Forum:	Environmental Commission (EC)
Issue:	Addressing the Challenges Associated with the Transition to Electric Vehicles
Student Officer:	Elena Protonotariou
Position:	Deputy President

PERSONAL INTRODUCTION

Dear Delegates,

Welcome to the Environmental Commission! My name is Elena Protonotariou, I am 15 years old, and I'm currently attending the 10th grade at Costeas-Geitonas School. At this year's PSMUN conference, I have the utmost honour of serving as one of your chairs. I find MUN to be a thrilling and most definitely, edifying experience. Personally, I have been engaged with this activity for approximately two years and this conference will mark my first chairing experience.

MUN apart from prompting debate and conversations on modern day issues, slowly encourages delegates to form an opinion and understand politics, the economy and the environment. This is very important since this way, delegates subconsciously or not, gain an understanding and shape their thesis on "topics that matter" being ready to participate in conversations and make their voice heard. Having said that, in the Environmental Commission, just as the name indicates, we will deal with topics concerning the environment.

Unarguably, the environment is a topic of universal interest. Climate change, global warming and pollution are phenomena that have, and if not should have, our undivided attention. On this year's agenda, one of the topics discussed is the transition to electric vehicles. Electric vehicles and their integration, while promising to lower transportation-derived pollution, present many challenges that should be carefully addressed.

In this study guide, a foundation of knowledge about this topic is provided but note that your own extensive research is required for a fruitful debate to be able to take place. I'm eager to meet you all and hear your ideas and views on the topic! Should you have any questions about the topic or the procedure itself, do not hesitate to reach out via my personal email. (elena.protonotariou@gmail.com)

Kindest regards,

Elena

INTRODUCTION

Pollution and climate change today hinder the prosperity of the world and lethally threaten the lives of future generations. Sadly, this problem is mostly driven by anthropogenic activity, and many different aspects and sectors of human life are to blame with the emissions of the transportation sector being a leading cause to the said issue. Just in 2020, the transportation sector was responsible for 16,2% of global Greenhouse Gas (GHG) emissions[1], and produced more than seven billion metric tons of Carbon Dioxide (CO2) in 2021[2]. Coming to the realisation that vehicle exhaust is one of the primary sources of air pollution, the global interest and attention have been channelled towards alternative means of transportation, and more specifically to electric vehicles.

What has rendered Electric Vehicles so attractive is the fact that they have zero exhaust emissions, something very appealing to countries that have made zero-emission commitments and policies. But the benefits of Electric mobility are not limited to the environment; the society, public health, and the economy are just some of the other aspects and sectors that enjoy the benefits of EVs.

That being said, the worldwide vigour on environmental action is intensifying, with governments, the civil society, the private sector, United Nations (UN) entities, etc., all trying to address humanity's environmental challenges. Many countries have already adopted zero-emissions policies and are actively engaged with the concept of electric mobility. UN entities also support countries in their transition to EVs and efforts to turn "green" and decarbonise the transportation sector. United Nation's e-mobility programme is, in fact, focused on introducing EVs, especially in emerging economies, with the smooth integration of the Electric Vehicle being its primary goal.

However, for the integration of the electric vehicle to be ultimately achieved, there is a plethora of issues that need to be addressed beforehand. The consumerist world on the one hand has many concerns involving EV's safety, reliability, charging speed, battery life, driving range, cost, etc. On the other hand, environmentalists, specialists and engineers are faced with many different issues and questions concerning the electric vehicle and its environmental footprint, therefore, delaying the integration of e-mobility.

[1] "Sector by Sector: Where Do Global Greenhouse Gas Emissions Come From?" Our World in Data, 18 Sept. 2020, https://ourworldindata.org/ghg-emissions-by-sector .

[2] "Global Transport CO2 Emissions Breakdown 2021 | Statista." Statista, 31 May 2023, www.statista.com/statistics/1185535/transport-carbon-dioxide-emissions-breakdown/#:~:text=The%20global%20transportation%20sector%20is,of%20carbon%20dioxide%20(GtCO2).

Having said all that, it is crucial for the betterment of the environment and the minimisation of air pollution, that the fleet expansion is zero or at least low-emission based, integrating e-mobility and EVs to every country's mobility programme. However, action must be planned thoroughly so that other problems do not spur. That is since the EV is connected to the paradox of progress through the dual nature of technological advancements; in the process of integrating the EV to the international mobility web and minimising emissions, EVs simultaneously introduce new challenges including problems associated with battery production and disposal, potential job displacement in traditional automotive industries, etc. Therefore, for the transition to EVs to be successful, global cooperation and open mindedness are required. After all, it would be the epitome of the paradox of progress if the world embraced EVs successfully (with a view to minimising pollution) and its own environmental impact was the one to hamper the industry's goals.

DEFINITION OF KEY TERMS

Electric Vehicle

"An electric vehicle (EV) is a vehicle that is driven by an electric motor which draws its current either from storage batteries or from overhead cables." Electric Vehicles are powered with electricity either by a collector system or a battery, in which electrochemical reactions take place and transform an energy source (fossil fuels, sun power, etc.) into electricity. Different types of Electric Vehicles consist of Battery Electric Vehicles (BEVs), Plug-In Hybrid Electric Vehicles (PHEVs), Hybrid Electric Vehicles (HEVs), Fuel Cell Electric Vehicles (FCEVs) and Solar Electric Vehicles (SEVs).[3]

Internal Combustion Engine Vehicle

Internal Combustion Engine Vehicles (ICEVs) are vehicles that are powered by an Internal Combustion Engine (ICE) in which fuel such as biofuels (e.g. Ethanol, biodiesel), hydrogen or most commonly fossil fuels (e.g. Petrol, diesel, et fuel, compressed natural gas) are combusted with the help of an oxidiser (e.g. Oxygen) and generate chemical power which is later transformed into kinetic energy. This process of combustion emits very polluting gases into the atmosphere and for that reason ICEVs are thought to be unsustainable.[4]

[3] "Electric Vehicle Definition and Meaning: Collins English Dictionary." Electric Vehicle Definition and Meaning | Collins English Dictionary, www.collinsdictionary.com/dictionary/english/electric-vehicle. Accessed 17 July 2023.

[4] "Internal Combustion Engine Vehicle (ICEV)." Car Rental Glossary, 13 June 2022, www.carrentalgateway.com/glossary/internal-combustion-engine-vehicle/.

Lithium-Ion Battery

A lithium-ion (Li-ion) battery is the most used battery technology today, which utilises lithium ions during the charging and discharging process that generate a flow of electrons and help power a device. More precisely, "in a Li-ion battery, lithium ions (Li+) move between the cathode and anode internally, while electrons move in the opposite direction in the external circuit. This mitigation creates the electrical current that powers a device". Li-ion batteries can be found in electronics, mobile phones, electronic vehicles, etc.[5]

Hybrid Electric Vehicle

Hybrid electric vehicles (HEVs) are vehicles which derive power from both an internal combustion engine and one or more electric motors that use electricity from their batteries. HEVs offer low tailpipe emissions, high fuel economy and the power and range of an ICEV. They have the ability to charge through regenerative braking where the energy that is normally lost when using the brakes is captured and reutilised. While producing less emissions than ICEVs, they are relatively more unsustainable than pure EVs.[6]

Greenhouse Gas

Greenhouse Gas, also referred to as GHG, is "any gas that has the property of absorbing infrared radiation (net heat energy) emitted from Earth's surface and reradiating it back to Earth's surface", thus, intensifying the greenhouse effect which itself results in global warming. Some of the most notable Greenhouse Gases are Carbon Dioxide (CO2), methane, water vapour, ozone, etc. Processes that emit such gases vary from intense tectonic activity, evaporation, the decomposition of plants and animals, to human activities such as the combustion of fossil fuels (in factories, vehicle engines, etc). Greenhouse Gas Concentrations can be located in the atmosphere, soil, ocean, vegetation and other GHG sinks. [7]

Fossil Fuels

Fossil Fuels is a generic term for non-renewable energy sources which are formed from the remains of organic matter and are results of the decomposition of animals and plants that existed in the geological past. Their combustion produces thermal and electrical energy which is, then, employed by humans and utilised for different

[5] "What Are Lithium-Ion Batteries?" UL Research Institutes, 14 Sept. 2021, ul.org/research/electrochemical-safety/getting-started-electrochemical-safety/what-are-lithium-ion.

[6] "Hybrid Electric Vehicles." Alternative Fuels Data Center: Hybrid Electric Vehicles, afdc.energy.gov/vehicles/electric_basics_hev.html#:~:text=Today%27s%20hybrid%20electric%20vehicles%20(HEVs,and%20range%20of%20conventional%20vehicles. Accessed 17 July 2023.

[7] Mann, Michael E. "Greenhouse Gas | Definition, Emissions, and Greenhouse Effect." Encyclopedia Britannica, 2 Aug. 2023, www.britannica.com/science/greenhouse-gas.

purposes (home furnaces, drive generators, gas turbines which transform the energy to motive power, etc.) However, their combustion also leads to the release of carbon to Earth's atmosphere contributing majorly to the greenhouse effect. Examples of fossil fuels are coal, coal products, natural gas, derived gas, crude oil, petroleum products and non-renewable wastes. [8]

Electromobility

Electromobility, also commonly referred to as e-mobility, is the concept of employing electric powertrain (electric circuits, batteries, wires, power electronic converters, etc) to transport people and goods, in order to support sustainable development. In more simpler terms, electromobility refers to the usage of electricity to power transportation.[9]

Renewable Resources

Renewable Resources are natural sources that are found in abundance or replenished faster than they are consumed. Such resources include sunlight, wind and water. From renewable resources, renewable energy is generated through different technologies such as solar panels, wind turbines, wells, reservoirs, etc. [10]

Tailpipe Emissions

"Tailpipe Emissions are the product of fuel combustion (gasoline, diesel or other liquefied fuel or biofuel)" which comprise of a rich composition of pollutants such as carbon dioxide, hydrocarbons, carbon, particulate matter, etc. Tailpipe emissions originate from the pipe of a car's exhaust system which exists in vehicles with an Internal Combustion Engine (ICEVs, HEVs, PHEVs, etc.). They are one of the primary sources of air pollution and the dominating cause of transportation derived pollution. Electric Vehicles have no tailpipe emissions meaning that during their operation, they do not emit and pollutants.[11]

Power Grid

The power or electric grid, "is a network of synchronised power providers and consumers that are connected by transmission and distribution lines." More specifically, the electric grid is comprised of a generating plant, transmission lines, a

[8] "Glossary:Fossil Fuel." Eurostar, 9 Sept. 2019, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Fossil_fuel#:~:text=Fossil%20fuel%20is%20a%20generic,%2C%20millions%20of%20years%20ago).

[9] Arora, Shashank, et al. "Heavy-duty Electric Vehicles and Society." Elsevier eBooks, 2021, pp. 1–34, doi:10.1016/b978-0-12-818126-3.00002-6.

[10] United Nations. "What Is Renewable Energy? | United Nations." United Nations, www.un.org/en/climatechange/what-is-renewable-energy.

[11] Fuels and Emissions -. 1 Sept. 2020, www.acela.org/fuels-basics/fuels-and-emissions/#:~:text=Tailpipe%20emissions%20are%20the%20product,and%20certain%20pollutants%20like%20sulfur.

substation, transformers, distribution lines and consumer connecting power with consumers making electricity accessible to all any minute.[12]

BACKGROUND INFORMATION

The History Electric Vehicles

The Electric Vehicle (EV) industry has received great attention in the last couple decades and it is very commonly thought that Electric Vehicles (EV) are a new invention of the 21st century. However, this is a big misconception as their origins can be traced back to the 19th century. At that time, many innovators had begun exploring the idea of a battery-powered vehicle; Robert Anderson's creation of a crude electric carriage in 1832 marked a significant milestone and became the prototype for the Electric Vehicle at the time. While different from modern EVs, it shared foundational principles.

Around the same period, many more notable scientists created their own models of small-scale EVs, each one taking the idea of another and evolving into something closer to the model of the electric vehicle known today. A few years later in 1859, Gaston Planté experimented with the construction of a battery for the storage of electrical energy and managed to create the first rechargeable lead-acid battery. Then, between 1887-1888, Nikola Tesla made the first practical induction motors, which are the most widely used form of electric motor today. Just a few years later, in 1890, William Morrison created the first practical battery-powered automobile which could maintain a speed of 23 kilometres per hour, a huge breakthrough for the time. It is considered by many that Morrison was the one to create the very first Electric vehicle. However, opinions differ as there were even more innovators who had produced their own version of an EV during the same time making it a collective effort.

[12] Student Energy. "Electrical Grid 101." YouTube, 17 May 2015, www.youtube.com/watch?v=CHeMbhk4Mmw.

Figure 1: Robert Anderson's crude electric carriage[13]

Around the same period as Morrison built the first Electric vehicle, Carl Benz built the world's first practical Internal Combustion engine automobile. At that time, gasoline powered vehicles required physical strength to be operated and were very noisy and their exhaust was unpleasant. Steam cars weren't any better; although quiet, they required long start-up times (e.g. 45 mins), especially during winter. Electric cars, however, didn't have any of the aforementioned issues: they were noiseless, easy to drive and didn't emit any smelly pollutants like gasoline cars did. Over the next few years, Electric vehicles illustrated strong sales with new models coming out from different automakers who had joined the new trend. By 1900, the EV was in its prime accounting for about one third of cars on the roads[14].

However, this period of prosperity for electromobility wouldn't last long. Henry Ford's Model T was the first ICEV to deal a blow to EVs. Introduced in 1908, Model T was widely available and affordable, waving a green flag over gasoline cars. By 1912, the gasoline car costed around 600 dollars while the electric around triple the money. With other developments on gasoline cars outweighing the benefits of EVs, the decline of electromobility was quick. In time, gas and gasoline became widespread, affordable and easily available as filling stations had begun popping up everywhere, while electricity, especially outside of cities, was not available. By 1935, Electric Vehicles had almost disappeared of the automobile market.

Things stayed like that for more than thirty years and it wasn't until the 70s that the interest on electromobility was renewed. The rising oil prices and the gasoline

[13] Photo courtesy of Wikimedia Commons.

[14] "The History of the Electric Car." Energy.gov, www.energy.gov/articles/history-electric-car.

shortages along with the 1973 Arab Oil Embargo brought to the forefront the idea of fuel-independency which re-sparked the interest on e-mobility. Researches and test programs featuring EVs and Hybrids were initiated boosting the profile of e-mobility. NASA's electric Lunar rover, in particular, stimulated an interest on EVs when it became the first manned vehicle to drive on the moon on July 31, 1971. But it wasn't anything more than pure interest on the matter as the low range and slow speeds of EVs prevented people from actually purchasing them. Fast forward to the 90s, engineers and scientists were working to better EV technology after having realised their prospects. Still, e-mobility's revival didn't happen until the 21st century when two ground-breaking developments became table-turners for EVs; Firstly, the introduction of the TOYOTA Prius which became the first mass-produced Hybrid Electric Vehicle (HEV), and, then, the announcement on July 19, 2006 that Tesla Motors would produce a luxury electric sports car that could go over 200 miles with one charge, made other automakers accelerate the production of other EVs turning over a new leaf for e-mobility.

Differences Between Electric Vehicles and Internal Combustion Engine Vehicles

A key step towards the empowerment of the integration of Electric vehicles is comprehending their differences with their market competition, Internal Combustion Engine Vehicles. Evidently, their primary difference is their source of power. EVs are powered by electricity, while ICEVs by different types of fuels, such as petrol or diesel, a fact that renders the former low to zero-emission and, therefore, sustainable, while the latter extremely polluting as it emits Greenhouse Gases (GHGs) through the combustion of these fuels. As far as noise production is concerned, EVs are noiseless, contrary to ICEVs whose engine produces a lot of noise, thus, contributing to noise pollution. EVs are significantly more efficient, boasting an approximately 80% efficiency compared to the roughly 30% efficiency of ICEs. Another difference between the two is that EVs utilise regenerative braking, where the kinetic energy is converted into electrical power, instead of heat, which, then, recharges the battery, a mechanism that ICEVs lack. Moreover, an ICEV takes less than 5 minutes to charge at a gas station, while an EV requires much more time, ranging from 30 minutes to 8 hours, depending on the wattage of the charger. Additionally, while the motor of an EV mostly needs little to no maintenance, the engine of an ICEV requires regular oil and fuel filter changes, which renders its maintenance relatively more costly. Apart from these, there are a few more differences between the two cars in terms of weight, space in the fuel tank, interior, power transmission, etc.

E-Mobility VS Eco-Mobility

Eco-mobility[15] and E-mobility, although interconnected by definition, represent two distinct concepts. The former has to do with vehicles and different means of transportation that are sustainable in every aspect and do not affect the environment. More precisely, eco-mobility relates to the mobility that is environmentally sound and

[15] "Ecomobility Definition." *EcoMobility World Festival*, www.ecomobilityfestival.net/home/idea-concept-experiences/definition-of-ecomobility.

economically feasible, thus, eco-efficient. For example, carpooling, biking and walking can be considered to fall under the category of eco-mobility. However, Eco-mobility isn't so much a specific means of transportation as much as the careful planning and choosing of the one which is most favourable at each situation both in relation to the environment and the individual (e.g.: bike for short distances, carpooling for people with the same/ similar destination). On the other hand, the latter, e-mobility concerns solely the transportation with electric vehicles. In e-mobility electric power train replaces combustion engines and fossil fuels in an effort to support Eco-mobility and sustainable transportation in general. E-mobility is a form of eco-mobility. However, this isn't necessarily true for the other way round, e.g., transporting by foot is eco-friendly but it obviously does not utilise electricity. Lately, countries have been making efforts to integrate eco-mobility by promoting e-mobility in particular.

The Benefits of E-Mobility

Environmental benefits

Most importantly, Electric Vehicles are being promoted as a key step to curbing the greenhouse effect and pollution. They have no tailpipe emissions since during their operation, the chemical reactions that occur in the battery (the charging of lithium ions in the case of a Li-ion battery) do not produce any GHG gases or other pollutants. Moreover, EVs perform more efficiently in heavy traffic and congestion than ICEVs thanks to their ability to stop and start without constantly running the engine. But apart from contributing to the minimisation of air pollution, EVs also help with noise pollution, a major problem in big urban centres which constitutes the cause of many chronic and other health problems. EVs, therefore, by having a motor instead of an engine, are almost noiseless and can minimise and potentially eradicate this type of pollution in cities.

Benefits on global health and economy

Studies have reported that certain pollutants emitted by vehicles are associated with various health problems such as asthma, high blood pressure, lung cancer, diabetes, Alzheimer's disease, dementia as well as premature deaths. Therefore, indirectly, exhaust emissions are also associated with human health problems through climate change and increasing atmospheric GHG concentrations. The World Bank estimated that in 2013, 5.5 million lives were lost due to diseases caused by outdoor and household air pollution[16], jeopardising economic development and resulting in the deterioration of quality of life. The World Bank calculated that diseases brought on by indoor

[16] World Bank Group. "Air Pollution Deaths Cost Global Economy US$225 Billion." World Bank, 9 Sept. 2016, www.worldbank.org/en/news/press-release/2016/09/08/air-pollution-deaths-cost-global-economy-225-billion#:~:text=An%20estimated%205.5%20million%20lives,suffering%20and%20reducing%20economic%20development.

and outdoor air pollution took the lives of 5.5 million people in 2013. Over 2 million people die each year from fine particle pollution, which is mostly caused by combustion sources like internal combustion engines in cars [17].
If the transition to electric vehicles is successful and the number of ICEVs on the road is minimised, premature mortality due to air pollution will witness significant reductions and asthma cases will potentially be lessened. The integration of EVs to every country's transport industry will substantially help in ameliorating global health and reduce many respiratory and other related diseases in the long run. There are various socioeconomic benefits associated with electric cars (EVs). With abundant and free renewable energy, they lower reliance on imports, improve national security, and promote energy independence all while saving money. In addition to resolving overload problems and providing grid support during periods of high demand, EVs also generate income and local jobs. Reusing and recycling EV batteries can potentially boost the economy by lowering imports and boosting the recycling industry. Furthermore, the ongoing development of EV technology—including the incorporation of AI—fuels the advancement and invention of broader technologies.

Challenges associated with the transition to Electric Vehicles

Environmental footprint of EVs

Although significantly more environmentally friendly, EVs are still linked with some drawbacks, especially concerning the environment. While being free of tailpipe pollution, their production isn't, and it accounts for a significant share of an EV's lifespan environmental impact, with the most unsustainable and pollution-producing component of an EV being its battery. Its production requires a significant amount of energy and water and can consequently produce emissions. Apart from that, EV batteries contain many rare earth elements such as lithium, nickel, cobalt, and graphite, which render their production as well as disposal difficult processes. For instance, the mining of lithium involves the evaporation of water (usually groundwater) so that what is left is a lithium-rich solution. This process can deprive local communities of their water supply, harm agriculture by reducing the water available for irrigation, and release toxic and radioactive elements if not handled properly. Cobalt mines, for instance, are not only environmentally but also socially harmful. They produce toxic residues that leach into the environment and pollute groundwater and, as a result, nearby communities while also raising concerns about forced labour and human rights violations.

[17] World Health Organization: WHO. "Tackling the Global Clean Air Challenge." WHO, 26 Sept. 2011, www.who.int/news/item/26-09-2011-tackling-the-global-clean-air-challenge.

Another extension of EVs' environmental impact lies in their charging. While being charged with electricity, their sustainability depends on the energy source that is used to generate the electricity that powers the vehicle. In simpler terms if the electricity that charges the vehicle is made out of fossil fuels, then, GHG emissions are added to the EV's footprint questioning its sustainability. In most places around the world, this is the case; fossil fuels are the ones that generate the electricity that powers cities, houses and vehicles. In fact, currently fossil fuels (coal, oil and natural gas) account for 65.3% of the global gross electricity production[18]. Energy production has to be free of fossil fuels and run on renewable energy sources so that EVs are truly "green" and emission-free. For countries that are heavily dependent on non-renewable sources, decarbonising their energy production is an equally important challenge as the adoption of EVs. Overall, it can be said that EVs are as "clean" as the underlying grid from which their electricity is sourced.

Many automakers by making heavier vehicles, end up making cars whose non-tailpipe emissions (emissions that do not stem from their tailpipe) account for the prevalent source of the EV's emissions. More specifically, tyre and break wear are responsible for a part of a car's non-tailpipe emissions and it's essential to deal with them. Recent tests and studies have indicated that the tiny particles produced by tyre wear are linked to respiratory problems and are notably worse in terms of particle pollution than tailpipes[19]. Tire and break wear produce fine particles, which can enter the bloodstream and harm organs. With EVs being heavier than ICE cars, this issue grows worse and with it being unregulated and the pollutants that come from tires and breaks being potentially very toxic, this needs to be urgently dealt with. For the moment this is unmapped territory for scientists as the particles, metals and carcinogens emitted from tires get washed up into drains or seep through soil becoming undetectable and hard to keep track of. The solution is believed to lie in natural or non-fossil fuel materials used for tires.

Electric vehicles seem to be the future of sustainable transportation. However, there is a possibility that not everyone will be living in it. Prior to the uptake of Electric Vehicles, cities and developed areas were mostly polluted due to the highly developed industries. Now, however, more economically developed areas with the ability to purchase EVs will enjoy a clean environment, while less economically developed communities will live in pollution. Basically, in such areas, people cannot afford EVs so the atmosphere will not witness any

[18] "Electricity Production – Electricity Information: Overview – Analysis - IEA." IEA, www.iea.org/reports/electricity-information-overview/electricity-production#.

[19] Molden, Nick. "PRESS RELEASE: Emissions Analytics Launches New Chemical Fingerprint Tyre Database Available by Subscription — Emissions Analytics." Emissions Analytics, May 2023, www.emissionsanalytics.com/news/press-release-emissions-analytics-launches-tyre-database.

improvement and the situation may even get worse since these areas are near factories which will get "overtaxed" with the accelerating EV demand. This is exacerbated by the proximity of factories, heavily trafficked freeways, and power plants. The new EV demand forces power plants to run more and generate more energy more quickly, releasing additional pollutants to the atmosphere. This is a problem since in many areas power plants are near what countries call "disadvantaged communities" where the people cannot do anything about the situation.

Affordability and Accessibility of EVs

In order for EVs to be accepted by consumers and the market, their costs need to be similar to those of conventional ICE cars. At the moment, EV prices are higher than those of their counterparts, so it is not surprising that the majority of their sales are in countries with a high Gross Domestic Product (GDP). Progress has been uneven across the world since while there have been a few positive EV-uptake-cases such as in Norway, the rest of the world is not yet ready to support EVs financially. Apart from that, finding an EV charging station may be a challenge depending on someone's location in the world. In contrast to gas and petrol stations which can be found easily everywhere, EV chargers are scarce and far in between. This illustrates how the transition from a fuel-dependent world to a clean energy dominated one is a delicate process which will take time. The raw materials required for the production of EVs are very scarce and expensive affecting their affordability and slowing down their production. It is of great importance that the installation and location of EV chargers is carefully planned taking into consideration places that are central so that their accessibility is ameliorated.

Implications

Transitioning from Internal Combustion Engine Vehicles, which currently account for the majority of cars in roads, to Electric Vehicles is a key step to addressing the climate crisis. However, there are some implications and technical hurdles that slow down this process. For instance, it is feared that if there were 100% EVs on the roads, the power grid wouldn't be able to handle that big of a power demand and would potentially overload. Basically, a grid overload occurs when the demand for electricity on an electrical grid exceeds its supply and power capacity and it fails to deliver power. High demand, weather conditions and fluctuations in renewable energy sources that equip the grid are responsible for grid failures. For example, during the night when there is no solar power or during very high temperatures, the grid may not be able to perform that well.

Electrical vehicles' batteries are also associated with a few implications. The possibility of their batteries catching fire due to overheating is one of them. While the chances of that happening are very little, people are fearful about

this due to the difficulty of putting the fire out (the flammability of the battery material will trigger a chain reaction and it will be difficult to put out such a fire). Another implication concerns the scarcity of the materials needed to produce EVs and their batteries, and their limited concentration in only a small number of countries. Cobalt, for instance, a material necessary for the production of Li-ion batteries, is predicted to be outstripped by 2030 based on projected demand.

Electric Vehicles and the Sustainable Development Goals (SDGs)

Electric vehicles being a rather sustainable means of transportation with low emissions, are inevitably interlinked with many of UN's SDGs. First and foremost, they contribute to the 7th and 13th SDG ("Affordable and Clean Energy" and "Climate Action" respectively) by replacing expensive fossil fuels with the already accessible to all electricity and as a result decarbonising the transport sector. Secondly, EVs are connected with the 11th goal (Sustainable Cities and Communities) since their adoption can reduce tailpipe emissions and air pollution and, therefore, improve air quality and reduce associated health problems such as respiratory difficulties, insomnia and even cancer. Additionally, it can be argued that EVs, if powered by renewable energy sources, are related to the SDG 12 (Responsible Consumption and Production) by encouraging the fostering of more sustainable consumption habits and patterns. The usage of local renewable energy (converted to electricity) to power vehicles is an act of responsibility towards the environment while also following the principles of the aforementioned goal. Except for these goals, Electric mobility (if powered by "clean energy" sources) is also linked with SDG 7.2 by enhancing the share of renewable energy in the global energy mix: while the amount of ICEVs lessens, the percentage of fossil fuel energy falls and the share of renewable energy rises along with the "EV population". Furthermore, by ensuring access to affordable, reliable and modern energy services when powered by renewable energy, EVs are participating in SDG 7.1. Last but not least, EVs are contributing to the SDG 11.2 by helping to provide access to safe affordable, accessible and sustainable transport systems for all. Taking everything mentioned above into consideration, it is evident that the full integration of EVs would contribute significantly to many SDGs. However, it is also clear that the environmental benefits of EVs only stand when the electricity that powers them originates from renewable sources.

MAJOR COUNTRIES AND ORGANISATIONS INVOLVED

Norway

Norway, along with many of its Scandinavian neighbours, is very engaged with e-mobility. Having one of the highest EV adoption rates globally, Norway has surpassed

the milestone of 50% EVs and is now moving closer to 100[20]. In the country, there are lots of other EVs except for electric cars. Electric ferries are very popular around the Nordic Fjords and there is a goal of replacing all buses with electric ones by the end of the year. So far, the atmosphere has gotten measurably cleaner, noise pollution has gotten down and the grid hasn't shown any signs that indicate an overload or a grid failure. They have almost entirely solved the problem of exhaust pollution. However, despite the success of the EV integration, some other problems have sprouted. An unhealthy number of particles from tire wear has been observed in the air and people living in apartments have difficulty in finding a plug to charge at home.

China

China holds the place for the world's largest EV market. For the past few years, it has been the main supplier of EVs of quality and good price to multiple countries. In fact, out of the 850.000 EVs imported to Europe in 2022, more than half originated from China.[21] Due to being one of the world's largest industries, the urban air pollution and GHG emissions were disturbingly high. The Chinese government, in order to counteract this situation, begun encouraging the adoption of electric mobility. So far it has invested in EV adoption by implementing strong incentives and regulations promoting EVs, expanding the charging infrastructure, and more. In 2009, the government provided subsidies for EV purchases, but since they ended up being too costly for the government, they were withdrawn by 2020. Instead, a mandate on car manufacturers was imposed, stating that a certain per cent of annual car sales should account for EVs and rewarding those who achieved that number based on a complex formula which references range, energy efficiency, performance, etc. The country overall hopes that EVs will make up 40 per cent of all car sales by 2030.[22]

United States of America (USA)[23]

The USA, in regard to e-mobility, has also made goals for zero-emission vehicles by 2030. Federal agencies are committed to installing 24,000 charging stations nationwide while many large companies have committed to turn electric. The provider of school buses has committed to replace around 30,000 buses with electric ones while Amazon has already swapped 3,000 transporter vans with electric ones. Simultaneously, education and marketing campaigns have been pledged by many different companies with a view to rendering EVs more tangible. The president's

[20] ---. "In Norway, the Electric Vehicle Future Has Already Arrived." The New York Times, 10 May 2023, www.nytimes.com/2023/05/08/business/energy-environment/norway-electric-vehicles.html#.

[21] Hawkins, Amy. "Battery Power: How China Could Take Charge of the Electric Vehicle Market." The Guardian, 29 July 2023, www.theguardian.com/environment/2023/jul/29/battery-power-how-china-could-take-charge-of-the-electric-vehicle-market.

[22] "China's Transition to Electric Vehicles." MIT News | Massachusetts Institute of Technology, 29 Apr. 2021, news.mit.edu/2021/chinas-transition-electric-vehicles-0429.

[23] Randall, Chris. "US Government Presents Comprehensive E-mobility Update." electrive.com, Mar. 2023, www.electrive.com/2023/03/31/us-government-presents-comprehensive-e-mobility-update.

administration has created a programme called "EV Acceleration Challenge" which includes all of these initiatives. So far, the EV fleet is around 3 million. However, with the country's total car population surpassing 200 million, this transition is truly going to be a challenge. Additionally, despite that the government is very optimistic and has overall invested in the future of EVs with all the states being actively engaged, there have been issues with the grid and a lack of charging infrastructure, which in order to be dealt with require coordination and investment across sectors.

The Netherlands

The Netherlands is also very interested in electromobility. Being known for its bicycling culture, they do not only support e-mobility but also eco-mobility in general. Having said that, setting a zero-emission goal by 2030, the Netherlands further clarified that all vehicles should make the best use of renewable energy sources. Having one of the densest charging networks in the world, their agenda entails the preparation of the charging network for the projected EV rise. So far, they have made remarkable progress and the future seems even more promising.

India

Electromobility has gained particular traction in India where despite being a developing economy, huge efforts are being made towards the transition to EVs. So far, India is on the verge of becoming one of the biggest EV markets, with its government aiming to achieve complete local production of the vehicles under its 'Make in India' initiative. FAME India, another government initiative standing for the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles in India[24], proved very popular and successful around the country. So far, the government is determined to create a thriving EV ecosystem by investing in their adoption, required infrastructure and production. However, their economy will constitute a significant setback and challenge in this journey.

International Energy Agency (IEA)[25]

The IEA provides research and policy analysis on many different energy-related topics including e-mobility. Being at the heart of global energy dialogue, the IEA provides analysis, data, policy recommendations, and realistic solutions to assist countries in their journey to providing secure and sustainable energy for all. Looking at the bigger picture, the IEA brings forward policies with the aim of enhancing the reliability, affordability and sustainability of energy. The agency participates in the EV growing culture by providing helpful information for governments and policy makers. The Electric Vehicles Initiative (EVI), in particular, is a multi-government policy forum

[24] Automobile | Make in India. www.makeinindia.com/sector/automobiles.

[25] "Electric Vehicles Initiative – Programmes - IEA." IEA, www.iea.org/programmes/electric-vehicles-initiative#.

coordinated by the IEA. EVI is dedicated to accelerating EVs' worldwide adoption and so far, sixteen countries are participating. From 2017 when EVI was founded, it has focused on reaching at least 30 percent sales of EVs by 2030 supporting best practices and collaboration aiding countries in their e-mobility journey.

Global Electric Mobility Programme (GEMP)

Operating under the auspices of the United Nations Environment Programme (UNEP), GEMP supports many low- and middle-income countries in their shift to e-mobility. Acknowledging the heavy dependence of today's world on fossil fuels, GEMP advocates for e-mobility targets and policies. Along with the IEA, the programme has set four Global Working Groups to advise policymakers and support them in their national projects and transition to EVs. Its goals and ambitions include providing policy advice and facilitating discussions to bring forward the global harmonisation of e-mobility standards and regulations, establishing marketplaces to mobilise financing and bring together countries, cities, and e-mobility suppliers and financiers, providing technical support and training to countries and cities and many more.

European Union (EU)

With Europe housing the world's most EVs, the European Union is approving, promoting and accelerating EV adoption through different policies, initiatives, bodies, etc. EU countries have made commitments to achieving climate neutrality by 2050 according to the decisions made under the Paris Agreement. The European Green Deal is the EU's strategy for reaching that goal and it includes the Fit for 55 package which aims to translate the climate ambitions of the deal into laws. The package aims at the revision of climate energy and transport-related legislation and their update in order for them to align with the European Union's climate goals. Countries that have agreed to the Fit for 55 package[26]such as Greece, Portugal, Spain and Croatia, are committed to cutting down on their GHG emissions by at least 55% by 2030 in relation to 1990 levels. All these projects promote electromobility by turning more and more countries' attention to carbon neutrality, renewable sources and "clean energy".

TIMELINE OF EVENTS

DATE	DESCRIPTION OF EVENT
29 August 1831	Michael Faraday establishes the concept of electromagnetic induction.
1832	The first crude electric carriage is created by Robert Anderson.

[26] "Fit For 55." European Council Council of the European Union, www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition.

1837	Thomas Davenport creates the first working DC motor.
1859	Gaston Planté creates the first rechargeable lead-acid battery.
29 January 1886	Carl Benz builds the first practical ICE automobile.
1887-88	Nikola Tesla develops the first AC induction motor which facilitates the long-distance distribution of electricity.
1890	William Morrison creates the first practical battery-powered automobile.
1908	Ford introduces Model T which becomes the ambassador of EVs at the time.
31 July 1971	NASA's electric Lunar rover lands on the moon.
1973	The Arab Oil Embargo is instituted.
19 July 2006	Tesla Motors announces it will produce a luxury electric sports car.
2010	The Electric Vehicles Initiative is established under the Clean Energy Ministerial (CEM).
4 November 2016	The Paris Agreement enters into force.
December 2019	The Green Deal is launched by the European Council.
2019	92% of cars road transport in Europe are fuel powered (diesel, petrol).
October 2022	Li-ion batteries are added to the list of goods produced by child labour, by the US Department of Labour.
December 2022	More than 80% of new vehicles purchased in Norway are electric.

PREVIOUS ATTEMPTS TO SOLVE THE ISSUE

Regulation (EU) PE-CONS 66/22[27]

This regulation from the European Union discussed in Brussels on the 22nd of February this year, while focusing on the strengthening of the CO2 performance standards of vehicles, it encourages the deployment of zero-emission vehicles in the Union's market share. The Regulation recognises that the automotive value chain is the leading actor in the transition to zero-emission mobility and addresses the transition to and production-increase of zero-emission vehicles, including EVs. This Regulation sets a very good example of a legislative measure taken in favour of Electric vehicles, but it solely focuses on European countries as it is from the EU. Additionally, the file talks about all zero-emission vehicles and not EVs in particular, making it broad and very general in relation to the transition to EVs.

Global Technical Regulation on Electric Vehicle Safety, ECE/TRANS/180/Add.20[28]

This Regulation, established on the Global Registry on March 14 2018, issues the creation of an Informal Working Group on Electric Vehicles to discuss about electro-mobility and zero-emission-mobility in general. The working group proposed will be responsible for exchanging information on developing techniques concerning EVs and the environment, researching, reporting and monitoring their safety and environmental footprint. While being helpful in providing critical information about EVs, the working group proposal does not directly address the transition to electric vehicles or the problems associated with it.

Clean vehicles Directive

Adopted by the European Parliament and Council in June 2019, the Clean Vehicle Directive, requires countries to set a national goal for the EV fleet size they opt to achieve by a certain date. The directive, by defining what is a “clean vehicle” further clarified the term so that potential legal misinterpretations are avoided. Additionally, the directive manages to ensure the monitoring and reporting of progress of its country in relation to its goals through the Tender Electronic Database (TED). A review is foreseen in 2027 in order to set new targets for the time period after 2030.

Norway’s national plan and Zero-Emission goal

Norway’s success story can be largely attributed to the country’s national plan, goals and big ambitions. More precisely, Norway has set a Zero-emission goal by 2025 promoting carbon-free products including electric vehicles. Additionally, the car tax system strictly and solely benefits EV users through incentives and reduced taxes while

[27] https://data.consilium.europa.eu/doc/document/PE-66-2022-INIT/en/pdf

[28] https://unece.org/fileadmin/DAM/trans/main/wp29/wp29wgs/wp29gen/wp29registry/ECE-TRANS-180a20app1e.pdf

"weighting" the "polluter" with additional taxes and higher parking prices. Apart from that, the Norwegian government has ensured that charging infrastructure is available and accessible to all at all times. By establishing specific laws, it has ensured that everyone can charge any given time their vehicle without having to deal with a grid overload. While Norway's national plan has noted great success and so far, no complications, it, of course, only focuses on Norway. It is of utmost importance that all countries set similar goals, realistic to their progress and create a strategic plan for their EV transition programme.

POSSIBLE SOLUTIONS

Stimulating attention around Electric Vehicles

The project of the transition to EVs can be broken down to three major step-categories. First and foremost, it is of utmost importance to clear up all EV-related misunderstandings, raise awareness on their abilities, benefits and drawbacks as well as promote them by all means so as to stimulate consumeristic interest on the matter. Any other effort to support and embrace EVs would be useless, should purchase rates be really low. That being said, it is crucial to the integration of the EV that all countries consider raising the awareness of the general public and actively change society's perception of EVs in order to permanently ensure a place for them in the market. For that to happen, an initiative that can be constantly sustained in society is of utmost importance. In such an initiative, the association of electromobility with eco-mobility could be very effective in boosting the profile of EVs. But comprehensive education on the matter should be provided not only in economically developed countries but in Less Economically Developed Countries (LEDCs) as well. In places where electric four-wheelers such as cars cannot be economically sustained, the usage and integration of rentable electric two-wheelers (e.g. Bikes and scooters) could be promoted as an alternative and economic EV 'choice' for LEDCs. In order to further engage people with electro-mobility considering using incentives can help spark conversation around EVs and increase their sales. Therefore, countries should carefully consider increasing and providing government and tax incentives for EV-buyers. However, before that, countries must commit to zero-emission or at least net zero policies and sales slowing down ICEV sales and purchases. After all, the more countries that commit to 100% zero-emission sales, the faster investment will shift and the faster costs will come down making EVs 'within reach' for most families.

Upgrading worldwide infrastructure

After educating people on e-mobility, it is necessary to prepare the world for a scenario in which EV sales grow rapidly and vastly. In terms of infrastructure, the world right now is far from prepared for a situation as such. Therefore, updating and expanding the grid and increasing the frequency and quality of chargers in cities are essential to rendering EVs the backbone of the urban mobility system. In order to avoid grid failures during peak hours updating the already-existing grid with a higher voltage one and expanding it will help. At that point employing reusable energy-

sources as a power source for the grid should be considered. However, this is a very expensive project so the cooperation of intergovernmental as well as international factors and bodies is absolutely necessary. In LEDCs and in countries where the update of the grid can't be funded, vehicle-to-grid integration (the employment of vehicles as a source of power for the grid, returning energy during times of overload) should be considered as a better load management alternative. Planning and adjusting to the ever-growing demands of the grid by creating a national plan of each country's approach strategy is equally important. Electrified roads and more charging stations also need to be considered and integrated according to each country's needs, environment and economy so as to support an EV fleet growth and calm consumers who have charging-related concerns.

Generally, in order to avoid grid failures, optimised grid planning and adjusting to the new power demands is essential, along with the expansion of grid infrastructure and the integration of renewable energy sources into it. Apart from updating grid infrastructure, enriching charging infrastructure is also necessary. With the ever-growing number of EVs and the long time needed to charge, the charging stations in many places are inadequate and unable to cater for a large number of people especially during periods of high demand. The lack of chargers in many places further prevents people from purchasing EVs, with them unwilling to deal with the stress of not knowing where to charge their vehicle.

Reducing the environmental footprint of EVs

Lastly and most importantly, the carbon footprint of an EV's lifecycle must be substantially reduced in order for it to succeed in achieving the environmental goals and milestones envisioned for it. Focusing on the production and recycling of an EV, countries could address electric vehicles thinking the full life circle of their batteries and promoting battery swapping technology and maintenance software, able to recycle an EV's parts. Additionally, global attention should be paid to the production and excavation of raw materials for batteries in order to prevent human rights violations and potentially find more sustainable alternatives than cobalt etc. Apart from that, another way to reduce the carbon footprint of an EV is by enforcing reusable energy usage as an electricity source. Solar, hydro and wind power must be considered as an energy source alternative and if chosen, the respective energy-factories, energy-storage and other needed infrastructure should be constructed in order for them to successfully power a location independently of its weather conditions any given time (cloudy, no wind, etc.). All in all, EVs should be handled very carefully always paying attention to their environmental footprint. Still, this is unmapped territory, so it is crucial that more research is funded and conducted, exploring alternatives and solutions to EVs' environmental issues.

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