



The Role of Electric Vehicles on Environment Pollution and its Sustainability in Uttarakhand

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Abstract: The increasing demand for sustainable and eco-friendly products has emerged due to the over exploitation and pollution of natural resources. Electric vehicles represent a notable example of such a product in response to this growing need. This emerging technology combines innovation with practicality and sustainability. Electric engines offer a cost-effective solution for consumers and hold the potential to substantially reduce pollution upon replacing internal combustion engines. Without the adoption of innovative mobility concepts, preferably in line with the ideals of sustainable social and economic growth, it is currently impossible to address the problems of excessive road transport dependence on crude oil and air pollution. The CO₂ emissions in the transport industry will rise by a third from 1990 to 2050, according to this forecast. Additionally, costs associated with traffic congestion will rise by roughly 50% until 2050. Electric vehicles have been emphasized by the auto industry as a vital technological advancement for reducing emissions and energy usage in the future. The focus of this article is to review and assess the benefits and role of electric vehicles in reducing environmental pollution and it will help in achieving a sustainable environment in Uttarakhand

Keywords: electric vehicles • Uttarakhand • environment • pollution • sustainable development

Introduction

Both developed and emerging nations require a high standard of living, commercial competitiveness, and economic and social progress. On the other hand, greater mobility led to increased motorization, the construction of new transportation infrastructure in place of natural spaces, and an increase in traffic volume, pollution, and noise, among other detrimental effects on human society. Finding solutions to lessen the negative consequences became required as they grew in severity over time. Electric vehicles (EVs) are promoted globally as a green mode of transport and as a possible way to help nations wean themselves off of fossil fuels (Breaking down EV Myths in India: EVs and Emissions | Climate Group, n.d.). Numerous socio-technical and environmental elements, such as government legislation, battery kinds, infrastructure

availability, understanding and knowledge stages, and psychological factors, among other people, determine the advancement and uptake of electric vehicles (EVs).

Electric Vehicles (EVs) are growing as an essential option for reducing GHG emissions, improving the availability of energy, and providing a low-cost mode of transportation internationally (Parmar & Dharmarao 2021). EVs are becoming increasingly popular in practically every corner of the planet. China, the United States, and the Netherlands together account for roughly 60% of global EVs. According to Bloomberg Opinion, worldwide sales of electric vehicle adoption are likely to climb substantially after 2030, including in India. India has the world's second-biggest transportation system and the world's fifth-largest vehicle market. According to the Society of Indian Automobile Manufactures



(SIAM) in their annual report 2020-21, Many Indian states have also integrated SIAM's recommendations from its original Paper on

Electric Vehicles into their state EV policies and through direct discussions

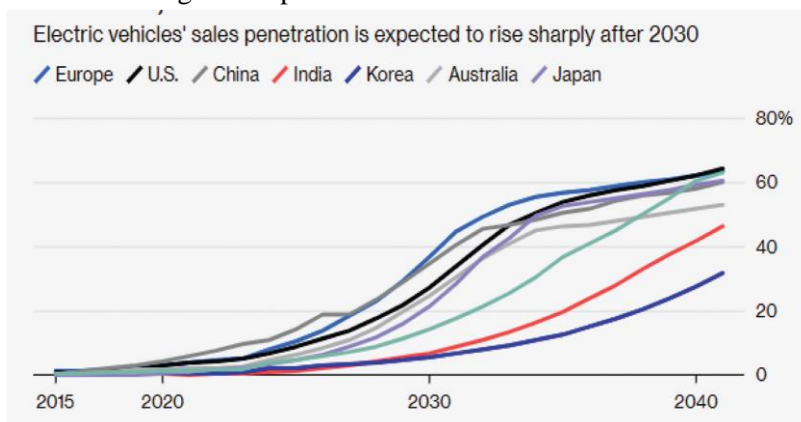


Fig 1. Sales expectations of Electric Vehicles among various countries around the world (Source: Khurana, A, Report from Bloomberg Opinion)

With nearly 3 million vehicles sold (a 4.6% sales share), Europe overtook China as the global biggest consumer market for electric automobiles (EVs) for the very first period (Bajaj FinServ, n.d.). Major markets have seen a rise in the registration of electric buses and trucks, with stocks worldwide exceeding 600,000 and 31,000, accordingly.

The Indian vehicle industry is on the verge of mass electrification, with several segments and applications preparing for the changeover. With a strong push from the government (both central and state), India is quickly catching up, with different measures in place, including monetary support, to support the EV industry in its early years. Since 2015, India has made significant progress, with electrification gaining traction (Clean Mobility: How Indian States Fare on Policy Front, 2019).

Various vehicle manufacturers in the country have developed EV vehicles as well as a manufacturing eco-system that includes crucial components like batteries, motors, and chargers.

Sustainable Development in a Glance

The term "Sustainable Development" stands as a globally embraced approach to the economic advancement of humanity for both current and future generations. It constitutes a socio-economic framework focused on meeting human needs while preserving the integrity of the natural environment over the long term. The idea of sustainable development gained widespread recognition after the release of a report in 1987 by the Brundtland Commission, which was established by the UN General Assembly in 1983 (Thomsen, 2013)

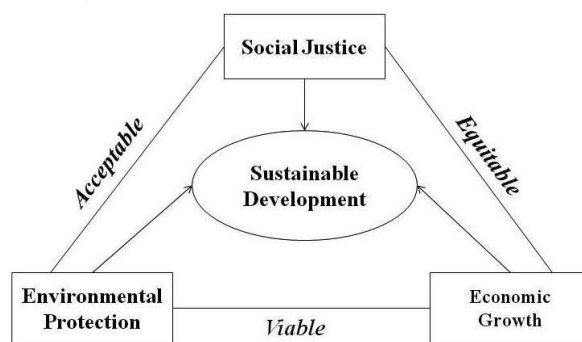


Fig 2. Three Foundational Elements of Sustainable Development



Figure 2 uses three primary concepts to illustrate the essential components of sustainable growth: "Social justice," "environment protection," and "Economic development." The "Environmental protection" and "Economic Development" pillars seem to go without saying. The "Social justice" pillar highlights how crucial it is to support a robust and long-lasting social framework that results from economic expansion. Since all three of these components have been linked by the concepts of "equitability," "bearability," and "economic viability," as shown in Figure 2, each of them is equally important in the implementation of sustainable development.

Having the capacity to satisfy present needs without sacrificing the accessibility of natural resources for future generations to come is referred to as environmental sustainability. This can be accomplished by putting in place suitable rules and guidelines that gradually conserve and safeguard the natural environment (Parmar & Dharmarao2, 2021). To achieve sustainable development for the environment, a variety of significant objectives need to be met, such as:

- Reducing emissions of greenhouse gases, especially in critical sectors such as transport, manufacturing, the agricultural sector, and the production of electricity.
- Boosting the quantity of energy produced and consumed through sources of clean energy.
- Enacting laws that address the causes of biodiversity loss intending to preserve it.
- Employing precise methods of farming to enhance and raise soil productivity and quality, as well as other sustainable agricultural and food chain practices.
- Spreading knowledge about environmental sustainability and incorporating local communities in a discussion about the sustainability of the environment.

Electric Vehicle and Environment Sustainability

Transportation is one of the significant contributors to climatic pollution in India, accounting for energy-related greenhouse gas (GHG) emissions. The earliest identifiable distinct cluster is found in vehicle exhaust emissions. The primary contributors of ambient air pollution, which has an adverse impact on the environment, raises the incidence of respiratory illnesses and even leads to premature death, are motor vehicle traffic and power plants powered by coal. Particulate matter (PM) and ground-level ozone are the two air pollutants that modern vehicles' exhaust emissions cause that are most concerning (Ewelina Sendek-Matysiak, 2019). The combined effect of daylight (UV radiation) and impurities like hydrocarbons (HCs), nitrogen oxides (NO_x), nitrous acid (HONO), and VOCs (volatile organic compounds) produces ozone at the ground level, which continuously threatens the well-being of humans and helped to create deadly smog.

To combat the global calamity, we have to make cars on our roads as environmentally friendly as feasible. We only have ten more years to adjust our energy-use habits in order to mitigate the worst effects of the changing climate. (Far, 2023).

The pollutants that are generated by vehicles have adverse effects on both the environment sustainability and the well-being of individuals. Air pollution from gasoline and diesel-powered automobiles is a contributing factor to diseases like cancer, asthma, and bronchitis, and early death. The concentrated pollution in the air has enduring adverse effects on health, leading to issues such as heart disease, lung damage, and recurrent asthma.

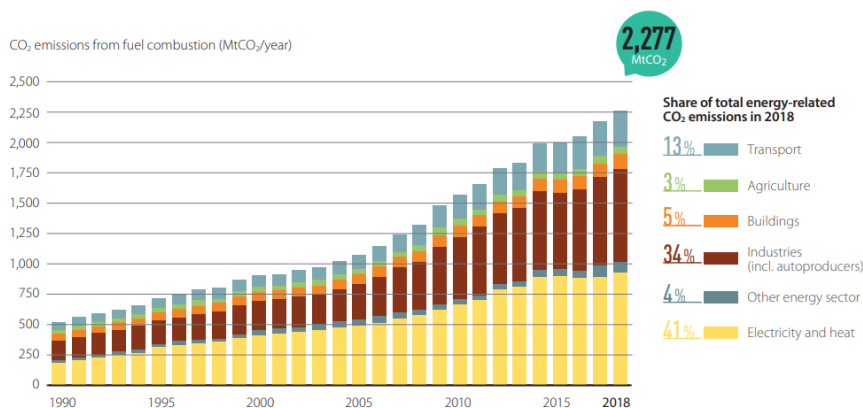


Fig 3. Share of total energy-related CO₂ emissions in 2018

One crucial step in creating an energy system that is better suited for mitigating the effects of climate change is the transition to powered mobility. Compared to normal automobiles powered by gasoline, which can transfer roughly 17% to 21% of the electricity stored in gasoline into power at the wheels, electric automobiles are more efficient, able to transform between 59% and 62% of the electrical supply originating from the electrical grid to generate electricity for the engines (Mendoza, 2024). According to recent studies, even cars powered by compressed natural gas, or CNG, are not completely environmentally beneficial because they emit a lot of particulate matter (PM), especially ultrafine particles, and produce ammonia, which is harmful to breathe in. Fig 4 consists of the

data collated Air Quality Index (AQI) level across two centers: Dehradun and Haldwani showing that the AQI level in each centre was between 50 and 100. After the enactment of these lockdowns in Uttarakhand City, the air pollution level has witnessed a significant reduction in air pollutants. During this lockdown period PM₁₀, PM₂₅, NO_x, and SO₂ concentrations have shown a notable declining trend. Combustion engines in cars, trucks, motorcycles, and other vehicles release pollutants such as nitrogen oxides (NO_x), carbon monoxide (CO), volatile organic compounds (VOCs), and particulate matter into the air. (“Air Quality Technical Report Turk Island Landfill Consolidation and Residential Subdivision Project,” 2017)

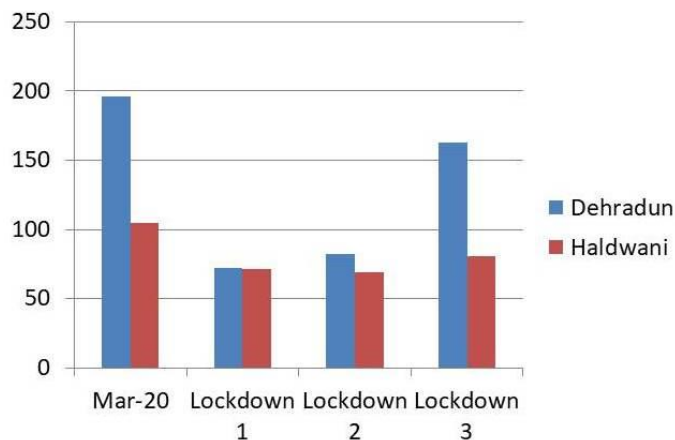


Fig 4. Variability in Air Quality Index across two cities of Uttarakhand before and after Lockdown



Environmental concerns related to air quality and sustainable development are addressed in large part by electric vehicles (EVs):

Power Source Electric vehicles never release exhaust gases or particulate matter from their internal power source, indicating they have zero tailpipe emissions. In the same way, because a portion of the power in plug-in hybrid electric cars comes from battery energy, these vehicles discharge significantly fewer pollutants. Electric vehicles play a crucial role not only in mitigating air pollution but also in potentially lowering the emissions of Greenhouse Gases (GHGs) responsible for climate change, such as CO₂. (Fowler, M., Sherman, S. B., et al., 2020, June 27).

The effects of integrating Electric Vehicles into the energy system are largely influenced by the electricity utilized for charging EV batteries. Electric Vehicles (EVs) generally exhibit reduced Emissions of greenhouse gases when compared to automobiles with traditional engines that use gasoline or diesel, especially when charged with electricity derived from renewable sources. The shift to electric mobility contributes to efforts to reduce carbon dioxide (CO₂) emissions, thereby mitigating climate change (Slovic et al., 2015).

Electric Vehicles typically demonstrate higher energy efficiency compared to traditional vehicles. The electric drive train converts energy from the power source to movement more efficiently; it requires a smaller amount of energy which reduces overall energy consumption.

The adoption of electric vehicles, when coupled with a transition to cleaner energy sources and supportive policies, can have a positive impact on air quality, mitigate climate change, and contribute to sustainable development objectives (Khalid & Khuman, 2022). It represents a key element in the

broader shift toward more sustainable and environmentally friendly transportation systems.

In systems with substantial renewable energy integration or notable renewable energy surplus, the introduction of Electric Vehicles (EVs) can mitigate environmental impact by displacing internal combustion engines, particularly when the EV batteries are charged with renewable electricity (Tran et al., 2020). EVs connected to the grid can serve as electricity storage solutions during emergencies or severe supply shortages, providing power back to the grid. The EVs charged by electricity generated from renewable sources further enhance their environmental benefits. As the portion of renewable energy in the power grid increases, the overall environmental impact of EVs becomes even more positive.

Regardless of where the power comes from, electric automobiles generate less carbon than cars operated by gasoline. Battery electrical and plug-in hybrid automobiles use electrical grids, which depend on a variety of energy sources, including clean renewable energy and fossil fuels, to charge and power them. Electric vehicles have become one of the foundations of today's worldwide sustainable consumption goals and it has a deep connection in terms of fuel efficiency, lower emissions, and lower operational cost, among others. India is identified as a key global market poised for rapid growth in electric vehicles in the future.

Green Power for Electric Vehicle: Running a battery-powered vehicle has a different environmental impact based on where the power comes from because different states may have distinct energy systems. Electrically powered vehicles were more efficient at transforming energy into power for trucks and cars, therefore regardless of whether the electricity comes straight from the worst grid, it is still a more environmentally friendly and economical energy for automobiles.



Toxic Exposures & Health Programme senior scientist Rashmi Joglekar cites research from Harvard University that shows "a significant connection between for a long time exposition to hazardous fine particulates and COVID-19 mortality in the United States." One of the primary causes of small particulate air pollution in automobiles is the internal combustion of engines powered by gasoline or diesel (PM2.5) (Pal et al., 2021)

According to Duke University research, the expense of both health and environmental

degradation can amount to \$3.80 for every gallon of gas purchased at the gas station. Commercial vehicles and agricultural machinery that run on diesel have greater social implications per gallon—an extra \$4.80 for the surroundings and human health. In addition to helping governments clean up their electrical systems, using hybrid or electric cars on the electrical grid increases the benefits of electric vehicles by lowering emissions of greenhouse gases when compared to vehicles powered by gasoline.

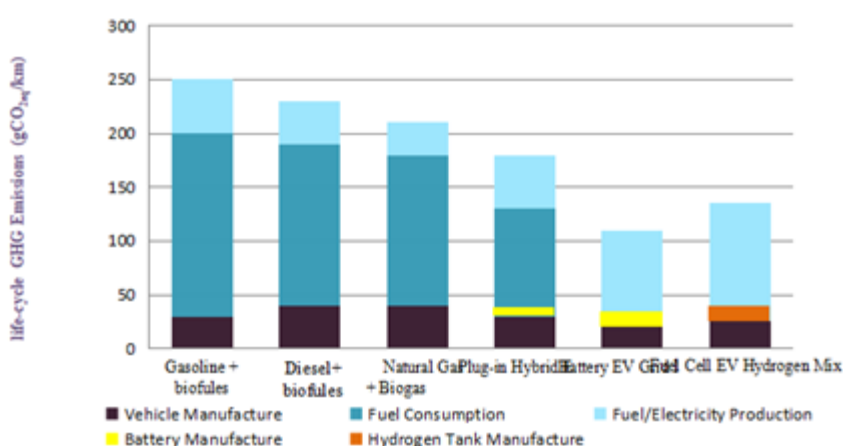


Fig 5. Life-cycle GHG emissions

Throughout their entire lives, electric automobiles prove more beneficial to the environment. Compared to the production of a regular gasoline motor vehicle, the production of a car powered by electricity will end up resulting in increased emissions of greenhouse gases due to the large lithium-ion batteries that are required to power them. The production procedure of an 84-mile-range medium-sized electric vehicle, for example, results in a 15% increase in pollutants. Once the cars are on the road, though, the energy situation completely changes.

Uttarakhand EV Policy: The state government of Uttarakhand introduced the "Uttarakhand EV Manufacturing EV Usage Promotion and Related Services Infrastructure Policy 2018" in October 2018 to establish Uttarakhand as a hub for electric vehicles in the future. Uttarakhand was the second state in

North India to create and implement an electric car policy, following Uttar Pradesh. The goal behind the Uttarakhand electric car strategy was to create jobs on both the supply and demand sides of the automotive sector and establish Uttarakhand as a destination of choice for the production of electric vehicles. The policy was also implemented to support the transition to electric vehicles and to increase human resources and power generation capacity to meet the demands of the electric vehicle (EV) industry. (Clean Mobility: How Indian States Fare on Policy Front, 2019)

The state has already signed Memorandums of Understanding (MoUs) worth Rs. 60,000 Crores with companies interested in these investment possibilities, and it has received investment offers totalling Rs. 74,000 Crores.



The key highlights of the Uttarakhand EV Manufacturing EV Usage Promotion and Related Services Infrastructure Policy 2018 are.

Demand-side Electric Vehicle Incentives

- The first 100,000 buyers of electric vehicles will receive a five-year exemption from motor vehicle taxes.
- This will apply to purchasers of electric stage carriages as well as electric cars.
- For fifteen years, land assigned to electric vehicle producers will not be used for any other purpose.
- Subsidy for Electric Vehicles and SUVs:
 - The state of Uttarakhand offers the following incentives for electric vehicle purchases: a subsidy of up to Rs. 50,000, or 5% of the car's price, whichever is lower.
- A five-year period during which the first 100,000 buyers of electric vehicles will not be required to pay motor vehicle taxes; and a temporary 100% exemption from road taxes.
- Infrastructure Incentives and Guidelines for Charging Electric Vehicles:
 - 250 charging stations for electric vehicles will be built throughout the state by the Uttarakhand Pollution Control Board (UPCB), at an estimated cost of Rs. 10 crore.
- All electricity costs associated with these stations will be valued at residential rates rather than falling under the purview of commercial rates.

Conclusion

The role of electric vehicles (EVs) in addressing environmental pollution and promoting sustainability is significant and multifaceted. As a cleaner and more sustainable alternative to traditional internal combustion engine vehicles, EVs contribute to several key aspects of environmental well-being and long-term sustainability.

Air Quality Improvement: EVs produce zero tailpipe emissions, reducing the levels of harmful pollutants such as nitrogen oxides (NOx), particulate matter (PM), and carbon monoxide (CO). This improvement in air quality has direct benefits for public health, especially in urban areas where traffic-related pollution is a significant concern.

Mitigation of Climate Change: The lower greenhouse gas emissions associated with EVs contribute to global efforts to mitigate climate change. As the electricity grid becomes cleaner and incorporates more renewable energy sources, the overall carbon footprint of EVs continues to decrease.

Reduced Dependence on Fossil Fuels: EVs play a crucial role in reducing dependence on finite and environmentally detrimental fossil fuels. The transition to electric mobility aligns with sustainable energy practices and promotes the use of renewable energy sources, further enhancing the environmental benefits of EVs.

Promoting Sustainable Transportation: Encouraging the use of public transportation, walking, cycling, and electric vehicles helps reduce the environmental footprint of transportation. **Improving Fuel Efficiency:** Implementing and incentivizing the use of fuel-efficient vehicles and technologies can reduce the number of greenhouse gases emitted per mile travelled.

The ongoing transition to EVs represents a positive step toward creating a more environmentally-conscious and sustainable transportation sector. As technology continues to advance and supportive policies proliferate, the environmental benefits of electric vehicles are likely to grow, making them a key component of a sustainable and resilient future.

The Uttarakhand policy for electric vehicles holds great potential for the future since it addresses both supply-side and demand-side subsidies. This will have a positive impact on both EV manufacturers and buyers. In the



future, the automotive sector's transformation, supported by initiatives such as these, will accelerate the uptake of electric vehicles (EVs) in Uttarakhand and increase the demand for electric vehicles and two-wheeler insurance in the region.

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