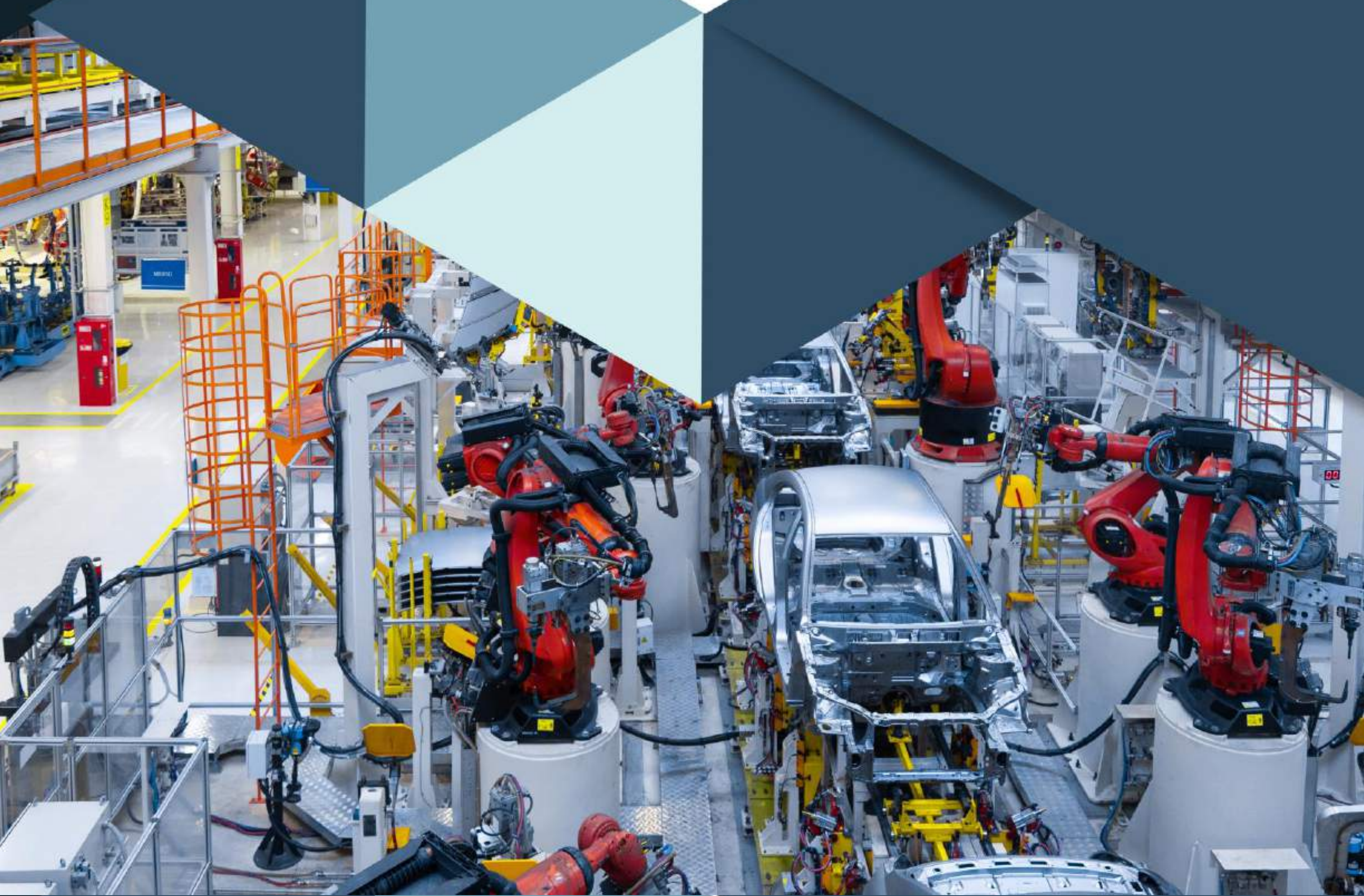
THE SHIFT TO EV PRODUCTION IN ONTARIO'S AUTOMOTIVE MANUFACTURING SECTOR

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 it are Ontario's automotive assembly and parts manufacturing industries where almost all of Canada's light-duty vehicles, as well as the majority of vehicle components and parts are produced.

The move from producing internal combustion engine vehicles (ICEVs) to electric vehicles (EVs) in Ontario's light-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 Ontario'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 EV consumer acceptance is assumed, with continued success in winning production mandates in Ontario. This includes producing and processing rare earth minerals domestically, and in manufacturing EVs and their batteries. In this scenario, significant economic expansion and job market boost is projected, with an output increase of over $40.0 billion by 2040, and nearly 60,000 net jobs created by 2040.

2. Scenario 2 assumes slower consumer acceptance of EVs, translating to a more gradual transition in EVs manufacturing and lower batteries production, which is further accompanied by less success in developing domestic rare earth mining capabilities, and in securing production mandates. These assumptions project a very minimal job impact in the province, and an overall output increase of $2.1 billion. However, this scenario also indicates initial job and economic losses in the first years of the transition.

3. Scenario 3, combining assumptions of scenarios 1 and 2, predicts output reaching $6.0 billion and almost 6,000 jobs added by 2040.

These scenarios highlight the variable impacts of Ontario's transition to EV production on economic output and employment across various industries and the overall economy. Most notably impacted is the gasoline engine manufacturing industry as a result of the weakening demand for ICEV-specific components, a factor of declining domestic ICEV production and exports of ICE components. On the other hand, battery manufacturing, 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 Ontario, delves into the significant transformation of the province's automotive manufacturing sector 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 automotive sector, a cornerstone of Ontario's economy, employs approximately 165,000 workers, contributes over $16 billion to the GDP, and is a major exporter[3,4,5]. The transition to EVs is marked by increasing consumer 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 Ontario. On one hand, it positions Ontario 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 Ontario. Since 2020, significant investments in EV, battery production, and components have been announced in Ontario and Canada, underscoring the gradual pivot towards EV manufacturing in the sector[6].

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[1] In this report, electric vehicles (EVs) refer to hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), 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] Industry Canada (2022). *International Trade Data and Market Intelligence*.
[6] Invest in Canada (n.d.). *EV Supply Chain*.

This report provides an extensive analysis and forecast of the implications of Ontario's automotive sector'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 Ontario, 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 Ontario's automotive sector'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 Ontario 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 Ontario's automotive manufacturing sector 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"[7]. 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.

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

Recent investment announcements to expand Ontario's EV and battery manufacturing capabilities underscore the importance of such analysis, especially as the transition in production is already underway. In recent years, alongside Toyota, which has been assembling hybrid vehicles in Ontario, Ford, General Motors (GM), and Stellantis have announced plans to retool and upgrade their production lines for EV manufacturing. Notable battery manufacturing announcements also include the NextStar battery production plant in Windsor (a partnership between Stellantis and LG Energy Solutions), VW's battery manufacturing facility in St. Thomas, and Umicore's battery materials plant in Loyalist . Other material processing and mining announcements have also accompanied Ontario'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 Ontario

Announcement	Details	Announced Capacity	Location	Production Planned / Commenced
General Motors CAMI Assembly Plant	Battery electric delivery van assembly	Up to 50,000 vehicles	Ingersoll, ON	2022
Ford Motor Company Oakville Assembly Plant	Electric vehicle and battery pack assembly	-	Oakville, ON	2025
Stellantis-LG Energy Solution Battery Plant (NextStar Energy)	Battery cell and module manufacturing	49.5 GWh	Windsor, ON	2024
Volkswagen PowerCo SE Battery Plant	Battery cell manufacturing	90 GWh	St. Thomas, ON	2027
Umicore EV Materials Plant	pCAM and CAM manufacturing	35 GWh eq.	Loyalist, ON	2025

Methodology

A comprehensive model was developed to assess the economic and labor market implications of Ontario'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[8], 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[9], 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 light-duty vehicles manufactured in Ontario. This includes adjustments for HEVs, PHEVs, 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 automotive and battery manufacturing supply chains, estimating 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 direct, indirect, and induced output and employment impacts within various industries and sectors.

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

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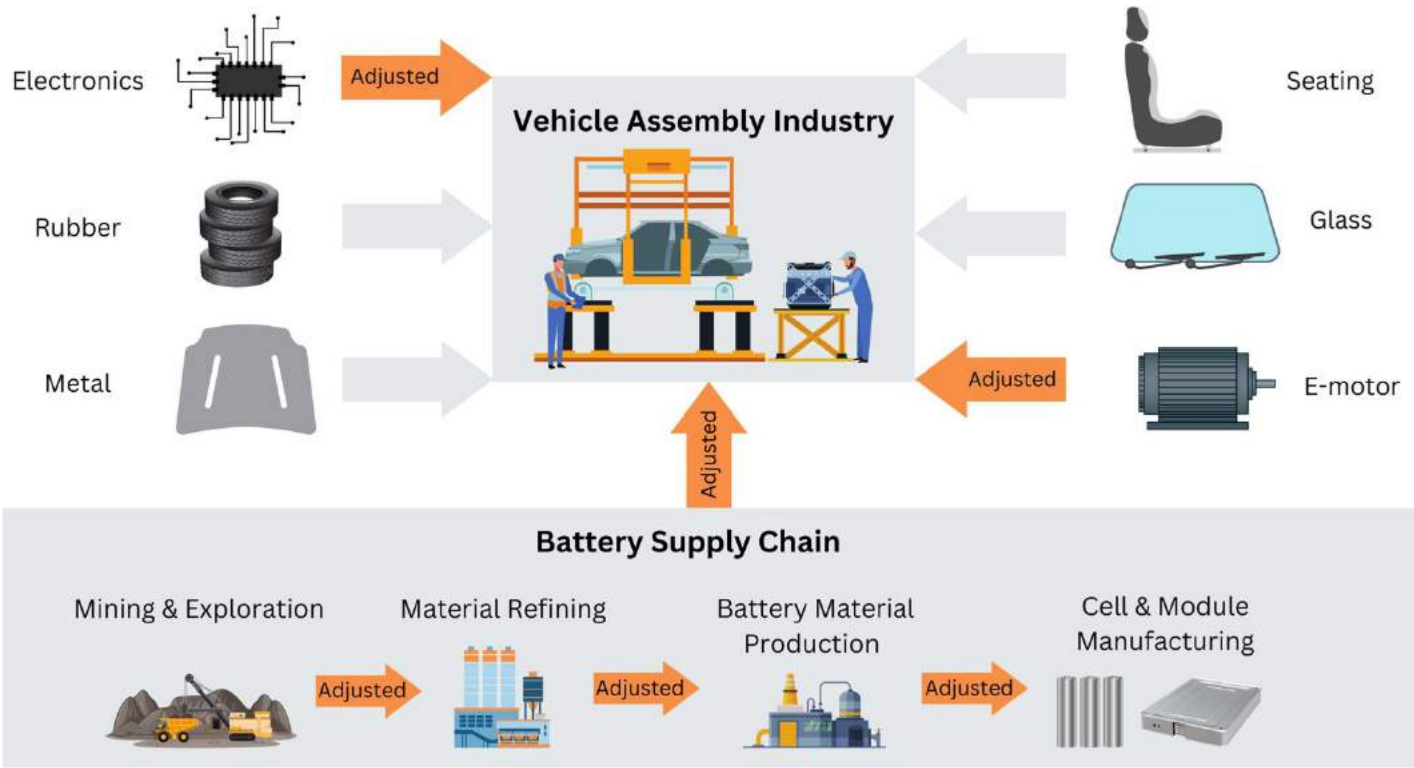
[8] Statistics Canada (2021). *Supply, Use and Input-Output Tables*.
[9] For more information on the IMPLAN modeling process, visit IMPLAN.com.

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 ICEV to EV production in Ontario is an essential component of this analysis. In this study, three scenarios were constructed, each based on a series of projections regarding light-duty vehicle production volumes[10], the pace of the shift to EV production, investment in battery manufacturing and its output, as well as the intensity of operations in the supply chain sectors of automotive and battery manufacturing. These scenarios provide a framework for appraising a spectrum of possible results and the uncertainties tied to this shift. Opting for multiple scenarios over a singular one further allows for a broader and more in-depth investigation into the varied impacts that different intensities of production and investment might have on the economic output and job market within the related industries and sectors of automotive and battery manufacturing.

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

Ensuring that these scenarios and their underlying assumptions are both practical and precise is crucial for gauging the effects of the switch to EV production. Hence, all three scenarios incorporate insights from a variety of data streams, encompassing historical automotive 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 Ontario's light-duty vehicle manufacturing sector could entirely shift to BEV production by 2040, while also increasing its vehicle production compared to 2022. Within this framework, Ontario 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 Ontario's light-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 sector 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 synthesizes elements from the first two, postulating that while vehicle manufacturing in Ontario shifts entirely to BEV production, the production rates do not increase. Although Ontario succeeds in boosting domestic battery production, the industry continues to rely 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:

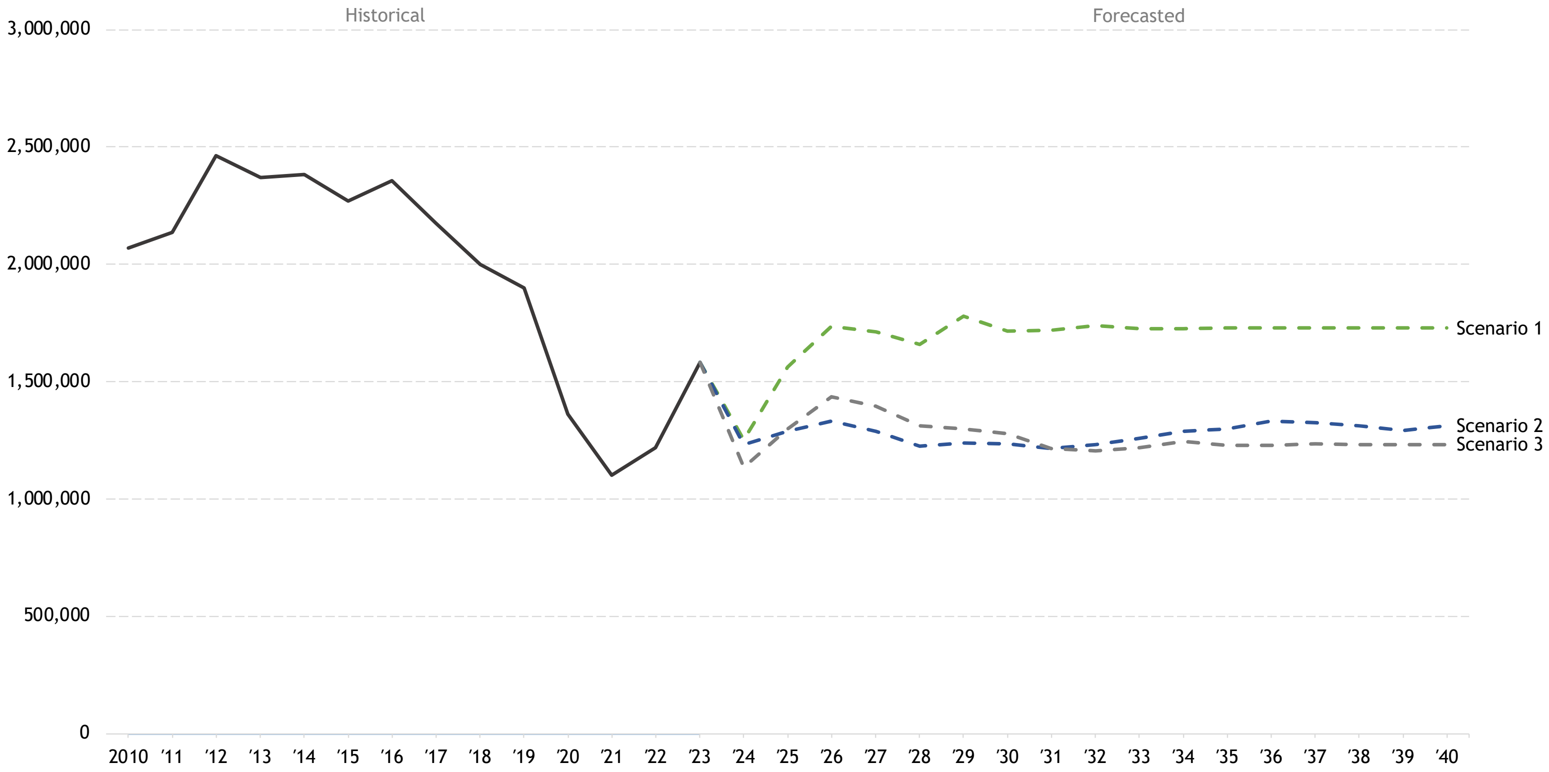
Scenario 1

In this scenario, it is assumed that Ontario’s light-duty vehicle manufacturing industry completely transitions to the production of BEVs over the forecast period. Concurrently, Ontario’s light-duty vehicle production levels increase from approximately 1.2 million in 2022 to over 1.7 million by 2040. It is also assumed that two battery plants (with capacity totalling 135 GWh) become operational in Ontario during this period and operate at 75% capacity producing close to 101 GWh equivalent (eq.) of EV batteries. Within its developing battery manufacturing supply chain, Ontario’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

Ontario’s light-duty vehicle manufacturing industry gradually transitions to the production of EVs and by 2040, is producing a mix of ICEVs, HEVs, PHEVs and BEVs. Light-duty vehicle production remains around 1.3 million vehicles throughout the forecast period. Two battery manufacturing plants come online during the period of 2025 - 2040 which operate at an average of 30% capacity and produce close to 41 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 Ontario that become operational between 2025 and 2040.

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



Sources: International Organization of Motor Vehicle Manufacturers (OICA), Marklines, & Author's

Scenario 3

In scenario 3, Ontario produces close to 1.25 million light-duty vehicles in 2040, all of which are BEVs. Similar to scenario 1, battery production is ramped up to reach 101 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 Ontario.

In constructing the three scenarios, automotive 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 (light-duty vehicle production for Ontario) and across North America over the upcoming 10 to 15 years.

To cover the period of this analysis, both datasets were extended till 2040. Both datasets were also used to inform the potential rates of transition in production.

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

	Scenario 1	Scenario 2	Scenario 3
Number of Battery Plants (by 2040)	2	2	2
Total Operational Battery Production Capacity (by 2040)	101.25 GWh	40.5 GWh	101.25 GWh
Cathode & Anode Manufacturing[11]	100%	10%	55%
Material Filtering[11]	100%	10%	55%
Mining[11,12]	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 Ontario. 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.

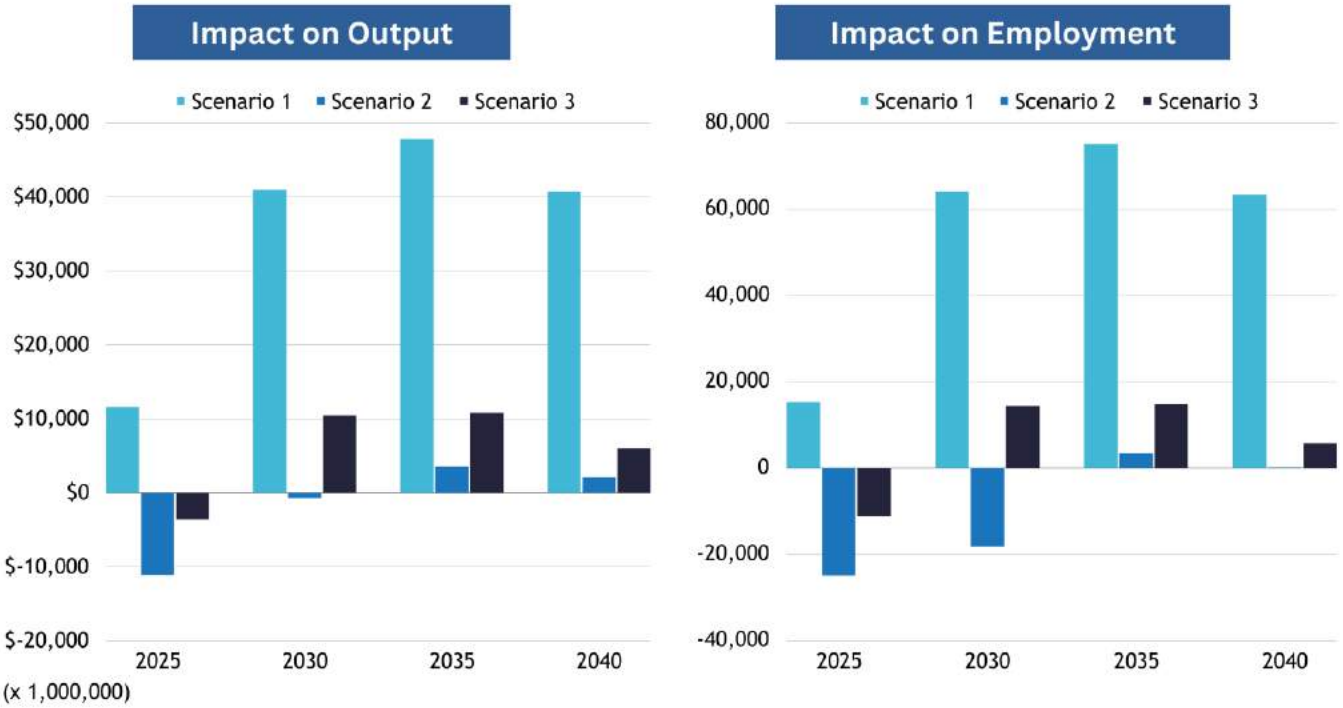
Results & Findings

The automotive manufacturing sector's transition towards EV and battery production under the three scenarios presented in this report reveals diverse economic impacts across the different industries and sectors in Ontario. These findings, presented relative to 2022 output and employment levels, reflect significant shifts in both economic indicators across the forecast period.

[11] Of battery material upstream domestic demand.

[12] Except Cobalt.

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



In scenario 1, with an aggressive shift towards EV and battery production, the provincial economy sees an increase in output which eventually grows to approximately $48 billion by 2035 before declining to around $41 billion by 2040. Employment in this scenario mirrors the optimistic economic output, with a rise to nearly 75,000 jobs by 2035 and a decrease to almost 63,000 jobs by 2040, highlighting the potential of aggressive EV-related investments for job creation.

Scenario 2, which models a gradual shift towards EV production and lower levels of battery manufacturing, shows a more tempered economic impact. After a decrease in output in the early years, there is a recovery, with output growing to around $4 billion by 2035 and $2 billion by 2040. Employment sees a decrease in 2025 and 2030 but recovers to add approximately 4,000 jobs by 2035. No change in provincial employment is projected by the end of the forecast period in this scenario.

Scenario 3 offers a middle ground, with output decreasing initially but then increasing to slightly over $10 billion by 2035 and over $5 billion by 2040. Employment follows a similar pattern, with a decrease in 2025, an increase to roughly 15,000 jobs in 2030 and 2035, and an increase of 5,000 jobs by 2040.

It's important to note that while there is a peak in provincial output and employment in all scenarios around 2035, a slight reduction is observed by 2040. This pattern is consistent with the maturation of battery manufacturing plants and the reduction in battery component and material prices due to advancements in production efficiency and scalability.

The detailed impacts on output and employment for each scenario are further outlined in Appendix *E*, which includes analyses for 18 automotive and battery manufacturing industries, the broader automotive manufacturing supply chain, and the rest of the economy.

Impact on Output

Scenario 1, which assumes an accelerate transition towards BEV and battery production, forecasts substantial changes in the output of Ontario's automotive manufacturing industry and its wider supply chain. Based on the estimated vehicle production volumes and the mix of powertrain technologies, the light-duty motor vehicle manufacturing industry is expected to see an increase in output by approximately $25.8 billion by 2040.

The output for the gasoline engine and engine parts manufacturing industry in Ontario is expected to face a significant downturn, with projections showing a decrease of around $4.3 billion by 2040. This downturn is consistent with the anticipated decline in ICEV-specific parts production and a pivot towards EVs. The overall output of the vehicle parts manufacturing industry is projected to contract by approximately $2.4 billion by 2040, underlining the impact of the shift towards BEV production.

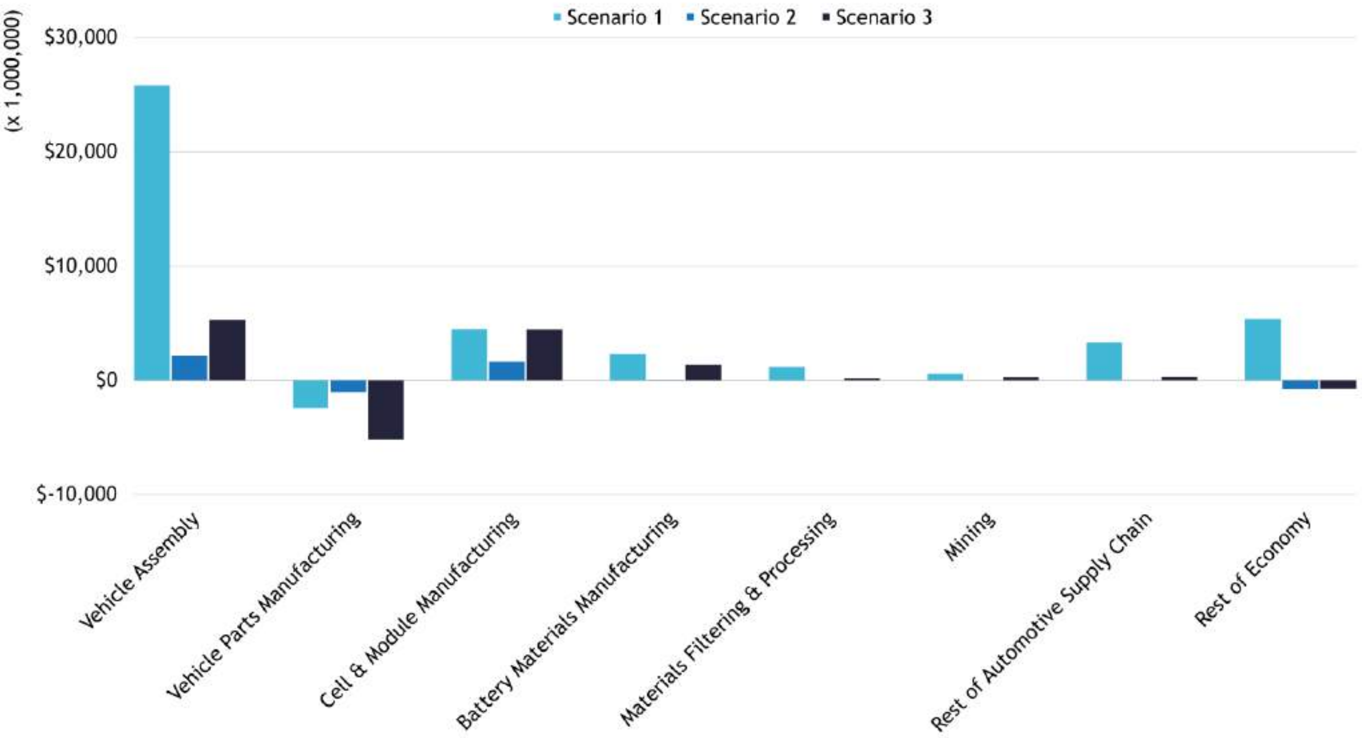
Battery manufacturing output is anticipated to increase, linked to the strategic investments in Ontario in battery cell and module manufacturing facilities considered in this scenario. The industry's output is expected to grow substantially in the upcoming years, peaking around 2035 with an addition of nearly $6.2 billion to the industry's activity in Ontario. A slight decrease in output is projected by 2040, which may be attributed to the declining cost of kWh of batteries.

The material processing and mining industries are both projected to experience growth in output, aligning with the increased demand for EV batteries. The material processing industry's output is expected to rise by about $3.5 billion, while mining is projected to add approximately $580 million by 2040, reflecting the industry's adaptation to the evolving demands of vehicle electrification.

Scenario 2, which assumes a moderate transition to EV and battery production, forecasts less pronounced impacts in Ontario's automotive industry and its supply chain by 2040 compared to Scenario 1. In this scenario, the industry is set to face initial output declines in 2025 and 2030, with recovery and growth in subsequent years.

Light-duty motor vehicle manufacturing is expected to rebound, with a modest output increase of $2.2 billion by 2040, after experiencing a $5.7 billion decline in 2025. Most vehicle parts manufacturing sub-industries are projected to decline throughout the forecast period. Gasoline engine manufacturing anticipates a $925 million decrease in output by 2040, less severe than in Scenario 1, correlating with a future vehicle mix that still includes ICEVs, HEVs, PHEVs, and BEVs.

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



Battery manufacturing's output growth is slower in this scenario, with an estimated increase of $1.6 billion by 2040, reflecting conservative investments and battery production volumes in Ontario in this scenario.

Finally, slight changes are projected in all other industries throughout the supply chain, and the rest of the economy.

Scenario 3 combines the accelerate move towards BEV production seen in scenario 1 with the production levels of scenario 2. Here, the output of light-duty vehicle manufacturing is expected to grow $5.3 billion growth by 2040, largely due to the relatively higher prices of BEVs.

The gasoline engine manufacturing industry is set to contract, with a forecasted reduction in output of $4.2 billion by 2040, as the industry transitions away from ICEV-specific parts.

Battery manufacturing, on the other hand, is on a significant upward trajectory with an expected output increase of $6.1 billion by 2035 and $4.5 billion by 2040, driven by ongoing investments and the ramp-up of battery production capabilities in the province.

Material processing and mining industries are poised to benefit from the BEV and battery production, despite lower production volumes compared to scenario 1. The output for material processing is projected to climb by $1.5 billion, while mining is anticipated to see a $320 million increase by 2040.

Impact on Employment

In scenario 1, employment in the automobile and light-duty motor vehicle manufacturing industry in Ontario is projected to see a significant increase, with an addition of approximately 18,00 jobs by 2040. The overall employment in vehicle parts manufacturing shows a mixed trend, with a projected net decline of approximately 1,300 jobs by 2040.

While most sub-industries within vehicle parts manufacturing are expected to increase employment, this is offset by significant declines in certain areas, including a loss of 4,560 jobs in gasoline engine and engine parts manufacturing, and a decrease of 660 jobs in transmission and powertrain parts manufacturing.

The battery manufacturing sector anticipates remarkable job growth, particularly in other electrical equipment and component manufacturing related to batteries, which is expected to add about 10,800 jobs by 2040. This growth reflects a slight decrease from the 14,261 jobs added by 2035, which can be attributed to increased productivity and more efficient manufacturing processes as the industry matures and achieves economies of scale.

Material processing is forecasted to add a total of 2,765 jobs, while the mining sector is set to grow by a total of 1,023 jobs by 2040.

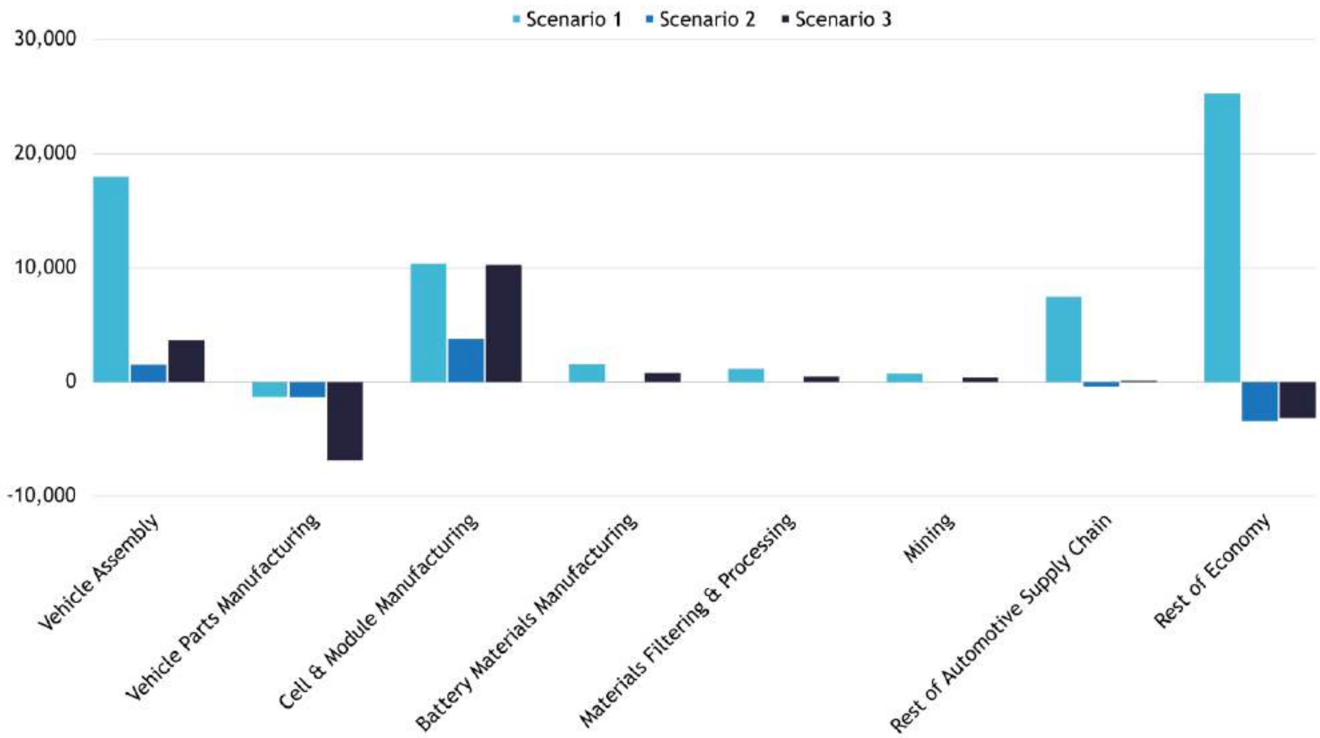
In addition to job increases in vehicle assembly and battery manufacturing, employment within the rest of the automotive supply chain is expected to grow by 7,500 jobs, with a significant projected expansion in the rest of the economy, contributing an additional 25,300 jobs by 2040 in scenario 1.

In scenario 2, employment changes are closely aligned with shifts in industry output. The light-duty vehicle manufacturing industry is expected to see a relatively small increase, with a projected addition of 1,500 jobs by 2040.

The overall trend in vehicle parts manufacturing indicates a slight contraction, with a forecasted decrease of 1,300 jobs by 2040. Within this sector, gasoline engine and engine parts manufacturing are projected to lose approximately 1,003 jobs, a significant number of its overall employment, though not as steep as the losses observed in scenario 1.

The supply chain of battery manufacturing in Ontario is poised for growth in this scenario, anticipated to add a little 3,800 jobs by 2040. This employment growth is predominantly attributed to the investment within cell and module manufacturing operations, with little change in jobs within the material processing and mining industries.

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



In scenario 3, the light-duty vehicle manufacturing sector in Ontario is projected to experience a notable increase, expected to add 3,685 jobs by 2040.

The vehicle parts manufacturing industry face a decline in employment, with a loss of 6,800 jobs anticipated by 2040. This contraction is more severe than in the previous scenarios, with the gasoline engine manufacturing subsector alone shedding 4,550 jobs. This downturn is attributed to the decreased role of gasoline engines and lower levels of overall vehicle production during the transition period.

The battery manufacturing supply chain presents a source of employment growth in the province, with 10,300 jobs expected to be added by 2040. Additionally, material processing and mining sectors are also set to benefit from the industry's evolution, with both expected to add around 1,300 and 400 jobs respectively by 2040.

Discussion

The analysis provided in this report delves into the transition towards EV and battery production within Ontario's automotive sector, offering a detailed examination of the potential economic and labour market outcomes which range between $2 billion and $41 billion in added output, and could create up to 75,000 jobs in the province. This transition is anticipated to have a broad and varied impact across numerous industries, extending beyond automotive 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 EV production, despite being at varying levels of vehicle production, suggest that Ontario's transition to EV production is crucial. Scenario 1 predicts a surge in output by over $40 billion and nearly 75,000 new jobs by 2040, driven by increased vehicle production, a rapid shift to EVs, 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.

Vehicle Assembly

The light-duty vehicle assembly sector in Ontario had an output of $46.5 billion and employed about 32,000 individuals in 2022. Across all scenarios, growth is observed by 2040, driven by various factors including increased production levels 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.

Gasoline Engine Manufacturing

Gasoline engine manufacturing, pivotal within vehicle parts manufacturing and mostly concentrated in Ontario, is expected to face significant declines in both output and employment due to the shift towards EVs, particularly BEVs. Factors such as reduced domestic demand and potential decreases in exports, given the global shift towards BEVs, contribute to this decline. By 2040, scenarios 1 and 3 project a reduction in gasoline engine manufacturing output and employment by over 90%.

Battery Manufacturing

The battery manufacturing sector is poised for significant growth, fueled by investments in battery cell and module manufacturing. This growth is reflected in a potential increase in output ranging from $1.6 billion (Scenario 2) to $4.5 billion (Scenario 1) by 2040, and a similar trend in employment growth. This expansion underscores the industry's potential to significantly contribute to the economy.

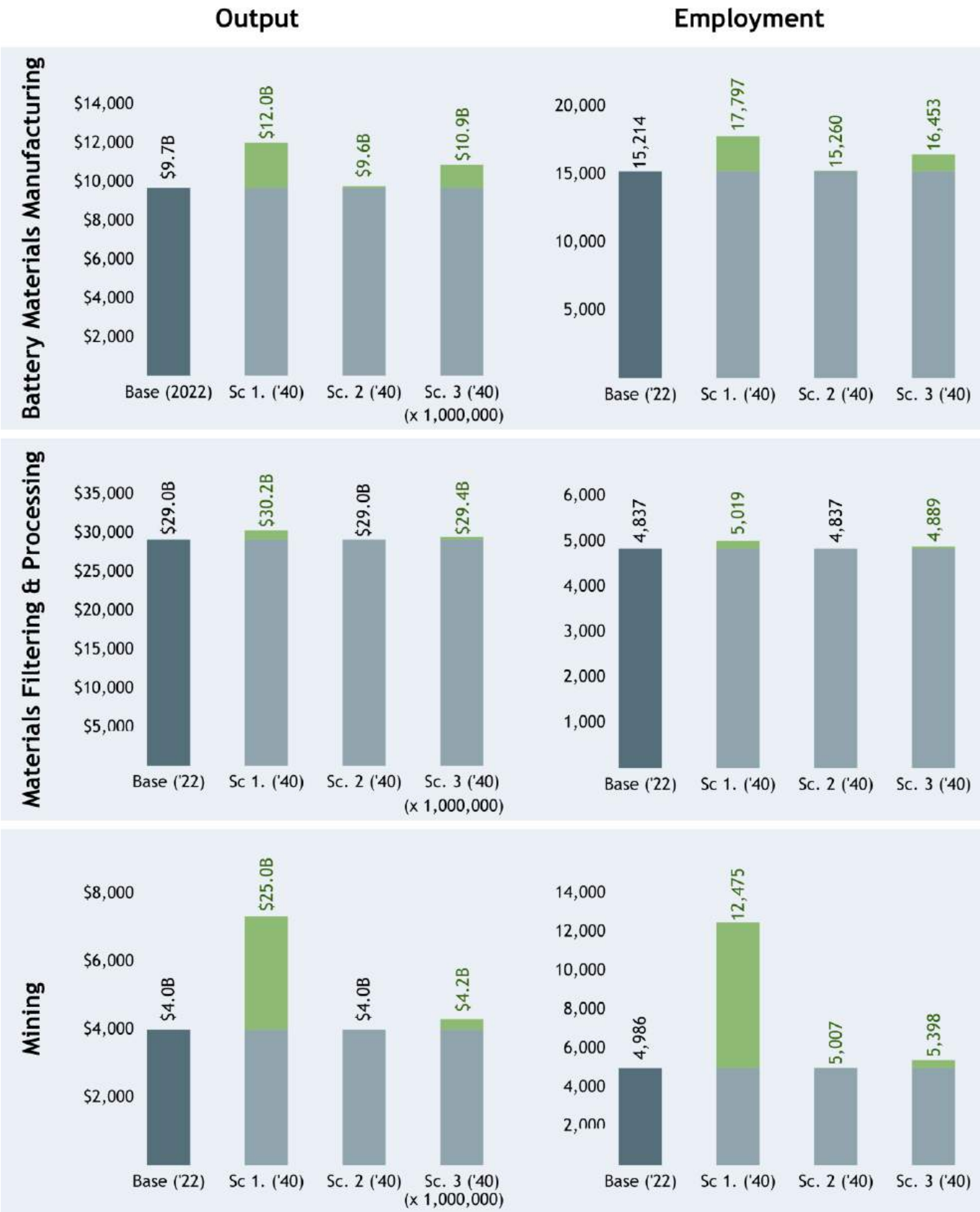
Battery Materials Manufacturing, Filtering and Mining

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 $4 billion in output and the addition of more than 3,250 jobs by 2040 in these industries.

Despite initial concerns about the decline of gasoline engine manufacturing, the analysis suggests that losses in this sector may be offset by gains in others, particularly in battery and material manufacturing, as well as mining. This shift indicates a reallocation of economic activity within the automotive sector towards emerging EV-related industries, posing challenges but also offering opportunities for transition and growth. Support for businesses and workers to adapt to this changing landscape, including retooling operations 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)

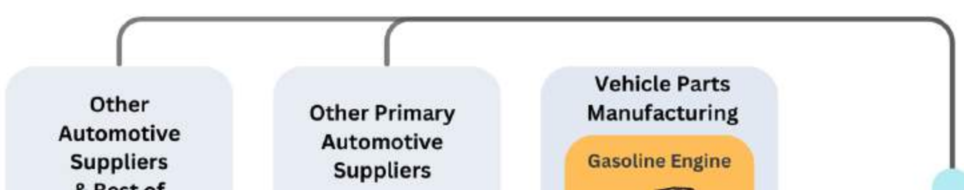


Concluding Remarks

From the analysis presented in this report, it is evident that this shift to EVs can bring both challenges and opportunities for the Ontario's automotive manufacturing sector and 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. However, this transition also presents immense potential for economic growth, job creation, and environmental sustainability for Ontario and Canada.

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 Ontario and Canada if the automotive manufacturing sector is successful in expanding its vehicle and battery manufacturing capacities. The results also indicate that Ontario's economy, particularly its automotive and battery manufacturing industries, have a lot at stake in this transition. The success of this transition is bound to multiple factors, including Ontario winning new vehicle 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 Ontario, 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 Ontario'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)[13]. 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 production of the automotive sector influence related industries, such as parts manufacturing (especially ICE production), battery production, chemical manufacturing and mining.

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[13] 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.

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 Ontario. By analyzing the I-O table, the input values or purchasing pattern of light-duty vehicle manufacturing (NAICS 336110) from each of the 236 industries in the I-O table was determined. These values were then divided by the total number of vehicles produced in Ontario 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 Canadian automakers in 2019 was the ICEV, the cost structure obtained primarily reflects that of a Canadian-produced ICEV.

Subsequently, to obtain the production costs and the cost structures of HEVs, PHEVs, 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, PHEVs, and BEVs. This included considerations for battery packs, electric drivetrain components, and other unique parts not found in ICEVs. For example, electric motors, as well as battery packs at an average capacity of 1.5 kWh and 12.5 kWh respectively were added to HEVs and PHEVs. For BEVs, three cost structure variations were developed. One electric motor and a 44-kWh battery pack was added to a small-sized BEV. For both compact and midsize BEVs, two electric motors, along with a 77-kWh battery pack was added to the cost structure. Finally, for large BEV such as pickup trucks, two electric motors and a 109-kWh battery pack was added to the vehicle cost structure[14,15]. 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 both HEVs and PHEVs, 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[16], Munro's vehicle cost breakdown data[17], and UBS's Evidence Lab Electric Car Teardown[18].

It is important to note that the production costs and the cost structures of these vehicles, particularly the three variations of BEVs, 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

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[14] The average battery capacity, electric motor power, and other vehicle specifications were derived from a comprehensive review of the specifications of commercially available vehicles (https://driving.ca/find-compare/).

[15] Module pricing is assumed for purchases made by the vehicle assembly industry from the battery manufacturing industry.

[16] Argonne National Laboratory (ANL) (2022). Battery Performance and Cost Modeling for Electric- Drive Vehicles (BatPaC).

[17] Munro & Associates (2020). *BMW i3 Cost Analysis*.

[18] UBS (2017). *UBS Evidence Lab Electric Car Teardown – Disruption Ahead?*

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 Ontario'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 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 light-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[19] of economic activities on industries within a specific sector or geographic region. In the context of Ontario's automotive and battery manufacturing

[19] 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.

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 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 Ontario'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.

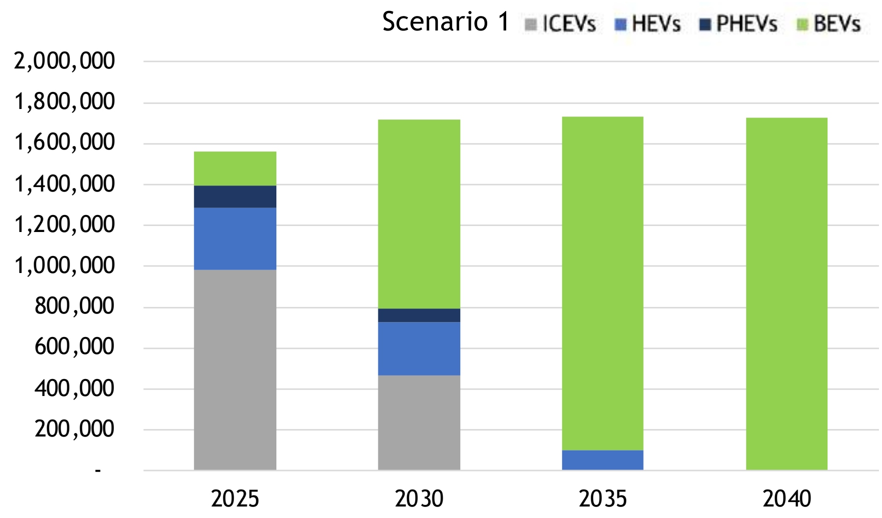
Industry	**North American Industry Classification System (NAICS) Code**	**Input - Output Industry Classification (IOIC) Code**	**Industry IMPLAN Code**
Vehicle Assembly			
Light-Duty Vehicle Assembly	336110 - Automobile and Light-Duty Motor Vehicle Manufacturing	BS336110	99

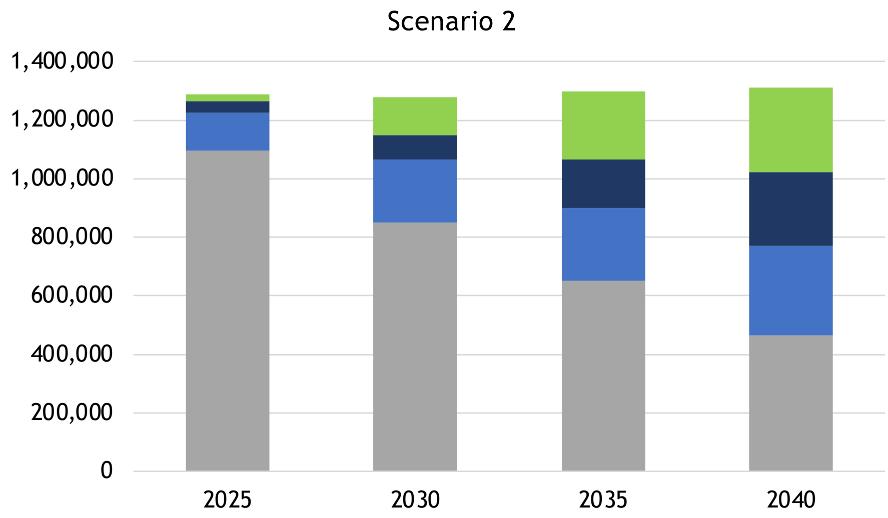
Heavy-Duty Bus and Truck Manufacturing	336120 - Heavy-Duty Truck Manufacturing	BS336120	100
Vehicle Parts Manufacturing			
Gasoline Engine Manufacturing	336310 - Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	BS336310	102
Vehicle Electrical and Electronics Component	336320 - Motor Vehicle 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

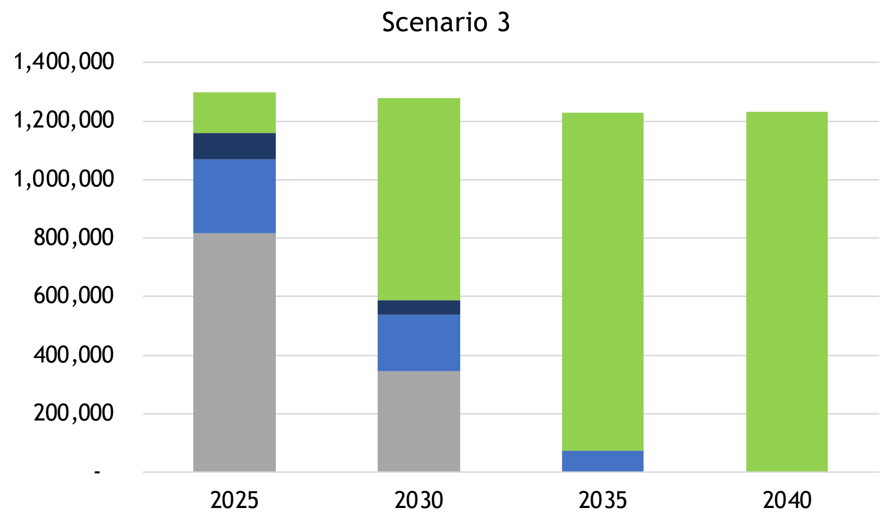
Battery Manufacturing			
Battery Cell & Module Manufacturing	335910 - Battery manufacturing	BS335900	98
Battery Material Manufacturing / Chemical Manufacturing			

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)	135 GWh	135 GWh	135 GWh
Number of Battery Plants (by 2040)	2	2	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)	101.25 GWh	40.5 GWh	101.25 GWh
Individual Battery Plant Production Capacity & Year Plant Commences Production	Plant 1 (2025): 45 GWh Plant 2 (2028): 90 GWh	Plant 1 (2025): 45 GWh Plant 2 (2028): 90 GWh	Plant 1 (2025): 45 GWh Plant 2 (2028): 90 GWh
Cathode & Anode Production[20]	100%	10%	55%
Material Processing & Filtering[43]	100%	10%	55%
Mining[43,21]	100%	10%	55%
Cobalt Mining	25%	10%	25%

[20] Of battery material upstream domestic demand.

[21] Except Cobalt.

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

Scenario 1

	Industry	Change in Output 2025	2030	2035	2040
Vehicle Assembly	**Automobile and light-duty motor vehicle manufacturing**	**$ 7,877,238,093**	**$ 22,688,953,787**	**$ 28,236,057,842**	**$ 25,822,717,566**
	Heavy-duty truck manufacturing	**$ -**	**$ -**	**$ -**	**$ -**
Vehicle Parts Manufacturing	Gasoline engine and engine parts manufacturing	$ (450,088,484)	$ (2,209,430,937)	$ (3,957,783,846)	$ (4,311,937,170)
	Electrical and electronic equipment manufacturing	$ -	$ -	$ -	$ -
	Steering and suspension components manufacturing	$ 109,405,525	$ 173,448,767	$ 176,885,059	$ 179,386,721
	Brake system manufacturing	$ 18,151,753	$ 28,657,772	$ 29,150,210	$ 29,446,082
	Transmission and power train parts manufacturing	$ 161,531,707	$ 15,599,633	$ (225,286,795)	$ (265,363,960)
	Seating and interior trim manufacturing	$ 538,080,688	$ 731,029,174	$ 606,088,833	$ 591,222,428
	Motor vehicle metal stamping	$ 157,592,277	$ 338,979,093	$ 401,549,574	$ 409,091,834
	Other motor vehicle parts manufacturing	$ 470,150,730	$ 823,484,247	$ 959,470,604	$ 960,522,854
	Total Vehicle Parts Manufacturing	**$ 1,004,824,196**	**$ (98,232,251)**	**$ (2,009,926,361)**	**$ (2,407,631,211)**
Battery Manufacturing	Other electrical equipment and component manufacturing	$ 688,826,827	$ 6,211,710,902	$ 6,203,604,414	$ 4,510,589,814
	Total Battery Manufacturing	**$ 688,826,827**	**$ 6,211,710,902**	**$ 6,203,604,414**	**$ 4,510,589,814**
Material Processing	Basic chemical manufacturing	$ 314,562,194	$ 2,568,606,923	$ 2,576,051,207	$ 1,887,419,331
	Non-metallic mineral product manufacturing	$ 63,669,992	$ 499,301,177	$ 560,202,168	$ 431,636,043
	Non-ferrous metal production and processing	$ 130,346,075	$ 1,277,361,397	$ 1,629,238,694	$ 1,190,612,634
	Total Material Processing	**$ 508,578,261**	**$ 4,345,269,497**	**$ 4,765,492,069**	**$ 3,509,668,008**
Mining	Iron ore mining	$ -	$ -	$ -	$ -
	Copper, nickel, lead and zinc ore mining	$ 14,494,902	$ 138,565,518	$ 176,635,147	$ 129,294,718
	Other metal ore mining	$ 40,758,853	$ 396,453,645	$ 503,000,694	$ 367,627,663
	Other non-metallic mineral mining and quarrying	$ 9,033,228	$ 86,975,318	$ 110,510,966	$ 80,962,586
	Total Mining	**$ 64,286,983**	**$ 621,994,481**	**$ 790,146,807**	**$ 577,884,967**
Rest of Automotive Supply Chain	**Total Rest of Automotive Supply Chain**	**$ 531,936,545**	**$ 2,328,539,360**	**$ 3,524,967,030**	**$ 3,341,902,176**
Rest of Economy	**Total Rest of Economy**	**$ 918,133,224**	**$ 4,890,561,573**	**$ 6,273,497,607**	**$ 5,376,623,702**
Total		**$ 11,593,824,129**	**$ 40,988,797,349**	**$ 47,783,839,408**	**$ 40,731,755,022**

	Industry	Change in Employment 2025	2030	2035	2040
Vehicle Assembly	**Automobile and light-duty motor vehicle manufacturing**	**5,489**	**15,811**	**19,677**	**17,995**
	Heavy-duty truck manufacturing	**-**	**-**	**-**	**-**
Vehicle Parts Manufacturing	Gasoline engine and engine parts manufacturing	(487)	(2,390)	(4,281)	(4,560)
	Electrical and electronic equipment manufacturing	-	-	-	-
	Steering and suspension components manufacturing	182	289	294	298
	Brake system manufacturing	68	107	109	110
	Transmission and power train parts manufacturing	402	38	(562)	(661)
	Seating and interior trim manufacturing	1,100	1,495	1,240	1,209
	Motor vehicle metal stamping	256	551	653	665
	Other motor vehicle parts manufacturing	807	1,414	1,647	1,650
	Total Vehicle Parts Manufacturing	**2,328**	**1,504**	**(900)**	**(1,289)**
Battery Manufacturing	Other electrical equipment and component manufacturing	1,583	14,279	14,261	10,369
	Total Battery Manufacturing	**1,583**	**14,279**	**14,261**	**10,369**
Material Processing	Basic chemical manufacturing	234	1,912	1,918	1,405
	Non-metallic mineral product manufacturing	173	1,362	1,529	1,178
	Non-ferrous metal production and processing	20	196	250	182
	Total Material Processing	**427**	**3,470**	**3,697**	**2,765**
Mining	Iron ore mining	-	-	-	-
	Copper, nickel, lead and zinc ore mining	12	120	153	111
	Other metal ore mining	48	474	602	440
	Other non-metallic mineral mining and quarrying	21	211	268	196
	Total Mining	**81**	**805**	**1,023**	**747**
Rest of Automotive Supply Chain	**Total Rest of Automotive Supply Chain**	**1,142**	**5,387**	**8,031**	**7,489**
Rest of Economy	**Total Rest of Economy**	**4,267**	**22,860**	**29,324**	**25,302**
Total		**15,317**	**64,116**	**75,113**	**63,378**

Scenario 2

	Industry	Change in Output 2025	2030	2035	2040
Vehicle Assembly	**Automobile and light-duty motor vehicle manufacturing**	**$ (5,785,289,138)**	**$ (1,379,851,543)**	**$ 2,372,709,094**	**$ 2,188,695,492**
	Heavy-duty truck manufacturing	**$ -**	**$ -**	**$ -**	**$ -**
Vehicle Parts Manufacturing	Gasoline engine and engine parts manufacturing	$ (79,548,207)	$ (470,706,189)	$ (752,076,514)	$ (927,424,752)
	Electrical and electronic equipment manufacturing	$ -	$ -	$ -	$ -
	Steering and suspension components manufacturing	$ (19,205,161)	$ (66,953,938)	$ 18,057,001	$ (8,152,699)
	Brake system manufacturing	$ (3,171,834)	$ (11,084,509)	$ 2,725,266	$ (1,246,199)
	Transmission and power train parts manufacturing	$ (32,824,544)	$ (142,019,477)	$ (27,286,114)	$ (80,227,217)
	Seating and interior trim manufacturing	$ (121,304,494)	$ (414,851,623)	$ (935,273)	$ (169,670,414)
	Motor vehicle metal stamping	$ (67,603,131)	$ (174,563,574)	$ (31,318,928)	$ (103,241,483)
	Other motor vehicle parts manufacturing	$ 11,033,383	$ (51,233,464)	$ 256,890,449	$ 242,080,656
	Total Vehicle Parts Manufacturing	**$ (312,623,985)**	**$ (1,331,412,772)**	**$ (533,944,108)**	**$ (1,047,882,104)**
Battery Manufacturing	Other electrical equipment and component manufacturing	$ 348,614,765	$ 2,431,988,911	$ 2,427,970,613	$ 1,643,320,795
	Total Battery Manufacturing	**$ 348,614,765**	**$ 2,431,988,911**	**$ 2,427,970,613**	**$ 1,643,320,795**
Material Processing	Basic chemical manufacturing	$ (3,466,106)	$ 101,726,405	$ 99,449,663	$ 69,662,971
	Non-metallic mineral product manufacturing	$ (98,213,933)	$ 29,864,467	$ (4,983,141)	$ (1,819,808)
	Non-ferrous metal production and processing	$ 3,549,627	$ (8,409,676)	$ (8,195,355)	$ (5,944,387)
	Total Material Processing	**$ (98,130,412)**	**$ 123,181,196**	**$ 86,271,167**	**$ 61,898,776**
Mining	Iron ore mining	$ -	$ -	$ -	$ -
	Copper, nickel, lead and zinc ore mining	$ 58,906	$ 4,554,750	$ 4,647,030	$ 3,386,302
	Other metal ore mining	$ 1,728,574	$ 16,736,529	$ 17,309,012	$ 12,445,569
	Other non-metallic mineral mining and quarrying	$ (507,880)	$ 3,448,740	$ 3,354,368	$ 2,387,016
	Total Mining	**$ 1,279,600**	**$ 24,740,019**	**$ 25,310,410**	**$ 18,218,887**
Rest of Automotive Supply Chain	**Total Rest of Automotive Supply Chain**	**$ (1,720,096,945)**	**$ (26,104,606)**	**$ (134,304,546)**	**$ (46,313,672)**
Rest of Economy	**Total Rest of Economy**	**$ (3,553,797,842)**	**$ (567,630,323)**	**$ (649,845,541)**	**$ (759,194,576)**
Total		**$ (11,120,043,957)**	**$ (725,089,118)**	**$ 3,594,167,089**	**$ 2,058,743,598**

	Industry	Change in Employment 2025	2030	2035	2040
Vehicle Assembly	**Automobile and light-duty motor vehicle manufacturing**	**(4,032)**	**(3,920)**	**1,653**	**1,525**
	Heavy-duty truck manufacturing	**-**	**-**	**-**	**-**
Vehicle Parts Manufacturing	Gasoline engine and engine parts manufacturing	(87)	(475)	(814)	(1,003)
	Electrical and electronic equipment manufacturing	-	-	-	-
	Steering and suspension components manufacturing	(32)	(101)	30	(14)
	Brake system manufacturing	(12)	(39)	10	(5)
	Transmission and power train parts manufacturing	(82)	(331)	(68)	(200)
	Seating and interior trim manufacturing	(249)	(778)	(2)	(348)
	Motor vehicle metal stamping	(110)	(270)	(51)	(168)
	Other motor vehicle parts manufacturing	18	(61)	441	415
	Total Vehicle Parts Manufacturing	**(554)**	**(2,055)**	**(454)**	**(1,323)**
Battery Manufacturing	Other electrical equipment and component manufacturing	801	5,589	5,581	3,777
	Total Battery Manufacturing	**801**	**5,589**	**5,581**	**3,777**
Material Processing	Basic chemical manufacturing	(3)	65	74	51
	Non-metallic mineral product manufacturing	(269)	(179)	(14)	(5)
	Non-ferrous metal production and processing	-	(2)	(2)	(1)
	Total Material Processing	**(272)**	**(116)**	**58**	**45**
Mining	Iron ore mining	-	-	-	-
	Copper, nickel, lead and zinc ore mining	-	3	4	2
	Other metal ore mining	2	20	20	14
	Other non-metallic mineral mining and quarrying	(2)	6	8	5
	Total Mining	**-**	**29**	**32**	**21**
Rest of Automotive Supply Chain	**Total Rest of Automotive Supply Chain**	**(4,430)**	**(3,652)**	**(580)**	**(409)**
Rest of Economy	**Total Rest of Economy**	**(16,379)**	**(14,063)**	**(2,904)**	**(3,406)**
Total		**(24,866)**	**(18,188)**	**3,386**	**230**

Scenario 3

		Change in Output			
	Industry	2025	2030	2035	2040
Vehicle Assembly	**Automobile and light-duty motor vehicle manufacturing**	**$ (1,181,567,405)**	**$ 5,172,472,195**	**$ 6,795,279,791**	**$ 5,288,558,674**
	Heavy-duty truck manufacturing	**$ -**	**$ -**	**$ -**	**$ -**
Vehicle Parts Manufacturing	Gasoline engine and engine parts manufacturing	$ (467,429,941)	$ (2,252,702,929)	$ (3,964,949,694)	$ (4,217,117,991)
	Electrical and electronic equipment manufacturing	$ -	$ -	$ -	$ -
	Steering and suspension components manufacturing	$ (13,701,530)	$ (26,418,746)	$ (54,098,665)	$ (50,016,808)
	Brake system manufacturing	$ (2,470,355)	$ (5,282,718)	$ (9,437,803)	$ (8,841,906)
	Transmission and power train parts manufacturing	$ (52,576,776)	$ (272,820,503)	$ (483,625,277)	$ (509,645,079)
	Seating and interior trim manufacturing	$ (129,630,788)	$ (329,844,998)	$ (559,031,335)	$ (558,040,253)
	Motor vehicle metal stamping	$ (78,989,290)	$ (65,825,040)	$ (75,280,779)	$ (65,155,477)
	Other motor vehicle parts manufacturing	$ 113,588,971	$ 191,940,610	$ 203,660,987	$ 211,924,725
	Total Vehicle Parts Manufacturing	**$ (631,209,709)**	**$ (2,760,954,324)**	**$ (4,942,762,566)**	**$ (5,196,892,789)**
Battery Manufacturing	Other electrical equipment and component manufacturing	$ 687,543,303	$ 5,999,646,460	$ 6,115,101,833	$ 4,479,954,145
	Total Battery Manufacturing	**$ 687,543,303**	**$ 5,999,646,460**	**$ 6,115,101,833**	**$ 4,479,954,145**
Material Processing	Basic chemical manufacturing	$ 162,137,875	$ 1,401,081,470	$ 1,401,704,658	$ 1,022,511,368
	Non-metallic mineral product manufacturing	$ (20,346,566)	$ 211,306,384	$ 240,413,358	$ 175,286,680
	Non-ferrous metal production and processing	$ 69,782,486	$ 363,285,038	$ 469,488,254	$ 343,057,604
	Total Material Processing	**$ 211,573,795**	**$ 1,975,672,892**	**$ 2,111,606,270**	**$ 1,540,855,652**
Mining	Iron ore mining	$ -	$ -	$ -	$ -
	Copper, nickel, lead and zinc ore mining	$ 7,486,521	$ 74,387,559	$ 95,177,505	$ 69,515,736
	Other metal ore mining	$ 22,790,546	$ 221,859,147	$ 268,184,227	$ 205,602,588
	Other non-metallic mineral mining and quarrying	$ 4,417,319	$ 47,161,930	$ 59,950,943	$ 43,688,741
	Total Mining	**$ 34,694,386**	**$ 343,408,636**	**$ 423,312,675**	**$ 318,807,065**
Rest of Automotive Supply Chain	**Total Rest of Automotive Supply Chain**	**$ (779,530,677)**	**$ (7,908,863)**	**$ 462,114,759**	**$ 351,443,891**
Rest of Economy	**Total Rest of Economy**	**$ (1,968,381,525)**	**$ (275,468,529)**	**$ (118,387,135)**	**$ (751,480,669)**
Total		**$ (3,626,877,832)**	**$ 10,446,868,467**	**$ 10,846,265,627**	**$ 6,031,245,969**

		Change in Output			
	Industry	2025	2030	2035	2040
Vehicle Assembly	**Automobile and light-duty motor vehicle manufacturing**	**$ (1,181,567,405)**	**$ 5,172,472,195**	**$ 6,795,279,791**	**$ 5,288,558,674**
	Heavy-duty truck manufacturing	**$ -**	**$ -**	**$ -**	**$ -**
Vehicle Parts Manufacturing	Gasoline engine and engine parts manufacturing	$ (467,429,941)	$ (2,252,702,929)	$ (3,964,949,694)	$ (4,217,117,991)
	Electrical and electronic equipment manufacturing	$ -	$ -	$ -	$ -
	Steering and suspension components manufacturing	$ (13,701,530)	$ (26,418,746)	$ (54,098,665)	$ (50,016,808)
	Brake system manufacturing	$ (2,470,355)	$ (5,282,718)	$ (9,437,803)	$ (8,841,906)
	Transmission and power train parts manufacturing	$ (52,576,776)	$ (272,820,503)	$ (483,625,277)	$ (509,645,079)
	Seating and interior trim manufacturing	$ (129,630,788)	$ (329,844,998)	$ (559,031,335)	$ (558,040,253)
	Motor vehicle metal stamping	$ (78,989,290)	$ (65,825,040)	$ (75,280,779)	$ (65,155,477)
	Other motor vehicle parts manufacturing	$ 113,588,971	$ 191,940,610	$ 203,660,987	$ 211,924,725
	Total Vehicle Parts Manufacturing	**$ (631,209,709)**	**$ (2,760,954,324)**	**$ (4,942,762,566)**	**$ (5,196,892,789)**
Battery Manufacturing	Other electrical equipment and component manufacturing	$ 687,543,303	$ 5,999,646,460	$ 6,115,101,833	$ 4,479,954,145
	Total Battery Manufacturing	**$ 687,543,303**	**$ 5,999,646,460**	**$ 6,115,101,833**	**$ 4,479,954,145**
Material Processing	Basic chemical manufacturing	$ 162,137,875	$ 1,401,081,470	$ 1,401,704,658	$ 1,022,511,368
	Non-metallic mineral product manufacturing	$ (20,346,566)	$ 211,306,384	$ 240,413,358	$ 175,286,680
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	Total Material Processing	**$ 211,573,795**	**$ 1,975,672,892**	**$ 2,111,606,270**	**$ 1,540,855,652**
Mining	Iron ore mining	$ -	$ -	$ -	$ -
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Rest of Economy	**Total Rest of Economy**	**$ (1,968,381,525)**	**$ (275,468,529)**	**$ (118,387,135)**	**$ (751,480,669)**
Total		**$ (3,626,877,832)**	**$ 10,446,868,467**	**$ 10,846,265,627**	**$ 6,031,245,969**

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