Impact of Renewable Energy Integration on the Overall Carbon Footprint and Environmental Sustainability of the Automotive Sector

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Abstract
The idea of integrating renewable energy in the automotive sector has surfaced in recent years. Most governments around the globe have already taken the initiative to promote specifically electric vehicles and impose a ban on conventional fuel vehicles, resulting an increase in demand for electricity, which has become the fundamental reason of generating electricity from various new sources i.e. unconventional sources (Solar energy, Wind energy, nuclear energy, etc.). The current trends of shifting towards electric vehicles is a topic of conflicting opinions. Some believe that the impact on the environment caused by the automotive sector would decrease by the adaption EV technology while others consider it as the process of shifting towards more hazardous environment. In this report/thesis a brief review of Electric vehicles and their effects of Renewable Energy Source (RES) integration on environment is presented. Additionally, a detailed comparison of the impacts of EVs v/s Conventional Fuel Vehicles (CFV) is presented. This document examines the existing body of literature pertaining to electric vehicles (EVs), the electrical grid, and the integration of renewable energy. It explores and elucidates the fundamental methodologies and underlying suppositions employed in the literature. Multiple scholarly investigations have appraised the capacity of electric vehicles (EVs) to integrate renewable energy sources. The existing literature strongly suggests that EVs have the potential to substantially diminish the surplus of renewable energy generated within an electric system

Keywords: Electric Vehicle, RES, Carbon footprint, CFV.

1. Introduction

The automotive industry plays a substantial role in global carbon emissions and the deterioration of the environment. Given the growing concerns regarding climate change, the shift towards sustainable energy sources has emerged as a crucial approach to curbing carbon emissions and attaining environmental sustainability. This research proposal endeavours to explore the influence of integrating renewable energy in the automotive sector on the overall carbon footprint and environmental sustainability. By examining the potential advantages, obstacles, and ramifications associated with the adoption of renewable energy in this field, the study aims to offer valuable insights for policymakers, industry stakeholders, and environmental advocates.

In recent years, a few articles have highlighted that roughly 60-65% of total energy generation is demanded by two industries – Automotive sector contributes energy via oils while Electricity generation contributes via coal. [1] Certain policies are formulated to reduce this dependency on non-renewable source and promote the adaptation of renewable sources like solar, wind, biomass, hydropower, geothermal, etc. Integration of RES into the power grid has a variety of challenges, like "Technical Challenges" – storage, protection issues, power quality, power fluctuation, etc. or "Non-Technical Challenges" – unavailability of technically skilled labour, absence of transmission lines, etc. These challenges need to be addressed first before integrating RES to automotive sector. [2]

The urgency of bringing different types of electric vehicles is to decrease the direct tailpipe carbon emissions. A number of technologies have been developed for the current EV segment. Currently, all vehicles are distinguished under 3 categories of vehicles; Battery Electric Vehicles (BEV), Internal Combustion Engine vehicle (ICEV) and Hybrid Electric Vehicle (HEV). HEV is a general term that is used to identify Plug-in Hybrids (PHEV) and Grid Independent Hybrids (GI-HEV). Here BEV is a type of vehicle that runs only via an electric motor while ICEV as name suggests run only via an internal combustion engine (ICE). PHEV is a type which can be charged either from the electricity grid or the ICE, while GI-HEV is charged only by ICE. [3]

2. Research Questions

The research will address the following key questions:

A. How does the integration of renewable energy sources affect the carbon footprint of the automotive sector?
B. What are the environmental sustainability implications of renewable energy integration in the automotive sector?
C. What are the potential barriers and challenges associated with the adoption of renewable energy in the automotive industry?
D. What are the strategies and policies that can facilitate the effective integration of renewable energy sources in the automotive sector?

3. Methodology

- **Research Design:** This research aims at assessing the impacts of renewable energy integration on the automotive sector. It is well known that traditional ICEs have a huge toll on the environment, specifically due to the greenhouse gas emissions and the burning of fossil fuels. So, we will focus on the automobiles that do not require the use of alternate sources of fuel and compare the net carbon footprint and assess the Energy Return On Energy Investment (EROEI) of these vehicles to the ones which utilize fossil fuels, how does the integration of such vehicle powered by alternate sources affect the carbon footprint, since the electric energy required to charge the vehicles will be obtained from the grid utilizing fossil fuels. Evidently, more EVs will result in a net increase in electricity usage, which will increase the usage of fossil fuels to meet the demands. These implications on environmental sustainability also need to be addressed.

  This report utilizes a real-life vehicle to compare the impacts of fossil fuels and impacts of renewable energy sources on overall carbon footprint and environmental sustainability of the automotive sector.
- **Variables:** There are some variables which vary depending on location, like production volumes, electricity costs, energy consumption. In order to make it easier to compare, this report has chosen a vehicle of which both petrol/diesel and EV counterparts exists, and all of the model types are produced in the same manufacturing plant. This particular Indian cross over was launched with both Petrol and Diesel engines in 2017, whereas the purely electrified version of it was launched in 2019. All the

versions of these cars are manufactured in a manufacturing plant located in Ranjangaon, Pune. The usage of these vehicles however will be considered in developing metropolises like Ahmedabad.

- **Analysis:** Several car journals and reviews have been gone through to obtain specific data related to the aforementioned vehicle. Research papers and review papers have been studied in sufficient numbers, and studies and experiments with the aim of comparing the various renewable sources have been studied. A quantitative analysis on Renewable sources of energy like, wind energy, solar energy and biomass energy has been done to give a better insight into the Energy Return on Energy Investment (EROEI).
- **Environmental Impacts:** The most important part of this research is to study the impacts on environment due to these renewable sources of energy. The integration of more and more EVs will take a toll on the net supply and demand of electricity. Since several nations are still not capable enough to supply electricity to all regions for 24 hours, the increase in electricity demand in the coming years due to more EVs on the road will become even more difficult. There are other sources of energy to produce electricity, but each has its own impacts on the environment, which are studied in this research paper.
- **Limitations:** This is a paper is a combination of both research review as well as assumption-based analysis for Indian market. While reviewing papers available globally, there is no particular study done for Indian Automotive sector.
  The result may vary in real life due to some factors like climate, surroundings, usage, etc. The data collected and used for this paper is easily available. The selection of one car available in both ICEV/BEV is done to help understand the prospect of the study, but this data is taken from online sources.
- **Policy Implications and recommendations:** Policies with an aim for better integration of EVs into grids, improvisation in EV sales, incorporating alternate sources of energy, better charging schedules, reducing load on existing grids etc, have also been discussed.

4. Significance

- Discussions on alternate sources of energy have been a very wide topic. Ever since the fossil fuels have known to be exhaustible, newer sources of energy have started being discovered, but each alternate source of fuel has its impacts on the environment. A scale to determine which type of renewable fuel is better; we have used Global Warming Potential (GWP), Energy Return On Energy Invested (EROI), Green House Gas emission (GHG) and carbon footprint. It has been studied by taking in consideration of total reserves of fossil fuels left on earth that, there will be no coal after the 2168, no petrol after the year 2071, no natural gas after the year 2074, until we find newer reserves, which might extend those time frames, which is out of any human's control since we can only find but not create reserves. However, we can limit the usage of fossil fuels and find alternate sources of fuel.
- The very invention of Electric Vehicles was because we needed to slow down the usage of petroleum, however EVs need charging which is delivered by power plants running on coal. EVs might seem a better option when it comes to saving petroleum, but it is not the best as more EVs hit the road, more coal will be burnt to keep them running. This indeed does take a toll on the Global Warming Potential (GWP), Energy Return On Energy Invested (EROI), Green House Gas emission (GHG) and carbon footprint, until we incorporate wind energy, biomass energy, and solar energy into the scenario.

- This research paper recommends policies and suggestions for changes that need to be made in order to better integrate EVs and reduce the Impacts. Valuable insights have been provided by this research, so policymakers can use the results to accelerate the adoption of renewable sources of energy. This research also aids in setting environmental standards and targets, ensuring the industry aligns with sustainability objectives and supporting the transition to a low-carbon transportation sector.
- It inspires the development of advanced vehicle technologies, such as electric vehicles, hydrogen fuel cell vehicles, and other alternative propulsion systems along with sources from which electric energy is harnessed, like wind energy, biomass, solar energy. By exploring the impact of renewable energy on the automotive sector, this research contributes to the growth of clean and sustainable transportation technologies, fostering innovation and promoting economic opportunities.
- Since, the aim of this research is to study the impacts of renewable energy on overall carbon footprint of automotive industry; it provides some valuable insights on the reduction of overall carbon footprint in order to make this earth more habitable for current & future generations. Accelerated adoption of renewable energy paves way for creating healthier and more habitable planet.
- This research also highlights the potential for economic benefits, as new job opportunities will be created, more charging infrastructure will be developed, better savings for the nation and customers. The automotive sector can position itself at the forefront of the global clean energy transition, fostering economic competitiveness and resilience.

5. Current Scenario

According to the Ministry of Power Govt. of India, the current target is to generate 1750 Billion Units (BU) of electricity in the financial year 2023-2024 see a growth of 7.2% over previous year's production of 1624.158 BU. This shows the current requirement of a large sum of electricity from every possible sector (private, central and state). According to the data of last year India had a requirement of 1511.847 BU, the installed generation capacity was able to provide only 1504.264 BU. This shows the incapabilities of the current generators as 56.8% of this electricity is generated using fossil fuels. Only 30.2% is generated using Renewable Energy Sources.

For a reference a coal plant is about 600MW in size (1 MW =1000 KW = 1000 Unit/h). An article from ETAuto suggests that by 2030 the requirement of electricity will be 2074TWh (2074 BU) in modest situations and from that about 97TWh will be utilised by the Automotive industry. This prediction has also raised some serious concerns. The widespread adoption of electric vehicles would result in strain on the country's grid, with abnormal peaks. To address this issue, more flexibility is required. According to Brookings, the total charging capacity of electric vehicles (EVs) will range from 334 to 1,814 Gigawatts under various different EV penetration scenarios and slow, medium, and fast charging. And this would only make up to a quarter of the total load capacity of all the electrical devices and equipment in all end-use sectors of the country. It has been observed, that last year out of 1624.158 BU only 194.9 BU were from Renewable Energy Sources (including hydro, solar, wind, biomass, etc.). EVs might destabilize the grid if this situation continues and the grid is not upgraded. For example, currently 16+ Lakh HEV/BEV are in used in India. A regular cross over EV would utilize approximately 30 Units for a single charge using an AC 3kW charger or 45 units using DC fast charging. If we see only BEV's then approx. 39 Million Units (MU) are used on a daily basis. The main difficulty for the grid with EVs will thus not be aggregate power units but rather "when" and "where" the demand is generated. EVs might add up to 50% to peak demand.

The breakdown of electricity requirement has been broken down into a flowchart to understand the needs and utilisation. This flowchart has been developed with the help of various government data as well as data available from the energy provider's website (torrentpower.com & adanipower.com).

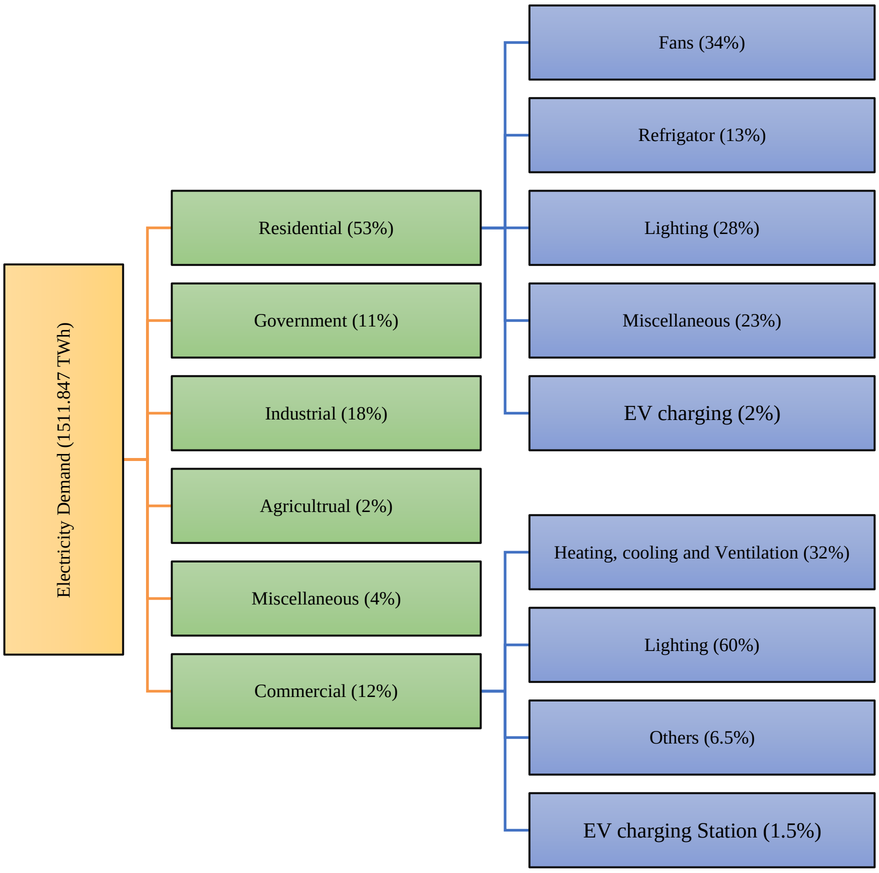

Figure 1: Flowchart of Electricity distribution in India

In order to address this issue, it is crucial to expand the utilization of Renewable Energy sources and integrate them with Grid specifically for the purpose of charging Electric Vehicles (EVs). Utilizing Renewable Energy sources can enable EVs to be charged in the late afternoon or evening to absorb Renewable Energy peak power, while still allowing base-load to function to meet the remainder of the demand, thus reducing the net load decrease in the current situation and contributing to the maintenance of a balanced load curve. Such a balanced load curve would lead to cost savings across the value chain, as it would result in increased base-load utilization (lower fixed costs per unit) and a decrease in the need for costly peaking capacity.

To understand the situation and the impact, an Indian manufactured car is used as an example. This particular car has been available in both formats, i.e., BEV as well as ICEV.

A simple comparison between a Nexon EV and a Nexon Petrol (Automatic variant) has been done for kilometre (KM) per Kilo watt hour (Kwh). An EV is always an automatic transmission car, it has no gears as the power produced by the electric motors have a very wide torque range. This also allows better efficiency as lesser number of parts are used in such a setup and as a result there are lower inertial forces to overcome. Thus, to compare it with an equivalent vehicle this paper has chosen the automatic petrol variant.

Table 1: Indian Crossover EV calculations

Indian Cross over EV version	
Requirements	Amounts
Battery Capacity	30.2 Kwh
Theoretical Range	312 Km
Real World Range (With 2 adults)	233 Km
Real World Range (With 5 adults)	225 Km
Units consumed to fully charge the car	30 Units
Calorific Value of coal	30 MJ/Kg
Average consumption of coal to produce one unit of electricity	0.7237 Kg
Amount of coal required to charge on Nexon EV	30 Units × 0.7237 Kg = 21.71 kg
Amount of energy provided by 21.71 Kilograms of coal	21.71 × 30 MJ/Kg = 651.33 MJ =180.925Kwh
Kilometers Per kwh	233/180.925 = **1.28 Km/Kwh**

Table 2:: Indian Crossover Petrol Calculations

Indian Crossover Petrol (Automatic)	
Requirements	Amounts
Fuel Tank Capacity	44 Litres
Range	18 × 44 = 792 Kms
Mass of one litre petrol	0.737 Kg
Amount of petrol in a Nexon tank when filled to brim	44 × 0.737 = 32.428 Kg
Calarofic Value	45 MJ/Kg
Average (KmpL)	18 Km/L
Amount of energy required	32.428 Kg × 45 MJ/Kg = 1459.26 MJ = 405.35 Kwh
Amount of energy per Kilometre	792/405.35 = **1.95 Km/Kwh**

This shows that currently the conventional version of the car gives better results when compared to its BEV counterpart. Even this is just the comparison based on range per unit of energy. According to studies, the payback period for a BEV is now 20 years when compared to a less expensive ICEV, but it should be less than five years by 2030.

6. Literature Review

Introduction:

The automobile sector has a huge impact on both environmental deterioration and global carbon emissions. The goal of this review of the literature is to look at the current studies on how the use of renewable energy affects the automobile industry's total carbon footprint and environmental sustainability. This study aims to identify the present level of knowledge, highlight major trends, and discuss the possible advantages and problems connected with the integration of renewable energy by analysing a variety of research and their conclusions.

Theme 1: Renewable Energy Adoption in Automotive Manufacturing

The subject of several research has been the usage of renewable energy sources in the manufacturing of automobiles. Proposed that installation of solar PV arrays over parking lots is a good idea to keep the cars cooler when parked and provide electricity to the EVs parked under it or to the grid. For instance, a comparison between fossil fuel, land usage and greenhouse gas emission substitution of biofuels in order to generate bio-electricity for electric cars in Austria has been made by [4]. [5] studied that 3 out of 5 researched companies already utilize Renewable and Sustainable sources of energy in Czech Republic for manufacturing. These studies provide light on the possible advantages of integrating renewable energy in lowering the carbon footprint of the automobile industry.

Theme 2: Electric Vehicles and Renewable Energy Synergy

The growth of electric vehicles (EVs) and the integration of renewable energy sources go hand in hand. For instance, [6] research by [7] demonstrates that the installed energy capacity will increase from 30% to 70% with EVs that are V2G capable, such EVs can charge from grid and discharge to the grid as and when required. Additionally, studies like [4] underlined use of biomass by converting it to biofuel is less effective than using it for charging EVs. These results highlight the synergistic potential for EV adoption and the integration of renewable energy in lowering the carbon footprint of the automotive sector.

Theme 3: Life Cycle Assessment of Renewable Energy-powered Vehicles

Studies on life cycle assessment (LCA) offer a thorough analysis of the environmental effects of renewable energy-powered vehicles over the course of their full life cycle. For instance, [3] carried out an LCA analysis to compare the environmental performance of conventional, hybrid, and electric cars while considering the energy sources utilised to power the vehicles. According to their research, automobiles fuelled by renewable energy had much reduced life cycle carbon emissions. Further it has been emphasised the need of taking into account the upstream emissions connected with electricity generation when assessing the environmental advantages of renewable energy-powered automobiles.

Theme 4: Challenges and Considerations in Renewable Energy Integration

Although incorporating renewable energy into the automobile industry has many advantages, there are drawbacks as well. Impacts were found in research by [1]. [8] research showed that there is a lack of renewable energy infrastructure, and technological limitations. Frameworks for policy and regulation are also very important in facilitating the integration of renewable energy.

7. Impact of RES integration

A thorough study has been undergone to understand various impacts of different RES's integration with grid. It would be a mistake to not understand the consequences on environment as well as human health due to this integration.

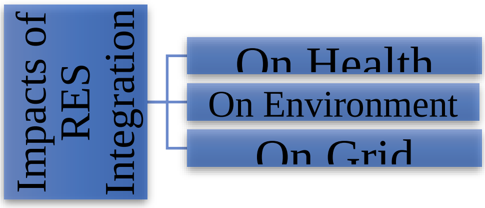

Figure 2: Sectors influenced by integration

7.1. Impacts on Health:

a) Wind Energy – A prolonged exposure to vibration and low frequency infrasound of wind turbine can cause wind turbine syndrome with symptoms like headache, exhaustion, anger, anxiety, loss of sleep, tinnitus, etc.
Another problem is vibroacoustic disease (VAD) causing problems like chest pain, haemorrhage, varicose veins, severe joint pain, neurological disturbances, pain & blood in urine, etc.

b) Hydropower – Working at a hydropower plant a person can get exposed to Electro Magnetic Fields (EMFs). The maintenance personnel also face dangers like falls, fire, electrical hazards, respiratory problems, hazards due to terrain as well as extreme weather.

c) Biomass/Bioenergy – Bioenergy is derived from performing certain chemical reactions to produce Biofuels from industrial as well as domestic waste. This chemical reaction has potential to toxic hazards as well as fire and explosive hazards. Health issues like Asthma, Neurodegenerative diseases, death, birth defects, etc.

d) Geothermal – One of the most hazardous RES is Geothermal. To obtain energy from this source, a trench needs to be developed to let the pipelines, which itself is dangerous. Hazards and health issues caused by Geothermal may vary from Asphyxia to Silica Exposure causing Silicosis.

e) Marine & Hydrokinetic – The primary hazard is the risk of drowning. Health risk that causes fatal injuries may occur due to onboard accidents, collision of ships, hurricane, earthquakes, etc. Public health risks are limited during site evaluation phase and are only associated with outdoor activities.

7.2. Impact on Environment: Although renewable energy sources (RES) have less negative environmental consequences than fossil fuels, they are not without downsides. Following is some of the adverse environmental impacts of renewable energy sources.

a) Land Use & Habitat Disruption – Large-scale green energy initiatives, specifically solar farms and wind power plants, may necessitate considerable land expanses, potentially resulting in habitat disturbance and loss for local animals. Clearing land for these projects may result in ecosystem relocation or fragmentation.

b) Appearance and Noise impacts – Wind turbines and solar panels can affect the looks of the landscape, which some communities may regard as a negative consequence. Furthermore, wind turbines can produce noise during functioning, which may disturb wildlife and surrounding inhabitants.

c) Green House Gas Emissions – RES like Biomass and Biofuels releases carbon monoxide and other toxic gases when they are processed.

d) Waste Generation – Some of the RES produces waste either during functioning or decommissioning or manufacturing, RES like solar plant and wind plant.

e) Intermittency and Grid Stability Challenges – Renewable energy sources like solar and wind are intermittent, meaning they depend on weather conditions. This intermittency can pose challenges for grid stability and energy storage, which might require complementary energy sources for backup.

f) Environmental Impact of Energy Storage Technologies – Batteries and other energy storage technologies have their own impacts on the environment, such as the extraction of natural resources, energy-intensive production processes, and possible difficulties with waste disposal.

7.3. Impact on Grid:

a) Continuity and Variability: The Internal Issues – The propensity for intermittency and fluctuation of Renewable Energy Sources (RES), such as solar and wind power, is one of the main problems when combining RES. Solar energy's development is reliant on the presence of sunshine, whereas wind energy depends on the erratic nature of wind speed and consistency. The challenge of maintaining grid stability is made more difficult by these mercurial changes, which cause abrupt vagaries in power production.

b) The Balancing Act: Juggling Grid Stability and Flexibility – Grid operators must perform a complex and ongoing balancing act to synchronize power supply and demand in real-time due to the inherent transience of RES. To address the irrationality inherent in the production of renewable energy, this mysterious undertaking may necessitate the escalation or de-escalation of alternative power sources, such as natural gas power plants.

c) Energy Storage: The Key to Stability – One of the most promising solutions to the enigma of intermittency is energy storage technology. Batteries, in particular, play a crucial role in storing excess renewable energy during periods of surplus and releasing it during lulls in generation, effectively bridging the gaps and enhancing grid reliability.

d) Transforming Grid Infrastructure – The integration of RES sometimes necessitates a transformation of the grid's transmission and distribution infrastructure. As renewable energy sources are often located in remote areas, new conduits and infrastructure are required to transmit electricity efficiently to populated regions.

e) Emissions Mitigation and Ecological Bonuses – Despite the complex challenges of intermittency, the integration of RES offers tangible benefits in terms of reducing greenhouse gas emissions and promoting environmental sustainability.

8. Impact of EV's

Some of the impacts of shifting towards Electric Vehicles are discussed briefly. For this section a comprehensive analysis is done to gather the data.

8.1. Impact on Grid: EVs are to a large extent influenced by free and uncensored charging of vehicles, which has implications in terms of the electricity grid's performance, efficiency or needed capacity.

a) Grid Load capacity – It is estimated, that for 1 million EVs there will be an increase of load up to 1.5% on grid, using a simulation. As a result, demand for electricity will increase by 92 % in total energy supply if the ownership of electric vehicles reaches 42 million. [9]

b) Power Quality – The erratic charging behaviour of the users of BEVs cause many damaging effects to the grid e.g., voltage discrepancies, overvoltage, harmonic distortion. The in-depth explanation is presented by [10].

c) Equipment wear - [11] assessed the influence of EV on a residential transformer. It states that the wear is minimal until the EV penetration at residential level is low, but equipment wear is significantly more when the EV number increases.

8.2. Impact on Environment: Multiple studies show the upside of boosting the EV sales and ownership, focusing on mainly the no "tailpipe" emissions but most of them forget the impact on environment due to battery discharging and end – of – life treatment of batteries.

a) Elimination of Tailpipe Emissions – Papers benchmarked by [3] includes emission like CO_2 , NO_x, N_2O, CO, PM, CH_4, Volatile Organic Compound (VOC} and different types of metals. These pollutants have impacts like global warming, climate change, air pollution and hazard to human health. Shifting towards EVs can eliminate most of these pollutants.

b) Battery Disposal and Recycling – [12] reviewed a major problem of BEV is the life cycle of the battery. A general assumption is 200000 miles (321868.8 kms) for any BEV. After the end of its lifespan, the batteries of BEVs need to be disposed into the environment properly. It is essential to prevent hazardous materials from leaching into the environment and causing pollution. [13]

c) Indirect Environmental Impacts – The growth of the EV industry can also have indirect environmental consequences, such as increased mining activities for raw materials, which can lead to deforestation, soil erosion, and water pollution. (Troy R. Hawkins, 2012)

8.3. Impact on Renewable Energy Source: EVs positively impact Renewable Energy Sources in following ways –

a) Demand for electricity – As EVs increase significantly, the demand for electricity will increase to charge them. This plays a pivotal role in propelling cleaner RES.

b) Storage – Vehicle to Grid (V2G) technology allows the surplus renewable energy to be stored, and also can supply back to the grid when required, thus improving grid stability. [1]

c) Uncertainty associated with RES – Using methods like Interval Optimization proposed by [14], can help distribution system operators to optimally schedule EVs with considering the uncertainty associated with RESs and loads.

d) Charging Infrastructure – According to [15] the increasing use of EVs may impose strain on the current electrical grid, particularly in regions with constrained RES capacity. To manage the growing demand, this necessitates extensive grid upgrades, which may be both expensive and time-consuming.

9. Results and Discussion

The paper presents a detailed review of electric vehicles (EVs) and their effects on the environment through the integration of renewable energy sources (RES) in the automotive sector. The existing literature strongly suggests that EVs have the potential to substantially diminish the surplus of renewable energy generated within an electric system. Studies on life cycle assessment (LCA) show that renewable energy-powered vehicles have much reduced life cycle carbon emissions compared to conventional vehicles. The research provides valuable insights for policymakers to accelerate the adoption of renewable sources of energy and set environmental standards and targets in the automotive sector. The paper emphasizes the need to consider the upstream emissions connected with electricity generation when assessing the environmental advantages of renewable energy-powered automobiles.

Note: The provided sources do not explicitly mention the specific results of the paper. However, the information provided in the sources gives an overview of the findings and implications of the research.

10. Conclusions

This report suggests that EVs have the potential to substantially reduce the surplus of renewable energy generated within an electric system. The research explores the impacts of renewable energy on the automotive sector and contributes to the growth of clean and sustainable transportation technologies, fostering innovation and promoting economic opportunities. The paper also discusses the policy implications and recommendations for better integration of EVs into grids, improvisation in EV sales, incorporating alternate sources of energy, better charging schedules, and reducing load on existing grids. The analysis includes a quantitative analysis on renewable sources of energy like wind energy, solar energy, and biomass energy, providing insights into the Energy Return on Energy Investment (EROEI). The paper emphasizes the need to find alternate sources of fuel due to the exhaustibility of fossil fuels and their impacts on the environment.

References

1. D. B. Richardson, “Electric vehicles and the electric grid: A review of modeling approaches, Impacts, and renewable energy integration,” *Renewable and Sustainable Energy Reviews,* pp. 247-254, 2013.
2. A. S. Anees, “Grid Integration of Renewable Energy Sources:Challenges, Issues and Possible Solutions,” *IEEE 5th India International Conference on Power Electronics (IICPE),* pp. 1-6, 2012.
3. O. M. G. &. A. H. S. Troy R. Hawkins, “Environmental impacts of hybrid and electric,” *The International Journal of Life Cycle Assessment,* pp. 997-1014, 2012.
4. G. V. &. S. E. Schmidt J, “Land use changes, greenhouse gas emissions and fossil fuel substitution of biofuels compared to bioelectricity production for electric cars in Austria.,” *Biomass and Bioenergy 35(9),* pp. 4060-4074, 2011.
5. V. Pechancová, “RENEWABLE ENERGY POTENTIAL IN THE AUTOMOTIVE SECTOR CZECH REGIONAL CASE STUDY,” *JOURNAL OF SECURITY AND SUSTAINABILITY ISSUES,* 2017.
6. B. D.P., “Analysis of energy capture by vehicle solar roofs in conjunction with workplace plug-in charging,” *Solar Energy, 125,* pp. 219-226, 2016.
7. &. M. F. Turton H., “Vehicle-to-grid systems for sustainable development: An integrated energy analysis.,” *Technological Forecasting and Social Change 75(8),* pp. 1091-1108, 2008.
8. J. H.-M. J. S.-C. S. G.-. C. R. &. C. -M. M. Martinez-Duart, “new Frontiers in Sustainable Energy production and storage.,” *Vaccum 122,* pp. 369-375, 2015.
9. S. H. a. A. Tsvetkova., ““Potential Impacts of Plug-in Hybrid Electric Vehicles on Regional Power Generation”.,” *Oak RIge National Laboratory,* 2008.
10. A. X. A. M. S. I. M. U. J. H. u. R. Syed Asad Abbas Rizvi, “Electric Vehicles and their Impacts on Integration into Power Grid: A Review,” *2nd IEEE Conference on Energy Internet and Energy System Integration (EI2).,* 2018.
11. M.-M. S. M. V. R. G. Gong Q, “Study of PEV charging on residential distribution transformer life.,” *IEEE Transactions on Smart Grid,* pp. 404-412, 2012.
12. O. J. D. G. D. S. H. S. T. B. Dhingra R, “A life-cycle-based environmental evaluation: materials in new generation vehicles.,” *SAE Tech. Paper Series. Oak Ridge National Lab., Univ. of Tennesee,* 2000.
13. G. M. W. R. W. P. S. A. Z. R. A. H. Notter D, “ Contibution of li-ion batteries to environmental impact of Electric vehicles,” *Environ Sci Technol 44(17),* pp. 6550-6556, 2010.
14. D. R. ,. K. M. Abdelfatah Ali, “Optimal scheduling of electric vehicles considering uncertain RES generation using interval optimization,” *Electrical Engineering 100(3), CrossMark,* pp. 1675-1687, 2017.
15. S. K. N. Sujitha, “RES based EV battery charging system: A review,” *Renewable and Sustainable Energy Reviews,* pp. 978-988, 2017.
16. Z. Casey, “How noisy is a wind turbine?,” *EWEA Blog,* 13 November 2012.
17. R. DiPippo, “Geothermal energy: electricity production and environmental impact: a worldwide perspective,” Energy and the Environment in the 21st Century, Cambridge, MA: MITPress, 1991.
18. C. C. F. M. E. E. Hajimiragha A, “Optimal transition to plugin hybrid electric vehicles in Ontario, Canada, considering the electricity-grid limitations,” *IEEE Transactions on Industrial Electronics,* pp. 690-701, 2010.
19. C. C. F. M. M. S. E. A. Hajimiragha A, “A robust optimization approach for planning the transition to plug-in hybrid electric vehicles,” *IEEE Transactions on Power Systems,* pp. 2264-2274, 2011.

20. K. Jorgensen, “Technologies for electric, hybrid and hydrogen vehicles: electricity from renewable energy sources in transport,” *Utilities Policy,* pp. 72-79, 2008.
21. O. R. N. Laboratory., “A comparative study of emerging vehicle technology assessments.,” *Oak Ridge, TN: Oak Ridge National Laboratory,* 2011.
22. R. Samson, “ Developing energy crops for thermal applications: optimizing fuel quality, energy security and GHG mitigation.,” Biofuels, Solar and Wind as Renewable Energy Systems: Benefits and Risks. , 2008.
23. K. W. Lund H, “. Integration of renewable energy into the transport and electricity sectors through V2G.,” Energy Policy , 2008.
24. OSHA., “Hearing Conservation,” Occupational Safety and Health Administration. , Washington, DC, 2002.