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A RESEARCH STUDY ON THE INFLUENCE OF TECHNOLOGY ON PEDAGOGICAL PRACTICES AND STUDENT ACHIEVEMENT

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Abstract:

The automated industry is undergoing transformative shift, with EVs emerging as prominent solution to address pressing environmental concerns and energy security challenges .Our research will help in studying socio-economic impact of EVs at the same time addressing consumer behaviour and challenges .The study focuses on understanding purchase and repurchase behaviour of EVs specially for two wheelers. Study also provides readers with sustainable practices with respect to development of EVs. The research is descriptive in nature. It is based on primary data collected through structured questionnaire and interview method. Data is collected from 130 respondents from KDMC region. Purposive sampling and convenience technique is employed for proposed research. Factors influencing consumer purchase ,repurchase behaviour and sustainability are analysed on quantitative and qualitative features. Data analysis was done using MS Excel and Vassar stats and Cronbach's Alpha , Split Half and Spearman Brown's tests were calculated to measure the internal consistency and reliability of the questionnaire. Current study also suggests innovative model to increase the efficiency of EVs , using non- conventional source of energy.

Keywords: *Electric vehicles (EVs), Consumer Behaviour, Consumer Repurchase Behaviour, Sustainability.*

Introduction:

The automotive sector has emerged as a key contributor to the global economy and a driving force in realm of innovation and technological development. With continuous refinement of digital solutions and progress in the industry vehicles have become more efficient, effective and contemporary making our travel experience much more comfortable and convenient. However, this has led to an increase in number of vehicles on road raising environmental challenges like rise in air pollution, significant amount of carbon emissions and deterioration of natural reserves. This growing awareness of ecological concerns has led to emergence of concept called "Sustainable Transportation", paving way for EVs (Electric Vehicles) as cleaner and greener alternative. An Electric Vehicle is a mode of transport that cannot be powered by gasoline and thus are operated partially or completely by rechargeable batteries. As EVs are gaining momentum, they are making substantial impact on the automotive industry. The demand for EVs is growing rapidly, as consumers and businesses seek eco-friendly transportation options battery technology continues to evolve and prices are becoming more affordable .Several prominent automotive companies are investing heavily in EV technology, while new startups are also entering the market, making the sector more competitive and fast evolving. While conventional electric vehicles rely on grid for drawing power , integration of solar energy marks the next transformation green mobility. As world is gradually adopting renewable sources of energy, solar powered

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EVs are emerging as next big leap in the field of Electronic Vehicles. With inclusion of regenerative braking, these solar powered EVs are not only enhancing energy efficiency but also setting a new benchmark for sustainable mobility.

Problem Statement:

Despite of growing popularity of Electric Vehicles there is still a huge chunk of customers who hesitate to buy an EV due to long charging time , limited charging infrastructure and range anxiety. Also, most of the current EV models lack proper use of renewable energies. The research aims to tackle these challenges by actively considering consumer viewpoints and deeply analysing their feedback , pain points. On basis of this a suggestive model has been proposed that can be employed in near future. The model relies on solar energy, harnessed via solar films or paints along with regenerative braking mechanism for enhanced efficiency. The research also provides insights about the perception of consumers regarding the repurchase aspect of EVs which is by far unexplored.

Objectives:

1. To study consumers' perception about Electric Vehicles.
2. To analyse the difference between Electric vehicles and traditional ICEs.
3. To explore the behavioural trends of customers regarding repurchase of Electric Vehicles and determine its future market scope.
4. To design a suggestive two wheeled EV model utilizing non-conventional source of energy and to highlight its potential benefits.

Review of Literature:

1. **"Advanced Concepts and Technologies for Electric Vehicles" by Akshay Kumar Rathore (2023) :**The book contains an overview of advancements in technology of EVs focusing mainly on the role of electric motor, used in battery, technology of wireless charging , integration of grid etc. It provides a comprehensive view of technology in all the electric vehicles .
2. **"Is India winning or losing the war of EVs"(2023):**The vlog provides insights into India's EV market which is estimated to grow alongside USA and China, numerically around 90% CAGR this decade. China controls essential resources for EV production, impacting global supply chains. The demand for Electric Vehicle is expanding in Domestic market on a rapid scale which is mainly due to incentives given by the government such as subsidy, consumer interest (mainly in two-wheeler).
3. "**Will Electric Cars Save The Planet? Or Is It Just Propaganda?**" **by Patrick Bet David (2022):** There are fears that EVs could become the new diesel scandal as unexpected health and environmental impacts . Moreover ,the podcast also delves into the health risks and other environmental impacts associated with solar electric vehicle technology.
4. **The Research by Eric W. Wood et al(2020):** The research paper discusses how growing environmental concerns are making consumers and government prefer an Electric Vehicle over ICEs. Further the paper also discusses how tax rebates, incentives and subsidies for manufactures and customers make EVs more affordable and attractive.
5. **The research paper "Effective Utilization of Regenerative Braking in Electric Bike" (2017):** The research paper emphasizes the potential benefits of incorporating energy recovery system in two wheeled EVs. It highlights that though the energy recovered from this mechanism is significantly lower in quantity still how it can contribute in increasing overall efficiency of the main battery pack.

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Research Methodology:

1. **RESEARCH DESIGN-** The proposed research is **descriptive** in nature as it collects and provides first hand insights on how consumers perceive and interact with EVs. The study aims to capture and deliver factual and authentic data on consumers' attitude , choices, preferences, behavioural patterns in context of Electric Vehicles without altering any variables or experimental intervention.
2. **RESEARCH APPROACH-** The proposed study employs **mixed method approach**. Both **qualitative** and **quantitative** research techniques have been employed to provide comprehensive understanding of the concerned subject matter. The qualitative approach focuses on understanding consumer perception, their preferences and opinions on EVs whereas quantitative approach concentrates on analysing data collected through questionnaire by 130 people of KDMC region, testing the concerned hypothesis and identifying the measurable variables , trends or patterns to determine the Market potential of EVs.

3. DATA COLLECTION

A. **Convenience Sampling and Online Questionnaire**-The primary data for this study was collected using the **survey** method, in which the **online questionnaire** was predominantly employed as the primary data collection tool. The survey received an impressive response of **130** participants from the **KDMC** region, indicating significant engagement and interest in the subject matter. These participants included both users and non-users of electric vehicles (EVs), ensuring a diverse and balanced range of consumer insights.

- **Questionnaire Development** - To test the validity of the instrument, **Cronbach's Alpha , Split Half and Spearman Brown's** tests were calculated to measure the internal consistency and reliability of the instrument. The Cronbach's Alpha came as **0.780** thus the instrument was considered as credible for the study. Split half reliability was calculated as **0.770** which is adequate in magnitude hence the questionnaire is internally consistent . Spearman Brown's corelation was calculated as **0.870** making the questionnaire correlated and reliable.

B. **Purposive Sampling and Interview** -In addition to the survey, a **purposive expert sampling technique** was employed to provide valuable, context-rich data from an individual with direct involvement and expertise in the electric vehicle industry. Specifically, an **interview** with **Mr. Shaqeer Khan, the Cluster Manager of Ola Electric Kalyan** was conducted. The discussion focussed on the company's electric operations, it's future vision , the challenges involved in growth of EV market , consumer complaints and feedbacks , market trends, future of electric vehicles , and the role of government policies in promoting Electronic Vehicles.

C. **Secondary Data**-Secondary data was collected from research papers available on DELNET, INFLIBNET, and Google search. Relevant articles, journals, books and reports along with YouTube videos and blogs, were also reviewed to support the research.

4. DATA ANALYSIS- Data Analysis was performed on Ms Excel and Vasarstats software.The collected data was analyzed using **Chi square analysis** and **percentage rank method** to test research hypothesis and assess key factors influencing consumer attitudes and behaviour towards electric vehicles.

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(INTERVIEW WITH CLUSTER MANAGER OF OLA ELECTRIC,KALYAN: SHAQEER KHAN)

HYPOTHESIS:

H0: Consumers have a negative perception towards EVs.

H1: Consumers have a positive perception towards EVs.

H0: Consumers do not prefer EVs over traditional vehicles.

H2: Consumers prefer EVs over traditional vehicles.

H0: Consumers are not willing to repurchase EVs.

H3: Consumers are willing to repurchase EVs

DATA ANALYSIS:

Hypothesis 1

Objective- To study consumer perception of EVs

Question- What is your perception towards EVs ?

Category	Observed Frequency	Expected Frequency	Expected Proportion	Percentage Deviation	Standardized Residuals
A	63	43.3	0.33307692:	+45.5%	+2.99
B	43	43.3	0.33307692:	-0.69%	-0.05
C	24	43.3	0.33307692:	-44.57%	-2.93
D				-----	-----
E				-----	-----
F				-----	-----
G				-----	-----
H				-----	-----

Reset Calculate

Sums:

Observed Frequencies: 130

Expected Frequencies: 130

Expected Proportions: 0.99923

[Note that for df=1, the calculated value of chi-square is corrected for continuity.] [For df=1, this is the uncorrected value of chi-square.]

chi-square = 17.57

df = 2

P = 0.0002

[P is non-directional]

(SOURCE: PRIMARY DATA -ONLINE QUESTIONNAIRE)

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Interpretation:

From above table it can be interpreted that 63 respondents had positive perception, 24 had negative perception while 43 people had neutral perception for EVs. The expected frequency of following data is 43.3 but when chi square analysis was performed on the above data , chi- square value came as 17.57 and p value as 0.0002 here(p is non directional). As p's value is less than 0.05,the alternative hypothesis i.e. consumers have positive perception towards EVs is affirmed.

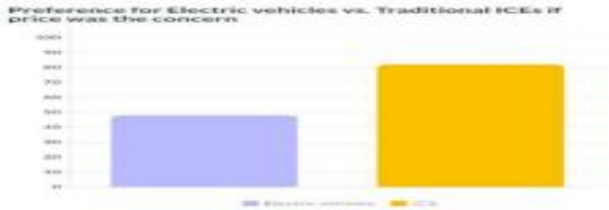
Hypothesis 2

Objective- To compare traditional and electronic vehicles

The following key variables were used to compare electric vehicles (EVs) and internal combustion engine (ICE) vehicles, based on responses from the online questionnaire. The attached table, bar and pie graphs provide a comprehensive visual analysis of the data, illustrating the differences and insights derived from the respondents' feedback.

VARIABLE FACTORS	ELECTRIC TWO WHEELERS	TRADITIONAL TWO WHEELERS(ICE)
PRICE	RS. 1- 1.5 LAKH (HIGHER DUE TO BATTERY AND SOLAR PANEL INTEGRATION)	RS. 60,000-RS. 1 LAKH(AFFORDABLE FOR MOST CONSUMERS).
ENVIRONMENTAL IMPACTS	ZERO EMISSION	EMITS 30-50 GM, C02/ KM
GOVERNMENT POLICIES	SUBSIDIES UPTO RS.15000 UNDER FAME-II SCHEME	NO DIRECT SUBSIDIES AND HIGHER TAX ON PETROL
MAINTAINENCE COSTS	RS. 1500-3000 PER YEAR,	RS. 3000- 5000 PER YEAR
RANGE	60-100 KM. PER CHARGE	400-500 PER FULL TANK
DURABILITY	BATTERY LIFE 5-7 YEARS, SOLAR PANELS LIFE 20+ YEARS	ENGINE LIFE 10-15 YEARS.
FUEL/ENERGY COST	RS. 0.25- RS. 0.50 PER KM	RS. 2- 3 PER KM

VARIABLE FACTORS	ELECTRIC TWO WHEELERS	TRADITIONAL TWO WHEELERS(ICE)
PRICE	RS. 1- 1.5 LAKH (HIGHER DUE TO BATTERY AND SOLAR PANEL INTEGRATION)	RS. 60,000-RS. 1 LAKH(AFFORDABLE FOR MOST CONSUMERS).



Interpretation: The first variable considered was PRICE in which 46 people preferred EVs whereas 84 people preferred ICEs.

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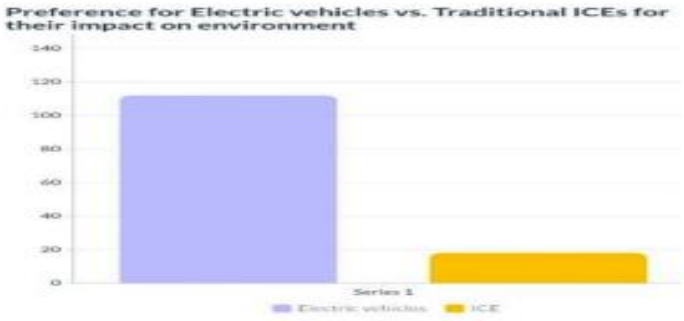
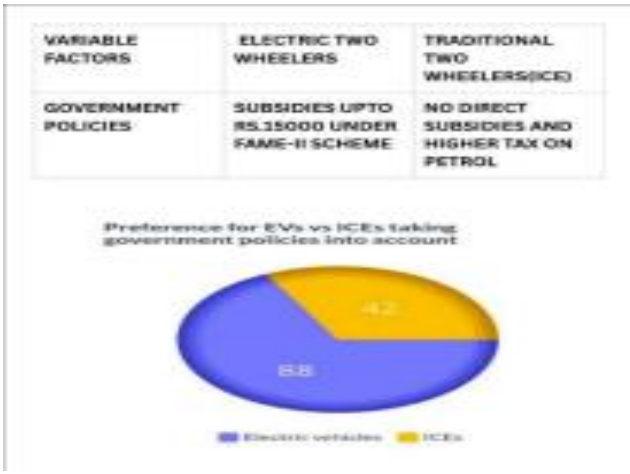
VARIABLE FACTOR	ELECTRIC TWO WHEELERS	TRADITIONAL TWO WHEELERS(ICE)
ENVIRONMENTAL IMPACTS	ZERO EMISSION	EMITS 30-50 GM, C02/ KM



Interpretation:

The second variable considered was ENVIRONMENTAL IMPACT in which 112 people preferred EVs whereas 18 people preferred ICEs.

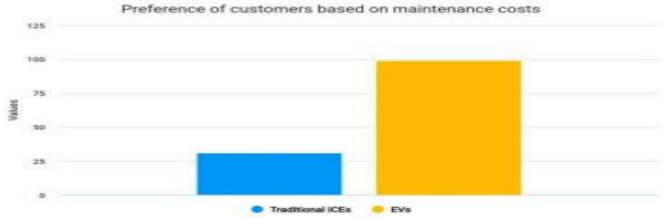
VARIABLE FACTORS	ELECTRIC TWO WHEELERS	TRADITIONAL TWO WHEELERS(ICE)
GOVERNMENT POLICIES	SUBSIDIES UPTO RS.15000 UNDER FAME-II SCHEME	NO DIRECT SUBSIDIES AND HIGHER TAX ON PETROL



Interpretation:

The third variable considered was GOVERNMNET POLICIES in which 88 people preferred EVs whereas 42 people preferred ICEs.

VARIABLE FACTORS	ELECTRIC TWO WHEELERS	TRADITIONAL TWO WHEELERS(ICE)
MAINTAINENCE COSTS	RS. 1500-3000 PER YEAR,	RS. 3000- 5000 PER YEAR



Interpretation: The fourth variable considered was MAINTAINENECE COST in which 98 people preferred EVs whereas 32 people preferred ICEs.

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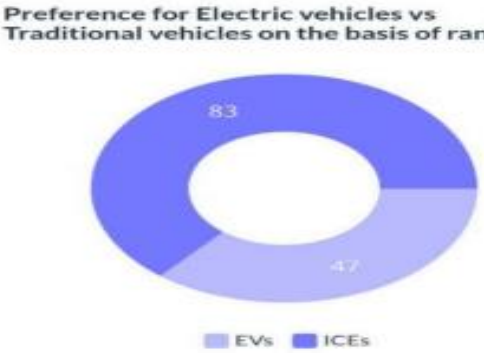
VARIABLE FACTORS	ELECTRIC TWO WHEELERS	TRADITIONAL TWO WHEELERS(ICE)
FUEL/ENERGY COST	RS. 0.25- RS. 0.50 PER KM	RS. 2- 3 PER KM

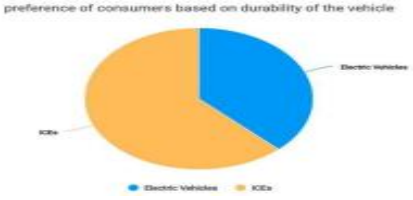
Interpretation: The fifth variable considered was FUEL/ENERGY COST in which 96 people preferred EVs whereas 34 people preferred ICEs.

VARIABLE FACTORS	ELECTRIC TWO WHEELERS	TRADITIONAL TWO WHEELERS(ICE)
RANGE	60-100 KM. PER CHARGE	400-500 PER FULL TANK



Interpretation: The sixth variable considered was RANGE in which 47 people preferred EVs whereas 83 people preferred ICEs.

VARIABLE FACTORS	ELECTRIC TWO WHEELERS	TRADITIONAL TWO WHEELERS(ICE)
DURABILITY	BATTERY LIFE 5-7 YEARS, SOLAR PANELS LIFE 20+ YEARS	ENGINE LIFE 10-15 YEARS.



Interpretation: The seventh variable considered was DURABILITY in which 49 people preferred EVs whereas 81 people preferred ICEs.

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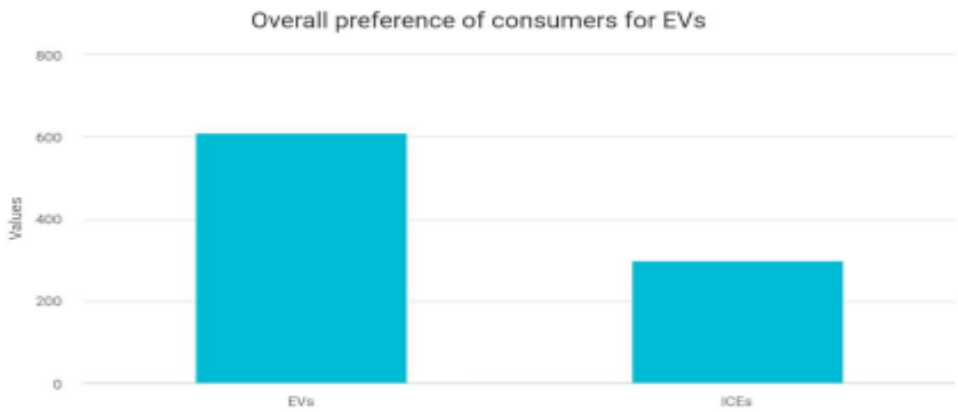

After analysing all the key variables independently, the final graph presented below was obtained.

610

300

(SOURCE: PRIMARY DATA -ONLINE QUESTIONNAIRE)

Interpretation:

After evaluation of all the considered variables, we can observe that 66% people prefer EVs over ICEs. Thus, by percentage rank method we accept H2, H2: consumers prefer EVs over traditional vehicles.

Hypothesis 3

Objective-To study repurchase behaviour of consumers for EV

Question- Would you consider repurchasing an electric vehicle in the future?

Cate-gory	Observed Frequency	Expected Frequency	Expected Proportion	Percentage Deviation	Standardized Residuals
A	24	43.3	0.33307692:	-44.57%	-2.93
B	64	43.3	0.33307692:	+47.81%	+3.15
C	42	43.3	0.33307692:	-3%	-0.2
D				----	----
E				----	----
F				----	----
G				----	----
H				----	----

Sums:

Observed Frequencies: 130

Expected Frequencies: 130

Expected Proportions: 0.99923

Reset Calculate

[Note that for df=1, the calculated value of chi-square is corrected for continuity.] [For df=1, this is the uncorrected value of chi-square.]

chi-square = 18.54

df = 2

P = <.0001

[P is non-directional]

(SOURCE: PRIMARY DATA -ONLINE QUESTIONNAIRE)

From above chart it can be interpreted that 24 people are not willing to repurchase an EV whereas 42 people are willing to repurchase an EV. Majority of them i.e. 64 people are still unsure whether they would repurchase an EV. On performing chi square analysis, it is found that there is significant deviation between variables.

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Interpretation-The expected frequency of data is 43.3

After analysis the chi square value is 18.54 and p's value is less than 0.0001

As p's value is found to be less than 0.05 , alternate hypothesis ie the consumers are willing to repurchase an EV is accepted.

Results and Key Findings:

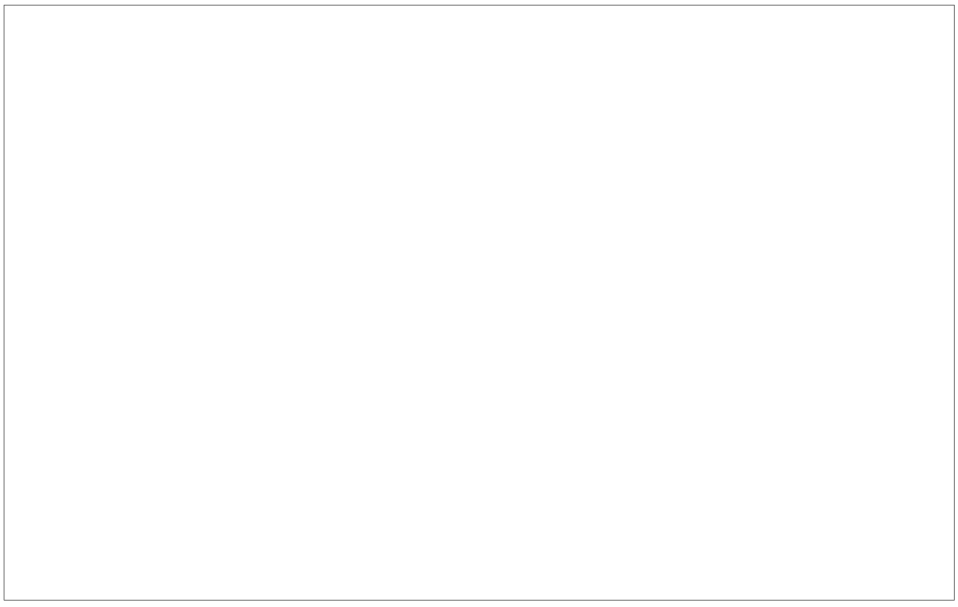
- Upon conducting the data analysis, the findings revealed that all three alternate hypotheses of the research have been supported.
- The findings reveal that Majority of the respondents had a positive perception towards EVs.
- Further, the analysis also show that significant proportion of consumers are willing to repurchase an EV in the future,indicating strong level of trust and satisfaction with the product.
- In addition , the data also suggests that majority of the respondents prefer EVS over ICEs ,reflecting a shift in preference of the customers towards more sustainable and environment friendly alternatives.
- The analysis thus concludes that though the future of automotive industry is uncertain, but it is clear that EVs will definitely play a major role in the future.

Limitations:

Though our study provides valuable key insights it has some limitations that can be considered.

1. The proposed research was conducted on a sample size of 130 people from KDMC region. However, it can be done on larger sample size from a greater sample space to provide deeper insights.
2. The study focuses primarily on 2-wheeler electric vehicles. However, extending the study to 4 wheelers can provide a broader understanding.

Recommended Conceptual Model and its Functioning:



Based on the analysis of problems and challenges faced by the consumers, their expectations towards EVs identified in this study, an eco-innovative model has been suggested. The proposed model integrates solar power technology complemented with regenerative braking mechanism boosting vehicle's efficiency and enhancing overall performance . The following section details the mechanism and functionality of the suggested model.

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The body of the vehicle is covered with solar paints or flexible solar films which consist of photovoltaic cells. The photovoltaic materials present in these cells (photons)absorb sunlight and excites electrons creating direct electric current. The generated electricity flows through conductive wires ,embedded within or beneath the solar surface to a Solar Charge Controller which stabilizes this unregulated DC current. The controller also adjusts the voltage and current to match requirements of EVs battery pack hereby ensuring no excess energy damages the battery. The current then flows into EVs lithium-ion battery where it is stored in form of chemical energy for future use. The whole mechanism is monitored by Battery Management System which ensures efficient charging and prevents overheating of the battery. It also optimizes battery's overall performance and helps in extending its lifespan.

Furthermore, the model also incorporates regenerative braking mechanism whose primary function is to directly power components such as headlights, indicators and horns without storing the power in the main battery. As soon as the rider applies brake the hub motors present in the wheels(functioning both as drive motors and generators)of vehicle convert rotational kinetic energy into electricity which is stored temporarily in supercapacitors as they can quickly absorb and release energy unlike batteries. The electricity from the supercapacitors is carried to various components such as headlights, horns, indicators etc via power distribution

unit. While the Energy Management System continuously monitors the energy available in the capacitor bank. The battery management system on detecting low charge reroutes power directly from the battery through the Power Distribution Unit to keep the components function seamlessly.

TRANSFORMATIVE OUTCOMES OF THE PROPOSED MODEL:

This model aims to bring significant socio-economic improvements, positively impacting key sectors such as:-

1. **ENVIRONMENT :**
   - **a) REDUCED CARBON FOOTPRINT**-Solar powered EVs considerably reduce reliance on fossil fuels, contributing to lower greenhouse gas emissions. They do not produce any kind of tail pipe emissions contributing to cleaner air healthier environment.
   - **b) SUSTAINABLE TRANSPORTATION SYSTEM**-Electric mobility utilizes energy sources which are renewable and less harmful to the planet thereby creating a future in which transport does not harm ecosystem or deplete any kind of natural resources.
2. **INDUSTRIES :**
   - **a) INNOVATIVE LEADERSHIP**- Automotive companies developing and deploying solar EVs can position themselves as leaders in green technology and innovation. They can attract more consumers and investors who care about environment. This will help them in enhancing their market reputation and will help them emerge as leaders in green technology.
   - **b) SUSTAINABILITY GOALS**- widespread adoption of EVs will help companies meet their sustainability targets set by government and international organisations. Developing Solar EVs will also help companies in achieving their Corporate Social Responsibility by promoting environmental sustainability.
3. **CONSUMERS :**
   - **a) REDUCED RELIANCE ON FREQUENT CHARGING**-Solar EVs are especially handy in situations where charging stations are far away as they provide reliable backup power source. They allow on the go charging and the power tops up even when the vehicle is idle ie you can charge the vehicle even while driving or even when it is parked under the sun thereby eliminating constant need of charging stations.

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b) HIGHER ENERGY EFFICIENCY-The solar energy generated supplements main battery's charge thereby extending the driving range. Furthermore, regenerative braking mechanism ensures less energy is wasted and vehicle runs more efficiently. Through this, the consumers not only save on prices of fuel but also use every bit of energy in the best possible way.

4. ECONOMY :

a) REDUCTION IN OIL IMPORTS-Mass adoption of Solar Powered EVs would considerably reduce dependence on oil imports. The nations that spend heavily on importing oil can save these foreign exchange reserves and invest in development of socio-economic infrastructure and more renewable sources of energy which are comparatively cleaner , greener and more sustainable.

KEY PROPOSALS:

Along with the suggestive model proposed there are some suggestions that would complement the suggestive model.

1. **Wireless Charging Technology :** wireless charging pads installed in parking spaces or around roads, can charge EVs during off peak hours or even at night without plugging charger. The integration of dynamic wireless charging technology would further reduce range anxiety.
2. **Al-Optimized Energy Management System:** Smart AI algorithms can predict energy requirements as per traffic jams or weather conditions and can also plan charging schedules or optimize energy consumption. This system ensures efficient charging distribution and reduces cost by charging during off peak hours making EVs more cost effective.
3. **Solar Charging Stations:** Build charging stations for electric vehicles that run on solar energy so that users can recharge their cars after long journeys or during low sunlight. These stations would be highly beneficial when people travel to remote areas or places with limited electricity access.
4. **Energy Recovery from wind:** Wind turbines can be integrated in vehicle's design to recover energy from wind resistance while driving thereby supplementing the main battery. This technology will help in extending vehicle's driving range and will contribute to a more sustainable driving experience.
5. **Battery Swapping Stations:** Battery Swapping Stations must be established at certain distances to allow consumers to quickly replace the discharged batteries with fully charged ones. This will reduce waiting time and will ensure that people don't have to worry about battery degradation.

Conclusion:

- In the bustling streets of India's metropolitan cities, a quiet revolution is taking shape. ▪ As the nation grapples with air pollution and rising fuel costs, the convergence of solar power and electric vehicles (EVs) presents a promising solution for sustainable transportation.
- As the world shifts towards renewable energy, solar-powered electric vehicles (EVs) are emerging as a revolutionary development in the automotive industry. This solar mobility transformation isn't just a distant dream it's the beginning of a journey towards cleaner, green, brighter and sustainable tomorrow.
- Though the impact of model suggested might seem small however, even if 10% of today's vehicles are replaced by suggestive model the carbon emissions can be reduced by 25 million metric tonnes.

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