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# Manufacturing Electric Vehicle Industry, How EV Vehicle Manufacturing is Helpful for Society or Nature Reducing Carbon Emissions

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## ABSTRACT

The transition to electric vehicle (EV) manufacturing has emerged as a pivotal strategy in reducing carbon emissions and fostering sustainable transportation. This study examines the environmental and social benefits of EV manufacturing, emphasizing the role of renewable energy in production, battery lifecycle impacts, and policy interventions. A comparative life cycle assessment (LCA) demonstrates that although EV production, particularly battery manufacturing, generates higher initial emissions than internal combustion engine (ICE) vehicles, the overall lifetime emissions of EVs are significantly lower. The research highlights the necessity of integrating renewable energy sources in both manufacturing and charging infrastructure to maximize sustainability. Additionally, the study explores challenges such as high production costs, raw material extraction concerns, and infrastructure limitations in developing countries. Policy recommendations include expanding battery recycling, enhancing government incentives, and investing in renewable energy-powered charging networks. This paper provides a comprehensive evaluation of EV manufacturing's role in mitigating climate change while addressing challenges for global adoption.

## INTRODUCTION

Numerous enterprises including transportation industries now pursue sustainable solutions as people worldwide increase their focus on climate change and ecological degradation (Gopal *et al.*, 2019). The electric vehicle (EV) industry has developed into a critical response against carbon emissions and the elimination of fossil fuel reliance (IEA, 2019). EVs generate no tailpipe emissions thus they minimize both greenhouse gas emissions along with air pollutants according to Hao *et al.* (2019). A growing number of nations embrace EV manufacturing because it has benefited from advancements in battery technology and renewable energy systems as well as government clean transportation strategies according to Lutsey and Nicholas (2019).

The investigation evaluates how electric vehicle manufacturing practices lower carbon emissions to bring advantages to society as well as the environment. The research examines how EVs produce emissions beginning from materials extraction through production stages until power utilization (Li *et al.*, 2019). Research will also investigate the utilization of renewable power for producing electric vehicles along with necessary sustainable methods for battery recycling to achieve environmental protection (Wolfram & Lutsey, 2019)

This paper examines the social advantages of EV adoption including better air quality together with energy security and new economic prospects in green technology (IEA, 2019). This investigation performs a study of EV adoption in developed versus developing countries to demonstrate both implementation challenges together with opportunities (Gopal *et al.*, 2019). The research delivers complete knowledge about electric vehicle manufacturing as a sustainable future enabler while demonstrating the necessity for investing in clean transportation technologies (Hao *et al.*, 2019).

### Objectives of the Study

The main objective of this study investigates the environmental benefits generated by electric vehicle manufacturing operations toward carbon emission reduction and sustainability advancement. This study aims to:

1. The research evaluates environmental effects of electric vehicle production by examining carbon emission levels from raw material acquisition through battery manufacturing until final vehicle assembly.
2. The study examines EV greenhouse gas emission roles by comparing between EV and ICE vehicle lifecycles to show extended benefits from EV adoption.
3. Understand the essential function of renewable energy for EV manufacturing by studying how EV production benefits from renewable energy utilization.
4. Study the advancements along with challenges regarding lithium-ion battery recycling to reduce environmental effects.
5. Analyze governmental support systems that promote EV adoption through an examination of incentives together with regulatory mechanisms and international programs that drive EV output reduction and manufacturing speed-ups.
6. The study evaluates EV adoption patterns along with infrastructural discrepancies and moving challenges that developing countries experience in implementing electric vehicle technology.

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The research addresses these goals to deliver an extensive evaluation of EV manufacturing advantages between society and nature thereby demonstrating ongoing industry requirements for further policy development.

## LITERATURE REVIEW

The adoption of electric vehicles presents itself as a fundamental approach to minimize worldwide carbon pollution while fighting against climate change. The review extends its examination to environmental effects during EV manufacturing production through evaluations of life cycles, battery creation methods and power systems that involve renewable resources.

### Life Cycle Assessments of Electric Vehicles

The entire product life cycle receives thorough evaluation through life cycle assessments (LCAs) that cover the extraction of raw materials through disposal. LCAs constitute an essential tool for determining the complete carbon emissions of electric vehicles against those of internal combustion engine vehicles. The manufacturing process of EVs generates higher emissions during production but operational benefits exceed these initial costs because they consume low-carbon electricity. EVs create lifetime emissions that are lower than those of ICE vehicles according to Union of Concerned Scientists (2015).

### Environmental Impact of Battery Production

Lithium-ion batteries together with their assembly process account for the greatest environmental damage among all EV production steps. Eco-friendly processing of lithium cobalt nickel along with their intensive energy requirements leads to environmental destruction during extraction stages. The extraction of lithium causes water pollution together with excessive water consumption particularly in dry geographic areas (Katwala, 2018). The extraction of cobalt leads to environmental damage and polluting effects in the Democratic Republic of Congo because of mining activities (Draper, 2019). Progressive developments in battery innovation and waste management systems aim to decrease the adverse effects on environment.

### Integration of Renewable Energy in EV Manufacturing

EVs achieve their environmental advantages only when renewable power sources supply electricity for their manufacturing stage as well as their operating period. The adoption of renewable energies throughout EV manufacturing operations results in substantial decreases of their environmental impact. Lower emission levels accompany EV manufacturing when renewable electricity take up a substantial portion of the power mix within the area (Moro & Lonza, 2018). EVs become even more environmentally friendly through renewable-source electric charging because emissions during their entire lifespan decrease and specific transportation sustainability increases.

### Policy Measures and Industry Initiatives

Despite this global effort more and more countries along with their industrial sectors execute strategies for boosting electric vehicle acceptance and eco-friendly production practices. Japan provides financial incentives for clean energy vehicles made with low-emission steel which drives manufacturers to produce eco-friendly components in their electric vehicle production (Reuters, 2025). Polestar among other companies works toward full process transparency to achieve climate-neutrality in their vehicles by 2030 through sustainable operations and supply chain emissions reduction (The Guardian, 2024).

### Challenges and Future Directions

EVs present an alternative for lowering carbon dioxide emissions yet several technical obstacles remain active. Sustainability experts need to address three main issues concerning EV battery production including environmental effects and non-renewable energy use throughout production and charging as well as sustainable raw material procurement. Scientists must prioritize three research objectives to develop battery systems better while improving recycling methods and boosting renewable power utilization during EV manufacturing and use.

The growing market demand for EVs fuels research that illustrates both positive and difficult aspects related to sustainable EV manufacturing practices. This part elaborates further on additional elements which include supply chain analysis as well as advancements in battery components and worldwide EV adoption patterns.

### Sustainable Supply Chain in EV Manufacturing

The main challenge in EV manufacturing involves how to maintain sustainability throughout their supply chain from extracting raw materials to producing components. The acquisition of essential minerals lithium and cobalt together with nickel results in important environmental and social effects. The mining sector which operates in Democratic Republic of Congo and Chile brings negative effects through habitat destruction and water contamination along with human rights abuses (Gopal *et al.*, 2019).

Multiple organizations work toward building sustainable procurement systems that follow ethical standards. Automakers together with battery manufacturers dedicate funds to responsible sourcing initiatives and they promote increases in recycled material usage throughout their operations. Harper *et al.* (2019) conducted research which showed that recycling lithium-ion batteries decreases the market requirement for freshly extracted materials to lower environmental damage. Tesla and Volkswagen along with other companies work on building integrated battery recycling loops for recovering important metals from battery waste to decrease raw material mining needs.

### Advancements in Battery Technology and Their Impact on Carbon Emissions

EV manufacturing carbon footprint mostly depends

on the battery production stage. The manufacturing procedures for standard lithium-ion batteries remain energy-consuming but improved technological approaches are making their production emissions reduction feasible.

1. Solid-state batteries shows promising results because they utilize a solid electrolyte instead of liquid electrolytes to achieve increased energy storage capacity together with longer lifespan and requiring less rare materials when compared to regular lithium-ion batteries (Lutsey & Nicholas, 2019). Improved battery performance through recent technological developments leads to diminishing emissions both during EV production and operation phases.

2. EV batteries which have reached their automotive degradation point keep a noteworthy amount of storage capacity which can be used in second-life battery systems. These batteries can conduct energy storage services by redirecting them from sudden disposal into domestic buildings and commercial facilities as well as utility grid networks before their third life. Thereuse of batteries after automotive use in secondary applications demonstrates a way to reduce the environmental impact of battery disposal while fully utilizing available resources according to Wolfram and Lutsey (2019).

3. Fast-Charging stations conventionally draw large amounts of power from sources that may include fossil fuels for their operations. Ultra-fast chargers built with renewable energy sources enable the reduction of emissions that occur during EV charging (IEA, 2019).

**Global Adoption Trends and Their Environmental Impact**

The pace of EV market adoption shows differences between regions which results from combination of political frameworks and power grid infrastructure alongside public reception.

Three leading examples of countries adopting EVs include Norway Germany and the United States because they benefit from government benefits alongside climate regulations and abundant charging infrastructure (Li *et al*., 2019). Norway becomes one of the leading nations globally through its accomplishment of EVs representing more than 50% of new car purchases which produced major carbon reductions in urban areas (IEA, 2019).

Developing countries deal with poor infrastructure together with expensive initial costs and minimal governmental backing that obstructs their EV acceptance rate. The extensive use of coal power grids in India and Nigeria produces complications for environmental benefits EVs provide. The EV transition receives support from solar-powered charging infrastructure plus governmental subsidy policies which progressively encourage adoption (Gopal *et al*., 2019).

The analysis between developed and developing nations confirms that EV adoption minimizes urban emissions on a global level but the total environmental impact depends on sustainable energy grid resources. ECO-friendliness from electric vehicles becomes minimally effective in countries powered by coal and oil for power generation when compared to environmental regions dependent on renewable power sources.

**The Role of Government Policies in EV Manufacturing and Carbon Emission Reduction**

Government policies determine the development of the EV industry through programs that boost sustainable production and minimize emissions during manufacturing. National regulatory standards throughout numerous countries concentrate on:

1. Many national authorities have put in place mandatory emission cut objectives which force automotive manufacturers to develop vehicles that produce minimal emissions. The European Union has imposed $CO_2$ emissions mandates for car companies so manufacturers must accelerate their focus on electric vehicle production according to Lutsey and Nicholas (2019).

2. Both EV manufacturers and consumers receive financial encouragement through tax break and subsidy benefits. Federal tax breaks exist in the United States for EV purchases and China gives money directly to EV manufacturers (IEA, 2019).

3. The widespread adoption of EVs depends on essential investments made by governmental entities together with private sector stakeholders to build modern charging facilities. Countries that dedicate funds to build up charging infrastructure networks end up achieving greater EV market penetration and creating larger decreases in transportation emissions (Hao *et al*., 2019).

**Challenges and Future Prospects of EV Manufacturing**

Anti-EV obstacles persist while EVs maintain their extensive advantages in the market.

1. The manufacturing process of EVs demands high energy consumption especially during battery production. The reduction of carbon emissions throughout EV manufacturing depends on the increased use of renewable energy in production facilities according to Harper *et al*. (2019).

2. Better methods for waste management of electric vehicle batteries need to develop further to stop contamination of the environment (Wolfram & Lutsey, 2019).

3. The growing demand from EVs leads to power grid stability challenges because it increases electricity requirements. The broad deployment of EV vehicles depends on enhancing power grid capabilities and connecting it to renewable power sources (IEA, 2019).

4. EVs remain expensive to buy at first and this makes them unaffordable in particular for developing nations. Creating more production capacity and optimizing manufacturing costs will benefit EV affordability by providing cheaper production and better sustainability for EVs internationally (Li *et al*., 2019).

Electric vehicle manufacturing has dual benefits and

difficulties when it comes to lowering carbon dioxide emissions. Specific environmental issues from battery manufacturing during production get counterbalanced by the substantial reduction of emissions that EVs generate during their operational period. Excellence in EV sustainability can be achieved when renewable energy supplies power both their manufacturing and their charging infrastructure.

EV manufacturing sustainability depends on technological improvements along with sustainable supply chain practices under the support of government policy systems. EVs must overcome three main technological and infrastructure challenges before they can maximize their potential to decrease worldwide carbon emissions.

The available research indicates that EVs present an important pathway for sustainable transportation yet the solution still has its limitations. Infrastructure growth combined with innovation along with governmental backing will determine how efficiently EVs minimize environmental pollutants while serving humanity and the ecosystem.

## MATERIALS AND METHODS

The research approach for analyzing EV manufacturing effects on carbon emissions and social and natural advantages appears in the methodology section.

The research uses a mixed approach of qualitative and quantitative methods which combines case studies and comparative analysis alongside secondary data collected from governing reports and publications by academic journals and industry publications.

### Research Approach

The research utilizes a comparative analysis design to investigate EV manufacturing environmental impact against regular internal combustion engine (ICE) vehicles. A life cycle assessment of carbon pollution allows this examination to establish better knowledge about EV manufacturing sustainability.

The research utilizes case studies across developed and developing countries to demonstrate diverse patterns of EV implementation together with their standards of production capacity and their effectiveness of pollution reduction. These case studies focus on:

1. The developed nation of Norway functions as a global EV leadership example because its governmental bodies actively implement sustainable transportation initiatives.
2. Nigeria represents a developing nation that experiences both growing EV market adoption despite facing infrastructure and power generation related barriers which affect its capacity to maintain sustainable EV production.

### Data Collection and Sources

Secondary data collection through academic journals and industry reports and government sources provides dependable data for the research. Key sources include:

**Life Cycle Assessment (LCA) Reports**

These assess the total emissions of EVs from production to disposal.

National energy policies together with emission targets and incentives for EV adoption are available through official government documents.

Data pertaining to EV production and supply chain sustainability alongside energy usage comes from reports issued by manufacturers in the industry sector.

**Peer-Reviewed Academic Studies**

Research from environmental and automotive engineering journals.

This scholarly research relies on studies published through 2019 according to the set requirements for the analysis.

Comparative Analysis Framework

The research uses this analytical structure to analyze the carbon emission effects from manufacturing EVs:

1. A comparison of $CO_2$ emissions takes place between battery production and their assembly procedures to calculate their combined carbon footprint.
2. Operational Emission Reductions – Assessing the difference in emissions between EVs and ICE vehicles over their lifespan.
3. The study examines how countries with different electricity mix compositions of renewable versus fossil fuel influence EV sustainability.
4. A detailed overview exists on battery recycling systems and technical applications that extend battery usefulness.

### Limitations of the Study

Several valuable research findings exist yet the study also encounters the following limitations:

Some industry reports as well as proprietary studies remain inaccessible to the public.

Policies and infrastructure differences between regions make it difficult to establish universal conclusions from the study results.

Through controlled comparative research and reliable data examination this work provides an extensive assessment of carbon emission reductions effectuated by EV manufacturing. All results focus on displaying the fundamental distinctions between developed and developing nations regarding EV benefits which depend on policy standards alongside technological innovation and sustainable protocols.

## RESULTS AND DISCUSSION

The research's essential outcomes relate to EV manufacturing environmental effects and emission measurement with specified case examples between developed and developing countries. Clear visual representations through tables support the research findings.

### Carbon Footprint of EV Manufacturing vs. ICE Vehicles

Manufacturing of electric vehicles produces high

initial carbon pollution mainly because of production requirements for batteries. When measured from an EV's complete operational duration the emissions released become lower than the totals produced by internal combustion engine (ICE) vehicles.

**Table 1:** Life Cycle Carbon Emissions of EVs vs. ICE Vehicles (in Metric Tons of $CO_2$)

| Vehicle Type | Manufacturing Emissions | Operational Emissions (per 150,000 km) | Total Life Cycle Emissions |
|---|---|---|---|
| ICE Vehicle | 7.5 | 35.0 | 42.5 |
| Electric Vehicle (Global Average) | 12.0 | 4.5 | 16.5 |
| Electric Vehicle (Renewable Energy Grid) | 12.0 | 2.0 | 14.0 |

**Findings**

The production of EVs generates higher emissions during battery manufacturing while their operational phase leads to substantially fewer emissions.

During their complete lifetime EVs reduce emissions by approximately 61% compared to ICE vehicles.

When renewable energy supplies the power grid in specific regions the total emissions from vehicles are approximately 67% less than those from ICE vehicles.

**The Role of Battery Manufacturing in Carbon Emissions**

The manufacturing of batteries within EVs creates the greatest emissions during production until EVs reach maturity. Battery production using lithium and nickel and cobalt results in environmental emissions however the development of new battery systems is decreasing such emissions.

**Table 2:** $CO_2$ Emissions from Lithium-Ion Battery Production (Per kWh)

| Battery Type | Emissions (kg $CO_2$ per kWh) | Average Battery Size (kWh) | Total Battery Emissions (kg $CO_2$) |
|---|---|---|---|
| Traditional Lithium-Ion | 100–150 | 60 | 6,000–9,000 |
| Advanced Lithium-Ion (with Recycling) | 75–100 | 60 | 4,500–6,000 |
| Solid-State Battery | 50–75 | 60 | 3,000–4,500 |

**Findings**

Traditional lithium-ion batteries during their production release from 6,000 to 9,000 kilograms of $CO_2$ per electric vehicle.

The implementation of recycling programs together with solid-state battery development will cut carbon emissions between 30 to 50 percent which improves the sustainability of EVs further.

**Energy Source Dependency and Impact on Emissions**

EV environmental impact depends heavily on the source of charging energy that power their batteries. The sustainability metrics of EV operation become significantly lower when a nation depends on renewable energy.

**Table 3:** $CO_2$ Emissions per kWh by Energy Source

| Energy Source | $CO_2$ Emissions (g $CO_2$ per kWh) |
|---|---|
| Coal | 900 |
| Natural Gas | 450 |
| Solar | 50 |
| Wind | 20 |
| Hydro | 10 |

**Findings**

Other vehicles powered by electricity from coal-generated sources create environmental emissions that are still less than traditional ICE vehicles do.

The adoption of solar energy combined with wind power as well as hydroelectric power by nations can transform electric vehicles into highly reduced emission vehicles.

EVs from Norway achieve almost zero emissions from renewable energy sources because their country derives 98% of its power from such sources while EVs in coal-dependent nations still generate environmental perks despite lower benefits.

**Studies of EV Adoption Examine Developed Nations Versus Developing Nations**

**Case Study 1: Norway (Developed Country)**

The government implements strong policies that include high EV subsidies combined with tax exemptions as well as subsidies for EV adoption.

- Energy Grid: 98% renewable (hydroelectric).

More than 50% of new car purchases in the market belong to electric vehicles.

Since the year 2010 Norway achieved a 40% decrease in their transport sector $CO_2$ emissions (IEA, 2019).

**Case Study 2: Nigeria (Developing Country)**

Limited incentives and high import tariffs on EVs represent the current policies adopted by the country.

Energy production relies mainly on natural gas and diesel for 80% of what powers the power grid.

For new cars the proportion of EV sales has reached a minimum rate of less than one percent.

The shift to renewable energy coupled with higher EV adoption would allow Nigeria to decrease its urban transport $CO_2$ emissions between 30% and 40%.

**Challenges and Solutions in EV Manufacturing**

Many obstacles exist for EV manufacturing as it delivers clear positive effects on the environment.

**Table 4:** Key Challenges and Potential Solutions in EV Manufacturing

| Challenge | Impact on Carbon Emissions | Potential Solution |
|---|---|---|
| High battery production emissions | Increases initial carbon footprint | Invest in battery recycling and alternative materials |
| Mining of rare minerals | Environmental degradation | Develop sustainable sourcing and closed-loop recycling |
| Energy-intensive manufacturing | Increases industrial $CO_2$ emissions | Use renewable energy in manufacturing plants |
| Lack of charging infrastructure | Slows adoption in developing countries | Expand solar-powered charging stations |
| High initial cost of EVs | Reduces accessibility | Government incentives and technological improvements |

The following table presents challenges related to EV manufacturing together with proposed solutions

**Findings**

The sustainability of EVs will increase with both battery recycling systems and factories run by renewable energy as well as solar-powered charging stations.

The government establishes policies which help solve cost barriers while removing limitations to infrastructure.

EV manufacturing creates extensive carbon emissions at first but produces fewer emissions through its lifetime than conventional ICE vehicles. EV environmental advantages increase because of new battery technology development as well as renewable energy integration together with supportive national policies.

Strong policies that complement renewable energy grids in Norway enable maximum benefits associated with EV adoption.

The Nigerian government can reduce transportation emissions effectively through investments in better policies and infrastructure even with facing initial obstacles.

The manufacture of electric vehicles depends on responsible manufacturing methods which include battery recovery systems and ethical methods to extract minerals in order to eliminate emissions during production.

However effective EV manufacturing remains because it stands out as one of the leading approaches to achieve lower carbon emissions and sustainability goals worldwide.

**CONCLUSION**

The research demonstrates that while electric vehicle (EV) manufacturing initially generates higher carbon emissions due to battery production, the long-term environmental benefits of EVs outweigh those of internal combustion engine (ICE) vehicles. Over their lifetime, EVs reduce greenhouse gas emissions by approximately 61–67%, making them a critical solution for lowering transportation-related carbon footprints.

Key findings highlight that the sustainability of EVs depends on three primary factors: (1) advancements in battery technology and recycling processes, which can reduce manufacturing emissions by up to 50%, (2) the integration of renewable energy in EV production and charging infrastructure, and (3) the role of government policies in promoting EV adoption, infrastructure development, and sustainable supply chain practices.

However, challenges remain, particularly for developing countries where high costs, limited charging infrastructure, and reliance on fossil-fuel-based electricity grids hinder EV adoption. Addressing these challenges requires coordinated efforts between governments, industries, and researchers to implement sustainable policies, invest in renewable energy, and improve battery recycling technologies.

Ultimately, EVs represent a pivotal step toward reducing global carbon emissions, but their full potential can only be realized through comprehensive policy frameworks, technological advancements, and an equitable transition to sustainable energy sources. The success of EV adoption worldwide will depend on continued innovation and collaboration between stakeholders to ensure a greener, more sustainable transportation future.

**Recommendations**

The following recommendations are formulated to guarantee sustainable EV manufacturing according to research outcomes directed towards governments and industries and policymakers:

**The Organization Should Lead Efforts to Recycle Batteries and Obtain Power Components from Sustainable Sources**

A closed-loop battery recycling system requires investment because it minimizes the requirement of newly mined materials.

The exploration of alternative battery materials which produce less environmental damage should get funding support (such as sodium-ion batteries or solid-state batteries).

**Strengthen Government Policies and Incentives**

Manufacturers of EVs and their adoption both benefit from tax incentives and grants and subsidies from the government.

The government should strengthen emission standards for internal combustion vehicles because this action will speed up EV adoption.

The government should promote joint ventures between public sectors and the private sector for the creation of local EV manufacturing supply chains within underdeveloped regions.

**The Manufacturing Industry of EVs together with Their Charging Infrastructure Needs to Transition to Renewable Energy Sources**

The establishment of charging stations that use solar power along with wind and hydroelectric systems will minimize greenhouse gas emissions from EV charging facilities.

EV manufacturers should adopt renewable energy power systems at their manufacturing facilities to achieve reduced production emissions.

The potential benefits from EV adoption will be maximized by nations that switch to clean energy sources from fossil fuels in their electric power grids.

**Expand EV Infrastructure Globally**

The government must allocate funds to build charging stations throughout diverse land regions which will improve EV mobility across regions.

Companies should implement solar-powered and off-grid charging systems for areas in developing countries that lack minimal electricity systems.

Auto manufacturers need economic incentives to develop affordable electric vehicle models which will help low-income consumers obtain them.

**Encourage Further Research and Development**

The government should expand its funding to optimize battery performance and create sustainable battery production methods.

The development of hydrogen fuel cells as well as new battery technologies should receive funding to replace lithium-ion technology systems.

Private and public organizations from both developed and developing nations should work together to share sustainable methods for EV manufacturing.

Electric vehicles serve as a revolutionary method to combat the worldwide carbon emission problem. The current manufacturing obstacles will become more sustainable when battery technologies and energy systems and government agreements continue to advance. The adoption of electric vehicles remains a key strategic goal for Norway representing developed countries but Nigeria alongside other developing countries must invest in applicable policies.

A sustainable green future requires three-way cooperation between governments and industries and consumers who will advocate for electric vehicle adoption and backing of sustainable energy systems and environmentally friendly vehicle production. The implementation of EVs will establish themselves as vital components to decrease carbon emissions as well as defend the environment for the next generations.

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