FOCAL Initiative

THE SHIFT TO EV PRODUCTION IN QUEBEC'S AUTOMOTIVE MANUFACTURING SECTOR

ASSESSING THE ECONOMIC AND LABOUR MARKET IMPACTS

MARCH 2024

About the FOCAL Initiative

The Future of Canadian Automotive Labourforce (FOCAL) Initiative, funded by the Government of Canada, is a collaboration of the Canadian Skills Training and Employment Coalition (CSTEC), the Automotive Policy Research Centre (APRC) and Prism Economics and Analysis.

The FOCAL Initiative has produced labour market information and data related to Canada's automotive manufacturing sector, examined key trends affecting the automotive labour market, and produced forecasts of supply and demand for key occupations in the broader automotive sector.

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Executive Summary

Canada's automotive manufacturing sector, a key driver of the country's manufacturing and economic growth, is undergoing a significant shift towards zero-emission vehicles (ZEVs) production, aligning with domestic and global efforts to reduce carbon emissions and achieve net-zero by 2050. At the core of its heavy-duty vehicle manufacturing industry is Quebec's assembly industry where the majority Canada's heavy-duty vehicles are produced.

The move from producing internal combustion engine vehicles (ICEVs) to electric vehicles (EVs) in Quebec's heavy-duty vehicle manufacturing industry presents both opportunities and challenges. The shift offers the opportunity to develop new domestic supply chains, expand existing manufacturing capabilities, and grow the economic contribution of the sector provincially and nationally. However, it poses multiple challenges to the sector and its supply chain including the need to adapt manufacturing processes, manage the fluctuating demand for components, and transition the workforce across industries and sectors. Industry stakeholders must also navigate the considerable uncertainties and risks of this transition.

This transition, and its significance to Quebec's economy, is the focus of this comprehensive report which analyzes its impacts from 2025 to 2040, offering insights to policymakers and industry stakeholders on the potential economic and labour market implications. This report presents detailed analysis of the shift to EV production, particularly battery electric vehicles (BEVs). This involves careful review of the automotive and battery manufacturing supply chains, including the announced plans for new production operations and related changes reaching upstream to chemical manufacturing, mineral processing and mining potential. In addition, the analysis tracks the related decline in assembling ICEVs and the shrinking demand for their components, the parallel aspect of this transition. The timing and magnitude of new production and shifts in the supply chain have been set out in three scenarios that reflect the various potential future outcomes – from rapidly growing BEV production capabilities depicting a successful shift in production over the upcoming years, to a more gradual shift in vehicle production, accounting for the various risks and barriers to EV production and adoption. The EV production analysis estimates specific output and employment changes expected across the different stages of the supply chain. Each scenario presents a multi-layered economic impact:

1. In scenario 1, greater BEV production in Quebec is assumed.This is accompanied with producing and processing rare earth minerals and battery materials domestically. In this scenario, around $7.0 billion and 17,000 jobs are added to the provincial economy of Quebec.

2. Scenario 2 assumes a slower shift to BEV production and lower volumes of battery production. This is further accompanied by less success in developing domestic rare earth mining capabilities, and in securing production mandates. Under these assumptions, $1.3 billion and 4,400 jobs are added to the provincial economy.

3. Scenario 3, combining assumptions of scenarios 1 and 2, predicts output reaching $4.8 billion and almost 13,000 jobs added by 2040.

These scenarios highlight the variable impacts of Quebec's transition to EV production on economic output and employment across various industries and the overall economy. Given the assumptions developed in this study around battery manufacturing, this industry, along with industries within its supply chain, are set to gain the most (in output generated and jobs created) as a result of the start up of battery manufacturing operations and its related activities.

While several risks, barriers and challenges may impede the shift in production and adoption of EVs, the successful transition to EV production requires coordinated efforts from industry and government to minimize impacts, and ensure the smooth transition of the workforce.

Introduction

This report is one of a series of FOCAL reports examining the transition to electric vehicle (EV)[1] production in Canada's automotive and battery manufacturing sector. This report, which is specific to the transition in Quebec, delves into the significant transformation of the province's heavy-duty vehicle manufacturing industry towards EV production, a shift driven by global decarbonization efforts and the push for zero-emission vehicles (ZEVs) to meet the 2050 net-zero carbon emissions goal[2]. The heavy-duty vehicle manufacturing industry and its supply chain, is a significant contributor to Quebec's economy and GDP, and employs approximately 10,000 workers[3,4]. The transition to EVs is marked by increasing demand and investments in EV technology, supported by government incentives aimed at fostering domestic production and adoption of ZEVs.

The movement towards EV production presents both opportunities and challenges for Quebec. On one hand, it positions Quebec and Canada as a leader in a growing industry, promising innovation, investment, new jobs, and an enhanced global standing in sustainable practices. On the other hand, it necessitates substantial adjustments in manufacturing processes, supply chains, and workforce skills, given the fundamental differences between EVs and traditional internal combustion engine vehicles (ICEVs).

This transition is not without its hurdles. Concerns about EV technology limitations, charging infrastructure, supply chain disruptions, and consumer preferences pose significant barriers to the widespread adoption and production of EVs. Moreover, policy and regulatory uncertainties could impact the pace and success of this transition.

The shift from ICEVs to EVs requires a reconfiguration of the automotive manufacturing supply chain. Traditional components like internal combustion engines (ICEs) and exhaust systems are being replaced by batteries, electric motors, and power control units, necessitating new partnerships with chemical manufacturers and mining companies. This evolution towards a supply chain centred around battery production signifies a departure from mechanical to more electronically complex manufacturing processes.

The transition is expected to reshape the industry's output and employment landscape, potentially leading to job creation in battery manufacturing and related sectors while causing a decline in ICEV-related manufacturing jobs, most of which are concentrated in Quebec. Since 2020, significant investments in EV, battery production, and components have been announced in Quebec and Canada, underscoring the gradual pivot towards EV manufacturing in the sector[5].

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[1] In this report, electric vehicles (EVs) refer to hybrid electric vehicles (HEVs) and battery electric vehicles (BEVs).
[2] Government of Canada - Environment and Natural Resources (2023). *Net-zero emissions by 2050*.
[3] FOCAL Initiative (2021). *Importance of the Canadian Automotive Manufacturing Sector.*
[4] Statistics Canada (2022). *Gross Domestic Product by Industry (Monthly)*.
[5] Invest in Canada (n.d.). *EV Supply Chain*.

This report provides an extensive analysis and forecast of the implications of Quebec's vehicle manufacturing industry's shift to EV production from 2025 to 2040. Through various scenarios, it explores potential outcomes of this transition, considering the risks and challenges that could hinder the shift to the production of EVs. The report aims to offer comprehensive insights into the economic and labour market impacts of this shift in Quebec, highlighting opportunities for job creation and economic growth.

This report seeks to equip policymakers, industry stakeholders, and the government with critical information on the impacts, challenges, and opportunities presented by Quebec's vehicle manufacturing industry's transition to EV and battery production. This thorough analysis aims to guide decision-making and strategy development to navigate the complexities of this transformative period in Quebec and Canada's automotive manufacturing.

Background

The FOCAL Initiative assists employers, workers, and job seekers in navigating labour market challenges. In addition to direct assistance through wage and training subsidies, FOCAL has been offering guidance in critical areas such as skills transferability, diversity, immigration and apprenticeship. The transition from ICEV to EV production in Quebec's vehicle manufacturing industry is expected to be a key area of focus over the upcoming years.

In 2021, the FOCAL Initiative released a report titled "The Impact of EV Production on the Automotive Manufacturing Supply Chain: Sources, Methods and Findings"[6]. The report was part of FOCAL's preliminary efforts to assess the impact of the shift to EV production on Canada's automotive manufacturing supply chain. Its analysis estimates that approximately 16,000 jobs and 64 companies are at high risk due to the transition towards EV production. The report also acknowledges the potential output and job gains in EV and battery-related manufacturing activities. It explored the best methods to quantify the broader impacts of the transition from ICEV to EV production on the automotive manufacturing sector, its supply chain, and the economy.

As automotive manufacturing is interlinked with numerous other sectors and industries, the economic and labour market impacts can include direct, indirect, and induced effects which can affect a wide number of these sectors and industries. For this reason, there was a need to methodologically measure the impacts of this transition which may lead to substantial shifts in labour markets, industrial outputs, and supply chain structures. In FOCAL's initial report, the Input-Output (I-O) method was identified as a more accurate tool for this purpose, capable of capturing the multi-layered effects of the transition on various economic sectors and industries.

[6] FOCAL Initiative (2021). *The Impact of EV Production on the Automotive Manufacturing Supply Chain: Sources, Methods and Findings*.

Recent investment announcements to expand Quebec's EV and battery manufacturing capabilities underscore the importance of such analysis, especially as the transition in production is already underway. In recent years, notable battery manufacturing announcements have been made including the Northvolt battery production plant in Montreal. Other battery material manufacturing, material processing and mining announcements have also accompanied Quebec's growing EV and battery manufacturing capabilities. A select number of automotive and battery manufacturing investment announcements are highlighted in table 1 below.

Table 1. Select EV & battery manufacturing investment projects and announcements in Quebec

Announcement	Details	Announced Capacity	Location	Production Planned / Commenced
Northvolt Battery Manufacturing	Battery cell manufacturing; Cathode components; Battery recycling	30 GWh	Montréal, QC	2026
General Motors – POSCO	Cathode Active Material (CAM) processing facility	-	Bécancour, QC	2025
Nouveau Monde Graphite Plant	Coated spherical purified graphite	42,600 tonnes per annum	QC	-
Baie-Comeau Battery Anode Material Plant	Battery anode material production	200,000 tonnes per annum	Baie-Comeau, QC	2026
Allkem - James Bay Lithium Project	Spodumene - high-grade lithium	321,000 tonnes per annum	QC	2024
Electra Battery Materials - Cobalt Refinery	Battery grade cobalt sulfate	6,500 tonnes per annum	Temiskaming Shores, ON	2023

Methodology

A comprehensive model was developed to assess the economic and labour market implications of Quebec's transition from ICEVs to EVs and associated battery production. Employing a methodical two-step approach, the model leverages various analytical tools and data sources, including Statistics Canada's Input-Output Tables[7], to calculate industry-specific output and procurement patterns for automotive and battery manufacturing. The model also projects broader economic impacts on output and employment up to 2040 using the IMPLAN Economic Software[8], with findings detailed at five-year intervals.

The industry output and purchasing patterns are first estimated using the 2019 Level D I-O table to reflect the cost structures of heavy-duty vehicles manufactured in Quebec. The price structure is then adjusted for HEVs, and BEVs to cater to their unique manufacturing components and costs, alongside consideration for the evolving prices of EV components, particularly batteries.

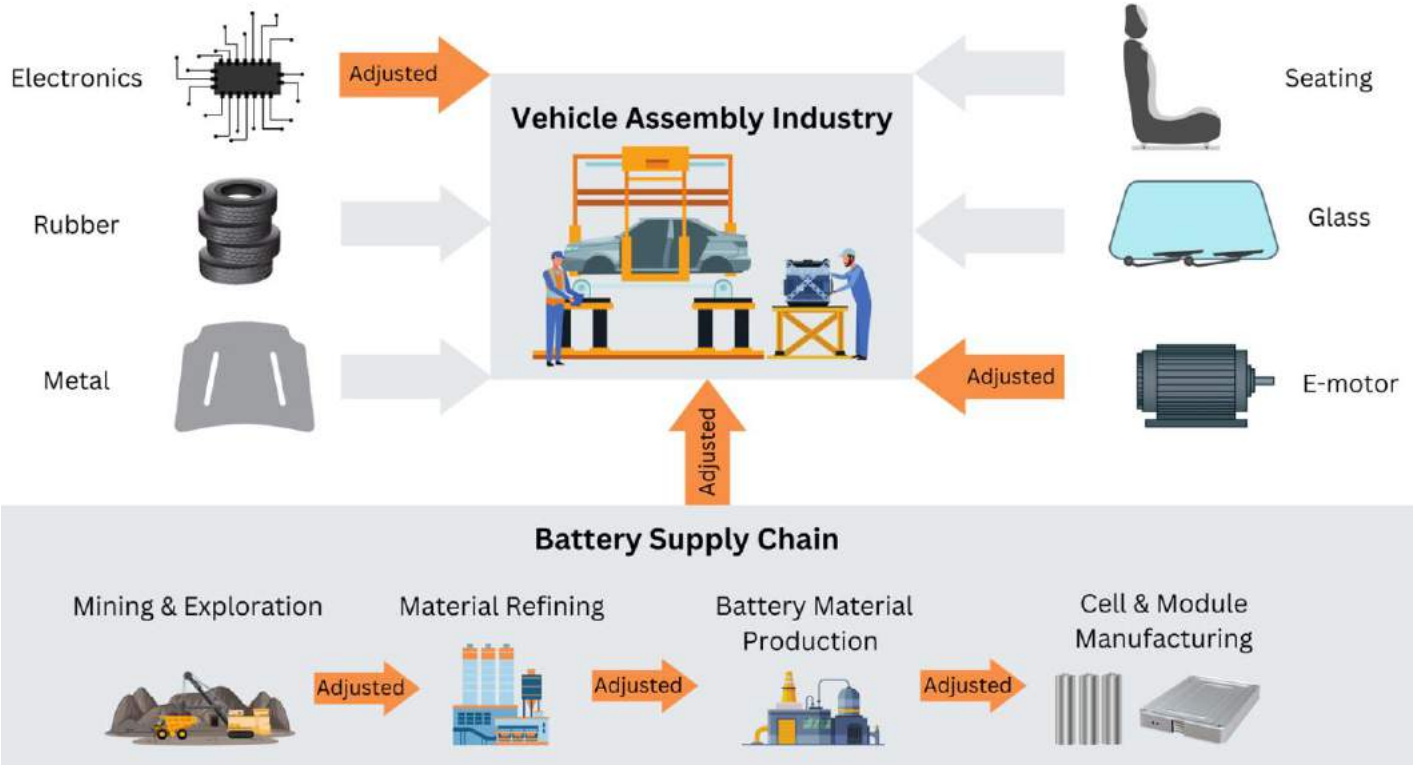
The model further adjusts for changes within the heavy-duty truck manufacturing and battery manufacturing supply chains and estimates the total output of these industries. This accommodates the varying requirements for battery cell and module manufacturing, as well as the cathode and anode production, refining, and mining sectors.

The model finally estimates the direct, indirect, and induced impacts across the economy, informed by output and purchasing patterns from the vehicle assembly industry, export levels, and production volumes from battery plants and material manufacturing. This comprehensive modeling assists in estimating the total output and employment impacts within various industries and sectors.

This methodology used in this study is further detailed in Appendix B.

[7] Statistics Canada (2021). *Supply, Use and Input-Output Tables*.
[8] For more information on the IMPLAN modeling process, visit IMPLAN.com.

Figure 1. Adjusted purchases and supply chain linkages within the automotive and battery manufacturing industries



Vehicle & Battery Manufacturing Scenarios

Creating scenarios to assess the economic and employment consequences of transitioning from ICE heavy-duty truck and bus to electric heavy-duty truck production in Quebec is an essential component of this analysis. In this study, three scenarios were constructed, each based on a series of projections regarding vehicle production volumes, the pace of the shift to electric bus and truck production, investment in battery manufacturing and its output, as well as the level of operations in the supply chain sectors of vehicle and battery manufacturing[9]. These scenarios provide a framework for evaluating a spectrum of possible outcomes and the uncertainties tied to this shift. Opting for multiple scenarios over a singular one further allows for a broader and more in-depth examination into the varied impacts that different levels of production and investment might have on the economic output and job market within the related industries and sectors of automotive and battery manufacturing.

Ensuring that these scenarios and their underlying assumptions are both realistic and precise is crucial for evaluating the effects of the switch to EV production. Hence, all three scenarios incorporate insights from a variety of data streams, encompassing historical automotive

[9] Given the minimal volumes of light-duty vehicle manufacturing in Quebec, only heavy-duty vehicle production assumptions were developed for this provincial study.

production figures, projections for vehicle production, announcements related to investments in battery components and materials manufacturing, and the current and anticipated mining development and exploration initiatives. Adopting this method guarantees that the scenarios are thoroughly researched, wide-ranging, and constructed upon a diverse array of data inputs.

To explore the potential impacts and contributions of vehicle and battery manufacturing, it was critical to develop a scenario in which Quebec's heavy-duty vehicle manufacturing industry could more swiftly shift to BEV bus and truck production throughout the period of 2025 - 2040, while also increasing its vehicle production compared to 2022. Within this framework, Quebec also manages to expand its battery manufacturing capabilities, encompassing the production of battery parts, materials, and minerals. Conversely, in a second scenario, the transition of Quebec's heavy-duty vehicle manufacturing sector toward EV production is more gradual, influenced by a range of risks and uncertainties including consumer preferences, supply chain dynamics, infrastructure development, and investment levels. By 2040, the industry produces a diverse range of vehicles, including ICEVs, hybrids, and BEVs, with vehicle production rates holding steady and only a modest increase in domestic battery manufacturing, which doesn't fully meet the low domestic and North American demand for battery components and materials. A third scenario uses elements from the first two, assuming that while vehicle manufacturing in Quebec shifts to EV production at a similar rate to scenario 1, but production rates do not increase. Although Quebec succeeds in boosting domestic battery production, the industry continues to rely partially on imported materials and minerals to meet its needs.

In developing the three scenarios, the following assumptions were made. These assumptions are summarized in Figure 2 and Table 2, and are detailed in Appendices C and D:

Scenario 1

In this scenario, it is assumed that Quebec's heavy-duty vehicle manufacturing industry transitions more swiftly to the production of BEVs over the forecast period. Concurrently, Quebec's heavy-duty vehicle production levels increase from approximately 9,300 vehicles in 2022 to over 15,000 in 2040. It is also assumed that two battery plants (with capacity totalling 67.5 GWh) become operational in Quebec during this period and operate at 75% capacity producing close to 50.5 GWh equivalent (eq.) of EV batteries. Within its developing battery manufacturing supply chain, Quebec's battery material manufacturing, material refining and filtering, as well as mining industries are capable of supplying 100% of domestic demand of battery materials and minerals to manufacture batteries.

Scenario 2

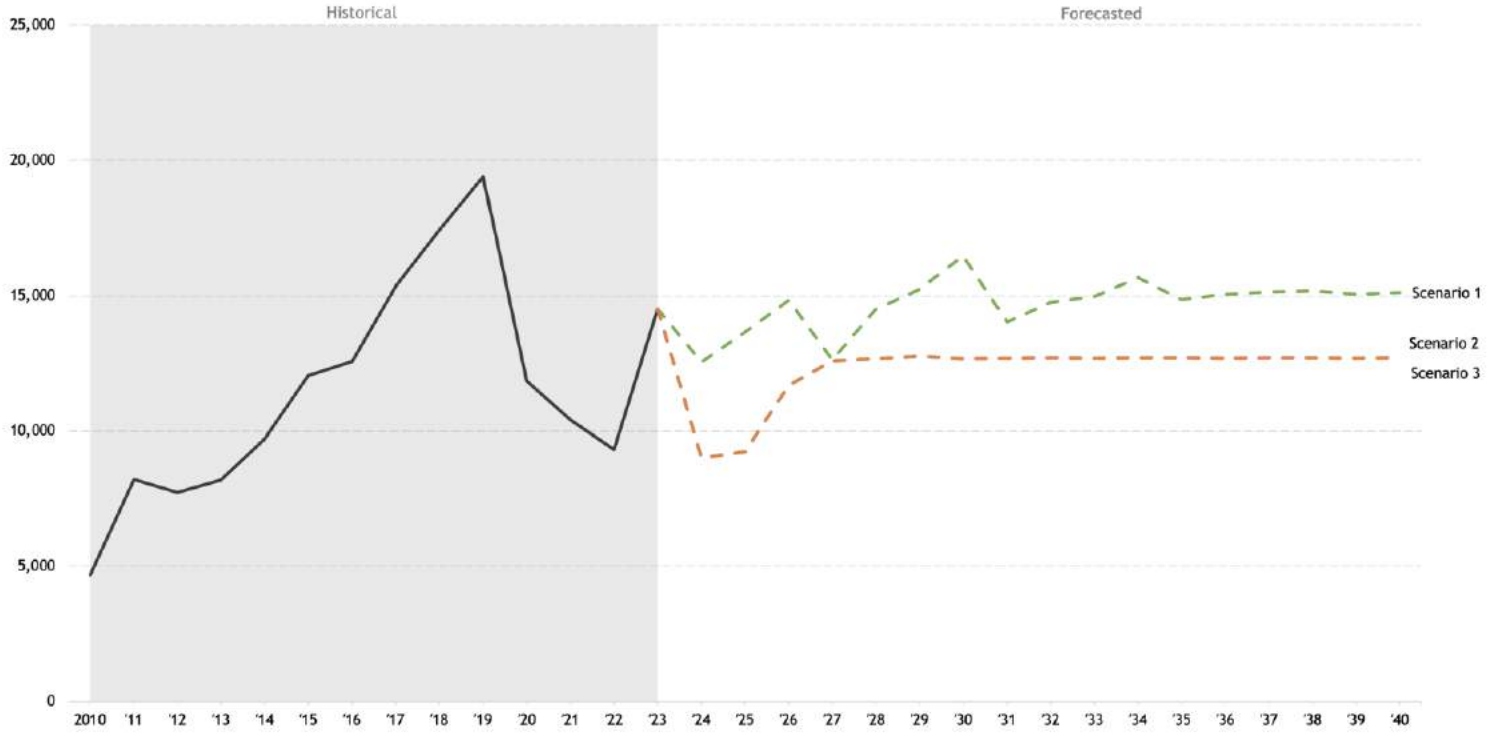
Quebec's heavy-duty vehicle manufacturing industry gradually transitions to the production of EVs and by 2040, is producing a majority of ICEVs, with a share of hybrids and BEVs. Heavy-duty vehicle production increases to around 12,700 vehicles throughout the forecast period. One battery manufacturing plant comes online during the period of 2025 - 2040 which operates at an

average of 30% capacity and produce close to 9 GWh. Battery material (cathode and anode materials), as well as battery minerals are mostly imported to satisfy domestic demand for battery production. Only 10% of the battery materials and minerals are supplied from projects in Quebec that become operational between 2025 and 2040.

Scenario 3

In scenario 3, Quebec produces close to 12,700 million heavy-duty vehicles in 2040. In this scenario, the rate of the transition is similar to that in scenario 1. Battery production is ramped up to reach 50.5 GWh eq. of EV batteries however, only 55% of the domestic demand of battery cathode and anode materials, as well as battery minerals are supplied from projects in Quebec.

Figure 2. Historical (2010 - 2023) and projected (2024 - 2040) vehicle assembly volumes in Quebec across three production scenarios



In constructing the three scenarios, heavy-duty vehicle production forecast data was purchased from both GlobalData Automotive Production Forecast and S&P Global Automotive Production Forecast. Both datasets offered a detailed breakdown of projected vehicle production by vehicle powertrain type and size in Canada (heavy-duty vehicle production for Quebec) and across North America over the upcoming 10 to 15 years. To cover the period of this analysis, both datasets were extended till 2040.

Table 2. Assumptions for battery manufacturing in Quebec by 2040 across the three scenarios

	Scenario 1	Scenario 2	Scenario 3
Number of Battery Plants (by 2040)	2	1	2
Total Operational Battery Production Capacity (by 2040)	50.5 GWh	9.0 GWh	50.5 GWh
Cathode & Anode Manufacturing[10]	100%	10%	55%
Material Filtering[10]	100%	10%	55%
Mining[10,11]	100%	10%	55%

As for existing and potential battery manufacturing capabilities, data was collected on all announced and planned battery component and material production projects across Quebec. This information and data were used to develop the assumptions in the three scenarios of this study. Industry experts were consulted on the range and feasibility of the assumptions of each of the three scenarios.

Results & Findings

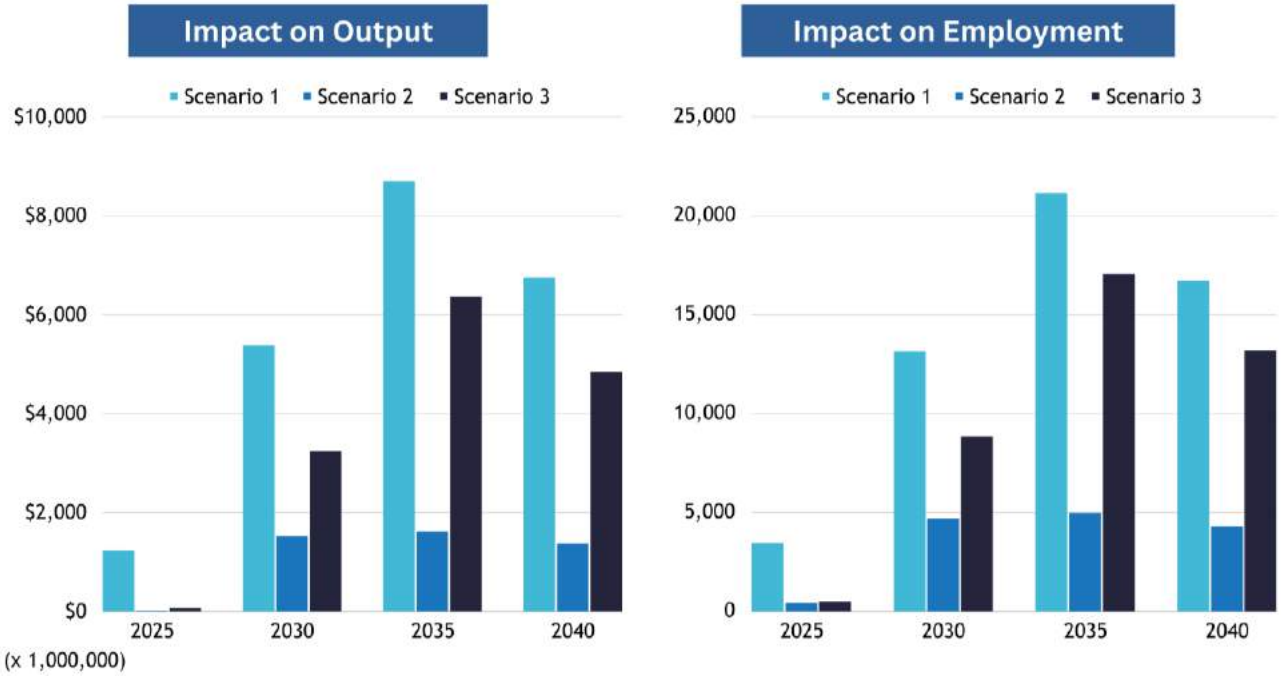
Quebec's heavy-duty truck manufacturing industry's transition towards electric bus and truck production, as well as battery manufacturing under the three scenarios presented in this report indicates varying impacts on the economy of Quebec, measured against 2022 output and employment levels.

Scenario 1 demonstrates an ambitious push towards electric bus, truck and battery production. Under this scenario, the provincial output sees growth, climbing to approximately $8.5 billion by 2035 and $6.5 billion by 2040. Employment also rises, reaching over 20,000 jobs by 2035 and over 16,000 by 2040, underlining the significant potential for job creation through aggressive EV-related investments.

In Scenario 2, a moderate shift with lesser emphasis on battery manufacturing results in a different economic footprint. In this scenario, output growth remains below $2.0 billion throughout this transition, meanwhile employment increase remains below 5,000.

[10] Of battery material upstream domestic demand.
[11] Except Cobalt.

Figure 3. Overall impact on output and employment in each of the three EV transition scenarios



Scenario 3 presents an accelerated transition towards electric bus and truck production, alongside modest battery manufacturing capacity development. This results in a moderate economic trajectory, with output increasing by around $5.0 billion by 2040. Employment growth is comparable to that of scenario 1, with approximately 14,000 jobs created by 2040.

It's important to recognize the common trend across all scenarios—a peak in provincial output and employment by 2035, followed by a marginal decline by 2040. This trend corresponds to the stabilization of battery manufacturing processes and cost reductions in battery components and materials due to enhanced production efficiency and scalability.

The specific impacts on output and employment under each scenario are detailed in Appendix E of the report, providing further analysis for 18 industries within heavy-duty truck manufacturing, battery production, and their extended supply chains.

Impact on Output

The heavy-duty truck manufacturing industry in Quebec shows an increase in output in scenario 1. By 2035 and 2040, the industry sees a substantial jump by around $850 million.

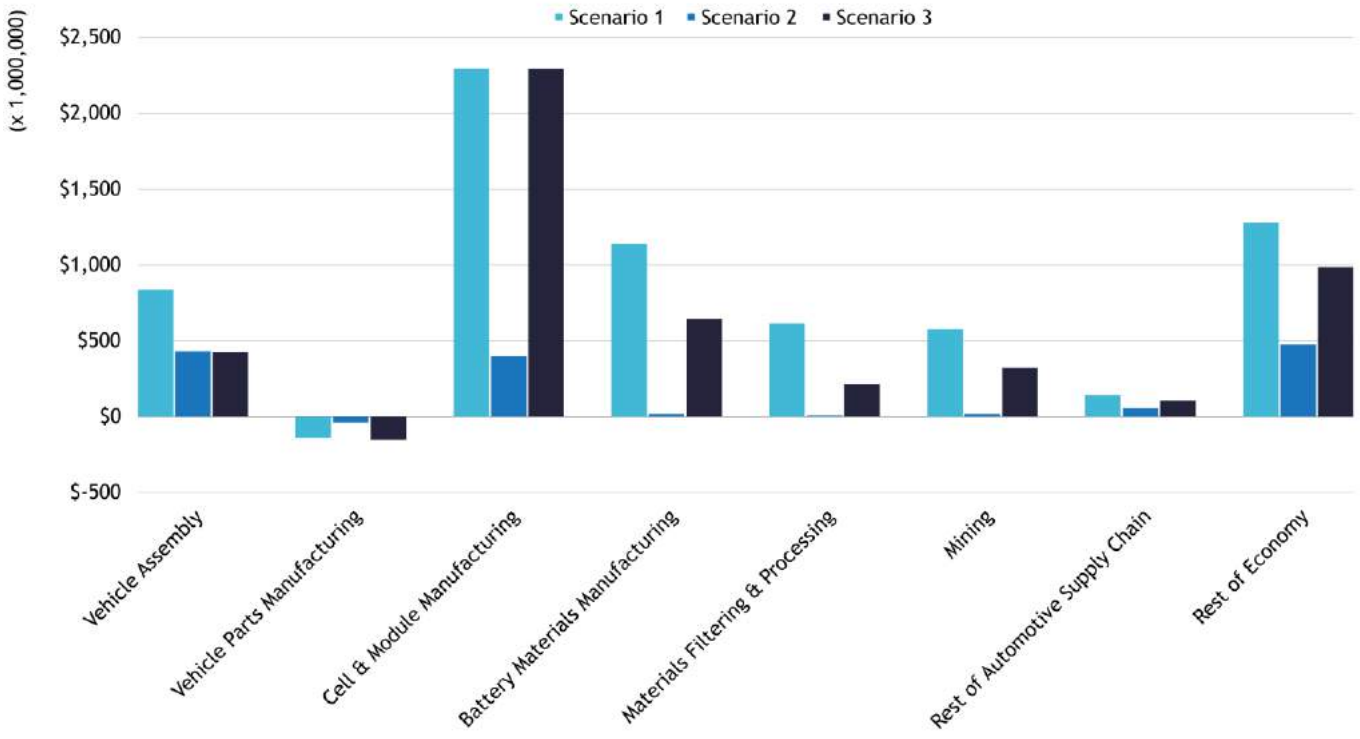
Given the relatively smaller size of Quebec's vehicle parts manufacturing industry compared to that of Ontario, minimal change in output of this industry is projected over the forecast period.

With the two battery plants assumed to come online within the forecast period in scenario 1 in Quebec, the output of the battery manufacturing industry is projected to increase by around $3.1 billion by 2035, and $2.3 billion by 2040. The slight decline in output between 2035 and 2040 can be attributed to lower battery prices, which are directly linked to scalability and productivity in manufacturing within this industry.
An increase in output is also expected for the material processing and mining industries in Quebec. The material processing industry, which consists of battery material manufacturing, as well as material processing and filtering, experiences an increase in output of around $1.7 billion by 2040. Meanwhile, the output of the mining industry is expected to grow by around $600 million by the end of the forecast period.

With the aggressive shift towards electric truck and bus production, as well as in battery manufacturing, the rest of the economy is set to benefit from an increase in activity equivalent to $1.3 billion by 2040.

In scenario 2, a less significant growth in output is expected in the heavy-duty truck manufacturing industry. The industry's output increases by around $450 million by the end of the forecast period.

Figure 4. Impact on output by 2040 in each of the three EV transition scenarios



Battery manufacturing also experiences a relatively lower increase in output of around $400 million by 2040. Minimal change is expected in the output of material processing and mining industries in this scenario. The rest of the economy only adds around $500 million in activity.

In scenario 3, heavy-duty truck manufacturing is expected to see a rise in output by around $450 million. Battery manufacturing see an increase in output of around $2.3 billion by 2040, similar to the increase in output in scenario 1 in this industry.

Material processing and mining industries in Quebec also benefit from the increase in battery production. However, at 55% of the upstream domestic demand, the material processing industry is projected to expand by $860 million by 2040 and mining by $325 million by 2040. Activity in the rest of the economy increases by around $1.0 billion by the end of the forecast period.

Impact on Employment

In scenario 1, for employment impact by 2040, the heavy-duty truck manufacturing industry is projected to add 1,460 jobs. The growth in battery manufacturing in Quebec is robust in this scenario, with an addition of around 5,950 jobs by 2040.

Material processing is expected to experience a rise in employment, with an increase of almost 1,600 jobs by 2040, while mining is set to grow by 1,000 jobs, reflecting the growing need for raw materials in battery production.

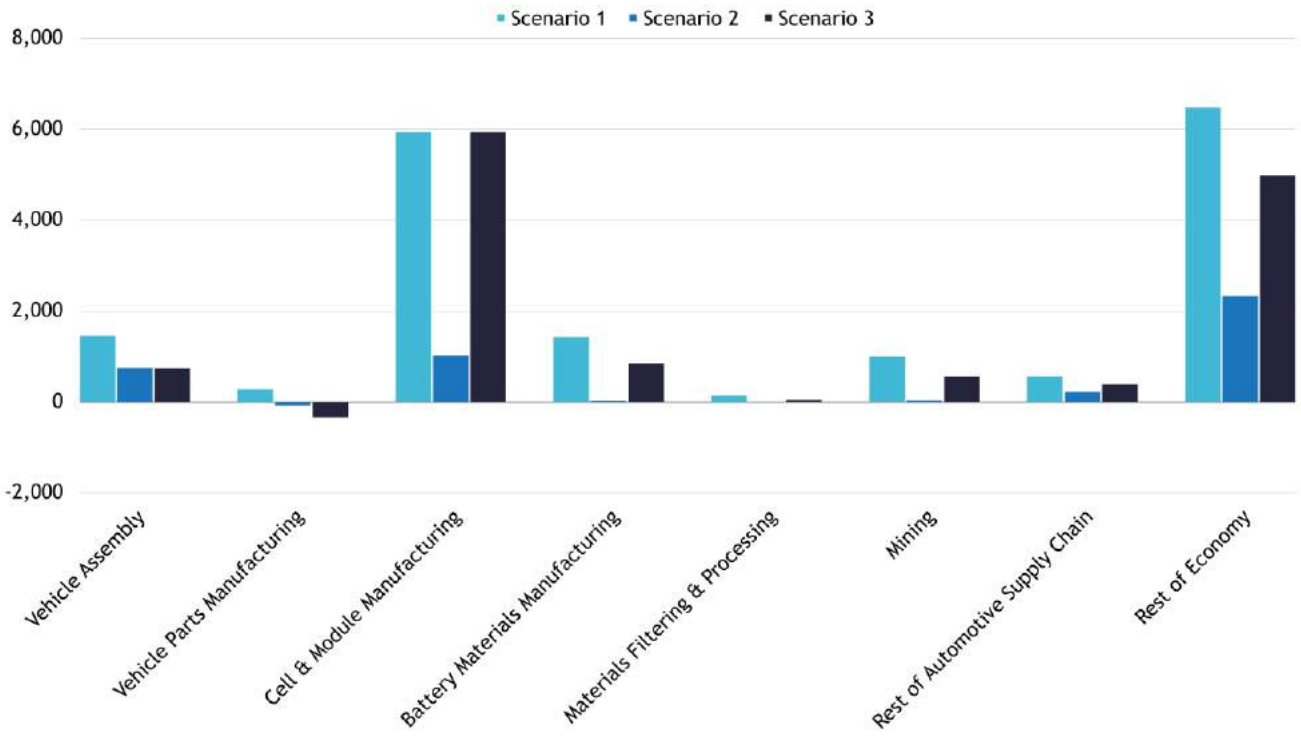
The rest of the automotive manufacturing supply chain, as well as the rest of the economy in Quebec is set to add around 7,000 jobs by the end of the forecast period in this scenario.

In scenario 2, employment projections indicate less significant changes across various industries throughout the transition period. For heavy-duty truck manufacturing, employment is expected to rise by 752 jobs by 2040.

Employment in the battery manufacturing industry also shows a less pronounced increase of 1,000 jobs by 2040. This is in line with the relatively lower capabilities of battery production in Quebec in this scenario 2.

Material processing and mining see a very minimal increase in employment, while the rest of the economy adds 2,300 jobs only.

Figure 5. Impact on employment by 2040 in each of the three EV transition scenarios



In scenario 3, the heavy-duty truck manufacturing industry expects to see a growth of 740 jobs by 2040. Similar to scenario 1, battery manufacturing is projected to experience a significant rise in employment, with a remarkable addition of around 5,950 jobs by 2040, in line with the strong investment in this industry in this scenario.

Material processing and mining are forecasted to add around 1,500 jobs by 2040, demonstrating the demand for materials, while the rest of the economy adds around 5,500 jobs.

Discussion

The analysis provided in this report delves into the transition towards electric truck and bus, and battery production within Quebec's automotive sector, offering a detailed examination of the potential economic and labour market outcomes which range between $2 billion and $6.5 billion in added output, and could create up to 16,000 jobs in the province. This transition is anticipated to have a broad and varied impact across numerous industries, extending beyond heavy-duty vehicle manufacturing, and reaching mining industries. Through the examination of three distinct scenarios, various insights into the economic impact, vehicle assembly, parts manufacturing, and battery manufacturing can be noted:

Overall Economic Impact

Scenarios 1 and 3, which both assume an accelerated shift towards BEV production, despite being at varying levels of vehicle production, suggest that Quebec's transition to EV production is crucial. Scenario 1 predicts a surge in output by over $6.8 billion and nearly 16,000 new jobs by 2040, driven by increased vehicle production, a rapid shift to battery electric trucks, and increased battery production capabilities. Scenario 3, despite anticipating lower vehicle production volumes than Scenario 1, also forecasts substantial economic benefits from the swift transition to EV production and investments in battery manufacturing. Scenario 2, illustrating a slower transition and minimal investment in battery production, underscores the risks of lagging behind in this shift to EV and battery production.

Heavy-Duty Truck Manufacturing Industry

The heavy-duty truck manufacturing industry in Quebec had an output of $1.8 billion and employed about 3,800 individuals in 2022. Across all scenarios, growth is observed by 2040, driven by various factors including increased production levels in scenario 1, and the shift to more expensive BEV production. Scenarios 2 and 3 highlight the economic potential of EV and BEV production over ICEVs, given their similar production levels but higher value output in BEV-focused manufacturing.

Automotive Parts Manufacturing Industry

Given the size of Quebec's vehicle parts manufacturing industry relative to Ontario's, despite some losses in this industry, minimal changes in output and employment are observed in this industry in Quebec as a result of the shift to vehicle electrification.

Battery Manufacturing

The battery manufacturing industry is poised for significant growth in Quebec, fueled by investments in battery cell and module manufacturing. This growth is reflected in a potential increase in output ranging from $400 million (Scenario 2) to $2.3 billion (Scenarios 1 & 2) by 2040, and a similar trend in employment growth. This expansion underscores the industry's potential to significantly contribute to the economy.

Battery Materials Manufacturing, Filtering and Mining

Investments in expanding domestic capabilities within the battery manufacturing supply chain are expected to benefit several industries, leading to substantial growth in output and employment in chemical manufacturing, material manufacturing, and mining sectors. Scenario 1, in particular, demonstrates the potential for over $2.3 billion in output and the addition of more than 2,600 jobs by 2040 in these industries.

The analysis in Quebec suggests that due to its smaller vehicle parts manufacturing industry, the economy is set to observe less pronounced losses as a result of the shift to electric vehicle and battery production in its automotive manufacturing industry. More importantly, the industry in Quebec, specifically the heavy-duty vehicle manufacturing industry, is not expected to fully shift to BEV production in any of the scenarios outlined in this report. Due to the size of the vehicles, the advancement of vehicle and battery technology (especially relating to range), and the overall lifetime of vehicles, a slower transition is anticipated in the heavy-duty truck manufacturing industry.

This shift to vehicle electrification and battery manufacturing will translate to a growth in economic activity within the automotive sector, specifically within emerging EV-related industries. Support for businesses and workers to adapt to this changing landscape, including retooling operations, upgrading machinery and upskilling workers, is crucial to navigate this transition successfully. The significant potential for economic and job growth in the battery manufacturing supply chain further suggests the need for a strategic approach at national or provincial levels to manage this transition effectively, incentivizing investment and growth in beyond vehicle and battery production.

Figure 6. Change in output and employment by 2040 relative to 2022 base levels

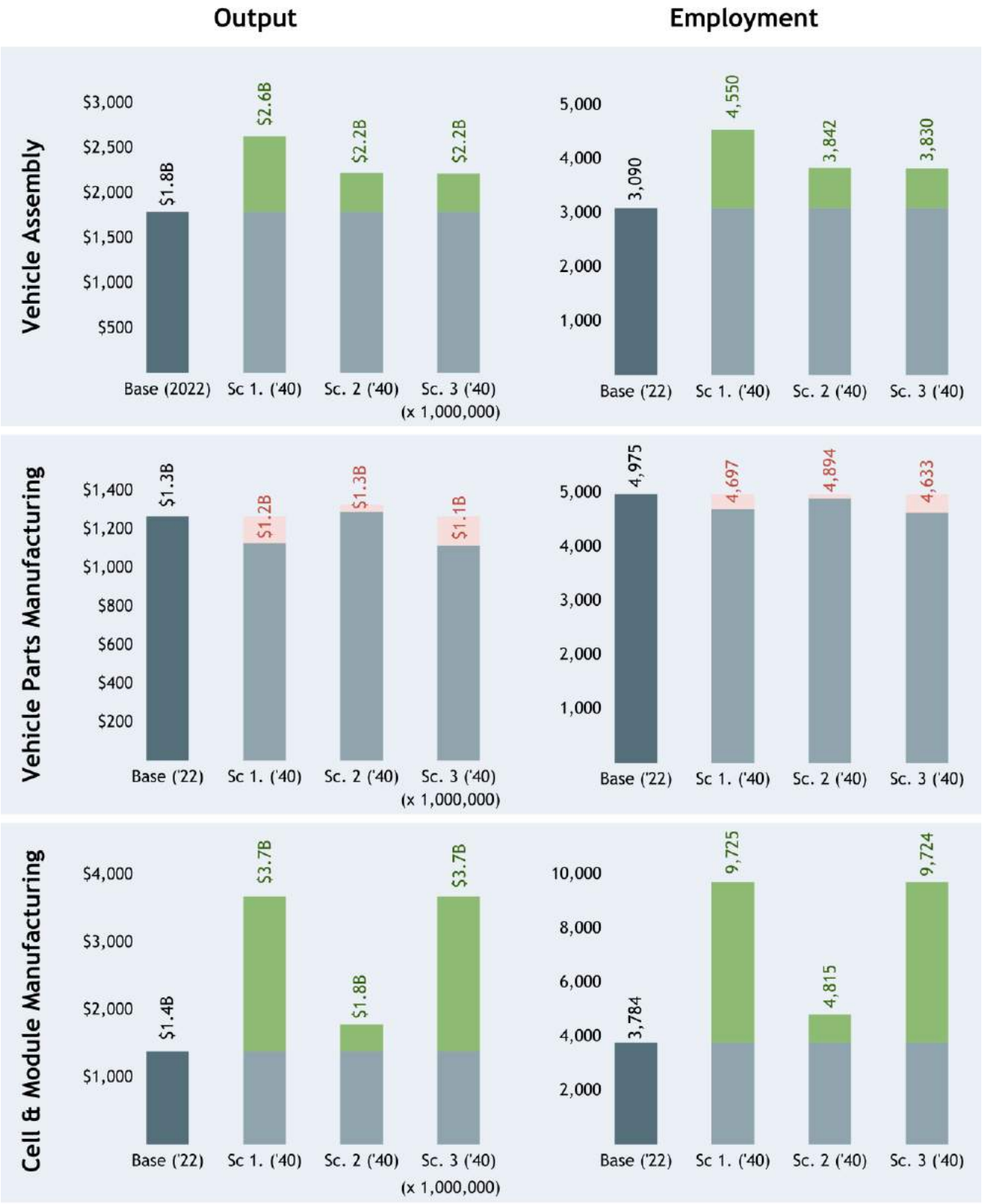
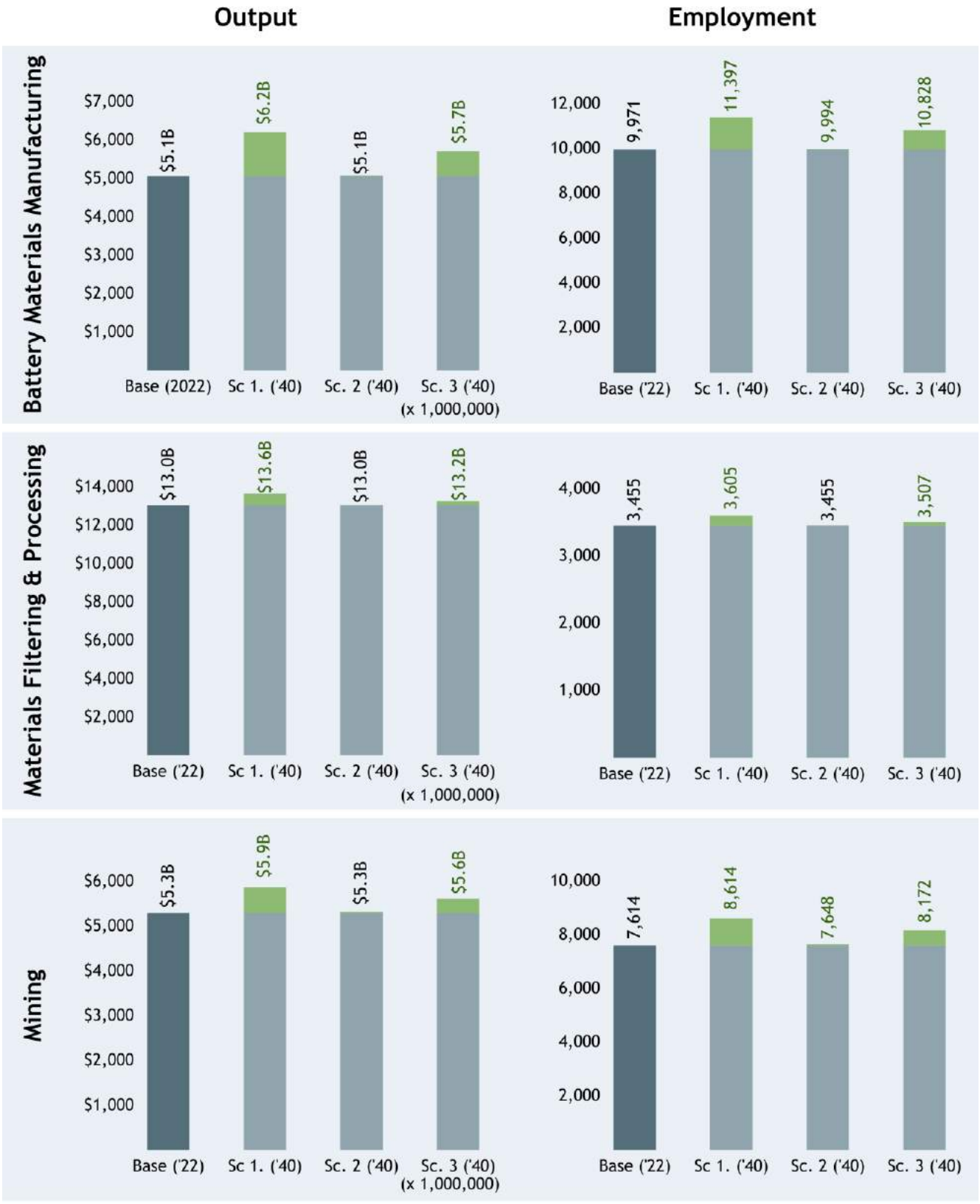


Figure 7. Change in output and employment by 2040 relative to 2022 base levels (cont'd)

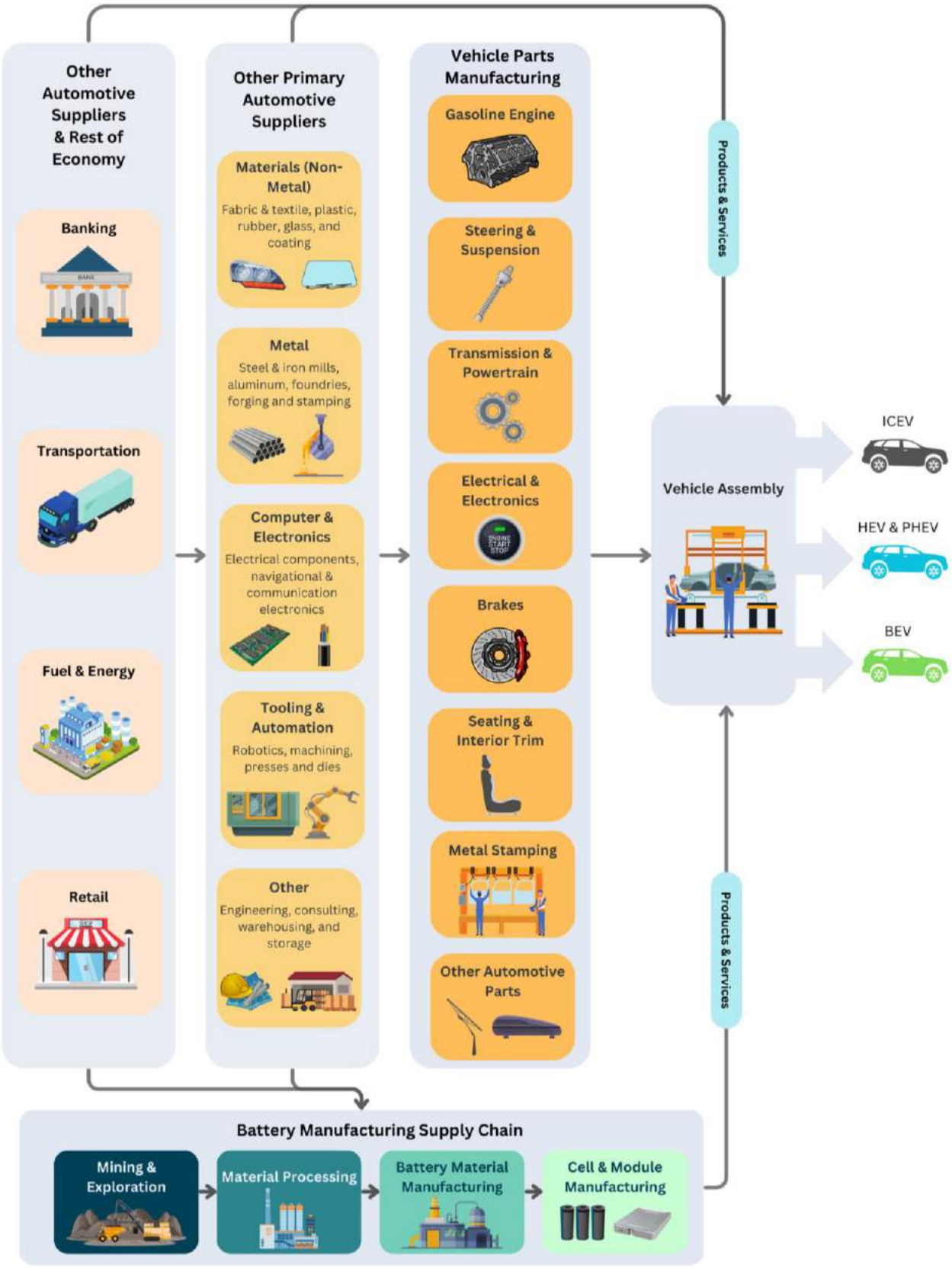


Concluding Remarks

From the analysis presented in this report, it is evident that this shift to EVs in Quebec's heavy-duty vehicle manufacturing industry will bring growth within and beyond this industry, extending to the overall economy. As the sector moves away from ICEV production, there is a need for significant technological adaptation, workforce reskilling and transitioning, and supply chain realignment. With these efforts, the immense potential for economic growth, job creation, and environmental sustainability for Quebec and Canada can be translated.

This report explored the various aspects of this shift, and in its scenarios accounted for the different potential outcomes of this transition. The results of this analysis demonstrated a significant output growth and job creation potential in Quebec and Canada if the automotive manufacturing sector is successful in expanding its vehicle and battery manufacturing capacities. The results also indicate that Quebec's economy, particularly its heavy-duty vehicle and battery manufacturing industries, have a lot at stake in this transition. The success of this transition is bound to multiple factors, including Quebec winning new production mandates, ramping up domestic battery production capacity, and sourcing the required battery components and materials.

Appendix A. Schematic of the Automotive & Battery Manufacturing Supply Chains



Appendix B. Detailed EV Impact Analysis Methodology

To forecast the economic and labour market impacts of transitioning to EV production and battery manufacturing in Quebec, an EV forecast model was developed. This model employs a two-step methodology and utilizes various analytical tools. The first step involves estimating the output and purchasing patterns of a select number of key industries within the automotive and battery manufacturing and their supply chains. For this, a model was developed in Microsoft Excel which incorporates technical and economic data drawn from multiple sources. After estimating the output and purchasing patterns of these industries, the second step entails utilizing the IMPLAN Economic Software to assess the direct, indirect, and induced impacts of transitioning to EV production and battery manufacturing. This assessment spans over 230 industries in Quebec's economy. The results yield two key economic indicators, the impact on output and impact on employment. The changes in output and employment are quantified and presented in five-year intervals, covering the period from 2025 to 2040. In the sections below, the structure of the EV forecast model is detailed.

Overview of Canadian Input-Output Tables

Input-Output (I-O) Tables are an integral part of the country and province's economic analysis tools, developed and maintained by Statistics Canada. These tables provide a comprehensive overview of the economic transactions between different sectors and industries within the economy. They track how outputs from one industry become inputs for another, offering insights into the interconnected nature of industries, sectors, and the whole economy. I-O tables are organized into a multi-level structure, ranging from high-level aggregates to detailed sector-specific data (levels L, M, H, and D)[12]. This structure allows for various degrees of analysis, from broad overviews of economic relationships to in-depth sectoral studies.

The level D I-O table represents the most detailed tier in the four-level structure of I-O tables, offering granular data on economic transactions. It includes 236 industries and approximately 500 commodities, enabling analysts to examine the intricate economic interactions with a high degree of specificity.

Detailed Cost Structure Analysis using I-O Tables

In the context of the automotive manufacturing sector's shift from the production of ICEVs to EVs, the level D I-O table is a valuable resource. It allows for the analysis of how changes in the

[12] I-O tables are organized into a multi-level structure. Level L (Lowest Level of Aggregation) offers a broad macroeconomic overview with the economy aggregated into a few large sectors; Level M (Medium Level of Aggregation) provides a medium level of detail, breaking the economy into more sectors; Level H (High Level of Aggregation) offers a higher level of detail with an increased number of sectors; and Level D (Detailed Level of Aggregation) presents the most granular view, detailing the economy into hundreds of specific sectors for in-depth analysis.

production of the automotive sector influence related industries, such as parts manufacturing (especially ICE production), battery production, chemical manufacturing and mining.

In this study, the 2019 I-O level D table was utilized to derive a detailed cost structure breakdown of an average vehicle produced in Quebec. By analyzing the I-O table, the input values or purchasing pattern of heavy-duty truck manufacturing (NAICS 336120) from each of the 236 industries in the I-O table was determined. These values were then divided by the total number of trucks and buses produced in Quebec in 2019 to obtain the average production cost, as well as the average input values contributed by each of the 236 industries on a per vehicle basis. Given that the predominant type of vehicle manufactured by heavy-duty vehicle manufacturers in 2019 was the ICEV, the cost structure obtained primarily reflects that of a Canadian-produced ICEV truck/bus.

Subsequently, to obtain the production costs and the cost structures of HEVs and BEVs, adjustments were made to these input values or purchasing pattern on a per vehicle basis. These adjustments took into account the different manufacturing requirements, and part and component costs specific to HEVs and BEVs. This included considerations heavy-duty battery electric trucks with an average battery capacity of 500 kWh[13]. Other components were also added to these vehicles including inverters, converters, high-voltage wires and power control units where applicable. The adjustments also took into account the lower ICEV-specific content in HEVs, and their absence in BEVs. For BEVs, any purchases of ICE-specific components such as pistons, mufflers, and fuel tanks were eliminated from the cost structure of the vehicle. Component cost and technical details on the vehicle were obtained from multiple sources including United States Department of Energy's Battery Performance and Cost Estimation (BatPaC) modeling tool[14], Munro's vehicle cost breakdown data[15], and UBS's Evidence Lab Electric Car Teardown[16].

It is important to note that the production costs and the cost structures of battery electric vehicles, vary significantly over time. The price per kWh of battery systems, in particular, has experienced fluctuations, influenced by advancements in battery technology, economies of scale in production, and changes in raw material costs. Looking ahead, it is expected that the price per kWh of battery packs will continue to decline significantly in the coming years. This price variability underscores the importance of accounting for the variations of battery and other vehicle component costs into production cost forecasts for each vehicle type. Such considerations are critical in understanding the impact of producing a mix of these vehicles on Quebec's automotive manufacturing sector. Therefore, in FOCAL's EV forecast model, the changes in component and part prices are accounted for as a function of time, ensuring a

[13] Module pricing is assumed for purchases made by the vehicle assembly industry from the battery manufacturing industry.
[14] Argonne National Laboratory (ANL) (2022). Battery Performance and Cost Modeling for Electric- Drive Vehicles (BatPaC).
[15] Munro & Associates (2020). *BMW i3 Cost Analysis*.
[16] UBS (2017). *UBS Evidence Lab Electric Car Teardown – Disruption Ahead?*

comprehensive and dynamic approach to the economic modeling of the sector and the supply chain.
For the purpose of this study, the battery pack assembly stage was assumed to be part of the vehicle assembly stage (the heavy-duty vehicle manufacturing industry). Therefore, the cost structure of each vehicle type (and consequently, the purchases of the vehicle assembly industry) includes purchases of battery thermal and power management systems, battery jackets, and heating systems.

Working backward through the automotive and battery manufacturing supply chains, adjustments were made to the purchasing patterns of the battery manufacturing industry (NAICS 335910). To determine the necessary material purchases per unit, cost structures for both battery cells and battery modules were developed. Based on technical data of battery cell composition, four distinct cost structures were developed, each corresponding to different chemical compositions: NCA, NMC622, NMC811, and LFP. These cost structures encompass components and materials for positive and negative electrodes, current collectors, separators, and cell containers, which are common across all battery cell variations. In the case of battery modules, the cost structure accounts for components such as enclosures, power regulators, and thermal conductors.

Finally, adjustments were made to the purchasing pattern of the cathode manufacturing industry (NAICS 325180) to account for the purchases of filtered material from the material refining industry (NAICS 331410), as well as to the purchasing patterns of the anode manufacturing industry (NAICS 327990) and the material refining industry (NAICS 331410) to account for purchases from the mining sector (primarily industry NAICS 212232, 212299 and 212398).

Estimating Industry Outputs and Purchasing Patterns

Using the adjusted purchasing patterns of the automotive and battery manufacturing supply chain industries, coupled with assumptions on domestic production levels within each of the identified industries (such as the number of vehicles produced, the manufacturing volume of battery cells and modules, and the tonnes of cathode material processed – discussed in section), it is possible to estimate the total output and purchasing pattern of each of the industries within the supply chain.

For the vehicle assembly industry, the total output was estimated for each year between 2025 and 2040 by summing the products of the total number of vehicles produced (by vehicle powertrain type and size) and their respective projected total production costs. Vehicle production forecasts by powertrain types and size were derived from various projections and sources, including S&P and LMC. Since some of these projections only reached up to 2030 or 2035, it was necessary to extend the forecasts to 2040 to cover the full duration of this study's impact analysis. To extend these forecasts up to the year 2040, data extrapolation was employed using a curve-fitting method. This approach allowed for a more comprehensive and long-term projection, taking into account emerging trends and market dynamics anticipated to influence the

automotive manufacturing sector over the upcoming two decades. Furthermore, using the volume of vehicles produced (by vehicle powertrain type and size) and their respective purchasing patterns, it is possible to estimate the total value of purchases made by the vehicle assembly industry from all other industries, along with the overall purchasing pattern of the industry.

The total output of the battery manufacturing industry (NAICS 335910) was estimated by considering a set of assumptions in each of the three scenarios. The assumptions include the number of operational battery plants, their individual production capacities, the year production commences for each plant, and the time needed for each plant to reach its operational capacity. The output of the industry also factored in the average price per kWh of batteries for each year, the proportion of battery cells to modules produced, as well as the market share distribution among various chemical compositions of the batteries manufactured. The total output of the battery manufacturing industry is calculated by combining the average price of each cell and module variation with the production volumes of cells and modules. This approach integrates detailed pricing and production data to accurately reflect the industry's output.

Using the developed cost structures of both battery cells and modules, it is possible to calculate the domestic economic output within each industry in the battery manufacturing supply chain (including cathode manufacturing industry (NAICS 325180), anode manufacturing industry, (NAICS 327990), material refining industry (NAICS 331410), and mining (NAICS 212232, 212299 and 212398). The economic output for each of these industries is estimated based on their assumed domestic production capacities in each scenario.

Application of IMPLAN in Measuring Broader Industry Impacts

IMPLAN (Impact Analysis for Planning) is an economic modeling system used to estimate the ripple effects of economic changes in a given area. It is a tool that can be used to assess the direct, indirect, and induced impacts[17] of economic activities on industries within a specific sector or geographic region. In the context of Quebec's automotive and battery manufacturing industry's transition from ICEVs to EVs, IMPLAN can play a key role in analyzing and forecasting the full economic and employment impacts.

Utilizing the projected total outputs and the adjusted purchasing patterns developed for the industries within automotive and battery manufacturing, IMPLAN can offer insights into how

[17] Direct impacts refer to the immediate effects of changes in industries. These impacts are the primary outcomes of an industry's activities, such as the creation of jobs, the generation of output (products or services), and the revenue earned by the businesses in the sector. Indirect impacts encompass the secondary effects experienced by the supply chain linked to the primary industry. These are the ripple effects that occur as a result of the interdependencies between industries. For instance, a boost in production in one sector may increase demand for raw materials or components from suppliers, thus impacting various upstream industries. Induced impacts are the tertiary economic effects generated by the spending of incomes earned in the direct and indirect phases. These impacts occur when employees in the primary and secondary industries spend their wages on goods and services in the wider economy.

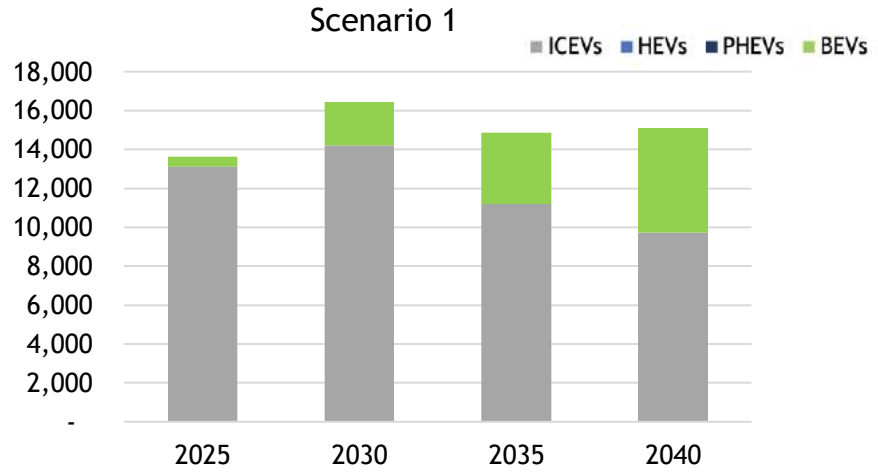
shifts towards EV and battery production will impact the broader economy. By inputting the data on the projected outputs and purchasing patterns, IMPLAN can estimate the direct, indirect and induced economic and labour market implications across 234 industries in Quebec's economy.

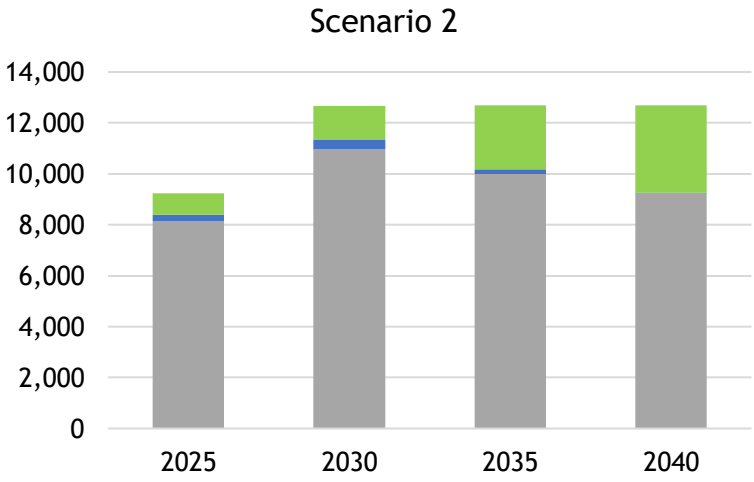
The table below maps the industries of the automotive and battery manufacturing industries to their respective North American Industry Classification System (NAICS) codes, Input-Output Industry Classification (IOIC) codes, and IMPLAN Industry codes.

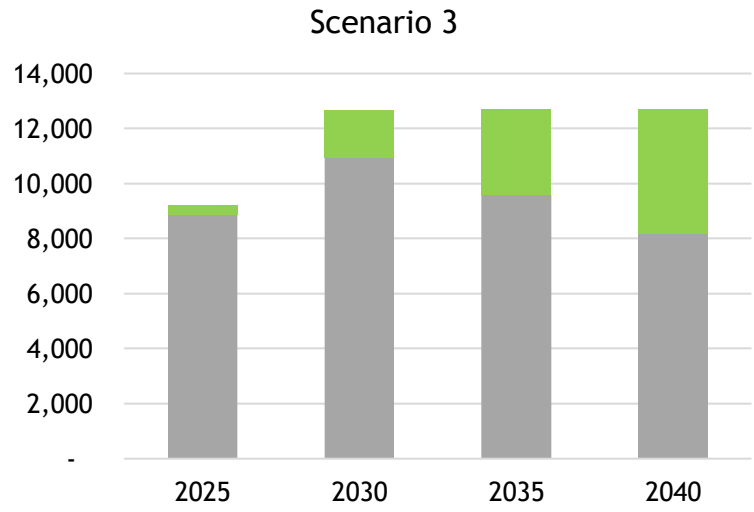
Industry	North American Industry Classification System (NAICS) Code	Input - Output Industry Classification (IOIC) Code	Industry IMPLAN Code
Vehicle Assembly			
Light-Duty Vehicle Assembly	336110 - Automobile and Light-Duty Motor Vehicle Manufacturing	BS336110	99
Heavy-Duty Bus and Truck Manufacturing	336120 - Heavy-Duty Truck Manufacturing	BS336120	100
Vehicle Parts Manufacturing			
Gasoline Engine Manufacturing	336310 - Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	BS336310	102
Vehicle Electrical and Electronics Component	336320 - Motor Vehicle Electrical and Electronic Equipment Manufacturing	BS336320	103
Steering and Suspension Parts Manufacturing	336330 - Motor Vehicle Steering and Suspension Components (Except Spring) Manufacturing	BS336330	104
Vehicle Brakes Manufacturing	336340 - Motor Vehicle Brake System Manufacturing	BS336340	105
Transmission and Powertrain Manufacturing	336350 - Motor Vehicle Transmission and Powertrain Parts Manufacturing	BS336350	106
Seat and Trim Manufacturing	336360 - Motor Vehicle Seating and Interior Trim Manufacturing	BS336360	107
Motor Vehicle Metal Stamping	336370 - Motor Vehicle Metal Stamping	BS336370	108
Other motor vehicle parts manufacturing	336390 - Other Motor Vehicle Parts Manufacturing	BS336390	109

Battery Manufacturing			
Battery Cell & Module Manufacturing	335910 - Battery manufacturing	BS335900	98
Battery Material Manufacturing / Chemical Manufacturing			
Cathode & Precursor Cathode Manufacturing	325180 - Other basic inorganic chemical manufacturing	BS325100	60
Anode Manufacturing	327990 - All other non-metallic mineral product manufacturing	BS327A00	69
Material Processing & Filtering			
Material Refining	3314 - Non-ferrous metal (except aluminum) smelting and refining	BS331400	74
Mining			
Iron Ore Mining	212210 - Iron Ore Mining	BS212210	14
Nickel Mining	212232 - Nickel-Copper Ore Mining	BS212230	16
Lithium, Cobalt and Manganese Mining	212299 - All Other Metal Ore Mining	BS212290	17
Graphite Mining	212398 - All other non-metallic mineral mining and quarrying	BS21239A	21

Appendix C. Detailed Vehicle Production Assumptions Across Three EV Transition Scenarios







Appendix D. Detailed Battery Manufacturing Assumptions Across Three EV Transition Scenarios

	Scenario 1	Scenario 2	Scenario 3
Battery Production Capacity (by 2040)	67.5 GWh	30 GWh	67.5 GWh
Number of Battery Plants (by 2040)	2	1	2
Peak Operational Capacity of Battery Plant	75%	30%	75%
Years to Ramp Up Battery Production	5	5	5
Operational Battery Production Capacity (by 2040)	50.5 GWh	9.0 GWh	50.5 GWh
Individual Battery Plant Production Capacity & Year Plant Commences Production	Plant 1 (2028): 30 GWh Plant 2 (2031): 38 GWh	Plant 1 (2028): 30 GWh	Plant 1 (2028): 30 GWh Plant 2 (2031): 38 GWh
Cathode & Anode Production[18]	100%	10%	55%
Material Processing & Filtering[18]	100%	10%	55%
Mining[18,19]	100%	10%	55%
Cobalt Mining	25%	10%	25%

[18] Of battery material upstream domestic demand.

[19] Except Cobalt.

Appendix E. Detailed Output and Employment Impacts of the Three EV Transition Scenarios

Scenario 1

		Change in Output			
	Industry	2025	2030	2035	2040
Vehicle Assembly	**Automobile and light-duty motor vehicle manufacturing**	$ 862	$ 2,691	$ 4,114	$ 3,302
	Heavy-duty truck manufacturing	$ 634,843,733	$ 1,141,969,024	$ 840,076,091	$ 839,192,257
Vehicle Parts Manufacturing	Gasoline engine and engine parts manufacturing	$ (21,081,873)	$ (73,541,003)	$ (145,742,976)	$ (157,273,677)
	Electrical and electronic equipment manufacturing	$ 5,243,608	$ 11,601,407	$ 7,692,680	$ 7,074,969
	Steering and suspension components manufacturing	$ 2,505	$ 120,799	$ 89,642	$ 91,466
	Brake system manufacturing	$ (105,588)	$ (3,015)	$ (24,574)	$ (24,411)
	Transmission and power train parts manufacturing	$ 376,825	$ 844,346	$ 418,023	$ 348,556
	Seating and interior trim manufacturing	$ 7,129,939	$ 2,825,041	$ 1,303,781	$ 1,403,389
	Motor vehicle metal stamping	$ (200,237)	$ 262,308	$ 91,225	$ 182,569
	Other motor vehicle parts manufacturing	$ 6,892,877	$ 11,476,497	$ 8,366,861	$ 8,607,850
	Total Vehicle Parts Manufacturing	$ (1,741,944)	$ (46,413,620)	$ (127,805,338)	$ (139,589,289)
Battery Manufacturing	Other electrical equipment and component manufacturing	$ 2,825,918	$ 1,142,362,981	$ 3,141,848,376	$ 2,295,097,124
	Total Battery Manufacturing	$ 2,825,918	$ 1,142,362,981	$ 3,141,848,376	$ 2,295,097,124
Material Processing	Basic chemical manufacturing	$ 688,005	$ 464,684,597	$ 1,277,345,962	$ 933,824,002
	Non-metallic mineral product manufacturing	$ 3,550,075	$ 79,768,254	$ 214,852,485	$ 204,670,499
	Non-ferrous metal production and processing	$ 64,908,595	$ 621,035,240	$ 841,578,286	$ 615,647,146
	Total Material Processing	$ 69,146,675	$ 1,165,488,091	$ 2,333,776,733	$ 1,754,141,647
Mining	Iron ore mining	$ 136,624	$ 172,338	$ 157,314	$ 154,323
	Copper, nickel, lead and zinc ore mining	$ 6,921,657	$ 67,478,268	$ 87,210,305	$ 63,758,063
	Other metal ore mining	$ 50,213,971	$ 577,942,266	$ 627,324,082	$ 458,524,307
	Other non-metallic mineral mining and quarrying	$ 6,130,099	$ 59,752,733	$ 75,885,551	$ 55,585,485
	Total Mining	$ 63,402,351	$ 705,345,605	$ 790,577,252	$ 578,022,178
Rest of Automotive Supply Chain	**Total Rest of Automotive Supply Chain**	$ 68,653,626	$ 143,441,678	$ 185,196,939	$ 145,373,199
Rest of Economy	**Total Rest of Economy**	$ 404,137,325	$ 1,132,990,338	$ 1,532,080,583	$ 1,282,677,050
Total		$ 1,241,268,546	$ 5,385,186,788	$ 8,695,754,750	$ 6,754,917,468

		Change in Employment			
	Industry	2025	2030	2035	2040
Vehicle Assembly	**Automobile and light-duty motor vehicle manufacturing**	-	-	-	-
	Heavy-duty truck manufacturing	1,104	1,987	1,462	1,460
Vehicle Parts Manufacturing	Gasoline engine and engine parts manufacturing	(48)	(166)	(328)	(354)
	Electrical and electronic equipment manufacturing	26	57	38	35
	Steering and suspension components manufacturing	-	-	-	-
	Brake system manufacturing	(2)	(1)	(1)	(1)
	Transmission and power train parts manufacturing	10	24	11	9
	Seating and interior trim manufacturing	26	10	4	5
	Motor vehicle metal stamping	(1)	-	-	-
	Other motor vehicle parts manufacturing	23	38	27	28
	Total Vehicle Parts Manufacturing	34	(38)	(249)	(278)
Battery Manufacturing	Other electrical equipment and component manufacturing	7	2,957	8,133	5,941
	Total Battery Manufacturing	7	2,957	8,133	5,941
Material Processing	Basic chemical manufacturing	-	362	995	727
	Non-metallic mineral product manufacturing	12	272	734	699
	Non-ferrous metal production and processing	15	152	206	150
	Total Material Processing	27	786	1,935	1,576
Mining	Iron ore mining	-	-	-	-
	Copper, nickel, lead and zinc ore mining	9	95	123	90
	Other metal ore mining	72	837	909	664
	Other non-metallic mineral mining and quarrying	27	265	337	246
	Total Mining	108	1,197	1,369	1,000
Rest of Automotive Supply Chain	**Total Rest of Automotive Supply Chain**	286	588	696	559
Rest of Economy	**Total Rest of Economy**	1,907	5,678	7,787	6,485
Total		3,473	13,155	21,133	16,743

Scenario 2

		Change in Output			
	Industry	2025	2030	2035	2040
Vehicle Assembly	**Automobile and light-duty motor vehicle manufacturing**	$ 208	$ 1,024	$ 1,075	$ 955
	Heavy-duty truck manufacturing	$ (118,976,424)	$ 471,788,181	$ 462,589,379	$ 432,232,503
Vehicle Parts Manufacturing	Gasoline engine and engine parts manufacturing	$ (15,337,610)	$ (24,784,879)	$ (38,812,703)	$ (43,073,845)
	Electrical and electronic equipment manufacturing	$ (3,887,707)	$ 3,258,006	$ 2,862,400	$ 2,149,477
	Steering and suspension components manufacturing	$ (21,196)	$ 45,776	$ 45,032	$ 44,157
	Brake system manufacturing	$ (108,328)	$ (60,269)	$ (60,767)	$ (61,475)
	Transmission and power train parts manufacturing	$ (566,755)	$ 116,677	$ 41,719	$ (20,877)
	Seating and interior trim manufacturing	$ (4,047,962)	$ (799,178)	$ (833,971)	$ (877,163)
	Motor vehicle metal stamping	$ (788,012)	$ (292,367)	$ (252,273)	$ (224,231)
	Other motor vehicle parts manufacturing	$ (1,777,693)	$ 4,527,623	$ 4,431,137	$ 4,366,702
	Total Vehicle Parts Manufacturing	$ (26,535,259)	$ (17,988,609)	$ (32,579,421)	$ (37,697,250)
Battery Manufacturing	Other electrical equipment and component manufacturing	$ (569,048)	$ 450,995,647	$ 549,626,356	$ 398,528,540
	Total Battery Manufacturing	$ (569,048)	$ 450,995,647	$ 549,626,356	$ 398,528,540
Material Processing	Basic chemical manufacturing	$ 143,645	$ 18,851,242	$ 22,946,938	$ 16,525,296
	Non-metallic mineral product manufacturing	$ (508,447)	$ 3,906,522	$ 4,575,442	$ 3,507,469
	Non-ferrous metal production and processing	$ 2,100,091	$ 11,173,571	$ 12,972,260	$ 9,989,690
	Total Material Processing	$ 1,735,289	$ 33,931,335	$ 40,494,640	$ 30,022,455
Mining	Iron ore mining	$ 54,270	$ 107,345	$ 107,011	$ 109,275
	Copper, nickel, lead and zinc ore mining	$ 261,129	$ 2,938,209	$ 3,064,103	$ 2,240,843
	Other metal ore mining	$ 2,099,652	$ 21,192,330	$ 21,846,812	$ 15,867,965
	Other non-metallic mineral mining and quarrying	$ 272,401	$ 2,438,682	$ 2,506,820	$ 1,833,981
	Total Mining	$ 2,687,452	$ 26,676,566	$ 27,524,746	$ 20,052,064
Rest of Automotive Supply Chain	**Total Rest of Automotive Supply Chain**	$ 5,881,687	$ 65,230,064	$ 64,257,391	$ 56,822,633
Rest of Economy	**Total Rest of Economy**	$ 158,551,517	$ 494,564,102	$ 507,535,243	$ 476,147,172
Total		$ 22,775,422	$ 1,525,198,310	$ 1,619,449,409	$ 1,376,109,072

		Change in Employment			
	Industry	2025	2030	2035	2040
Vehicle Assembly	**Automobile and light-duty motor vehicle manufacturing**	-	-	-	-
	Heavy-duty truck manufacturing	(208)	821	805	752
Vehicle Parts Manufacturing	Gasoline engine and engine parts manufacturing	(35)	(56)	(88)	(97)
	Electrical and electronic equipment manufacturing	(20)	16	14	10
	Steering and suspension components manufacturing	(1)	-	-	-
	Brake system manufacturing	(2)	(2)	(2)	(2)
	Transmission and power train parts manufacturing	(17)	3	1	(1)
	Seating and interior trim manufacturing	(16)	(4)	(4)	(4)
	Motor vehicle metal stamping	(2)	(1)	(1)	(1)
	Other motor vehicle parts manufacturing	(6)	15	14	14
	Total Vehicle Parts Manufacturing	(99)	(29)	(66)	(81)
Battery Manufacturing	Other electrical equipment and component manufacturing	(2)	1,167	1,422	1,031
	Total Battery Manufacturing	(2)	1,167	1,422	1,031
Material Processing	Basic chemical manufacturing	-	14	17	12
	Non-metallic mineral product manufacturing	(2)	13	15	11
	Non-ferrous metal production and processing	-	2	3	2
	Total Material Processing	(2)	29	35	25
Mining	Iron ore mining	-	-	-	-
	Copper, nickel, lead and zinc ore mining	-	4	4	3
	Other metal ore mining	3	30	31	23
	Other non-metallic mineral mining and quarrying	1	10	11	8
	Total Mining	4	44	46	34
Rest of Automotive Supply Chain	**Total Rest of Automotive Supply Chain**	22	259	252	230
Rest of Economy	**Total Rest of Economy**	735	2,428	2,497	2,333
Total		450	4,719	4,991	4,324

Scenario 3

		Change in Output			
	Industry	2025	2030	2035	2040
Vehicle Assembly	**Automobile and light-duty motor vehicle manufacturing**	**$ 226**	**$ 1,804**	**$ 3,284**	**$ 2,578**
	Heavy-duty truck manufacturing	**$ (137,096,354)**	**$ 475,742,085**	**$ 463,525,820**	**$ 425,550,414**
Vehicle Parts Manufacturing	Gasoline engine and engine parts manufacturing	$ (22,280,271)	$ (74,508,600)	$ (146,242,890)	$ (157,756,859)
	Electrical and electronic equipment manufacturing	$ (4,313,215)	$ 3,325,802	$ 3,030,377	$ 2,057,651
	Steering and suspension components manufacturing	$ (19,532)	$ 46,902	$ 47,331	$ 44,836
	Brake system manufacturing	$ (106,935)	$ (57,556)	$ (56,697)	$ (59,127)
	Transmission and power train parts manufacturing	$ (531,575)	$ 89,281	$ 3,099	$ (96,008)
	Seating and interior trim manufacturing	$ (3,965,668)	$ (753,920)	$ (740,404)	$ (853,391)
	Motor vehicle metal stamping	$ (816,178)	$ (284,591)	$ (229,322)	$ (183,985)
	Other motor vehicle parts manufacturing	$ (1,623,170)	$ 4,528,524	$ 4,427,755	$ 4,244,375
	Total Vehicle Parts Manufacturing	**$ (33,656,544)**	**$ (67,614,158)**	**$ (139,760,751)**	**$ (152,602,508)**
Battery Manufacturing	Other electrical equipment and component manufacturing	$ (570,098)	$ 1,142,218,675	$ 3,141,727,770	$ 2,294,986,634
	Total Battery Manufacturing	**$ (570,098)**	**$ 1,142,218,675**	**$ 3,141,727,770**	**$ 2,294,986,634**
Material Processing	Basic chemical manufacturing	$ 200,248	$ 255,801,562	$ 703,459,910	$ 514,271,766
	Non-metallic mineral product manufacturing	$ (471,717)	$ 43,544,797	$ 118,290,268	$ 133,779,568
	Non-ferrous metal production and processing	$ 34,210,411	$ 188,309,413	$ 293,021,845	$ 214,377,774
	Total Material Processing	**$ 33,938,942**	**$ 487,655,772**	**$ 1,114,772,023**	**$ 862,429,108**
Mining	Iron ore mining	$ 55,723	$ 113,319	$ 120,765	$ 115,534
	Copper, nickel, lead and zinc ore mining	$ 3,763,348	$ 37,102,940	$ 48,667,280	$ 35,577,420
	Other metal ore mining	$ 28,046,939	$ 275,567,898	$ 351,899,850	$ 257,207,618
	Other non-metallic mineral mining and quarrying	$ 3,373,798	$ 59,710,710	$ 41,769,593	$ 30,645,023
	Total Mining	**$ 35,239,808**	**$ 372,494,867**	**$ 442,457,488**	**$ 323,545,595**
Rest of Automotive Supply Chain	**Total Rest of Automotive Supply Chain**	**$ 5,325,380**	**$ 87,144,117**	**$ 146,497,031**	**$ 106,825,298**
Rest of Economy	**Total Rest of Economy**	**$ 167,268,715**	**$ 751,808,236**	**$ 1,204,168,594**	**$ 987,155,898**
Total		**$ 70,450,075**	**$ 3,249,451,398**	**$ 6,373,391,259**	**$ 4,847,893,017**

		Change in Employment			
	Industry	2025	2030	2035	2040
Vehicle Assembly	**Automobile and light-duty motor vehicle manufacturing**	**-**	**-**	**-**	**-**
	Heavy-duty truck manufacturing	**(239)**	**828**	**806**	**740**
Vehicle Parts Manufacturing	Gasoline engine and engine parts manufacturing	(51)	(168)	(330)	(356)
	Electrical and electronic equipment manufacturing	(22)	16	15	10
	Steering and suspension components manufacturing	(1)	-	-	-
	Brake system manufacturing	(2)	(1)	(1)	(2)
	Transmission and power train parts manufacturing	(16)	2	-	(3)
	Seating and interior trim manufacturing	(15)	(3)	(3)	(4)
	Motor vehicle metal stamping	(2)	(1)	(1)	(1)
	Other motor vehicle parts manufacturing	(6)	15	14	14
	Total Vehicle Parts Manufacturing	**(115)**	**(140)**	**(306)**	**(342)**
Battery Manufacturing	Other electrical equipment and component manufacturing	(2)	2,956	8,132	5,940
	Total Battery Manufacturing	**(2)**	**2,956**	**8,132**	**5,940**
Material Processing	Basic chemical manufacturing	-	199	548	400
	Non-metallic mineral product manufacturing	(2)	148	404	457
	Non-ferrous metal production and processing	8	46	71	52
	Total Material Processing	**6**	**393**	**1,023**	**909**
Mining	Iron ore mining	-	-	-	-
	Copper, nickel, lead and zinc ore mining	5	52	68	50
	Other metal ore mining	40	399	510	372
	Other non-metallic mineral mining and quarrying	14	265	185	136
	Total Mining	**59**	**716**	**763**	**558**
Rest of Automotive Supply Chain	**Total Rest of Automotive Supply Chain**	**24**	**342**	**524**	**391**
Rest of Economy	**Total Rest of Economy**	**778**	**3,762**	**6,124**	**4,992**
Total		**511**	**8,857**	**17,066**	**13,188**

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