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ENVIRONMENTAL IMPACTS OF RENEWABLE ENERGY TECHNOLOGIES IN THE TRANSPORTATION SECTOR: A BIBLIOMETRIC REVIEW

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Abstract— Renewable energy sources have gained substantial significance concerning the depletion of non-renewable energy resources and the adverse environmental consequences associated with their consumption. However, the possible impact of shifting from non-renewable energy to renewable energy sources is still debatable. Moreover, the broadening development of renewable energy technologies mainly in the

Environmental Impact, Renewable Energy, Sustainable Energy

transportation sector determines the viability of renewable energy is scarce. Hence, this study aims to provide an understanding of the impact of Renewable energy technology on the environment and to evaluate the viability of renewable energy implementation in the transportation sector. This bibliometric review provides insights on advancing renewable energy technology, and current evidence present from different perspectives. The extensive search of this study revealed that the negative impacts of renewable energy can be mitigated through careful planning and implementation of renewable energy projects, such as conducting thorough environmental impact assessments and developing appropriate waste management. The environmental impact associated when electrical generation relies on fossil fuel is worse, while renewable energy can substantially reduce emissions, for example in electric vehicles. This literature review provides fundamental evidence that highlights the strong viability of renewable energy specifically in electric vehicle applications in terms of economic, social, environmental, and technical aspects.

I. Introduction

The growth of renewable energy technologies, particularly solar energy, gained significant traction with the creation of the International Solar Energy Society (ISES). This organization played a key

role in advancing solar energy research and development across various industries. The progress made was further boosted by an energy crisis marked by rising oil prices. This crisis highlighted the problems of relying on fossil fuels and led to increased focus on alternative energy sources. As a result, this period became crucial for accelerating developments in solar technology and setting the stage for the rapid growth of renewable energy technologies. In the 21st century, concerns about climate change and the environmental impact of fossil fuels have prompted a rapid shift towards renewable energy. Technological advances have made renewable energy more powerful, affordable and widely used. According to the global energy review 2021, the global energy production had increased from 27% to 29% from the year 2019 to 2020 respectively. It was further anticipated that renewable energy sources will account for over 42% of global electricity generation by 2028 [1].

Recently, the usage of renewable energy in the transportation sector has gained momentum. One of the most notable advancements is the development of electric vehicles (EVs), which utilize electricity generated from renewable sources such as wind, solar, and hydro power. EVs have become a focal point in the transition towards cleaner transportation due to their potential to significantly lower greenhouse gas emissions compared to conventional internal combustion engine vehicles. Studies demonstrate that EVs can significantly cut CO2 emissions, with reductions of up to 72% [2]. This reduction is primarily due to the fact that EVs produce zero tailpipe emissions, and when charged with electricity from renewable sources, their overall carbon footprint is considerably lower compared to conventional internal combustion engine vehicles [3].

Despite significant advancements in utilizing renewable energy technologies in the transportation sector,

challenges remain in fully integrating these solutions into global energy systems and achieving widespread adoption [4]. Therefore, it is essential to understand and identify the potential benefits and drawbacks from this towards the environment. Moreover, in general, People in remote areas lack access to necessities. Renewable energy projects may not necessarily benefit local communities economically, which exacerbates socioeconomic inequality. However, the viability of transforming the world into renewable energy technologies is significantly vital to accommodate the needs of each individual.

The challenges facing EVs include insufficient charging infrastructure, limited battery range, high initial costs, concerns about battery life and recycling, dependence on the electricity source, limited model availability, and difficulties in integrating with existing automotive technologies. These issues collectively impact the widespread adoption and practicality of EVs. Hence, a bibliometric review is developed to fully understand the current research status of renewable energy technology in the transportation sector and explore research hot spots and frontiers, an in-depth analysis of the scholarly communication. This study aims to understand the impact of renewable energy technology on the environment and to evaluate the viability of renewable energy (e.g. EV) implementation in the transportation sector.

II. Significant of Study

The significance of this work stems from its potential to increase the understanding on how EVs might contribute to environmental sustainability. Furthermore, the results offer significant perspectives on the wider advantages of combining renewable energy sources with EVs, underscoring the significance of shifting to sustainable energy options. The findings of this study can help develop policies that will lower greenhouse gas emissions, enhance air quality, and

encourage environmentally friendly transportation. In summary, it highlights the significance of EVs in accomplishing environmental objectives and backs initiatives to create and execute regulations that promote their extensive integration.

III. Bibliometric Review

A bibliometric review is a comprehensive and quantitative analysis of published literature in a particular field, aimed at identifying patterns, trends, and influential works. This method involves the use of statistical tools to analyze publications, citations, authorship, and research impact, providing insights into the development and structure of research domains [5, 6].

Unique features of a bibliometric review include the ability to objectively assess the influence of individual articles, authors, or journals through citation analysis, co-citation analysis, and keyword co-occurrence. It helps in mapping the intellectual structure and evolution of a field, identifying key research themes, and highlighting gaps in the literature [7].

Prominent studies using this method include the work by Chen et al. [7], which mapped the knowledge domain of nanotechnology, and the study by van Eck and Waltman [5], which developed the VOSviewer software for constructing and visualizing bibliometric networks. Another significant example is the analysis by Donthu et al. [6], which examined the impact of COVID-19 on business and economics research using bibliometric techniques.

The bibliometric review process in Table 1 provides insights into advances in renewable energy technology, current evidence presents from different perspectives. We chose specific keywords relevant to our study. These included “viability renewable energy implementation electric vehicle transportation sector” and “total pollution electric fossil fuel vehicle”. These keywords were

Table 1: Detailed Process of Search Keywords and the Total Number of Articles Retrieved from the Database of the review opt to this study

Step	Description		
Selection of Keywords	- Specific keywords chosen: 1. "viability renewable energy implementation electric vehicle transportation sector" 2. "total pollution electric fossil fuel vehicle" - Aim: Encompass literature on renewable energy in transportation.		
	"total pollution electric fossil fuel vehicle"		
Database Search (*Coverage: Wide range of academic journals and publications)*	Google Scholar		
	Scopus		
	Web of Science		
	Jstor		
	ScienceDirect		
Search Criteria	Articles published from 2018 onwards		
	English		
Initial Search Results	17,300 results for the first set of keywords		
	16,800 results for the second set of keywords		
Refinement of Search	"total pollution"		Refined results = 337 results
	"electric vehicle"		
	"fossil"		
	"fuel vehicle"		
Screening Process	Criteria for screening	Relevance to research questions	Final selected articles = 18
		Significance of findings	
		Number of citations	
Content Analysis	Conducting a detailed review of the selected articles to extract qualitative information on the benefits, drawbacks, and viability of renewable energy technologies in the transportation sector.		
Thematic Analysis	Identifying and analyzing recurring themes and patterns within the literature to provide a structured understanding of the research topic.		

chosen to capture literature discussing the feasibility of incorporating renewable energy into the transportation sector, particularly focusing on EVs, and comparing the total pollution generated by electric and fossil fuel vehicles. We employed a range of reputable academic databases recognized for their comprehensive collections of scholarly articles across diverse disciplines. These databases included Google

Scholar, Scopus, Web of Science, Jstor, and ScienceDirect. Each of these databases covers a wide range of academic journals and publications, providing a comprehensive pool of literature to search from. The search was limited to articles published from the year 2018 onwards. This timeframe selection ensured that the literature considered was up-to-date and reflected recent advancements and findings in the field. The initial searches returned a large number of results, indicating the abundance of literature on the chosen topic. Specifically, there were 17,300 results for the first set of keywords and 16,800 results for the second set of keywords. The searches were refined with grouping of "total pollution" "electric vehicle" "fossil fuel vehicle", which returned 337 results. From the refined set of results, we selected 18 relevant literatures for review. These selections were based on the significance of the findings, relevance to the research questions, and possibly the number of citations indicating the impact and recognition of the study within the academic community. This involved critically assessing the methodologies, results, and conclusions of each study to extract relevant insights and information for our research.

Table 2 provides an overview of research studies on renewable energy and EVs including the number of citations. Citation analysis was conducted to assess the scholarly impact and relevance of key publications pertinent to the intersection of renewable energy technologies and the transportation sector. This approach involved the systematic identification and evaluation of academic articles, selected based on their thematic alignment with the research objectives, which focus on the integration of renewable energy, EVs, and sustainability within transportation.

Table 2 also provided a concise summary of the articles reviewed, including details such as the title, authorship, and the number of citations each publication has accrued. Citation data were sourced from

Table 2: The list of publication that are relevant to research questions and the number of citations

Title	Citation
Brown vs Green Energy Sources and Resource Productivity: The Role of Human Capital and Technology Transfer in Developing Economies [8]	1
Electric Vehicles and Biofuels Synergies in the Brazilian Energy System [9]	34
A Comparison of Battery and Hydrogen Fuel Cell Electric Vehicles for Clean Transportation [10]	3
On the Role of Renewable Energy Policies and Electric Vehicle Deployment Incentives for a Greener Sector Coupling [16]	23
Hybrid PV Systems and Colocalization of Charging and Filling Stations for Electrification of Road Transport Sector [20]	1
Implementation of Electric Vehicles to Support Energy Conservation and Efficiency Improvement in the Transportation Sector in Indonesia [17]	3
Electric Vehicle and Renewable Energy Sources: Motor Fusion in the Energy Transition From a Multi-Indicator Perspective [21]	26
The Synergies of Shared Autonomous Electric Vehicles With Renewable Energy in a Virtual Power Plant and Microgrid [12]	23
The role of renewable energy technologies in enhancing human development: Empirical evidence from selected countries [26]	11
The Renewable Energy Production Capability of Settlements to Meet Local Electricity and Transport Energy Demands [23]	5
A Novel Doubly-Green Stand-Alone Electric Vehicle Charging Station in Saudi Arabia: An Overview and a Comprehensive Feasibility Study [13]	9
Mobility From Renewable Electricity: Infrastructure Comparison for Battery and Hydrogen Fuel Cell Vehicles [22]	49
Review of energy system flexibility measures to enable high levels of variable renewable electricity [32]	1810
The Impact of Electrical Vehicles on Sustainability: Jordan as a Case Study [25]	3
Experimental and Modeling Analysis of Graphite Electrodes With Various Thicknesses and Porosities for High-Energy-Density Li-Ion Batteries [24]	66
A Review of the Technologies, Challenges and Policies Implications of Electric Vehicles and Their Future Development in India [18]	3
A Review of Renewable Energy Sources, Sustainability Issues and Climate Change Mitigation [33]	35

reputable academic databases, including Scopus and Google Scholar. The citation counts serve as a quantifiable measure of the scholarly impact and recognition each work has achieved within the academic community.

Citation analysis was employed as a key methodological tool, predicated on the premise that the frequency of citations is indicative of an article's influence and academic significance. However, it is acknowledged that citation counts alone do not fully encapsulate the quality, rigor, or relevance of the research. To address this limitation, the content and thematic focus of each article were critically appraised to ensure their substantive contribution to the research area.

The articles were meticulously selected to reflect a broad spectrum of perspectives and research outcomes relevant to the study. These include the synergies between EVs and renewable energy sources, the role of policy frameworks and human capital in fostering the adoption of green technologies, and the diverse challenges and opportunities associated with the deployment of these technologies across different geopolitical contexts. This methodological approach enabled the compilation of a robust and comprehensive body of literature, thereby underpinning the subsequent analysis and discussions within the study.

Table 3 presents a thematic analysis of key findings from research studies related to renewable energy, EVs, findings, the authors, and the publication year for each study. This structured approach allows for a clear understanding of the diverse research areas and their implications for advancing renewable energy and EV adoption. and associated technologies. The table includes the theme, a summary of the findings is organized into distinct themes, highlighting the contributions and insights of each study.

Table 3: Thematic analysis of findings from relevant literatures

Theme	Findings
Renewable Energy and Resource Productivity	Human capital and technology transfer enhance the productivity of green energy sources in developing economies [8].
Electric Vehicles (EVs) and Synergies with Other Technologies	Synergies between EVs and biofuels improve sustainability and reduce emissions in Brazil [9].
	BEVs are more energy-efficient, while FCEVs offer faster refueling times; infrastructure development is critical for adoption [10].
	Innovative cooling techniques improve temperature uniformity in EV battery packs [11].
	Shared autonomous EVs integrated with renewable energy in a virtual power plant enhance energy efficiency [12].
	Demonstrates the feasibility of a doubly-green stand-alone EV charging station in Saudi Arabia [13].
	EV adoption can result in significant carbon savings even in regions dominated by thermal power plants [14].
	Reviews the progress and perspectives of using EVs for vehicle-to-grid services, highlighting the benefits and challenges [15].
Policy and Development	Effective renewable energy policies and EV deployment incentives are essential for promoting greener sector coupling [16].
	EV implementation significantly improves energy conservation and efficiency in Indonesia's transportation sector [17].
	Reviews current EV technologies and challenges in India, discusses policy implications, and suggests future development pathways [18].
	A 100% renewable energy-based transport sector in Europe is feasible with appropriate technological and policy measures [19].
Renewable Energy Integration and Flexibility	Hybrid PV systems with colocalized charging and filling stations support the electrification of road transport [20].
	Integrating EVs with renewable energy sources is crucial for a sustainable energy transition [21].
	Highlights various flexibility measures in energy systems to accommodate high levels of variable renewable electricity [22].
	Assesses the capability of settlements to produce renewable energy to meet local electricity and transport energy demands [23].
Energy Storage and Battery Technologies	Optimizing electrode thickness and porosity can significantly enhance energy density and battery performance [24].
	The adoption of electric vehicles (EVs) in Jordan has a significant positive impact on sustainability [25].

IV. Analysis

A. Renewable Energy and Resource Productivity

The research by Aladejare and Salihu [8] highlights the crucial role of human capital and technology transfer in enhancing the productivity of green energy sources within developing economies. The study emphasizes that by effectively building capacity in human capital and transferring advanced technologies, these economies can achieve better resource productivity and sustainable development outcomes.

B. Electric Vehicles (EVs) and Synergies with Other Technologies

A collection of studies explores the synergies between EVs and other renewable technologies. Dranka and Ferreira [9] focus on the integration of EVs and biofuels in Brazil, demonstrating how this synergy can improve sustainability and reduce emissions. Endiz [10] compares battery electric vehicles (BEVs) and hydrogen fuel cell electric vehicles (FCEVs), highlighting that while BEVs are more energy-efficient, FCEVs provide faster refueling times, which is crucial for long-distance travel.

Additionally, Gungor and Cetkin [11] discuss innovative cooling techniques that enhance temperature uniformity in EV battery packs, thereby improving performance and longevity. Another study by Iacobucci et al. [12] examines the integration of shared autonomous EVs with renewable energy in virtual power plants, emphasizing the enhanced energy efficiency this model offers. Finally, Oladigbolu et al. [13] demonstrate the feasibility of a doubly-green stand-alone EV charging station in Saudi Arabia, which has significant implications for sustainable transportation infrastructure in the region.

Further, Pyakurel et al. [14] provide an analysis showing that EV adoption can lead to significant carbon savings even in areas where electricity generation is primarily

dependent on thermal power plants. Ravi and Aziz [15] review the progress and potential of using EVs for vehicle-to-grid services, focusing on the benefits and challenges associated with this technology.

C. Policy and Development

Within the policy realm, Esmaeili et al. [16] emphasize the importance of renewable energy policies and EV deployment incentives for promoting greener sector coupling. These policies are crucial for accelerating the adoption of renewable energy technologies and EVs. Fitriana [17] further illustrates how the implementation of EVs can significantly improve energy conservation and efficiency in Indonesia's transportation sector, highlighting the role of supportive policy and infrastructure development.

Mittal [18] provides a comprehensive review of the current state of EV technologies in India, the challenges faced, and the policy implications. The study suggests future development pathways that could enhance the adoption of EVs. Meanwhile, Ram et al. [19] analyze the feasibility of a 100% renewable energy-based transport sector in Europe, concluding that it is achievable with the right technological advancements and policy measures.

D. Renewable Energy Integration and Flexibility

The studies under this theme explore the integration of renewable energy with various technologies. Fagerström et al. [20] examine hybrid photovoltaic systems co-located with charging and filling stations, showing how this setup supports the electrification of road transport. Gil-García et al. [21] stress the importance of integrating EVs with renewable energy sources to ensure a sustainable energy transition.

Ligen et al. [22] highlight the need for flexibility in energy systems to manage high levels of variable renewable electricity. Their findings suggest that implementing flexibility measures is critical to

accommodating the intermittent nature of renewable energy. Kulcsár et al. [23] assess the capability of settlements to produce renewable energy that meets local electricity and transport energy demands, providing a framework for optimizing energy production at the community level.

E. Energy Storage and Battery Technologies

Research in energy storage and battery technologies focuses on optimizing performance to support the broader adoption of renewable energy and EVs. Malifarge et al. [24] investigate how optimizing the thickness and porosity of graphite electrodes can significantly enhance energy density in Li-ion batteries, which is critical for improving EV range and performance. Additionally, Shatnawi [25] examines the impact of EV adoption in Jordan, concluding that it positively contributes to sustainability through reduced greenhouse gas emissions and decreased reliance on fossil fuels.

The findings presented in this table 3 reflect a broad spectrum of research dedicated to advancing renewable energy technologies, enhancing the efficiency and sustainability of EVs, and formulating effective policies to support these transitions. Each study contributes valuable insights into how different technologies and policies can synergize to address the global challenges of energy sustainability and climate change.

F. Benefit And Drawback of Renewable Energy Application Toward Environment

Numerous social, environmental, and economic benefits come with using renewable energy. The two main advantages of producing energy are lowering air pollution and carbon emissions. Workers with the necessary skills in the production and manufacturing sectors might find several employment opportunities in renewable energy technology. Additionally, this guarantees the use of less expensive energy,

which eventually strengthens the national economy [26].

While renewable energy sources offer numerous environmental benefits, it is important to acknowledge that there are also some disadvantages associated with their implementation. These disadvantages include the potential impact on wildlife and ecosystems during the installation and operation of renewable energy infrastructure, such as wind turbines and solar panels [27].

Additionally, the production and disposal of renewable energy technologies can result in their own environmental impact, such as the extraction of raw materials and the generation of waste [28]. Furthermore, there may be challenges in the integration of renewable energy into existing power grids, as well as issues with intermittency and storage of renewable energy.

G. Advantage and Disadvantage of Renewable Energy Application In EV

Overall, the advantages of using renewable energy for EVs outweigh the disadvantages. By adopting renewable energy sources to power EVs, we can mitigate air pollution, enhance energy security, and promote sustainability in the transportation sector. In order to overcome the barriers and maximize the benefits of EVs and renewable energy integration in the transportation sector, it is crucial to implement appropriate strategies and policies that address the challenges and promote the widespread adoption of clean energy solutions [29].

The comparison of total pollution between EVs and fossil fuel vehicles is a multi-perspective issue that requires a thorough analysis. While the production of EVs can lead to higher CO_2 emissions compared to traditional internal combustion engine vehicles [14], it is important to evaluate the

end-to-end lifecycle of both vehicle types for a fair comparison.

When EVs are powered by electricity generated from renewable sources, their carbon footprint is significantly lower than that of fossil fuel vehicles [11]. This highlights the importance of transitioning towards cleaner energy sources to maximize the environmental benefits of EVs. However, if EVs continue to rely on electricity generated from fossil fuels, their emissions can indeed surpass those of conventional vehicles [15].

The transition to EVs is primarily motivated by the aim to reduce reliance on fossil fuels and combat environmental pollution [18]. EVs offer advantages such as zero exhaust emissions and the possibility to be powered by renewable energy sources, ranking them as a promising alternative to conventional vehicles [10]. The global trend towards adopting EVs is pushed by concerns about air pollution, greenhouse gas emissions, and the scarce nature of fossil fuel resources [30].

While EVs have the potential to reduce air pollution and greenhouse gas emissions, the environmental impact of their widespread adoption relies on factors like the energy sources used for electricity generation and the materials and technologies involved in EV production [24]. It is crucial to consider the holistic environmental implications of transitioning to EVs, covering aspects such as source of electricity and disposal of batteries at the end of their service life.

In conclusion, the assessment of total pollution between EVs and fossil fuel vehicles is not so straightforward and demands a more complete evaluation of various factors. While EVs can substantially reduce emissions when powered by renewable energy sources, their environmental impact may escalate if electricity generation relies on fossil fuels. Transitioning towards cleaner energy sources and sustainable practices is vital to optimize the environmental advantages of EVs.

H. Viability Of Renewable Energy in EV

Renewable energy integration for EV in the transportation sector is a promising approach for reducing greenhouse gas emissions and promoting sustainability. Numerous studies showcased the significance of combining renewable energy sources with EVs to improve energy efficiency and environmental benefits.

The optimization of EV deployment in the transportation sector can be achieved by utilizing new and renewable energy sources in power plants to minimize emissions [17]. Studies stress the importance of evaluating the impact of EVs on energy systems that incorporate various renewable energies for electricity production and biofuels in the transportation sector [9]. The global adoption of EVs presents an opportunity to advance environmental decarbonization efforts and increase the demand for renewable energy resources [13].

Efficient electrification of the transport sector can be realized by co-locating hydrogen refueling stations with EV charging stations to incorporate more intermittent renewable energy sources [20]. EVs, in conjunction with renewable energy sources, have the potential to significantly reduce carbon emissions in both the power generation and transportation sectors [31]. The shift from fossil fuels to renewable energy sources, coupled with the uptake of EVs, is essential for decreasing greenhouse gas emissions and fostering sustainable transportation systems.

EVs provide grid balancing flexibility and enable the integration of renewable energy sources, underscoring the synergies between shared autonomous EVs and renewable energy in virtual power plants and microgrids [12]. Policies that promote renewable energy and offer incentives for EV deployment play a crucial role in achieving greener sector coupling and the long-term integration of renewable energy resources [16]. Integration of EV fleets with renewable energy generation systems can help

offset fluctuations in energy outputs and support zero-emission transport systems [23].

The combination of EVs and renewable energy sources is viewed as an optimal solution to mitigate climate change and facilitate the energy transition [21]. Also, the adoption of EVs powered by renewables can contribute to reducing air pollution, enhancing energy security, and promoting sustainability in the transportation sector [25]. EVs, powered by renewable electricity, can address environmental challenges by eliminating fossil fuel combustion and promoting the use of clean energy sources [22].

In conclusion, the incorporation of renewable energy for EVs in the transportation sector shows great promise in achieving sustainability objectives, reducing emissions, and enhancing energy efficiency. By integrating EVs with renewable energy sources, the world can progress towards decarbonizing their transport systems and moving towards a greener future.

V. Discussion and Conclusion

Key initiatives are essential to enhance the adoption and effectiveness of renewable energy technologies. Governments should implement policies that incentivize renewable energy sources and electric vehicles (EVs). Financial incentives such as subsidies, tax credits, and grants can boost renewable energy projects and EV affordability. Stricter emissions regulations for automobiles will also expedite the shift from fossil fuels to cleaner energy sources.

Significant investment in infrastructure is critical for integrating renewable energy into existing systems. Upgrading and expanding grid infrastructure, particularly through advanced smart grid systems, will stabilize energy supply and improve storage capabilities as renewable energy inputs increase.

Ongoing research and development (R&D) are vital for addressing technical challenges. Advances in battery technology, energy storage systems, and

cost-effective renewable energy solutions will further accelerate the adoption of sustainable technologies.

Raising public awareness about the environmental and economic benefits of renewable energy and EVs is equally important. Educational initiatives can foster positive attitudes and greater support for sustainable technologies.

Global cooperation is essential for addressing climate change and promoting renewable energy adoption. Collaboration among nations can facilitate knowledge sharing, support for developing countries, and faster progress in sustainable energy implementation.

Ensuring sustainable supply chains for renewable energy technologies and EVs is also crucial. Responsible sourcing, recycling, and minimizing environmental impacts in production processes will enhance their overall sustainability.

The transition to renewable energy technology is key to addressing global environmental challenges. Renewable energy offers significant potential to reduce greenhouse gas emissions and mitigate climate change, especially through its application in the transportation sector with EVs. Shifting from fossil fuels to renewable sources, such as wind, solar, and hydropower, reduces air pollution, conserves resources, and improves energy security.

Challenges such as grid infrastructure upgrades, energy storage solutions, and renewable energy intermittency must be addressed. However, the benefits, including lower emissions, improved public health, and environmentally friendly job creation, far outweigh these obstacles. The adoption of renewable energy and EVs presents a sustainable pathway for the future.

Supportive policies, infrastructure investments, R&D advancements, public awareness initiatives, global cooperation, and sustainable supply chains are collectively necessary to accelerate the transition to renewable energy, reduce carbon emissions, and build a sustainable energy future.

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VII. References

[1] "Renewables – Global Energy Review 2021 – Analysis," IEA. Accessed: Jan. 17, 2025. [Online]. Available: https://www.iea.org/reports/global-energy-review-2021/renewables

[2] M. Alanazi *et al.*, "Developing a Transactive Charging Control Framework for EV Parking Lots Equipped With Battery and Photovoltaic Panels: A MILP Approach," *IEEE Access*, vol. 12, pp. 108731–108743, 2024, doi: 10.1109/ACCESS.2024.3439212.

[3] M. Koengkan *et al.*, "The Capacity of Battery-Electric and Plug-in Hybrid Electric Vehicles to Mitigate CO2 Emissions: Macroeconomic Evidence from European Union Countries," *World Electric Vehicle Journal*, vol. 13, no. 4, Art. no. 4, Apr. 2022, doi: 10.3390/wevj13040058.

[4] R. Bointner, S. Pezzutto, G. Grilli, and W. Sparber, "Financing Innovations for the Renewable Energy Transition in Europe," *Energies*, vol. 9, no. 12, Art. no. 12, Dec. 2016, doi: 10.3390/en9120990.

[5] N. J. van Eck and L. Waltman, "CitNetExplorer: A new software tool for analyzing and visualizing citation networks," *Journal of Informetrics*, vol. 8, no. 4, pp. 802–823, Oct. 2014, doi: 10.1016/j.joi.2014.07.006.

[6] N. Donthu, S. Kumar, D. Mukherjee, N. Pandey, and W. M. Lim, "How to conduct a bibliometric analysis: An overview and guidelines," *Journal of Business Research*, vol. 133, pp. 285–296, Sep. 2021, doi: 10.1016/j.jbusres.2021.04.070.

[7] C. Chen, F. Ibekwe-SanJuan, and J. Hou, "The structure and dynamics of cocitation clusters: A multiple-perspective cocitation analysis," *Journal of the American Society for Information Science and Technology*, vol. 61, no. 7, pp. 1386–1409, Jul. 2010, doi: 10.1002/asi.21309.

[8] S. A. Aladejare and B. Salihu, "Brown vs Green Energy Sources and Resource Productivity: The Role of Human Capital and Technology Transfer in Developing Economies," Jul. 05, 2023, *Research Square*. doi: 10.21203/rs.3.rs-3129535/v2.

[9] G. G. Dranka and P. V. Ferreira, "Electric Vehicles and Biofuels Synergies in the Brazilian Energy System," *Energies*, 2020, doi: 10.3390/en13174423.

[10] M. S. Endiz, "A Comparison of Battery and Hydrogen Fuel Cell Electric Vehicles for Clean Transportation," *Orclever Proceedings of Research and Development*, 2023, doi: 10.56038/oprd.v2i1.230.

[11] S. Gungor and E. Cetkin, "Enhanced Temperature Uniformity With Minimized Pressure Drop in Electric Vehicle

Battery Packs at Elevated C-rates," *Heat Transfer*, 2022, doi: 10.1002/htj.22654.

[12] R. Iacobucci, B. McLellan, and T. Tezuka, "The Synergies of Shared Autonomous Electric Vehicles With Renewable Energy in a Virtual Power Plant and Microgrid," *Energies*, 2018, doi: 10.3390/en11082016.

[13] J. O. Oladigbolu, A. Mujeeb, Y. Al-Turki, and A. M. Ali Rushdi, "A Novel Doubly-Green Stand-Alone Electric Vehicle Charging Station in Saudi Arabia: An Overview and a Comprehensive Feasibility Study," *Ieee Access*, 2023, doi: 10.1109/access.2023.3266436.

[14] P. Pyakurel, F. Quintal, J. Auger, and J. Hanna, "Analysis of Carbon Saving by the Adoption of Electric Vehicles in a Region Where Electricity Generation Is Dominated by Thermal Power Plants," *Strategic Planning for Energy and the Environment*, 2023, doi: 10.13052/spee1048-4236.39146.

[15] S. S. Ravi and M. Aziz, "Utilization of Electric Vehicles for Vehicle-to-Grid Services: Progress and Perspectives," *Energies*, 2022, doi: 10.3390/en15020589.

[16] M. Esmaeili, A. Anvari-Moghaddam, S. M. Muyeen, and V. S. Perić, "On the Role of Renewable Energy Policies and Electric Vehicle Deployment Incentives for a Greener Sector Coupling," *Ieee Access*, 2022, doi: 10.1109/access.2022.3176012.

[17] I. Fitriana, "Implementation of Electric Vehicles to Support Energy Conservation and Efficiency Improvement in the Transportation Sector in Indonesia," *Iop Conference Series Earth and Environmental Science*, 2023, doi: 10.1088/1755-1315/1268/1/012051.

[18] G. Mittal, "A Review of the Technologies, Challenges and Policies Implications of Electric Vehicles and Their Future Development in India," *Energy Storage*, 2024, doi: 10.1002/est2.562.

[19] M. Ram *et al.*, "European Energy System Based on 100% Renewable Energy – Transport Sector," in *Mobilität der Zukunft: Intermodale Verkehrskonzepte*, W. Siebenpfeiffer, Ed., Berlin, Heidelberg: Springer, 2021, pp. 519–562. doi: 10.1007/978-3-662-61352-8_36.

[20] J. Fagerström, L. Kvalbein, J. Danebergs, T. U. Nærland, M. B. Ogaard, and K. A. Espegren, "Hybrid PV Systems and Colocalization of Charging and Filling Stations for Electrification of Road Transport Sector," *Solar RRL*, 2022, doi: 10.1002/solr.202100461.

[21] I. C. Gil-García, M. S. García-Cáscales, H. J. Dagher, and Á. Molina-García, "Electric Vehicle and Renewable Energy Sources: Motor Fusion in the Energy Transition From a Multi-Indicator Perspective," *Sustainability*, 2021, doi: 10.3390/su13063430.

[22] Y. Ligen, H. Vrubel, and H. H. Girault, "Mobility From Renewable Electricity: Infrastructure Comparison for Battery and Hydrogen Fuel Cell Vehicles," *World Electric Vehicle Journal*, 2018, doi: 10.3390/wevj9010003.

[23] B. Kulcsár, T. Mankovits, and P.

Ailer, "The Renewable Energy Production Capability of Settlements to Meet Local Electricity and Transport Energy Demands," *Sustainability*, 2021, doi: 10.3390/su13073636.

[24] S. Malifarge, B. Delobel, and C. Delacourt, "Experimental and Modeling Analysis of Graphite Electrodes With Various Thicknesses and Porosities for High-Energy-Density Li-Ion Batteries," *Journal of the Electrochemical Society*, 2018, doi: 10.1149/2.0301807jes.

[25] Shatnawi, Malak, "The Impact of Electrical Vehicles on Sustainability: Jordan as a Case Study," *International Journal of Engineering and Management Sciences*, vol. 4, no. 1, Art. no. 1, Mar. 2019, doi: 10.21791/IJEMS.2019.1.49.

[26] T. T. H. Nguyen, G. Q. Phan, T. K. Tran, and H. M. Bui, "The role of renewable energy technologies in enhancing human development: Empirical evidence from selected countries," *Case Studies in Chemical and Environmental Engineering*, vol. 8, p. 100496, Dec. 2023, doi: 10.1016/j.cscee.2023.100496.

[27] M. S. Nazir, N. Ali, M. Bilal, and H. M. N. Iqbal, "Potential environmental impacts of wind energy development: A global perspective," *Current Opinion in Environmental Science & Health*, vol. 13, pp. 85–90, Feb. 2020, doi: 10.1016/j.coesh.2020.01.002.

[28] A. Siddiqua, J. N. Hahladakis, and W. A. K. A. Al-Attiya, "An overview of the environmental pollution and health effects associated with waste landfilling and open dumping," *Environ Sci Pollut Res Int*, vol. 29, no. 39, pp. 58514–58536, 2022, doi: 10.1007/s11356-022-21578-z.

[29] N. Tilly, T. Yigitcanlar, K. Degirmenci, and A. Paz, "How sustainable is electric vehicle adoption? Insights from a PRISMA review," *Sustainable Cities and Society*, vol. 117, p. 105950, Dec. 2024, doi: 10.1016/j.scs.2024.105950.

[30] M. Wu and W. Chen, "Forecast of Electric Vehicle Sales in the World and China Based on PCA-GRNN," *Sustainability*, 2022, doi: 10.3390/su14042206.

[31] J. Xu, A. Liu, Y. Qin, G. Xu, and Y. Tang, "A Cost Effective Solution to Dynamic Economic Load Dispatch Problem Using Improved Chimp Optimizer," *Frontiers in Energy Research*, 2022, doi: 10.3389/fenrg.2022.952354.

[32] P. D. Lund, J. Lindgren, J. Mikkola, and J. Salpakari, "Review of energy system flexibility measures to enable high levels of variable renewable electricity," *Renewable and Sustainable Energy Reviews*, vol. 45, pp. 785–807, May 2015, doi: 10.1016/j.rser.2015.01.057.

[33] P. A. Owusu and S. Asumadu-Sarkodie, "A review of renewable energy sources, sustainability issues and climate change mitigation," *Cogent Engineering*, vol. 3, no. 1, p. 1167990, Dec. 2016, doi: 10.1080/23311916.2016.1167990.