: Effect of economic development policies on employment outcomes in 2030[18]



Economic development policies also help to limit outflows of workers from provinces with fossil fuel dependent communities. In 2030, there are 20 thousand more people in Alberta due to the economic development policy package, with Saskatchewan and Newfoundland and Labrador also benefiting from increased population. Increased economic activity in these provinces translates to better employment opportunities, which helps to retain workers.

Boosted economic activity from the economic development package leads to lower unemployment and increased wages in the targeted regions while the policies are in effect. In 2030, all occupation types in Alberta see a dip in the unemployment rate as a result of the economic development policy package. Further, most occupations see a small increase in real wages in response to economic development policies. This suggest that funding for clean economy initiatives is effective at improving employment outcomes for workers across the economy.

In Alberta, manufacturing and utilities occupations, as well as trades professions see unemployment rates fall by 0.5% and 0.2%, respectively, in 2030 in response to economic development policies.

[18] See Appendix A for definitions of the low-carbon economy

Labour market

While assessing macroeconomic impacts provides insight into the net impact of policies, the most significant impact of the modeled labour policies is the distributional effects on labour market outcomes. The proposed policy measures explored in this analysis improve outcomes for occupations disproportionately exposed to the oil and gas industry, with counteracting effects on the occupations people retrain into. This subsection explores the impact of labour policies on select occupations which illustrate this model result.

Example 1: Heavy equipment operators in Alberta

As of 2020, there are 27 thousand heavy equipment operators in Alberta. A quarter of these workers work in mining, quarrying, and oil and gas extraction. Workers in this occupation are deemed to be 'at risk' in the energy transition due to the concentration of employment in conventional energy sectors.

Under a net zero scenario, heavy equipment operators in Alberta experience high unemployment and a decline in real wages. The unemployment rate reaches a peak of 16% in 2030, accompanied by a $0.16 per hour decline in real wages every year. The unemployment rate is equivalent to 4.6 thousand unemployed workers out of 28.8 thousand workers in the province. The year 2030 has an acute impact in the net zero scenario due to reaching an emissions level 45% below the 2005 level.

Implementing retraining and EI supports alleviates unemployment and boosts wages for heavy equipment operators in Alberta (see Figure 9 and Figure 10). Offsetting part of the tuition costs associated with retraining (Bucket 1) reduces the unemployment rate in most years relative to a net zero scenario with no supports, and in all periods the number of unemployed persons is lower when Bucket 1 is implemented.

Layering on EI support while retraining (Bucket 2), which offsets the opportunity cost of lost wages while retraining, further reduces the unemployment rate in all periods. By 2035, unemployment in the occupation is 9% lower when Bucket 1 and 2 are implemented (Figure 9).

By 2050, there are fewer labourers unemployed but there are also fewer overall labourers in the occupation relative to a scenario with no labour policies. This is a result of the training and EI supports incentivizing workers to move to other occupations. Having fewer heavy equipment operators leads to higher wage rates for those workers that remain in the occupation (Figure 10).

Figure 9: Unemployment rate of heavy equipment operators in Alberta under net zero

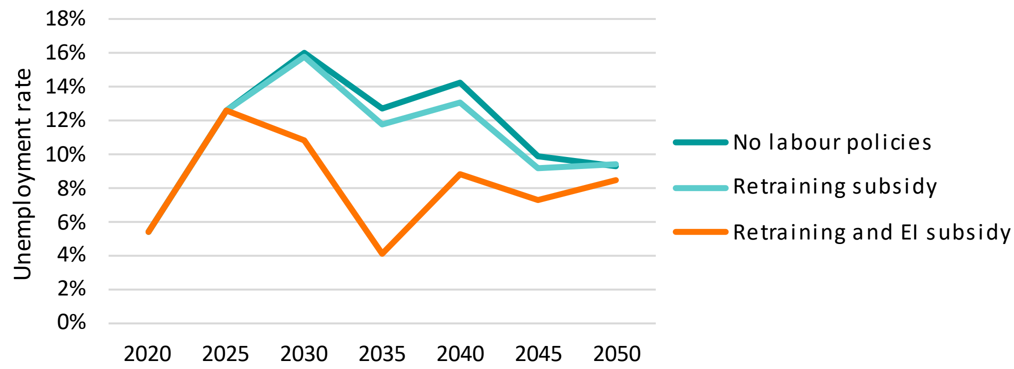
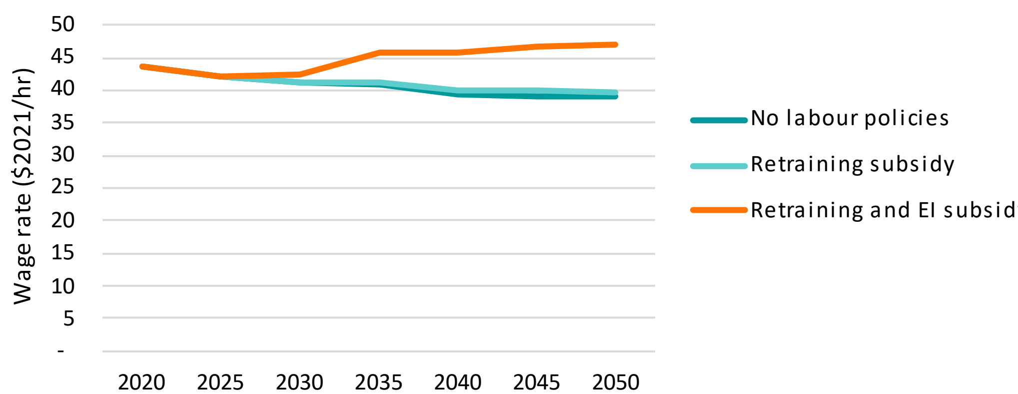


Figure 10: Wage rate of heavy equipment operators in Alberta under net zero



Example 2: manufacturing, and utilities workers in Ontario

While there are beneficial outcomes of tuition and EI support for 'at risk' occupations, some professions have mixed outcomes. As retraining subsidies help alleviate labour market frictions, some occupations will see an influx of workers. This influx could supress wages and lead to higher unemployment.

Demand for workers in manufacturing and utilities is expected to increase under a net zero scenario. The number of manufacturing, and utilities workers in Ontario grows from 50 thousand in 2020 to just under 70 thousand by 2050. This increase in demand for labourers puts upward pressure on the real wage rate.

When retraining and EI subsidies are available, some workers in this occupation retrain into other professions, leading to fewer manufacturing and utilities workers in the province. This dynamic allows for workers to command higher wages out to 2035 (Figure 11) and reduces the unemployment rate (Figure 12).

After 2035, higher wages for manufacturing and utilities jobs attracts more workers from within province. The influx of workers as people retrain into the occupation and/or migrate to the province puts downward pressure on wages and increases the unemployment rate. This leads to lower overall wages for manufacturing and utilities workers in Ontario and higher unemployment in 2050, relative to a net zero scenario without labour policy interventions.

Figure 11: Wage rate of manufacturing and utilities workers in Ontario under net zero

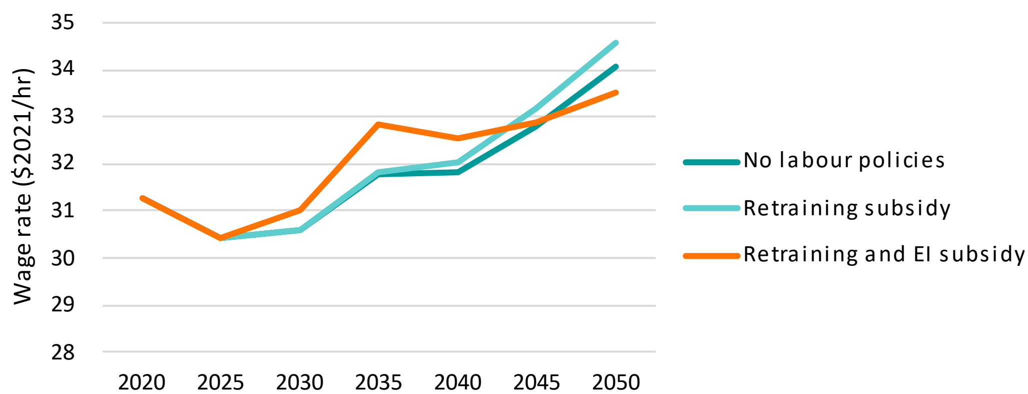
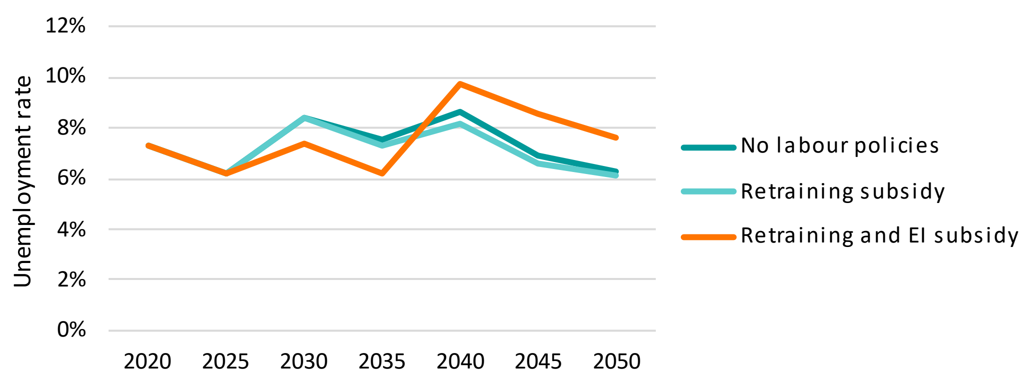


Figure 12: Unemployment rate of manufacturing and utilities workers in Ontario under net zero



Net zero policy impacts

A net zero policy scenario was simulated for this analysis which assumes that Canada achieves a 2030 emissions target of 45% below 2005 levels and net zero emissions in

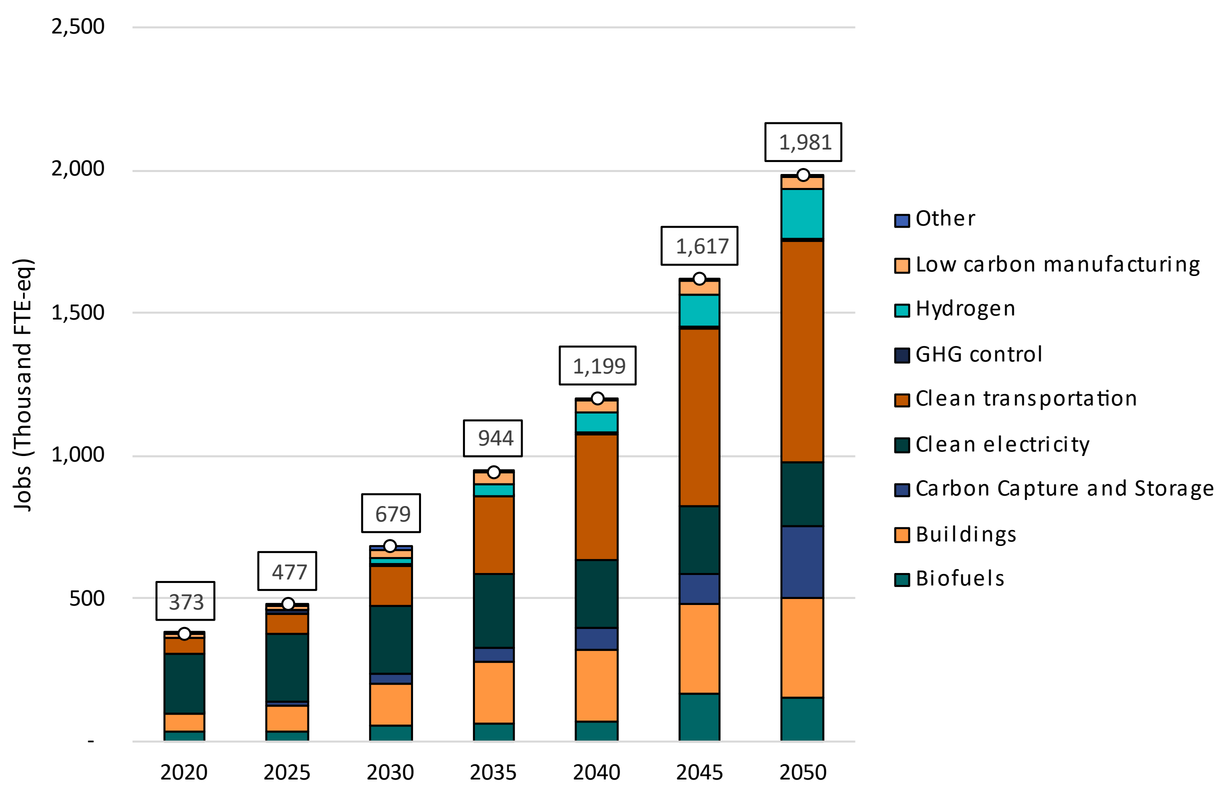
2050. The scenario follows the Net Zero Emissions oil price forecast from the International Energy Agency's 2022 World Economic Outlook. This section presents key results of this net zero scenario.

Employment

Results of this analysis find that in response to net zero policy:

Canada's clean economy supports two million jobs in Canada by 2050. Major contributing sectors include the electric vehicle supply chain and operation (723 thousand FTEs); low carbon buildings (352 thousand FTEs); carbon capture and storage (CCS) and direct air capture (DAC) (253 thousand FTEs); hydrogen (174 thousand FTEs); and biofuels and waste (147 thousand FTEs). By 2050, the clean economy makes up about 10% of total employment in Canada in a net zero scenario.

Figure 13: Clean economy jobs in Canada under net zero emissions

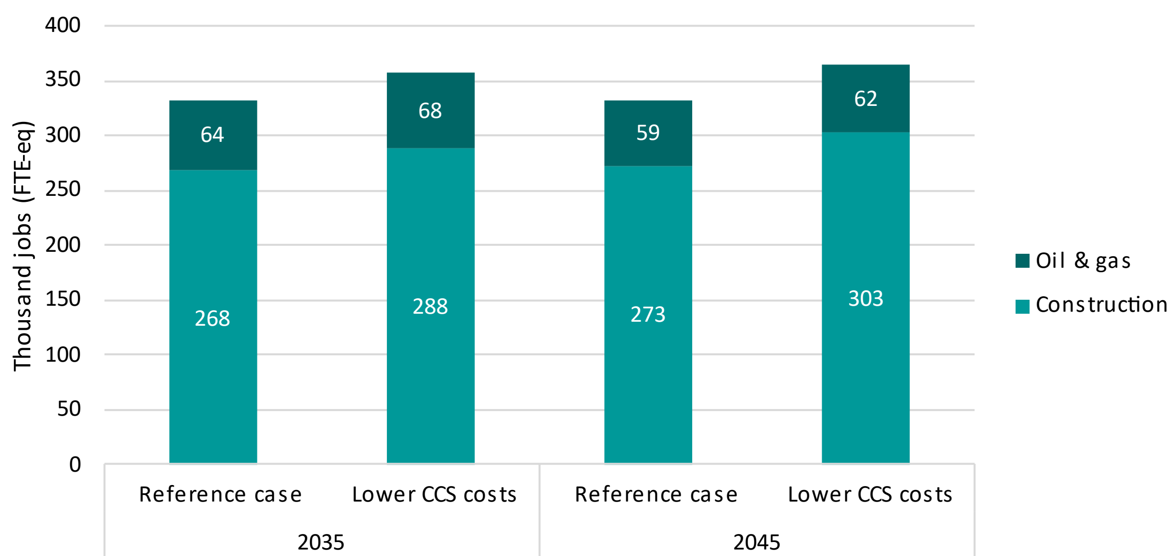


Nationally, job growth in the clean economy exceeds declines in conventional energy sectors in Canada. Clean economy jobs grow by 1.6 million between 2020 and 2050, while conventional energy jobs decline by 900 thousand. The rate of decline in conventional energy sectors, which includes oil and gas, coal mining, and fossil fuel electricity generation, is sensitive to the cost and availability of CCS and DAC. There are 40 percent more conventional energy jobs in 2050 when CCS and DAC costs are lower than the reference case.

Alberta, the province with the most job losses in conventional energy, gains more clean economy jobs by 2050 than are lost in the conventional energy sectors. CCS and DAC technologies are the main contributors of direct and indirect employment in Alberta's clean economy (148 thousand FTEs), with the oil and gas sector contributing to the adoption of CCS. These jobs make up more than half of nationwide employment in CCS and DAC.

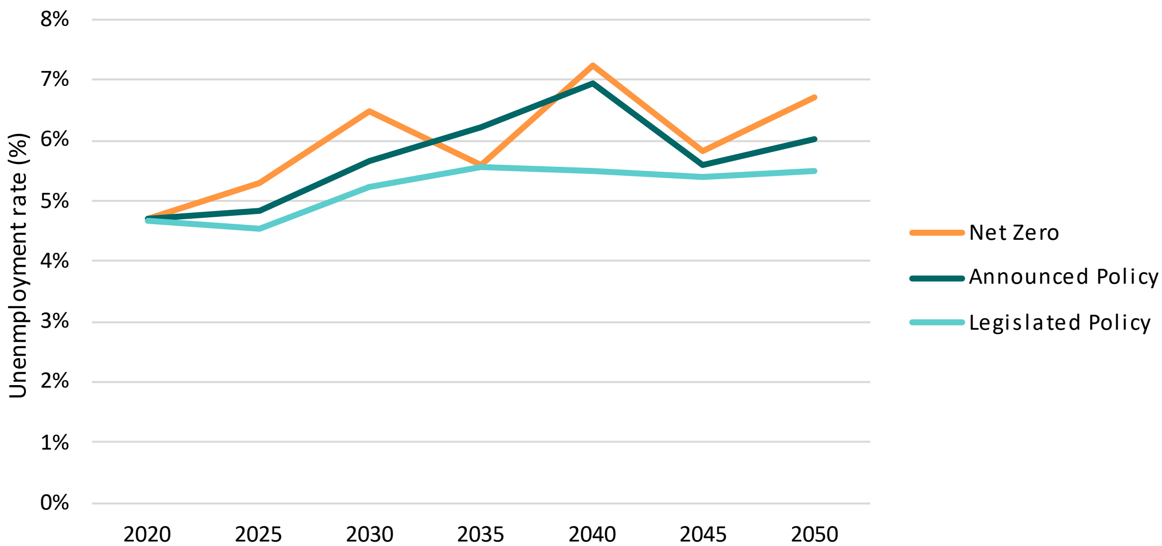
Economy-wide employment in Alberta remains steady between 2025 and 2045, despite growth in clean sectors. Growth in employment in Alberta's manufacturing and services sectors is offset by a decline in employment in the oil and gas and construction sectors. This trajectory is dependent on cost assumptions for CCS and DAC – when technology costs are lower DAC is adopted sooner, which helps limit the loss of employment in construction and oil and gas (Figure 14).

Figure 14: Construction and oil & gas sector jobs in Alberta



In 2030 and 2050, national economy-wide unemployment is about 1 percentage point higher under net zero relative to legislated policy (Figure 15). The most affected occupations include natural resources related occupations, as well as trades, transport and equipment operators. Many of these occupations are highly concentrated in the oil and gas and construction sectors, which suffer from stagnant or declining employment.

Figure 15: National unemployment rate under each policy scenario



Real wages in fossil-fuel producing provinces increase moderately between 2020 and 2050, but outcomes vary by occupation and with the presence of retraining support policies. Occupations concentrated in the oil and gas sector, such as those in natural resource related occupations or heavy equipment operators, see flat or declining real wages.

Population

This modeling exercise allows for regional population to diverge from the Canadian Energy Regulator's forecast[19], with population growth instead re-allocated based on the real wage growth.[20] A worker's decision to leave or remain in a province is based on the delta between the expected wages at home and in a different province. Such decisions affect labour availability and economic growth in each model period, allowing for additional insight into the effect of climate policy on labour outcomes.

[19] Canada Energy Regulator's 2021 Canada's Energy Future

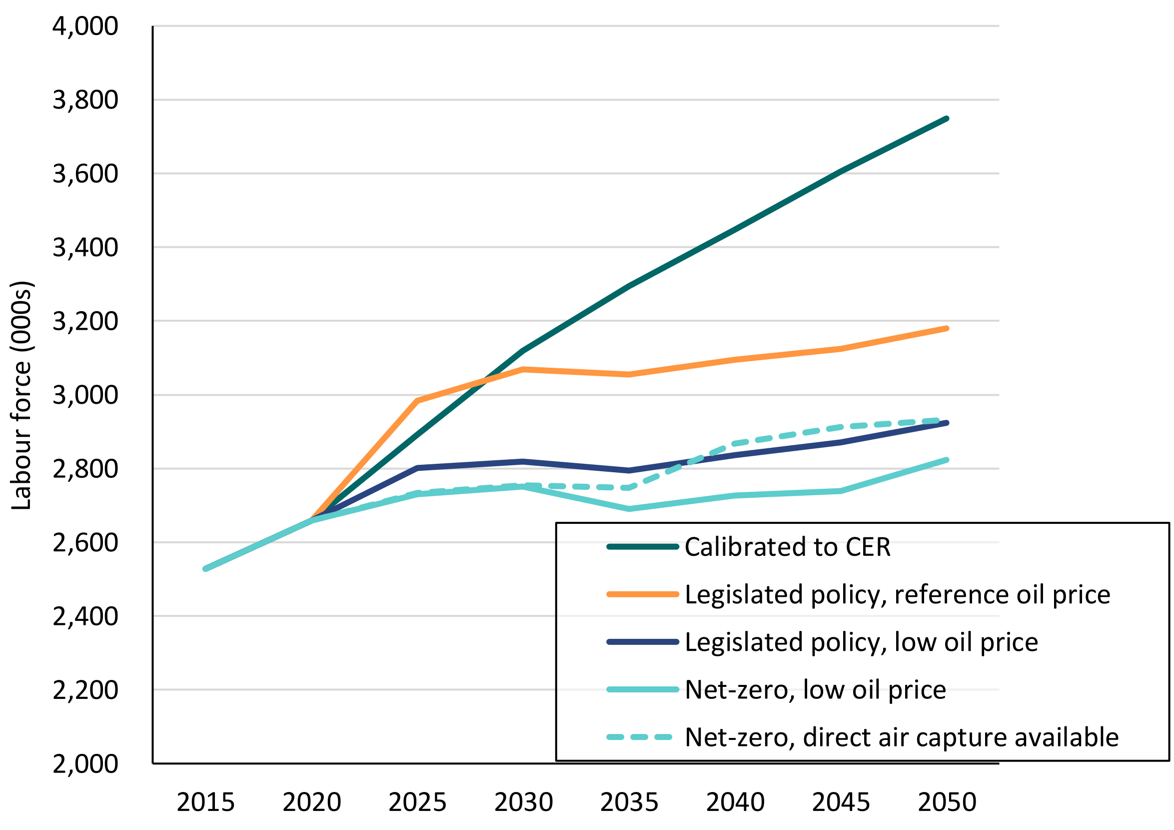
[20] The model is calibrated to the CER forecast under Legislated Policy, but can deviate under a different policy mix.

Results of this analysis find that:

Productivity growth and international demand for Canadian oil are greater determinants of labour growth in Alberta than the implementation of domestic net zero policy. Figure 16 below shows the effect of different policy scenarios on the size of Alberta's working population. Relative to the CER forecast, there is comparably lower productivity growth in Alberta after 2030 under legislated policy, leading to over half a million fewer workers in the province by 2050. This is because post-2030, wage growth is lower and more consistent with other provinces.

Following the IEA's Net Zero Emissions oil price trajectory (~$30/bbl 2020 USD), intended to reflect a scenario where the rest of the world moves to net zero by 2050, the number of workers in the province declines a further 256 thousand. Layering on a domestic net zero by 2050 policy leads to differing outcomes depending on the cost and availability of emerging technologies, such as DAC (Figure 16).

Figure 16: Labour force growth in Alberta under different climate policy and oil price futures



Provincial population growth under net zero deviates markedly from business-as-usual growth taken from the CER estimates. By 2050, there are fewer people in Alberta (1.0 million persons) and Saskatchewan (0.2 million persons) relative to the CER forecast in the low oil price, net-zero scenario, and additional people in Quebec and BC. Stagnant wages in Alberta and Saskatchewan lead to fewer workers than forecasted moving to these provinces, while wage growth in Quebec and BC helps attract additional workers to those provinces.

If direct air capture is available, this creates new economic activity in Alberta, which results in a similar labour force size to the low-oil price scenario where Canada does not reach net-zero. This is because the market for carbon removal as a service only exists in the scenario where Canada pursues net-zero, but the oil sector activity is driven by the assumption about global oil prices.

Most provincial populations still increase out to 2050, with a Canada-wide population growth of 0.85% per annum. Alberta and Saskatchewan both end up with lower populations relative to the CER forecast but still grow annually by 31 thousand people and 11 thousand people between 2020 and 2050, respectively. Newfoundland and Labrador is the only province to experience negative population growth in a net zero scenario.

4. Limitations

This section provides a discussion on the limitations of the modeling approach used and areas for future research work or model development that have been identified during the project.

General modeling limitations

Despite the numerous refinements made to gTech's representation of labour markets in this project, forward-looking modeling is still an inherently uncertain process. Model outputs reflect the combinations of assumptions in scenario inputs, and are not a depiction of the most likely future that will materialize in Canada. In particular, there a few main types of uncertainty.

First, even the best models are simplifications of complex real-world systems which rely on user inputs. Model outputs will not reflect every factor that will influence the future, and are best used to evaluate the relative impact of policies and how they interact in a certain scenario. For example, the modeling conducted in this project was focussed evaluating the impact of labour market interventions in low oil price scenarios in which there is little global demand for Canadian oil in a net-zero future. Modeling a different outlook for international oil markets would naturally produce different results for wages and employment in Canada.

Second, the assumptions used to parameterize models are uncertain. These assumptions include commodity and technology costs (e.g., the cost of electric vehicles), the availability of emerging technologies (e.g., is direct air capture an option?), and assumptions about human behaviour (e.g., how will wage rates affect labour force participation?). Specific to this analysis, the results for wage growth and the inter-provincial distribution of population growth are sensitive to exogenous inputs for provincial labour productivity growth and equilibrium rates of unemployment.

Third and finally, design and eligibility of simulated policies are uncertain; the policies modeled in this project have been proposals, and the model results provide economic insight into the potential effect of policies such as these. For example, the eligibility criteria for who is able to claim EI for re-training, or which workers are able to claim retirement bridging, has the potential to have a large impact on costs to government depending on how targeted or broad policies are set to be.

Non-financial determinants of labour market outcomes

The customized version of the gTech model used in this analysis allows for conversion of labour from one occupational class to another based on an estimated retraining cost, but does not include non-financial determinants of which training pathways specific individual workers may be likely to pursue based on their preferences. Training pathways that would be "profitable" at the baseline wages (e.g., teacher -> mine labour) are turned off as a proxy for these transitions being undesirable or infeasible, but the remaining pathways are not differentiated based on preferences.

In the model, the training pathways are utilized are based on the wage differential between available occupations and the estimated training cost, such that workers move into higher-earning jobs from their current occupation. This results in workers transitioning into higher-wage occupations when training is available, which may disproportionately transition workers into professional occupations and certain trades, regardless of whether individual workers would find these jobs pleasant. Accounting for worker's preferences via survey data or calibrated welfare costs associated with certain jobs could result in fewer occupational transitions, or transitions being limited to more similar jobs.

Disaggregation of labour market entrants and existing workers

The model development for this project disaggregated the labour supply into occupational classes and allowed the transition from one occupational class to another for a cost, based on the wage differential between occupations. An area for further model development would be to disaggregate the share of the labour supply that is new within each model period. Arguably, this portion of the labour supply should be more flexible in how it is allocated between occupations. Incorporating this dynamic into the model would reduce the rigidity of the labour supply.

Migration and productivity growth

The model changes introduced in this study have result in provincial labour force growth which is not fixed across scenarios. This represents a reasonable regional response to economic shocks and provides interesting observations on the inconsistency of "business-as-usual" population forecasts with potential net-zero scenarios where there is little international demand for Canadian oil. However, the model results are still heavily influenced by exogenous assumptions for provincial labour productivity growth, which are ultimately uncertain, and will also be influenced by industrial composition of provincial economies.

For this analysis, the model was calibrated to the oil and gas price, oil and gas production, GDP, and provincial labour force results from the CER's Canada's Energy Future 2021[21]. Using a different source for productivity growth (e.g., extrapolating productivity trends by industrial sector, rather than region) rather than calibrating to an external GDP forecast would result in different outcomes.

The approach of using a CES function to represent the allocation of workers within a given occupation between regions provides a simplified representation of where specific households may prefer to move. There may be regional preferences among new immigrants and households within a certain region that this approach overlooks. Similarly, the modeling does not account for language-based limitations for population growth in or out of Québec and English-dominant regions.

Lack of free ridership

This study examined how enhanced employment insurance (EI) for occupational re-training may affect wage and employment outcomes. In the modeled scenarios, workers transitioning from one occupation to a higher-wage occupation were given EI for their time spent retraining without a requirement to search for work, which substantially reduces the opportunity costs of forgone wages associated with the decision to re-train. The model did not include behavioural changes that may appear as a by-product of this policy, such as an increased number of young people working for a certain number of years before attending post-secondary education in order to meet an eligibility criterion for the policy. The modeling also did not assume these subsidies would be available, intentionally or unintentionally, for a baseline level of occupational transitions that would take place anyway for non-financial reasons.

Accounting for potential free ridership on these policies, and establishing clear eligibility criteria for which workers could use the policy (specifically the policy proposal to provide EI for retraining), would be a valuable area for future research. If policy eligibility was broad enough, accounting for free ridership could substantially increase the estimated costs to government.

Structural level of unemployment

With the revised approach to modeling involuntary unemployment, the equilibrium level of unemployment is an exogenous input which is fixed across scenarios and varies by province based on historical data. Following a shock to the model, the

[21] Canada Energy Regulatory (2021). *Canada's Energy Future 2021.* Available at: https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/

unemployment rate will gradually rise/fall back to this equilibrium level as wages adjust.

Historically, different provinces have had variable average rates of unemployment. For example, in 2022, the rate of unemployment in Newfoundland (10.8%) is more than twice the national average (5.3%)[22]. One potential explanation for this deviation from the national average is that provinces which have undergone substantial changes to the industrial composition will still have fluctuations in unemployment, but cyclical fluctuations will take place around a higher baseline.

The gTech model used in this project represents involuntary unemployment above an equilibrium level, but does not adjust the equilibrium level of unemployment based on changes to industrial composition that differ between scenarios. This is an area for future research and model development. This equilibrium level of unemployment could potentially be determined internally within the model based on several simulated metrics, such as the rate of population change or change in output from incumbent industries.

Union membership rates

The gTech model does not include differential rates of unionization across sectors, or the ability to simulate changes to the rate of union membership and how this may affect the wages of unionized and non-unionized workers. Conducting model development to represent workers' bargaining power, and how this may be different between emerging and incumbent economic sectors, is an area for future research.

[22] Statista, Unemployment rate in Canada in 2022, by province. Available at: https://www.statista.com/statistics/442316/canada-unemployment-rate-by-provinces/

Appendix A: Defining the low-carbon economy

To categorize the low-carbon economy in gTech, we assign economic activity into one of three categories:

- **Low-carbon energy** (i.e., as defined below).
- **Conventional energy** (i.e., most activities related to fossil energy supply and use, other than those considered low carbon such as emissions control efforts).
- **Non-energy** (e.g., insurance services, education).

This report builds on previous work by Navius that defines the clean energy economy as:

> *"The technologies, services and resources that increase renewable energy supply, enhance energy productivity, improve the infrastructure and systems that transmit, store and use energy while reducing carbon pollution."*

Naturally, this definition could be applied in different ways. For example, what is the baseline level of carbon intensity that distinguishes clean from not clean? This study generally applied definitions with reference to net zero; in other words, is a technology or fuel likely to be consistent with net zero in Canada?

Table 7 lists the specific low-carbon energy sectors that are considered under this definition for the purposes of this project. Each sector includes jobs spread out across multiple activities related to the low-carbon technologies or fuel in questions. Jobs are attributed to one of three categories:

- **Direct.** This category includes employment of (1) sectors producing low-carbon energy services (e.g., renewable electricity) and (2) value-added associated with the use of low-carbon technologies in other sectors (e.g., a plug-in electric vehicle may be used to provide transport services).
- **Indirect.** This category includes indirect jobs related to the low-carbon technology or fuel, such as construction (e.g., building an automotive manufacturing plant), manufacturing (e.g., assembling an electric vehicle) and services (e.g., selling or operating an electric vehicle).

Table 7: Low-carbon energy taxonomy

Sector category	Low-carbon energy sector
Energy supply	
Low-carbon energy	Renewable electricity
	Conventional nuclear
	Small modular reactors
	Bioenergy
	Waste to energy
	Hydrogen
	Carbon capture
	Emission detection and control
Supply infrastructure	Electricity transmission & distribution
	Hydrogen pipelines & storage
Energy demand	
Buildings	Efficient building envelopes
	Efficient HVAC and building controls systems
	Efficient appliances & lighting
Transport	Plug-in electric vehicles
	Hydrogen fuel cell electric vehicles
	Low-carbon transit
Industry	Low-carbon machinery
	Low-carbon steel
	Emission detection and control
	Carbon capture and storage
	Hydrogen consumption
	Direct air capture

Table 8: Conventional energy

Sector category	
Energy supply	
Fossil fuel production	Coal mining
	Oil and gas production
	Enhanced oil recovery
Transportation and conversion	Transmission and distribution pipelines
	Refining
	Liquified natural gas
	Thermal electricity generation
Energy demand	
Buildings	Code-minimum building envelopes
	Standard efficiency appliances and lighting
	Fossil-fuel fired space and water heat
Transport	ICE vehicles
	Natural gas vehicles
	Hybrid vehicles
	Fossil fuel air, rail, and marine transport
Industry	Fossil fuel heat
	Unabated process emissions
	Electric motors
	Non-energy fuel use