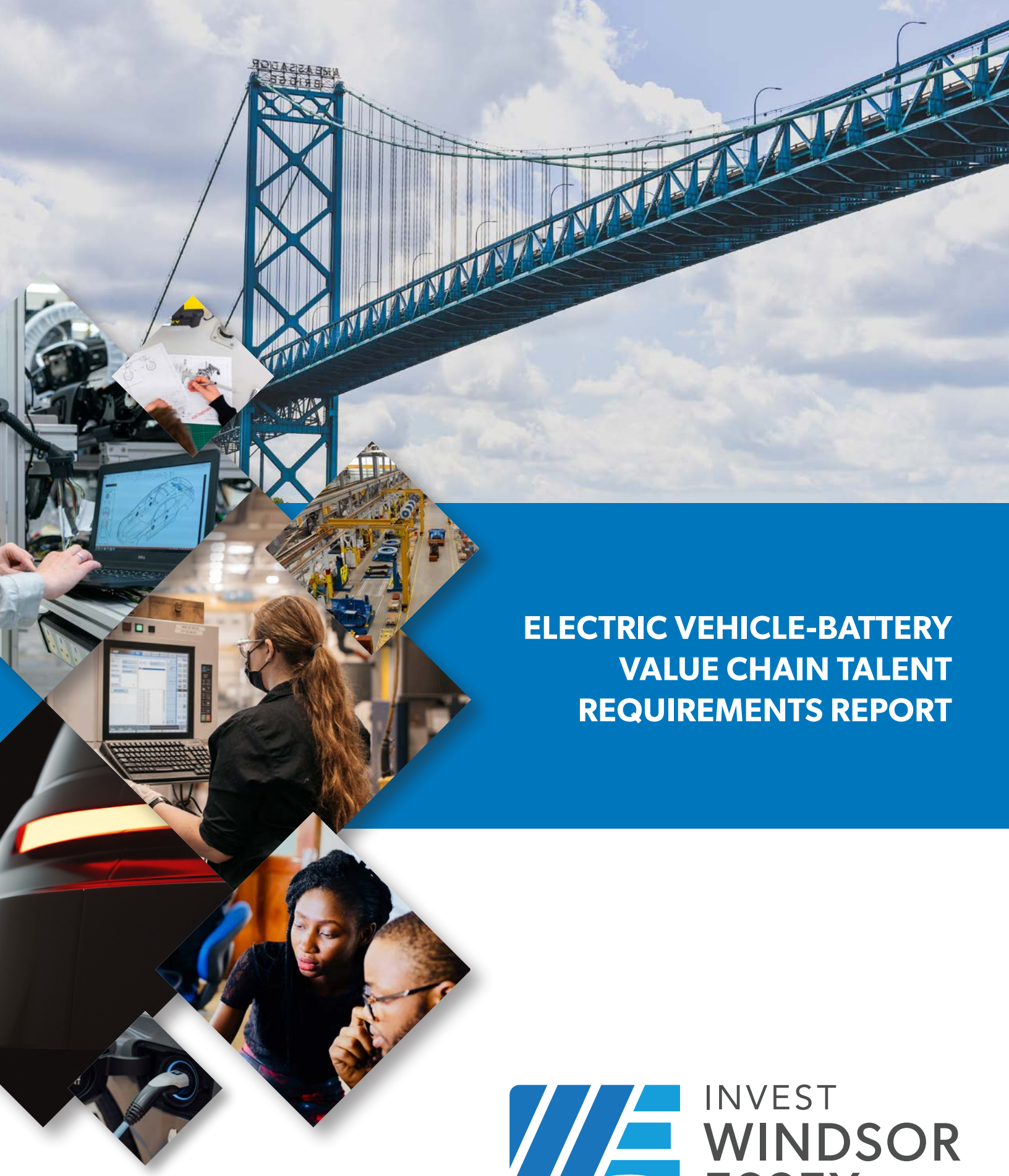

ELECTRIC VEHICLE-BATTERY VALUE CHAIN TALENT REQUIREMENTS REPORT

INVEST WINDSOR ESSEX

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INTRODUCTION

In February 2021, it was announced that Invest WindsorEssex and the City of Windsor had submitted a bid to secure investment from an electric vehicle battery production plant.

The bid has been described as the most advanced Canadian effort to date to secure the country's first such facility. If successful, a $2-billion plant would be established in the Windsor-Essex region that would employ approximately 2,000 workers. This potential investment would have positive implications for the region, including establishing a starting point for developing an electric vehicle (EV) and battery supply chain in Canada.[1] Windsor-Essex would act as a catalyst for such a supply chain and could potentially become the epicentre for the future of automobility in Canada as home to this type of facility.

Windsor-Essex is a logical choice for the location of an EV battery production plant, as it is already home to approximately 350 automation technology and approximately 1,000 manufacturing companies. All together, these companies employ over 35,000 individuals in the Windsor-Essex region.[2] The region possesses a strong talent base of individuals trained for careers in the automotive industry. This talent fuels the region's current automotive companies and allows them to expand and grow, showcasing Windsor-Essex as an ideal location for EV and battery value chain companies to invest in and establish their facilities.

Another strategic advantage that Windsor-Essex possesses is sharing an international border with Detroit, Michigan. Both the city of Detroit and the state of Michigan are recognized as world leaders in connected and automated vehicle legislation and infrastructure investment. Michigan is a global mobility hub, home to the testing and development of connected, automated, and EV manufacturing.[3] This proximity provides a geographical advantage for Windsor-Essex over other regions in Ontario and Canada.

Work is well underway in Windsor-Essex to establish the region as the automobility capital of Canada. In May 2021, the Liberal Minister of Economic Development and Official Languages, the Hon. Mélanie Joly, gave a vote of support to the region's bid to become a "centre of high-tech development, research, and innovation in the automobility sector". This initiative was already seven months in the making before receiving its vote of confidence from the Liberal party Minister. The bid to become the automobility capital of Canada has been kickstarted by in-kind investments from private sector partners, who have also been keen to establish partnerships with the region's post-secondary education institutions. An important aspect of this

1. Dave Waddell. "Windsor pursuing $2B battery plant that would employ 2,000," *Windsor Star*, February 25, 2021.
2. Statistics Canada. Canadian Business Counts, December 2020.
3. Detroit Regional Chamber. "2020 Michigan is Automobility Report," February 25, 2020.

proposal is to develop a talent pipeline that would support growth in select industries, such as battery and electric powertrain production.[4]

The Windsor-Essex region is currently following the lead of major industry stakeholders in its bid to become an automobility capital by establishing an EV value chain cluster in the region. In February 2021, Ford Motor Company of Canada announced a doubling of its investment in electrified vehicles to $22 billion through 2025 and an increase in its total investment in automated driving to $7 billion from $4 billion.[5] Similarly, General Motors (GM) announced in June 2021 that the company would raise spending to $35 billion on electric and autonomous vehicles from 2020 to 2025.[6] Just recently, Stellantis revealed its company strategy to spend $44.5 billion by 2025 to accelerate the electrification of its 14 vehicle brands. Stellantis stated its future would be built on four new platforms, offering three battery types and as many electric motor options. Part of this plan would be retooling its Windsor Assembly Plant toward the production of EVs, though it was not specified exactly which models would be produced at the Windsor plant.[7]

Electrification is clearly becoming the future of transportation. On June 29, 2021, it was announced that the Government of Canada is setting a mandatory target for all new light-duty cars and passenger trucks sales to zero-emission by the year 2035. They have also imposed interim 2025 and 2030 targets to make sure the main goal of lowering greenhouse gas emissions can be achieved.[8] This type of initiative shows why Windsor-Essex's desire to pave the way as a leader in the manufacturing of electrified transportation comes at a perfect time.

This report will accompany and support a larger campaign to transition Windsor-Essex to the automobility capital of Canada, specifically as Invest WindsorEssex and the City of Windsor attempt to secure investment from companies operating within the EV-battery production value chain. The report will identify specific occupations required for the EV-battery production value chain, as well as provide an understanding of where these occupations are located domestically and internationally. It will also outline the required post-secondary curriculum needed to train individuals for careers in this sector and where these programs currently exist domestically and internationally, as well as provide an understanding of best practices globally and a jurisdictional scan for international programs and professors. Lastly, this report will identify talent retention and recruitment strategies for individuals looking for careers in this space.

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4. Dave Waddell. "Minister boosts Windsor's bid to transform into high-tech auto-mobility centre," *Windsor Star*, May 12, 2021.
5. Sam Abuelsamid. "Ford doubling investment in electric cars and trucks to $22 billion," *Forbes*, February 4, 2021.
6. Tom Krisher. "GM, Ford outdo each other with electric vehicle investments," *CTV News*, June 16, 2021.
7. Dave Waddell. "Windsor part of $44.5B Stellantis plan to electrify offerings by 2025," *Windsor Star*, July 9, 2021.
8. Transport Canada. "Building a green economy: Government of Canada to require 100% of car and passenger truck sales to be zero-emission by 2035 in Canada," *Government of Canada*, June 29, 2021.

WHAT IS THE EV AND BATTERY PRODUCTION VALUE CHAIN?

In order to better understand the talent requirements for the EV and battery production value chain, readers of this report will benefit from learning about different stages of the value chain and key activities involved in each stage. This section of the report will briefly describe five stages of the EV and battery production value chain to be focused on.

Mineral Extraction

The first stage of the EV and battery production value chain is mineral extraction. The majority of EVs are powered by lithium-ion batteries and lithium is a key component in green energy storage. The EV market and the production of EVs places an emphasis on lithium as a power source and this is driving new demand for lithium resources.[9] Lithium is a mineral that must be mined for. Lithium can be derived from one of two main forms, brines or hard rock. Lithium brines are typically located closer to the surface than hard rock deposits and drilling can be done at shallower depths as a result. Lithium brine exploration is also usually much less expensive than hard rock exploration.[10] Countries like Australia, China, and Chile are known for the large amounts of lithium they produce from mining. Lithium-ion batteries found in today's EV batteries would not exist without consistent mining efforts to ensure a global lithium supply.

Battery Manufacturing

Battery manufacturing for EVs is the multi-step process of combining all the materials that make up the final battery module that will act as the main source of power for an EV. There are three main components typically involved when producing a lithium-ion battery that will be used in an EV. The three main components are the battery module, the fully-equipped case that houses the battery module, and the battery's electronic components. The battery module and its electronic components must be packed into the case, which is typically a process undertaken at a battery packing facility. A great example of a battery packing facility is Lion Electric's facility located in Quebec. The majority of batteries found in today's EVs are manufactured with automation and robotic technologies, to allow for more precision in the manufacturing process. Currently, the battery manufacturing market is dominated by China, Japan, and Korea. However, more progress is being made in European and American markets to shift some of the market share away from the Asian countries previously mentioned.[11,12]

9. Laurence Kavanagh et al, "Global Lithium Sources – Industrial Use and Future in the Electric Vehicle Industry: A Review," *Resources* 57, no. 7 (2018): 1.
10. Jeff Desjardins. "A cost comparison: Lithium brine vs. hard rock exploration," Visual Capitalist, June 2, 2015.
11. Skoda Auto. "Battery Production: How the Heart of an Electric Car is Made," August 21, 2020.
12. James Eddy et al. "Recharging economies: The EV-battery manufacturing outlook for Europe," *McKinsey & Company*, June 13, 2019.

EV Assembly and Maintenance

Similar to Internal Combustion Engine Vehicles (ICE-V) production, EVs go through a design and assembly process, involving putting together the numerous components that will result in the final EV product. The design process of an EV typically focuses on creating a vehicle that is efficient, produces little to no pollution, and is silent. There are more complexities involved when designing an EV, since it contains many different components and these components need to be modelled properly in order to prevent potential issues with the vehicle.[13]

As original equipment manufacturers (OEMs) and suppliers continue to produce EVs, more robots and automation technologies will be used to assemble smaller parts and subassemblies, in addition to the entire motor itself. These robots and automation technologies will all be part of assembly lines that combine the numerous components necessary to arrive at a finished EV product. Assembly lines for EVs typically involve different processes from those of ICE-Vs. For example, there is much less metal cutting and machining involved for the component parts.[14]

An advantage EVs possess over ICE-Vs is the easier and more affordable maintenance process. For example, there are a smaller number of mechanical parts that need to be checked on a regular basis in an EV compared to an ICE-V. EVs have a smaller number of parts, less wear on the brakes, and a simplified transmission, all of which lead to less maintenance needed to prolong vehicle life. There are also studies that show the maintenance cost of an EV can be 20-35% lower than that of an ICE-V. However, one downside of EV maintenance is that many garages are currently not authorized to carry out maintenance on EVs, and technicians in these garages will have to undergo new training before certification is granted. As EVs become more popular as a consumer option in the future, we can expect more garages to gain EV maintenance certification.[15]

13. Amir Guizani et al, "Electric vehicle design, modelling and optimization," *Mechanics & Industry* 17, 405 (2016): 1.
14. John Challen. "Assembling Electric Vehicle Motors," *Assembly Magazine*, May 20, 2021.
15. Renault Group. "All There is to Know About Electric Car Maintenance," April 27, 2021.

Charging Infrastructure

Proper charging infrastructure is crucial to ensure the success of EVs. EV charging stations are necessary to recharge the batteries that currently exist in EVs. There are different levels of charging stations currently available for EVs to be plugged into. Level 1 and 2 charging stations are typically found in private households and public places and use 110V and 240V systems that can add anywhere from approximately 8-50km of range per hour of charging. Level 3 and 4 charging stations charge EVs at much faster rates and can add more than 100km of range per hour of charging.[16]

Battery Recycling

Once EVs reach the end of their life cycles, the batteries that powered them must be recycled. As EVs increase in popularity, they present a battery waste problem that needs to be addressed.[17] New companies are being created that promise to recover and recycle as much of the materials used in EV batteries once they have reached the end of their life cycles. For example, a Quebec-based battery recycler has teamed up with Hyundai Canada and claims their battery recycling process is able to recover 95% of spent battery materials, which can then be used in new batteries.[18]
As recycling technologies advance, recycled lithium-ion batteries from EVs could provide a valuable secondary source of materials as opposed to continuously increasing mining efforts to find new materials for EV batteries.

16. Ontario Ministry of Transportation. "About Electric Vehicle (EV) Charging," December 22, 2020.
17. Jason Vermes, "As electric vehicles age, here's how the batteries are finding a second life," CBC Radio, November 12, 2019.
18. Emma Jarratt, "Canadian technology in recycling end-of-life lithium-ion batteries continues to make headlines, with Hyundai the latest OEM to partner with a recycler while growing its electric model offerings," Electric Autonomy Canada, March 12, 2021.

ATTRACTING AND RETAINING TALENT FOR THE EV VALUE CHAIN

In order to build a successful EV value chain cluster in Windsor-Essex, the region must possess the talent to do so. This means being able to attract and retain trained professionals from other regions in Canada and around the world, as well as retaining valuable talent the region is growing locally, such as educated graduates from the region's post-secondary institutions. Good news for the region of Windsor-Essex is that the population has continued to grow since 2016. A promising sign for the region is that the population is growing in age demographics 0-44, with more rapid growth from 0-17, providing a potential for employers in the region's key industries to retain available talent now through the prime working age demographic and into the future through the youth age demographic. However, between 2011-2016, the Windsor-Essex region experienced a decline in population of individuals with a university education. This could be an issue for the region as many of the jobs identified as necessary for the EV value chain require a university education. This data leads to the obvious question: what can Windsor-Essex do to attract and retain qualified individuals who will be able to help a potential EV value chain cluster grow successfully in the region? One solution may be to tap into the growing international student population, who are often enrolled in college and university programs suited for careers in an EV value chain. For example, international students are enrolled at a higher percentage in the variety of engineering programs at the University of Windsor than any other program offered.[19] In 2019, the Minister of Immigration, Refugees, and Citizenship Canada (IRCC) was mandated to "Introduce a Municipal Nominee Program (MNP) that will allow local communities, chambers of commerce, and local labour councils to directly sponsor permanent immigrants. At least 5,000 new spaces will be dedicated for this program. This would allow existing federal, provincial, and territorial economic immigration pathways to target various types of skills and candidate profiles to address various needs and gaps. This MNP program would contribute to filling labour needs by increasing the amount of permanent resident admissions to immigrants and could potentially be used to recruit international students upon graduation. Another solution would be to create attraction campaigns for trained individuals in other regions of Canada and internationally.

In a 2019 report published by Workforce WindsorEssex, "Attracting and Retaining Talent in Windsor-Essex," a list of top factors that attract individuals to a specific reason was shared. Two of the top reasons given for individuals to consider relocation were salary, and more specifically, job opportunities that allowed an individual the opportunity to increase their salary throughout time. In order to attract and retain trained professionals to the Windsor-Essex region to support a successful EV value chain cluster, more jobs need to be created in these fields. However, this can create a chicken and egg situation for the region, as an argument can be made that companies will not be attracted to the region without the required talent being available to them.

19. UWindsor Data, "Student Enrollment at the University of Windsor." University of Windsor, Fall 2020.

In July 2021, Stellantis announced a plan to spend $44.5 billion by 2025 to accelerate the electrification of its 14 vehicle brands. The Stellantis Windsor Assembly Plant location was promised one or two new electric models in the contract negotiations from 2020, meaning that EVs will be produced in the region in the foreseeable future. It was also announced that the Canadian government was supporting the retooling of the Windsor Assembly Plant to ensure that it is prepared for the future of EV production.[20] These announcements could be the beginning stage of growth that is needed to attract and retain the talent necessary for a successful EV value chain cluster in the Windsor-Essex region.

In order to help support these announcements and keep the potential EV value chain growth momentum moving forward, the Windsor-Essex region should consider focusing on competitive advantages it already holds, while developing new advantages through investment in more EV value chain infrastructure. Through consultations with post-secondary institutions in the region, it has been identified that new course and program offerings directly related to research on and the production of EVs are currently being introduced, and more programming is being planned. The efforts of education to support the growth of talent in the EV value chain will be shared in more detail in the next section of this report. In terms of the Windsor-Essex region investing in more infrastructure to support a transition to an EV-based society, the region can look to examples from other regions and/or municipalities. One idea to consider would be potential electrification of City of Windsor Transit buses. The City of Brampton recently introduced battery electric buses (BEBs) to its transit system on May 4. At the time, this was the largest single global deployment of standardized and fully inter-operable BEBs and high-powered overhead on-route charging systems. Another best-practice example would be the Town of Oakville, which recently oversaw the installation of considerable charging infrastructure for EVs. As EV popularity grows in the Windsor-Essex region, the need for charging stations will be critical to support this growing demand. In 2019, the Town of Oakville applied for a provincial government grant through the Zero Emission Vehicle Infrastructure Program (ZEVIP) to help support its transition to a more EV-based society by installing more charging stations throughout the municipality. Most of the installations were able to be completed on the existing power grid – only one location required upgrades to be made. The City of Windsor recently moved in this direction by announcing a $525,000 investment in partnership with ENWIN Utilities to establish 22 new EV charging stations citywide. Another example Windsor-Essex could look to is the Municipality of Clarington, in Durham County. The Municipality of Clarington recently partnered with Trent University to create a robust EV plan, including research and recommendations for the region.[21]

Windsor-Essex already possesses a good base workforce to grow an EV value chain cluster in the region. The region is home to over 380 automation companies involved in the engineering, design, and production of cutting-edge advanced manufacturing systems for a wide range of industries, including automotive. Windsor-Essex is also home to one of the largest manufacturing workforces in all of Canada (approximately 40,000 employees and 1,115 businesses). Many of the individuals working in this sector are already qualified or would require minimal re-training to be prepared for occupational roles in an EV value chain. This competitive advantage should be highlighted when attempting to attract EV value chain-based employers to the region.

In February of 2020, the Windsor City Council commissioned an economic development report called Windsor Works - An Economic Development Strategy for the City's Future Growth. Some of the specific recommendations made in this report are for Windsor to improve infrastructure and revive downtown, become the site of Canada's future auto sector, and attract and retain more national and global talent. These recommendations can be used as an informed starting point for attracting an EV value chain sector to Windsor-Essex and are perfectly aligned with information and initiatives shared in this report.

20. Dave Waddell. "Windsor part of $44.5B Stellantis plan to electrify offerings by 2025," *Windsor Star*, July 9, 2021.
21. Municipality of Clarington, "Mitigating the impacts of Climate Change: Clarington launches new Community Electric Vehicle Report," December 2, 2020.

EV AND BATTERY PRODUCTION VALUE CHAIN TALENT REQUIREMENTS

In order for a potential EV value chain cluster to thrive in Windsor-Essex, the correct talent and skills need to be made available. The following section will outline the talent and skills requirements for an EV value chain, based on research and consultations with stakeholders involved in EV value chain activities. Location quotients – ratios that allow an area's distribution of employment by industry, ownership, and size class to be compared to a reference area's distribution – from Windsor-Essex and Canadian CMAs will be compared, as well as absolute numbers of individuals employed in each identified occupation internationally, according to the International Standard Classification of Occupations (ISCO). Identifying areas where individuals are employed in these occupations will give necessary stakeholders in Windsor-Essex a better idea of where to attract and recruit trained individuals from.

Each following section will provide information about identified talent required for the EV value chain.

Description

A brief description of the duties of each occupation, as well as some of the skills that would be required.

Required education

What type of training, diploma, and/or degree would be required for each of the identified occupations.

Education offered locally

Identification of local post-secondary programming that would provide the necessary education to enter a specified occupation.

Windsor-Essex location quotient

To help stakeholders identify if the region already possesses a large enough talent pool to support an EV value chain cluster. Red font indicates a low location quotient (0.00-0.74), yellow indicates a medium location quotient (0.75-1.24), and green indicates a high location quotient (1.25+).

Top Canadian CMA location quotients with 100+ jobs

To help stakeholders identify locations to potentially recruit from if the Windsor-Essex region does not possess a large enough talent pool of the specified occupation.

Top international locations with 100+ jobs

To help stakeholders identify international locations to potentially recruit from if the Windsor-Essex region does not possess a large enough talent pool of the specified occupation. Absolute numbers for each region will be provided based on ISCO standardization equivalent of each National Occupation Classification (NOC) code provided.

Mineral Extraction

Typically, occupations such as miners, electricians, environmentalists, geologists, health and safety managers, heavy equipment operators, metallurgical engineers, millwrights, prospectors, surveyors, and welders would be included in the mining process. However, it is highly unlikely that Windsor-Essex would be able to attract mining companies involved in collecting minerals for the EV value chain process, since it is not a region where these mines exist. If an individual is looking for training and/or employment experience in the mining sector, specifically in mines that provide essential minerals for EVs, good areas in Canada to consider would be Northern Manitoba, Northern Quebec, Voisey's Bay, Newfoundland, or Sudbury, Ontario.

BATTERY MANUFACTURING & RECYCLING

Chemical engineers, chemists, and materials scientists have been identified as key occupations necessary for the battery manufacturing and recycling stages of the EV value chain. EV battery manufacturing is an early stage of the EV value chain, while EV battery recycling represents the final stage of the value chain.

CHEMICAL ENGINEERS (NOC 2134)

Description:

Apply the principles of chemistry to design or improve equipment or to devise processes for manufacturing chemicals and products

Responsible for developing new battery designs and improving current battery technologies

Vital in designing equipment and processes for large-scale manufacturing and in planning and testing the methods of battery manufacturing

Required education:

Bachelor's and/or Master's degree or PhD in chemical engineering

Local education offered:

N/A

Windsor-Essex Location Quotient:

0.59 (53 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Sarnia, ON – 4.84 (113 jobs)

Wood Buffalo, AB – 3.06 (117 jobs)

Calgary, AB – 2.55 (946 jobs)

Edmonton, AB – 1.92 (668 jobs)

Vancouver, BC – 1.27 (885 jobs)

Top 5 international region locations with 100+ jobs:

Finland – 4,673

Houston-The Woodlands-Sugar Land, TX, USA – 4,400

Skåne County, Sweden – 913

Beaumont-Port Arthur, TX, USA – 590

Lake Charles, LA, USA - 390

CHEMISTS (NOC 2112)

Description:

Investigate the properties, composition, and structure of matter, and the laws that govern the reactions of substances to each other

Chemists working on EVs find new chemicals to use in batteries or ways to make existing batteries work better

Work closely with engineers and other scientists to develop new batteries and other technologies

Required education:

Bachelor's degree in chemistry or biochemistry

Master's degree or PhD for employment as a research chemist

Local education offered:

University of Windsor – Chemistry and Biochemistry

Windsor-Essex Location Quotient:

0.34 (51 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Ottawa-Gatineau, ON-QC – 1.95 (1,225 jobs)

Montreal, QC – 1.72 (3,079 jobs)

Quebec City, QC – 1.50 (574 jobs)

Toronto, ON – 1.37 (3,759 jobs)

Sherbrooke, QC – 1.16 (100 jobs)

Top 5 international region locations with 100+ jobs:

New York-Newark-Jersey City, NY-NJ-PA, USA – 7,960

Philadelphia-Camden-Wilmington, PA-NJ-DE-MD, USA – 4,280

San Francisco-Oakland-Hayward, CA, USA – 3,140

Los Angeles-Long Beach-Anaheim, CA, USA – 2,990

Washington-Arlington-Alexandria, DC-VA-MD-WV, USA – 2,890

MATERIAL SCIENTISTS (NOC 2115)

Description:

Conduct research into the properties, composition, and production of materials such as ceramics and composite materials involved in the EV battery manufacturing and/or recycling process

Required education:

Bachelor's degree in metallurgy, physics, chemistry, or a related physical science

Master's degree or PhD required for employment as a research scientist

Local education offered:

University of Windsor – Chemistry and Biochemistry

University of Windsor – Physics

Windsor-Essex Location Quotient:

0.82 (21 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Ottawa-Gatineau, ON-QC – 2.75 (304 jobs)

Calgary, AB – 1.64 (179 jobs)

Vancouver, BC – 1.08 (222 jobs)

Montreal, QC – 0.87 (274 jobs)

Toronto, ON – 0.64 (309 jobs)

Top 5 international region locations with 100+ jobs:

N/A (equal ISCO classification does not exist for this NOC code)

EV DESIGN & ASSEMBLY

EV design and assembly are the stages in an EV value chain that come after battery manufacturing. These stages are very important, as they represent the design and assembly of all component parts of an EV except the battery, including chassis, electronics, and drivetrain. Most of the identified occupations for an EV value chain are part of these two stages.

CONTROLS TECHNICIANS (NOC 2243)

Description:

Consult manufacturer's manuals, circuit diagrams, and blueprints to determine tests and maintenance procedures for instruments used for measuring and controlling flow, level, pressure, temperature, chemical composition, and other variables in manufacturing and processing

Inspect and test operation of instruments and systems to diagnose faults using pneumatic, electrical and electronic testing devices, and precision measuring instruments

Repair and adjust system components, such as sensors, transmitters, and programmable logic controllers, or remove and replace defective parts

Calibrate components and instruments according to manufacturers' specifications

Perform scheduled preventative maintenance work and complete test and maintenance reports

Install control and measurement instruments on existing and new plant equipment and processes

Required education:

Completion of a four- or five-year apprenticeship program in industrial instrument repair

Local education offered:

St. Clair College – Electromechanical Engineering Technician – Robotics

St Clair College – Electromechanical Engineering Technology – Robotics

Windsor-Essex Location Quotient:

0.40 (37 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Wood Buffalo, AB – 6.70 (269 jobs)

Edmonton, AB – 4.29 (1,463 jobs)

Lethbridge, AB – 3.45 (111 jobs)

Calgary, AB – 2.54 (988 jobs)

St. John's, NL – 1.72 (100 jobs)

Top 5 international region locations with 100+ jobs:

East Derbyshire, UK – 1,296

Los Angeles-Long Beach-Anaheim, CA, USA – 1,150

Detroit-Warren-Dearborn, MI, USA – 1,060

Latvia – 682

Chicago-Naperville, Elgin, IL, USA - 660

ELECTRICAL AND ELECTRONICS ENGINEERS (NOC 2133)

Description:

Design, develop, test, and supervise the manufacture of electrical components in an EV

Responsible for designing the electrical circuitry that allows a gas engine to charge the battery and distribute the electricity from the battery to the electric motor

Might work on the heating and air-conditioning systems, vehicle lighting, and visual displays

Required education:

Bachelor's degree in electrical or electronics engineering

Master's degree or PhD may be required

Local education offered:

University of Windsor – Electrical and Computer Engineering

Windsor-Essex Location Quotient:

0.82 (301 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Oshawa, ON – 2.43 (638 jobs)

Granby, QC – 2.33 (201 jobs)

St. John's, NL – 1.76 (403 jobs)

Calgary, AB – 1.73 (2,636 jobs)

Peterborough, ON – 1.63 (195 jobs)

Top 5 international region locations with 100+ jobs:

New York-Newark-New Jersey, NY-NJ-PA, USA – 8,670

Finland – 8,458

Los Angeles-Long Beach-Anaheim, CA, USA – 8,310

Stockholm County, Sweden – 8,125

Boston-Cambridge-Nashua, MA-NH, USA – 7,640

ELECTRICIANS (NOC 7241)

Description:

Read and interpret drawings, circuit diagrams, and electrical code specifications to determine wiring layouts for new or existing installations during EV manufacturing stage

Pull wire through conduits and through holes in walls and floors

Install brackets and hangers to support electrical equipment

Install, replace, and repair lighting fixtures and electrical control and distribution equipment, such as switches, relays, and circuit breaker panels

Splice, join, and connect wire to fixtures and components to form circuits

Test continuity of circuits using test equipment to ensure compatibility and safety of system, following installation, replacement, or repair

Troubleshoot and isolate faults in electrical and electronic systems and remove and replace faulty components

Connect electrical power to audio and visual communication equipment, signalling devices, and heating and cooling systems

Conduct preventive maintenance programs and keep maintenance records

Required education:

Completion of a four- to five- year apprenticeship program

Local education offered:

St. Clair College – Electrical Engineering Technician

St. Clair College – Electrical Techniques

St. Clair College – Electrician: Construction & Maintenance (Apprenticeship Program)

Windsor-Essex Location Quotient:

0.97 (777 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Medicine Hat, AB – 2.30 (345 jobs)

Wood Buffalo, AB – 2.05 (709 jobs)

Edmonton, AB – 1.97 (6,211 jobs)

Lethbridge, AB – 1.96 (541 jobs)

Grand Prairie, AB – 1.94 (299 jobs)

Top 5 international region locations with 100+ jobs:

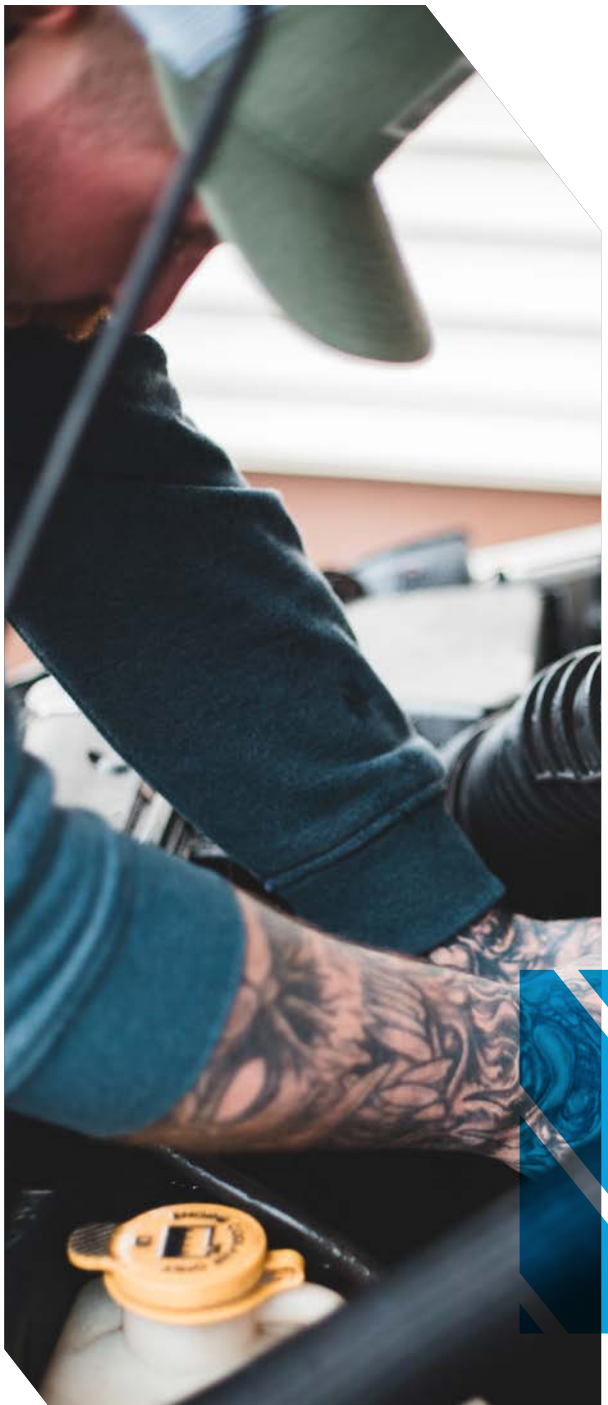
New York-Newark-Jersey City, NY-NJ-PA, USA – 43,760

Los Angeles-Long Beach-Anaheim, CA, USA – 19,470

Chicago-Naperville-Elgin, IL-IN-WI, USA – 18,160

Houston-The Woodlands-Sugar Land, TX, USA – 17,860

Dallas-Forth Worth-Arlington, TX, USA – 17,500



INDUSTRIAL AND COMMERCIAL DESIGNERS (NOC 2252)

Description:

Responsible for the style, function, quality, and safety of vehicles

Must consider the preferences of potential consumers as well as the production abilities of manufacturers

Must work with engineers and other members of the production team to ensure that the vehicles meet specified requirements

Prepare sketches or diagrams, usually with the aid of computers, and work with engineers and other designers to improve a design

Required education:

University degree in industrial design, architecture, engineering, or a college diploma in industrial design

Local education offered:

University of Windsor – Mechanical, Automotive, and Materials Engineering

St. Clair College – Mechanical Engineering Technology – Automotive Product Design

Windsor-Essex Location Quotient:

1.01 (110 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Granby, QC – 4.12 (106 jobs)

Saguenay, QC – 2.20 (103 jobs)

Quebec City, QC – 1.98 (553 jobs)

Montreal, QC – 1.61 (2,113 jobs)

Ottawa-Gatineau, ON-QC – 1.49 (687 jobs)

Top 5 international region locations with 100+ jobs:

N/A

INDUSTRIAL ELECTRICIANS
(NOC 7242)

Description:

Read and interpret drawings, blueprints, schematics, and electrical code specifications to determine layout of industrial electrical equipment installations during EV manufacturing process

Install, examine, replace or repair electrical wiring, receptacles, switch boxes, conduits, feeders, fibre-optic and coaxial cable assemblies, lighting fixtures, and other electrical components

Test electrical and electronic equipment and components for continuity, current, voltage, and resistance

Maintain, repair, install, and test switchgear, transformers, switchboard meters, regulators, and reactors

Maintain, repair, test, and install electrical motors, generators, alternators, industrial storage batteries, and hydraulic and pneumatic electrical control systems

Troubleshoot, maintain, and repair industrial, electrical and electronic control systems, and other related devices

Conduct preventive maintenance programs and keep maintenance records

May install, maintain, and calibrate industrial instrumentation and related devices

Required education:

Completion of a four- or five-year industrial electrician apprenticeship program

Local education offered:

St. Clair College – Electronics Engineering Technology – Industrial Automation

St. Clair College – Industrial Electrician (Apprenticeship Program)

Windsor-Essex Location Quotient:

1.36 (429 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Fort St. John, BC – 3.30 (113 jobs)

Stratford, ON – 3.09 (117 jobs)

Sault Ste. Marie, ON – 2.97 (184 jobs)

Guelph, ON – 2.77 (499 jobs)

Woodstock, ON – 2.73 (132 jobs)

Top 5 international region locations with 100+ jobs:

New York-Newark-Jersey City, NY-NJ-PA, USA – 43,760

Los Angeles-Long Beach-Anaheim, CA, USA – 19,470

Chicago-Naperville-Elgin, IL-IN-WI, USA – 18,160

Houston-The Woodlands-Sugar Land, TX, USA – 17,860

Dallas-Forth Worth-Arlington, TX, USA – 17,500

INDUSTRIAL ENGINEERING AND MANUFACTURING TECHNOLOGISTS AND TECHNICIANS (NOC 2233)

Description:

Develop and conduct production, inventory, and quality assurance programs in manufacturing of EVs

Develop applications using CAD/CAM (computer-assisted drafting, computer-assisted manufacturing) for the control of robots, computer numerical control (CNC) machines, and other manufacturing processes and operations

Conduct work measurement or other studies

Collect and compile operational or experimental data and assist in the development of estimates, schedules, specifications, and reports

Develop manufacturing and processing procedures and variables, set machine or equipment controls, oversee production, and inspect processes

Required education:

Completion of a two- or three-year college program or equivalent in industrial engineering technology or manufacturing technology for manufacturing technologists

Completion of a one- or two-year college program in industrial engineering technology for manufacturing technicians

Local education offered:

St. Clair College – Mechanical Engineering Technology, Automotive Product Design

St. Clair College – Mechanical Engineering Technician, Industrial

Windsor-Essex Location Quotient:

2.35 (541 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Granby, QC – 2.93 (159 jobs)

Saguenay, QC – 2.16 (213 jobs)

Guelph, ON – 1.87 (245 jobs)

Peterborough, ON – 1.76 (133 jobs)

Drummondville, QC 1.72 (112 jobs)

Top 5 international region locations with 100+ jobs:

N/A

INDUSTRIAL ENGINEERS (NOC 2141)

Description:

Determine the most effective ways to use the basic factors of production—people, machines, materials, information, and energy—to manufacture vehicles

Concerned primarily with increasing productivity through the management of people, use of technology, and improvement of production methods

Design innovative manufacturing processes and retool plants that formerly made different models of cars

Required education:

Bachelor's degree in industrial engineering

A Master's degree or PhD may be required

Local education offered:

University of Windsor – Industrial Engineering

Windsor-Essex Location Quotient:

1.90 (293 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Granby, QC – 4.03 (146 jobs)

Guelph, ON – 2.35 (206 jobs)

Montreal, QC – 1.58 (2,934 jobs)

Greater Sudbury, ON – 1.39 (104 jobs)

Kitchener-Cambridge-Waterloo, ON – 1.38 (345 jobs)

Top 5 international region locations with 100+ jobs:

Detroit-Warren-Dearborn, MI, USA – 20,490

Los Angeles-Long Beach-Anaheim, CA, USA – 10,220

Boston-Cambridge-Nashua, MA-NH, USA – 10,030

New York-Newark-Jersey City, NY-NJ-PA, USA – 7,800

Minneapolis-St. Paul-Bloomington, MN-WI – 7,630

MACHINISTS (NOC 7231)

Description:

Use machine tools, such as lathes, milling machines, and grinders, to produce precision metal parts

Producing large quantities of a single part may be partially or fully automated, and machinists are responsible for monitoring the machines and the quality of the output

Responsible for producing small batches or making one-of-a-kind parts for prototypes or testing. If many more pieces are needed, they are often mass-produced using computer-controlled machines

Required education:

Completion of a four-year apprenticeship program

Local education offered:

St. Clair College – General Machinist (Apprenticeship Program)

St. Clair College – Mould Maker (Apprenticeship Program)

St. Clair College – Tool & Die Maker (Apprenticeship Program)

Windsor-Essex Location Quotient:

5.17 (1,914 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Granby, QC – 3.81 (332 jobs)

Sorel-Tracy, QC – 3.63 (141 jobs)

Stratford, ON – 3.52 (157 jobs)

Guelph, ON – 3.26 (685 jobs)

Drummondville, QC – 2.93 (307 jobs)

Top 5 international region locations with 100+ jobs:

Finland – 4,099

Cork County, Ireland – 1,917

Dalarna County, Sweden – 1,723

Södermanland, Sweden – 1,597

Chicago-Naperville-Elgin, IL-IN-WI, USA – 1,370

MECHANICAL AND MECHATRONICS ENGINEERS (NOC 2132)

Description:

Design, develop, and test the tools, engines, machines, and other mechanical devices in EVs. These devices may be components of EVs, or machines that are used in the manufacture or repair of these vehicles

May focus on engines, electric motors, or other mechanical devices, such as transmissions, drivetrains, or steering systems

Required education:

Bachelor's degree in mechanical engineering

Master's degree or PhD may be required

Local education offered:

University of Windsor – Mechanical Engineering

Windsor-Essex Location Quotient:

3.59 (1,286 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Sarnia, ON – 3.92 (371 jobs)

Peterborough, ON – 2.56 (301 jobs)

Chatham-Kent, ON – 2.38 (207 jobs)

Calgary, AB – 1.91 (2,865 jobs)

Guelph, ON – 1.90 (388 jobs)

Top 5 international region locations with 100+ jobs:

Detroit-Warren-Dearborn, MI, USA – 31,280

Finland – 16,685

Los Angeles-Long Beach-Anaheim, CA, USA – 14,080

Chicago-Naperville-Elgin, IL-IN-WI, USA – 12,010

Houston-The Woodlands-Sugar Land, TX, USA – 11,080

MECHANICAL ASSEMBLERS (NOC 9526)

Description:

Use a variety of tools to build and assemble electromechanical components used in EVs, such as gasoline engines, electric motors, and generators

Required education:

Some secondary school education is required

On-the-job training provided

Local education offered:

N/A

Windsor-Essex Location Quotient:

1.47 (214 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Winkler, MB – 14.29 (185 jobs)

Woodstock, ON – 4.95 (109 jobs)

Guelph, ON – 4.24 (351 jobs)

Winnipeg, MB – 3.61 (1,312 jobs)

Drummondville, QC – 3.24 (134 jobs)

Top 5 international region locations with 100+ jobs:

Finland – 12,274

Detroit-Warren-Dearborn, MI, USA – 6,810

Västra Götaland County, Sweden – 2,445

Los Angeles-Long Beach-Anaheim, CA, USA – 2,440

Tulsa, OK, USA – 2,410

MECHANICAL DRAFTING TECHNOLOGISTS AND TECHNICIANS (NOC 2253)

Description:

Prepare detailed drawings that show how to assemble machinery and mechanical devices

Responsible for producing visual guidelines that illustrate the construction methods for mechanical components of vehicles

Most drafters use CAD systems to prepare drawings

Required education:

Completion of a two- to three-year college program in engineering design and drafting technology is usually required for drafting and design technologists

Completion of a one- to two-year college program in drafting or completion of a three- to four-year apprenticeship program or four to five years of related experience plus completion of college or industry courses in drafting are usually required for drafting technicians

Local education offered:

St. Clair College – Mechanical Technician

Windsor-Essex Location Quotient:

0.60 (168 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Granby, QC – 2.04 (134 jobs)

Calgary, AB – 1.98 (2,303 jobs)

Edmonton, AB – 1.97 (2,148 jobs)

Saguenay, QC – 1.83 (219 jobs)

Saskatoon, SK – 1.76 (449 jobs)

Top 5 international region locations with 100+ jobs:

N/A

MECHANICAL ENGINEERING TECHNOLOGISTS AND TECHNICIANS (NOC 2232)

Description:

Assist engineers with solving technical problems in research, development, manufacturing, construction, inspection, and maintenance of EVs

Work is more narrowly focused and is more oriented toward applications than that of engineers or scientists

Will build or set up equipment, prepare and conduct experiments, collect data, and calculate or record results

May also help engineers or scientists to make prototypes of newly designed equipment or assist with CAD equipment

Required education:

Completion of a two- or three-year college program in mechanical engineering technology is usually required for mechanical engineering technologists

Completion of a one- or two-year college program in mechanical engineering technology is usually required for mechanical engineering technicians

Local education offered:

St. Clair College – Mechanical Engineering Technology, Automotive Product Design

St. Clair College – Mechanical Engineering Technician, Industrial

St. Clair College – Mechanical Technician

Windsor-Essex Location Quotient:

1.63 (311 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Saguenay, QC – 3.05 (250 jobs)

Granby, QC – 2.47 (111 jobs)

Quebec City, QC – 2.44 (1,198 jobs)

Guelph, ON – 2.36 (256 jobs)

Peterborough, ON – 2.14 (134 jobs)

Top 5 international region locations with 100+ jobs:

New York-Newark-Jersey City, NY-NJ-PA, USA – 43,760

Los Angeles-Long Beach-Anaheim, CA, USA – 19,470

Chicago-Naperville-Elgin, IL-IN-WI, USA – 18,160

Houston-The Woodlands-Sugar Land, TX, USA – 17,860

Dallas-Forth Worth-Arlington, TX, USA – 17,500

METALLURGICAL AND MATERIALS ENGINEERS (NOC 2142)

Description:

Involved in the development, processing, and testing of materials used in EVs. Many EVs are made of newer materials that are lighter and stronger than those in traditional cars

May also incorporate environmentally friendly materials that are derived from plant-based materials or recycled materials

Required education:

Bachelor's degree in metallurgical, materials, ceramic, or chemical engineering

Master's degree or PhD may be required

Local education offered:

University of Windsor – Mechanical Engineering with a Materials Option

Windsor-Essex Location Quotient:

0.73 (20 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Calgary, AB – 1.54 (173 jobs)

Edmonton, AB – 1.30 (138 jobs)

Vancouver, BC – 1.21 (256 jobs)

Montreal, QC – 1.20 (392 jobs)

Toronto, ON – 0.47 (232 jobs)

Top 5 international region locations with 100+ jobs:

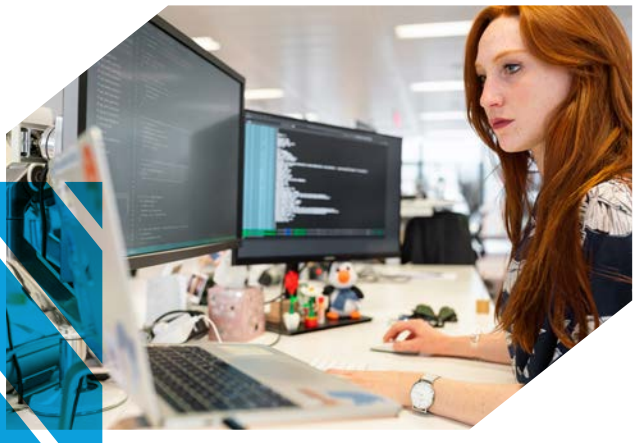
Houston-The Woodlands-Sugar Land, TX, USA – 12,530

Dallas-Fort Worth-Arlington, TX, USA – 3,080

Los Angeles-Long Beach-Anaheim, CA, USA – 2,120

Denver-Aurora-Lakewood, CO, USA – 1,450

New York-Newark-Jersey City, NY-NJ-PA, USA – 1,210



MILLWRIGHTS AND INDUSTRIAL MECHANICS (NOC 7311)

Description:

Read blueprints, diagrams and schematic drawings to determine work procedures

Operate hoisting and lifting devices such as cranes, jacks, and tractors to position machinery and parts during the installation, set-up, and repair of machinery used for EV manufacturing process

Inspect and examine machinery and equipment to detect and investigate irregularities and malfunctions

Install, troubleshoot, and maintain power transmission, vacuum, hydraulic, and pneumatic systems, and programmable logic controls

Adjust machinery and repair or replace defective parts

Operate machine tools such as lathes and grinders to fabricate parts required during overhaul, maintenance, or set-up of machinery

Clean, lubricate, and perform other routine maintenance work on machinery

Construct foundations for machinery or direct other workers to construct foundations

Assemble machinery and equipment prior to installation using hand and power tools and welding equipment

Required education:

Completion of a three- to four-year apprenticeship program

Local education offered:

St. Clair College – Industrial Mechanical Millwright (Apprenticeship Program)

Windsor-Essex Location Quotient:

1.94 (1,673 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Quesnel, BC – 5.75 (291 jobs)

Ingersoll, ON – 4.69 (195 jobs)

Tillsonburg, ON – 3.55 (157 jobs)

Williams Lake, BC – 3.13 (162 jobs)

Thompson, MB – 3.02 (124 jobs)

Top 5 international region locations with 100+ jobs:

Houston-The Woodlands-Sugar Land, TX, USA – 22,080

Finland – 19,288

Chicago-Naperville-Elgin, IL-IN-WI, USA – 18,750

New York-Newark-Jersey City, NY-NJ-PA, USA – 16,450

Los Angeles-Long Beach-Anaheim, CA, USA – 15,120

MOLD DESIGNERS AND TOOLMAKERS (NOC 7232)

Description:

Read and interpret engineering drawings and specifications of tools, dies, prototypes, or models of EVs

Prepare templates and sketches, and determine work processes

Compute dimensions and tolerances and set up machine tools

Position, secure, measure, and work metal stock or castings to lay out for machining

Set up, operate, and maintain a variety of conventional and CNC machine tools to cut, turn, mill, plane, drill, bore, grind, or otherwise shape workpiece to prescribed dimensions and finish

Verify machined parts for conformance to specifications using precision measuring instruments such as verniers, callipers, micrometers, co-ordinate measuring machines (CMM), and electronic measuring devices

Fit and assemble or disassemble parts using hand tools

Test completed tools, dies, jigs, or fixtures for proper operation

May program CNC machine tools

Required education:

Completion of a four- or five-year tool and die making apprenticeship program

Local education offered:

St. Clair College – Mould Maker (Apprenticeship Program)

St. Clair College – Tool & Die Maker (Apprenticeship Program)

Windsor-Essex Location Quotient:

1.63 (311 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Saguenay, QC – 3.05 (250 jobs)

Granby, QC – 2.47 (111 jobs)

Quebec City, QC – 2.44 (1,198 jobs)

Guelph, ON – 2.36 (256 jobs)

Peterborough, ON – 2.14 (134 jobs)

Top 5 international region locations with 100+ jobs:

Detroit-Warren-Dearborn, MI, USA – 8,090

Finland – 5,221

Chicago-Naperville-Elgin, IL-IN-WI, USA – 4,510

Latvia – 3,655

Grand Rapids-Wyoming, MI, USA – 3,180

PIPEFITTERS (NOC 7252)

Description:

Read and interpret drawings, blueprints, and specifications to determine layout requirements for manufacturing of EVs

Install supports, valves, piping, and control systems

Test system for leaks using testing equipment

Clean and maintain pipe units and fittings and flush system

Remove and replace worn components and reactivate system

Required education:

Completion of a four- to five-year apprenticeship program

Local education offered:

St. Clair College – Plumber (Apprenticeship Program)

Windsor-Essex Location Quotient:

0.93 (206 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Wood Buffalo, AB – 4.97 (473 jobs)

Medicine Hat, AB – 3.59 (148 jobs)

Edmonton, AB – 2.89 (2,504 jobs)

Sarnia, ON – 2.73 (159 jobs)

Grand Prairie, AB – 2.64 (112 jobs)

Top 5 international region locations with 100+ jobs:

Gauteng, South Africa – 32,140

Houston-The Woodlands-Sugar Land, TX, USA – 18,360

Eastern Cape, South Africa – 14,489

KwaZulu-Natal, South Africa – 12,213

Western Cape, South Africa – 10,880

PROJECT MANAGERS (NOC 0911)

Description:

Plan, direct, and coordinate the production activities required to manufacture vehicles and vehicle components

Make sure that goals for output and quality are met while still remaining within budget

Responsible for monitoring the production run to make sure that it stays on schedule and for correcting any problems that may arise

May oversee the entire plant or just one area of it

Required education:

Bachelor's degree in engineering

Bachelor's degree in business administration

Local education offered:

University of Windsor – Engineering General

University of Windsor – Business Administration

Windsor-Essex Location Quotient:

1.62 (1,026 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Granby, QC – 2.63 (394 jobs)

Drummondville, QC – 2.46 (442 jobs)

Guelph, ON – 2.32 (837 jobs)

Brantford, ON – 2.08 (465 jobs)

Saint-Hyacinthe, QC – 2.02 (278 jobs)

Top 5 international region locations with 100+ jobs:

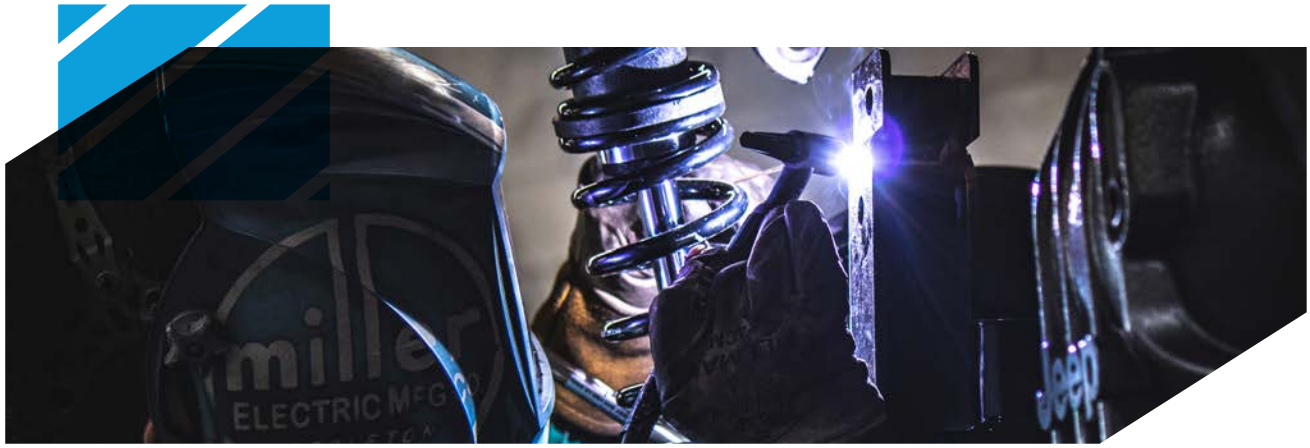
Gauteng, South Africa – 23,420

Western Cape, South Africa – 10,814

Finland – 10,562

Worcestershire, UK – 8,796

Chicago-Naperville-Elgin, IL-IN-WI, USA – 7,910



SOFTWARE DEVELOPERS (NOC 2174)

Description:

Design and create software

Apply the theories of computer science and mathematical analysis to create and evaluate software applications and systems that make the computers run

Create the software that controls EVs. In addition, hybrid and EVs use on-board computers to produce and distribute the proper amount of electricity to power the vehicle in given conditions. The on-board computer also determines when to use the gasoline engine to power the vehicle and when to use the engine to recharge the battery

Required education:

Bachelor's degree in computer science

College diploma in computer science

Local education offered:

University of Windsor – Computer Science

St. Clair College – Internet Applications and Web Development

Windsor-Essex Location Quotient:

0.36 (559 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Ottawa-Gatineau, ON-QC – 1.97 (12,922 jobs)

Kitchener-Cambridge-Waterloo, ON – 1.92 (4,852 jobs)

Toronto, ON – 1.57 (44,910 jobs)

Montreal, QC – 1.56 (29,215 jobs)

Quebec City, QC – 1.38 (5,488 jobs)

Top 5 international region locations with 100+ jobs:

New York-Newark-Jersey City, NY-NJ-PA, USA – 98,650

San Jose-Sunnyvale-Santa Clara, CA, USA – 78,730

Seattle-Tacoma-Bellevue, WA, USA – 65,760

Washington-Arlington-Alexandria, DC-VA-MD-WV, USA – 63,760

San Francisco-Oakland-Hayward, CA, USA – 59,550

SOFTWARE ENGINEERS (NOC 2173)

Description:

Collect and document users' requirements and develop logical and physical specifications for EVs

Research, evaluate, and synthesize technical information to design, develop, and test computer-based systems including mobile applications

Develop data, process, and network models to optimize architecture and to evaluate the performance and reliability of designs

Plan, design, and co-ordinate the development, installation, integration, and operation of computer-based systems including mobile applications

Assess, test, troubleshoot, document, upgrade, and develop maintenance procedures for operating systems, communications environments, and applications software

May lead and co-ordinate teams of information systems professionals in the development of software and integrated information systems, process control software, and other embedded software control systems

Required education:

Bachelor's degree in computer science, computer systems engineering, or software engineering

College diploma in computer science

Master's degree or PhD may be required

Local education offered:

University of Windsor – Computer Science

University of Windsor – Electrical and Computer Engineering

St. Clair College – Computer Systems Technology, Networking

Windsor-Essex Location Quotient:

0.27 (153 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Ottawa-Gatineau, ON-QC – 2.59 (6,107 jobs)

Vancouver, BC – 2.24 (9,798 jobs)

Kitchener-Cambridge-Waterloo, ON – 2.22 (2,022 jobs)

Toronto, ON – 2.01 (20,710 jobs)

Halifax, NS – 1.21 (912 jobs)

Top 5 international region locations with 100+ jobs:

New York-Newark-Jersey City, NY-NJ-PA, USA – 98,650

San Jose-Sunnyvale-Santa Clara, CA, USA – 78,730

Seattle-Tacoma-Bellevue, WA, USA – 65,760

Washington-Arlington-Alexandria, DC-VA-MD-WV, USA – 63,760

San Francisco-Oakland-Hayward, CA, USA – 59,550

EV MAINTENANCE

EVs require regular maintenance, although the maintenance process is typically easier and required as often as ICE-Vs. Automotive service technicians and mechanics who are trained to operate on EVs will be crucial in supporting an EV value chain.

AUTOMOTIVE SERVICE TECHNICIANS AND MECHANICS
(NOC 7321)

Description:

Inspect, maintain, and repair automobiles that run on gasoline, electricity, or a combination of the two

Plan and perform basic car maintenance and vehicle repairs

The job of automotive service technicians and mechanics has evolved from simple mechanical repairs to high-level technology-related work. Integrated electronic systems and complex computers regulate vehicles and their performance on the road. Fixing problems with these systems requires workers to use computerized shop equipment and work with electronic components as well as traditional hand tools

Required education:

Completion of a four-year automotive service technician apprenticeship program

Local education offered:

St. Clair College – Motive Power Technician

Windsor-Essex Location Quotient:

1.06 (1,154 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Brandon, MB – 2.38 (461 jobs)

Ingersoll, ON – 2.24 (118 jobs)

Woodstock, ON – 2.19 (362 jobs)

Kentville, NS – 2.05 (164 jobs)

Terrace, BC – 2.00 (122 jobs)

Top 5 international region locations with 100+ jobs:

Gauteng, South Africa – 68,777

New York-Newark-Jersey City, NY-NJ-PA, USA – 56,430

Los Angeles-Long Beach-Anaheim, CA, USA – 35,490

Chicago-Naperville-Elgin, IL-IN-WI – 35,020

KwaZulu-Natal, South Africa – 33,427

CHARGING INFRASTRUCTURE

In order for EVs to be viable, they will require a robust infrastructure of charging stations to be easily accessible to consumers. Many charging stations can be built upon existing power grids in some regions, but upgrades to select grids will still be required to support this new infrastructure. Civil engineers, electrical engineers, electricians, and power line installers/repairers will be the key occupations needed to build proper charging infrastructures. Installing charging stations will also require careful planning to make sure the right types of chargers are available in efficient and convenient locations. Urban/regional planners will be necessary when planning future charging infrastructure builds.

CIVIL ENGINEERS (NOC 2131)

Description:

Confer with clients and other members of the engineering team and conduct research to determine project requirements for EV manufacturing process

Develop construction specifications and procedures

Evaluate and recommend appropriate building and construction materials

Interpret, review, and approve survey and civil design work

Conduct field services for civil works

Ensure construction plans meet guidelines and specifications of building codes and other regulations

Establish and monitor construction work schedules

Conduct feasibility studies, economic analyses, municipal and regional traffic studies, environmental impact studies, or other investigations

Monitor air, water, and soil quality and develop procedures to clean up contaminated sites

Conduct technical analyses of survey and field data for development of topographic, soil, hydrological, or other information and prepare reports

Act as project or site supervisor for land survey or construction work

Prepare contract documents and review and evaluate tenders for construction projects

Supervise technicians, technologists, and other engineers and review and approve designs, calculations, and cost estimates

Required education:

Bachelor's degree in civil engineering

Master's degree or PhD may be required

Local education offered:

University of Windsor – Civil Engineering

Windsor-Essex Location Quotient:

0.85 (411 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Sarnia, ON – 1.80 (229 jobs)

Calgary, AB – 1.79 (3,599 jobs)

St. John's, NL – 1.72 (519 jobs)

Regina, SK – 1.49 (557 jobs)

Quebec City, QC – 1.47 (1,822 jobs)

Top 5 international region locations with 100+ jobs:

New York-Newark-Jersey City, NY-NJ-PA, USA – 16,480

Los Angeles-Long Beach-Anaheim, CA, USA – 14,480

Finland – 13,899

San Francisco-Oakland-Hayward, CA, USA – 10,400

Houston-The Woodlands-Sugar Land, TX, USA – 9,420

ELECTRICAL ENGINEERS (NOC 2133)

Description:

Design, develop, test, and supervise the manufacture of electrical components for EV manufacturing process

Responsible for designing the electrical circuitry that allows a gas engine to charge the battery and distribute the electricity from the battery to the electric motor

Might work on the heating and air-conditioning systems, vehicle lighting, and visual displays

Required education:

Bachelor's degree in electrical or electronics engineering

Master's degree or PhD may be required

Local education offered:

University of Windsor – Electrical and Computer Engineering

Windsor-Essex Location Quotient:

0.82 (301 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Oshawa, ON – 2.43 (638 jobs)

Granby, QC – 2.33 (201 jobs)

St. John's, NL – 1.76 (403 jobs)

Calgary, AB – 1.73 (2,636 jobs)

Peterborough, ON – 1.63 (195 jobs)

Top 5 international region locations with 100+ jobs:

New York-Newark-Jersey City, NY-NJ-PA, USA – 8,670

Finland – 8,458

Los Angeles-Long Beach-Anaheim, CA, USA – 8,310

Stockholm County, Sweden – 8,125

Boston-Cambridge-Nashua, MA-NH, USA – 7,640

ELECTRICIANS (NOC 7241)

Description:

Read and interpret drawings, circuit diagrams, and electrical code specifications to determine wiring layouts for new or existing installations for EV manufacturing process

Pull wire through conduits and through holes in walls and floors

Install brackets and hangers to support electrical equipment

Install, replace, and repair lighting fixtures and electrical control and distribution equipment, such as switches, relays, and circuit breaker panels

Splice, join, and connect wire to fixtures and components to form circuits

Test continuity of circuits using test equipment to ensure compatibility and safety of system, following installation, replacement, or repair

Troubleshoot and isolate faults in electrical and electronic systems and remove and replace faulty components

Connect electrical power to audio and visual communication equipment, signalling devices, and heating and cooling systems

Conduct preventive maintenance programs and keep maintenance records

Required education:

Completion of a four- to five- year apprenticeship program

Local education offered:

St. Clair College – Electrical Engineering Technician

St. Clair College – Electrical Techniques

St. Clair College – Electrician: Construction & Maintenance (Apprenticeship Program)

Windsor-Essex Location Quotient:

0.97 (777 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Medicine Hat, AB – 2.30 (345 jobs)

Wood Buffalo, AB – 2.05 (709 jobs)

Edmonton, AB – 1.97 (6,211 jobs)

Lethbridge, AB – 1.96 (541 jobs)

Grand Prairie, AB – 1.94 (299 jobs)

Top 5 international region locations with 100+ jobs:

New York-Newark-Jersey City, NY-NJ-PA, USA – 43,760

Los Angeles-Long Beach-Anaheim, CA, USA – 19,470

Chicago-Naperville-Elgin, IL-IN-WI, USA – 18,160

Houston-The Woodlands-Sugar Land, TX, USA – 17,860

Dallas-Forth Worth-Arlington, TX, USA – 17,500

POWER-LINE INSTALLERS/ REPAIRERS (NOC 7244)

Description:

Install and maintain the power grid—the network of power lines that move electricity from generating plants to customers. Many EVs require special power stations to charge their batteries, and owners of these vehicles require more electricity than ordinary consumers

Install new lines that are capable of handling this increased load

In addition, many local governments are adding public charging stations that must be fed by new power lines. These installers place the new lines and connect them to the grid

Required education:

Completion of a provincial three- or four-year lineman/woman apprenticeship

Local education offered:

St. Clair College – Powerline Technician

Windsor-Essex Location Quotient:

1.04 (152 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Peterborough, ON – 5.13 (246 jobs)

Brandon, MB – 3.86 (100 jobs)

Oshawa, ON – 2.58 (271 jobs)

Barrie, ON – 2.17 (150 jobs)

Wood Buffalo, AB – 1.69 (107 jobs)

Top 5 international region locations with 100+ jobs:

Atlanta-Sandy Springs-Roswell, GA – 3,500

New York-Newark-Jersey City, NY-NJ-PA, USA – 3,480

Houston-The Woodlands-Sugar Land, TX, USA – 2,980

Los Angeles-Long Beach-Anaheim, CA, USA – 2,560

Dallas-Forth Worth-Arlington, TX, USA – 2,520

URBAN/REGIONAL PLANNERS (NOC 2153)

Description:

Plan and implement infrastructure upgrades to support EVs

Determine how many charging stations are necessary to support a given number of vehicles, as well as where to situate them to reach the greatest number of citizens

Required education:

Bachelor's degree in urban and regional planning

Master's degree or PhD may be required

Local education offered:

N/A

Windsor-Essex Location Quotient:

0.58 (51 jobs)

Top 5 Canadian CMA location quotients with 100+ jobs:

Calgary, AB – 2.32 (856 jobs)

Edmonton, AB – 1.81 (627 jobs)

Halifax, NS – 1.37 (154 jobs)

Ottawa-Gatineau, ON-QC – 1.26 (469 jobs)

Quebec City, QC – 1.17 (266 jobs)

Top 5 international region locations with 100+ jobs:

Finland – 3,467

Los Angeles-Lon Beach-Anaheim, CA, USA – 2,180

Hertfordshire, UK – 1,677

San Francisco-Oakland-Hayward, CA, USA – 1,500

New York-Newark-Jersey City, NY-NJ-PA, USA – 1,260

EDUCATION AND THE EV VALUE CHAIN

An important issue to consider as Windsor-Essex attempts to position itself as an automobility capital in Canada and a potential location for an EV-battery value chain cluster is how educational institutions can play a supportive role. As the future of transportation moves toward EV consumption and production, our region's educational institutions will have to undergo changes in curriculum and programming in order to reflect the new skillsets that will be required for EV-battery value chain careers. This section of the report will analyze the required post-secondary curriculum and programming needed to train individuals for careers in the EV sector and where these programs currently exist domestically and internationally. This section of the report will also provide an understanding of best practices currently being used in EV sector education globally that Windsor-Essex post-secondary institutions could look to for examples from of how to adapt their own programming.

WINDSOR-ESSEX REGION EDUCATIONAL BEST PRACTICES

A positive note for Windsor-Essex region post-secondary institutions (the University of Windsor, St. Clair College, and Collège Boréal) is that they have already established curriculum and programming to develop talent in the automotive industry. The chart below shares examples of pre-existing curriculum and degree programs that serves to develop talent in the region's automotive industry:

Name of Program	Type of Degree(s)/Diploma Offered	Institution
Electrical and Computer Engineering	BASc, MASc, MEng, PhD	University of Windsor
Industrial Engineering	BASc, MASc, MEng, PhD	University of Windsor
Mechanical, Automotive, and Materials Engineering	BASc, MASc, MEng, PhD	University of Windsor
Architectural Technology	Ontario College Advanced Diploma	St. Clair College
Electromechanical Engineering Technology	Ontario College Advanced Diploma	St. Clair College
Mechanical Engineering Technology	Ontario College Advanced Diploma	St. Clair College
Motive Power Technician	Ontario College Diploma	St. Clair College
BEV Battery Electric Vehicle Training	Certificate of Achievement	Collège Boréal

Each of these programs listed on the previous page offers education for unique skillsets that are currently in-demand in the automotive industry. Some of the programs are currently offering training and experience that would be transferable to the EV-battery production sector. Both the University of Windsor and St. Clair College have established partnerships with industry leaders – the University of Windsor with Stellantis and St. Clair College with Ford – to create research centres that allow students to develop practical and hands-on experience with current technology and equipment being used in today's automotive supply chain.

Alterations to existing programs would be an effective way of growing talent locally and training students for careers in the EV-battery space. However, the necessary changes to adapt existing automotive curriculum and programming to move toward the future of EV-battery production is often a lengthy process and not something that can be done overnight. Curriculum and programming changes often take extended periods of time to fully implement. EV engineering focuses also change and progress very quickly as technology advancements are made locally and around the globe.[22] It is therefore recommended that Windsor-Essex post-secondary education institutions begin to discuss modifications to existing automotive-related curriculum and programming as soon as possible to better position the region to be able to produce the talent required by the EV value chain.

Many changes to the automotive sector are coming with the increased popularity of EVs as a desired form of transportation, so adjustments made to existing curriculum in Windsor-Essex should reflect these changes. Through consultations with staff and faculty at the University of Windsor and St. Clair College, the following recommendations for new curriculum and changes to existing programming were made:

Data and information analytics, as well as data collection skills, should be added to pre-existing engineering programs. These are skills that may be missing from curriculum in more traditional engineering courses/degrees. Data is widely used in EV technology and production and the data collected is used for things like customer preference, range prediction for EVs, and EV trims based on customer characteristics. The data is also often used to predict consumer driving habits.[23]

Cybersecurity is becoming a more important issue as our transportation systems modernize and continue to include more advanced technology. Vehicles are moving toward having more electronics and driver assisted technologies inside them. These types of hardware could be open to data breaches. Institutions and policy-makers need to be more aware that automotive cybersecurity is a larger domain than it actually seems. Students need to be well-versed not only in the electronics installed in vehicles, but also how to secure this hardware from potential outside attacks. Although courses are currently taught at the University of Windsor in the principle of design, the concept of "secure by design" is not currently included in this curriculum. Discussions with tier one and two OEM suppliers support the need for altering current curriculum to include some focus on cybersecurity in vehicles.

22. Xiaobin Fan, "Research on Undergraduate Education of Vehicle Engineering," *Contemporary Logistics 11*, (2013): 44.
23. Hyundai Motor Group. "Data Analysis of Electric Vehicles: For Convenient and Smart Life," June 10, 2020.

EV automotive service technicians will require an updated skillset compared to ICE-V automotive service technicians. EV automotive technicians will require knowledge about digital electronics included in EVs that do not currently exist in ICE-Vs. A positive note is that EVs will have several components in common with gas-powered cars, so the base knowledge currently offered in these programs is a good start to develop this new type of talent and skillset. However, the powertrains in EVs are completely different than those in gas-powered vehicles and will require a significant amount of training to service them correctly, even for more experienced auto technicians. Ideally, technicians should now be trained for both ICE-Vs and EVs, especially if they are required to work on increasingly popular hybrid-engine vehicles (HEVs).

More education needs to be established around EV batteries, specifically energy storage technology. Currently in EVs, there is a relatively short range for the release of energy from batteries. Introducing more education around battery energy storage could potentially lead to innovations that increase the current range of our EVs on the road today.

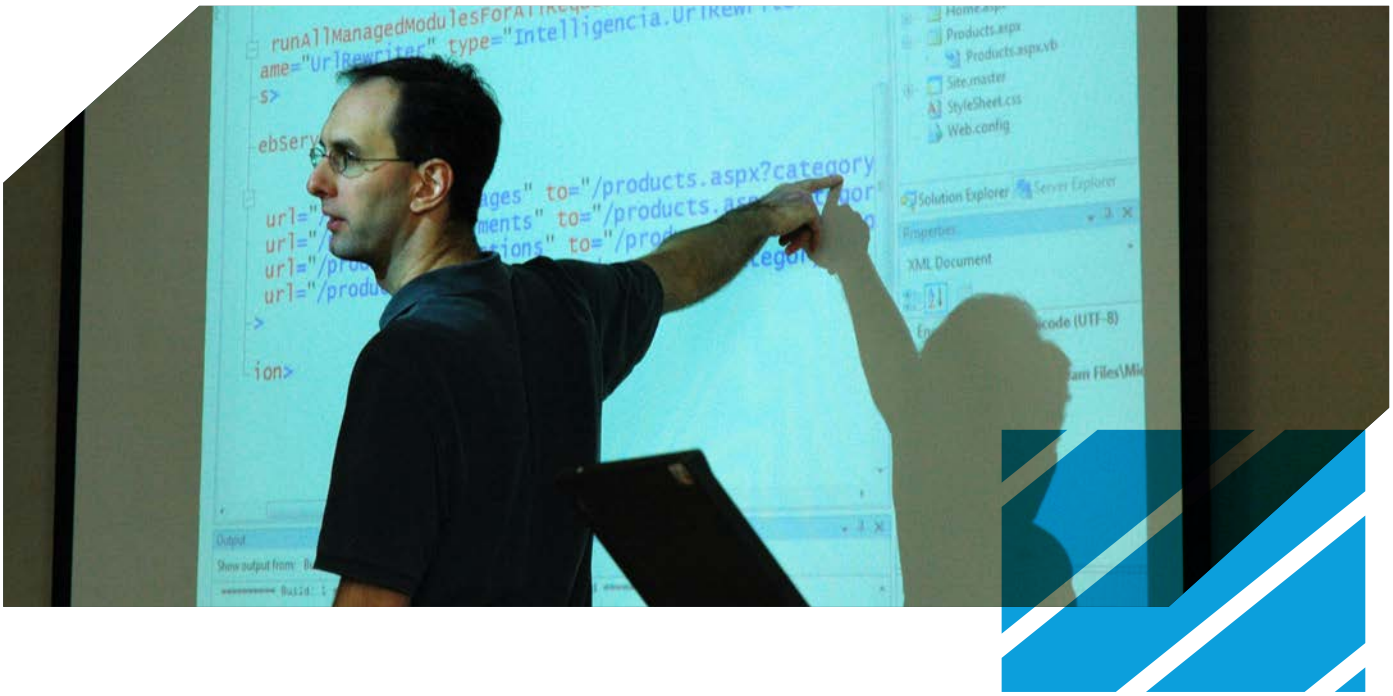
Education on recharging infrastructure will also be very important when developing qualified workers for the EV value chain. More education about charging infrastructure should be added to existing curriculum. For example, more research needs to be done on when and how often EVs should be charged. Studies also need to be done on how much energy larger charging infrastructures will draw from current electric grids – can they be adapted to work off existing grids or will new grids have to be created to support the new demand for electricity? It is predicted that $110-$180 billion will need to be invested from 2020-2030 to meet the global demand for EV charging infrastructure and by 2025, 22-27 million combined charging stations will be needed in China, Europe, and the U.S. by themselves.[24] All of the above represents research that can be done in partnership between education and industry partners in newly developed educational programming. This research can then help identify what types of occupations would be needed to develop required charging infrastructure in the future.

As the demand for EVs increases, there is an increased need for education about how different regions will be affected as a result. EVs will have large effects on urban planning, settlement patterns, transportation modes and patterns, and carbon footprints in society. How do we educate students in programs that cover the above topics to ensure we have talent that is ready to prepare us for the future that is inevitably coming? We need additional courses in urban planning, geography, and environmental studies programs that discuss societal impacts of increased EV use and infrastructure development, such as pedestrian, bicycle, and automotive transportation, infrastructure changes, and cultural changes.

24. The Autonomous Vehicle Innovation Network, "Introduction to Electric Vehicles and Charging Infrastructure," June 2021. Government of Ontario.

More effort needs to be made to connect EV education and its adapted curriculum to industry. This will allow students to develop practical skills and gain hands-on experience for future careers in EV transportation by being able to work on projects with local and non-local industry partners.

Another potential opportunity to develop talent locally and secure a talent pipeline for the foreseeable future in Windsor-Essex is to introduce more opportunities for co-op or apprenticeship in the EV value chain to secondary school students. School boards in Windsor-Essex have been improving their efforts in recent years to offer more diverse co-op or apprenticeship placements for students, and there are ideal employers currently working with industry leaders in EV value chain sectors that would likely provide these opportunities. For example, employers consulted in the research process of this report mentioned they are under contract to develop equipment and vehicle parts for EV industry leaders such as Tesla.



22. Xiaobin Fan, "Research on Undergraduate Education of Vehicle Engineering," *Contemporary Logistics 11*, (2013): 44.
23. Hyundai Motor Group. "Data Analysis of Electric Vehicles: For Convenient and Smart Life," June 10, 2020.

SOME GOOD NEWS IS THAT WINDSOR-ESSEX POST-SECONDARY INSTITUTIONS HAVE ALREADY STARTED TO POSITION THEMSELVES FOR THE CHANGES THAT EVS WILL BRING TO AUTOMOTIVE CURRICULUM.

The University of Windsor has a longstanding partnership with Stellantis, dedicated to research development and education in the form of the Fiat Chrysler Canada Automotive Research and Development Centre (ARDC), which opened in 1996. St. Clair College also has an existing partnership with Ford Canada in the form of the Ford Centre for Excellence in Manufacturing, which offers students hands-on training using some of the world's most sophisticated technology offered in a single college setting. At the University of Windsor's SHIELD Automotive Cybersecurity Centre of Excellence, they have been targeting provincial funding and are on the verge of creating two dedicated automotive cybersecurity courses to add to the electrical and computer engineering curriculum. Lastly, St. Clair College is involved in current discussions to create a standalone EV automotive design program, as well as an EV technician program. These are the types of initiatives in post-secondary education that Windsor-Essex will benefit from when attempting to create an EV value chain cluster in the region. It was also mentioned by faculty and staff from post-secondary institutions in consultations that certificate programs or micro-credential programs built around the skills necessary for the EV value chain would help support the region to develop its own talent to enter EV value chain careers. These certificate or micro-credential programs will support those currently working in the automotive sector to transition to careers in an EV value chain without requiring a heavy re-training load or complete re-education. Offering short-term skills upgrading in areas of an EV value chain (including engineering, technicians, and design) will ensure that the current 40,000+ manufacturing workforce in Windsor-Essex can remain employable/employed as EVs increase in demand and businesses' focus.

CANADIAN EDUCATIONAL BEST PRACTICES

Currently, there are numerous other post-secondary programs offered nationally and internationally that support the development of necessary skills and experience for careers in the EV-battery value chain. Windsor-Essex post-secondary institutions may be able to look to these other programs for best practices on how to adapt their own curriculum. Below is a chart with examples of Canadian post-secondary programming.

Curriculum/Program/ Resource	Institution(s)	Location(s)	Type of Degree(s)/ Diploma(s) Offered	Description
Canada Excellence Research Chair in Hybrid Powertrain Program	McMaster University	Hamilton, ON	N/A*	Developing the next generation of smart energy systems and electrified and autonomous vehicles, Masters, PhD, and Post Doc students specialize in various areas of engineering, including electrical, mechanical, and computer software.[25]
Bachelor of Technology	Mohawk College	Hamilton, ON	B.Tech.	Offering a Bachelor of Technology in partnership with McMaster University, this program teaches aspects about electric/hybrid vehicle design.
Battery Electric Vehicle Technician	Northern College	Timmins, ON	Ontario College Diploma	In partnership with Swedish engineering group, Sandivik, this program will train students about aspects of battery-electric vehicles.

25. McMaster University. "'It's great to be back:' Researchers return to McMaster Automotive Resource Centre," July 31, 2020.

Curriculum/Program/ Resource	Institution(s)	Location(s)	Type of Degree(s)/ Diploma(s) Offered	Description
University of Toronto Electric Vehicle (UTEV) Research Centre	University of Toronto	Toronto, ON	N/A*	Focused on power electronic converters for EV drivetrains, charging infrastructure, energy storage for EVs, and autonomous operation of EVs.
Hybrid and Electric Vehicles (course offering)	Centennial College	Toronto, ON	N/A**	Students will gain the skills and experience necessary to service hybrid and electric cars.
Clean Energy Resource Centre	University of British Columbia	Vancouver, BC	N/A*	Education for students about the rapidly advancing industry of sustainable energy.
EV Maintenance Training	Camosun College, Okanagan College, College of New Caledonia	Victoria, Kelowna, and Prince George, BC	Certificate	Partnership among different educational institutions, allowing students to upgrade their automotive technician skills to be certified to work on EVs.

*These programs and/or resources are facilities created to teach students from multiple degree programs specifics about EV trends and topics. They do not offer any specific type of degree or diploma, but are additions to existing degree or diploma programs.

**This is a standalone course, offering a credit toward an Ontario College Diploma.

Progress is also being made internationally to introduce curriculum to support developing talent for the EV value chain. For the purposes of this report, best-practice curriculum and educational examples will be focused on the U.S., Germany, and East-Asian countries (specifically China). Each of these regions have been leaders in developing EV-based curriculum and programming.

U.S. EDUCATIONAL BEST PRACTICES

In the U.S., one does not need to look far to find a great example for EV-based curriculum. Located directly across the border in Detroit, Michigan, is Wayne State University. In 2010, Wayne State became the first university to launch a comprehensive EV engineering curriculum.

This was able to happen thanks to a $5 million investment by the U.S. Department of Energy and surrounding automotive manufacturers and suppliers. The curriculum allows students to gain the tools and knowledge to enter careers in the automotive industry, particularly related to the development of EVs. The program states it will educate and prepare the technical and scientific workforce for the emerging electric-drive vehicle industry; promote and mobilize/align available resources to develop interdisciplinary research programs; and disseminate technical information and raise public awareness on emerging electric-drive vehicle technologies. The outcome of this program for students is accreditation through the form of either a bachelor's degree in electrical transportation technology (ETT), a master's degree in electric-drive vehicle engineering (EVE), or an associate's degree in automotive technology and electronic engineering technology with an emphasis on electric-drive vehicles.[26] This curriculum can set a great example for the Windsor-Essex region on how partnerships between government, industry, and education can lead to the creation of valuable educational programming that can secure a talent pipeline for the current and future jobs available in the EV value chain sectors. Partnerships already exist between the University of Windsor and Wayne State in other programming, such as nursing, pharmacy, and law. It may be possible for these institutions to reach a new agreement in the future to cover EV-related curriculum.

With a longstanding history of being involved in the automotive industry and now being considered a leader in EV value chain research and education, the state of Michigan has become a leader in the development of EV-based curriculum. Both the University of Michigan and Michigan State University are engaged in research on vehicle electrification. For example, the University of Michigan has created a certificate program designed for engineers and managers who are involved in the design and development of hybrid and electric vehicles and/or their key components. It also has opened a world-class battery research lab and is home to the Automotive Research Center, a university-based U.S. Army Center of Excellence for modeling and simulation of ground vehicle systems.

26. College of Engineering, "Electric-drive vehicle engineering," 2021. Wayne State University.

The Center for Advanced Automotive Technology (CAAT) in the U.S. has also partnered with multiple Michigan post-secondary institutions to create EV-based curriculum for students, including the following institutions:

- Lawrence Technological University (Southfield, MI)
- Grand Rapids Community College (Grand Rapids, MI)
- Lansing Community College (Lansing, MI)
- Grand Valley State University (Allendale/Grand Rapids, MI)
- Kettering University (Flint, MI)

CAAT has also partnered with the Kent Intermediate School District and Utica Community Schools in Michigan to introduce EV-based curriculum to high school students wishing to gain relative knowledge and skills. The partnership developed by CAAT with the above post-secondary institutions and secondary education is another great example of how industry partnering with education can help advance talent development in EV value chain sectors.[27]

California is another U.S. state leader in the development of of EV-based curriculum. The state has been a national leader in creating policies and mandates for the future of EVs and is home to many companies involved in activities along the EV value chain. For example, Silicon Valley, California, is home to many EV-based operations. California also typically ranks #1 with total number of new hybrid and EV sales in the U.S. Some notable institutions that are leading the way in EV-based curriculum in California are Stanford, the California Institute of Technology (CALTECH), and the University of California, Davis (UC Davis). Stanford is home to a Center of Automotive Research, bringing together students, industry, government, and the community to enable a future of human-centered mobility.[28] CALTECH is home to the Adaptive Charging Network Research Portal, which houses a collection of tools to help researcher and other stakeholders understand the challenges of large-scale EV charging and develop practical solutions to those challenges.[29] Lastly, UC Davis is home to the Plug-In Hybrid and Electric Vehicle Research Center, collaborating with California utilities, automakers, regulators, and other research institutions on research aimed at developing a sustainable market for plug-in vehicles.[30] Once again, it is evident with the institutions and programming listed above that partnerships between major stakeholders such as government, industry, and educational institutions are crucial when attempting to create robust research and education options for those interested in EV-based activities.

27. Center for Advanced Automotive Technology, "Funded programs," 2021. Macomb Community College.
28. Center for Automotive Research at Stanford, "About us." Stanford University.
29. Adaptive Charging Network Research Portal, "EV Research @ Caltech." California Institute of Technology.
30. Plug-In Hybrid & Electric Vehicle Research Centre of the Institute of Transportation Studies, "About." University of California, Davis.

Although Michigan and California can be considered leaders in EV-based curriculum, there are a number of other educational institutions in the U.S. that currently have strong EV-based curriculum. Many of these institutions offer EV-related extracurricular activities or research opportunities to further provide hands-on and real-world learning for students. Some of these notable institutions, and a brief description of how each is involved in EV-based activities, are listed below.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY (MIT), CAMBRIDGE, MA

MIT is home to the MIT Electric Vehicle Team. This team is a group of active undergraduate and graduate students who are engaged in the research, design, and operation of EVs. The team focuses on research such as defining EVs, the environmental impact of EVs, fuel economy of EVs, defining battery specifications, EV policies, and what the future holds for EVs. The team also demonstrates and researches EV technologies, provides opportunities for project-based educational opportunities for MIT students, and increases public awareness of electric and other advanced vehicle technologies.[31]

NORTHWESTERN UNIVERSITY, EVANSTON, IL

Northwestern University is home to the Northwestern-Argonne Institute of Science and Engineering. This institute brings together researchers at Northwestern and Argonne National Laboratory to create powerful collaborations in fields such as energy, biological and environmental systems, data science and computation, materials, and national security.[32]

OHIO STATE UNIVERSITY, COLUMBUS, OH

The Center for Automotive Research at the Ohio State University allows students to be involved in research on the electrification of vehicles. The research center specializes in electrification areas such as energy storage, hybrid and electric powertrain, EV charging and grid interaction, and electric machine design. It is also partnered with industry leaders, such as Ford, Honda, and Toyota to allow students to conduct research on current activities that are being undertaken along the EV value chain.[33]

UNIVERSITY OF CHICAGO, CHICAGO, IL

The Energy Policy Institute at the University of Chicago (EPIC), is an interdisciplinary research and training institute focused on the economic and social consequences of energy policies. As the popularity of EVs increases in the U.S. in the near future, more mandates and policies will likely be made by government related to the EV value chain. This institution is providing students with the opportunity to gain knowledge on the potential mandates and policies that will likely be introduced.[34]

UNIVERSITY OF COLORADO, COLORADO SPRINGS/BOULDER, CO

The University of Colorado, Colorado Springs (UCCS) and the University of Colorado, Boulder (CU-Boulder) jointly offer a Graduate Certificate in Electric Drivetrain Technology to students. This program teaches students skills and knowledge in power electronics, battery controls, and/or automotive industries. Courses in the program cover battery modeling and battery management systems, motor drive, and vehicle power electronics for

31. MIT Electric Vehicle Team, Massachusetts Institute of Technology.
32. Northwestern-Argonne Institute of Science and Engineering, Northwestern University.
33. Center for Automotive Research, the Ohio State University.
34. Energy Institute at Chicago, University of Chicago.

applications including hybrid, plug-in hybrid, extended-range, and battery electric vehicles.[35]

UNIVERSITY OF TEXAS, AUSTIN, TX

The Cockrell School of Engineering at The University of Texas at Austin is quite unique. One of the lead professors of the Cockrell School is Dr. John Goodenough, the inventor of the lithium-ion battery. In 2017, Goodenough's team developed the first all-solid-state battery cells that could lead to safer, faster-charging, longer-lasting rechargeable batteries.[36] In 2020, student members of Goodenough's lab began working in partnership with EnergyX, a young energy technology company with labs near Silicon Valley, California, in an effort to radically rethink the approach to energy storage.[37]

Being home to the Big-3 automobile manufacturers and a leader in the development of EVs, the U.S. is a logical place for reputable EV-based curriculum to be located. A commonality between all of the curriculum mentioned in this section are the partnerships that exist between multiple stakeholders, allowing education and research opportunities related to the EV value chain to be available to students who are able to participate in the activities made possible by these partnerships. Windsor-Essex region educational institutions can look to all of the previously mentioned programs and curriculum for examples on how to model potential, future local programs for students. Developing local talent will be necessary if the region wants to succeed in developing its own cluster of EV value chain operations.

35. Graduate Certificate in Electric Drivetrain Technology, University of Colorado.
36. UT News, "Lithium-Ion Battery Inventor Introduces New Technology for Fast-Charging, Noncombustible Batteries," February 28, 2020. The University of Texas at Austin.
37. Cision PR Newsire, "Nobel prize winning inventor of the lithium-ion battery has his eyes set on the next big breakthrough in energy storage," September 16, 2020. EnergyX.

GERMAN EDUCATIONAL BEST PRACTICES

Another logical place to study EV-based curriculum is Germany. The country is home to automotive giants, such as BMW, Mercedes, and Volkswagen, all of which produce EVs under their brands. There are many examples of post-secondary institutions in Germany that are engaged in research on EVs, or offer course programming to gain skills and knowledge about the EV value chain. A list of these institutions with a brief description of the EV-based curriculum at each is as follows.

Esslingen University offers a master's degree in engineering for automotive systems, which includes modules in car electronics. This three-semester program offers students the opportunity to build important skills and knowledge about EV value chain activities.[38]

The Karlsruhe Institute of Technology began establishing its Transformation Hub Electric Mobility in 2019. Once of the projects this hub works on is called the Fit4E project, which identifies strengths and weaknesses of worldwide leading automotive companies that are still mainly involved in processes for ICE-Vs and how to help them pivot, using their skills and competencies, toward a production chain of an electro mobile drivetrain. The institute is also involved in the AgiloBat lighthouse project to establish a modular plant for manufacturing battery cells on the pilot scale that responds flexibly to changes of numbers of pieces and formats. Lastly, the institute is involved with the Training Factory for Stator Manufacture, working together with vocational school and Karlsruhe to address trainees with the skills necessary to work on special wire windings for electric motors.[39]

Technische Hochschule Ingolstadt offers a master's degree in engineering, specializing in electrical engineering for mobile systems. In this program, students learn methods for mathematically depicting all key aspects of electric mobility. This involves the depiction of key components such as electrical machines, power electronics, energy storage systems, gears, and combustion engines through the entire vehicle.[40]

Technische Universität Berlin's E-Mobility Research Network is a collaboration of five of the schools' faculties, which cooperate to conduct research on e-mobility. The main areas of their research include energy storage and conversion, vehicle and manufacturing concepts,

38. Esslinglen University, Automotive Systems (M.Emg) Modules in Car Electronics.
39. Karlushe Instiute of Technology, "Electric Mobility: Using Existing Competencies," 2019.
40. Technische Hochschule Ingolstadt. Electrical Engineering for Mobile Systems (M.Eng).

transportation systems and mobility concepts, charging infrastructure and grid integration, and integration technologies and drive train concepts.[41]

Technische Universität Munchen (TUM) is engaged in a partnership with Tsinghua University in Beijing, China, as part of EV research managed by the Joint Research Institute for Advanced Power Sources (IAPS). The IAPS was established in 2010 and carries out research and development of electromechanical energy technologies with a focus on electromobility. This program is unique because of its cooperation with China, another global leader in EV research and production. The university also houses the Electric Powertrain Research Group through the mechanical engineering faculty, in which students investigate and optimize the high-voltage battery, power electronics, and electric motor and the interaction of the components in the electric drive train. The university also offers courses in electric mobility and the design of electric vehicles.[42]

Technische Universität Dortmund has its own on-board systems lab. The research at this lab focuses on simulation and measurement methods for optimization and safeguarding of any EV component, as well as overall on-board systems.[43]

TH Koln's Institute of Automotive Engineering offers a bachelor's degree program in Automotive Engineering, a master's degree program in Automotive Engineering, and a master's degree program in Mechatronics. The school is home to the Formula Student Electric Team, which competes in an international competition with vehicles that are classically powered by combustion engines and one electrically powered vehicle.[44]

The University of Bayreuth is home to the Centre for Energy Technology (ZET). As part of the research centre's programming, students look at the battery from the perspective of power electronics. This is the intermediary between battery and drive motor for every electrically driven vehicle.[45]

41. Dr. Dietmar Gohlich, "E-Mobility Research Network." Technische Universitat Berlin.
42. Technical University of Munich.
43. On-board Systems Lab. TU Dortmund.
44. TH Koln, Institute of Automotive Engineering.
45. Mark M. Bakran et, al, "Batteries and electric devices," Energy Systems 1, 2019.

CHINESE EDUCATIONAL BEST PRACTICES

China is another world leader when it comes to the development of EVs. The country's large population acts as a lucrative potential consumer base and is currently the largest national market for EVs since 2015. The government has also been offering subsidies and incentives for individuals who wish to purchase an EV.[46] China is also home to over 31 companies that are involved with EV value chain activities, from the manufacturing of EVs to developing software for EVs.[47] Thus, China has developed quality educational programs to offer skills and knowledge of the EV value chain to interested students. Similar to the U.S., the identified opportunities tend to exist because of cooperation between education and industry stakeholders in China.

The Beijing Institute of Technology in China is home to the National Engineering Laboratory for Electric Vehicles and was approved and established by the National Development and Reform Commission, a Chinese government organization, in 2009. According to the laboratory, it focuses on research about the needs of energy conservation and emission reduction, the key technologies, system integration, and key components of EVs to realize the standardization of power systems and provide effective data for the formulation of various EV policies and specifications.[48] In 2019, Toyota and Tsinghua University established the Tsinghua-Toyota Joint Research Institute. Toyota and Tsinghua University had actually engaged in research projects together since 1998, but the establishment of the newer research facility will enable the two to cooperate in research not only related to cars for Chinese consumers, but also in research related to active utilization of hydrogen energy that can help solve China's energy problems and other certain social issues.[49] It was also announced in May 2021 that Chinese EV maker Nio Inc. had signed a strategic cooperation agreement with the University of Science and Technology of China (USTC) to cooperate in smart EV technology research. This agreement would establish the USTC-NIO Smart Electric Vehicle Joint Laboratory to conduct research on cutting-edge issues, major scientific and technological issues, and strategic new technologies.[50] Lastly, industry-leading SAIC Motor Corporation sponsors research on EV-based activities at Tongji University, including hydrogen fuel-cell powertrain technology, batteries for EVs, technology and development of e-motor systems,

46. Youlin Huang et al, "What electric vehicle manufacturers can learn from China – their biggest market," August 3, 2021. The Conversation.
47. Jeremy Goldkorn et al, "All the electric car companies in China – a guide to the 31 top players in the Chinese EV industry," April 20, 2021. SupChina.
48. Zhao Lin, "National Engineering Laboratory for Electric Vehicles," May 12, 2020. Beijing Institute of Technology.
49. Green Car Congress, "Toyota establishes joint research institute with Tsinghua University; hydrogen and advanced mobility," April 22, 2019.
50. Phate Zhang, "NIO builds lab with one of China's best universities," May 2, 2021. CNEVPost.

internal combustion engine technologies for hybrid vehicles, lightweight structures for EVs, and dynamics control in distributed drive EVs.[51]

Another progressive action China has taken to promote EV education is early introduction to kindergarten-level students. In 2016, EV industry leader Tesla invited kindergarten students to learning sessions at their service centres to learn more about EVs.[52] The Windsor-Essex region could learn from this example by inviting younger generations of students to manufacturing facilities that are involved in EV value chain activities. Windsor-Essex currently hosts an annual Manufacturing Day, which invites high school-aged students to tour local manufacturing facilities to learn about the jobs that are available and/or in-demand in the region. This type of effort could likely be replicated for elementary school-level students to introduce them to this field as early as possible.

Another educational best-practice worth mentioning is currently being used in Korea. In order to keep costs lower for students conducting research on EVs, they have developed EV maintenance education using twin technology and virtual reality (VR). This saves costs by not actually having to purchase hard materials or components for students to conduct research on. Rather, a digital twin image is produced that can be studied and worked on virtually through VR technology.[53] Currently, Windsor-Essex is home to the Invest WindsorEssex Virtual Reality CAVE – an immersive and interactive VR environment, integrated with state-of-the-art hardware and software. The facility serves as a teaching, training, and research tool for the region. This technology located in our region could act as training grounds for the development of future talent in the EV value chain. Students enrolled in EV programming, such as EV maintenance certification courses at St. Clair College, would potentially be able to use this technology to learn about the maintenance of different EV components through digital twinning and VR.

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51. Tongji University, "Reimagining new energy vehicles: Research innovations at Tongji University."
52. Fred Lambert, "Tesla is bringing EV education to the kindergarten level in China," May 23, 2016. Electrek.
53. Sang-Hyun Lee and Byeong-Soo Jung, "Development of electric vehicle maintenance education ability using digital twin technology and VR," *International Journal of Advanced Culture Technology* 8, 2 (2020): 58.

RECOMMENDATIONS

The main goal of this report is to identify the talent and educational requirements for building a robust EV value chain cluster in the Windsor-Essex region. Considering all the information that this report has provided on these topics, the final recommendations that should be considered are as follows:

Upon identification of the specific types of occupations that will be required to grow an EV value chain cluster in the Windsor-Essex region, it should be noted which occupations are present at a lower rate. The region should then develop targeted recruitment and attraction campaigns for other regions with higher numbers of these occupations in order to fill potential talent gaps. Stakeholders that would likely be involved in this process would be economic development, government, and educational institutions. Attracting more qualified candidates to the region would allow industry stakeholders already involved in EV-based activities to thrive, as well as attracting potential investment from stakeholders searching for suitable regions to locate new businesses. All of the above points would lead to a more successful EV value chain cluster in the region, also leading to increased attraction and retainment of trained graduates and jobseekers searching for careers in the EV field.

Windsor-Essex should attempt to transition to a more EV-based society. The benefits of such a society would be sustainable mobility and positive environmental impacts such as less greenhouse gas emissions, increased regional technological capacity, and regional economic growth. This can be done through research in partnership with educational institutions and industry leaders, as well as investing in infrastructure that would help support this transition.

Doing so should create more employment opportunities along the EV value chain and make the region more attractive to investors involved in EV value chain activities.

Windsor-Essex should take advantage of its growing international student population. The region can do so by leveraging IRCC's newly proposed MNP program to directly sponsor permanent immigrants. In particular, the program can be used to target international students who have graduated from post-secondary programs with curriculum suited for careers in an EV value chain.

Educational institutions should build on existing programming and create more programming to develop curriculum that is better aligned with developing talent for occupations available in an EV value chain. Creating partnerships with government and industry to create new programming and curriculum will greatly support this educational transition. The region can look to programming and curriculum in the U.S., Germany, and China for best-practice examples. Articulation agreements can potentially be developed with specific post-secondary institutions mentioned in this report, particularly those located in nearby Michigan, that have implemented EV-based curriculum.

Attracting and securing investment and talent to build a robust and successful EV value chain in Windsor-Essex will require a lot of work moving forward. However, Windsor-Essex is already beginning to position itself well for this type of transition and possesses a valuable talent-base to fill the future occupations that will be necessary to support such a value chain.

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