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Electric Vehicles Integrated with Renewable Energy Sources for Sustainable Mobility.

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Abstract- EVs will not be 'zero emission' unless the electricity for charging them is fossil-based electricity. Energy production has to be free of fossil fuels for EVs to run truly emission-free. In India 67%electricity is generated from coal which is another source for greenhouse gas emissions and air pollution. To reduce, we need to shift the electricity generation to renewable energy resources like solar, wind, geothermal energy. Solar and wind have already played a good role in the generation of electricity in India and are also increasing day by day. This paper studies how and at which locations India has huge potential in generating ecofriendly and cost-effective geothermal energy. If we successfully shift a major percentage of electricity generation from fossil fuel to renewable energy then we can truly say that Electric vehicles are really environment friendly.

Keywords: Electrical Vehicles, Renewable Energy, Eco-friendly.

Introduction

India is among a handful of countries that support the global EV30@30 campaign, which targets to have at least 30% new vehicle sales be electric by 2030[1]. One important factor to take into consideration when it comes to electric cars (EVs) is that most of them run on coal-derived electricity. The connection between EVs and coal creates a crucial conflict between the growth of technology and the environment, even though EVs are a cleaner option than conventional cars. The objective of this research is to analyse the difficulties and possible remedies related to electric vehicles (EVs) that run on coal while managing the fine line between innovation and sustainability. The purpose of this research is to analyse the integration of electrical vehicles with renewable energy for environmental resilience and energy efficiency.

What is Renewable Energy?

Energy that comes from naturally existing, sustainable sources that don't run out when consumed is referred to as renewable energy. Renewable energy sources are long-term sustainable, in contrast to finite resources like fossil fuels (coal, oil, and natural gas). Because they generally emit fewer greenhouse gasses than more conventional energy sources, these sources are regarded as environmentally beneficial.

Types of renewable

1. Solar Energy – Solar energy is the result of the sun's radiant energy being captured. Solar panels typically contain photovoltaic cells, which directly convert sunlight into electrical power. When these cells are exposed to sunlight; they use semiconductor materials to produce an electric current.
2. Wind Energy-Energy produced by utilizing the wind's kinetic energy: Wind turbines, which have big blades attached to a central hub, are used to capture wind energy. The blades rotate as a result of the kinetic energy transferred to them by the wind. After that, a generator transforms this rotational motion into electrical energy. Multiple turbine wind farms are placed strategically in areas with strong and consistent wind patterns.
3. Hydroelectric Energy-One of the earliest renewable energy sources is hydropower, which produces electricity by harnessing the energy of flowing water. Reservoirs are often created by damming water and releasing it gradually through turbines, which

transforms the kinetic energy of the water into electrical energy. Because of its versatility, hydropower can be used to power tidal movements, waterfalls, and rivers.

4. Geothermal-Geothermal energy extracts heat from the Earth's interior by means of tapping into its natural heat source. Typically, hot springs and steam reservoirs located beneath the Earth's surface are used by geothermal power plants. Geothermal energy is then transformed into electricity by using the steam generated to power turbines that are connected to generators. Due to the nearly limitless supply of heat within the Earth, geothermal energy is a consistent and dependable source.
5. Biomass Energy-Sourced from organic materials: Plants, agricultural waste, and municipal solid waste are examples of organic matter that can be used to generate biomass energy. This substance can be processed to create biofuels, such as ethanol and biodiesel, which are used to power machinery and produce electricity. Direct combustion of biomass can also be used to generate electricity or heat.
6. Tidal Energy-Using the force of the tides in the ocean, tidal energy is a renewable energy source that produces electricity. Because the tides are impacted by the gravitational pull of the sun and moon, it provides a dependable and predictable source of energy.

The Following tables provides us with an overview of India's total installed power generated capacity [2]

Power Sector at a Glance ALL INDIA

Updated on 12-06-2023
Source: OM SECTION

1.Total Installed Capacity (As on 31.05.2023) - Source : Central Electricity Authority (CEA)

INSTALLED GENERATION CAPACITY (SECTOR WISE) AS ON 31.05.2023

Sector	MW	% of Total
Central Sector	1,00,055	24.0%
State Sector	1,05,726	25.3%
Private Sector	2,11,887	50.7%
Total	**4,17,668**	

Installed GENERATION CAPACITY(FUELWISE) AS ON 31.05.2023

CATAGORY	INSTALLED GENERATION CAPACITY(MW)	% of SHARE IN Total
Fossil Fuel		
Coal	205,235	**49.1%**
Lignite	6,620	1.6%
Gas	24,824	**6.0%**
Diesel	589	**0.1%**
Total Fossil Fuel	**2,37,269**	**56.8 %**
Non-Fossil Fuel		
RES (Incl. Hydro)	**173,619**	**41.4%**
Hydro	**46,850**	**11.2 %**
Wind, Solar & Other RE	125,692	30.2 %
Wind	42,868	10.3 %
Solar	67,078	16.1 %
BM Power/Cogen	10,248	2.5 %
Waste to Energy	554	0.1 %
Small Hydro Power	4,944	1.2 %
Nuclear	6,780	**1.6%**
Total Non-Fossil Fuel	**179,322**	43.0%
Total Installed Capacity (Fossil Fuel & Non-Fossil Fuel)	**4,17,668**	**100%**

Fig 2. Power Sector at a glance ALL INDIA

How Renewable Energy Will Power Electrical vehicles?

Electric vehicles (EVs) are one of the most promising technologies for reducing emissions in global transportation, but the benefits they bring depend on the provenance of the power they run on. Today, too few EVs are powered by renewable energy. For them to be a truly green option, this has to change.[3]

In addition to the electricity already produced by way of sun and wind energy, geothermal and tidal energy also can be employed to generate energy.

Geothermal Energy:

Mile-or-more-deep wells can be drilled into underground reservoirs to tap steam and very hot water that drive turbines that drive electricity generators. Four types of power plants are operating today.

1. Flashed steam plant – The extremely hot water from drill holes when released from the deep reservoirs high pressure steam (termed as flashed steam) is released. This force of steam is used to rotate turbines.
2. Dry steam plant – Usually, geysers are the main source of dry steam. Those geothermal reservoirs which mostly produce steam and little water are used in electricity production systems.
3. Binary power plant – The geothermal water is passed through a heat exchanger where its heat is transferred to a secondary liquid, namely isobutene, iso-pentane or ammonia–water mixture present in an adjacent, separate pipe. Due to this double-liquid heat exchanger system, it is called a binary power plant.
4. Hybrid power plant-Some geothermal fields produce boiling water as well as steam, which are also used in power generation. In this system of power generation, the flashed and binary systems are combined to make use of both steam and hot water.

It has been estimated from geological, geochemical, shallow geophysical and shallow drilling data it is estimated that India has about 10,000 MWe of geothermal power potential that can be harnessed for various purposes. Rocks covered on the surface of India ranging in age from more than 4500 million years to the present day and distributed in different geographical units. The rocks comprise of Archean, Proterozoic, the marine and continental Palaeozoic, Mesozoic, Tertiary, Quaternary etc., More than 300 hot spring locations have been identified by Geological survey of India (Thussu, 2000). The surface temperature of the hot spring's ranges from 35 C to as much as 98 C. These hot springs have been grouped together and termed as different geothermal provinces based on their occurrence in specific geo-tectonic regions, geological and structural regions such as occurrence in orogenic belt regions, structural grabens, deep fault zones, active volcanic regions etc., Different orogenic regions are – Himalayan geothermal province, Naga-Lushai geothermal province, Andaman-Nicobar Islands geothermal province and non-orogenic regions are – Cambay graben, Son- Narmada-Tapi graben, west coast, Damodar valley, Mahanadi valley, Godavari valley etc.

Example: Manilkara in Himachal Pradesh and Puga Valley in Ladakh.[4]

Tidal Energy –

Tidal energy refers to the power generated from the movement of tides in the ocean. As the waves rise and fall, tidal turbines capture the energy by converting the kinetic energy of the moving water into electricity.

1. The Cause of Tides-The gravitational forces of the moon and, to a lesser extent, the sun, pull on Earth's waters. This tug of war causes the oceans to bulge out in the direction of the moon and on the opposite side due to Earth's rotation. The rise and fall of ocean levels due to this phenomenon are what we observe are as tide.
2. Selecting the Right Location-The strength and consistency of tides vary around the world. To harness the maximum energy, sites with the highest tidal range or strongest tidal currents are sought. Coastal areas where water is funnelled into narrows or bays often amplify tidal action, making them prime spots for energy extraction.
3. Tidal Energy Technology Installation-

- Tidal Stream Systems- These devices are anchored to the seabed and feature turbine blades that move with the flow of the water. They're essentially underwater wind turbines, optimized for the density and behaviour of water rather than air.
- Tidal Barrage Systems- A tidal barrage is similar to a dam built across the entrance to a tidal basin. It has a series of sluice gates and turbines. When the tide rises and water flows into the basin, the gates close, trapping water inside.

4. Converting Movement into Electrical Energy The spinning turbines are mechanically connected to generator. As the turbine spins the rotor inside the generator, the movement of coils within a magnetic field induces an electric current. This motion and interaction generate electricity.

5. Transmitting the Generated Electricity-Once generated, electricity has to be transported to consumers. The cables transport the electricity from the generation site to a shore-based substation.

6. End Use-Once it reaches homes or businesses, it can power appliances, light rooms, run machines in factories, and more. The

primary benefit is its sustainable and renewable nature, offering an alternative to fossil fuels and reducing greenhouse gas emissions [5]

A brief overview of government policies5:

In order to boost EV adoption, the central government and various state governments have already launched various policies. Here is a brief overview of them:

1. FAME India scheme (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles) launched with implementation in effect from April 2015 to support the market development and manufacturing eco- system. The scheme has four focus areas: technology development, demand creation, pilot projects and charging infrastructure.
2. Karnataka Electric Vehicles and Energy Storage Policy for a period of 2017-2022 with the objective of attracting investment of Rs. 31,000 crores with special incentives for EV manufacturing and facilitating energy storage and charging equipment manufacturing.
3. Maharashtra government approved Electric Vehicle policy 2018 for enabling manufacturing of 500,000 EVs in the next five years. The policy also provides various subsidies to EV owners as well as charging infrastructure owners for setting up charging stations across the state.
4. Through Uttar Pradesh Electric Vehicles Manufacturing policy 2018, the state not only wants to promote EV battery and charging equipment manufacturing, but also incentivize manufacturing of solar cells to generate clean energy.
5. Andhra Pradesh, Telangana and Tamil Nadu governments have also rolled out similar policies to incentivize demand for EVs as well as attract manufacturing investments in the respective states.[6]

According to the objectives, these EVs and RESs coordination works are grouped into three categories:[7]

1. Cost-aware EVs interacting with RESs: The research works in this category focus on reducing operational cost, electricity generation cost, and charging cost, or how to increase profit for service provider.

2. Efficiency-aware EVs interacting with RESs: The focus of this category is how to improve the efficiency of renewable energy utilization. Most of them leverage EVs batteries as energy buffering, where charging EVs batteries when RESs production is surplus and discharging EVs batteries when the power supply is in shortage.

3. Emissions-aware EVs interacting with RESs: These research works discuss how to leverage the integration of EVs and RESs into the electric grid to further reduce emissions.

Methodology

This research paper combines qualitative and quantitative analysis to learn what people think about Electrical vehicles being integrated with renewable energy. We can analyse and draw a conclusion from people's responses. In order to gather data regarding people's awareness, we first polled those who used online form creators and data collection services.

Public Survey

The survey is used to gather the data. Both the outcome and the process by which it was arrived at will be examined. In this instance, 100 people were asked their opinions about questions pertaining to the subject of electrical vehicles integrated with renewable energies. Conducting a survey is essential to obtaining reliable data that can be analysed and used to determine the survey's outcome.

Questionnaire

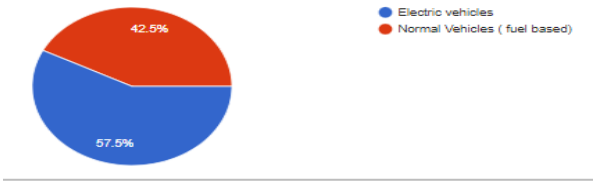
- Which vehicle do you prefer?
- According to you, select the benefits of owning electric vehicles.
- According to you, select the barriers in widespread adoption of electric vehicles?
- According to you, which factors do you consider important when choosing a vehicle.
- On a scale from 1 to 5, how supportive are you of replacing coal-based electricity with renewable energy sources, where 1 is strongly against and 5 is strongly in Favor?
- Are you aware of any renewable energy options available for charging electric vehicles?
- Do you believe that the integration of electric vehicles with renewable energy can contribute to reducing greenhouse gas emissions and combating climate change?
- Would you be more likely to support the transition to renewable energy if it meant creating more jobs in your community?
- Are you familiar with any government policies or incentives that promote the integration of electric vehicles with

renewable energy?

- According to you, which factors worries you regarding the integration of electric vehicles with renewable energy.
- Have you ever used or considered using renewable energy sources to charge your electric vehicle?

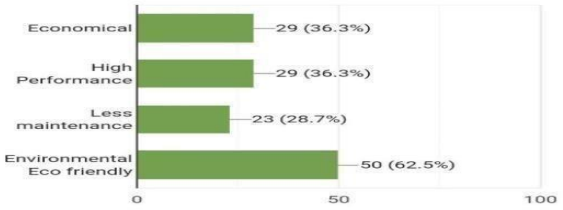
Results:

1.



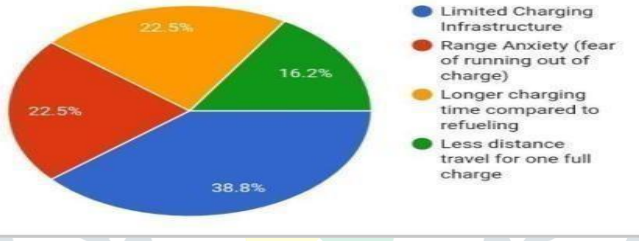
When People were asked which vehicle do they prefer, 57.5% prefers Electric Vehicles and the rest 42.5% prefers Normal Vehicles.

2.



When people were asked to select the benefits of owning electric vehicles, 36.3% of people chose economic benefits, 36.3% people chose high performance, 28.7% people chose less maintenance, & 62.5% people chose environmental eco-friendly.

3.



When people asked to select the barriers in widespread adoption of EV, 22.5% chose longer charging time compared refueling, 22.5% chose Range Anxiety, 16.2% chose less distance travel.

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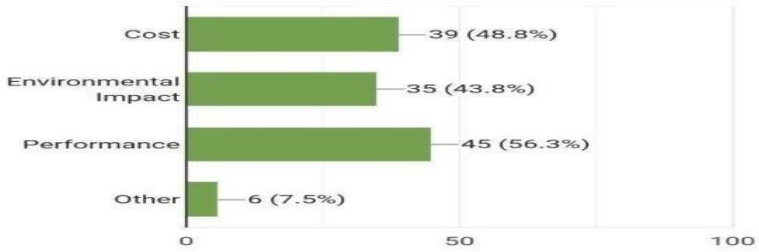
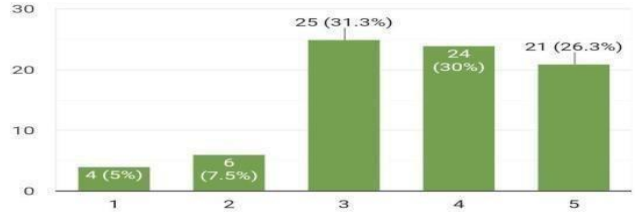


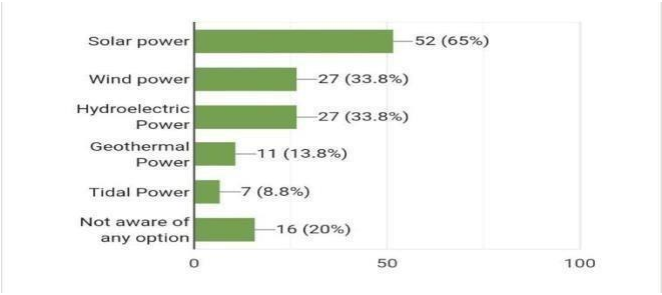
When people were asked which factors do you consider important when choosing a vehicle ,48.8% chose cost, 43.8% chose environmental impact, 56.3% chose performance, 7.5% chose other.

5.



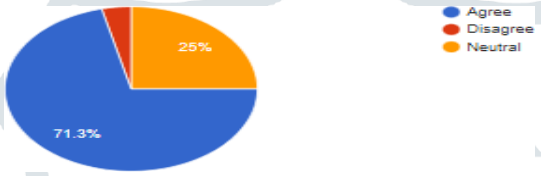
When people were asked on a scale from 1 to 5, how supportive are you of replacing coal-based electricity with renewable energy sources, 26.3% are in strongly favor and 5% are in strongly against and remaining are in between the scale.

6.



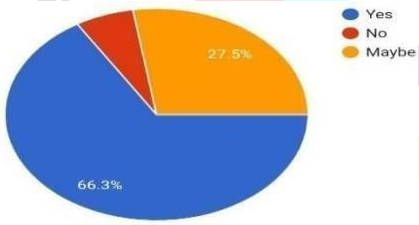
When people were asked Are you aware of any renewable energy options available for charging electric vehicles, 65% knew solar power, 33.8% knew wind power 33.8% knew hydroelectric power, 13.8% geothermal power, 8.8% knew tidal power and 20% are not aware of any of them.

7.



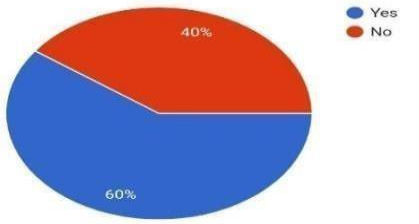
When people were asked if they believe that the integration of electric vehicles with renewable energy can contribute to reducing greenhouse gas emissions and combating climate change, 71.3% agreed, 25% were neutral and 3.7% disagreed.

8.



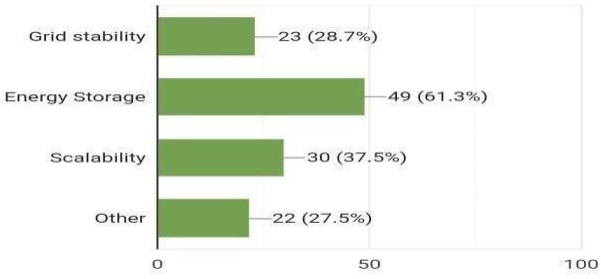
When people were asked would you be more likely to support the transition to renewable energy if it meant creating more jobs in your community, 66%.3 said yes,27.5% said maybe and 6.3% said no.

9.



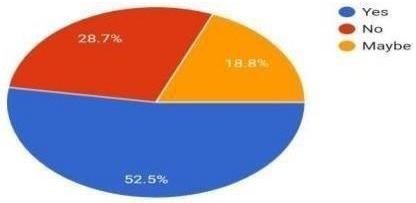
When people were asked if they were familiar with any government policies or incentives that promote the integration of electric vehicles with renewable energy, 60% said yes, 40% said no.

10.



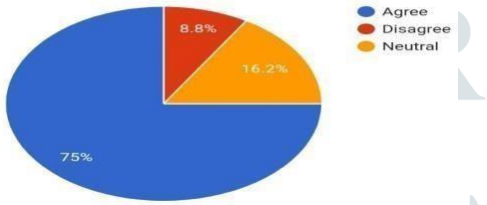
When people were asked which factors worried them regarding the integration of electric vehicles with renewable energy, 28.7% chose grid stability, 61.3% chose energy storage, 37.5% scalability,27.5% chose other.

11.



When people were asked Have you ever used or considered using renewable energy sources to charge your electric vehicle, 52.5%said yes,18.8% said maybe and 28.7% said no.

12



When people were asked if they are likely to purchase an electric vehicle if it was powered by renewable energy sources, 75% agreed, 16.2% neutral, 8.8% disagreed.

Hypothesis Testing

Hypothesis testing is a sort of statistical reasoning that includes analyzing data from a sample to derive inferences about a population parameter or probability distribution. First, a hypothesis is created regarding the parameter or distribution.

This is known as the null hypothesis, abbreviated as H0. After that, an alternative hypothesis (denoted Ha) is defined, which is the polar opposite of the null hypothesis. Using sample data, the hypothesis- testing technique determines whether or not H0 may be rejected. The statistical conclusion is that the alternative hypothesis Ha is true if H0 is Rejected.

For this paper,

Null hypothesis (H0): Electric vehicles can be charged with renewable energy.

Alternative hypothesis (Ha): Electric vehicles cannot be charged with renewable energy.

TEST (STATISTICS)

There are many tests available to determine if the null hypothesis is to be rejected or not. Some are:

1. Chi-squared test
2. T-student test (T-test)
3. Fisher's Z test.

For this paper, we will be using Chi-Squared Test Pearson's chi-square test is a statistical test for categorical data. It is used to determine whether your data are significantly different from what you expected. (Also known as alpha or α). A significance level of 0.05, for example, means there's a 5% probability of discovering a difference when there isn't one. Lower significance levels indicate that more evidence is required to reject the null hypothesis. The confidence level indicates the probability that the location of a statistical parameter (such as the arithmetic mean) measured in a sample survey is given below,

Sr	Name	Gender	Grade
1	Suryaa	F	Agree
2	Apurva	F	Agree
3	Arya	F	Agree
4	Jaya	F	Agree
5	Neha	F	Agree
6	Laxmi	F	Agree
7	Akshada	F	Agree
8	Suyash	M	Agree
9	Antima	M	Agree
10	Ashwin	M	Agree
11	Bhakti	F	Disagree
12	Kshitij	F	Disagree
13	Krupal	F	Disagree
14	Sonak	M	Disagree
15	Akshay	M	Disagree
16	Anisha	F	Neutral
17	Tahreem	F	Neutral
18	Vinish	M	Neutral
19	Sahil	M	Neutral
20	Kartik	M	Neutral

	Agree	Disagree	Neutral	Total	
Girls	7	3	2	12	1
Boys	3	2	3	8	1
Total	10	5	5	20	10
Ei	5	2.5	2.5	10	
					5.9914
				H0 accepted	

Level of significance = 0.05 i.e., 5%Level of confidence = 95%

The chance of accepting the null hypothesis in a chi- squared test depends on the chosen significance level and whether the calculated Chi-value is more than or equal to that significance level. Then we can reject the alternative hypothesis and conclude that electric vehicles can be charged by renewable sources…

Step 1: Determine what the null and alternative hypothesis are-

Null hypothesis (H0): Electric vehicles can be charged with renewable energy.

Alternative hypothesis (Ha): Electric vehicles cannot be charged with renewable energy

Step 2: Find the test statistic – Calculating Ei value-

For agreed = total number of agreed people/2 10/2=5

For disagreed = total number of disagreed people/2 5/2=2.5

For Neutral= total number of neutral people/2 5/2=2.5

Step 3- Calculating ∑(Oi-Ei2)/Ei

For girls = ∑ (7-5)2/5=0.8, ∑ (3-2.5)2/2.5 = 0.1, ∑ (2- 2.5)2/2.5 = 0.1 = 0.8+0.1+0.1=1

For boys = ∑ (3-5)2/5 = 0.8, ∑(2-2.5)2/2.5 = 0.1,

∑ (3-2.5)2/2.5 = 0.1=1=0.8+0.1+0.1=1

For total girls and boys= ∑ (10-5)2/5 = 5, ∑ (5- 2.5)2/2.5 = 2.25, ∑ (5-2.5)2/2.5 =.5=5+2.5+2.5=10

Step 4-To Calculate Chi Squared value

The formula Is =CHIINV (0.05,2)

Where 0.05 is the level of significance and 2 is the degree of freedom (3-1) *(2-1) =2

CHIINV (0.05,2) = 5.991464547

Since this Chi Squared-value is greater than our chosen alpha level of 0.05, we can accept the null hypothesis. Thus, we have sufficient

Evidence to say that electric vehicles can be charged with renewable resources.

Findings

1. The majority of individuals are interested in buying electric vehicles instead of regular vehicles due to environmental worries.
2. The majority of individuals agreed that renewable energy should be used to charge cars instead of coal-based electricity.
3. 71.3% individuals agreed that the integration of electric vehicles with renewable energy can contribute to reducing greenhouse gas emissions and combating climate change.
4. 4.75% of individuals are inclined to buy an electric car if it runs on renewable energy.

Conclusion

In conclusion, integrating renewable energy sources with electric vehicles is a sustainable and long-term approach to transportation. This strategy lowers carbon emissions, enhances independence from fossil fuels, stabilizes the grid, and supports technological development. This synergy holds great promise for a cleaner and more resilient transportation future with supportive laws and rising public awareness.

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