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Clean Energy Using Transportation Systems

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ABSTRACT

The increasing need to address climate change and minimize environmental degradation has positioned the issue of utilizing transportation systems for clean energy at the center of international sustainability. Conventional transportation systems, which are dependent on fossil fuels, are among the most prominent sources of greenhouse gas emissions, air pollution, and depletion of resources. Shifting toward clean energy source like electricity obtained from renewable like solar, wind, and hydro sources for powering transport modes is critical in order to contain these effects and promote a low-carbon economy.

Clean energy through transport involves a broad array of inventions and systems such as electric vehicles (EVs), hydrogen fuel cell cars, biofuel-powered transportation, and electrified public transport networks. These technologies not only decrease tailpipe emissions but also enhance energy efficiency and reduce long-term cost of operation. Electric vehicle adoption, in turn, has picked up tremendous momentum, with the help of evolving battery technology, rising energy storage capabilities, and improvements in charging infrastructure.

As the globe transitions towards carbon neutrality, clean energy with the use of transport systems is emergg as a vital support of national and international strategies towards environmental conservation, health for the public, and economic stability. The intersection of technology, policy, and grassroots participation is at the center of achieving a future where transport no longer damages but benefits the health of the planet. In summary, clean energy with transportation systems represents a revolutionary mobility strategy that combines environmental sustainability and technological advancement, leading the way towards a cleaner, smarter, and more inclusive future.

Keyword : **sustainability; transportation; electric vehicles; grid integration; grid impact; renewable charging infrastructure; strategic policies.**

1. INTRODUCTION:

The idea of clean energy through transportation systems has been a key element in the worldwide attempt to become environmentally sustainable and reduce climate change. The transportation industry, including private cars, public transport, freight, aviation, and shipping, is one of the biggest users of greenhouse gas emissions globally because it is over-reliant on fossil fuels like gasoline and diesel fuel. Such emissions not only intensify global warming but also cause air pollution that seriously endangers populations, particularly in urban centers. To overcome such challenges, the adoption of clean energy sources, including solar, wind, hydroelectric, and bio energy, into transportation systems has become increasingly significant. This method seeks to substitute or complement traditional fuel sources with renewable and low-emission forms, thus minimizing the ecological impact of mobility.

Clean transport energy encompasses a variety of technologies and solutions, including electric vehicles (evs), hydrogen fuel cell vehicles, bio fuel buses, electric rail systems, and other low-carbon modes of transport. The engineering and rollout of such systems are enabled by growth in energy storage technologies, smart grid applications, and infrastructure construction, including EV charging infrastructure and hydrogen fueling networks. In addition, clean transport energy coheres with diversification of energy, decreased reliance on foreign oil, and greater national energy security. It also enables sustainable urban planning efforts through promotion of green public transport and non-motorized transport modes such as e-bikes and electric scooters. The shift to clean energy in transportation is not without challenges, such as high up-front investment, technology constraints, and the requirement of pervasive behavior change. But with sustained innovation, policy incentives, and public involvement, clean energy through transportation systems can transform mobility around the world and construct a cleaner, healthier, and more sustainable future.

At the time of writing this journal, countries around the world are preparing to attend the 26th Conference of the Parties (COP26) to the United Nations Climate Change Meeting Glasgow. Some of the essential topics to be addressed will be around the conservation of our environment, decarburization measures to realize a net-zero future and an evaluation of the2015 Paris Agreement aimed to realize the 1.5 ◦C global average temperature. This research makes an important contribution from the viewpoint of the transportation sector's embracement of electric vehicles and how the transport sector's electrocution wills also further global climate change. It is extremely well known that worldwide climate deterioration is caused by the consumption and combustion of fossil fuels by the industrial and residential sectors of all economies in the world. The United States and China are currently the biggest economies in the world utilizing fossil fuels.

The lead consumer of fossil fuels, by the average energy consumption by industry, is the transportation industry, using over 91% of petroleum energy consumed. The shift from internal combustion engine (ICE) cars to zero-emission electric cars has already commenced, with the majority of the world's economies using 2050 as the date when net-zero emissions within the transport industry. The United States of America, Canada, China, Britain, and the majority of the European Union plan to phase out and ban the sale and production of petrol and diesel cars from 2030.

These initiatives towards a greener industrial revolution will further curb the tide of world environmental pollution and enhance on the "Paris Agreement" of the 2015 conference of the parties (cop) to the United Nations Framework Convention on Climate Change (UNFCCC). Catalyst to this pact, as observed in "Article 2(1)(a)(b) of the 2015 Paris Agreement" , was the pledge made by the 195 nations to propel decarburization efforts to the level whereby the global average temperature is capped at 1.5oc and GHG emissions are reduced. Undeniably, mass adoption of electric vehicles, batteries, and renewable energy-powered charging infrastructure (and not those powered by fossil fuel power plants) will drive the transformation towards the green industrial revolution in the transportation industry.

In a report by the Bloomberg New Energy Finance on Electric vehicle outlook 2021 Executive Summary , there are presently 12 million passenger eve and commercial evs are estimated to have hit 1 million, while the segment of two- and three-wheeler evs are estimated at 260 million.

The report also painted a global electric vehicle picture by segment and market, as shown in Figure 1, in the sense that by 2025,the number of passenger evs will be estimated at over 54 million and commercialism and E-buscombined at more than 5 million, while electric two- and three-wheel will exceed 300 million.

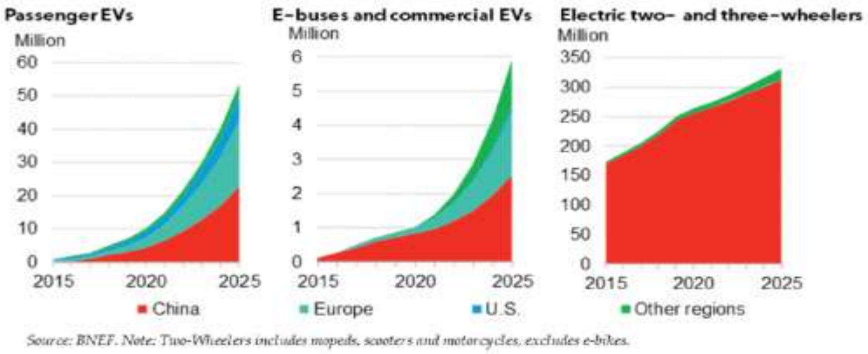

Figure 1. Global Electric Vehicle by Segment and Market. Bloomberg NEF: EV Outlook 2021

2.SUSTAINABILITY IN CLEAN ENERGY USING TRANSPORTATION SYSTEMS:

Sustainability, when applied to clean energy through transport systems, is the long-term sustainability of shifting from traditional, fossil fuel-based transport to ecologically friendly alternatives fueled by clean, renewable energy sources. This is necessary in meeting the urgent challenges of climate change, resource depletion, and urban air pollution. Clean energy-powered transportation solar, wind, hydroelectric, and bio energy lowers greenhouse gas emissions considerably, thus assisting the world in its goal of becoming carbon neutral and achieving sustainability goals enshrined in treaties like the Paris Climate Accord. Electric vehicles (eve), fuel cell hydrogen vehicles, and bio fuel-run transport modes are at the heart of this green transition, providing low-emission, efficient alternatives to conventional internal combustion engines.

From the point of sustainability, clean transport systems utilizing clean energy support environmental well-being, energy efficiency, and financial resilience. Public transportation like buses, trains, and trams, when electrified and run on renewable energy, not only reduces carbon footprints but also aids in decreasing noise pollution and cost of operation in the long run. The systems also facilitate the growth of circular economies, especially if EV batteries are made recyclable or viable for second lives. Infrastructure installation, including extensive EV charging networks and hydrogen refueling stations, also enhances sustainable urban and rural mobility.

The complete sustainability of the systems depends on overcoming issues like the environmental footprint of battery manufacturing, mining of rare earth minerals, and handling at the end of the vehicle's life. Life cycle analyses (LCA) are becoming more common to assess the sustainability of these systems from manufacturing through disposal. With further innovation, friendly policy environments, and public awareness efforts, clean energy transportation systems can become completely sustainable options. Eventually, these systems contribute to not just the protection of the environment but also social equity and economic growth, making for a balanced and long-lasting model for future mobility..

3.LARGE SCALE ELECTRIC VEHICLE IMPACT:IMPLICATIONS FOR GRID INTEGRATION:

One trend in software industry is going into the direction of integrated packages, which combine parametric design programs and simulation software in the same environment. Although this strategy reduces data interface losses, it has been criticized for resulting functional reduction in directly compatible program platforms. However, Next-Generation intelligent geometry data exchange formats, which can support both geometry data and richer product information, are capable of accelerating the efficiency of virtual product development processes substantially.

Virtual development will be carried out on the whole spectrum of product creation, beginning at concept stage, proceeding through various steps of development (including manufacturing and production engineering), facilitating sales and after-sales, and culminating in the coordination of disposal procedures. This calls for an additional incorporation of product properties into 3D models, such that they can act as in real life.

This time, there are a number of integrated development platforms, but they are plagued by high complexity, resulting in drawbacks in operation efficiency and user management. Overloaded with interconnected software modules for design, digital mock-up, simulation and data management, these platforms have developed into huge software giants, which provide more functionalities than ever before. Platforms for future developments must offer a smarter integration of various disciplines so that they become more efficient and easier to handle. Apart from that, the licensing models have to shift from inflexible, module-based systems towards adaptive accounting, which can take into account single software use. Options to conventional CAD software will emerge with a growing proportion of open-source CAD systems.

Open source CAD of today, such as BRL-CAD , are not yet as prevalent, but there is strong demand for basic, versatile CAD software particularly in small- and mid-range supplier enterprises. Just like Linux , open office or Firebird , such kind of programs will be open-source-based on platforms such as the Open CASCADE engine , and have the capacity to offer adequate functionalities for product and systems design . One of the main challenges for the development of such software packages is the potential incorporation of generated data into already installed data management frameworks of large (car) producers. Overall, cooperating CAD systems and environments come to hold a more central position within the global acting automotive sector. In order to face this challenge, next-generation CAD systems will offer capabilities of cloud-based development that allow all engineers on a design team to work together at the same time with a web browser, phone or tablet, as some programs already do.

Thus, interoperability between various CAD platforms and data management systems becomes a pre-condition for achieving a high level of interoperability . Due to high complexity, automotive development process data management is done by Product Data Management Systems (PDM), which represent a subset of Product Life Cycle Management Systems (PLM). These platforms are much more than simply data management software: Wide-ranging functionalities are made available to facilitate the whole development, production and use phases. In this manner, PLM tools are embedded in data transfer, visualization and assessment procedures . Development trends in data management are treated in several literature Target is an increased integration of design, engineering and data management for the global acting industry. The integration of mass-scale EVs into the power grid has continued to generate serious issues regarding the stability and security of the grid. A study by G adrenal. explored the uncertainty regarding the impact of mass-scale EVs on the distribution network and the issue of coordinating them.

In order to rectify this issue, the use of parametric diffusion kernel density estimation (DKDE) was utilized to determine the energy needed for charging big-scale EVs. With respect to the power flow problem for this research work ,an alternating direction method of multipliers was used to rectify this problem Singh is studied the impact analysis of plug-in electric vehicles (PEVs) on the distribution network based on various charging models. The research emphasized that the rise in the number of PEV has a substantial effect on the distribution network with evident losses, peak load, and transformer overload. The effect of EV energy demand on the distribution network of five European Union countries (the UK, Germany, Spain, Portugal, and Greece) was examined in a study by Hatziargyriou et al. . The analysis entailed the application of dumb charging (electric vehicle charging on a domestic grid system) as a means to prove that household energy consumption rises with the incorporation of EV. With this scenario, the increase in peak load energy demand on residential distribution networks. A study of the effect that various EV charging will have on Germany's national grid by 2030 was carried out by Hartmann .The study employed three scenarios to estimate the future effects of the growing large-scale integration of EVs on Germany’s power system.

Employing synthetic data with a minimum of one million EVs and maximum of 42 million charging on the grid, the research created an increase in thepeak demand of daily electricity. This first scenario showed that the uncoordinated charging of EVs will definitely destabilize the stability of the distribution network. To mitigate the impact of the first scenario, Hartmann looked at utilizing big EV batteries to stabilize the power grid, which registered an increase of 16% in the second scenario. This gain over the second scenario was mainly due tothe coordinated and strategic charging of the EVs at off-peak hours and returning the battery energy of the EVs back to the grid (stabilization). The third situation was for its economic advantage only, where EVs were employed in energy trading. Wailer carried out a research study examining the impact of EVs' hourly energy custom on the US energy system. When investigating the pattern of charging and load profile of EVs' hourly energy demand, the research employed the US National Household Travel Survey that recorded over 365,000 private vehicle trips. With this dataset, a simulation model was performed with parameters of input such as battery charge drain based on mileage, battery size of EV, efficiency of the charger, and power rating of the charger used, amongst others. The outcomes showed that EV energy consumption can reach 8.5 kWh/day, which raises the electricity consumption per capita . That is, massive EVs charging simultaneously will bring a severe burden to the peak demand of daily power consumption and limit the stability of the power grid. Axsen et al. undertook a study with three scenarios to explore the effects of plug-in hybrid electric vehicles (PHEVs) in California. In the first case, employing the unconstrained method of charging EVs, in this study, the possible effect of augmented peak demand, which can significantly impact grid stability and necessitates that more electricity be produced to satisfy the heightened demand of uncontrolled large-scale EVs charging.

The second case, which entailed utilizing workplace facilities to charge EVs, revealed a growth of27% in electricity usage, while the final case entailed a load shifting control strategy of EVs charging to off-peak hours, which revealed a meaningful decrement of 25%in the overall electricity usage problem. Salah through research based on utilizing the distribution substations in Switzerland's energy network, claimed that with more and more large-scale EV penetration, there will be a meaningful effect on the national grid. In an attempt to determine how EV charging will affect the energy system, live capacity data sets from SWISS high-voltage grid substations, EV data sets with 30 kWh battery capacity, EV power consumption of 0.15 kWh/km estimated, and the highest travel range of 200 km on the basis of the battery capacity and estimated consumption were employed in modeling and analysis. With the prevailing electricity tariff and under 16% EV penetration, the results indicated a stable performance from the distribution substation, despite uncoordinated charging activities. Nonetheless, with an exponential growth of large-scale EVs' uncoordinated charging beyond the 50% penetration mark, the performance of the distribution substations is likely to be significantly affected by overloads. Among the suggestions proposed by are implementing adaptive and dynamic electricity tariff schemes that promote load shifting of EV charging to off-peak hours. Foley analyzed the effect of 213,561 EVs on the Republic of Ireland and Northern Ireland single electricity market (SEM) with the aid of a model founded complexes. In the examination of the possible effect, two scenarios that involved the charging of EVs in off-peak and peak hours were utilized.

The overall finding suggested that off-peak charging has a negligible effect on the stability and safety of the electricity network. Widespread deployment of electric vehicles (EVs) offers both opportunities and challenges for power grid infrastructure and management. As millions of EVs will be rolled out around the world in the next few years, their combined effect on electricity demand, grid stability, and energy distribution is a field of primary concern. The underlying assumption of mass deployment of EVs is the huge boost in electricity usage, especially peaking during charging times, that can overwhelm available grid capacity and infrastructure if mishandled. The spike in demand necessitates upgrading the transmission and distribution network, instituting smart charging practices, and capital investment in grid modernization technologies.

One of the biggest issues is the risk of demand peaks, particularly if multiple EVs are charged at the same time in residential locations in the evenings. This causes localized network congestion, voltage swings, and even outages. In order to reduce such problems, smart charging or controlled charging systems are under development to charge optimally depending on grid status, energy tariffs, and availability of renewable energy. These systems can shift EV charging to off-peak hours, reducing pressure on the grid and allowing better integration of renewable energy sources like solar and wind.On the other hand, EVs also present grid support opportunities in the form of technologies like vehicle-to-grid (V2G). V2G allows EVs to send electricity back to the grid during high-demand times, essentially making them mobile energy storage devices. This two-way energy transfer can make grids more flexible, stable, and resilient, particularly when combined with renewable power generation.

In addition, mass-scale EV integration promotes decentralized energy management since EVs are included in distributed energy resources (DERs) along with solar panels and battery storage. Utilities and policymakers have to collaborate to come up with standards, pricing structures, and infrastructure that facilitate this new power dynamics.

In summary, though EV mass deployment challenges the conventional grid infrastructure, it also offers cutting-edge options for increased energy efficiency and renewable support. Proper planning ahead, investment in intelligent technologies, and planned grid upgrade are necessary to provide successful and sustainable integration of EVs into the power system.

4. LARGE-SCALE ELECTRIC VEHICLE IMPACT: IMPLICATIONS FOR GRID INTEGRATION:

Since the penetration of Plug-in Electric Vehicles (PEVs) is increasing aggressively, their aggregated demand on the electric grid poses serious challenges and opportunities. Uncontrolled charging may result in higher peak demand, grid congestion, and power quality problems without proper coordination. Hence, adopting efficient energy management strategies is essential to maximize PEV load demand and ensure the grid runs reliably and efficiently. The most efficient of these strategies is smart charging, which is also referred to as controlled or managed charging. Smart charging systems use current information, communication technologies, and grid signals to charge PEVs during off-peak times when the demand for electricity is lower. Not only does this ease the grid, but it also balances supply and demand, particularly when combined with renewable sources of energy like wind or solar power. Time-of-use (TOU) pricing tariffs, which provide reduced electricity prices during off-peak periods, can encourage consumers to charge their cars during periods of low grid demand. The effect of vehicle electrocution has been found to pose a threat to secured stability of the electricity supply, as defined. In this section, the emphasis on thecontext surrounding the energy management strategy assessment of EVs and reducing the impudence of EVs on the distribution network, including optimization methodologies and tools utilized, is presented.

Another sophisticated technique is Vehicle-to-Grid (V2G) technology, where PEVs are enabled to release stored power back into the grid. V2G makes electric cars distributed energy resources (DERs) and allows them to be used for stabilizing the grid during peak hours or crisis situations. The two-way energy flow stabilizes the grid, improves frequency regulation, and offers backup power in case of outages. V2G, however, necessitates spending on compatible charging systems, standardized communication protocols, and appropriate regulation. Load forecasting and predictive analytics are also critical in maximizing PEV demand optimization. Historically, by examining past data, weather trends, user patterns, and market indications, utilities can forecast load demand and adjust generation and grid operations in response. This enables anticipatory energy dispatching and increased integration of intermittent renewable resources. Also, decentralized energy management systems through micro grids, energy storage, and local generation can assist in managing PEV loads at the building or community level. These systems improve the resilience of the grid and lower the reliance on centralized power plants, particularly in those areas with limited grid capacity .In short, efficient load demand of PEVs needs to address the dimensions of smart charging, V2G, predictive analytics, and decentralized energy systems. With synchronized energy management strategies in place, the increasing penetration of PEVs can be turned into an exemplary chance for the improvement of the power system's energy efficiency, sustainability, and reliability.

4.1. ELECTRIC VEHICLE CLASSFICATION:

Electric vehicles (evs) are categorized according to their powertrain setup and how they combine electric and traditional energy sources. The primary categories are Battery Electric Vehicles (bevs), Hybrid Electric Vehicles (hevs), Plug-in Hybrid Electric Vehicles (phevs), and Fuel Cell Electric Vehicles (fcevs). Battery Electric Vehicles (bevs) run on electric power from a stored battery pack and lack an internal combustion engine (ICE). They are charged outside and have zero tailpipe emissions, making them clean and efficient for city and highway driving. Hybrid Electric Vehicles (hevs) put together a standard ICE with an electric motor and battery. The battery is replenished by regenerative braking and the ICE itself, and not with an outside power supply. Hevs maximize fuel economy and lower emissions but are not able to run long distances solely on electric power. Plug-in Hybrid Electric Vehicles (phevs) both have an ICE and a recharged battery that can be replenished from an outside electric supply. Phevs possess more electric-only driving range than hevs and transition to the ICE when their battery has been used up. Phevs allow for convenience in both short electric drives and longer gasoline excursions.

In the PHEV category, there are two types:

- Series PHEV, or Extended-Range Electric Vehicle (EREV), employs the electric motor as the only source of power driving the wheels, while the ICE is only used as a generator to charge the battery when necessary.
- Parallel PHEV permits both the electric motor and ICE to power the vehicle individually or in combination, depending on driving situations.
- Fuel Cell Electric Vehicles (faces) employ hydrogen gas to generate electricity from a fuel cell with only water vapor as a waste product. They provide extended ranges and rapid refueling capabilities, thus being ideal for heavy-duty and intercity uses.

4.2. BATTERY ELECTRIC VEHICLE (BEV):

A Battery Electric Vehicle, also known as a fully electric vehicle or purely electric vehicle, is defined by the fact that it has no internal combustion engine (ICE) at all. Rather, it depends exclusively on a large capacity battery pack to save electrical energy and is thus a 100% electric-powered power train. This basic difference makes BEVs stand out from hybrid or plug-in hybrid cars, which continue to burn some type of traditional fuel. The BEV is an efficient and environmentally friendly mobility solution that generates zero tailpipe emissions, making it well-suited for urban air pollution mitigation and fossil fuel dependence reduction.

At the heart of operating a BEV is its Intelligent Energy Management System (IEMS). The IEMS manages the flow and conversion of energy within the vehicle. It translates the direct current (DC) electricity stored in the battery to alternating current (AC) electricity, which it supplies to the electric motor. The electric motor, in a conversion, converts this electrical energy into mechanical energy to power the vehicle's wheels. This power train technology is very efficient, with electric motors offering immediate torque and smooth acceleration, providing a better overall driving experience.

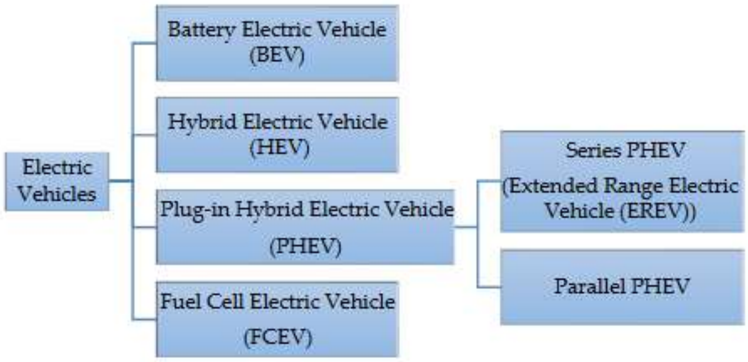

Figure 2. General Classification of Electric Vehicles

One of the most progressive and energy-saving technologies built into a BEV is its regenerative braking system. In braking or decelerating, rather than waste energy in the form of heat as current conventional braking systems do, the electric motor reverses roles and is used as a generator (much like an alternator). In this process, referred to as kinetic energy recovery, the system harnesses the mechanical energy that results from the movement of the wheels and regenerates it as electrical energy. The recovered energy is stored in the battery, thus increasing the vehicle's driving range and efficiency in energy usage. BEVs are also equipped with advanced electronic control systems that check battery health, regulate temperature, and optimize charging cycles. Such features result in long-term reliability and performance. Also, advances in battery technology continue to expand energy density, shorten charging time, and lengthen vehicle range.

4.3.PLUG-IN HYBRID ELECTRIC VEHICLE (PHEV):

Plug-in Hybrid Electric Vehicles (PHEVs) are sophisticated vehicle systems that integrate the characteristics of conventional Hybrid Electric Vehicles (HEVs) and, in addition, the facility of being plugged into the electrical grid. The dual capability makes it possible for PHEVs to drive more efficiently and flexibly in different driving situations. A PHEV is structurally equipped with an ICE, an electric motor, and a bigger battery pack than that of a normal HEV. It is due to the bigger battery that the vehicle can travel for longer distances under electric power alone.One of the distinguishing features of PHEVs is that they can utilize power from two sources. The electric motor can be charged from the battery, the ICE, or a combination of both, based on road conditions and power availability. The battery in a PHEV can be recharged in three different manners: by the internal combustion engine, by regenerative braking, and by plug-in to external electrical outlets embedded in the electricity grid.

Generally, PHEVs have two primary operating modes. The first is the all-electric mode or charge-depleting (CD) mode, in which the vehicle is powered purely on stored electric energy in the battery. In this operating mode, the Intelligent Energy Management System (IEMS) is crucial as it controls and monitors the state of charge (SoC) of the battery, regulates energy transfer, and maintains maximum efficiency. The IEMS decides when to transition from electric to hybrid operation, based on battery state and driving requirements.

When the battery reaches a lower charge level, the car enters the second operating mode: the hybrid mode, or charge-sustaining (CS) mode. In this operating mode, the ICE is the major source of propulsion, and the battery's SoC is kept at a constant level. The IEMS ensures this balance by utilizing energy from the ICE and by capturing kinetic energy during deceleration through regenerative braking. During braking, the electric motor acts as a generator (similar to an alternator), converting mechanical energy into electrical energy and feeding it back into the battery to preserve its charge.

5.ENERGY MANAGEMENT OF PEV LOAD DEMAND ON THE DISTRIBUTION NETWORK:

The adoption of electric vehicles (evs), especially plug-in electric vehicles (pevs), into power grids has far-reaching implications concerning energy demand, grid stability, and infrastructure. To mitigate anticipated uncertainties within Colombia's energy infrastructure by 2030 as a result of widespread EV adoption, Betancur et al. Created a Monte Carlo simulation model to evaluate prospective impacts. Their model addressed many of the parameters including daily mileage, battery state of charge (soc), charging habits, and energy consumption. The research indicated that PEV charging had the potential to increase transformer and power line overload by 20–40%, meaning the immediate need to implement proactive grid management strategies.

To predict charging demand and reduce negative grid impacts, Jahangir et al. Used an Artificial Neural Network (ANN) method. They used a Recurrent ANN with the feed forward technique and trained data through the Liebenberg-Marquardt algorithm. The ANN successfully predicted travel mode and charging behavior, and when compared to Monte Carlo simulations, showed potential in decreasing energy consumption cost with the utilization of an aggregator, making it possible for improved electricity distribution network management. Used Deep Neural Networks (dnns) to simulate PEV energy demand by developing two predictive models—one to predict battery soc and driving fuel use, and the other to predict the vehicle's all-electric range, or CD mode. In contrast to conventional response surface methods, dnns demonstrated dramatic improvements in reducing charging energy costs for large-scale PEV penetration.

Investigated energy-efficient EV routing based on actual driving data. A Multiple Linear Regression (MLR) was employed in order to predict energy consumption as a function of internal vehicle parameters such as speed and acceleration, and external parameters including temperature. Neural networks were also used to predict unknown variables, which led to a mean absolute error in the range 12–14% for energy consumption predictions.

Nageshrao. Explored optimal charging policies to balance EV load demand and lower electricity prices. Synchronized charging scenarios demonstrated 54% cost optimization improvement compared to uncoordinated techniques. Neural networks were utilized again to forecast energy demand as a function of soc and temperature, providing realistic scheduling of EV charging and discharging.

A neural network from smart meter data to forecast residential power usage and EV demand. Utilizing a feed forward network with a sigmoid function, they trained models based on soc, trip duration, and usage patterns to facilitate smart energy scheduling. Likewise, Jimenez-Bermejo et al. Employed an NARX neural network to forecast battery soc based on voltage and current as input values to achieve improved predictive capability for EV battery condition. Pereira et al. Created an energy management system (EMS) for Fuel Cell evs (fcevs) with a nonlinear Model Predictive Control (MPC) approach. The proton exchange membrane of the fuel cell was simulated by a Recurrent Neural Network (RNN), which was trained on Bayesian regularization in MATLAB. Outcomes showed precise voltage prediction and reduced hydrogen consumption.. Designed an MPC controller for hevs, incorporating ANN-based duty cycle predictions to maximize fuel economy. Zhang et al. Used MPC to coordinate power distribution in phevs between the battery and ultra capacitor with optimal control under dynamic programming under different driving cycles, which improves fuel efficiency. These strategies together indicate the promise of machine learning and predictive control in maximizing EV integration into smart grids of the future.

6. ENERGY MANAGEMENT OF PEV LOAD DEMAND ON THE DISTRIBUTION NETWORK:

As the world transitions from internal combustion engine (ICE) vehicles to electric vehicles (EVs) rapidly, the creation of sustainable and scalable charging infrastructure for EVs becomes a necessity. Charging stations are becoming an important investment in facilitating this change. One of the most promising ways to increase the environmental advantages of EVs is by the incorporation of renewable energy power sources—especially solar photovoltaic power (SPP) integrated with battery energy storage systems (BESS)—into charging stations for EVs. Such systems curtail carbon emissions and lessen the strain on power distribution networks arising from the high energy consumption of EVs.

Among the principal obstacles to an entirely carbon-neutral EV system is the underdeveloped nature of technologies supporting fully off-grid, fossil fuel-free charging. The techno-economic utilization of SPP and BESS is being underutilized mainly because solar energy is stochastic and intermittent in nature. In Germany, Laurischkat. used system dynamics modeling to evaluate the feasibility of SPP and BESS for EV charging, considering aspects like EV driving profile, electricity prices, and home energy usage. Their study brought forth the economic and environmental advantages of incorporating renewable energy in the EV sector.

Based on this, Monte Carlo simulations by Lazzeroni assessed the economic viability of SPP-driven EV-to-grid (EV2G) and EV-to-home (EV2H) applications in a domestic environment. The criteria involved battery constraints, driver behavior, power requirements in the home, and electricity prices. The objective was to maximize the utilization of solar power to minimize grid-based electricity usage. designed an optimization framework with convex programming that integrated SPP, BESS, and PEVs efficiently to energize residential systems. The research showed that houses with such systems could save considerable amounts of money on electricity bills, particularly during off-peak times, compared to conventional grid-based households. compared the economic and environmental advantages of SPP-driven EV charging, and Minh et al. considered Vietnam for a techno-economic feasibility study of charging stations integrated with SPP. Their results highlighted the need to tailor configurations according to local solar irradiation levels for sustainable large-scale EV charging. studied rapid charging infrastructure with combined SPP and BESS systems. Their optimization model took EV arrival time, charging schedules, and energy loads into account with the goal of developing an optimal model for renewable energy-based charging stations.

An interesting application model is from the United States, where Deshmukh is examined the possibility of installing solar-powered EV charging points in Walmart's large chain of parking lots. It was estimated that one store would be able to generate 3.1 MW of solar power, enough to charge about 100 EVs, and the whole network of Wal-Mart would be able to accommodate over 346,000 charging points and generate over

11.1 GW of clean energy. Lastly, Kobashi is. studied the application of residential SPP and BESS in Japan and China under larger 2030 decarburization strategies. From their study, economic and environmental advantages of these systems were proved, decreasing coal-fired electricity dependency and carbon emissions. The research promoted supportive policy environments for widespread adoption of SPP and BESS into residential EV charging systems. All such combined research work confirms that the inclusion of renewable energy and storage technologies in EV charging systems is the key to sustainable transport and energy futures.

A study on the feasibility carried out by a model SPP charging stations for massive EVs was proposed for China's Shenzhen city. Among its primary objectives, one was founded on the economic and technical feasibilities of creating an SPP charging station that will satisfy the increasing energy demand of EVs charging needs. The outcome from this established model shows a combined reduction of GHG emission of carbon dioxide, sulphur dioxide, and nitrogen oxide with an insignificant percentage of reduction at 99.8%, 99.7%, and 100%, respectively. In examining the suggested model for SPP EV charging stations and their effects perform sensitivity analysis with the capital cost of the SPP system, carbon price, interest rate ,and feed-in tariff policy as parameters for estimating the effects. Sensitivity analysis for the capital expenditure of SPP system development reveals to have an effect on the Cost of Energy (CoE), in the form of a rise in the cost of the PV system which including module prices will increase the CoE. The effect of a rise in carbon pricing and increasing the emission tax for non-RES will attract investment and raise the penetration ofRES. While a rising interest rate is a significant drawback to investments in RES, policy mechanisms supporting feed-in tariffs for SPP generation are undoubtedly set to raise investment in RES and a lessening in the worldwide carbon footprint of emissions.

Mezzo carried out an analysis on implementing the use of SPP and BESS to establish residential charging facility for EVs. The test procedure used three charging scenarios involving charging of EVs directly from residential electrical plug. The second scenario uses SPP, BESS, and grid connection, while the third scenario uses all of the power sources in scenario two in the presence of residential load. These energy models or scenarios in one, two, and three were used to determine the significant impact SPP and BESS have on the load satisfaction of EV energy demands when off-grid or grid-connected. From the literature surveyed in this section, it is important to note the significance of sustainable charging infrastructure for the future of EVs and the battle against the growing global footprint of GHG emissions. While this research didn't examine the various plug configurations and communication protocols that EV makers have integrated into their cars, this research posits that the future of EVs, in terms of its sustainability, much depends on the compatibility of any EV's charging connector to any charging station equipment. Alternatively, at minimum, the EV companies ought to have a common adapter that can be purchased off the shelf, this will allow various EVs to convert or accommodate their charging outlets to any charging station network. The current EV market has provided the charging connectors J1772, CCS, Caedmon and Tesla connectors, found usually in the United States and countries in Europe, while the Chinese EV market has its own GB/T proprietary connector. provides access to the visual depiction of these EV charger connectors and common power ratings . A review that offers an ample overview on EV charging methods such as charging standards, charging levels, and charging configurations . The review offers a path for countries to embrace methodologies based on an achievable framework set for the successful implementation of EVs.

7. CONCLUSIONS:

The shift towards clean energy through transportation systems is a key pillar in the world's fight against climate change and the creation of a greener future. Since the transportation industry is among the biggest emitters of greenhouse gases, embracing cleaner fuels like electric vehicles (evs), plug-in hybrids (phevs), fuel cell electric vehicles (fcevs), and bringing renewable energy sources into the transport infrastructure is no longer an option but a requirement. Clean transportation systems depend greatly on advancements in energy management, battery technologies for storing energy, and smart grid integration, all working towards making the sector less dependent on fossil fuels and more efficient overall.

Development and use of evs that run on renewable energy sources like solar power, wind power, and hydroelectric power are one of the prime strategies of accomplishing this. When paired with intelligent energy management systems (IEMS), these cars can not only run efficiently but also supply energy back to the grid via vehicle-to-grid (V2G) technology. Solar photovoltaic (SPP) systems and battery energy storage systems (BESS) at charging stations provide an environmentally friendly solution to regulate peak loads, decrease energy expenses, and curtail the carbon footprint of electricity generation. Research and simulations have indicated that these technologies can drastically cut coal-based grid dependency and put less pressure on energy infrastructure.

The effective integration of clean energy into transport systems depends on a variety of conditions such as strong policy backing, technological innovation, investment in infrastructure, and citizen awareness. Governments and private actors need to jointly craft supportive policy frameworks, fiscal incentives, and awareness campaigns that promote the use of clean energy transport solutions. The development of renewable-powered transport technologies must continue to concentrate on improving the efficiency, affordability, and availability of these resources. In summary, the transition to clean energy in transport is not only an environmental necessity but a socio-economic opportunity. It holds the prospect of cleaner air, lower reliance on imported fuel, greater energy security, and the generation of green jobs. Although the journey is complicated and requires concerted international action, the rewards of a cleaner, more sustainable transport system are deep and lasting. Through the use of innovation and clean energy, the transportation industry can be a driver for a low-carbon economy.

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