A Study on Minerals Used in Electric Cars Compared to Conventional Cars: Implications for Conventional Vehicle Advantages

Sai Deepak, Manisha Tripathi, Dhanu Shree, Kotni haneesh, Khushal Katariya,Nithish S
Student, Asst. Professor, Student, Student, Student, Student
Center for Management Studies, Jain (deemed-to-be) University, Bangalore, India.

Abstract:

The automotive industry is undergoing a profound transformation driven by the urgency to address environmental concerns associated with conventional internal combustion engine (ICE) vehicles. Electric vehicles (EVs) have emerged as a promising solution, powered by critical minerals used in batteries, motors, and electronics. This study examines the environmental impact, availability, sourcing challenges, and implications of these minerals in comparison to conventional vehicles. Key concerns include the resource intensiveness of EV production, environmental impacts of mineral extraction, supply chain vulnerabilities, recycling challenges, and the role of clean energy sources. By addressing these issues, we aim to shed light on the evolving landscape of automotive technology and the potential shifts in advantages and disadvantages between EVs and conventional vehicles. This research informs policymakers, manufacturers, and consumers in the pursuit of sustainable transportation solutions.

Keywords: Electric vehicles (EVs), Conventional vehicles, Environmental impact, Sustainability, Critical minerals, Mineral extraction, Mineral sourcing, Mineral recycling, Supply chain analysis, Comparative research, Battery technology, Life Cycle Assessment (LCA), Environmental footprint, Mineral utilization, Sustainable transportation, Energy sources, Policy recommendations, Recycling infrastructure, Geopolitical vulnerabilities, Resource efficiency.

Introduction:

The global automotive landscape is currently undergoing a profound and transformative shift, driven by the urgent need to mitigate the environmental impacts associated with conventional internal combustion engine (ICE) vehicles. As concerns surrounding climate change, air quality, and fossil fuel dependency continue to escalate, electric vehicles (EVs) have emerged as a promising solution, poised to usher in a more sustainable era of transportation. At the heart of this transition lie the critical minerals that constitute the essential components of EVs. Understanding the implications of these minerals in comparison to their counterparts in conventional ICE-powered cars is of utmost importance.

For many decades, traditional internal combustion engine vehicles have heavily relied on fossil fuels, primarily gasoline and diesel, for propulsion. However, the combustion of these fuels has been inexorably linked to the release of greenhouse gases, particulate matter, and other pollutants that not only contribute to air pollution but also exacerbate climate change. In stark contrast, electric vehicles operate using electric motors powered by electricity stored in onboard batteries. This fundamental shift in power source carries the potential to significantly reduce greenhouse gas emissions and diminish the overall environmental footprint of the transportation sector.

A pivotal aspect of this transition to electric vehicles is the pivotal role played by heavy minerals in their production. These minerals are critical for the manufacturing of key components such as batteries, electric motors, and power electronics. While conventional vehicles also rely on minerals, the types and quantities used in EVs diverge substantially due to their distinct propulsion systems. This shift towards electric mobility raises crucial questions concerning the availability, sustainability, and environmental impacts of the minerals utilized in EV production.

Of particular interest is the comparison between the minerals employed in electric cars and those used in conventional vehicles, and the potential ramifications this may have for the advantages traditionally associated with the latter. Conventional vehicles have well-established infrastructures for manufacturing, fueling, and maintenance. Nevertheless, their reliance on internal combustion engines gives rise to challenges linked to emissions, fossil fuel dependency, and urban air quality. A comprehensive understanding of how heavy minerals are employed in electric vehicles in comparison to their use in conventional vehicles can offer profound insights into potential shifts in advantages and drawbacks between these two distinct automotive technologies.

The primary objective of this study is to thoroughly explore and analyze the minerals integral to electric cars, with a specific focus on their environmental impact, availability, sourcing practices, and the implications these factors might hold for the perceived advantages of conventional vehicles. By conducting an exhaustive assessment of the mineral requirements for both electric and conventional vehicles, this research aims to make a meaningful contribution to the ongoing discourse on sustainable transportation options. It also seeks to inform policymakers, manufacturers, and consumers about the evolving landscape of automotive technology.

In the subsequent sections of this research paper, we will delve into the specific minerals that are crucial for electric vehicle production. We will closely examine their applications, delve into the challenges associated with their sourcing, and explore potential environmental considerations. These findings will then be meticulously compared with the mineral requirements of conventional vehicles, with a focus on highlighting the potential shifts in advantages and disadvantages between the two technologies. Through this meticulous analysis, we aspire to provide a nuanced understanding of the mineral-related implications of electric vehicles and their broader impact on the automotive industry.

Statement of Problem

The rapid ascent of electric vehicles (EVs) as an eco-friendly mobility solution raises several pivotal concerns. A paramount issue lies in the resource-intensive nature of EV production, heavily reliant on critical minerals like lithium, cobalt, nickel, and rare earth elements for high-capacity batteries and motors. This escalating demand strains global mineral reserves, prompting concerns about future availability and environmental ramifications of their extraction. Environmental distress deepens as mining these minerals often leads to degradation, habitat disruption, and pollution. Additionally, energy-intensive extraction processes contribute to greenhouse gas emissions, questioning the ecological sustainability of EVs. The intricate global supply chain, often concentrated in geopolitically sensitive regions, presents challenges such as supply disruptions, price volatility, and geopolitical conflicts. Efficient recycling of EV batteries is essential, and the source of electricity for EV charging significantly impacts environmental benefits. Hence, transitioning to cleaner energy sources is imperative. In sum, EV proliferation presents a multifaceted challenge, requiring a balanced approach to address mineral resources, environmental impact, supply chain complexity, recycling, and energy sources for sustainable and eco-friendly transportation.

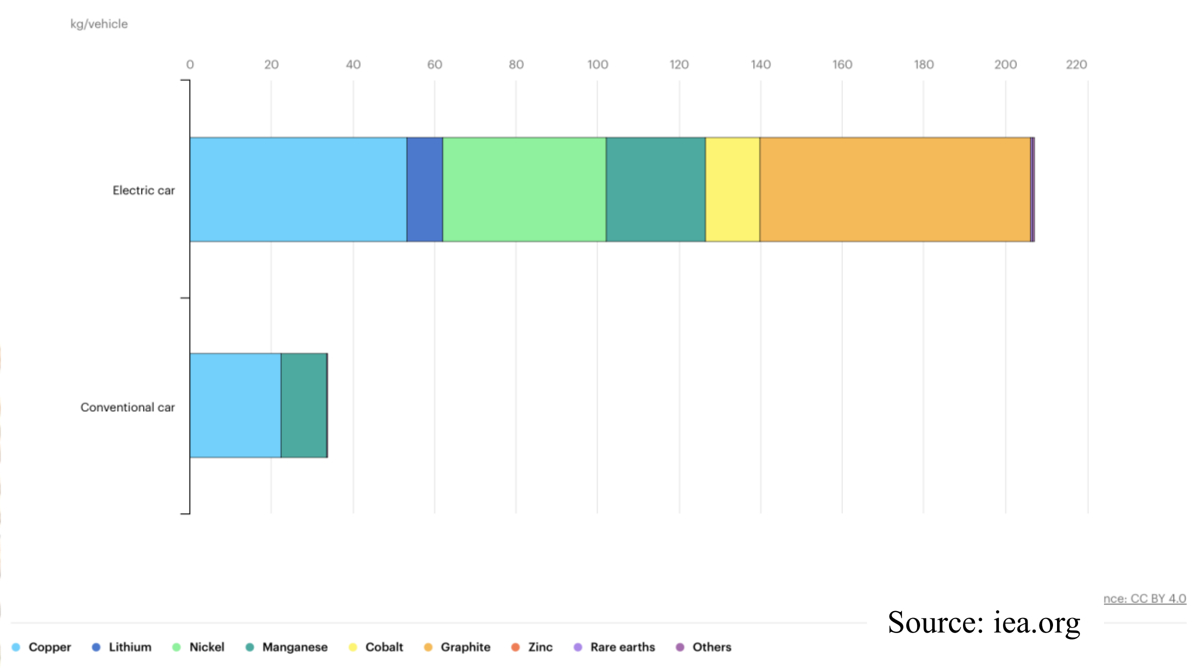
Objective Of Study

1) To analyze the comprehensive role of minerals in EVs vs. Conventional Vehicles, the analysis focuses on comparing the role of minerals in electric vehicles (EVs) with that in conventional vehicles, with a strong emphasis on environmental and sustainability aspects.
2) To understand the assessment of critical minerals, meticulous assessment is conducted to comprehend the types and quantities of critical minerals in EV components such as batteries, motors, and electronics. This assessment aims to reveal disparities in mineral resource utilization between EVs and traditional vehicles.
3) To investigate the environmental impact of mineral extraction, the research aims to understand the environmental impacts of mineral extraction and processing for EVs. This investigation includes factors like habitat disruption, pollution, and greenhouse gas emissions.
4) To scrutinize the global supply chain, an in-depth analysis is conducted to comprehend the global supply chain for these minerals. This analysis aims to identify suppliers, concentrations, and geopolitical vulnerabilities that could potentially impact EV production stability and cost-effectiveness.

5) To evaluate recycling practices, the research seeks to understand current recycling practices for EV batteries. It emphasizes the importance of transitioning to cleaner energy sources for EV charging to maximize environmental benefits.

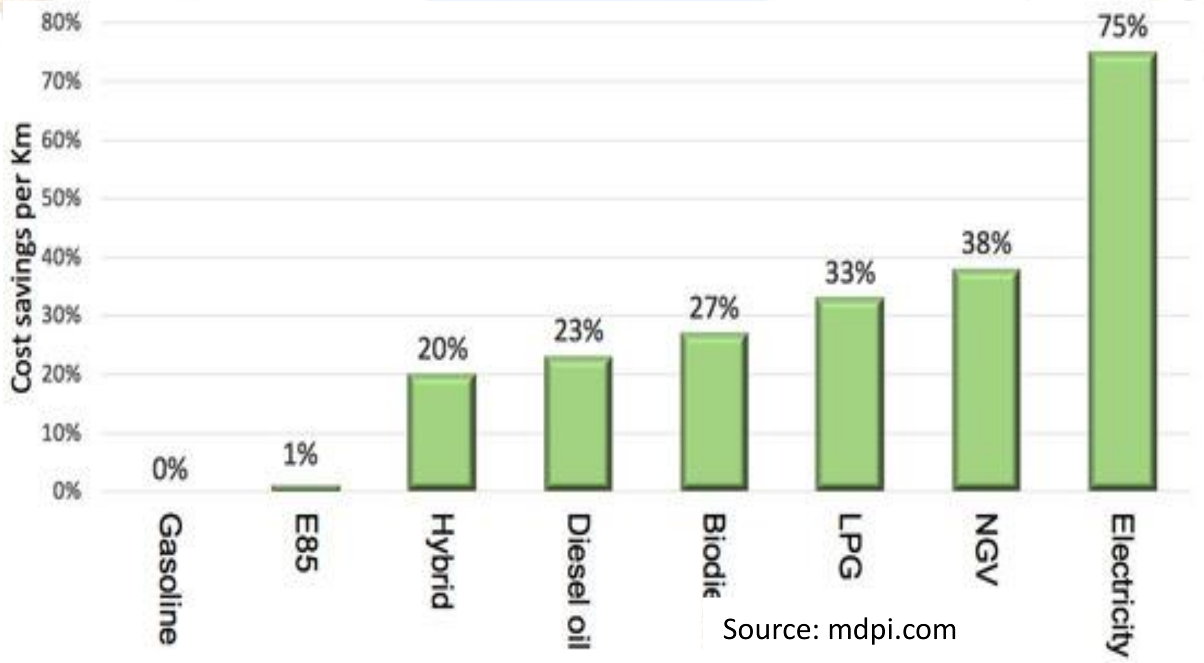
Review of Literature

In this comprehensive literature review on Electric Vehicles (EVs), we embark on a multifaceted exploration of this transformative technology. The central theme is the pivotal role that EVs are poised to play in addressing pressing environmental challenges and ushering in sustainable mobility solutions. We commence by categorizing EVs into five primary types, providing the foundational framework for our analysis. Government incentives, including tax breaks and purchase subsidies, emerge as powerful catalysts in propelling the EV market forward, despite initial cost disparities.



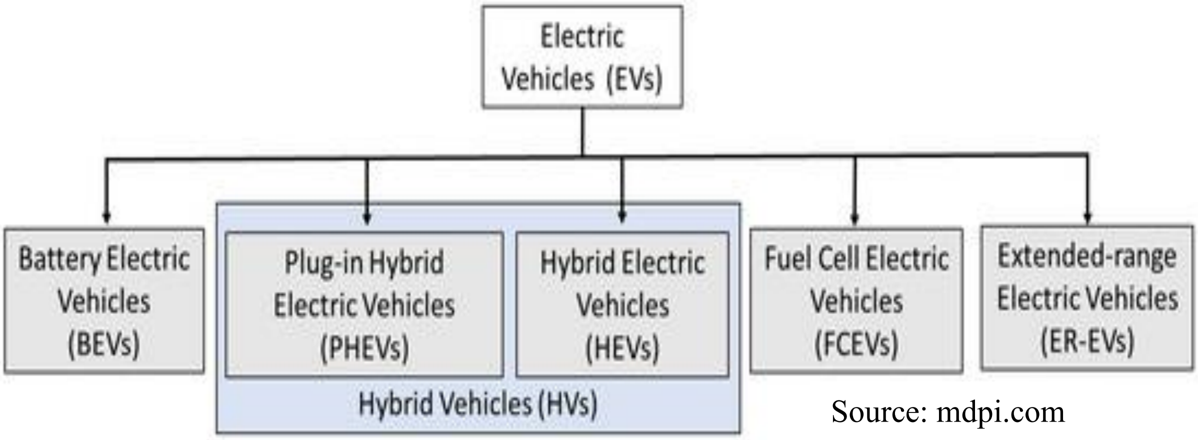
Source: iea.org

Battery technology emerges as a cornerstone in the EV landscape, with discussions spanning advancements, increased production, and the potential game-changing impact of emerging technologies like graphene. Charging infrastructure, both at home and in public stations, assumes a crucial role in facilitating widespread EV adoption. The adaptability of Battery Management Systems (BMS) to evolving battery technologies and Smart City requirements is emphasized for seamless integration.

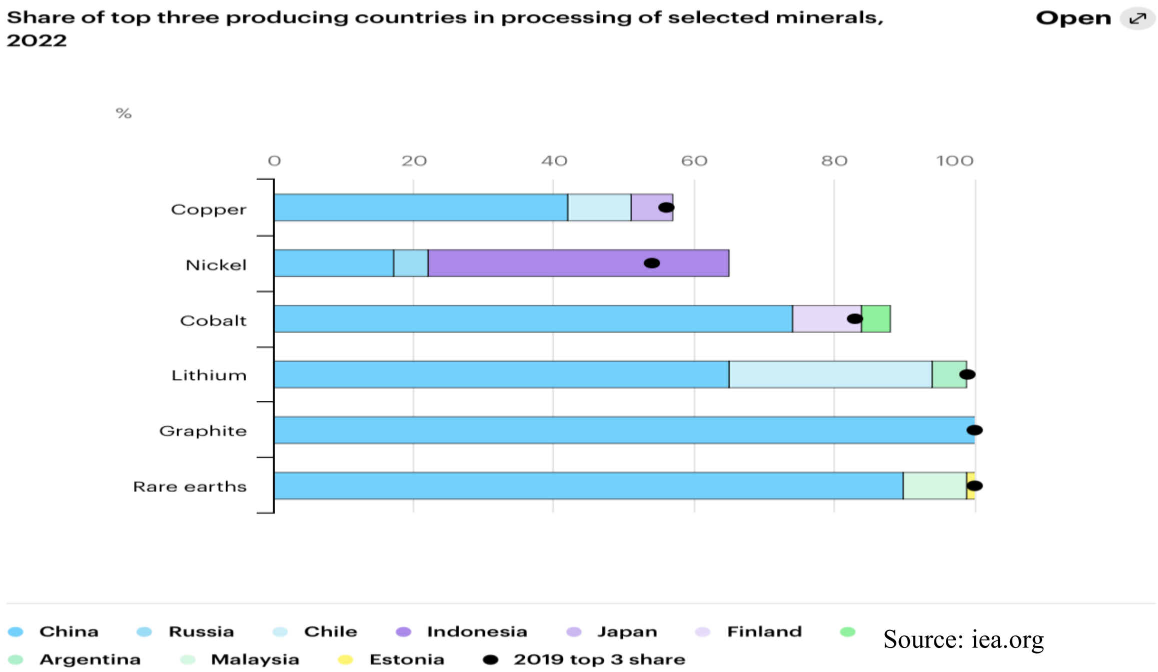


Source: mdpi.com

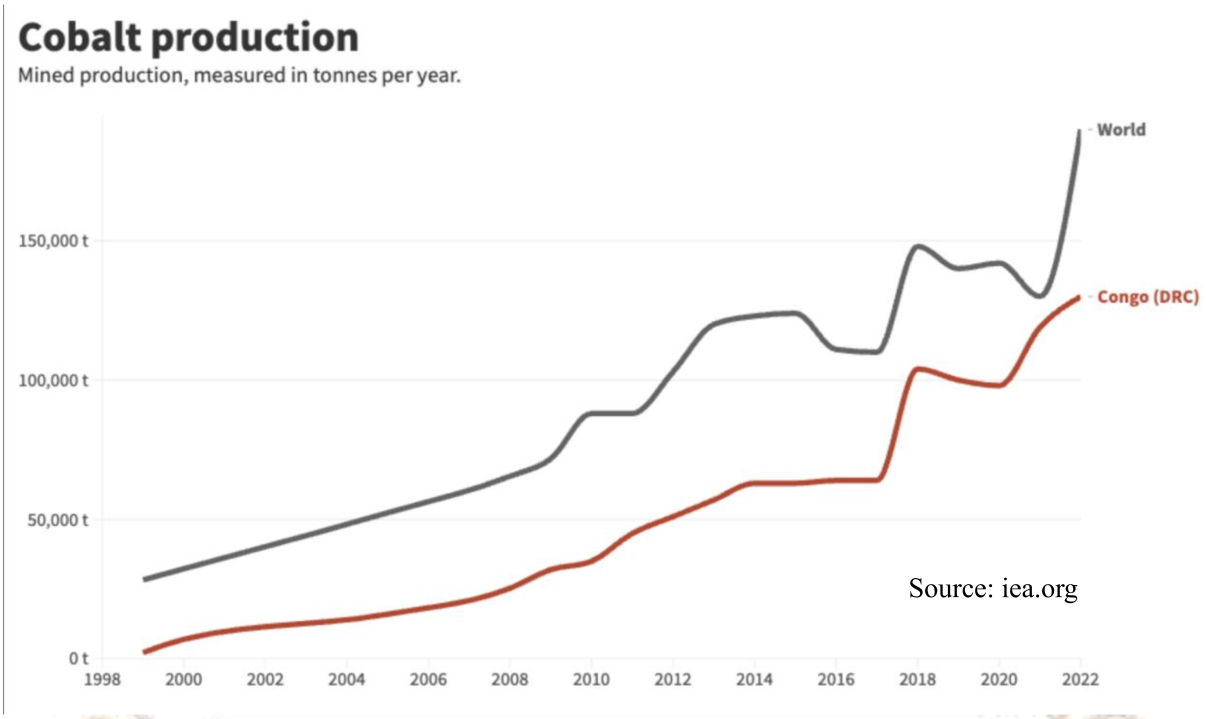
The concept of the "Material Footprint" (MF) is introduced, highlighting its significance in shaping environmental policies and its integration into the assessment of EVs' environmental impact. Recycling essential metals from lithium-ion batteries (LIBs) used in EVs becomes a focal point, and concerns over raw material demand and improper LIB disposal are underlined. Environmental implications of the global shift to EVs are explored, revealing their potential to mitigate emissions while acknowledging the complexity of their environmental impact. Comparative assessments with conventional vehicles throughout their life cycles underscore the need for comprehensive environmental evaluations and mitigation measures. Finally, we examine Brazil's unique journey toward EV adoption, taking into account its biofuel history and emphasizing the role of battery technology, energy management, charging infrastructure, and the contribution of Hybrid Electric Vehicles (HEVs) in this regional context.



Source: mdpi.com



Source: iea.org

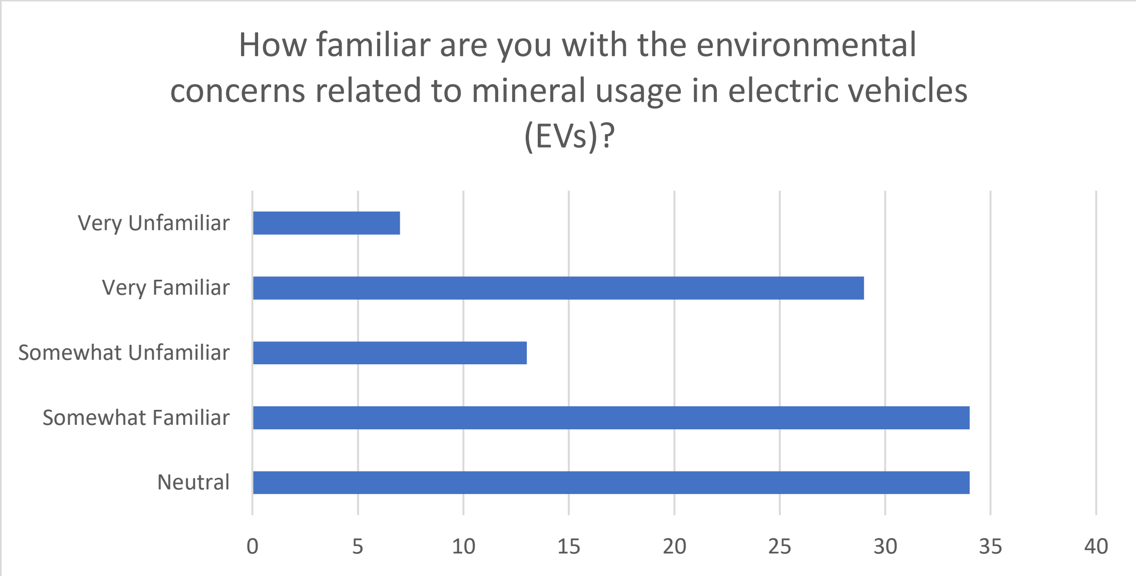


Literature review unveils the multifaceted realm of Electric Vehicles, touching upon their diverse types, the role of government incentives, pivotal battery technology, charging infrastructure, the Material Footprint, recycling processes, environmental impact, and regional considerations. Above all, it emphasizes the central role of EVs in addressing critical environmental challenges and highlights the ongoing imperative for research and development to drive sustainable mobility on a global scale.

Research Methodology

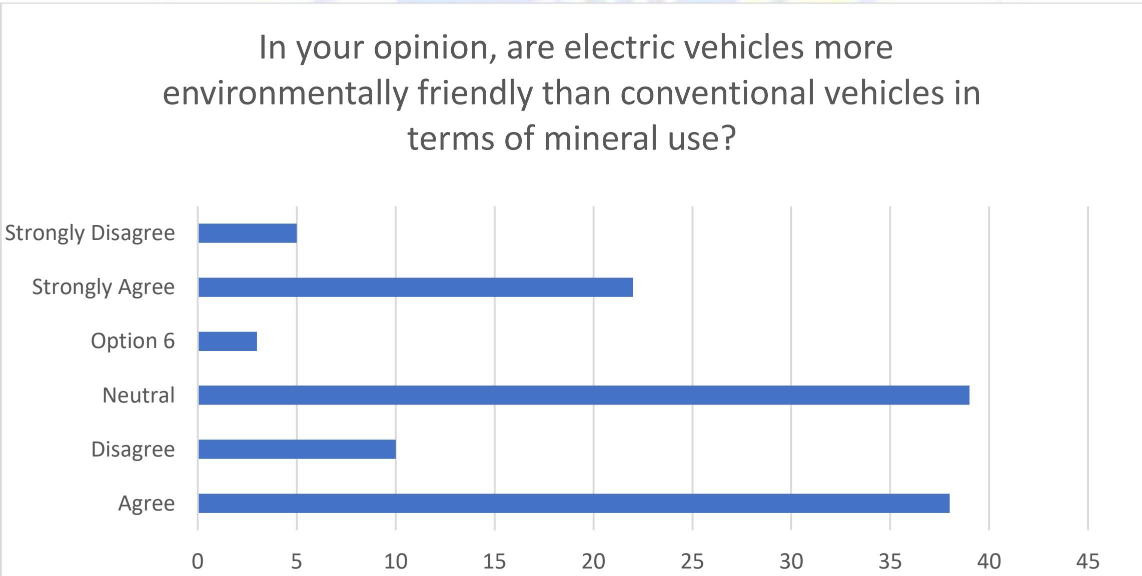
The research methodology for this study adopts a comparative research design to thoroughly investigate the role of minerals in electric vehicles (EVs) versus conventional vehicles, with a specific emphasis on environmental and sustainability considerations. Data collection involves structured surveys targeting automotive manufacturers, mineral suppliers, and recycling facilities to quantify critical mineral usage in both vehicle types and assess environmental impacts using Life Cycle Assessment (LCA) techniques. Supply chain mapping, risk assessment, and recycling infrastructure analysis offer insights into sourcing complexities and recycling practices. Additionally, an evaluation of energy sources for vehicle charging considers emissions and energy generation profiles. The integration of these findings aims to inform policy recommendations and industry-specific guidelines, with dissemination efforts through academic publications and stakeholder engagement to promote sustainable transportation solutions. This methodology provides a holistic understanding of mineral-related implications in EVs and conventional vehicles, contributing to the advancement of sustainable transportation options.

Data Analysis and Interpretation



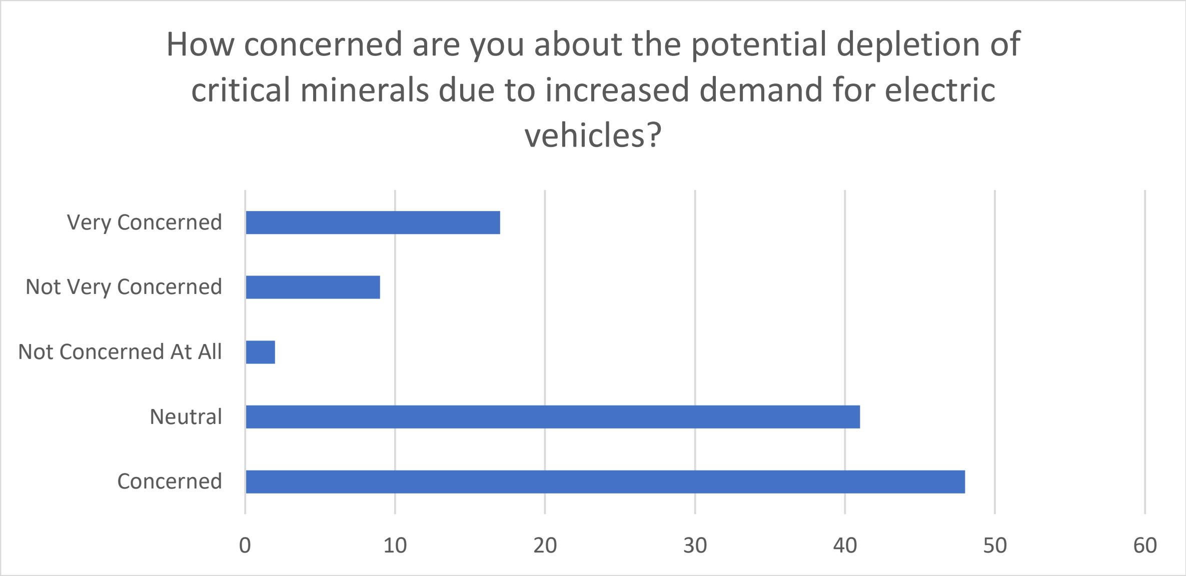
Interpreting this in percentage terms:

1. **24.55**% of respondents are very familiar with the environmental concerns related to mineral usage in EVs.
2. **34.55**% of respondents are somewhat familiar with these concerns.
3. **19.09**% of respondents expressed a neutral stance.
4. **14.55**% of respondents are somewhat unfamiliar with the environmental concerns.
5. **7.27**% of respondents are very unfamiliar with these concerns.



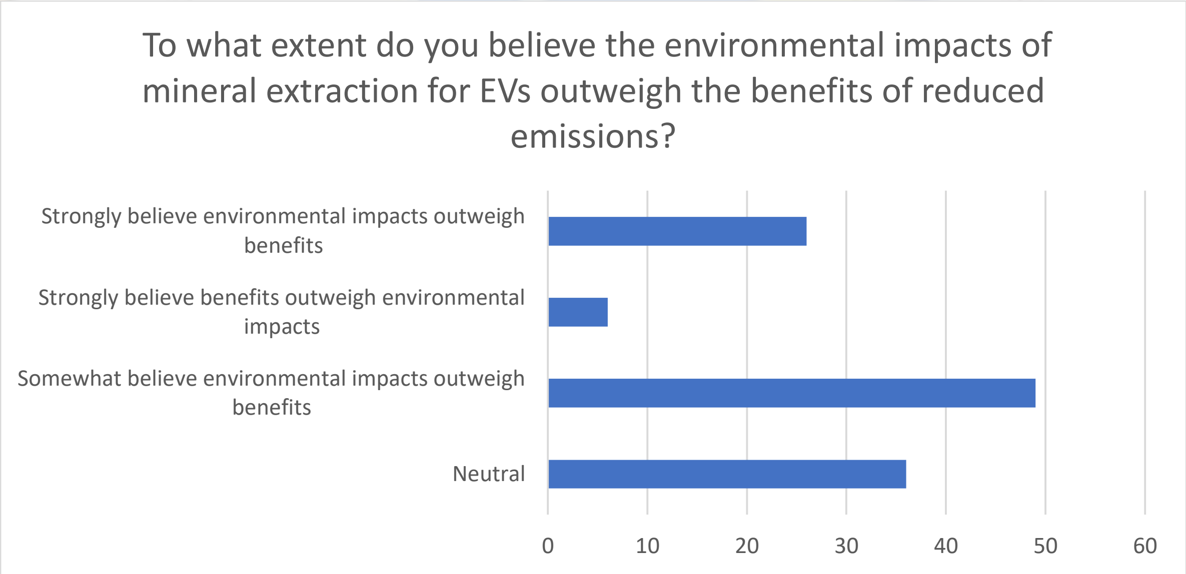
Interpreting this in percentage terms:

1. **26.36**% of respondents strongly agree that electric vehicles are more environmentally friendly than conventional vehicles in terms of mineral use.
2. **34.55**% of respondents agree with this statement.
3. **21.82**% of respondents are neutral on the matter.
4. **9.09**% of respondents disagree.
5. **8.18**% of respondents strongly disagree with the statement.



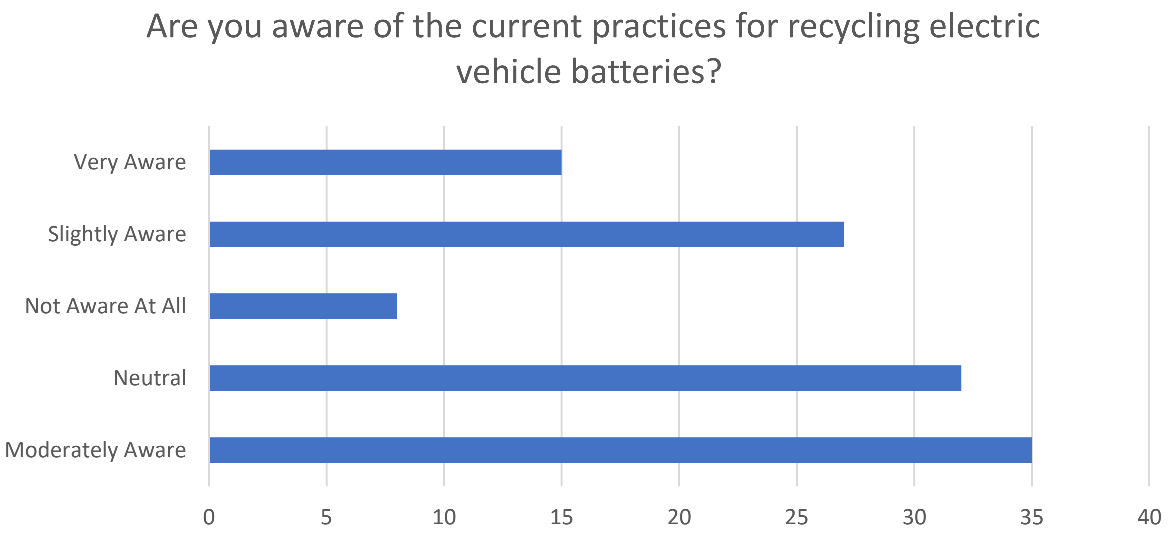
Interpreting this in percentage terms:

1. **22.5**% of respondents are very concerned about the potential depletion of critical minerals due to increased demand for electric vehicles.
2. **44.17**% of respondents are concerned.
3. **24.17**% of respondents are neutral on the matter.
4. **5.83**% of respondents are not very concerned.
5. **3.33**% of respondents are not concerned at all.



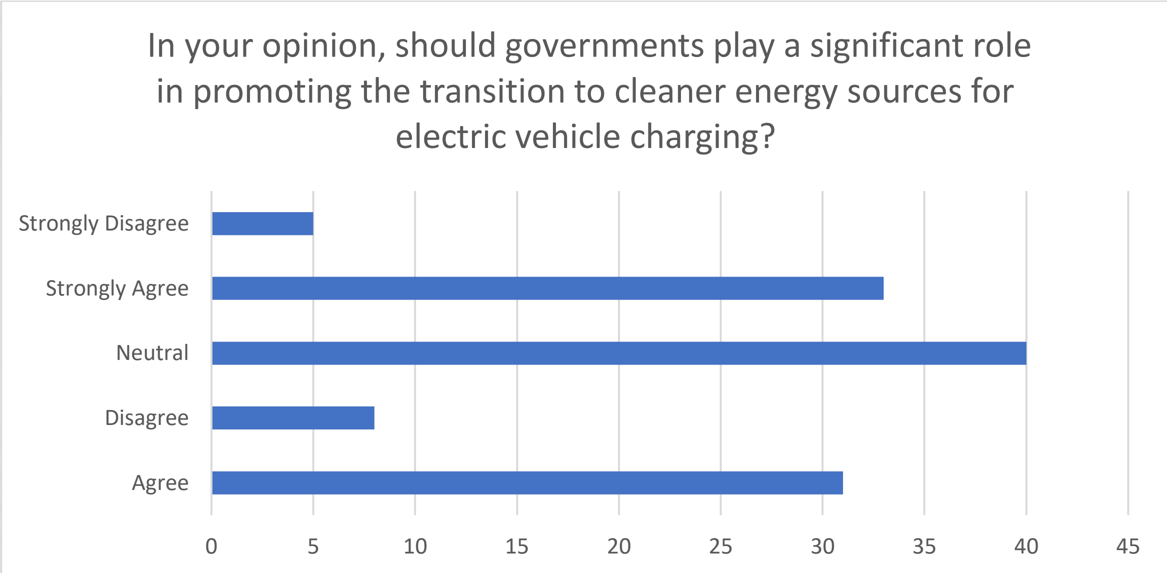
Interpreting this in percentage terms:

1. **27.5**% of respondents strongly believe that the environmental impacts of mineral extraction for EVs outweigh the benefits of reduced emissions.
2. **53.33**% of respondents somewhat believe the environmental impacts outweigh the benefits.
3. **10.83**% of respondents are neutral on the matter.
4. **8.33**% of respondents strongly believe that the benefits of reduced emissions outweigh the environmental impacts.



Interpreting this in percentage terms:

1. **10**% of respondents are very aware of the current practices for recycling EV batteries.
2. **38.57**% of respondents are moderately aware.
3. **15**% of respondents are slightly aware.
4. **29.29**% of respondents are neutral regarding their awareness level.
5. **7.14**% of respondents are not aware at all of the current practices for recycling EV batteries.



Interpreting this in percentage terms:

1. **35.66**% of respondents strongly agree that governments should play a significant role in promoting the transition to cleaner energy sources for EV charging.
2. **33.57**% of respondents agree with this statement.
3. **20.98**% of respondents are neutral on the matter.
4. **3.50**% of respondents strongly disagree.
5. **6.29**% of respondents disagree with the statement.

Learnings and Suggestions

Recognizing the nuances revealed in our analysis, it becomes evident that a spectrum of perspectives exists regarding the environmental implications of mineral utilization in electric vehicles (EVs). It is imperative to acknowledge this diversity and prioritize educational initiatives aimed at enhancing awareness of the associated challenges in sustainable transportation. While a substantial proportion views EVs as superior in environmental terms due to mineral usage, addressing concerns of dissenting voices is paramount. To mitigate worries regarding mineral depletion, strategic approaches such as diversifying sourcing and investing in recycling technologies should be pursued vigorously. Furthermore, advocating for comprehensive life cycle assessments is essential to accurately evaluate environmental impacts and identify opportunities for improvement. Elevating awareness of recycling practices for EV batteries and endorsing government intervention in promoting clean energy sources for EV charging are crucial steps. Crafting specific policy recommendations rooted in empirical evidence will pave the way for sustainable mineral usage in EVs. Lastly, fostering stakeholder engagement and dissemination efforts will facilitate collective action towards a greener transportation landscape.

Future Scope and Discussion

The study's findings on environmental awareness and concerns surrounding mineral usage in electric vehicles (EVs) offer invaluable insights for future research and policy endeavors in sustainable transportation. These insights underscore the necessity for targeted education initiatives to enhance public understanding of the environmental impacts associated with mineral utilization in EVs and the importance of reconciling diverse perspectives on their environmental benefits. Urgent action is required to adopt sustainable mineral practices, including diversifying sourcing and advancing recycling technologies, to mitigate environmental harm and resource depletion. Rigorous life cycle assessments are essential for informed decision-making and policy formulation, guiding efforts to quantify and compare the environmental footprints of EVs and conventional vehicles. Additionally, promoting circular economy principles, fostering policy and industry collaboration, and engaging stakeholders on a global scale are critical steps towards realizing a cleaner, greener transportation future.

Conclusion

This comprehensive research delves into the intricate relationship between mineral usage in electric vehicles (EVs) and conventional vehicles, shedding light on their environmental implications and the evolving dynamics of sustainable transportation. Our findings underscore the imperative of recognizing and addressing the diverse spectrum of perspectives surrounding EV sustainability, emphasizing the pivotal role of targeted educational campaigns in enhancing public awareness. Moreover, our analysis highlights the critical need for strategic interventions, such as diversifying mineral sourcing and advancing recycling technologies, to effectively mitigate concerns related to resource depletion and environmental degradation. While our study provides valuable insights, it's essential to acknowledge its limitations. One limitation is the potential for bias in survey responses, which may influence the accuracy of our findings. Additionally, the dynamic nature of environmental challenges necessitates ongoing research and adaptation of strategies to address emerging issues effectively.

Nevertheless, our research lays a robust foundation for policymakers, manufacturers, and stakeholders to formulate evidence-based strategies and policy frameworks for sustainable mineral practices. Moving forward, it is imperative to continue exploring innovative solutions and fostering global collaboration to accelerate the transition towards a cleaner and more sustainable transportation ecosystem. Future research endeavors should aim to delve deeper into specific environmental impacts, explore the socio-economic implications of EV adoption, and evaluate the effectiveness of policy interventions in promoting sustainable transportation solutions. This study contributes significantly to the discourse on sustainable transportation, providing valuable insights and recommendations for navigating the complex challenges associated with mineral usage in EVs. By embracing a holistic approach and fostering collaboration across sectors, we can pave the way for a greener, more resilient transportation future that benefits both present and future generations.

References:

1. 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.
2. AUTHOR'S:- Hawkins, T. R., Singh, B., Majeau-Bettez, G., & Strømman, A. H. (2013). Comparative environmental life cycle assessment of conventional and electric vehicles. Journal of Industrial Ecology
3. Blázquez Lidoy, J.; Martín Moreno, J.M. Eficiencia energética en la automoción, el vehículo eléctrico, un reto del presente.
4. Charles Lincoln Kenji Yamamura ,Harmi Takiya , Cláudia Aparecida Soares Machado , José Carlos Curvelo Santana , José Alberto Quintanilha and Fernando Tobal Berssaneti
5. Computer Science and System Engineering Department (DIIS), University of Zaragoza, Atarazana, 2, 44003 Teruel, Spain
6. Francisco J. Martinez
7. https: //unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
8. https://anfavea.com.br/docs/ apresentacoes/APRESENTAÇ~{A}O-ANFAVEA-E-BCG.pdf
9. https://doi.org/10.1787/4a4dc6ca-en
10. https://doi.org/10.3390/smartcities4010022
11. https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2011_en/
12. https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1530-9290.2012.00532.x
13. https://theicct.org/sites/default/files/publications/Brazil_L7L8_policy_update_01302020.pdf
14. https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
15. https://www.iea.org/
16. https://www.nissan.co.uk/vehicles/new-vehicles/leaf/range-charging.html
17. https://www.oecd-ilibrary.org/agriculture-and-food/ oecd-fao-agricultural-outlook-2020-2029_1112c23b-en
18. https://www.researchsquare.com/article/rs-3332463/v1
19. https://www.sciencedirect.com/science/article/abs/pii/S0892687522002072
20. https://www.tesla.com/en_EU/supercharger (accessed on 21 February 2021
21. IDLab—Faculty of Applied Engineering, University of Antwerp—imec, Groenenborgerlaan 171, 2020 Antwerp,
22. Johann M. Marquez-Barja
23. Julio A. Sanguesa
24. Piedad Garrido
25. Vicente Torres-Sanz