Supply Chain Challenges and Solutions

Sofya Chudaeva and Jenny Xiang

University of Toronto
Outstanding Teenager Leadership Foundation, Youth Entrepreneurship Forum
6 September, 2024

A successful implementation of electric vehicles into the market depends on the advancement of battery technology, economical factors such as oil and electricity prices, charging infrastructure, and user behaviours. Indubitably, any country who has begun to implement strategies to further the aforementioned aspects has faced challenges and setbacks, and has also developed methods to remedy those challenges and continue improving the electric vehicle supply chain.[1] An effective means of cost reduction is the recycling of batteries. This would reduce the toll on the environment and economy, as costs of production and energy use would be reduced, and dependency on imports would decrease as well. In order for this to be efficient, at least 50% of the batteries need to be recycled.[3] This report explores the ways that Germany, China, and the United States have encountered and overcome challenges in improving their supply chain. These countries are some of the most developed leaders of the electric vehicle market and analysing their methodology in advancing the electric vehicle market provides some key insights that are applicable to Canada. We will begin by examining Germany and the ways that it has focused mainly on strengthening their supply chain and implementing a circular economy. For Germany, their main strategic actions for electric vehicle industry growth are centred around fostering a resilient supply chain that supports the sustainable and competitive transformation of the German automotive industry, mainly Volkswagen.[2] As for China, their main strategic actions for the growth of the industry is to develop more advanced batteries and technologies for the electric vehicles, so that the new type of model can be sustainable to the environment. Other ways they are trying is to develop recycling strategies so that used batteries will not end up in the landfill, as this is in the development phase, it is projected to see developments in the future.

Literature Review

The shift towards electric vehicles promises significant impacts on electricity prices and market dynamics. Hanke, Hüelsmann, and Fornahl (2014)[3] present a comprehensive literature review on the socio-economic aspects of EVThe increasing interest in EVs, reflected in Google searches since the early 2000s and a surge in "electric car" queries from 2010 to 2011, highlights a growing market trend. From a management perspective, embracing electric mobility requires strategic planning to harness opportunities in technology and market positioning. The automotive industry must adapt to new value chains and prepare for volatile global markets amidst economic cycles and globalisation. Standardisation efforts across EVs, smart grids, and charging infrastructure are crucial for industry cohesion and scalability. Research and development remain pivotal in navigating these evolving landscapes, ensuring economic resilience and industrial integration in regional markets. This source provides insight towards the economic and supply chain conditions of Germany that could potentially be extrapolated towards Canada. However, research indicates that the German context does not directly parallel the Canadian situation, and as a result, solutions effective in Germany may not be applicable to Canada.

Rapson and Muehlegger (2023)[4] take on a different approach and highlights geographical nuances in market failures, emphasising the need for tailored policies that reflect local conditions and evolving environmental impacts as electricity generation shifts towards decarbonization. It argues for a phased reduction in subsidies as EV technologies mature, cautioning against premature infrastructure investments without clear evidence of widespread network benefits. The discussion

---

[1] Till Gnann, Patrick Plötz, André Kühn, and Martin Wietschel, "Modelling Market Diffusion of Electric Vehicles with Real World Driving Data – German Market and Policy Options," Transportation Research Part A: Policy and Practice 77 (2015): 95-112, https://doi.org/10.1016/j.tra.2015.04.001.

[2] Mohammad Ali Rajaeifar, Pezhman Ghadimi, Marco Raugei, Yufeng Wu, Oliver Heidrich, Challenges and recent developments in supply and value chains of electric vehicle batteries: A sustainability perspective, Resources, Conservation and Recycling, Volume 180, 2022, 106144, ISSN 0921-3449, https://doi.org/10.1016/j.resconrec.2021.106144.

[3] Hanke, C., Hüelsmann, M., Fornahl, D. (2014). Socio-Economic Aspects of Electric Vehicles: A Literature Review. In: Hülsmann, M., Fornahl, D. (eds) Evolutionary Paths Towards the Mobility Patterns of the Future. Lecture Notes in Mobility. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-37558-3_2

[4] Rapson, D. S., & Muehlegger, E. (2023). The economics of electric vehicles. *Journal of Political Economy, 17*(2). Retrieved from https://www.journals.uchicago.edu/doi/epdf/10.1086/725484

integrates considerations of social and environmental justice with cost-effectiveness, advocating for nuanced subsidy strategies that maximise public benefits and align with long-term policy goals in a resource-constrained economy. This work provides some valuable insight but could benefit from more detailed case studies or real-life data illustrating the effectiveness of different policy approaches in various geographic contexts. In this context, it pairs well with the Hanke, Hüelsmann, and Fornahl's article which provided a concrete case study.

Considering that electric vehicles require large amounts of electricity to produce and run, Lee, Haram, Ramasamy, Thiagarajah, Ngu,and Lee (2021)[5] suggest that reducing electricity costs is an essential part of production to consider for both a more economical and environment-friendly production process. Managing electricity costs through operational adjustments involves several strategies. The simplest method is manual interruption, where machinery causing electricity spikes is manually shut down. While straightforward, this approach is prone to human error, which can lead to costly bills. A more efficient alternative is controller-based interruption, which uses programmed controllers to manage machinery during peak hours, enhancing overall efficiency. On-site generation is another option, involving the production of additional power locally during peak times to reduce reliance on grid electricity. Historically, this method has used diesel generators or gas turbines, which, although initially cost-effective, can become expensive due to fuel and maintenance costs. Lastly, load scheduling, whether done manually, semi-automatically, or fully automatically, shifts heavy loads from peak to off-peak hours to capitalise on lower electricity rates. This strategy optimises costs but may affect business operations due to necessary adjustments in load management. This source provided some valuable insight into the economics of reusing EV batteries, not just for EVs but other sources as well. This collaboration of industries could lead to a more economical future in the field of EVs and other processes which use similar batteries.

Challenges

Raw Materials

Lithium-Ion Batteries (LIBs) are essential components in many advanced technologies, particularly in electric vehicles (EVs) and grid energy storage systems. These batteries rely on a variety of raw materials such as Nickel, Cobalt, Aluminium, Magnesium, Copper, Titanium, Manganese, Iron, and Silicon. Among these, Lithium, Cobalt, Magnesium, and natural Graphite are identified as critical raw materials due to their high supply risks and potential for price volatility. While there is relatively less concern over the scarcity of Lithium compared to Cobalt, significant challenges exist in scaling up Lithium production to meet future LIB demands, especially as the adoption of EVs continues to grow.[6]

Lithium extraction poses considerable environmental and logistical challenges. The process of extracting Lithium from brine or hard rock deposits requires substantial amounts of energy and water, which can affect local water resources and agricultural production.[7] For instance, large-scale Lithium extraction operations can deplete freshwater resources and potentially disrupt local ecosystems. Although Direct Lithium Extraction (DLE) technologies offer a promising alternative by potentially

---

[5] Jia Woon Lee, Mohammed Hussein Saleh Mohammed Haram, Gobbi Ramasamy, Siva Priya Thiagarajah, Eng Eng Ngu, Yuen How Lee, Technical feasibility and economics of repurposed electric vehicles batteries for power peak shaving, Journal of Energy Storage,
Volume 40, 2021, 102752, ISSN 2352-152X, https://doi.org/10.1016/j.est.2021.102752.

[6] Mohammad Ali Rajaeifar, Pezhman Ghadimi, Marco Raugei, Yufeng Wu, Oliver Heidrich, Challenges and recent developments in supply and value chains of electric vehicle batteries: A sustainability perspective, Resources, Conservation and Recycling, Volume 180, 2022, 106144, ISSN 0921-3449, https://doi.org/10.1016/j.resconrec.2021.106144.

[7] Harper, G., Sommerville, R., Kendrick, E., Driscoll, L., Slater, P., Stolkin, R., Walton, A., Christensen, P., Heidrich, O., & Lambert, S. (2019). Recycling lithium-ion batteries from electric vehicles. *Nature, 575*(7781), 75-86. https://doi.org/10.1038/s41586-019-1682-5

reducing water usage and improving efficiency, these methods are still under development and require further research to optimise their operation and cost-effectiveness.[8]

Cobalt is another critical material used in LIBs. Most of the world's Cobalt (about 70%) is mined in the Democratic Republic of Congo (DRC)[9], a country that faces significant political instability and social issues, including child labour in some mining operations. Furthermore, the dominance of Chinese companies in the Cobalt mining and refining sectors adds another layer of complexity, as these firms might prioritise their own domestic battery manufacturers over international customers in the event of supply disruptions.[10] While the geological concentration of Cobalt from Nickel mining operations is less problematic, the reliance on Nickel demand for Cobalt as a by-product remains a point of concern.

Graphite is also a key material for LIBs, with most of the global production and reserves concentrated in China.[11] While this concentration poses potential risks, such as supply disruptions and price volatility, the overall abundance of Graphite and recent efforts to explore new sources in other countries mitigate these risks to some extent. Nevertheless, there is still uncertainty in predicting future mineral supplies and LIB demands due to the speculative nature of emerging markets for EVs and grid storage applications.

Cost trends and projections for LIBs have been largely positive over the past decade. According to a Bloomberg NEF report, the average cost of LIBs has decreased by 89% from $1,191 per kilowatt-hour (kWh) in 2010 to $137/kWh in 2020. Of this 2020 cost, approximately $35/kWh, or 26%, was attributed to the pack portion, which includes pack-level materials excluding the cells themselves. The remaining costs are associated with the cells.[12] This significant price drop reflects improvements in manufacturing processes and economies of scale. Looking forward, it is expected that the average LIB market price will approach $100/kWh by 2023 and could fall further to $58-$73/kWh by 2030.[13] Despite these optimistic forecasts, achieving these targets will require ongoing advancements in battery technology and cost reduction strategies to ensure the broader adoption of EVs and support for renewable energy sources in grid storage.

Strategies for cost reduction include several innovative approaches such as new material selections, improvements in manufacturing processes, and advancements in battery design. Techniques like water-based processing and the development of solid-state batteries represent potential avenues for reducing costs and improving battery performance. However, these approaches face their own set of challenges, such as technical feasibility and cost-effectiveness, which will influence the timing and extent of future cost reductions.[14]

---

[8] Harper, G., Sommerville, R., Kendrick, E., Driscoll, L., Slater, P., Stolkin, R., Walton, A., Christensen, P., Heidrich, O., & Lambert, S. (2019). Recycling lithium-ion batteries from electric vehicles. *Nature, 575*(7781), 75-86. https://doi.org/10.1038/s41586-019-1682-5

[9] Ibid.

[10] Mohammad Ali Rajaeifar, Pezhman Ghadimi, Marco Raugei, Yufeng Wu, Oliver Heidrich, Challenges and recent developments in supply and value chains of electric vehicle batteries: A sustainability perspective, Resources, Conservation and Recycling, Volume 180, 2022, 106144, ISSN 0921-3449, https://doi.org/10.1016/j.resconrec.2021.106144.

[11] Ibid.

[12] Bloomberg, N. E. F. (2020). Battery pack prices cited below $100/kWh for the first time in 2020, while market average sits at $137/kWh. Bloomberg NEF blog, December, 16.

[13] Ibid.

[14] German Federal Ministry for Economic Affairs and Climate Action. (2023, September 20). Habeck discusses future of automotive industry in Germany with expert group. Retrieved June 27, 2024, from https://www.bmwk.de/Redaktion/EN/Pressemitteilungen/2023/09/20230920-habeck-discusses-future-of-automotive-industry-in-germany-with-expert-group.html

Recycling presents another important opportunity for both cost reduction and environmental impact mitigation. Improving the design of LIBs to facilitate recycling and considering end-of-life treatment options can help close the loop in the LIB value chain, reducing overall costs and minimising environmental impacts. Nevertheless, current LIB designs make recycling difficult, and there is a need for better methods and technologies for recycling battery materials.[15]

Environmental impacts of LIB manufacturing are significant, with recent life cycle assessment (LCA) reports showing that the manufacturing stage is a major contributor to both energy consumption and greenhouse gas (GHG) emissions in the life cycle of LIBs. In some cases, these emissions can be higher than those from internal combustion engine vehicles when considering cradle-to-gate emissions. Addressing these issues requires optimising energy use in manufacturing processes and increasing the share of renewable energy sources to reduce the carbon intensity of LIB production.[16]

Natural Supply Shortage

It has been an initiative for many countries around the world to aim for a greener future, due to the known risks of global warming as a consequence of industrialization. It is also known that industries are aiming to manufacture more electric vehicles to make transportation more sustainable for the environment. To manufacture these electric vehicles, natural resources, like cobalt, are used as an important source of horsepower to fuel them. However, cobalt is a limited resource, and just like coal, when once all of it is used, the resources for manufacturing the batteries would be gone. There are ways to sustain the resources for longer, like inventing better batteries or recycling used ones, but both strategies still face challenges to sustaining the supply of natural minerals, which are crucial for powering electric vehicles.

As for technological innovation, it has been discovered that even if there is a decline in using natural resources for batteries, higher demand for electric vehicles would still deplete the natural resources, and it would lead to a supply shortage. For example, the NMC-811 cobalt batteries were invented to replace the NMC-111 batteries so that fewer cobalt would be used to generate similar results. However, with the expansion and an increase in electric vehicle demand in the future, researchers worry that there will be an inevitable cobalt shortage. It is known that cobalt-free technologies are being invented to combat this supply risk, and they are planned to be commercialised by 2030. However, the demand-supply gap would still be at risk to occur around 2028-2033.[17]

Recycling has always been a strategy for manufacturers to use around the world so that natural materials can be reused and this strategy can reduce the risk of natural supply shortage. However, this strategy can only reduce the chance natural supplies are depleted, as recycling cannot fully prevent the risk from happening. It is also the case with battery manufacturing for electric vehicles, and suppliers worry that even with recycling strategies, it cannot prevent the day all natural resources for making the batteries are depleted. Some of the main concerns about recycling are the high cost and lack of strong initiatives for every company to take.

The first concern is that only 10% of industries are applying recycling to their manufacturing practices. This means that only a small fraction of the electric vehicle industry is reusing natural

---

[15] Mohammad Ali Rajaeifar, Pezhman Ghadimi, Marco Raugei, Yufeng Wu, Oliver Heidrich, Challenges and recent developments in supply and value chains of electric vehicle batteries: A sustainability perspective, Resources, Conservation and Recycling, Volume 180, 2022, 106144, ISSN 0921-3449, https://doi.org/10.1016/j.resconrec.2021.106144.

[16] Chen Lipeng, Yaobin Liu, and Xi Tian. 2024. “Progression of Lithium Industry for Power Battery in China: Resource Reclamation and Carbon Reduction Initiatives,” January. https://doi.org/10.2139/ssrn.4843826.

[17] Battery technology and recycling alone will not save the electric mobility transition from future cobalt shortages, Zeng et. al, 2022

materials, and most industries still rely on first-handed resources for their batteries. This means that cobalt resources are still at a relatively fast rate of depletion, and a global cobalt supply risk will happen sooner. The second concern is that because manufacturing from raw materials is much cheaper, companies would rather prioritise profits than sustainability when they manufacture electric vehicles. This means that they would not include recycling in their practices as it would add more costs to the manufacturing process. The exclusion of that can be consequential, as it can cause the global cobalt depletion to occur at a faster rate.[18]

Both perspectives have shown the challenges of sustaining natural materials, which exist in only a selection of countries, while expanding the electric vehicles market. The innovation of battery technologies needs to take time, and while they are aiming to decrease their reliance on minerals like cobalt like the example discussed previously, they will still one day be all depleted. As for recycling, it is also not a sustainable strategy because it is a very costly process, and there are very few companies that have the wealth to include the technology for manufacturing their vehicles. Also, as long as using recycled materials is more expensive than using first-hand materials from the mines, companies would still prefer utilising the cheaper method for higher profitability. It is important for companies to realise that for the long-term sustainability of this industry, efficient technologies and recycling at a friendlier cost should be implemented.

Solutions

Raw Materials

A solution to the high cost of materials and thus high cost of production of electric vehicles is to streamline the production process and form partnerships with raw material companies. Similarly, localising battery production is also a means of reducing cost and improving efficiency. Learning from Germany's approach to creating a more robust supply chain, one means of obtaining necessary materials is to organise a trade network with China(the biggest suppliers of Cobalt).[19] This proved to be unsuccessful for both Germany and China. However, Canada has existing business relationships with China, so the outcome may be different than it was for Germany. In terms of other options for Germany, with the support of the Federal Ministry for Economic Affairs and Climate Action, they decided to implement large-scale production plants in order to ensure a secure supply of raw materials. Additionally, funding is available in order to ensure that this process goes smoothly as it greatly benefits the automotive industry in Germany. This funding goes towards the fields of extraction of both primary and secondary raw materials in order to secure a sufficient and efficient supply of necessary materials for EV construction. Considering that Canada is plentiful in resources necessary for EV construction, it is a feasible idea to invest in localising and securing a reliable supply of raw materials, and if some cannot be found, establishing a trade network with China to obtain them.[20]

To further improve the supply chain, experts in Germany recommend keeping transparency regarding up-to-date information on supply, demand, prices, and the criticality of raw materials, as well as establishing a comprehensive European database on raw materials. Similarly, Canada could develop a Canadian database of raw materials, which would make it easier for companies and producers to know which materials are available, where they are sourced from, and in what amounts. Germany achieved this transparency by streamlined monitoring at the country level as well as at the

---

[18] Ibid.

[19] German Federal Ministry for Economic Affairs and Climate Action. (2023, September 20). Habeck discusses future of automotive industry in Germany with expert group. Retrieved June 27, 2024, from https://www.bmwk.de/Redaktion/EN/Pressemitteilungen/2023/09/20230920-habeck-discusses-future-of-automotive-industry-in-germany-with-expert-group.html

[20] Natural Resources Canada. (2024). *Electric vehicle charging infrastructure for Canada*. Government of Canada. https://natural-resources.canada.ca/energy-efficiency/transportation-alternative-fuels/resource-library/electric-vehicle-charging-infrastructure-for-canada/25756

European Union level. They also suggest diversifying and thus securing their imports of raw materials to non-European countries in order to reduce risk, provide more stability and partnerships, and strengthen the circular economy, which is important for long-term supply security.[21] Since Canada borders the United States, creating a trade network or simply importing materials from the United States could benefit Canada's supply chain. This would also allow Canada to be in-the-know of any new modifications in terms of sustainability and new emerging technology in the United States, which is useful as the United States are more advanced in the electric vehicle industry and thus Canada could learn from their strategies. Challenges for Germany when getting imports from non-European countries include environmental regulations and societal acceptance, which they have worked to overcome.

For Canada, if collaborating with the United States, this would be less of a problem as Canada and the United States follow similar regulations and have many connections that would allow them to establish similar standards and regulations.[22] Furthermore, German experts suggest reducing import dependence and increasing value creation by developing and processing domestic raw materials, as well as establishing foundations such as modernised mining laws. Canada is able to do this due to its abundance in raw materials necessary for electric vehicle production, namely the batteries, which could serve as an asset when building trade relations with other countries. In addition, technological advancements are crucial in improving the efficiency and environmental sustainability of recycling processes, thereby reducing reliance on primary sources. By adopting these comprehensive actions, the automotive sector aims not only to mitigate immediate supply risks but also to position itself resiliently amidst evolving global dynamics and technological advancements.[23] On the side of economic incentives, experts suggest that preferential treatment of suppliers from Europe in public tenders, tax benefits for sustainable investments, and funding for supply chains, and raw materials deposits are necessary to ensure that the car industry increasingly depends on local supply chains and raw materials deposits.[24]

Some challenges and concerns regarding the future of the supply chain for this industry include the fact that as transformation processes for EV construction increase, the demand for critical raw materials will skyrocket. The German automotive industry competes for these raw materials not only with electric vehicle manufacturers from other economic regions but also with other industries such as renewable energy, information and communication technology, aerospace, additive manufacturing, and robotics, all of which are also increasingly demanding these raw materials.[25] To make matters worse, forecasts for future raw material needs are imprecise, as the exact requirements per vehicle, the number of vehicles produced, and technological developments (such as raw material substitution and recycling options) are difficult to predict. However, the short study commissioned by ETA shows that even in a low-demand scenario for 2040, there is a risk of insufficient raw material supply to the German automotive industry. For this reason, diversifying supply from countries outside

---

[21] German Federal Ministry for Economic Affairs and Climate Action. (2023, September 20). Habeck discusses future of automotive industry in Germany with expert group. Retrieved June 27, 2024, from https://www.bmwk.de/Redaktion/EN/Pressemitteilungen/2023/09/20230920-habeck-discusses-future-of-automotive-industry-in-germany-with-expert-group.html

[22] Clean Energy Canada. (2024). *Final U.S.-Canada tailpipe regulations pave the way to a clean car future*. https://cleanenergycanada.org/final-u-s-canada-tailpipe-regulations-pave-the-way-to-a-clean-car-future/

[23] German Federal Ministry for Economic Affairs and Climate Action. (2023, September 20). Habeck discusses future of automotive industry in Germany with expert group. Retrieved June 27, 2024, from https://www.bmwk.de/Redaktion/EN/Pressemitteilungen/2023/09/20230920-habeck-discusses-future-of-automotive-industry-in-germany-with-expert-group.html

[24] Till Gnann, Patrick Plötz, André Kühn, Martin Wietschel, Modelling market diffusion of electric vehicles with real world driving data – German market and policy options, Transportation Research Part A: Policy and Practice, Volume 77, 2015, Pages 95-112, ISSN 0965-8564, https://doi.org/10.1016/j.tra.2015.04.001.

[25] Mohammad Ali Rajaeifar, Pezhman Ghadimi, Marco Raugei, Yufeng Wu, Oliver Heidrich, Challenges and recent developments in supply and value chains of electric vehicle batteries: A sustainability perspective, Resources, Conservation and Recycling, Volume 180, 2022, 106144, ISSN 0921-3449, https://doi.org/10.1016/j.resconrec.2021.106144.

of Europe is a crucial part in the German EV industry, as raw material resources in Europe are concerningly scarce and as of now seem quite unreliable.[26] For this same reason, Canada, as an abundant source of raw materials, has a large competitive advantage in being able to produce electric vehicles without being overly reliant on imports, and can also expand its international connections to create trade networks that benefit both countries. This could also improve Canada's economic situation and thus make more funds available for supporting the creation of a database of raw materials and streamlining the production process.

Ultimately, strategic actions for electric vehicle industry growth are centred around fostering a resilient supply chain that supports the sustainable and competitive transformation of the Canadian automotive industry, allowing new brands to emerge and develop successfully.[27] These measures, if done correctly, could ensure long-term viability and leadership in the global automotive market.

Battery Materials and Recycling Initiatives

Recently, with the increasing climate concerns due to the emission of greenhouse gases, electric vehicles have been developed to combat the concern. It is a popular choice for people who care for the environment because it does not emit greenhouse gases, which are harmful to the planet. But, there are new problems that people are worried about with the market thriving. Supply chain issues have been a concern within the electric vehicles market, because the resources used for making the batteries, which is a vital component to power the vehicles, cannot be regenerated. Even with the advancement of technologies and recycling, there are sustainability concerns in the electric vehicle market. There are discussions among professionals about inventing a battery that is independent from natural resources to power up, and strategies to generate better initiatives for industries to recycle used batteries so that sustainability initiatives are more likely to be met.

There are concerns about the advancement of technology not being enough to combat supply chain issues. This is why other ways are explored to lengthen the power of the battery, so natural resources can be used for a longer period of time. An upcoming cobalt-free technology penetration is being developed so that the cumulative demand for cobalt is reduced by 41%.[28] As for the LSP batteries, the cumulative demand for cobalt can be reduced by 62%.[29] Another research has shown that when battery lifespan is doubled, it can reduce nearly half of the demand for natural resources, like cobalt. The two ways that are developed for the purpose of having more powerful batteries for electric vehicles are crucial for extending the lifespan of natural supplies. This means that electric vehicles can truly reach their sustainability goal for a longer period of time, resulting in an extended amount of time that the population can use a more sustainable means to commute. Although it is not a technology that has been actively explored in Canada yet, it is something that the country can definitely expand on with domestic battery production.

Another innovation strategy that the industries are planning to implement is to make batteries not powered by natural minerals but by other energies like hydrogen. In fact, hydrogen-powered vehicles are already in development, and they are shown to recharge vehicles faster than electric vehicles, making them a more convenient model for consumers. However, hydrogen is found to be generated from fossil fuel, a mineral that can emit greenhouse gases. Other alternatives that make hydrogen generation greener are much more costly, and it means a limited amount of industries can afford this technology. However, Europe is planning to implement a campaign to make hydrogen powered technologies more affordable, and it is projected to launch by 2040.[30] This means that by

[26] Chen Lipeng, Yaobin Liu, and Xi Tian. 2024. "Progression of Lithium Industry for Power Battery in China: Resource Reclamation and Carbon Reduction Initiatives," January. https://doi.org/10.2139/ssrn.4843826.
[27] Ibid.
[28] Ibid.
[29] Ibid.
[30] Sustainable management of lithium and green hydrogen and long-run perspectives of electromobility, Sadik-Zada et. al, 2023

then, Canada should collaborate with these European companies so that the domestic market can access this technology at a more affordable price.

Currently, recycling is only practised within 10% of the entire electric vehicle industry. Because it is very costly, and not many industries can afford to include it in their companies. Another strategy that is being developed to extend the lifespan of natural supplies is to motivate a more advanced network between suppliers and recycling institutions, so that recycling can be practised more, resulting in the further reduced demand for raw materials. This network can also allow companies that may not have the technology within their factories to reach out to recycling professionals so that they can receive supplies to manufacture the electric vehicles. The problem with this network is that there will be a lack of fairness between buyers and sellers. This means that public policies and industrial regulations should be implemented so that the network is more friendly for companies of all financial capacities so that sustainability can be achieved for a longer period. Another initiative from policymakers that should be made is to find ways to motivate these companies to participate in such kinds of programs so that they can make a similar level of profit but also contribute to using recycled materials.[31] Some of the ways that can be used are to provide subsidies when recycling machines need to be repaired, or new technologies are being innovated. By implementing these strategies revolving around recycling, it is believed that more than one-tenth of the electric vehicle industry will be implementing recycling into their industries in the future. It would result in a more environmentally friendly practice as it can keep the raw materials from being depleted for longer.

There are some solutions that can be implemented so that a more sustainable outcome would happen for the electric vehicle industry. These solutions are feasible to implement in Canada, as other countries' are taking their initiatives to make similar improvements. The manufacturing sector is looking at ways to reduce the usage of natural minerals by creating mineral-free batteries, like the cobalt-free batteries that are expected to enter the market in the future. As for other industries, they are looking to implement hydrogen to power the batteries, but policies need to be made so that a greener alternative can be more affordable. Recycling is another solution that industries are actively looking to develop, and the concern is that a lack of initiatives from policymakers is making the market more fair for both buyers and sellers. This is why researchers are suggesting a network where industries can reach out to recycling institutions. With the implementation of public regulations, it would motivate smaller industries to use more recycled materials in battery manufacturing. These ideas are what was being made globally in recent years, so they are great approaches Canada should be aware of, or try to implement within the domestic market. In conclusion, the electric vehicle market is thriving for the betterment of the environment, but careful strategies should be developed so that the market will always have the materials for manufacturing the most important component, the batteries.

Conclusion

Overall, the successful integration of electric vehicles into the market depends on several factors, such as but not limited to: advancements in battery technology, economic factors, natural resource trading systems, and robust supply chains. Countries such as Germany, China, and the United States have faced challenges but have developed effective strategies to overcome them and improve their electric vehicle supply chains.Analysing their approaches provides valuable insights for other nations, such as Canada, in advancing their own electric vehicle markets and strengthening their supply chains. Other globally faced challenges are the projected shortage of raw supplies and the high cost of recycling. Some solutions to both challenges are to produce technologies that reduce the reliance on raw materials and a higher recycling initiative taken by the government, so recycling would be cheaper and more companies would use it.

[31] Battery technology and recycling alone will not save the electric mobility transition from future cobalt shortages, Zeng et. al, 2022

References

1. Bloomberg NEF. (2020). Battery pack prices cited below $100/kWh for the first time in 2020, while market average sits at $137/kWh. *Bloomberg NEF blog*, December 16.
2. Chen, L., Liu, Y., & Tian, X. (2024). Progression of lithium industry for power battery in China: Resource reclamation and carbon reduction initiatives. *SSRN*. https://doi.org/10.2139/ssrn.4843826
3. Clean Energy Canada. (2024). *Final U.S.-Canada tailpipe regulations pave the way to a clean car future*. https://cleanenergycanada.org/final-u-s-canada-tailpipe-regulations-pave-the-way-to-a-clean-car-future/
4. German Federal Ministry for Economic Affairs and Climate Action. (2023, September 20). Habeck discusses future of automotive industry in Germany with expert group. Retrieved June 27, 2024, from https://www.bmwk.de/Redaktion/EN/Pressemitteilungen/2023/09/20230920-habeck-discusses-future-of-automotive-industry-in-germany-with-expert-group.html
5. Harper, G., Sommerville, R., Kendrick, E., Driscoll, L., Slater, P., Stolkin, R., Walton, A., Christensen, P., Heidrich, O., & Lambert, S. (2019). Recycling lithium-ion batteries from electric vehicles. *Nature, 575*(7781), 75-86. https://doi.org/10.1038/s41586-019-1682-5
6. Hoyer, C., Kieckhäfer, K., & Spengler, T.S. (2015). Technology and capacity planning for the recycling of lithium-ion electric vehicle batteries in Germany. *Journal of Business Economics, 85*, 505–544. https://doi.org/10.1007/s11573-014-0744-2
7. Mohammad Ali Rajaeifar, Pezhman Ghadimi, Marco Raugei, Yufeng Wu, & Oliver Heidrich. (2022). Challenges and recent developments in supply and value chains of electric vehicle batteries: A sustainability perspective. *Resources, Conservation and Recycling, 180*, 106144. https://doi.org/10.1016/j.resconrec.2021.106144
8. Natural Resources Canada. (2024). *Electric vehicle charging infrastructure for Canada*. Government of Canada. https://natural-resources.canada.ca/energy-efficiency/transportation-alternative-fuels/resource-library/electric-vehicle-charging-infrastructure-for-canada/25756
9. Sadik-Zada, E. R., Gatto, A., & Scharfenstein, M. (2023). Sustainable management of lithium and green hydrogen and long-run perspectives of electromobility. *Technological Forecasting and Social Change, 186*, 121992. https://doi.org/10.1016/j.techfore.2022.121992
10. Till Gnann, Patrick Plötz, André Kühn, & Martin Wietschel. (2015). Modelling market diffusion of electric vehicles with real world driving data – German market and policy options. *Transportation Research Part A: Policy and Practice, 77*, 95-112. https://doi.org/10.1016/j.tra.2015.04.001
11. United States Geological Survey. (2020). *Cobalt statistics and information*. https://www.usgs.gov/centers/national-minerals-information-center/cobalt-statistics-and-information
12. Zeng, A., Chen, W., Rasmussen, K. D., Zhu, X., Lundhaug, M., Müller, D. B., Tan, J., Keiding, J. K., Liu, L., Dai, T., Wang, A., & Liu, G. (2022). Battery technology and recycling alone will not save the electric mobility transition from future cobalt shortages. *Nature Communications, 13*(1), 1341. https://doi.org/10.1038/s41467-022-29022-z