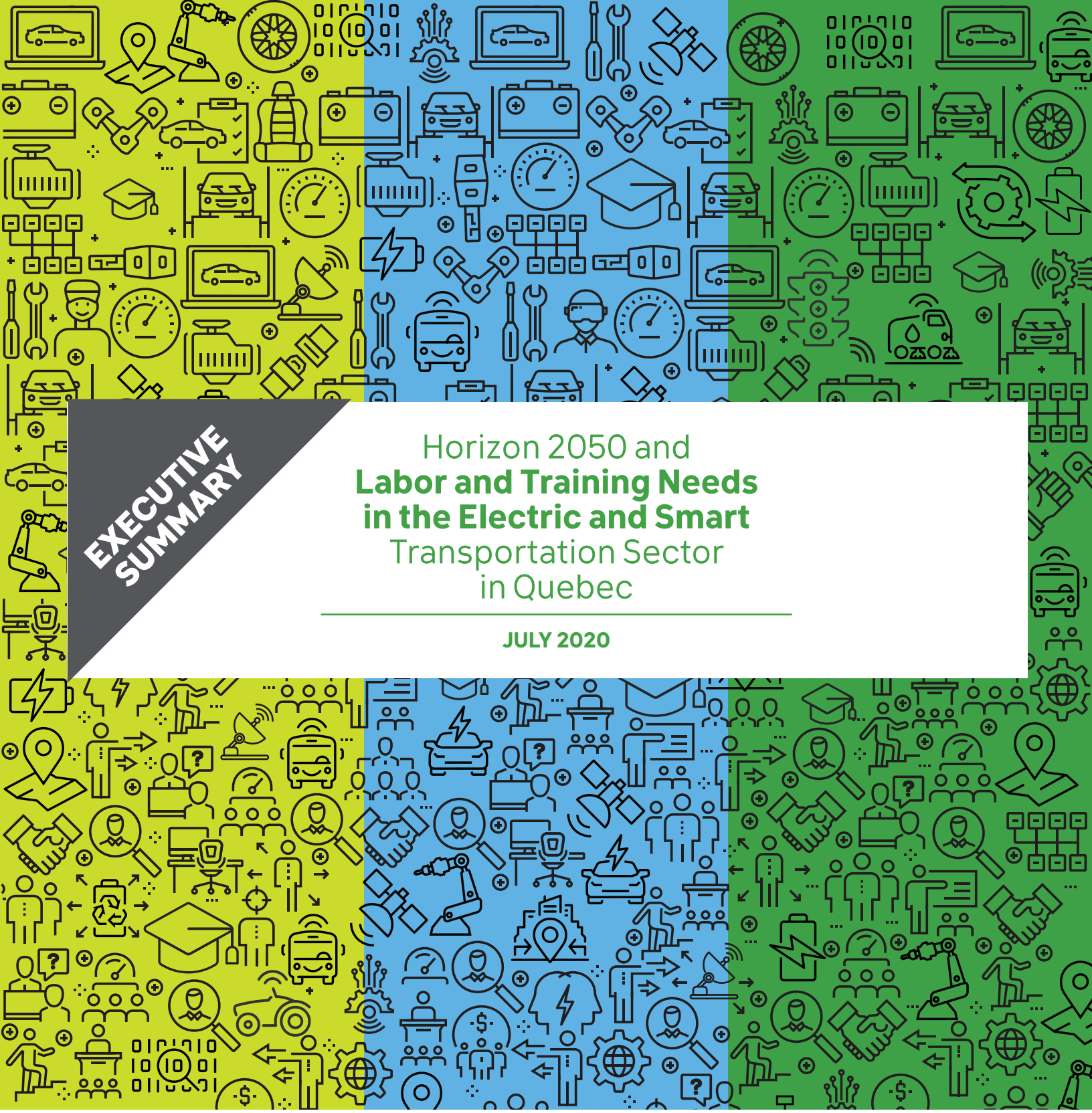

EXECUTIVE SUMMARY

Horizon 2050 and **Labor and Training Needs in the Electric and Smart** Transportation Sector in Quebec

JULY 2020

With funding from:

Québec

propulsion Québec

Cluster for Electric and Smart Transportation

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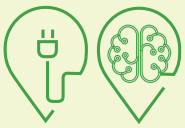
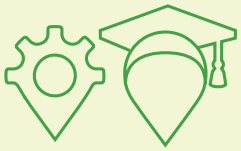




1 Introduction

1.1. Background and content of the study

Propulsion Québec, an electric and smart transportation cluster, hired MARCON to conduct an initial study on the labor and training needs in the electric and smart transportation (EST) industry in Quebec and calculate projections. The study was made possible thanks to the financial support of Services Québec.

Since nearly 70% of the cluster's members consider labor shortages to be an obstacle to growth[1], Propulsion Québec launched this study to help it document and identify measures and address labor and training needs in the EST industry.

The study is divided into three sections and includes recommendations and suggested measures:

1. **Analysis of the projected impact of electric and smart transportation on the movement of people and goods out to 2050**
2. **An overview of currently available labor and training specific to the EST industry in Quebec**
3. **Changing labor and training needs, industries at risk, and suggested measures**

1.2. Methodological approach

The method used to assess labor and training needs was based on EST deployment scenarios for the movement of people and goods out to 2050. They will be presented in the next section.

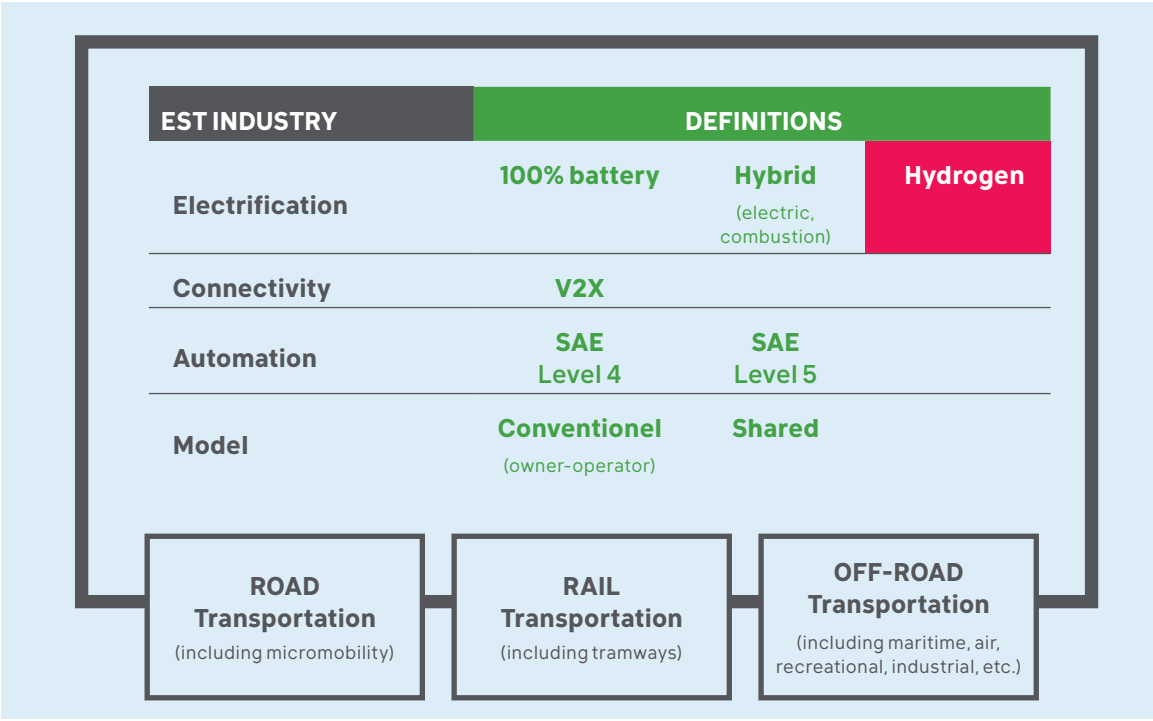
Diagrams 1 and 2 show the scope of the EST cluster's research and its research universe, which helped frame the study.

Except for hydrogen-powered vehicles, the study looked at all on-road and off-road vehicles, with different levels of electrification, connectivity, and automation[2] as well as both conventional and shared ownership models.

1 KPMG for Propulsion Québec, Portrait économique de la filière des transports électriques et intelligents du Québec, 2019, p. 18.

2 For the purposes of the study, a connected vehicle is a vehicle with an on-board communication system that provides access to the Internet. This allows the vehicle to connect to the road network, other vehicles, passengers, and the cloud in general, hence the term V2X (vehicle to everything). An autonomous vehicle, on the other hand, does not need a human being to drive it. Self-driving automation levels are based on the Society of Automotive Engineers (SAE) nomenclature, which includes five levels. The two highest levels cover advanced automation and, for the purposes of the study, define the term autonomous vehicle.

Diagram 1 – Research scope



For the purposes of the study, the research universe of the EST cluster has been simplified to include the following:

Industry value chain

- Component manufacturing
- Vehicle manufacturing
- Infrastructure manufacturing, including charging stations
- Mobility services and vehicle use

Vehicle technology

- Electrification
- Smart technology (connectivity, automation)

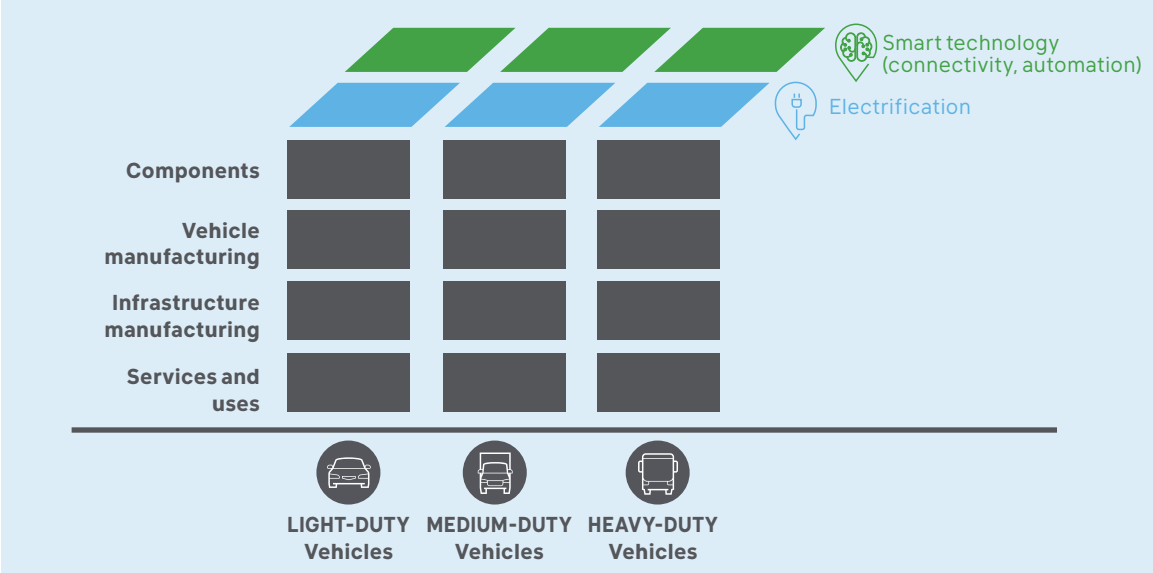
Vehicle categories[3]

- **Light-duty**: classes 0, 1 and 2, including on-road and off-road applications
  This category includes cars, vans, and ambulances.
- **Medium-duty**: classes 3 to 6, including road and off-road applications
  This category includes certain trucks and tool vehicles.
- **Heavy-duty**: classes 7 and 8, including on-road, rail, and off-road applications
  This category includes buses and some trucks.

Except for locomotives and other rail traction vehicles, unregistered vehicles were not quantified due to a lack of reliable data.

3 Since vehicle registration is a provincial (in Canada) and state (in the U.S.) responsibility, 65 separate jurisdictions handle vehicle classification, which unfortunately is not standardized. For the purposes of this study, the vehicle fleet was broken down as follows: Light-duty vehicles: net weight 4,536 kg or less, medium-duty vehicles: net weight 4,537 to 11,793 kg, and heavy-duty vehicles: net weight of 11,794 kg and over.

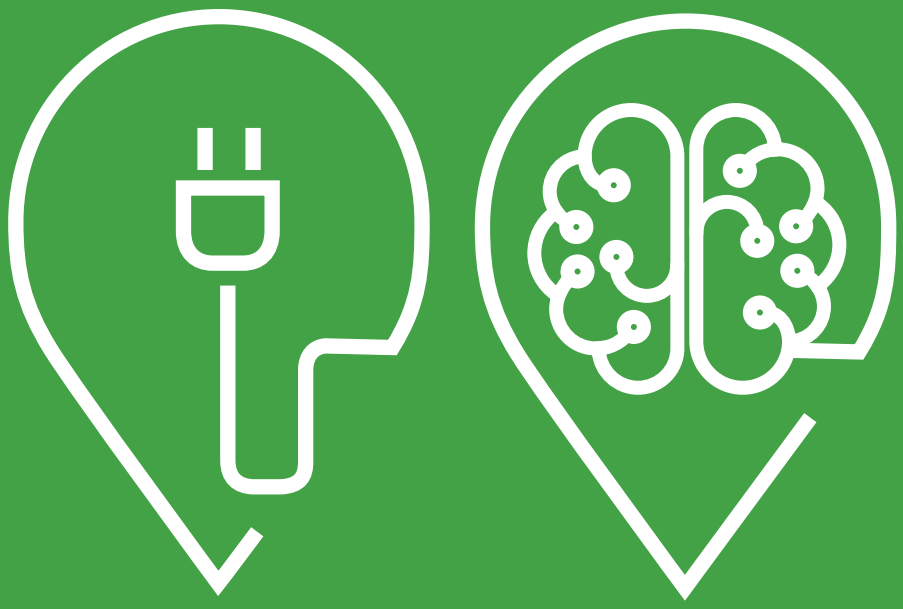
DIAGRAM 2 Research universe



The methodological approach that guided this study and led to an analysis of labor and training needs is summarized in the table below. Note that the study is based on a secondary data search, workshops with a panel of international experts, primary data collection workshops as part of a labor forum organized by Propulsion Québec, and targeted interviews with companies and industry experts.

DIAGRAM Methodological approach

Demand for transportation of people and goods	Adoption rate of electric and smart vehicle technology	Demand for electric and smart vehicles	Market share of Quebec manufacturers	Labor needs	Training
Data from Quebec, US, and Canadian governments	Sectoral studies MARCON analysis Discussions with experts	Trends and hypotheses: • Sociodemographic • Environnemental • Economic • Technological Growth in demand for EST	Interviews Estimates	Market share estimates for Quebec companies Estimate of jobs at Quebec companies that will be based in Quebec	Assessment of labor needs Assessment of technology trends Identification of training needs



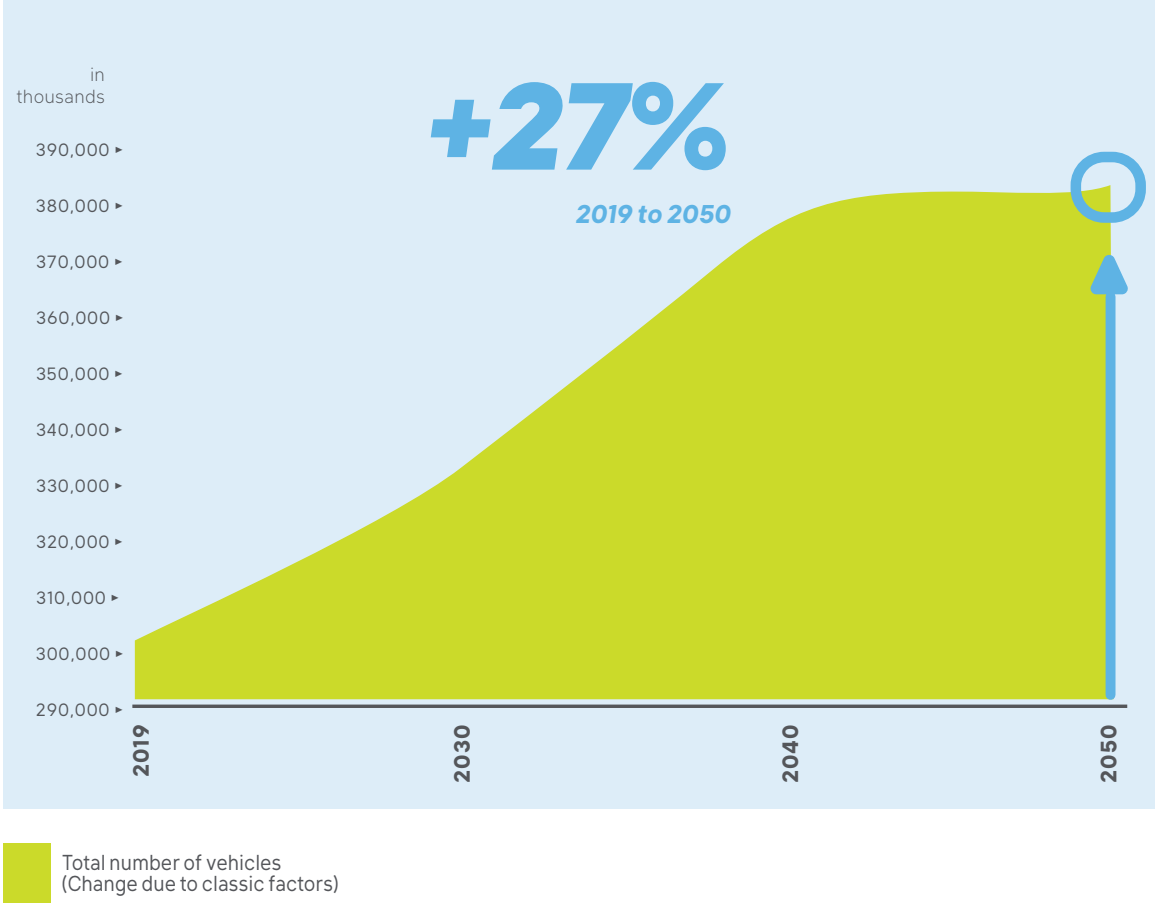
2

Horizon 2050: the deployment of electric and smart transportation

2.1. Transformation of the North American vehicle fleet

Based only on classic factors such as population and GDP growth, the North American vehicle fleet should increase in the coming decades, as illustrated in Graph 1.

GRAPH 1 **"Classic" changes in the North American vehicle fleet, 2019–2050 (all vehicle categories)**



Source: MARCON, 2020.

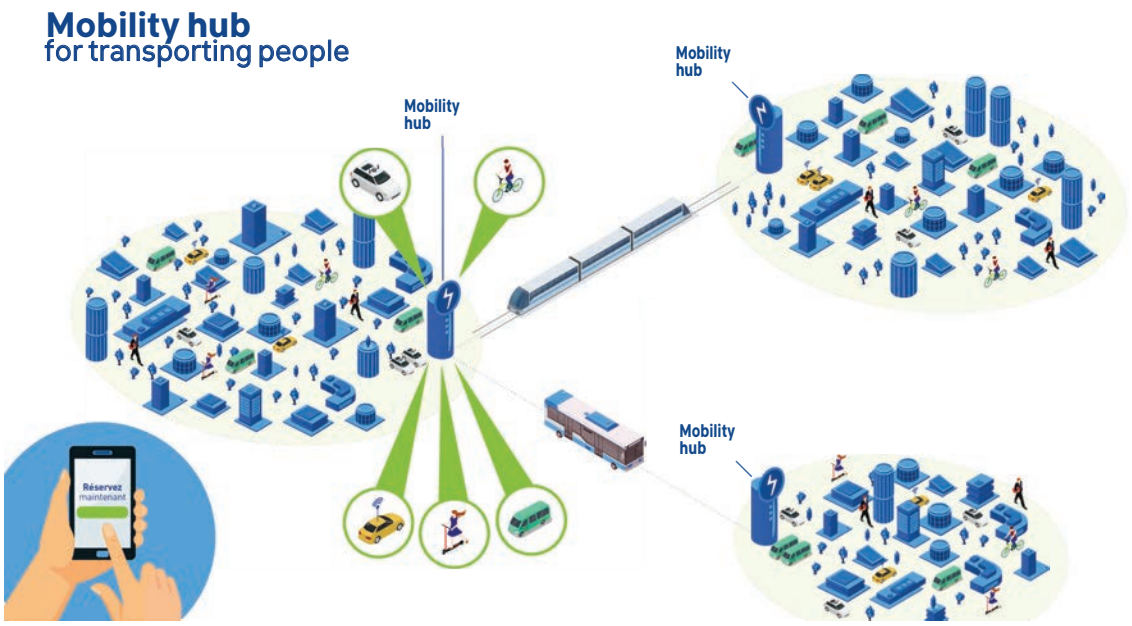
However, the first part of this study shows that the combination of a number of factors will cause gradual changes in people's transportation habits and freight transport practices. So gradual market penetration by EST technologies will bring about substantial changes in the makeup and size of the North American vehicle fleet by 2050.

Advances in EST will change this "classic" trend in the North American vehicle fleet.

Other socioeconomic and regulatory factors and new business models will also affect the size of the fleet.

It is anticipated that the development of mobility hubs for passenger transportation, facilitating urban and interurban travel, will generate significant growth in medium- and heavy-duty vehicles (buses, light rail, tramways, etc.), as shown in Figure 4 below. This will also lead to a decrease in the number of light vehicles, due to a more intensive and shared use, despite an increase in passenger trips generated in particular by the increase in MaaS[4].

DIAGRAM 4 Individual mobility model in North America in 2050



Source: MARCON, 2019.

4 Mobility as a Service: Mobility as a Service is a digital service that provides access to all means of transportation via a single smartphone app. HUB DE MOBILITÉ pour le transport de personnes = MOBILITY HUB for transportation of people HUB DE MOBILITÉ = MOBILITY HUB

As regards freight transport, the growth of consolidation centers on the outskirts of urban centers will encourage an increase in the number of heavy-duty vehicles for long-distance transport, while medium-duty vehicles, which take up less space for local deliveries, will reduce congestion over shorter distances.

DIAGRAM 5 Model of goods mobility in North America in 2050

Source: MARCON, 2020.

Due to advances in EST, the North American vehicle fleet is expected to decrease in the coming decades in contrast with what the "classic" model predicts. Table 1 and Graph 2 show this expected change.

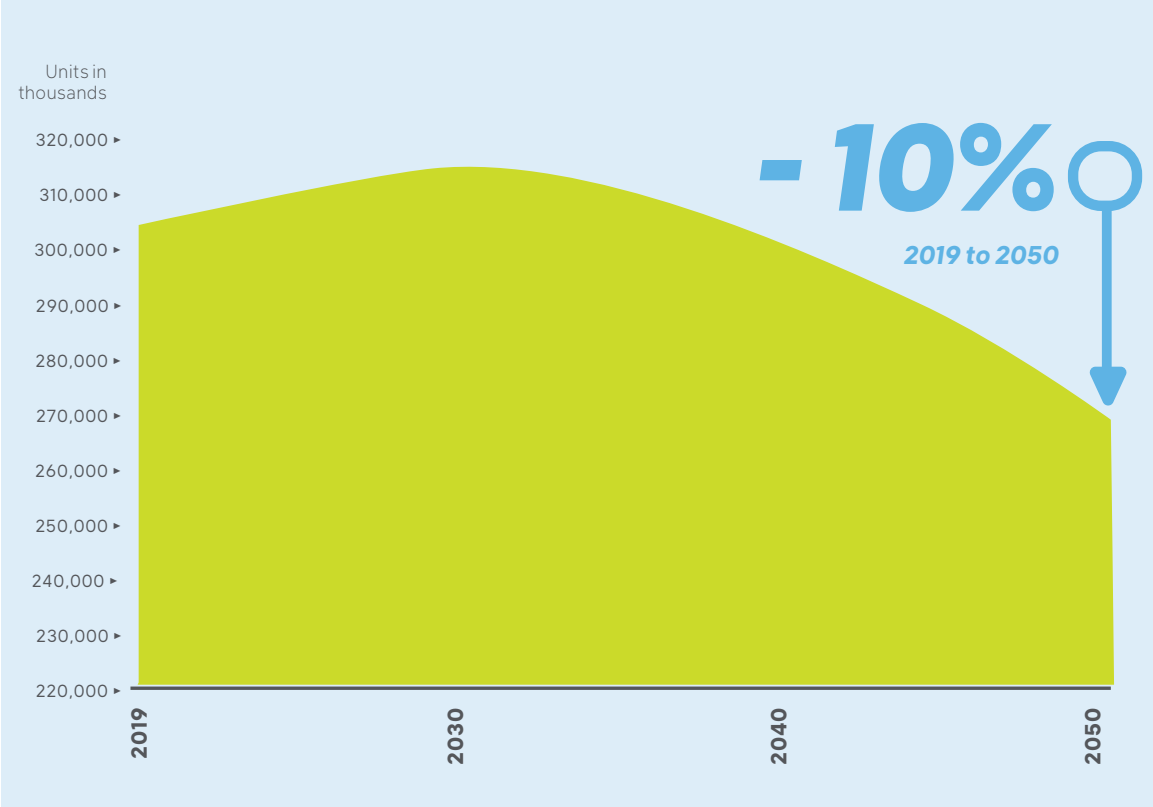
TABLE 1 Percent change in the North American vehicle fleet influenced by advances in EST (%)

Category	2019	2030	2040	2050
	%	%	%	%
Light-duty vehicles	94.2%	91.5%	87.8%	81.8%
Medium-duty vehicles	3.4%	5.4%	8.1%	12.3%
Heavy-duty vehicles	1.6%	2.2%	3.2%	4.8%
Other vehicles	0.8%	0.8%	0.9%	1.0%
Rail	0.0%*	0.0%*	0.0%*	0.0%*
TOTAL	**100%**	**100%**	**100%**	**100%**
	302,695.7 thousands of units	**314,595.1** thousands of units	**300,771.2** thousands of units	**270,954.9** thousands of units

* Certain figures are low and rounded down, giving 0.0% in the table. Readers may think that there are no electric and smart vehicles in circulation in certain categories. Whereas this is not the case.

Source: MARCON, 2020.

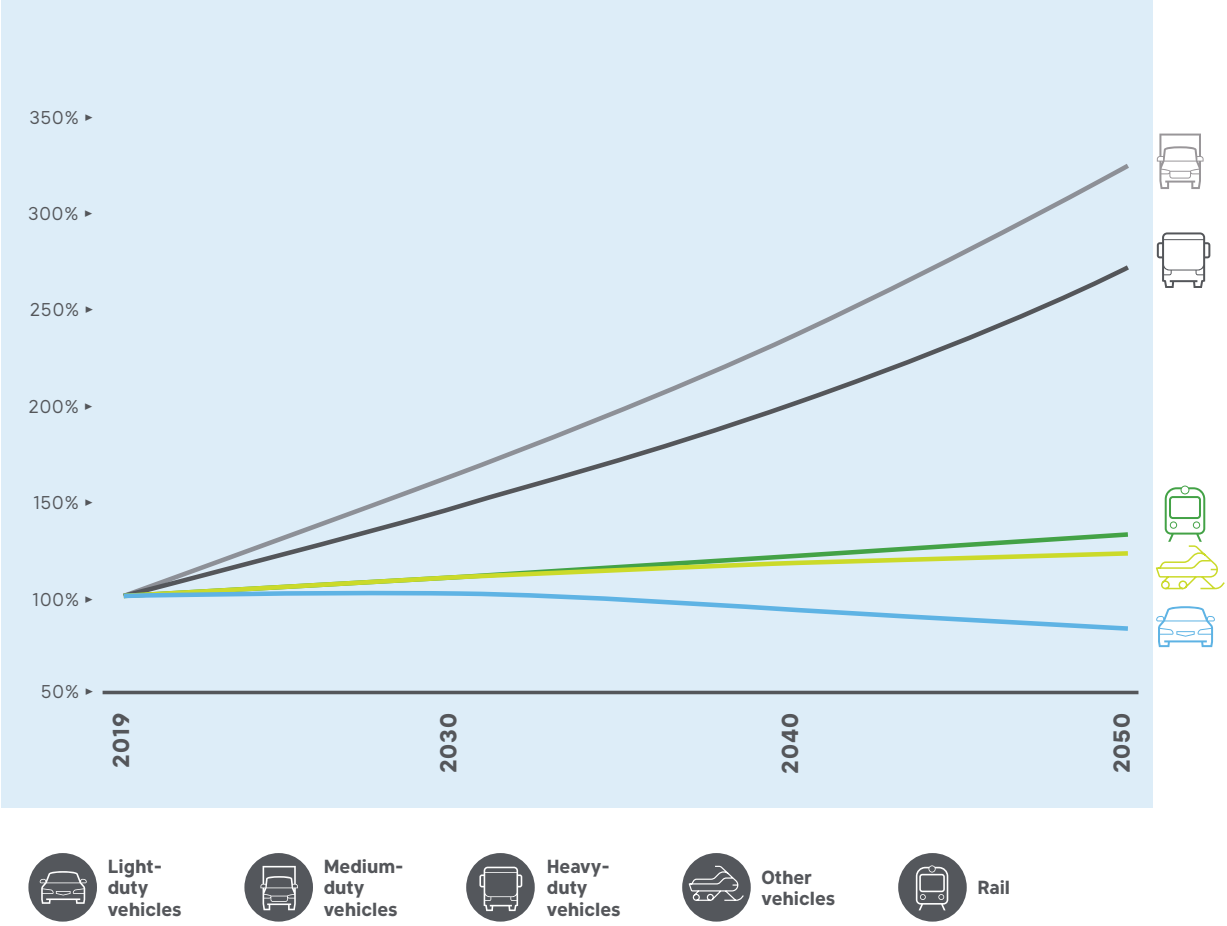
GRAPH 2 Change in the size of the North American vehicle fleet due to advances in EST, 2019–2050 (All categories combined



Source: MARCON, 2020.

However the study clearly shows that different categories of vehicles will not evolve in the same way in the coming decades. More specifically, it shows that EST will transform the nature of the North American vehicle fleet over the long term (2050), with a marked decrease in light vehicles (about -22%), a major increase in the number of medium-duty and heavy-duty vehicles (+220% and +165%, respectively), and a significant increase in rail vehicles (about 30%).

GRAPH 3 Variations in different vehicle categories in North America out to 2050 (%)



Source: MARCON, 2020.

2.2. Changes in the percentage of electric and smart vehicles in the North American fleet

The future percentage of electric and smart vehicles was assessed according to a predictive (non-econometric) model developed during the study that includes numerous socioeconomic, technological, and regulatory parameters.

Electric vehicles: A wider choice of electric light vehicles, especially in the important subcategory of utility vehicles, pickup trucks, and vans

Smart vehicles: Commercialization of autonomous vehicles (SAE level 4 and/or 5) as of 2030

Despite the gradual decrease in the total number of light vehicles in the North American fleet, there will be a marked increase in electric and smart vehicles from 1.4 million units to 155.2 million by 2050.

The move toward electric and smart medium-duty and heavy-duty vehicles will be even more significant, as at the moment they are still virtually inexistent on the market. This situation is illustrated in the table below.

TABLE 2 **Changes in the North American electric and smart vehicle fleet according to the realistic scenario, 2019–2050 (in thousands of units and percentage of the total number of vehicles in use)[5]**

	2019	2030	2040	2050
Light-duty vehicles	0.5%	27.5%	43.9%	57.3%
Medium-duty vehicles	0.0%	1.1%	3.7%	9.9%
Heavy-duty vehicles	0.0%	0.2%	0.6%	1.4%
Other vehicles	0.0%	0.1%	0.2%	0.4%
Rail	0.0%	0.0%	0.0%	0.0%
TOTAL NUMBER OF ELECTRIC AND SMART VEHICLES	**0.5%**	**28.9%**	**48.4%**	**69.0%**
	1 430.4 thousands of units	**90,897.2** thousands of units	**145,603.5** thousands of units	**186,956.7** thousands of units
VEHICLES IN CIRCULATION	**100%**	**100%**	**100%**	**100%**
	302,695.7 thousands of units	**314,595.1** thousands of units	**300,771.2** thousands of units	**270,954.9** thousands of units

Legend:

Electric and smart vehicles

All types of vehicles (Internal combustion engine)

Source: MARCON, 2020.

It should be mentioned that the EST adoption rates in the table above are based on a realistic scenario, like the one developed by the consultant in the study. According to this scenario, it is predicted that 69% of the ground vehicle fleet will be electric and/or smart by 2050. However, we should remain cautious about this figure, which should not be interpreted as an absolute prediction, but rather as a trend.

5 In some cases, vehicle numbers are low and rounded down, so that 0.0% is indicated in the table. Readers may think that there are no electric and smart vehicles in circulation in certain categories. Whereas this is not the case.

To develop these scenarios, the study assessed the impact of various factors on the mobility of people and goods and the penetration of electrification, connectivity, and automation technology into the North American fleet. Although they include numerous parameters, these scenarios can be summed up as follows:

Pessimistic: Insufficient technological progress and lack of regulatory support to encourage adoption of the technology

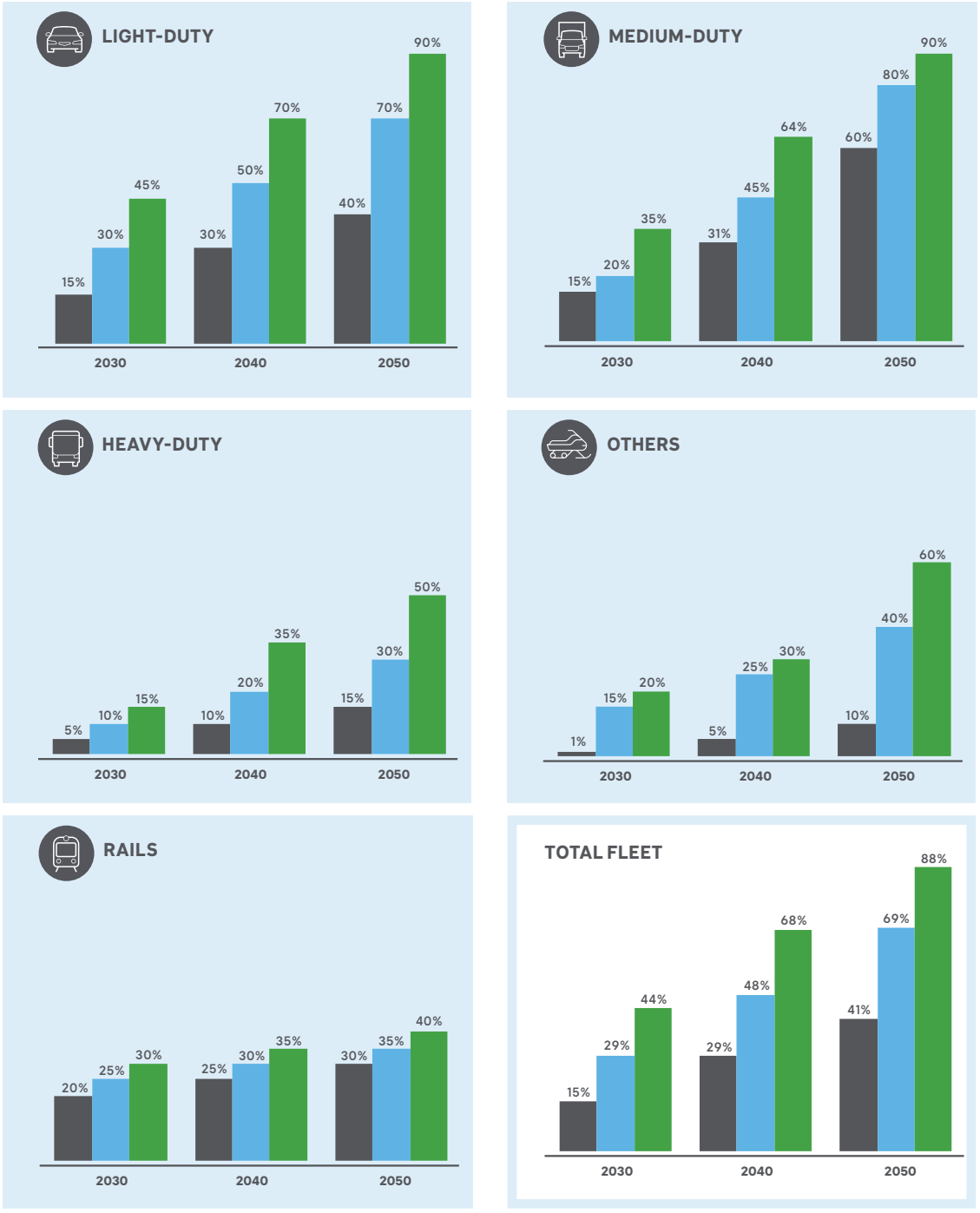
Realistic: Balanced regulatory support, improved battery technology, battery prices considerably lower than in 2020, and commercialization of connected level 4 and 5 autonomous vehicles as of 2030

Optimistic: Technological advances in vehicle electrification and automation, widespread adoption by much of the population, and regulatory support, incentives, and programs encouraging the adoption of electric and smart vehicles

Graph 4 shows that the approximate percentage of electric and smart vehicles in the North American fleet from 2030 to 2050 varies considerably, depending on the scenario. Because of the COVID-19 pandemic and its possible consequences for the industry, which are difficult to predict, we considered it important to present a number of scenarios on the penetration of electric and smart vehicles given such a long and uncertain time span.

Faster penetration of electric and smart vehicles by 2030 and beyond is anticipated to different degrees for all the scenarios.

GRAPH 4 Changes in the percentage of electric and smart vehicles in the North American fleet, 2030–2050 Approximate proportion (%)



Legend:

- **Pessimistic scenario**
- **Realistic scenario**
- **Optimistic scenario**

Source : MARCON, 2020.

2.3. Impacts on the industry value chain in Quebec

The transformation of the vehicle fleet will have a big impact on the value chain of Quebec's electric and smart transportation industry over the medium and long term.

According to the consultant's experience, gained through a number of assignments conducted in the industry, Quebec's potential in this sector varies by type of technology and step in the value chain. This is illustrated in diagrams 6 and 7.

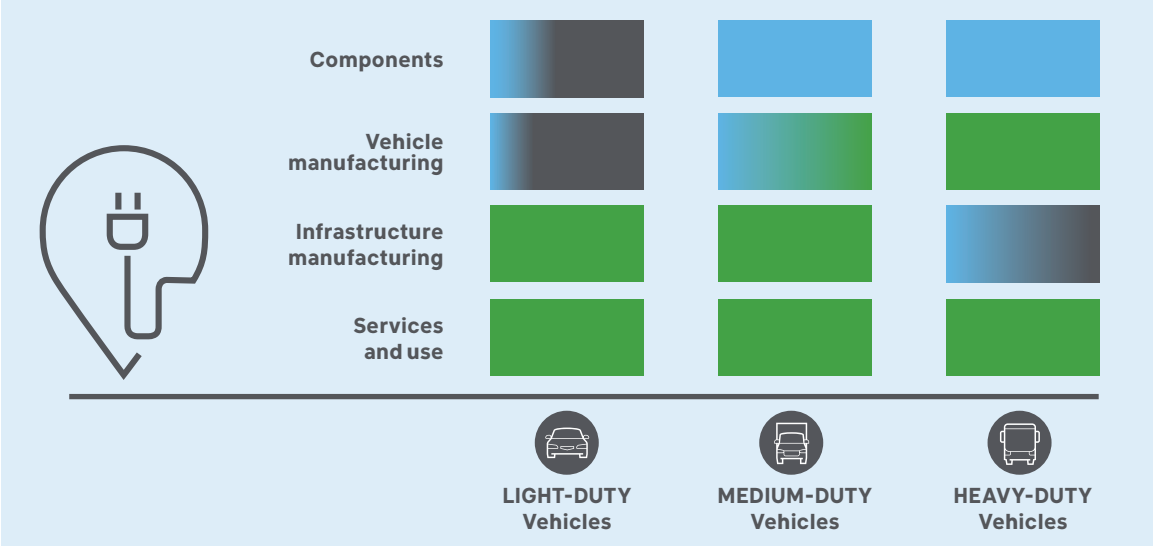
Regarding electric transportation, Quebec's potential is high for the following links in the value chain:

- **Manufacturing of medium-duty vehicles (especially for specialized uses)**
- **Manufacturing of heavy-duty vehicles (trucks, buses, and trains)**
- **Charging infrastructure**
- **Services and use in connection with all types of vehicles**

In the case of smart transportation, the potential of Quebec industry is highest in the following categories:

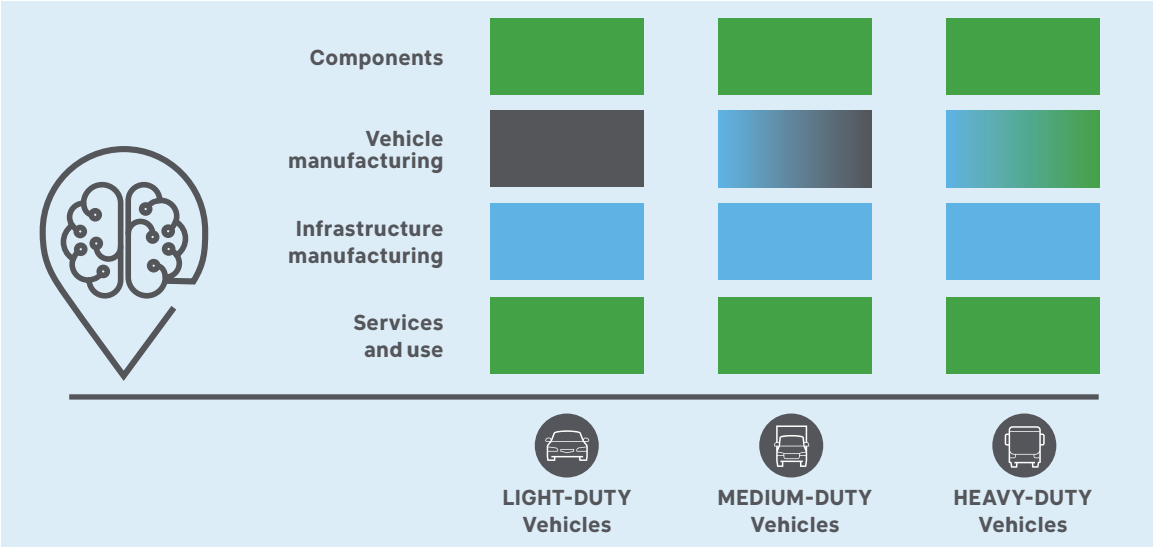
- **Vehicle and infrastructure components in the optics and artificial intelligence sectors**
- **Services and use in connection with all types of vehicles**

Diagram 6 Quebec's potential in the electric transportation industry



Source : MARCON, 2020.

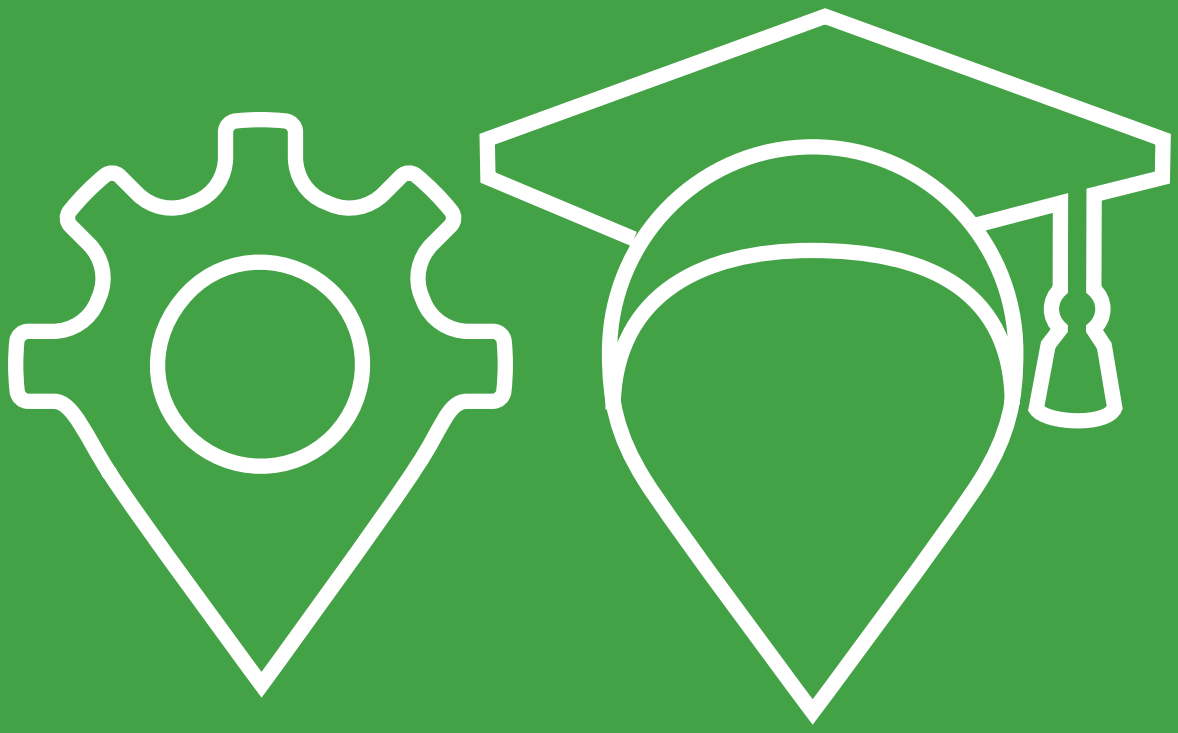
Diagram 7 Quebec's potential in the smart transportation industry



Source : MARCON, 2020.

After analyzing the deployment of electric and smart transportation out to 2050, we were able to determine the projected impact on the movement of people and goods and the Quebec value chain to better predict labor and training needs in the province. These will be discussed in detail in the following section.

EXECUTIVE SUMMARY



3

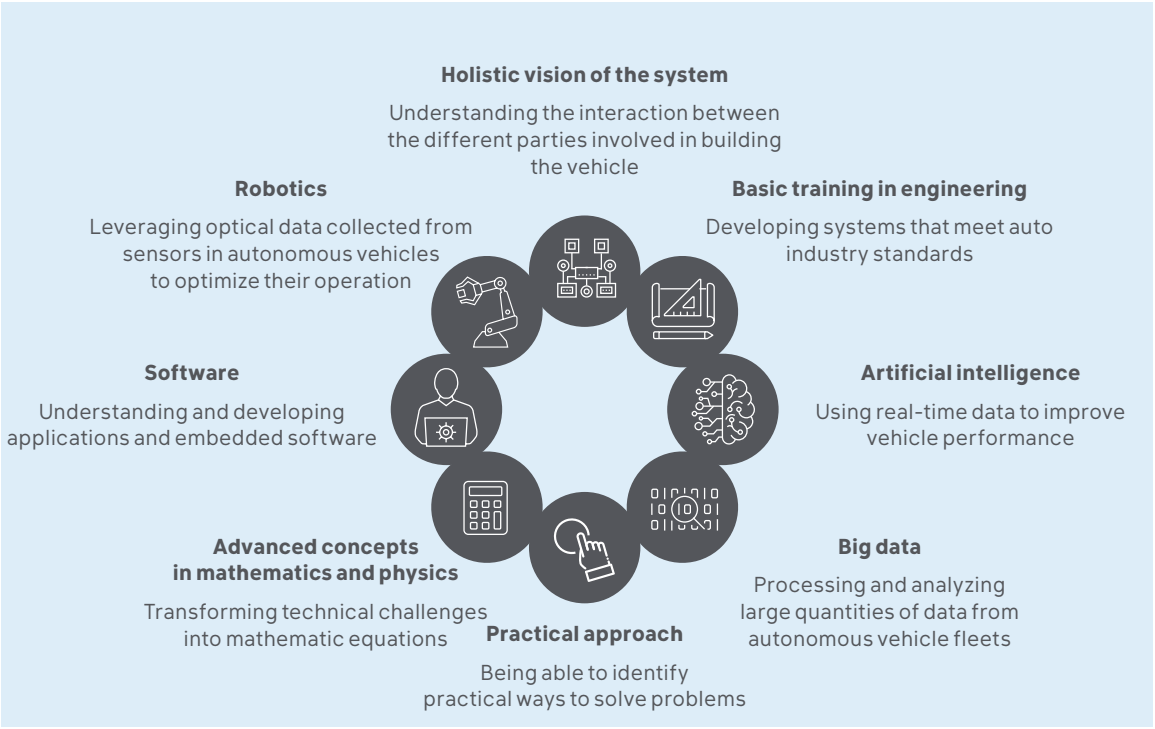
Labor and training needs in Quebec's electric and smart transportation industry

3.1. Overview and evolution of labor in the EST industry

The study estimates that in 2019, 14,200 jobs in Quebec were fully or partly tied to EST[6].

As the EST industry is mainly made up of SMEs, employers are looking for highly versatile workers who can carry out the many different tasks involved in developing, manufacturing, and servicing vehicles and infrastructure. This wide range of skills is illustrated in Diagram 8. This trend makes it more difficult to find suitable candidates, and companies have to compete harder to attract and retain the most qualified workers.

DIAGRAM 8 Key skills required by the EST industry



Adapted from BCG

6 Fifty occupations, as defined in the National Occupation Classification (NOC), have been identified as being directly related to electric and smart transportation. These occupations include jobs in both the manufacturing and service industries.

The main finding of the analysis on the current labor and training situation is that the electric and smart vehicle industry does not suffer from a greater labor shortage than other Quebec industries.

The labor analysis of the EST industry identified approximately ten occupations that are key for developing Quebec businesses in the industry. These are mainly engineering jobs, but also include positions in technical sales and vehicle maintenance.

Some of the key occupations are in higher demand by industry and therefore are more likely to negatively affect its growth in Quebec.

TABLE 3 Key occupations in electric and smart transportation in 2019

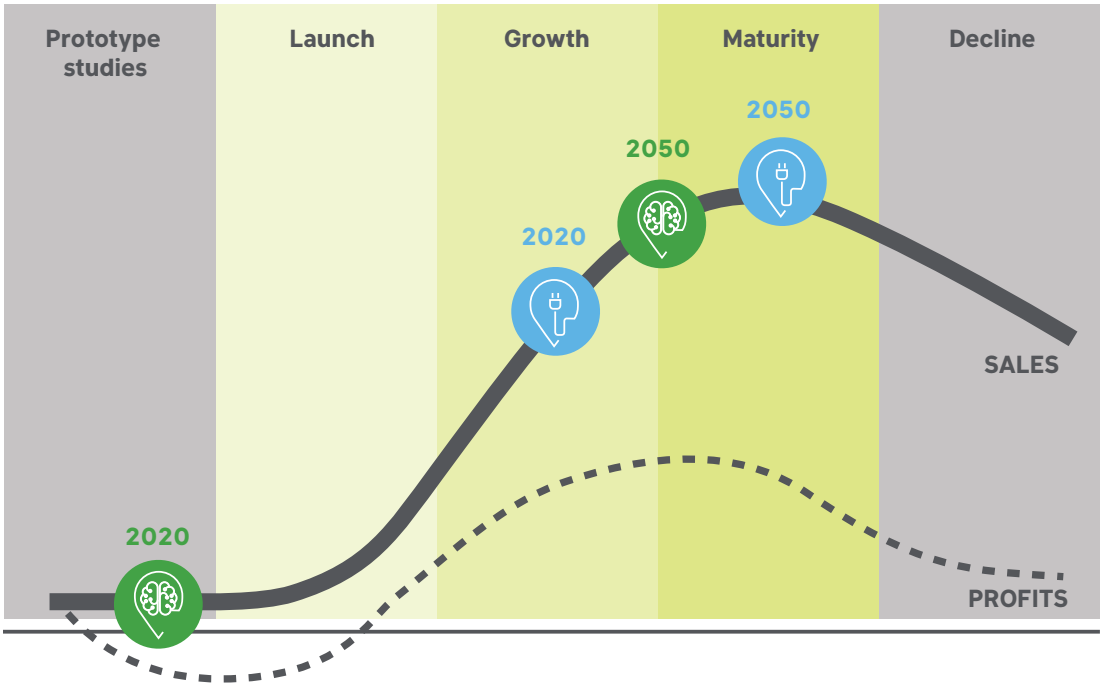
Occupation	Key	Risk of shortages	All jobs	% of EST jobs[7]	Jobs linked to EST
Electrical and electronics engineers (including those specializing in reliability, operability, and advanced driver assistance and driver support systems) NOC 2133	X	X	9,387	5%	469
Database analysts and administrators NOC 2172	X	X	5,103	1%	51
Software engineers and designers, especially those specializing in image processing, optics, and artificial intelligence NOC 2173	X	X	7,124	5%	356
Interactive media programmers and developers NOC 2174	X	X	29,657	1%	297
Electrical and electronics engineering technologists and technicians NOC 2241	X	X	12,470	5%	623
Technical sales specialists NOC 6221	X		13,666	1%	137
Automotive service technicians, truck and bus mechanics and mechanical repairers NOC 7321	X		38,353	0.5%	192
Electrical mechanics NOC 7333	X		7,021	0.4%	28

Source: MARCON, 2020.

Labor needs in electric transportation out to 2030 will be different than those in smart transportation since the former will enter its growth phase over the next decade while the latter will still be in its pre-commercial phase.

7 These percentages are based on data collected from the experts consulted, the expertise of the professionals at MARCON, and a general literature review. These figures were submitted to members of the study committee for comments and discussion.

DIAGRAM 9 EST lifecycle



Source: MARCON, 2020.

Labor needs for electric transportation will mainly concern production in fields related to electricity, electronics, and mechanics. Electrification of vehicle fleets and their maintenance will also generate numerous jobs. The growth in electric vehicle sales will substantially increase demand for after-sales service. This will create jobs at the vocational, technical, and university levels.

Smart transportation needs will mainly concern knowledge acquisition and design. University graduates, especially those with graduate science and engineering degrees in artificial intelligence, software development, and communications security will be in high demand.

3.2. Overview and evolution of training in the EST industry

The study presents the training and skills required for key occupations in the industry. All initial vocational, CEGEP, and university level training and professional development courses specific to EST across Quebec were identified. Among the initial training programs, a minority explicitly target electric and smart transportation.

Although the data on initial training at high school, CEGEP, and university generally suggest that the basic concepts are taught and are sufficient in most cases, it would be highly beneficial to include course content specific to electric and smart transportation.

.

For example, the industry would like to see the following additions to the curricula:

- Course content on security and reliability standards in the auto industry that apply to embedded software
- Course content on developing new cars
- Integration of artificial intelligence into engineering programs
- Inclusion of management and marketing concepts in engineering courses
- Addition of a training module spread over two to three years on vision and optics applied to autonomous vehicles (software engineering)
- More in-depth training on data security and cybersecurity

As for professional development, the industry suggests the following training:

- Training to upgrade heavy-duty vehicle mechanics to electrical mechanics
- Training on electric vehicle engines for car mechanics
- A course on OHS procedures for handling, storing, and recycling electric vehicle batteries
- A course on management tools for practicing engineers working in cloud computing, databases, and proactive performance management (monitoring, reporting and performance assessment)

Lastly, companies and institutions consulted as part of the study suggested that new programs be created to complete currently available training, namely:

- Specialized bachelor's courses on electric and smart transportation for electrical engineering programs, including additional training content on urban mobility, the Internet and connected objects, artificial intelligence, autonomous driving, and so on.
- Specialized bachelor's course on smart transportation

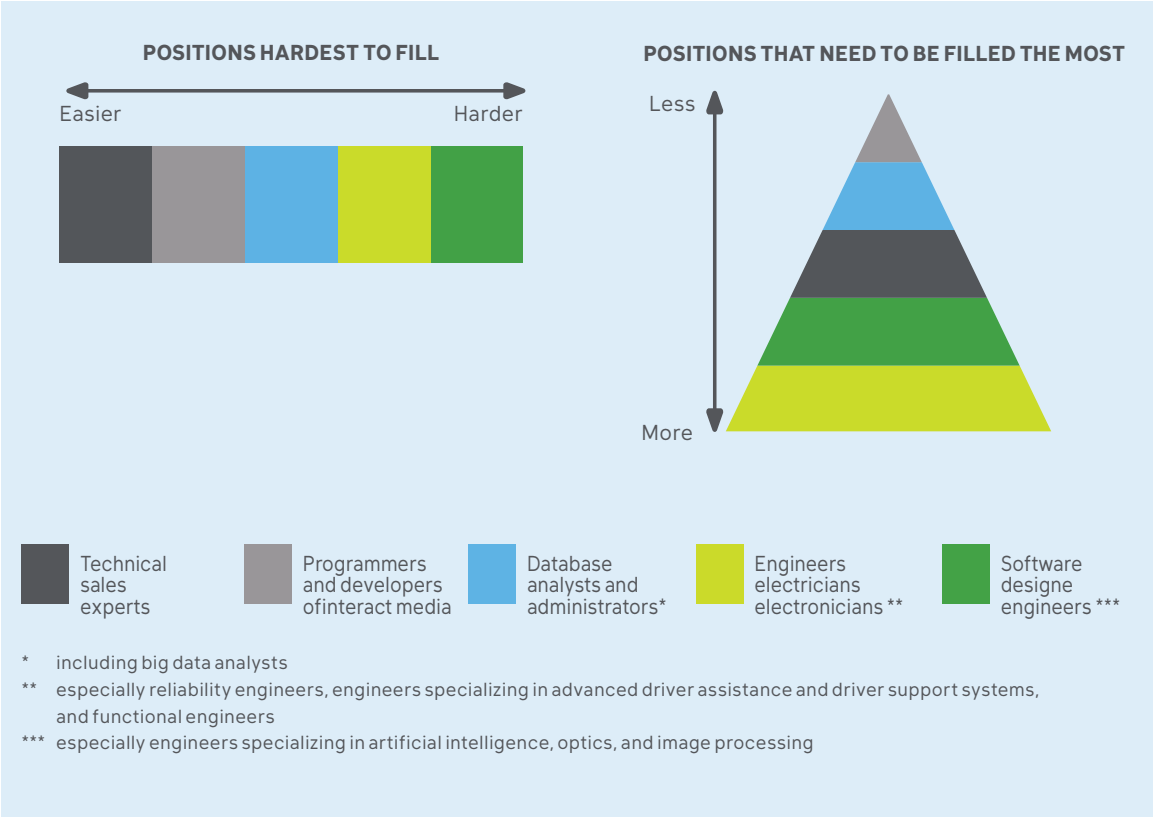
3.3. Changing labor needs and industries at risk

The quantity and nature of future training needs will partly depend on a common vision on the part of government and the industry regarding electric and smart vehicles and related technology.

In the case of electric vehicles and their value chain, the Quebec government has already clearly expressed a shared vision with industry and has launched a range of initiatives to accomplish it. However to date, no goals have been put forward concerning smart vehicles. Training needs specific to the connected and smart vehicle industry can only be identified once a Quebec strategy is set out and measures to promote its expansion are announced.

The following diagram illustrates the key occupations now and over the next decade.

DIAGRAM 10 **Key EST occupations, 2020-2030**



* including big data analysts
** especially reliability engineers, engineers specializing in advanced driver assistance and driver support systems, and functional engineers
*** especially engineers specializing in artificial intelligence, optics, and image processing

Source : MARCON, 2020.

Electrification and transportation automation technologies will significantly change the transportation of people and goods.

The mobility models developed in this study suggest radical change over the coming decades. Certain occupations will be severely impacted by this transportation revolution. Professional drivers of all types of road vehicles and conventional powertrain mechanics will gradually disappear as electric and smart vehicles replace those commonly used today.

Technological and industrial shifts always require that labor adapt to changing needs. As the changes will happen over a long period (20 to 30 years), voluntary departures and attrition (retirement, etc.) will help phase out most of the positions that will be eliminated and there will be no need for major measures to retrain workers.

A number of sectors will be indirectly affected by growth of EST, and a broad range of occupations will feel the impact over the long term. For example, the cybersecurity sector will be reinforced because an industry will emerge to protect vehicles subject to this risk. The entertainment industry will also see benefits because the market for entertainment in the vehicles will expand. On the other hand, the insurance industry will be negatively affected if original equipment manufacturers (OEM) of motor vehicles assume liability and/or insure themselves. The same is true for the hotel industry, because travelers will be able to sleep in their vehicles instead of hotels, and for parking lots as many vehicles will be in constant or almost constant use.

4

Suggested measures and conclusion

The study proposes the following measures to increase the availability of skilled workers for the industry and facilitate any required retraining of employees likely to see their jobs evolve due to the expected changes:

- **SELECT** the most promising niches in the smart transportation industry for Quebec and develop a Quebec EST strategy to harmonize stakeholder initiatives and guide government action in terms of investment, training development, and international recruitment.
- **TASK** Propulsion Québec and/or its partners with developing and implementing a series of measures to promote industry jobs and training to university, CEGEP, and high school students.
- **WORK** with post-secondary institutions and their representatives to adapt existing curricula to include teaching of EST-related concepts.
- **ADD** internships at companies working in the EST industry to increase student awareness of the possible applications of their knowledge in the industry.
- **AGGRESSIVELY RECRUIT** world-class resources in the selected smart transportation niches to create strong local expertise built on existing foundations.
- **CONDUCT** a more exhaustive quantitative assessment of jobs directly and indirectly at risk and regularly monitor the speed at which positions are lost in each occupation, with a view to preventing both labor surpluses and labor shortages in Quebec.
- **CREATE** a mechanism to coordinate the efforts of industry and academia to ensure the best possible match between the training offered and the needs of each sector.
- **EXAMINE** the possibility of creating a training brokerage system at Propulsion Québec to help its members quickly find the resources they need.

To sum up,

the study clearly shows that electric and smart transportation is a promising industry *because the number of electric and smart vehicles is expected to increase substantially. It is anticipated that certain categories of electric and smart vehicles, such as medium- and heavy-duty vehicles, will experience significant growth because production of these vehicles is still limited.*

Quebec could occupy a key position *in the value chain of the electric and smart transportation industry, thanks in particular to its expertise in manufacturing medium- and heavy-duty vehicles, charging infrastructure, and vehicle components in the field of optics and artificial intelligence.*

Lastly, ***the study concludes that the electric and smart transportation industry will rely on approximately ten key occupations,*** *mainly in engineering, technical sales, and vehicle maintenance. To fill these positions, training must be adapted to include content specific to electric and smart transportation in Quebec.*

To learn more about Horizon 2050, EST, and Quebec's labor and training needs in this sector, please refer to the full study available on our website.

6666 rue Saint-Urbain,
bureau 360
Montreal, Quebec
H2S 3H1
Canada

1150 rue de Claire-Fontaine,
bureau 740
Quebec City, Quebec
G1R 5G4
Canada

propulsionquebec.com/en/

propulsion Québec

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