A STUDY ON ELECTRIC VEHICLES CHALLENGES AND ITS BARRIERS: A REVIEW

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ABSTRACT

Electric Vehicles (EVs) are picking up energy due to a few components, counting the costdiminishment as well as the climate and natural mindfulness. This paper surveys the progresses ofEVs with respect to battery innovation patterns, charging strategies, as well as modern inquire about challenges andopen openings. More particularly, an investigation of the around the world advertise circumstance of EVs and theirfuture prospects is carried out. and what obstructions they are confronting and how to overcome the impediments .

At long last, we conclude ourwork by showing our vision almost what is anticipated within the close future inside this field, as well asthe investigate angles that are still open for both industry and scholarly communities.

Keywords: Electric Vehicles, Plug-In Hybrid Electric Vehicle, Barriers.

1. INTRODUCTION

The car industry plays a pivotal part within the worldwide economy and in investigate and improvement, with a developing center on mechanical headways pointed at improving the security of both travelers and people on foot[1]. Be that as it may, the expanding number of vehicles on the streets has contributed to a noteworthy rise in discuss contamination, [2]especially in urban ranges, where poisons like particulate matter (PM), nitrogen oxides (NOx), carbon monoxide (CO), and sulfur dioxide (SO2) are predominant. Agreeing to a European Union report, the transport division accounts for about 28% of add up to carbon dioxide (CO2) outflows, with street transport capable for over 70% of those outflows. In reaction, numerous created nations are advancing Electric Vehicles (EVs) as a arrangement to relieve discuss contamination and nursery gas outflows.[3] Specialists are actualizing different activities, counting charge motivations, buy helps, and benefits such as free open stopping and motorway get to, to energize

the appropriation of EVs. These vehicles show a few points of interest over conventional combustion motor vehicles, contributing to a more feasible and proficient mode of transportation.

Electric Vehicles (EVs) offer numerous benefits, such as zero emissions, lower maintenance costs, increased reliability, cost-effectiveness, enhanced comfort, high efficiency, access to restricted areas, and government incentives. EVs produce no tailpipe pollutants, reducing CO2 and nitrogen dioxide emissions. Battery production can have a negative impact on the environment, but advancements in recycling and sustainable sourcing are helping to mitigate this issue. The simplicity of EV motors leads to reduced maintenance costs as they have fewer components than traditional combustion engines. With fewer moving parts, EVs experience fewer breakdowns and have lower ownership costs. EVs are generally more cost-effective to run than traditional vehicles, with savings on energy costs per kilometertraveled. Additionally, EVs provide a smoother and quieter driving experience. Governments often offer incentives for purchasing EVs, further reducing the overall cost and promoting the adoption of these environmentally friendly vehicles.

1.1 CHALLENGES IN EV

Electric vehicles face several challenges, including limited driving range, lengthy charging times, high battery costs, increased weight, environmental concerns surrounding battery production and disposal, and the need for expanded charging infrastructure. While many EVs have a driving range of 200-350 km, advancements like the Tesla Model S offer over 500 km to alleviate range anxiety. [4]Charging can be time-consuming, taking 4-8 hours for a full charge, despite fast-charging options. Battery costs remain a significant factor, although advancements are expected to lower prices. Research into lighter battery materials and sustainable practices is ongoing to address these challenges and improve the overall lifecycle of EVs. Expanding charging networks is critical for the continued growth of electric vehicles.

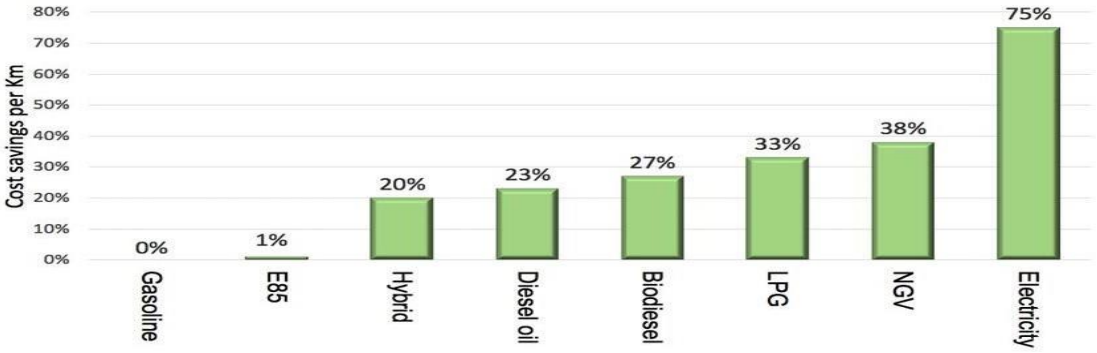

Fig1: Comparison of savings in terms of cost per km offered by vehicles

On the other hand, EVs confront a few noteworthy battery-related challenges:

• **Driving Run:** The ordinary driving run for most EVs is between 200 to 350 km on a full charge.[6] Be that as it may, headways are being made to move forward this run. For occasion, the Nissan Leaf offers a most extreme run of 364 km, whereas the Tesla Demonstrate S can accomplish over 500 km, tending to concerns approximately extend uneasiness for longer trips .

• **Charging Time:** Charging an EV can be time-intensive. A total charge can take anyplace from 4 to 8 hours. Indeed with quick charging, coming to 80% capacity may take around 30 minutes. For illustration, Tesla's Superchargers can charge the Show S up to 50% in around 20 minutes and 80% in roughly 30 minutes, in spite of the fact that these times can change based on charging framework[7].

• **Battery Costs:** The taken a toll of expansive battery packs remains a critical calculate within the generally cost of EVs[8]. Whereas battery costs have been diminishing due to mechanical progressions and expanded generation, they still speak to a considerable speculation for buyers[9].

• **Bulk and Weight:** Battery packs are overwhelming and involve significant space inside the vehicle. The normal weight of an EV battery is around 200 kg [10], in spite of the fact that this may shift depending on the particular battery capacity and plan. This included weight can impact vehicle productivity and taking care of.

Within the coming years, electric vehicles (EVs) will play a pivotal part within the improvement of shrewd cities in India, nearby shared versatility arrangements and improved open transport frameworks. To back this move, critical endeavors must center on progressing the EV charging foundation and progressing battery advances[11].

One of the essential challenges confronting EV appropriation in India is restricted driving extend, or independence. Analysts and producers are effectively investigating inventive battery innovations to improve driving extend, diminish charging times, lower weight, and diminish costs [12]. Tending to these challenges will be essential for the far reaching acceptance and victory of EVs in India, eventually forming the long run of transportation within the nation[13].

2. EXISTING EV RELATED SURVEYS

In recent years, there has been significant progress in the production, technology adoption, and sales growth of electric vehicles (EVs)[14]. This has led to increased research efforts and the creation of new jobs related to EVs. Many studies have examined the historical evolution of EVs, the impact on electrical infrastructure, and the integration of renewable energy sources into the EV sector[15]. Researchers have also analyzed the environmental impacts of

different types of EVs, such as Hybrid Electric Vehicles (HEVs) and Battery Electric Vehicles (BEVs)[16]. Strategies for charging EVs, including vehicle-to-grid (V2G) technology, have been discussed, along with challenges related to charging infrastructure for Plug-in Hybrid Electric Vehicles (PHEVs) and BEVs[17].

One study focused on the emerging economic model associated with EVs, exploring unidirectional and bidirectional energy flows and the potential of EVs as energy storage solutions for renewable energy. Various optimization strategies for V2G technology were categorized by objectives such as operation costs, profit, and support for renewable energy generation. Intelligent charging methods for fleet operators were also discussed, along with strategies for addressing charging infrastructure challenges in different contexts[18].

The integration of EVs into smart grids has also been examined, with a focus on mitigating renewable energy source intermittency [19] through vehicle-to-grid technology. Discussions have also included energy transfer, grid integration, and distributed energy resources in the Internet of Energy (IoE)[20]. The influence of future connected EVs and autonomous driving on EV charging and grid integration has been evaluated, along with advancements in Big Data analytics for battery health estimation and machine learning systems for predicting battery aging[21].

Overall, research on EVs has concentrated on understanding the impacts of EV charging on electric demand, the use of renewable energy for charging, and the development of new optimization methods for charging infrastructure[22]. This paper provides an overview of the current state of the electric vehicle market, key battery characteristics, technologies, and charging processes, while addressing the challenges faced by EVs and outlining areas for future exploration in research[23].

3. ELECTRIC VECHICLES

In this area, we classify the different sorts of electric vehicles (EVs) and highlight their fundamental characteristics. We moreover analyze the current showcase circumstance by looking at deals information for these vehicles and giving deals estimates for diverse nations around the world[24]. This diagram will offer assistance outline the advancing scene of the EV showcase, counting patterns in buyer selection and the variables impacting development in different districts[25].

Nowadays, electric vehicles (EVs) can be categorized based on their motor innovation, ordinarily isolated into five sorts (see Figure 2):Electric vehicles (EVs) can be classified into a few sorts based on their motor innovation, each with oneof a kind characteristics:

1. Battery Electric Vehicles (BEVs): These vehicles are totally fueled by power, highlighting no inner combustion motor or fluid fuel utilize. BEVs ordinarily utilize huge battery packs to supply satisfactory extend, ordinarily accomplishing between 160 to 250 km on a single charge, with a few

models competent of up to 500 km. For instance, the Nissan Leaf could be a completely electric vehicle prepared with a 62 kWh battery, advertising an independence of around 360 km[26].

2. Plug-In Cross breed Electric Vehicles (PHEVs): PHEVs combine a routine combustion motor with an electric engine, which can be charged from an outside electric source. They store sufficient power to essentially lower fuel utilization amid standard driving. The Mitsubishi Outlander PHEV highlights a 12 kWh battery, permitting around 50 km of all-electric driving. In any case, real-world fuel utilization may surpass producer gauges.

3. Half breed Electric Vehicles (HEVs): These vehicles work utilizing both a conventional inside combustion motor and an electric engine, but they cannot be stopped into the network. Instep, their batteries are charged by the combustion motor and through regenerative braking, which captures motor vitality. The Toyota Prius (4th era) may be a noticeable example, equipped with a 1.3 kWh battery that gives an electric-only extend of approximately 25 km[27].

4. Fuel Cell Electric Vehicles (FCEVs): FCEVs utilize a hydrogen fuel cell to create power, emanating as it were water vapor as a byproduct. Whereas showcased as zero-emission vehicles, it's vital to note that most hydrogen is as of now delivered from natural gas, though green hydrogen is an developing elective. The Hyundai Nexo FCEV embodies this category, bragging a extend of 650 km on a full tank[28].

5. Extended-Range Electric Vehicles (ER-EVs): Comparative to BEVs, ER-EVs include an extra combustion motor that serves exclusively to energize the batteries, instead of controlling the wheels. The BMW i3 is an case, including a 42.2 kWh battery for an electric run of 260 km, supplemented by an extra 130 km from the combustion m otor when required[29].

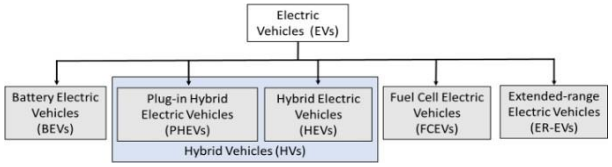

Figure 2 illustrates the classification of electric vehicles based on their engine technologies and configurations.

3.1 MARKET POSITIONS

Deals of electric cars begun from a moo base but are developing rapidly in numerous markets.Globally, around 1-in-4 modern cars sold were electric in 2023. This share was over 90% in Norway, and in China, it was nearly 40%.In the chart underneath, we are able investigate these patterns over the world.Here, “electric cars incorporate completely battery-electric vehicles and plug-in crossovers[30].

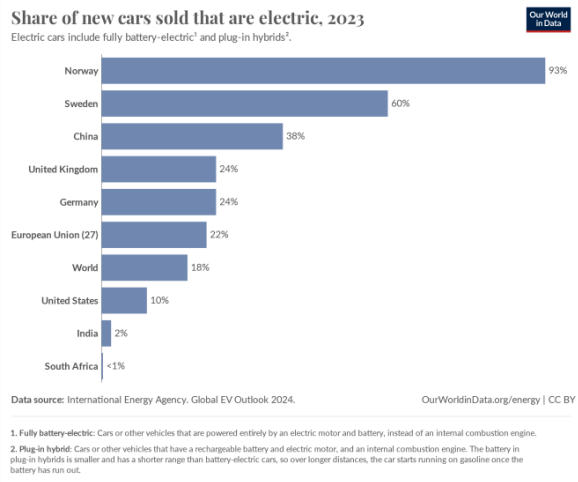

Fig 3: Electric Cars Shares in 2023

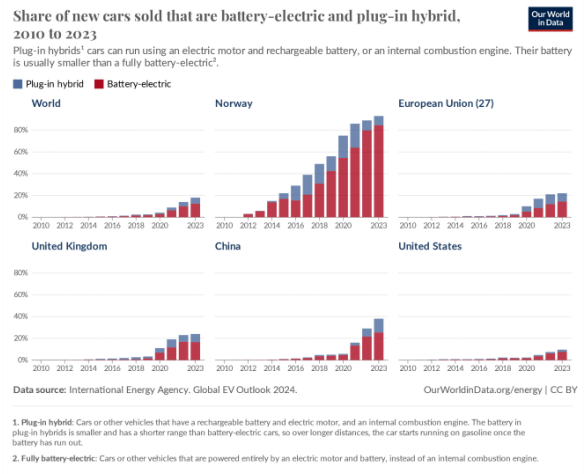

Fig 4 : Shares of Cars sold Battery – Electric and plug – in hybrid.

3.2 FULLY – ELECTRIC CARS VS PLUG IN HYBRIDS

electric powered vehicles can embody both battery-electric powered and plug-in hybrid motors. The primary difference is that battery-electric cars do no longer have an internal combustion engine, even as plug-in hybrids have each a chargeable battery and electric motor, in addition to an inner combustion engine that runs on gasoline. Plug-in hybrids may be driven as a conventional petrol automobile if the battery isn't always charged. while plug-in hybrids emit more carbon than battery-electric powered motors, they normally have decrease emissions than traditional petrol or diesel motors. the article additionally presents statistics on the proportion of electric vehicles sold which are completely battery-electric [31].

4. BATTERY ELECTRIC VECHICLES

Battery electric vehicles (BEVs) are fully electric vehicles that rely on rechargeable battery packs for power, without any gasoline engines. They play a crucial role in reducing carbon dioxide emissions from light-duty vehicles and decreasing reliance on fossil fuels. In India, BEVs held a significant market share, with over 70% of electric vehicle sales in 2017, and this trend is expected to grow. Lead-acid, nickel-metal hydride, and lithium-ion batteries are the options used in the Indian market, with Maharashtra leading in electric car sales in 2017.

Research has focused on evaluating the state of charge (SOC) and state of health (SOH) of hybrid and battery electric vehicles. BEVs are characterized by their reliance on batteries to replace internal combustion engines. Lithium-ion batteries are preferred for hybrid and electric vehicles due to their high energy density, long lifecycle, and

efficiency. EVs can be categorized based on factors such as charging time, driving range, and maximum load capacity, with some achieving top speeds of up to 160 km/h. Interest in hybrid electric vehicles is growing in developing countries like India, with advancements in EV technology expected to drive future developments in the industry[32].

Fig 5. Difference between Electric Vehicles Vs. Hybrid Vehicle.

Specifications	Hybrid Cars	Electric Cars
Power/Fuel Source	Electricity and Fossil Fuel (Petrol and Diesel)	Electricity Through Battery Pack (DC)
Engine	Internal Combustion Engine (ICE) and Electric Motor(s)	Electric Motor(s)
Fuel Efficiency	Combination of ICE and Battery Range	Depends on Battery Range
Emission Levels	Higher Compared to Electric Cars	Lower Compared to ICE and Hybrid Cars
Price Range	Similar to Conventional ICE Cars	High
Charging	Not Needed	Needed

4.1 BATTERY THERMAL MANAGENENT SYSTEM

The selection of electric vehicles (EVs) is anticipated to extend altogether within the close future, highlighting the critical require for the advancement of compelling battery innovations. A major challenge in this region is warm corruption, which impacts the execution and extend of EVs. The essential objective of a Battery Warm Administration Framework (BTMS) is to control the temperature of battery cells to improve their life expectancy. Lithium-ion (Li-ion) batteries are ordinarily favored for vitality capacity in electric vehicles due to their tall vitality thickness and proficiency.

In any case, a few challenges endure, counting diminished effectiveness at extraordinary temperatures, quickened debasement of anodes at tall temperatures, and the related dangers of warm runaway. These components can straightforwardly influence the execution, unwavering quality, and security of the vehicle[33]. Hence, actualizing an compelling warm administration framework is pivotal for the long-term victory of electric vehicles. In a perfect world, Li-ion batteries work ideally between 25 °C and 40 °C, and temperatures surpassing 50 °C can essentially abbreviate their life expectancy. Tending to these warm challenges will be basic for maximizing the execution and security of EV batteries

4.2 TO ELECTRIC VEHICLE BATTERY BARRIERS.

In 2023, the EV market is rapidly expanding, driven by automakers shifting towards electrification and governments sets ambitious targets to reduce carbon emissions. Despite the numerous benefits of EVs such as lower emissions and operating costs, there are many challenges which hindering their widespread adoption. As we know International Energy Agency projects that EVs will make up 60% of global vehicle sales by 2030, up from14% in 2022.

Various obstacles, including high initial expenses, variety anxiety, charging infrastructure obstacles, and battery generation issues, need to be addressed to facilitate the mass adoption of EVs. Understanding and overcoming these challenges are crucial for establishing a sustainable and environmentally friendly transportation system. With continuous advancements in technology and infrastructure, the EV market holds immense potential for growth.

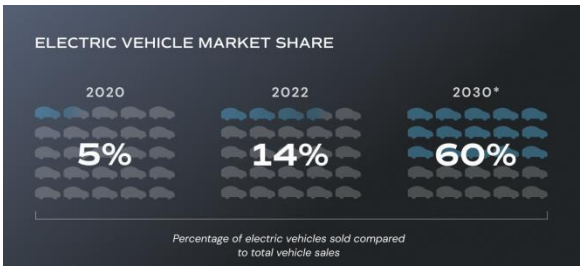

Fig 6 : EV Market Share

4.3 HIGH UP FRONT COSTS

The main barrier for consumers in adopting electric vehicles (EVs) is the higher initial purchase price compared to traditional Internal Combustion Engine (ICE) vehicles. As per records of March 2023, the average cost of a new vehicle was US$48,008, while the average EV cost was US$58,940, making EVs approximately 23% more expensive. In the United States, incentives like the EV Tax Credit offer a US$7,500 credit towards new EV purchases, reducing the average cost to around US$51,440. Despite rising automobile expenses, automakers like Tesla, Chevrolet, and Hyundai have been able to decrease base version costs every yr by means of introducing extra efficient era improvements inside the powertrain. as an instance, Tesla's version 3 base model dropped through US$3,000 to a starting price of US$43,990 as of January 2023[34].

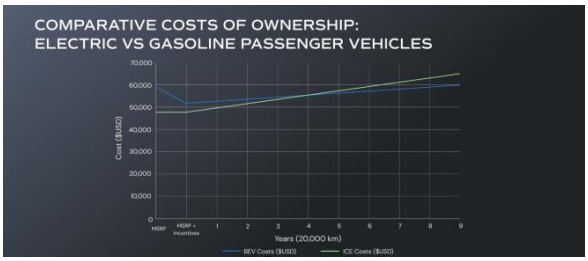

Fig 7 :Comparative Costs Of Ownership Electric vs Gasoline Vehicles

According to a study, EVs cost $485 per year for electricity compared to $1,117 per year for gasoline. In addition to lower fuel costs, EVs also have lower maintenance costs due to having fewer mechanical parts that final longer. client reports discovered that the lifetime repair and renovation expenses for an EV powertrain are $4,600, compared to $9,200 for an internal combustion engine (ICE) powertrain. EVs also benefit from regenerative braking, which not only extends the life of the brakes but also reduces energy waste, making them more efficient and environmentally friendly. Despite the higher upfront cost of EVs, savings from incentives and lower operating costs can make them a more cost- effective option in the long run as technology advances and prices decrease.

4.4 BATTERY TECHNOLOGY:

Fig 8 :65% Increase in Demand for Li-on Batteries in 2022

The heart of the transformation in the EV industry lies in lithium-ion battery technology, which saw a significant 65%

increase in demand in 2022, reaching 550 GWh globally. This surge was driven by a 55% growth in electric passenger vehicle sales, with the United States experiencing an even higher demand increase of 80%. As battery demand rises, so does the need for key materials like lithium, cobalt, and nickel, with 60% of lithium, 30% of cobalt, and 10% of nickel being directed towards EV batteries in 2022.

Addressing end-of-life concerns for EV batteries is becoming increasingly important, with Exro Advances leading the way in innovative solutions to extend battery life and reduce environmental impact. By repurposing batteries for 2d-lifestyles applications, the demand for brand spanking new mining sports may be decreased, aligning with sustainability goals and minimizing the environmental footprint of the EV industry.

As the industry looks towards a more sustainable and economically viable future for electric mobility, advancements in battery technology and reuse offer promising solutions. However, challenges related to material availability, cost flow, and global supply chains must be overcome to ensure widespread EV adoption. By improving and adapting to these complexities, the industry can pave the way for a more environmentally friendly and efficient electric vehicle market[35].

4.5 EV PERFORMANCE

EVs have made considerable strides in latest years, presenting cleaner and extra sustainable transportation alternatives. but, despite the numerous benefits they bring about to the desk, there are still overall performance demanding situations that influence customer perceptions and adoption charges.

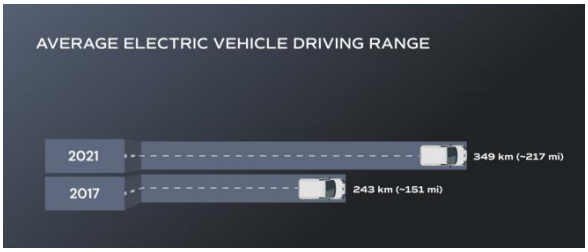

Fig 9 : The Average Driving Range

5. SOLUTION TO OVERCOME CHALLENGES AND BARRIERS

To address obstacles and challenges in electric vehicle (EV) adoption, several strategies can be implemented:

1. High Initial Costs - Governments can offer incentives like tax credits, rebates, and subsidies to reduce the purchase price of EVs.
- Provide financing options with low-interest loans to make EVs more affordable.
- Encourage automakers to invest in production efficiency to lower manufacturing costs.
2. Battery Technology Challenges - Invest in research and development for sustainable battery technologies like solid-state or sodium-ion batteries.
- Promote battery recycling programs to recover valuable materials and reduce the need for new mining.

- Explore repurposing EV batteries for energy storage systems to extend their lifespan.

3. Range Anxiety and Performance Issues - Launch awareness campaigns to educate consumers about EV capabilities and trip planning.
- Improve battery efficiency and range through innovation.
- Develop technologies to manage battery performance in cold weather conditions.

4. Charging Infrastructure - Governments should invest in expanding public charging networks and incentivize private companies to create charging infrastructure.
- Upgrade the electrical grid to support increased demand for charging stations and integrate renewable energy sources.
- Promote standardized charging solutions for easier compatibility across different EV models.

5. Regulatory Support and Collaboration - Establish clear policies that support EV infrastructure development.

- Foster collaboration between governments, automakers, utilities, and other stakeholders to align goals and resources for EV adoption.

6. Community Engagement - Encourage local governments to create initiatives supporting EV adoption like car-sharing programs.
- Develop feedback mechanisms to address community concerns and customize solutions accordingly.

6. CONCLUSION

By tending to these boundaries with focused on methodologies, we are able cultivate a more steady environment for electric vehicle appropriation. Collaboration between governments, industry, and shoppers is basic to encourage the transition to cleaner, maintainable transportation arrangements. Through these endeavors, able to not as it were increment EV selection but moreover contribute to broader natural objectives and a more maintainable future.

7. REFERENCES

[1] European Commission. Transport in Figures'—Statistical Pocketbook. 2011. Available online: **https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2011_en/** (accessed on 21 February 2021).

[2] Chan, C.C. The state of the art of electric, hybrid, and fuel cell vehicles. *Proc. IEEE* **2007**, *95*, 704–718. [**Google Scholar**] [**CrossRef**]

[3] Albatayneh, A.; Assaf, M.N.; Alterman, D.; Jaradat, M. Comparison of the Overall Energy Efficiency for Internal Combustion Engine Vehicles and Electric Vehicles. *Environ. Clim. Technol.* **2020**, *24*, 669–680. [**Google Scholar**]

[4] OECD iLibrary. *Non-Exhaust Particulate Emissions from Road Transport: An Ignored Environmental Policy Challenge*; Technical Report; OECD Publishing: Paris, France, 2020; Available online: **https://doi.org/10.1787/4a4dc6ca-en** (accessed on 22 February 2021).

[5] BlázquezLidoy, J.; Martín Moreno, J.M.

Eficienciaenergéticaen la automoción, elvehículoeléctrico, un reto del presente. *Econ. Ind.* **2010**, *377*, 76–85. [Google Scholar]

[6] Nissan. Nissan Leaf. Available online: https://www.nissan.co.uk/vehicles/new-vehicles/leaf/range-charging.html (accessed on 20 February 2021).

[7] Tesla. Tesla Official Website. 2019. Available online: https://www.tesla.com/en_EU/supercharger (accessed on 21 February 2021).

[8] Berjoza, D.; Jurgena, I. Effects of change in the weight of electric vehicles on their performance characteristics. *Agron. Res.* **2017**, *15*, 952–963. [Google Scholar]

[9] Yong, J.Y.; Ramachandaramurthy, V.K.; Tan, K.M.; Mithulananthan, N. A review on the state-of-the-art technologies of electric vehicle, its impacts and prospects. *Renew. Sustain. Energy Rev.* **2015**, *49*, 365–385. [Google Scholar] [CrossRef]

[10] Richardson, D.B. Electric vehicles and the electric grid: A review of modeling approaches, Impacts, and renewable energy integration. *Renew. Sustain. Energy Rev.* **2013**, *19*, 247–254. [Google Scholar] [CrossRef]

[11] Habib, S.; Kamran, M.; Rashid, U. Impact analysis of vehicle-to-grid technology and charging strategies of electric vehicles on distribution networks—A review. *J. Power Sources* **2015**, *277*, 205–214. [Google Scholar] [CrossRef]

[12] Liu, L.; Kong, F.; Liu, X.; Peng, Y.; Wang, Q. A review on electric vehicles interacting with renewable energy in smart grid. *Renew. Sustain. Energy Rev.* **2015**, *51*, 648–661. [Google Scholar] [CrossRef]

[13] Hawkins, T.R.; Gausen, O.M.; Strømman, A.H. Environmental impacts of hybrid and electric vehicles—A review. *Int. J. Life Cycle Assess.* **2012**, *17*, 997–1014. [Google Scholar] [CrossRef]

[14] Vasant, P.; Marmolejo, J.A.; Litvinchev, I.; Aguilar, R.R. Nature-inspired meta-heuristics approaches for charging plug-in hybrid electric vehicle. *Wirel. Netw.* **2019**, *26*, 4753–4766. [Google Scholar] [CrossRef]

[15] Shuai, W.; Maillé, P.; Pelov, A. Charging electric vehicles in the smart city: A survey of economy-driven approaches. *IEEE Trans. Intell. Transp. Syst.* **2016**, *17*, 2089–2106. [Google Scholar] [CrossRef] [Green Version]

[16] Tan, K.M.; Ramachandaramurthy, V.K.; Yong, J.Y. Integration of electric vehicles in smart grid: A review on vehicle to grid technologies and optimization techniques. *Renew. Sustain. Energy Rev.* **2016**, *53*, 720–732. [Google Scholar] [CrossRef]

[17] Hu, J.; Morais, H.; Sousa, T.; Lind, M. Electric vehicle fleet management in smart grids: A review of services, optimization and control aspects. *Renew. Sustain. Energy Rev.* **2016**, *56*, 1207–1226. [Google Scholar] [CrossRef] [Green Version]

[18] Rahman, I.; Vasant, P.M.; Singh, B.S.M.; Abdullah-Al-Wadud, M.; Adnan, N. Review of recent trends in optimization techniques for plug-in hybrid, and electric vehicle charging infrastructures. *Renew. Sustain. Energy Rev.* **2016**, *58*, 1039–1047.

[Google Scholar] [CrossRef]

[19] Mahmud, K.; Town, G.E.; Morsalin, S.; Hossain, M. Integration of electric vehicles and management in the internet of energy. *Renew. Sustain. Energy Rev.* **2018**, *82*, 4179–4203. [Google Scholar] [CrossRef]

[20] Das, H.; Rahman, M.; Li, S.; Tan, C. Electric vehicles standards, charging infrastructure, and impact on grid integration: A technological review. *Renew. Sustain. Energy Rev.* **2020**, *120*, 109618. [Google Scholar] [CrossRef]

[21] Li, Y.; Liu, K.; Foley, A.M.; Zülke, A.; Berecibar, M.; Nanini-Maury, E.; Van Mierlo, J.; Hoster, H.E. Data-driven health estimation and lifetime prediction of lithium-ion batteries: A review. *Renew. Sustain. Energy Rev.* **2019**, *113*, 109254. [Google Scholar] [CrossRef]

[22] Liu, K.; Li, Y.; Hu, X.; Lucu, M.; Widanage, W.D. Gaussian Process Regression With Automatic Relevance Determination Kernel for Calendar Aging Prediction of Lithium-Ion Batteries. *IEEE Trans. Ind. Inform.* **2020**, *16*, 3767–3777. [Google Scholar] [CrossRef] [Green Version]

[23] Hu, X.; Zhang, K.; Liu, K.; Lin, X.; Dey, S.; Onori, S. Advanced Fault Diagnosis for Lithium-Ion Battery Systems: A Review of Fault Mechanisms, Fault Features, and Diagnosis Procedures. *IEEE Ind. Electron. Mag.* **2020**, *14*, 65–91. [Google Scholar] [CrossRef]

[24] insideEVs. Nissan Reveals LEAF e-Plus: 62 kWh Battery, 226-Mile Range. 2019. Available online: https://insideevs.com/nissan-reveals-leaf-e-plus-ces/ (accessed on 17 February 2021).

[25] Mitsubishi Motors. Mitsubishi Outlander PHEV 2018. 2019. Available online: https://www.mitsubishicars.com/outlander-phev/2018/specifications (accessed on 17 February 2021).

[26] Plötz, P.; Moll, C.; Bieker, G.; Mock, P.; Li, Y. *Real-World Usage of Plug-In Hybrid Electric Vehicles: Fuel Consumption, Electric Driving, and CO_2 Emissions*; Technical Report; International Council on Clean Transportation Europe (ICCT): Washington, DC, USA, 2020; Available online: https://theicct.org/sites/default/files/publications/PHEV-white%20paper-sept2020-0.pdf (accessed on 22 February 2021).

[27] The Car Guide. 2014 Toyota Prius PHV: To Plug in or Not to Plug in? 2014. Available online: https://www.guideautoweb.com/en/articles/21152/2014-toyota-prius-phv-to-plug-in-or-not-to-plug-in/ (accessed on 21 February 2021).

[28] Hyundai. All-New Hyundai NEXO—Technical Specifications. 2019. Available online: https://www.hyundai.news/eu/press-kits/all-new-hyundai-nexo-technical-specifications/ (accessed on 21 February 2021).

[29] insideEVs. 2019 BMW i3, i3 REx, i3s & i3s REx: Full Specs. 2019. Available online: https://insideevs.com/2019-bmw-i3-rex-i3s-rex-full-spec/ (accessed on 21 February 2021).

[30] Sanguesa, J.A.; Torres-Sanz, V.; Garrido, P.; Martinez, F.J.; Marquez-Barja, J.M. A Review on Electric Vehicles: Technologies and Challenges. *Smart Cities* **2021**, *4*, 372-404. *Smart Cities* **2021**, *4*(1), 372404; **https://doi.org/10.3390/smartcities4010022**

[31] https:www.goldmansachs.com/insights

Google Scholar

[32] https://en.wikipedia.org/wiki/Electric_vehicle_industry_in_India

Google Scholar

[33] N. Daina, A. Sivakumar, J.W. PolaModelling electric vehicles use: a survey on the methods

Renew. Sustain. Energy Rev., 68 (2017), pp. 447-460

View PDFViewarticleView in ScopusGoogleScholar

[34] https://www.exro.com/industry-insights/barriers-to-battery-electric-vehicle-adoption#:~:text=Predominant%20factors%20to%20consider%20when,widespread%20adoption%20of%20electric%20vehicles.

[35] https://www.caranddriver.com/news/a43611570/average-new-car-price-down-still-high/