Electrification in Logistic transportation for imports/exports between Mexico and the United States of America

Aldair Aragon Concha

Haaga-Helia University of Applied Sciences
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Author(s)
Aldair Aragon Concha

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This thesis explores the fundamental facets of electrification within the realm of logistics for imports and exports between Mexico and the US. It aims to shine a light on the ongoing transformative shifts and the favourable ramifications they carry for the landscape of cross-border trade.

This research-based thesis has the purpose of understanding more about what electrification looks like at the time it is written (2024) for imports/exports between Mexico and the US, and some projections on its future.

This thesis reviews the current state of electrified transport in foreign trade between Mexico and the United States, by diving deeper into its advantages and disadvantages, pertinent data, and finally, into projections for the future.

The study was involved both quantitative and qualitative methods. First, a survey was conducted to ground transportation and electrification experts in the subject topic, the results were later developed and measured using statistics for the quantitative questions and with descriptions for the qualitative questions. Second, the webropol survey tool was used to gather information from a group of industry workers in imports/exports between Mexico and the United States, to obtain a more accurate depiction of electrification in its current state and projections for the future.

This research, together with the results of interviews and surveys to experts in the area, provides an overview on electrification and what it can entail for foreign ground transport trade between Mexico and the United States

Keywords
Electrification, foreign trade, ground transport, supply chain, logistics and Electric vehicles

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1 Introduction

Efficient transportation of goods is of utmost importance for businesses and countries, enabling the movement of commodities, manufacturers, suppliers, and consumers. It involves careful planning, logistics management, and coordination to make sure that the goods are delivered punctually, securely, and cost-effectively. As the demand for border-crossing trade continues to grow, there is an increasing focus on reducing the environmental impact of transportation activities. Electrification, with its emphasis on electric vehicles and green technologies, emerges as a pivotal solution to address both economic and environmental challenges in the logistics sector.

1.1 Background

Over 77% of worldwide freight is road/ground transportation (Statista.com, 2020), which is very polluting. Many companies in the world, and particularly in North America are starting to implement electrification in their logistics, wanting to decrease carbon emissions, and ideally reduce their carbon footprint. This thesis will review the current state of electrified transport in foreign trade between Mexico and the United States, by diving deeper into its advantages and disadvantages, pertinent data, and finally, into projections for the future.

The potential for electric vehicles (EVs) and their corresponding infrastructure to change the logistical environment for trade between the USA and Mexico is truly enormous. Electric vehicles (EVs) provide zero-emission transportation (US Department of Energy 2024), lowering greenhouse gas emissions and considerably lowering the environmental effect of cross-border freight movement. Furthermore, the efficiency and range of electric trucks and vans are improving due to developments in battery technology and charging infrastructure, rendering them suitable and even ideal candidates for both last-mile deliveries and long-distance transportation.

Moreover, electrification in logistical transportation involves more than just new technological advancements. It includes collaborative supply chain projects, integration of renewable energy sources, and the creation of smarter logistics systems. For example, implementing real-time monitoring systems and intelligent routing algorithms to optimize delivery routes, reduce dead miles, and increase fleet efficiency overall. This thesis will explore the fundamental facets of electrification within the realm of logistics for imports and exports between Mexico and the US. It aims to shine a light on the ongoing transformative shifts and the favourable ramifications they carry for the landscape of cross-border trade.

1.2 Research question

The research that will be conducted has the purpose of understanding more about what electrification looks like today for imports/exports between Mexico and the US, and some projections on its future. For the sake of cohesion and specificity, this research will revolve around this Research Question (RQ).

RQ. What is the current and future outlook of electrified ground transport in international logistics between Mexico and the US?

In order to develop this thesis effectively, and to appropriately address this research question, this document will introduce 4 Investigative Questions (IQs), with their purpose being bringing order and continuity to the paper.

- IQ1. What is the current scope of electrification in Logistics in ground transportation between Mexico and the US?
- IQ2. What advantages and disadvantages can electrification bring into international logistics between Mexico and the US?
- IQ3. How could electrification in logistics look like in the near/distant future for imports and exports between Mexico and the US?
- IQ4.How can electrification become the future of International Logistics between Mexico and the US?

Table 1. Overlay matrix (Author,2023)

Investigative Questions (IQs)	Theoretical Framework [1]	Methods	Data Analysis/ Results
IQ 1. What is the current scope of electrification in Logistics in ground transportation between Mexico and the US?	**2.1, 2.2**	Qualitative and quantitative data. Digital interview	P.19
IQ 2. What advantages and disadvantages can electrification bring into interna-	**2.3, 2.4.1**	Qualitative and quantitative data. Digital interview	P.21

tional logistics between Mexico and the US?		Face-to-face interview Webropol survey	
IQ 3. What could electrification in logistics look like in the near/distant future for imports and exports between Mexico and the US?	**2.4, 2.4.1**	Qualitative and quantitative data. Digital interview Face-to-face interview	P.24
IQ 4. How can electrification become the future of International Logistics between Mexico and the US?	**2.4, 2.4.1**	Qualitative and quantitative data. Webropol survey	P.24

1.3 Demarcation

This study will exclusively deal with electrification for logistics in ground transportation (heavy vehicles, such as trucks, except for railroad), not air nor ocean transportation. Additionally, this study will only be focused on imports/exports to Mexico/United States. This means that it will not be focusing on the logistics of other continents (except for context). Furthermore, this study will focus specifically on the manufacturing industry, it will not speak of logistics for livestock, food, textiles, etc.

This will not be a technical study on electrification and its processes, it will only be focusing on what electrification means for supply chain and logistics. It will not be focused on environmental or cultural impacts, although it might be mentioned to further expand the topic and further enrich the research. Finally, this paper will not explain how electrification works; it will only focus on its impact on logistics companies with an international presence.

1.4 International aspect

This thesis aims to get a better understanding of the current and outlook of electrification in Logistics. International trade plays a massive role in logistics nowadays, and understanding the trends and practices, such as logistics, and supply chain can bring a wider scope of opportunities for everybody in the area.

In recent years, governments, businesses, and industry stakeholders on both sides of the Mexico-US border have recognized the potential massive benefits of electrification. The integration of electric trucks, cargo vans, and other sustainable technologies is not only helping to meet environmental goals but is also enhancing the reliability and cost-effectiveness of transportation networks. This study will look further into what electrification could entail for both nations on a small and large scale.

1.5 Benefits

This research has no commissioning company. This will give the author more freedom to further expand on the topic as desired, and to explore more areas and companies that are involved in the topic. The main intended benefit is to get a deeper understanding of the subject, and the main party benefitted will be the author, along with whoever reads the paper, getting access to condensed information retrieved by the author.

Haaga-Helia University and Mondragon Mexico University will also receive the benefit of having this thesis as part of their thesis webpage, where students will be able to access to gather more information on electrification in logistics for imports/exports between Mexico and The United States, a topic seemingly lacking in research as of the time this document is being authored (2023).

1.6 Key concepts

Transportation: Transportation of goods refers to the process of moving products or commodities from one location to another. Different types of goods may require specific transportation methods based on factors like fragility, perishability, or size. The transportation of goods plays a vital role in global trade, supporting economic growth and facilitating the availability of goods to consumers worldwide.

Ground transportation: Ground transportation refers to the movement of people, goods, or cargo over land, it is a fundamental component of transportation systems, providing crucial connectivity within cities, regions, and countries.

Electrification: Electrification refers to the process of converting systems, services, or technologies from being powered by non-electric sources to utilizing electricity as the primary source of energy.

Foreign trade: Foreign trade, also known as international trade or global trade, refers to the exchange of goods, services, and capital across international borders. It is a fundamental aspect of the global economy, enabling countries to access resources, products, and markets beyond their domestic borders.

1.7 Risk analysis.

The author will most certainly face challenges during the writing of this paper, some more problematic than others. The following table presents a matrix on how those challenges might affect the end result of the thesis and a rather simple way of dealing with the risks discussed. The aim of developing them is to get a better understanding of what could happen during the extensive process of writing this paper and rather than having a reactive approach, to have a proactive approach for problem-solving.

These risks will be measured by how likely they are to happen, and they will be developed on what the risk could have as consequences as well as the measures that could and should be taken to guarantee the quality is not affected, and most importantly, that objective of the thesis is fulfilled as intended.

Table 2. Risk Matrix (Author, 2023)

Possible risk	How likely they are to occur, and what impact it would mean	Prevention/actions to take
No access to experts in the area of electrification for logistics	2. - Highly unlikely to occur. There are multiple experts in the area, the author will have access to the experts due to his background in logistics for a multinational company. It would have a catastrophic impact	Contacting experts via the author's connections, and deeply committing into the interview's questions for quality data retrieving

Lack of time to develop a complete thesis	5. - Unlikely to occur but could happen in an extreme case. This would have a catastrophic impact	Time management and dedicating exact times per week to only focus on writing
Not enough assistance from advisors	7. - Likely to occur because of lack of time by advisors. This would have a reasonable impact	Self-work and just having specific questions for assistance
Bad academic writing / Wrong writing formats	4. - Possible to occur because of lack of preparation. This would have a considerable impact	Preparation and feedback from the author's advisors

2 Electrification in Logistics

In this chapter, the author will get into the specifics of what electrification really means, by first defining important concepts, then providing an overview of how logistics is working in current times, and finally developing the main advantages and disadvantages of electrifying logistics fleets for foreign trade between the United States and Mexico. This will serve as a basis for understanding deeper the intricacies of electrification through hard data and analysis of available sources of information by experts in the area.

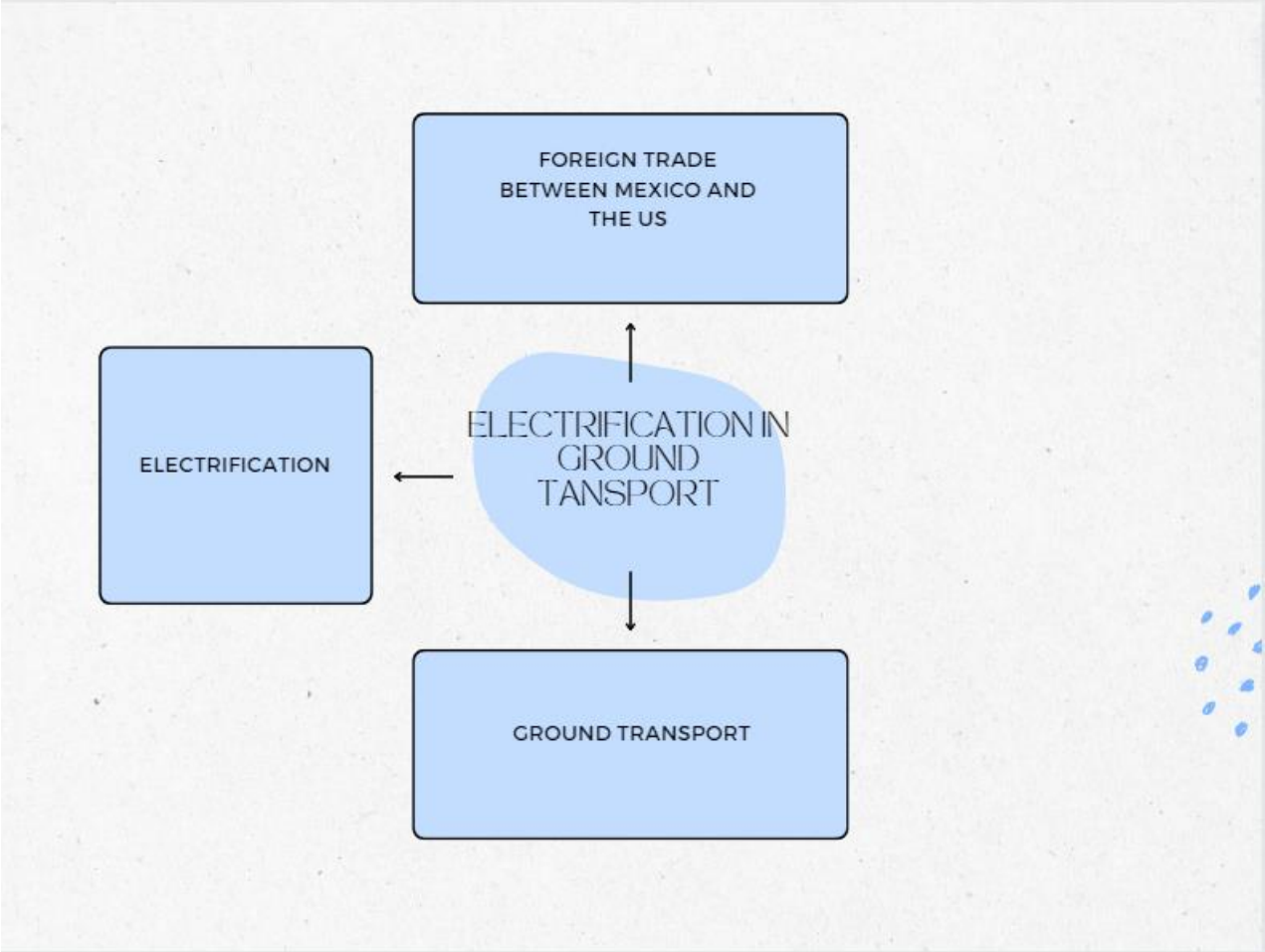


Figure 1. Theoretical framework (Author, 2023)

Because of growing concerns about pollution and environmental justice, the depreciating cost of EV trucks, and growing attention to pollution, the adoption of clean technology in the trucking industry is gaining momentum and developing at a staggering pace. Just some of the co-benefits from these trucks include lower noise levels, safer driving, better equity, and improvements to public health (Smith and Ulu, 2012).

In the USA and Mexico, long-haul trucks usually cover 300 miles or more a day, and occasionally

up to 800 miles, for a total of over 100,000 miles annually. Typically, these are tractor-trailers with a gross vehicle weight (GVW) of 80,000 pounds, which allows them to tow almost 40,000 pounds of cargo. Diesel fuel is ideal for long-distance travel because of its high energy density, which is why they were created for it. Replacing diesel long-haul trucks by EVs is most certainly a challenge, but one that could eventually lead to benefits not only for the companies owning these vehicles, but for the general population affected by emissions (Wood-Mackenzie, 2020)

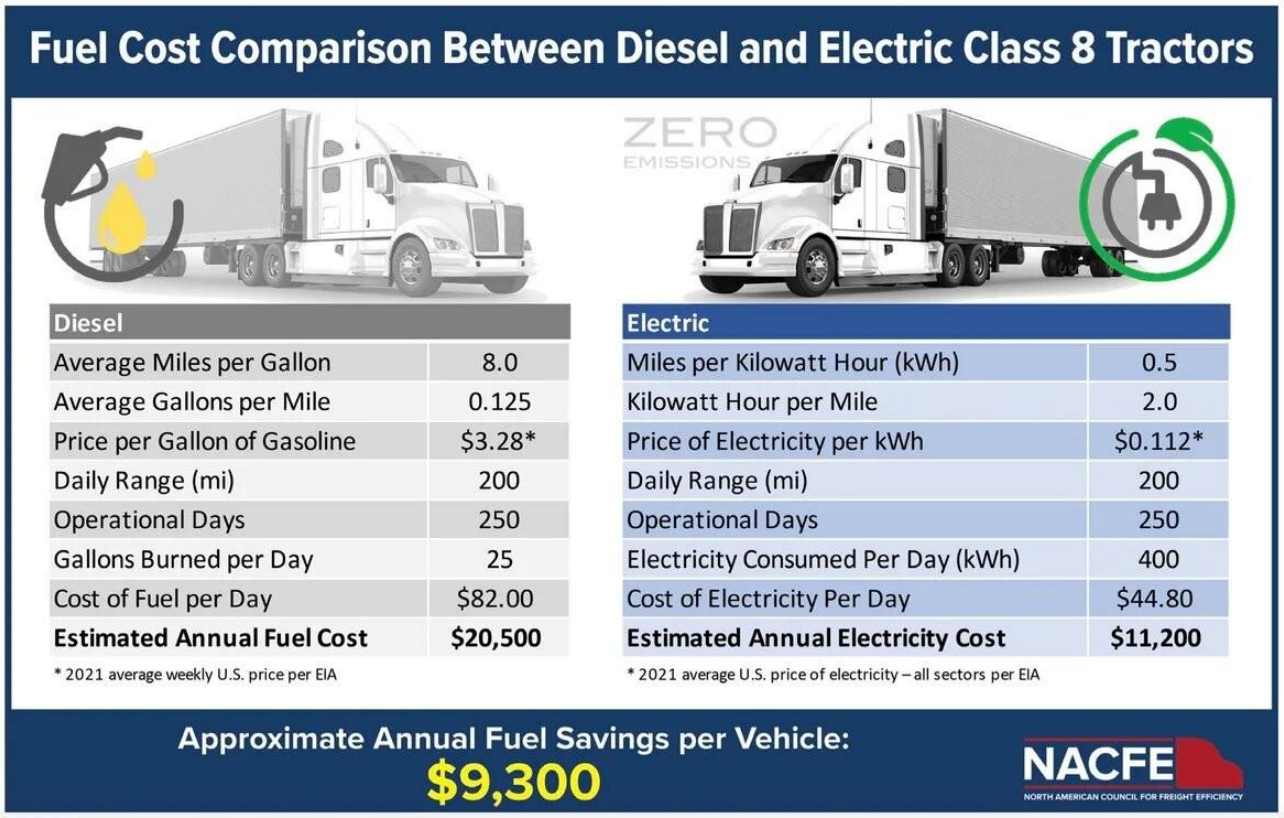


Figure 2: Fuel Cost comparison between Diesel and Electric Class 8 Tractors, (NACFE, 2021)

2.1 Definitions

Before understanding the concept, applications, and reasoning behind using electrification, it is imperative to understand the concepts and break down what electrification in ground transportation for foreign trade actually means. There are 3 crucial concepts to define the main focus of this research. Firstly, the concept of electrification. Electrification is the process of converting an energy-consuming device, system, or sector from non-electric sources of energy to electricity. (US Office of Electricity 2020)

Electrification is not necessarily the goal, but rather a means to achieving a community goal such as reducing greenhouse gas emissions or lowering energy costs. For utilities, the goal and the

benefits of electrification are to support system optimization, improve efficiencies, and increase resiliency. Ultimately, people and businesses will choose beneficial electric technologies.

The second concept to be defined is ground transport. Ground transport is the movement of goods, through locations on land. It encompasses trucking, railroad and even pipelines. Pertinent to this document is the trucking. Trucking was chosen as the subject of study of this document due to its flexibility, ability to reach otherwise inaccessible locations and because its infrastructure networks, such as highways. are very well developed and are expansive in the US-Mexico border. Additionally, it shows a great potential to be electrified due to the nature of the used vehicles.

Essential to ground transport are medium-duty vehicles (MDVs) and heavy-duty vehicles (HVDs), which are defined as vehicles over 10,000 pounds and which are used for most of the deliveries of goods. Unfortunately, MDVs and HVDs are the most prevalent source of polluting emissions of greenhouse gases (GHGs) and particulates. Therefore, any long-term strategy aiming for the reduction of said emissions in the interest of public and environmental health and safety must address the polluting potential of these vehicles. As they run mostly on diesel internal combustion engines, their replacement for EVs is a very promising part of one such potential strategy.

Lastly, foreign trade. Foreign trade is the exchange of goods and services between countries. It's essentially the buying and selling across international borders. Foreign trade allows countries to access goods and services they lack domestically, sell their products to a wider market, and boost their economy and increase competition, potentially leading to lower prices and better-quality goods for consumers.

2.2 Current scope of electrification in Logistics

Registrations of electric buses and heavy-duty trucks increased in 2021 in China, Europe, and the United States. Sales of electric trucks increased 40% over the previous year even as the global bus market remained roughly constant. Global sales of electric medium- and heavy-duty trucks more than doubled over 2020 volumes, while total sales volumes remained at roughly the same level as in previous years. Electric medium- and heavy-duty truck sales totalled more than 14 200 in 2021, which represents less than 0.3% of the total number of registrations for medium- and heavy-duty vehicles worldwide. (ZETI,2021). In 2021, the global electric bus stock was 670 000 and electric heavy-duty truck stock was 66 000. This represents about 4% of the global fleet for buses and 0.1% for heavy-duty trucks.

The past few years have seen a sharp surge in sales in both Europe and the United States, mostly due to the availability of more models in those regions, regulatory backing, and the increasingly advanced technological viability and economic competitiveness of electric trucks in specific applications.

Currently, the most common form of electrification in logistics is the use of electric vehicles in urban and regional logistics. Electrification on a small scale, that is urban logistics, is perhaps the most beneficial use of electrification today. The reason behind this is that urban freight and its transit times are not affected as much by the charging time that an electric vehicle requires. The rapid growth of urban areas has posed significant challenges to the environment, public health, and overall quality of life. This is where electrification shines the most.

Today's most common use of electrification in logistics is for" short" distances, such as the transportation between outlets and distribution stations, as well as the latest part of urban delivery. Multiple cases throughout Europe and North America of smaller package deliveries, such as groceries, are now starting to be moved with electric vehicles. Electrification presents a significant opportunity to transform urban logistics into a cleaner and more sustainable system. Cities can profit economically and environmentally from electric delivery fleets by tackling the obstacles and putting good plans in place. Electrification has the potential to become the dominant force in urban logistics as infrastructure grows and technology evolves, hence influencing a greener future for our cities.

In contrast, electrification on a large scale, which refers to cross-country or even international delivery depends on the development of EVs designed for long-distance travel. All EVs rely on electric batteries or fuel cells for power and are constrained by the efficiency of the propulsion systems as well as the batteries' energetic density (capacity) for their autonomy. Because of this, having an adequate and extensive network of stations able to supply the energy for the EVs is of utmost importance for supporting the adoption of electrification of cross-country vehicles on a large scale.

Besides the challenge in managing charge times and in strategically planning the deployment of charging infrastructure, it is important to note that one of the partners in the trade relationship, Mexico, suffers from widespread violence and a chronic inability of its state to provide sufficient security in its roads. This, combined with expensive new vehicles, potentially valuable cargo, and long charging times rendering the transport units immobile, could lead to targeted attacks on EV transports.

Nevertheless, increased efficiency and battery capacity in newer EVs, as well as reduced emissions and lower operating costs compared to conventional vehicles, are making the electrification transition an attractive prospect.

2.3 Advantages and disadvantages

Some of the main benefits of electrification in urban logistics are Environmental Benefits, cost savings and public relations. First, talking about environmental benefits, electrification in urban logistics significantly reduces carbon emissions and air pollution, leading to cleaner and healthier urban environments. (Jones et al., 2019; Dean et al., 2022) Electric vehicles (EVs) produce zero tailpipe emissions, which is especially crucial in densely populated areas.

When fuelled by renewable electricity sources, EVs have a net-zero environmental impact and emit no pollutants. On the other hand, vehicles functioning with internal combustion engines, like those running on gasoline or diesel, release greenhouse gasses and carbon dioxide (CO2) while they are in motion. The industry's carbon footprint can be greatly decreased by putting fleet-wide electrification initiatives into action, particularly for long-haul transportation.

In addition to greenhouse gasses which contribute to global warming and climate change, traditional internal combustion engines release toxic pollutants such as nitrogen oxides (NOx), volatile organic compounds (VOCs), and particulates, which are harmful when breathed by humans and wildlife and cause the degradation of air quality. On the contrary, EVs produce no emissions, of this type, as they don't depend on combustion for operation, helping to improve air quality in urban areas and transport corridors. (IEA, Global EV outlook, 2022)

Electric vehicles can convert a much higher percentage of the electric energy supplied to them by the grid into usable kinetic (propulsion) energy than the possible conversion from chemical energy in internal combustion engines, making them more efficient and leading to a lower rate of energy used per mile travelled. This in turn can lead to a lower operating cost for logistics fleets using EVs.

The fact that internal combustion engines can be quite noisy and can become a public nuisance in cities or along transit corridors is another significant advantage. Electric cars are quieter than conventional cars, especially while traveling at slower speeds.

While EVs usually require energy-intensive and high-emission processes, especially considering the production of their batteries, they also could reduce the emissions associated with the transportation process, especially as the energy grid supplying them with power become cleaner.

Secondly, referring to cost savings, in urban logistics, it is more common to use small units, be it vans, or small trucks. According to Julia Hildermeier and Andreas Jahn in" An analysis of energy demand and charging cost" An operator of a 10-truck electric fleet can achieve considerable savings—up to 15,000 USD annually, or about 10%-15% of total energy costs, including charging—by designing optimal charging scenarios based on estimates of the combined costs for charging and

grid use. A very important thing to consider here is that the initial investment for an electric vehicle is much higher than that of a fossil fuel-based vehicle, For example, a diesel Class 8 truck costs roughly $180,000, while a comparable battery-electric truck costs over $400,000. (Mayer, M. 2024)

Eventually, purchase costs will be lower for most types of electric trucks, so the payback times for initial investments will be below zero, i.e., they will be cheaper than diesel powered trucks from day one. It is important to consider all the additional expenses that come with electrifying logistics fleets, such as all hardware required to bring power from the grid to the charging stations including transformers, trenching, conduits, and power cables. The overall cost of make-ready infrastructure necessary to greatly expand the electric vehicle fleet is not well known but is expected to be significant. Additionally, any changes that must be made in operations, such as changes to duty cycles or operating times to allow for recharging, would also add up to the cost.

Finally, there is an added bonus for applying electrification to logistics fleets, which is public relations. With the new wave of trends in socially and environmentally responsible companies in the last decade, global enterprises can take advantage of Electric vehicles as a proof they are reducing greenhouse emissions and provide a good image to their stakeholders and customers, something that can be invaluable for investors.

Some of the main challenges for urban logistics are the transition periods, range limitations, and initial investments. First, regarding the transition periods, companies that have been operating for multiple years, already have a sense of how their logistics work. Transitioning from fossil-fuel-powered vehicles to electric vehicles requires retraining employees and adapting logistics operations. This process may temporarily disrupt business operations and lead to money and time setbacks, which can be catastrophic for certain companies.

Furthermore, there are range limitations, this means that the range that an electric vehicle can cover is not as broad as what a “regular” vehicle can cover. This represents a challenge because planning must be extremely precise if an uninterrupted route is needed. Logistics is based on the most efficient transit times and the most optimized way to move materials, which can be tricky considering the vehicle has to stop to be charged, and the charging infrastructure is not advanced enough in the current state of North America for it to not be an issue.

Finally, the initial investments are very high for starting to electrify logistics. For starters, electric motors are more expensive than regular motors, which increases the price of electric vehicles. Currently, there is not a huge supply of electric vehicles, and this makes them harder to get, and extremely costly. Moreover, charging infrastructure is really overpriced, particularly for smaller companies. One upside is that multiple countries are now giving Government incentives and subsidies.

Full electrification of the U.S. commercial truck fleet would require nearly $1 trillion in infrastructure investment alone, according to a new report released by the Clean Freight Coalition (CFC).

Ground transportation systems are designed to be efficient, safe, and environmentally sustainable, often integrating technologies such as GPS, traffic management systems, and eco-friendly vehicles to optimize routes and reduce emissions. The development and improvement of ground transportation infrastructure are essential for enhancing accessibility, reducing congestion, and promoting economic development in various parts of the world.

2.4 Future of electrification in Logistics

The future of logistic transportation between the United States and Mexico is potentially a bright one, especially for electrification. As the need for sustainable methods of transportation keeps growing, and the global economy evolves, this trade corridor will be at the forefront and in need of innovation.

A critical factor in determining the potential feasibility of an electric future in transportation is the enhancement and expansion of EV infrastructure. Although charging stations are the most critical components of this infrastructure, procuring clean energy for the stations and having adequate facilities for battery swapping are critical. Because of this, collaboration between each countries' respective governments, private stakeholders and energy providers will be crucial in accelerating and allowing the widespread adoption of cross-border electrification.

Still, this new technology also brings with it new challenges, such as the need for units to spend long hours charging against the comparatively near-instantaneous refuelling process. These periods may put strain on an operation, so harnessing smart technologies to optimize logistics operations will become a characteristic of the electrified era. This may include Artificial Intelligence, block-chain for real-time tracking. Route optimization, predictive maintenance and even inventory management. Another technology-related train could be the introduction of fully Autonomous Vehicles (AVs). The introduction of AVs could revolutionize last-mile deliveries, warehouse operations and even freight transportation.

2.4.1 5 Year projection and 10+ year projection

The reliability and durability of the current gasoline-based vehicles influence fleet turnover, which influences a higher rate of EV adoption. A lot of Automakers have committed to making a switch to

all-electric options there is no set date as of now, but certain jurisdictions have already called for a ban on new gasoline-powered vehicle sales from 2035.

Developing the infrastructure, particularly the global deployment of charging stations, is more than ever, essential to guaranteeing mass market acceptance of electric vehicles. It will be essential to overcome range anxiety, pricing, and driving habits before people and companies can truly embrace electric vehicles to the fullest. As these obstacles are removed, electromobility seems to be about to go through a paradigm change.

EVs have a high energy density and battery costs are predicted to decrease by 70% by 2025. This is seen in the instance of lithium-ion batteries (Li-Ion), the cost of which has significantly decreased because of their increasing usage in laptops and mobile devices (Fayez Alanazi, 2023).

Electric trucks have changed the face of freight transportation. With ground-breaking innovations like the Tesla Semi, an all-electric Class 8 heavy-duty vehicle, businesses like Tesla are paving the way for the future of electrification in Logistics. The Tesla Semi presents incredible characteristics including a sleek design, extended range, and semi-autonomous driving capabilities, and it was created with the intention of revolutionizing the freight industry, and it is projected to do so within the next 5-10 years, opening the market for other companies to continue the same path for electric trucks in the following decade.

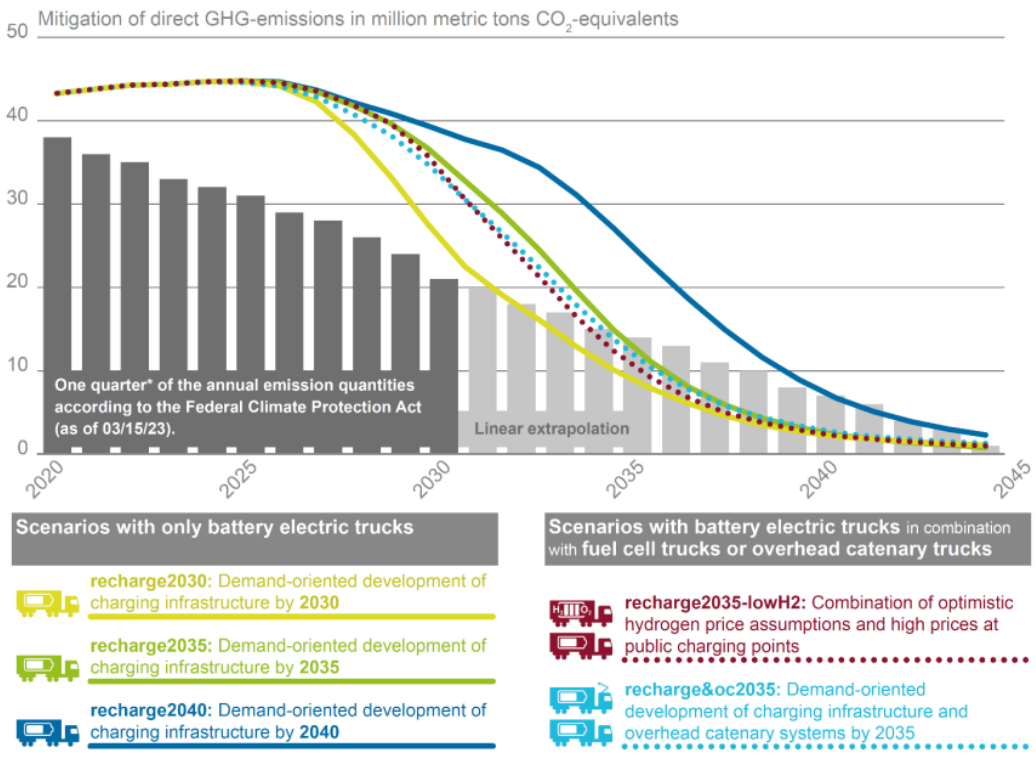


Figure 3. Mitigation of direct GHG-emissions (StratES, 2023)

Several giant businesses are already incorporating EVS into their logistics operations. Amazon, for example, has committed to electrifying its delivery fleet, with the goal of reaching carbon neutrality by 2040, this is a huge step forward in the right direction, and will continue to provide more freight movement options in foreign trade between Mexico and the United States of America.

Similarly, to reduce their environmental footprint, shipping company UPS has invested in electric vehicles and charging infrastructure, mainly for urban and last mile deliveries. Furthermore, Coca-Cola has launched an ambitious road toward sustainability by introducing electric delivery trucks into its distribution network. This is consistent with Coca-Cola's overall commitment to environmental responsibility, demonstrating how several industries are leveraging electromobility to construct a cleaner future. Giants such as Coca-Cola are currently setting an example on what will eventually become a standard for all companies world-wide, and this demand for ecological alternatives for freight transportation will make it so there is no other option, than to adopt electrification in logistics as the norm.

The logistics scene is set to undergo a significant change with 2030 closing in: environmental concerns, consumer demands, and industrial heavyweights are driving the electrification of last-mile deliveries. It will become critical and imperative to shift strategy and operations from the ground up in order to actualize the electrification goal for last mile deliveries. First and foremost, as businesses manage the change in cost dynamics brought about by the switch to electric vehicle fleets, reviewing current policies is essential. Second, the smooth integration of EVs into last-mile delivery networks is made possible by the formation of strategic alliances and competition. Early strategic alliance formation with EV producers and providers of charging infrastructure will guarantee a steady supply, and creative "competition" models lower costs and encourage shared accountability for the industry's sustainable adoption of EVs.

Increasing the EVs share in the market depends primarily on the expansion rate of charging infrastructure. If by 2035 an efficient and sufficient network is made available to the public, the following model predicts that 100% of new heavy-duty commercial vehicles will be emission free in the years following 2035. Because of this, GHGs emissions resulting from road freight transport are projected to drop to almost zero by 2045.

3 Research methods.

This thesis is both qualitative and quantitative, it is focused on hard DATA and provable facts, but it is also a projection on what electrification might look like in the future. With the help of experts in the areas of transportation and electrification, this study aims to gain a better understanding of the true current state of electrification for ground transport in imports/exports between Mexico and the US, as well as an outlook on how it might look like in the future.

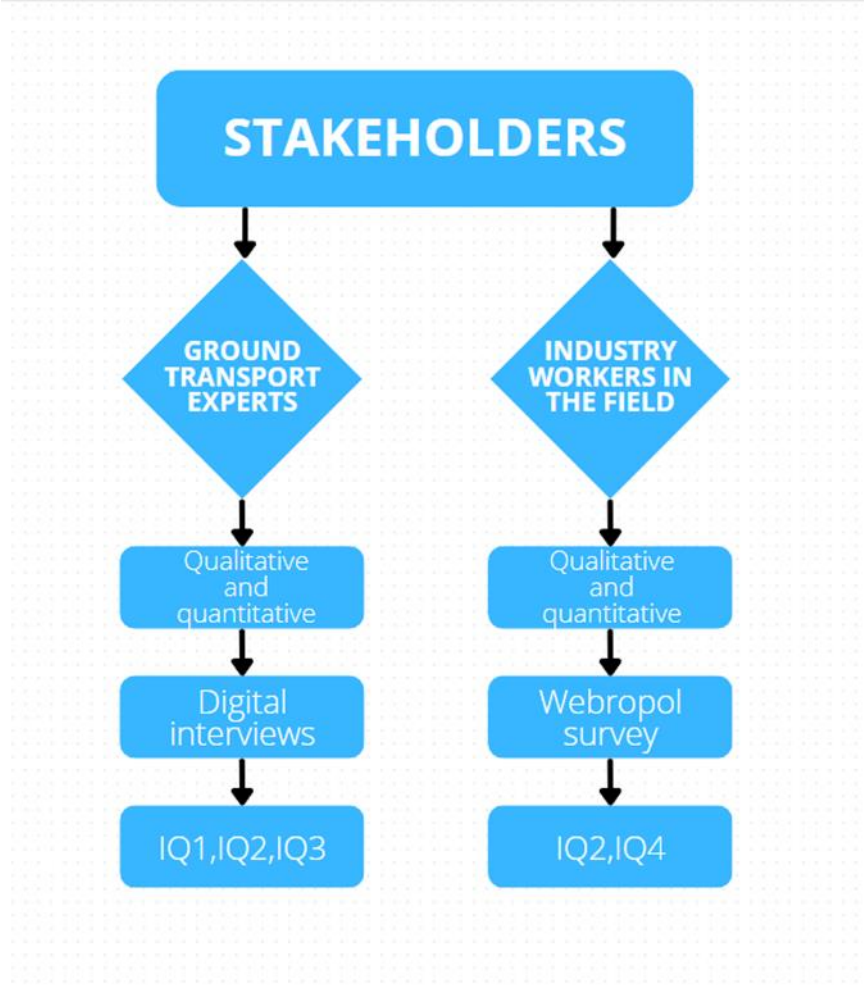


Figure 4. Research methods chart (Author, 2023)

The author decided to obtain 2 different sources of information, with the aim to cover the most out of the topic. The 1st source will be ground transportation experts, and ideally people with 10+ years of experience. These interviews aim to speak with experts who know the ins and outs of ground transportation, if electrification is relevant now, data on why it is used/ not used, and thoughts on what the future might entail for electrification in logistics.

The author has decided to interview a small group of informants for the first source of information, to have more in depth and objective answers. The informants all have different backgrounds and experiences which will provide invaluable information and results for this thesis. They will all be asked the same questions, but with them being digital interviews, there will be room for additional conversation and question not prepared beforehand.

The 2nd source will be a group of people working in the field of imports/exports between Mexico and the United States. Instead of a personal or digital interview, the Data will be collected through a Webropol survey, to provide a wider range of opinions. This will be mostly qualitative research, and the aim is to find out what the industry thinks of electrification. The survey will be sent to at least 25 people, including material planners, logistics specialists, electrification experts, and freight forwards.

By having these both sources, the author will be able to retrieve valuable qualitative and quantitative from people that are constantly involved in the industry in day-to day activities, as well as experts that have the power of decision-making when it comes to this topic.

4 Results

Throughout this chapter, the author will describe the results received from the two surveys described on chapter three. Each question and their corresponding answers will be analysed and illustrated by the author. Both surveys incorporate the topics that have been mentioned in previous chapters and will help provide greater context as to what people in the industry are experiencing with the current state of electrification in logistics, and thoughts for the future to come.

4.1 Ground transport experts results

In order for the results to be homogeneus, the people interviewed were asked the same questions, this with the purpose of maintaing a standard within the answers, and to be able to compare the data. The questions will be analyzed and be aided by illustrations made by the author.

The first question is **" How long have you been part of the ground logistics industry?"** hoping to find out the experience the participants have, which is invaluable information, given that they are experts in the area. The youngest person interviewed is 25 years old, a customer service manager for a freight forwarder and has 5 years of experience, while the eldest of the interviewees is 65 years old, a logistics director for a manufacturing company with over 25 years of experience in the area. The median of experience years between the interviewees came up to 12 years of experience.

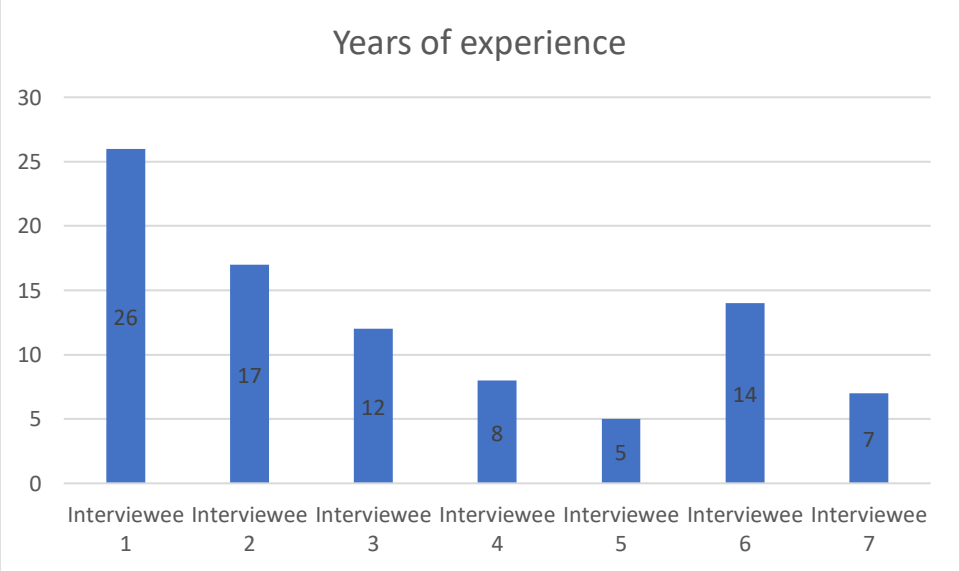


Figure 5. Question number 1, Ground transport experts interviews (Author,2024)

The second question is **”How does your company currently incorporate sustainability initiatives, including electrified ground transport, into its international logistics operations between Mexico and the US?”** and one very interesting result that the author did not expect, was that out of the informants, 43%, mentioned they are in plans, or planning on looking into electrification, but are currently doing nothing related to it right now. Additionally, none of the participants mentioned their company is having electrification as a standard for their logisitcs. But one interviewee did mention they are implementing electrification for short-haul freight movement, and they are hoping it becomes a standard in a couple of years

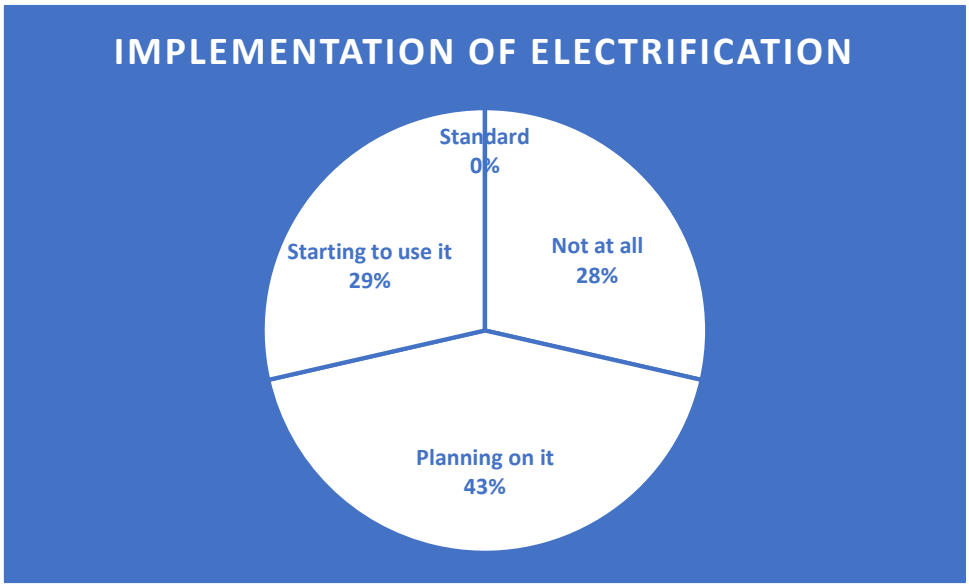


Figure 6. Question number 2, Ground transport experts interviews (Author,2024)

The third question is **”Do you think electrification is a good idea now?And how about in the future?”** and there were some unexpected answers, as only 28% of the interviewees responded that electrification is a good idea to have as the norm for all logistics operations now. The justification was that the current infraestructure is enough for short distance travel, and as long as the company is careful, the initial investments are well worth it, considering the savings on fuel. Moreover, 43% of the informants mentioned that in the current state of North-American foreign trade, electrification is not a good idea, but perhaps with the new technological and social advancements that will most certainly come, it will become a good idea. The last two informants mentioned that it is not a good idea now, and it won’t be a good idea in the future either, because there are better options, such as hybrid vehicles, etc.

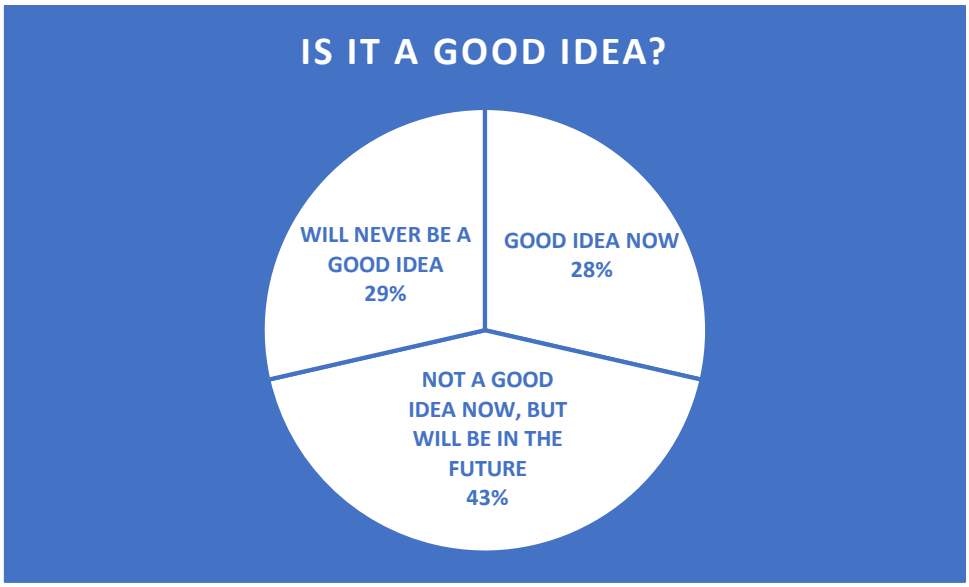


Figure 7. Question number 3, Ground transport experts interviews (Author,2024)

The fourth question is **"Do you think electrification will be the future of logistics? If yes, How soon?"** and this too came with shocking results. To no surprise, the informants that mentioned that it is a good idea to implement electrification in question three, also answered that electrification will become the future of logistics. One of them mentioned it could become the norm within 5 years, given the infraestructure investments currently taking place in North America.

Out of the informants that mentioned it would be a good idea in the future, the answers on how soon it would become a standard varied. One of them mentioned it would become a standard starting the new decade in 2030, provided that infraestructure and regulations take place in the next couple of years. Another informant mentioned it would take upwards of ten years, and lastly another informant explained it could even take more than 15 years, by which point, new technologies could delevop, and electrification might not even be taken into consideration.

On that same note, the informants that don't believe electrification will be the future of logistics, had similar answers. One focusing mostly that in a short period of time, both diesel powered vehicles and electric vehicles will become obsolete. On the other hand, the other informant had a much different approach, focusing more on mentioning that hybrid heavy trucks will be the future of electrified transport, developing the idea that it takes all of the advantages of electrification (environmental benefits, cost savings in fuel, public relations benefits, etc.) and removing all of the main disadvantes of it (high initial investments, reduced transit times, and battery life).

The fifht question **is ”What is currently refraining you from making electrification a standard?”** And as it has become recurrent in this thesis, the main challenge for implementing electrification were two, with 85% of the interviewees mentioning them both. Costs and security.

For this question in particular there were many similar answers, and figure 8 is a breakdown of the answers that were repeated amongst the subjects of the interview. A lot of focus was shed on the security in the United States and Mexico. A comment that was made is that most of the ground transport foreign trade between Mexico and the United States is done through border crossings in Laredo, Texas, and Nuevo Laredo, Tamaulipas, two high risk cities when talking about security, with an imminent risk of robberies, especially when dealing with high-end, top of the line electric vehicles.

The second most repeated answer was referring to costs, and not only initial investment costs, which by itself, makes it a difficult choice for most companies, but also referring to maintenance costs, repairs and miscellaneous expenses related to electrification.

Two more challenges were mentioned, efficiency and battery life, both referring to decreased opportunity for transit times, with charging times being so high, and less horsepower in Electric Vehicles.

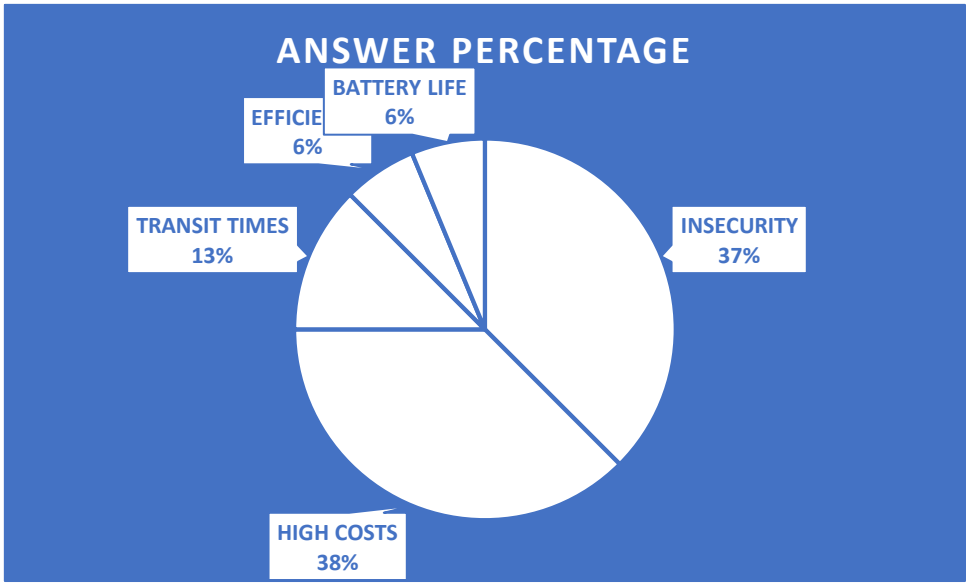


Figure 8. Question number 5, Ground transport experts interviews (Author,2024)

The sixth and last question is **”Looking ahead, what are your company's long-term goals and projections for electrified ground transport in international logistics between Mexico and the US, and how do you plan to achieve them?”** and the most recurring answer for this was to ”start small” with implementing a few electric truck to the companies logistics fleet, probably with

short-haul shipments, to get a test of how theelectrified logistics work, to then realize if the advantages outweight the disadvantes and it can become a standard for them.

4.2 Industry workers results

There were six questions in the Webropol survey for people working in the logistics industry and 17 people answered the survey. Question one intended to understand how relevant electrification was for the participants in their line of work and they were requested **from 1-5 with 5 being the highest, to share how relevant electrification is in your line of work right now.**

It is to no surprise the results gathered, as the author made sure the participants of the survey were somewhat knowleadgable on electrification, and most of the participants mentioned that electrification is relevant, with only 12% mentioning it is only slightly relevant, with only 6% mentioning it is the most relevant thing in their current line of work, rating it a five out of five in the scale provided by the author.

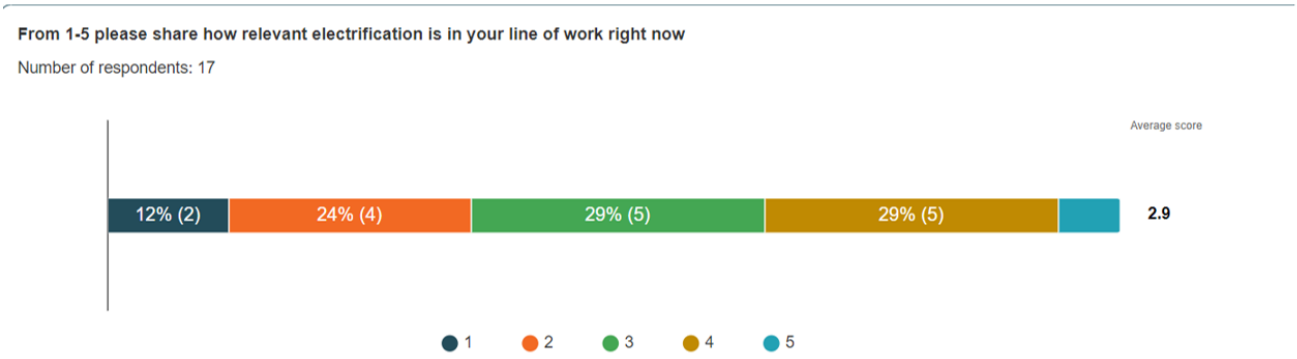


Figure 9. Question number 1, Industry workers survey (Author,2024)

After analysing the data from the first answer, we can see that for most of the participants, electrification is at least a bit relevant, but not something crucial in their line of work. The participants were later requested to answer the question **“Is the use of electrification for logistics beneficial in the current state of the industry?”** and the results were shcoking to the author, with pretty much a split decision between yes and no. Compared to experts in the first survey, 47% of the participants answered that electrification is not beneficial in the current state of the industry, while 53% answered that it is.

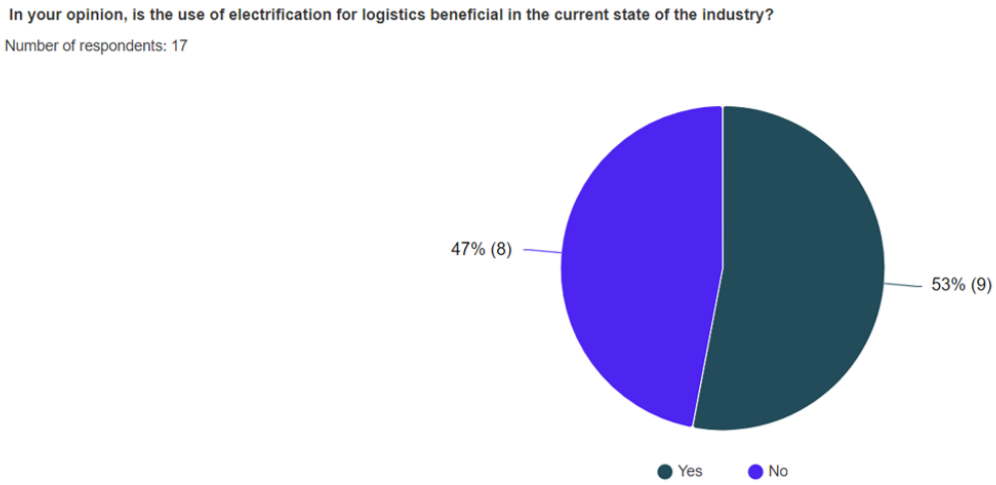
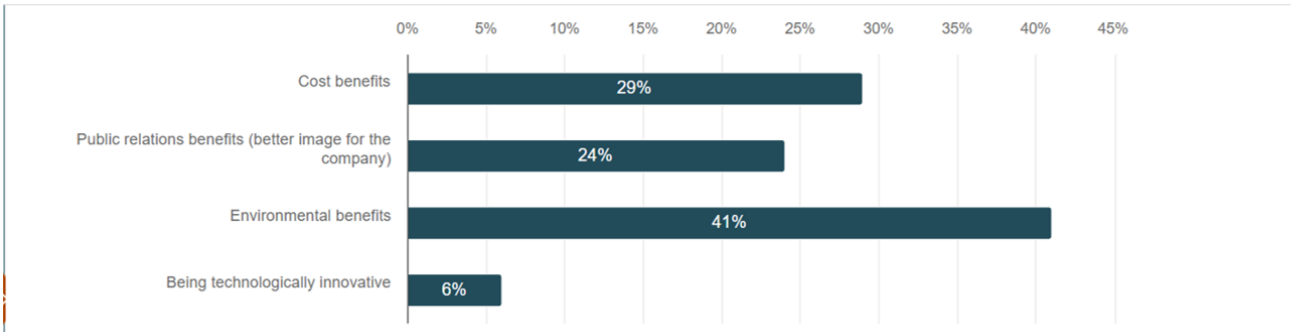


Figure 10. Question number 2, Industry workers survey (Author,2024)

For the third question, the author provided four different answers to the question "**What would be the main appeal for electrification in logistics in your case?"** and those answers were Cost benefits, public relations benefits (better image for the company), Environmental benefits and being technologically innovative. As expected, the most attractive feature for the respondents, with a 41% was environmental benefits, followed by cost benefits and public relations benefits close to each other at 29% and 24% respectively. The answers are backed up by the data presented in previous chapters of this research based thesis



	n	Percent
Cost benefits	5	29.4%
Public relations benefits (better image for the company)	4	23.5%
Environmental benefits	7	41.2%
Being technologically innovative	1	5.9%

Figure 11. Question number 3, Industry workers survey (Author,2024)

For the fourth question, the participants were given 4 different choices to answer from, and the author was surprised to see that out of the four, two of the options were not selected by any of the respondents. As expected, the most selected answer to the question **“What would you say is the biggest disadvantage of electrification in logistics?”** was “It is too expensive” with a staggering 82% compared to the 12% of people who answered that the biggest disadvantage was the lack of efficiency in transit times. Zero out of the participants responded that there is not really a big difference with current transportation, and nobody decided to add a different answer than the three options given.

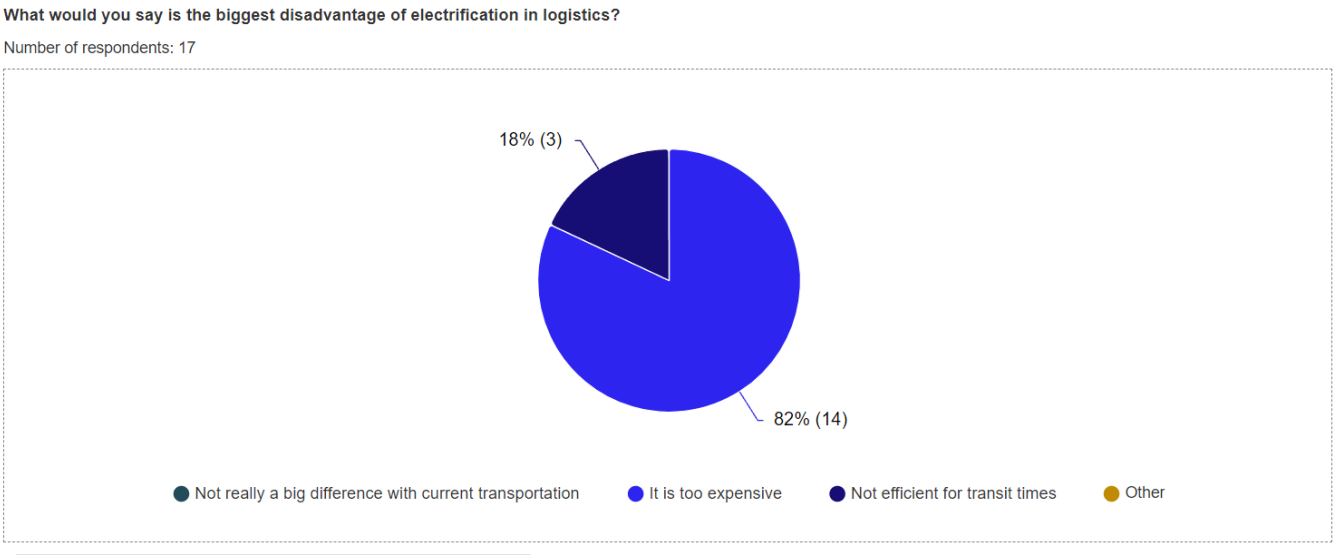


Figure 12. Question number 4, Industry workers survey (Author,2024)

On question number five, the same style of question one was applied, and with the aim of better understanding the industry, the respondents were requested to answer “**From 1-5 with 5 being the highest how likely is electrification in logistics to become a standard in the industry within 10 years?”** and much like the interviews with the ground transportation experts, the majority leaned into the idea that it will become a standard practice in logistics to use Electric Vehicles, but in contrast to the experts, out of 17 respondents, not even one of them could say with 100% certainty that it will.

The majority (35% of the respondents) settled for a four, which means they have confidence or hope that it will become a standard, but could not be sure.

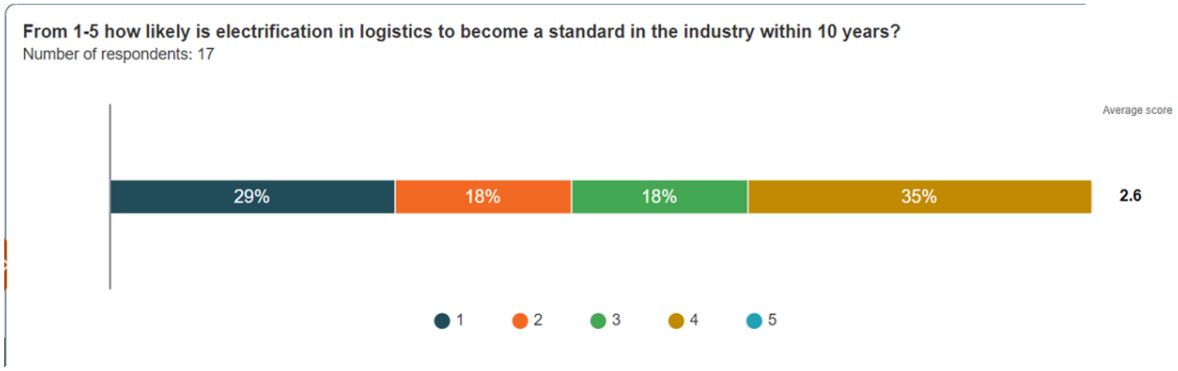


Figure 13. Question number 5, Industry workers survey (Author,2024)

For the last question, number 6, the most interesting results were gathered. With it being an open-ended question ("**Please share your thoughts on the current landscape of electrification and what do you think it can become in 5/10 years)"**, the respondents had the opportunity to provide their opinion on the subject. The most used word between all respondents was "expensive" which provides an insight as to what the people in the industry really feel about electrification.

Multiple people mentioned that it is a great idea, and an impressive technological advancement, but it will not replace gasoline, unless a lot of things change. Another recurring theme between the participants was the insecurity and how it could be dangerous to implement in the current state of North America

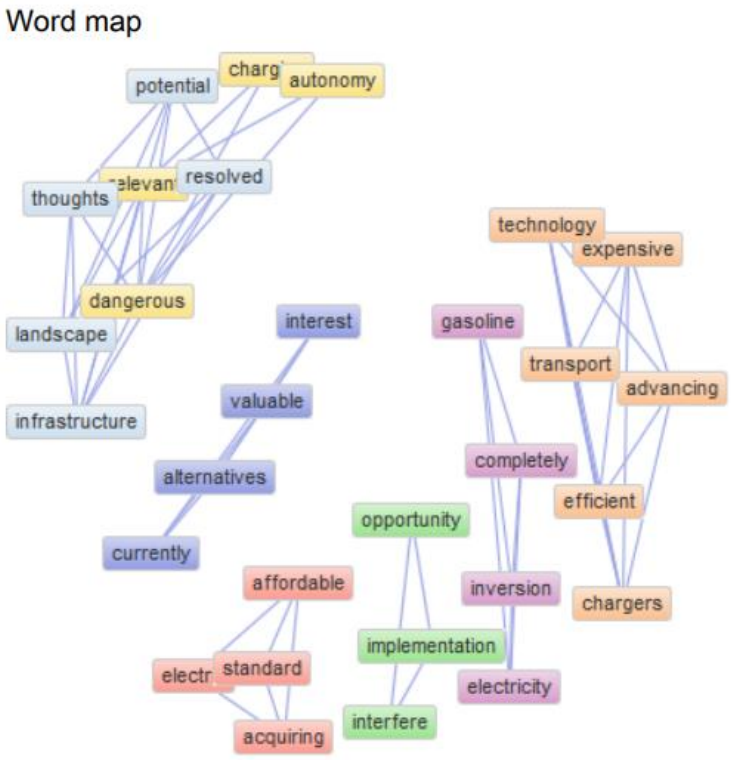


Figure 14. Question number 6, Industry workers survey (Author,2024)

The results gathered from the industry workers survey were extremely valuable, and provided with a very interesting approach to the difference between the anwers given by the experts. Multiple answers had a lot in common, like the importance on security and initial investments for electrification

5 Conclusions

In the final chapter of this thesis, the author will present the findings gathered from the previous chapters and provide discussions on the information that was obtained from research in the theoretical framework, an analysis of the results from both research methods conducted, and an overview of the Investigative questions and the research question that was set at the beginning of this thesis.

5.1 Discussion

In this subchapter, the author will circle back to the investigative questions, and discuss in the form of conclusions, what has been researched with the aid of the experts and interviewees, as well as data gathered by the author, closing the final chapter.

IQ1. What is the current scope of electrification in Logistics in ground transportation between Mexico and the US?

Currently, the most common form of electrification in logistics is the use of electric vehicles in urban and regional logistics, but longer-haul trips are starting to be done with Electric vehicles, as mentioned throughout this thesis, There are certainly a variety of challenges that come with implementing electrification for logistics, but currently there are multiple technological advancements, infrastructure changes and nationwide restrictions that are making electrification become something real and viable as mentioned in chapter 2.

Increased efficiency and battery capacity in newer EVs, as well as reduced emissions and lower operating costs compared to conventional vehicles, are making the electrification transition an attractive prospect. There are now very attractive projects, such as the Tesla Semi-truck and the BYD truck, which can run up to 1100 km harbouring up to 2 tons of weight, in just one charge. These advancements are a step in the right direction and will most certainly be a cornerstone for the future of electrification.

IQ2. What advantages and disadvantages can electrification bring into international logistics between Mexico and the US?

The advantages and disadvantages of implementing electrification have been a pivotal subject of this thesis. As mentioned in chapter 2 and chapter 4, there are many advantages, such as, are Environmental Benefits, cost savings and public relations.

The environmental benefits are a given, but there is a struggle to find out if companies will deem it worth it to take on the disadvantages that electrification poses. The reduction of greenhouse emissions and the massive carbon footprint deduction that electrification can bring, is one of the most attractive features for massive companies.

As of the time this thesis is being published, cost savings are still extremely rare when it comes to electrifying logistics fleets, but eventually, with the advancements shown in chapter 2, the return rate, and break-even points, will be achieved rather quickly, which will become imperative in the next couple of years. Moreover, public relations are an added bonus not many people might think of, but it will be attractive to big companies.

In contrast, the disadvantages can become a deal-breaker for a lot of companies. As mentioned, currently electrification is expensive, and there is not a huge supply of electric vehicles, which makes them harder to get, and extremely costly. Furthermore, charging infrastructure is really overpriced, particularly for smaller companies.

Something that will be a challenge for most companies, will be transit times, a result of extended periods of charging. This can be solved by better inventory management, but companies that have been doing their logistics for years the same way, will have trouble adapting.

IQ3. How could electrification in logistics look like in the near/distant future for imports and exports between Mexico and the US?

As mentioned in chapter 2, there are many incentives and regulations being done by the governments, which will eventually lead to the adoption of hybrid and electric vehicles. The widespread use of electric vehicles (EVs), such as trucks and vans, for the transportation of goods could be a component of the electrification of logistics between the US and Mexico. enhanced infrastructure for charging along important trade routes, and developments in battery technology for increased range and faster charge could all help to support this move. Furthermore, enhancing sustainability could be achieved by integrating renewable energy sources to power charging stations. Drones and autonomous electric cars may be very important tools in the far future for cutting expenses, maximizing carbon savings, and optimizing cross-border operations.

IQ4.How can electrification become the future of International Logistics between Mexico and the US?

Through several crucial tactics, electrification has the potential to become the future of international logistics between the US and Mexico. Government Support such as Tax exemptions, grants, and

subsidies for the purchase of EVs and the construction of charging infrastructure are just a few of the ways that both governments can encourage the use of electric vehicles (EVs) in logistics.

The broad adoption of electric trucks and vans will depend on investments made in the construction of charging infrastructure at strategic transportation hubs and along significant trade routes. If battery technology continues to progress, electric vehicles will become more practical for long-distance driving by increasing their range, charging speed, and durability.

Overall, the future is bright for electrification, and implementing the new technologies will most certainly be a challenge. Nevertheless the subjects discussed in this thesis will be important when applying electrification in a small and large scale

5.2 Research outcome.

The research question of this thesis was "**What is the current and future outlook of electrified ground transport in international logistics between Mexico and the US"** and with the support of invaluable data sources and research methods the author has provided an overview of what electrification currently looks like for foreign trade between Mexico and the United States, in a small and large scale, while also providing hard data, and examples of current appliances.

As it has been mentioned throughout the chapters of this thesis, environmental Benefits, cost savings and public relations are some of the main advantages to implementing electrified fleets in logistics, and many companies are beginning to do so in this decade. Moreover, the challenges are prominent at the time this thesis is written. It will be interesting to see which appliances of the ones mentioned in this paper become true, and used in a large and small scale.

Overall, while there are challenges to overcome, with the initial costs and security being the biggest ones, the trajectory of electrified ground transport in international logistics between Mexico and the US is positive. How to implement this new technologies will certainly be different amongst companies and many experts believe with proven results that the best way to start is by hauling short distances to later implement longer distances. Electrification has significant potential to transform the industry towards a more sustainable and efficient future, and later becoming a norm alongside different non fossil-fuel based alternatives.

Appreciations

To be perfectly candid, it seemed impossible to write the final lines of this thesis, but with it I am writing the final lines of my academic journey through Mondragon University and Haaga-Helia.

Seems like a perfect way to close out a perfect chapter of my life.

First and foremost, I would like to thank my parents for their undying support. To Juan Carlos Aragon, this is for you. Thank you for trusting in me even when I couldn't trust in myself, I would be nothing and nowhere without you, without your words of encouragement, wisdom, and support. We did it, and I couldn't have done this without you. I love you.

To Ana Lidia Concha, I would not be the person I am without you, it fills me with joy when people tell me I look like you. I could only hope to be as strong, loving and kind as you are. I will keep trying, and as long as I live, I will love you with all my heart.

I would like to thank Iker Aragon, my brother and best friend, for always having my back, for teaching me so much in every little aspect of my life, and for always allowing me to have someone I can trust. I strive to be like you every day and I have nothing but respect and love for you.

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Appendix 2. Research tools

Questions to ground transport experts

1. - How long have you been part of the ground logistics industry?

2. How does your company currently incorporate sustainability initiatives, including electrified ground transport, into its international logistics operations between Mexico and the US?

3. - Do you think electrification is a good idea now? How about in the future? Why?

4. - Do you think electrification will be the future of logistics? If yes, How soon?

5. - What is currently refraining you and your company from making electrification a standard?

6. - Looking ahead, what are your company's long-term goals and projections for electrified ground transport in international logistics between Mexico and the US, and how do you plan to achieve them?

In your opinion, is the use of electrification for logistics beneficial in the current state of the industry?

- ○ Yes
- ○ No

What would be the main appeal for electrification in logistics in your case?

- ○ Cost benefits
- ○ Public relations benefits (better image for the company)
- ○ Environmental benefits
- ○ Being technologically innovative

What would you say is the biggest disadvantage of electrification in logistics?

- ○ Not really a big difference with current transportation
- ○ It is too expensive
- ○ Not efficient for transit times
- ○ Other

From 1-5 how likely is electrification in logistics to become a standard in the industry within 10 years?

1	2	3	4	5
○	○	○	○	○

Please share your thoughts on the current landscape of electrification and what do you think it can become in 5/10 years