A REVIEW ON INTEGRATION OF ELECTRIC VEHICLES AND OPTIMAL POWER MANAGEMENT STRATEGY FOR SUSTAINABLE DEVELOPMENT

Honey Dasireddy[1], Vasupalli Manoj[2], Gadagamma Sai Tharun[3], Cheemala Harika[4]

[1,3,4]B.Tech Student, Department of EEE, GMR Institute of Technology, Rajam-532127, Andhra Pradesh, India

[2]Assistant Professor, Department of EEE, GMR Institute of Technology, Rajam-532127, Andhra Pradesh, India

Email: 21341A0237@gmrit.edu.in[1]

---***---

Abstract - The integration of electric vehicles (EVs) into our transportation system is a pivotal step towards sustainable development. EVs are gaining traction as a cleaner and more energy-efficient alternative to traditional internal combustion engine vehicles. Their adoption holds the promise of reducing greenhouse gas emissions and decreasing our reliance on fossil fuels, contributing significantly to environmental sustainability .One of the critical aspects of effective EV integration is the development and implementation of optimal power management strategies. These strategies play a pivotal role in ensuring that the charging and discharging of EV batteries are not only efficient but also seamlessly integrated with the existing power grid infrastructure. An optimal power management system takes into consideration factors such as load balancing, peak demand management, and the integration of renewable energy sources, making it a key component of a sustainable and resilient energy ecosystem. By efficiently scheduling when and how EVs charge or discharge, these strategies can reduce the strain on the electrical grid during peak periods, lower electricity costs, and minimize the carbon footprint associated with charging. Moreover, they can contribute to grid stability and reliability, making the entire energy system more sustainable. This research explores the synergistic potential of EVs and smart grid technologies, aiming to create a harmonious relationship between transportation and energy systems.

Key Words: Electric Vehicles, Sustainable Development, Optimal Power Management, greenhouse gas emissions, fossil fuels, clean environment, smart grid technology.

1.INTRODUCTION

The realization that finite resources currently satisfy a substantial portion of our energy requirements has triggered a shift in consumer expectations and industrial practices, driven by legislative mandates to transition toward "more electric" systems. Notably, about 36% of the UK's energy consumption pertains to the transportation sector, with 75% of that stemming from cars and light goods vehicles, amounting to 41,199 tons of equivalent oil (ktoe) or 479.2 terawatt-hours (TWh). Transitioning this energy demand to terrestrial electrical networks presents formidable logistical challenges encompassing power generation, transmission, and distribution. This shift essentially necessitates doubling the existing energy output. Figure 1 illustrates the electrical energy trends in the UK, with the light-shaded area indicating the installed network capacity, emphasizing the impact of aging generating infrastructure on the energy supply. Addressing these challenges is paramount as the world pivots towards sustainable and electric energy solutions[7]. The Control Configured Vehicle (CCV) concept, originally applied in aircraft, merges mechanical components with electric control systems, much like X-by-wire (XBW) techniques, enhancing performance. CCV techniques in aircraft encompass aspects like flight active load control and limit envelope control, especially crucial for military fighter aircraft. Prior to CCV, aircraft design treated mechanical and electric systems independently, limiting layout flexibility. Ground vehicle design presently mirrors this approach, where mechanical components dictate the layout, and electric control systems are added later. However, the emergence of Four-Wheel-Independently-Actuated (FWIA) electric vehicles, with quick and independent control of in-hub motor torques in each wheel, offers a unique configuration for collaborative electric control. This enables traction control, Direct Yaw Control (DYC) for cornering stability, and tire driving force allocation. Various control strategies, including robust controllers, have been explored, making FWIA electric vehicles ideal testbeds for demonstrating collaborative dynamics electric control systems, like Active Front Steer (AFS)/DYC controllers[10]. Electric vehicles (EVs) hold promise for decarbonizing transportation and creating low-carbon cities through energy efficiency and reduced pollution. The automotive industry focuses on EV development, emphasizing technological innovation, a trend supported by various nations like Sweden, China, Malaysia, and Korea. Rising environmental concerns, particularly vehicle emissions in densely populated areas, have spurred the shift from conventional vehicles to hybrid electric vehicles (HEVs) and, ultimately, pure electric vehicles (PEVs). PEVs can mitigate greenhouse gas emissions and particulate matter pollution, essential for public health. Research suggests that without GHG standards, CO_2 emissions from passenger vehicles would double by 2030, whereas implementing such standards could reduce emissions significantly. Still, debates exist about the environmental benefits of EVs, linked to their power source's cleanliness. For instance, in regions where electricity is primarily coal-based, EVs might appear less environmentally friendly[2]. Global concern over air pollution and greenhouse gas emissions from hydrocarbon-based transportation has led to the promotion of electric vehicles (EVs). The transportation sector consumes a significant portion of oil resources and contributes to emissions. Governments of developed nations encourage EV adoption to combat air pollution and greenhouse gases. While hybrid electric vehicles (HEVs) have succeeded due to renewable energy intermittency, public hesitations about EVs include cost, range, and technological advancement. Energy Management Strategies (EMS) are essential for optimizing powertrains in these vehicles. Research into EMS for both HEVs and full electric vehicles (FEVs) remains dynamic and vital[3]. Efforts to replace fossil fuels due to environmental concerns and global warming have led to the investigation of alternative energy sources. One critical area for change is the transportation sector, with a focus on electrifying vehicles. Electric vehicles (EVs) come in various forms: battery electric vehicles (BEVs), hybrid electric vehicles (HEVs), and fuel-cell electric vehicles (FCVs). Plug-in EVs (PEVs) connect to the grid, offering two modes: grid-to-vehicle (G2V) and vehicle-to-grid (V2G). High penetration of PEVs without V2G can strain grid reliability, necessitating grid reinforcement. Smart charging scenarios can alleviate these issues. The study explores PEV impacts considering charging at home and (dis)charging.

2. LITERATURE REVIEW

In "Integrated vehicle-following control for four-wheel-independent-drive electric vehicles against non ideal V2communication", Liu, Jizheng, Zhenpo Wang, and Lei Zhang, discussed about an integrated control system for Four-Wheel-Independent-Drive Electric Vehicles (FWID EVs) with Vehicle-to-Everything (V2X) communication. It addresses communication issues like delays and packet dropouts, introducing a compensator for information loss. The system combines longitudinal and lateral control, validated through tests, showing its effectiveness in vehicle platoon control despite non ideal V2X communication.[1]

A "comprehensive review on the integration of electric vehicles for sustainable development.", Hossain, M. S., et al, discussed the complex sustainable development hampers EV adoption. Policy makers should incentivize grid-EV innovation and provide strong policy support for emissions reduction [2]. "Hybrid Sources Powered Electric Vehicle Configuration and Integrated Optimal Power Management Strategy" Gautam, Abhinav K., et al discussed about , research interest in hybrid/electric vehicle powertrains & EMS for fuel efficiency. Different optimization techniques, driving cycles, and intelligent systems discussed.[3].

"Hybrid control-based acceleration slip regulation for four-wheel-independent-actuated electric vehicles", Ding, Xiaolin, Zhenpo Wang, and Lei Zhang, discussed about the hybrid control for slip regulation in electric vehicles, combining adaptive methods at low speeds and sliding mode control at high speeds, enhancing performance and safety. [4].

"Evaluation of waste heat recovery of electrical powertrain with electro-thermally coupled models for electric vehicle applications." Chen, Xiao, et al, introduces accurate, efficient electro-thermally coupled models for EV HVAC using waste heat. Dual heat source architecture improves thermal comfort in cold weather[5].

"Longitudinal vehicle speed estimation for four-wheel-independently-actuated electric vehicles based on multi sensor fusion.", Ding, Xiaolin, et al., discussed about the multi-sensor fusion speed estimator for electric vehicles, compensates for road gradient, offers accuracy, efficiency, and reliability in hardware-in-the-loop tests[6].

"The Impact of Transport Electrification on Electrical Networks", Kevin J. Dyke, Nigel Schofield, Mike Barnes, discussed about. Transitioning the energy demand to terrestrial electrical networks presents formidable logistical challenges encompassing power generation, transmission, and distribution.[7].

"Catch Energy Saving Opportunity in Charge-Depletion Mode, a Real-Time Controller for Plug-In Hybrid Electric Vehicles", Amir Rezaei , Jeffrey B. Burl, Mohammad Rezaei, and Bin Zhou, discussed about the control techniques like blended discharge, charge depletion and charge sustaining.[8].

" Probabilistic Analysis of Plug In Electric Vehicles Impact on Electrical Grid Through Homes and Parking Lots",Saeed Rezaee, Ebrahim Farjah, and Benyamin Khorramdel , discussed about the Electric vehicles (EVs) come in various forms: battery electric vehicles (BEVs), hybrid electric vehicles (HEVs), and fuel-cell electric vehicles (FCVs). Plug-in EVs (PEVs) connect to the grid, offering two modes: grid-to-vehicle (G2V) and vehicle-to-grid (V2G).[9].

" Control Configured-Vehicle Design and Implementation on an X-by-Wire Electric Vehicle", Jun Ni , Jibin Hu, and Changle Xerox's , discussed about the Control Configured Vehicle (CCV) concept, originally applied in aircraft, merges mechanical components with electric control systems, much like X-by-wire (XBW) techniques, enhancing performance.[10].

3.METHODOLGY:-

The methodology for integrating electric vehicles (EVs) and developing an optimal power management strategy for sustainable development involves several key steps. First, it requires a comprehensive analysis of the local energy grid's capacity to accommodate EV charging, considering the impact of increased electricity demand. Second, data on driving patterns and EV charging behavior must be collected to optimize charging schedules. Third, smart charging infrastructure and vehicle-to-grid (V2G) technology may be implemented to enhance grid stability and manage energy flow. Finally, a robust power management strategy is formulated, ensuring efficient energy use while minimizing environmental impact, thereby promoting sustainable development in the transportation sector.

3.1.Smart Grid Structure:

The smart grid is a complex system that integrates with all grid networks, but the current powergrid lacks the necessary flexibility for efficient electric vehicle (EV) charging. To enable comprehensive functionality for this application, various networks must be seamlessly interconnected and authorized. The key components for designing a smart grid system include ensuring adaptability in the system's infrastructure and components, supporting future expansion in the grid model, considering the structure and objectives of programming, devices, and grid systems during planning, and implementing automated execution of any system update programs. These elements are crucial for developing an effective smart grid network for EV charging.

3.2.Impact of EV Integration on the Grid:

This section highlights the crucial considerations regarding the impact of Electric Vehicle (EV) integration on the power grid. The effects of introducing EVs into the grid can be categorized as both negative and positive.

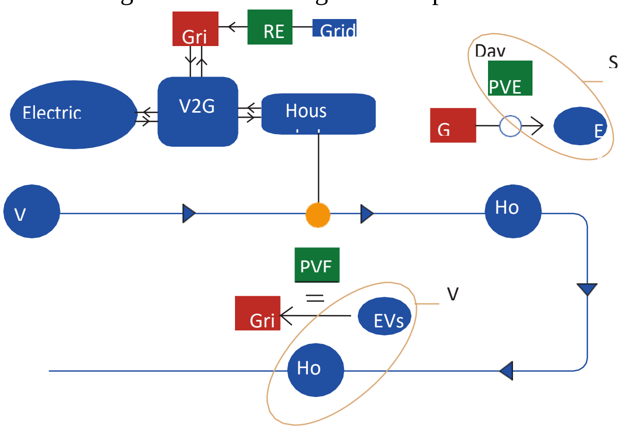

Fig.1.The relationship between electric vehicles and the grid.[2].

On the negative side, integrating electric cars into a decentralized grid can potentially disrupt grid stability strain component limitations, lead to voltage fluctuations, trigger frequent grid disturbances, cause power outages, and even impact financial stability. Conversely, there are positive effects to consider. While widespread EV adoption can strain the grid and possibly degrade power quality, these issues can be effectively addressed through advanced grid management and control techniques. By leveraging smart grid technologies, load balancing, and grid optimization, the power grid can mitigate the negative impacts and harness the potential benefits of EV integration for a more sustainable and efficient energy ecosystem.

3.3.CO2 Emission and Reduction Approaches:

The issue of locating refueling stations for alternative fuel vehicles (AFVs) is a critical aspect of promoting sustainable development. Various countries have implemented strategies for AFVs, including Battery Electric Vehicles (BEVs) and Fuel Cell Vehicles (FCVs), in response to environmental concerns. Whileinternal combustion engine vehicles (ICEVs) may have advantages in terms of convenience and charging infrastructure, they produce higher greenhouse gas (GHG) emissions. The challenge lies in establishing a sufficient network of refueling stations to support AFVs, considering customer preferences, charging times, andregional variations, to reduce GHG emissions and promote a cleaner transportation sector for a more sustainablefuture.

3.4.Energy Management Strategies:

Vehicle Fully Electric Vehicles (FEVs) and (Plug-in) Hybrid Electric Vehicles ((P)HEVs) have intricate electro-mechanical drive systems. The configuration and Engine Management System (EMS) choices significantly impact power flow, fuel efficiency, and emissions reduction. EMS's primary goal is to optimize power control for improved efficiency, emissions reduction, drivability, and extended Energy Storage System (ESS) life.

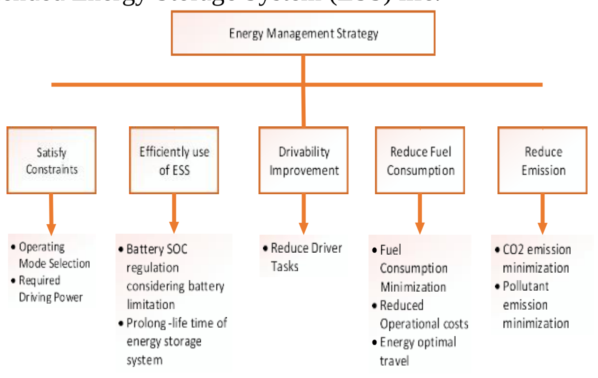

Fig.2. General Objective of EMS.

3.4.1.Rule-Based Control Method:

Various deterministic rule-based methods play a significant role in the energy management systems (EMS) of Hybrid Electric Vehicles (HEVs) and Fully Electric Vehicles (FEVs). These methods are based on predefined rules and data related to fuel economy, power distribution, and engine operating conditions. Here aresome key strategies within this category: a:Thermostat Control Strategy: This approach efficiently manages the Internal Combustion Engine (ICE) and generator to maintain the battery's state of charge (SOC) within specified limits. It starts the ICE at its optimal efficiency point, enhancing fuel savings while ensuring SOC remains within the desired range. b: Power Follower (Baseline) Control Strategy: This control strategy adjusts the power output, primarily from the ICE, to maintain battery SOC. It is suitable for both parallel and series-parallel HEVs, offering better performance when combined with other control strategies. c: Modified Power Follower-Adaptive RB (ARB): This adaptive rule-based strategy combines elements of the thermostat and power follower techniques. It optimizes power management through stepwise decision-making, enhancing efficiency and emissions control. d:Frequency-Based Approach: This approach considers power distribution based on low and high-frequency components to meet load demands. It can significantly improve fuel efficiency and reduce emissions, contributing to battery longevity. e: Optimal Points Tracking: This method allows the adjustment of the IC engine's operating point to achieve optimal efficiency. It enables the optimization of power flow, taking into account efficiency and emissions. . It's particularly useful for series-parallel HEVs, enhancing control over battery power. These rule-based strategies provide valuable tools for EMS in HEVs and FEVs, contributing to better fuel economy, emissions reduction, and overall system performance. Researchers have explored these methods in various vehicle configurations to enhance the efficiency and sustainability of electric and hybrid vehicles

3.4.2.Optimization based Power Management Control Method:

Optimization-based power management focuses on achieving optimal control to minimize operational costs over a specific timeframe. This approach can be categorized into offline and online methods. Research has shown that Optimization-Based (OB) methods receive greater attention, accounting for 56.7%, compared to Rule-Based (RB) methods at 32.9% in the field, indicating their significance in this area. n the realm of optimization-based power management, various methods seek to minimize operational costs over time. These methods can be broadly categorized into offline and online approaches. Offline methods require advance knowledge of driving cycles and offer standardized solutions suitable for further causal methods. They encompass direct algorithms, like dynamic programming (DP), which decompose complex optimization problems by discretization. DP has been used for energy management, reducing fuel consumption and emissions in hybrid electric vehicles (HEVs). Other offline approaches include Deterministic Dynamic Programming (DDP), which subdivides optimization problems into discrete temporal sub-problems. DDP, however, suffers from high computational demands and dependence on specific driving cycles. Stochastic Dynamic Programming (SDP) aims to address these limitations by modeling problems as Markov chain processes. It optimizes power management for improved performance in different driving cycles. Indirect algorithms, like Pontryagin's Minimum Principle (PMP), resolve optimal control issues via a mathematical approach but are limited by their reliance on specific driving cycles. They can be further optimized to address the driving cycle dependency issue. . Gradient algorithms, such as Linear Programming (LP) and Quadratic Programming (QP), provide solutions with linear objectives and constraints. They are used to optimize the energy management of electric and hybrid vehicles. Sequential Quadratic Programming (SQP) offers iterative solutions for nonlinear controlled optimization problems. . Multi-objective Genetic Algorithms (MOGA) are used to address problems with multiple optimization goals. These algorithms, combined with fuzzy clustering and other techniques, are employed to reduce computational effort while enhancing vehicle performance. Particle Swarm Optimization (PSO) offers efficient optimization by simulating the behavior of groups of entities. It has been used to optimize fuel consumption, power-sharing, and the design of electric vehicles and hybrid powertrains.

3.4.3. Online based Strategies:

Online-based energy management strategies (EMS) are crucial for optimizing the performance of hybrid and electric vehicles in real-time, without prior knowledge of driving conditions. Two notable online strategies are Equivalent Consumption Minimization Strategies (ECMS) and Model Predictive Control (MPC). ECMS, introduced by Paganelli et al., focuses on minimizing fuel consumption by estimating an equivalent fuel factor (EF). Researchers have enhanced ECMS through adaptive approaches, neural networks, and Markov chain models, improving fuel efficiency by up to 5%. Additionally, MPC is employed to address multi-dimensional control problems. Unlike Dynamic Programming, it doesn't require prior knowledge of future conditions. Various studies have applied MPC to optimize power management, improve regenerative systems, and enhance overall vehicle efficiency. Beyond ECMS and MPC, other methods like Extremum Seeking (ES), Robust Control (RC), Decoupled Control (DC), and Pseudo Spectral Optimal Methods (PSOC) offer different ways to optimize energy management in vehicles. Moreover, Learning-Based EMS leverages data mining and machine learning to extract control laws from real-time and historical data, reducing the need for precise models and enhancing performance under varying conditions. These strategies collectively contribute to more efficient and adaptable energy management in vehicles.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 12 | December - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

3.5.V2G Communication:

This section discusses the V2G communication architecture for vehicle-following control, focusing on the transmission of various parameters from the preceding vehicle to the following ones. The transmitted data includes position, longitudinal velocity, longitudinal acceleration, front-wheel steering angle, and yaw rate of the preceding vehicle. The trajectory tracking for the following vehicles is generated based on historical position information received through V2G communication. The communication model used in this study addresses the non ideal aspects of V2G communication. It considers communication delays and packet dropouts. The communication delay, denoted as θ d(t), is considered stochastic but is approximated as a constant value not exceeding the maximum upper bound. Packet dropouts are modeled using a Bernoulli process to

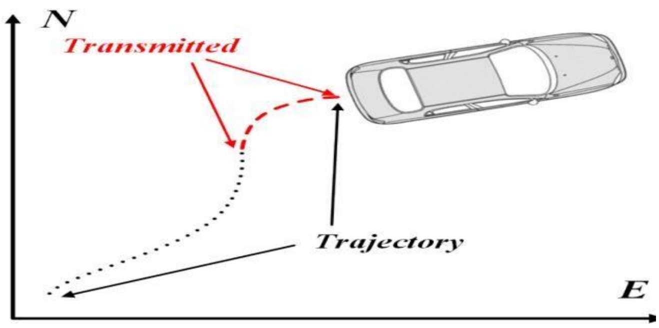

Fig. 3.The trajectory of the preceding vehicle.

capture the random and unpredictable nature of packet delivery. The transition probabilities in the Bernoulli model determine the success or failure of packet delivery, which depends on the current channel state. This communication model is essential for understanding the reliability and robustness of V2G communication in vehicle-following control, providing valuable insights into the challenges of real-world communication systems for autonomous vehicles.

3.6.Distributed Generation:

3.6.1.Present Grid Structure:

One of the critical factors in establishing a sustainable electricity supply is the increased adoption of renewable and low-carbon embedded generation, often requiring a connection to low-voltage networks withoutlocal voltage regulation. However, this poses limitations on the amount of renewable energy that can be integrated in a specific location. Electrical network analysis has shown that local energy storage with simple voltage control can significantly increase the capacity for renewable energy injection at the point of connection,

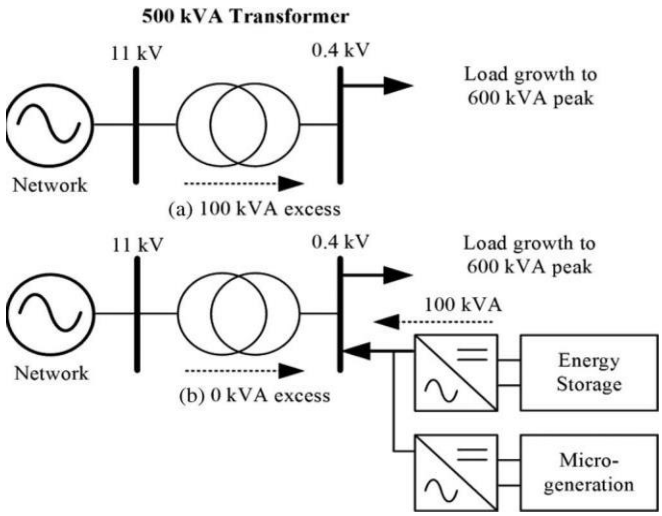

Fig.4.Avoidance of network reinforcement

150%. When local demand surpasses the infrastructure's rated capacity, solutions typically involve costly network reinforcements or upgrades. Alternatively, dis patchable micro generation, connected through power electronics, can reduce peak demand and defer network upgrades, offering economic benefits, particularly when demand peaks require additional power generation**.**

3.6.2.Grid Standards:

Microgrids, which can disconnect from the main utility grid during disturbances, offer a solution to power quality issues and frequent outages.

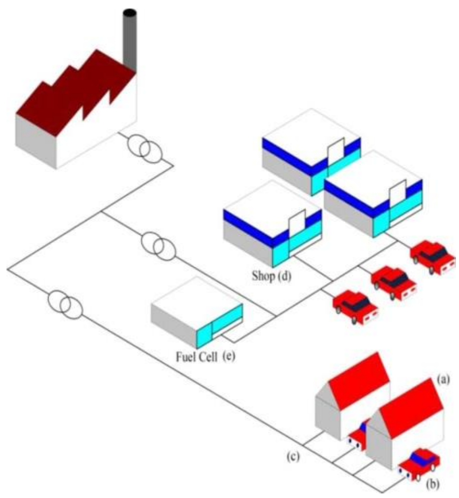

Fig.5.Grid Standards

. While load shedding may still be necessary, these intelligent consumer networks are under investigation in many countries and can be enhanced through the integration of Plug-in Hybrid Electric Vehicle (PHEV) fleets**.**

3.7.Health Impact:

Vehicle innovations, particularly electric vehicles (EVs), hold the potential for significant economic, environmental, and health benefits. However, the success of widespread EV adoption depends on understanding consumer behaviors and preferences while considering competition from conventional fuel and diesel vehicles. EVs powered by low-emission electricity sources, such as natural gas, wind, water, or solar power, can reduce environmental health impacts by over 50% compared to internal combustion engine vehicles (ICEVs). In Germany, sustainable energy usage has led to 62-64% lower emissions from electric vehicles compared totraditional vehicles. However, in some regions like China, promoting EVs may not result in significant energy savings or greenhouse gas reductions due to regional variations in power sources.

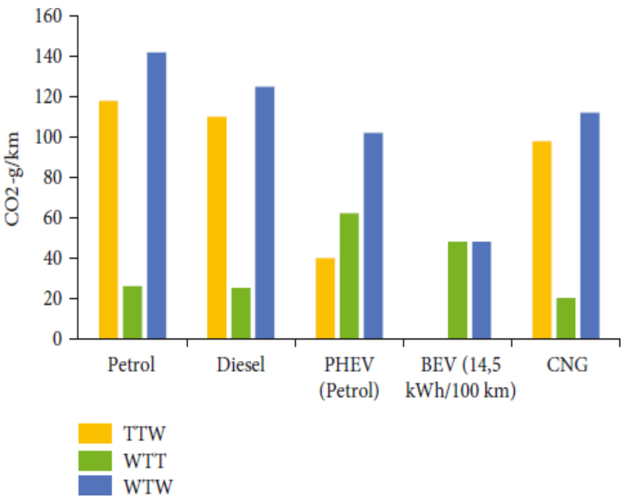

Fig 6. WTW Emissions Comparison

The "well-to-wheel" approach is a critical method for assessing the impact of transportation fuels and vehicles on energy and climate change. It considers the entire lifecycle of fuel, from production to consumption. Electrified solutions, like battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), tend to perform better in terms of emissions when considering only the vehicle's direct impact (tank- to-wheel). However, when factoring in the emissions associated with fuel or electricity production (well-to-tank and well-to-wheel), BEVs offer better performance, primarily due to their more efficient powertrains. This highlights the importance of not only the vehicle itself but also the energy sources that power it in assessing environmental impact. The automotive industry remains a significant contributor to greenhouse gas emissions (GHGs), accounting for a quarter of these emissions. Organization (WHO). Introducing new energy vehicles, including electric and hydrogen-powered ones, presents a compelling solution for cities. These vehicles offer the advantage of minimal to zero tailpipe emissions, reduced noise levels, and the potential to support innovative services.In response, the European Union (EU) is considering implementing driving bans for diesel cars in various European and German cities. Such measures aim to reduce local emissions, particularly nitrogen oxides, to address environmental and health concerns. Additionally, policymakers are looking to lower greenhouse gas emissions by promoting alternative technologies, such as battery electric vehicles (BEVs) powered by sustainable energy sources. This move is vital, as the road transport sector has been responsible for 18% of all greenhouse gas emissions over the past decade. Increasing the adoption of BEVs could significantly contribute to reducing these emissions and mitigating environmental challenges.

4.RESULTS AND DISCUSSIONS:-

4.1.Energy Management Strategy:

Machine Learning-based EMS (ML-based EMS): This approach incorporates techniques like neuro-dynamic programming, Q-learning, and instance-based machine learning. These methods estimate energy costs, driving conditions, and optimize power distribution, improving efficiency without prior knowledge of driving cycles. 2)Reinforcement Learning (RL) Method: RL frameworks consist of learning agents interacting with environments, making control decisions based on rewards. Deep Reinforcement Learning (DRL) has been applied, achieving significant improvements in fuel economy and adaptability to varying driving conditions. 3)Neural Network-based Learning Method: Neural networks, inspired by human brain neurons, have been used to model energy management. They involve multi-layer networks for optimal control. Techniques like loss model control (LMC), search control (SC), and evolutionary algorithms have been employed to address vehicle routing and optimize vehicle control systems.

4.2. EV Environmental Impact:

Electric Vehicle Battery Recycling: The rapid growth of the electric vehicle market presents both environmental opportunities and challenges. As the global electric vehicle population is projected to surge from 55,000 in 2018 to 3.4 million by 2025, there will be a substantial number of lithium-ion batteries reaching the end of their lifespan. These batteries may no longer meet the demands of electric vehicles but still have useful capacities for other applications, such as energy storage at a smaller scale. Nissan CEO Francisco Carranza notes that the price of materials for recycling used EV batteries is considerably lower than for new ones. Therefore, repurposing these batteries for less demanding tasks, like renewable energy storage, is a smart strategy known as "second-life" usage, endorsed by companies like Nissan and Hyundai. Studies suggest that the potential for reusing such batteries far exceeds their suitability for recycling.Electric Vehicle Impact on Power Grid: As concerns about global temperature changes andenvironmental pollution grew at the beginning of the 21st century, electric vehicles emerged as a promising alternative to fossil fuels. Simultaneously, the expansion of electricity supply networks became essential. However, the widespread adoption of electric vehicles has the potential to impact power systems significantly. This "top-down" effect, described by Huang et al., could lead to challenges such as increased short-circuit currents, voltage fluctuations beyond standard limits, higher power demand, and impacts on the lifespan of power grid equipment. The integration of electric vehicles into the energy landscape demands careful planning and management to ensure grid stability and reliability.

5.CONCLUSIONS:

The development of electric vehicles (EVs) can play a crucial role in promoting renewable energy use and alleviating environmental pressures caused by internal combustion engine (ICE) vehicles. This paper delvesinto EV-related technologies and critical policy considerations to foster sustainable EV development. The following key conclusions have been drawn:1.The study suggests that the intricate nature of sustainable development may slow down the adoption of EV technology. 2.Policymakers can encourage EV development by introducing more incentive programs, particularly in the areas of grid and EV integration.3.Proposed technology trajectories for future EV development include wireless charging and advanced energy networks. These models could guide the future evolution of EVs and energy systems. Addressing negative impacts of power electronics in EV integration is also vital. 4.EVs have the potential to contribute to renewable energy and reduce CO_2 emissions, but their sustainable development requires robust policy support. The study provides several policy recommendations to promote EV adoption: 1. Provide incentives for EV users, including cash rebates and subsidized loans for EVSE installation and building upgrades. 2. Offer financial assistance to landlords and strata councils for the installation of charging stations.3. Encourage and financially support strata councils and landlords to upgrade building power distribution systems for future charging needs. 4. Regularly update regulatory requirements to reflect technological advancements and avoid unnecessary oversizing of electrical equipment. 5. Regulate the rights and responsibilities of EV users, building residents, strata councils, and landlords regarding the installation and use of charging stations within multiunit residential buildings (MURBs) to ensure fairness and equality. 6. Develop guidelines for technical and governance issues, including ownership and infrastructure costs. 7. Create a program or guideline to help strata councils and landlords establish long-term EV charging infrastructure plans, guiding infrastructure deployment, upgrades, and governance considerations. These recommendations aim to facilitate the adoption of EVs and the installation of charging infrastructure while addressing associated challenges and uncertainties.

The analysis of Electric Management Systems (EMS) for Hybrid Electric Vehicles (HEV) and Fully Electric Vehicles (FEV) demonstrates significant research efforts with promising results. However, recent rapid developments in smart transportation systems, advancements in powertrain components, and computational methodologies present significant opportunities for improving EMS performance. Innovations like renewable energy charging systems and communication techniques such as Vehicle-to-Vehicle (V2V), Vehicle-to- Infrastructure (V2I), and Automated Connected Vehicles (ACV) offer the potential for enhanced driving performance and fuel efficiency. This section explores previously unaddressed perspectives in EMS research that have received limited attention but could be significant future research directions. It emphasizes the role of intelligent transportation systems and highlights the need for incorporating newer optimization algorithms and computational techniques into EMS applications. Existing EMS strategies are compared in Table 6, outlining their benefits and drawbacks. However, none of them can fulfill all control objectives simultaneously, prompting the need for combining optimization algorithms to enhance EMS performance. The integration of newer optimization algorithms, especially in solar PV-based FEV and the application of real-time prediction, is suggested as a promising avenue for future research. The use of Off-Board (OB) algorithms in conjunction with machine learning techniques can accelerate the evaluation of EMS. Fleet-level EMS applications, interactions with the smart grid, and the optimization of charging rates are areas of growing importance, especially in heavy- duty applications like city buses. The concept of an Integrated EMS (i-EMS) that incorporates various data sources, time horizons, and the number of vehicles is introduced. Potential integration possibilities include Waste Heat Recovery (WHR) systems and self-learning and model-based control systems. The integration of multiple control layers into a holistic EMS framework, including eco-driving and adaptive/predictive cruise control, is a potential future trend.

It emphasizes the trade-off between optimality and execution and suggests that integrating new technologies, algorithms, and communication concepts into EMS design can enhance real-time robustness and overcome current uncertainties. This study has established a series of distinct electric vehicles to analyze their electricity usage and storage within the context of a more electrified road transportation landscape. These analyses were then applied to a European Union residential load profile to assess the impact of increased electrification of private vehicles on local energy demand and the potential for integrating vehicle and residential loads. The findings emphasize the necessity of a synergistic relationship between electric vehicles and electrical networks. This symbiosis allows electric vehicles to help meet residential peak loads and fast- acting energy demands while also generating well-defined load profiles that align with low-emission distributed generation sources. To accommodate a future in which Battery Electric Vehicles (BEVs) play a central role in UK road transportation, substantial investments in the UK's electrical infrastructure, including both traditional and distributed generation methods, will be essential.

6.REFERENCES

[1]. Hughes, T.J.R. The Finite Element Method: Linear Static and Dynamic Finite Element Analysis; Prentice-Hall: Englewood Cliffs, NJ, USA, 1987.

[2]. Saleh, M.; Kovacs, E.; Barna, I.F.; Matyas, L. New analytical results and comparison of 14 numerical schemes for the diffusion equation with space-dependent diffusion coefficient. Mathematics 2022, 10, 2813.

[3]. Butcher, J.C. Numerical Methods for Ordinary Differential Equations; John Wiley & Sons, Ltd.: Chichester, UK, 2016.

[4]. Bank, R.E.; Coughran, W.M.; Fichtner, W.; Grosse, E.H.; Rose, D.J.; Smith, R.K. Transient simulation of silicon devise and circuits. IEEE Trans. Comput.-Aided Des. Integr. Circuits Syst. 1985, 32, 1992–2007.

[5]. Bathe, K.J.; Baig, M.M.I. On a composite implicit time integration procedure for nonlinear dynamics. Comput. Struct. 2005, 83, 2513–2524.

[6]. Chandra, Y.; Zhou, Y.; Stanciulescu, I.; Eason, T.; Spottswood, S. A robust composite time integration scheme for snap-through problems. Comput. Mech. 2015, 55, 1041–1056.

[7]. Wen, W.B.; Wei, K.; Lei, H.S.; Duan, S.Y.; Fang, D.N. A novel sub-step composite implicit time integration scheme for structural dynamics. Comput. Struct. 2017, 182, 176–186.

[8]. Zhang, H.M.; Xing, Y.F. Optimization of a class of composite method for structural dynamics. Comput. Struct. 2018, 202, 60–73.

[9]. Xing, Y.F.; Ji, Y.; Zhang, H.M. On the construction of a type of composite time integration methods. Comput. Struct. 2019, 221, 157–178..

[10]. Noh, G.; Bathe, K.J. The Bathe time integration method with controllable spectral radius: The ρ∞-Bathe method. Comput. Struct. 2019, 212, 299–310.

[11]. Shahidinejad, S. Filizadeh, and E. Bibeau, “Profile of charging load on the grid due to plug-in vehicles,” IEEE Trans. Smart Grid, vol. 3, no. 1, pp. 135–141, Mar. 2012.

[12]. Hajimiragha, C. A. Caizares, M. W. Fowler, and A. Elkamel, “Optimal transition to plug-in hybrid electric vehicles in Ontario, Canada, considering the electricity-grid limitations,” IEEE Trans. Ind. Electron., vol. 57, no. 2, pp. 690–701, Feb. 2010.

[13]. K. Clement, E. Haesen, and J. Driesen, “The impact of vehicle-to-grid on the distribution grid,” Elsevier Elect. Power Syst. Res., vol. 81, pp. 185–192, Jan. 2011.

[14]. X. Yu, “Impacts assessment of PHEV charge profiles on generation expansion using national energy modeling system,” in Proc. IEEE Power and Energy Society General Meeting—Conversion and Delivery of Electrical Energy in the 21st Century, 2008, pp. 1–5.

[15]. S. D. Jenkins, J. Rossmaier, and M. Ferdowsi, “Utilization and effect of plug-in hybrid electric vehicles in the united states power grid,” in Proc. IEEE Vehicle and Propulsion Conf. (VPPC), 2008, pp. 1–5.

[16]. S. Bashash and H. K. Fathy, “Transport-based load modeling and sliding mode control of plug-in electric vehicles for robust renewable power tracking,” IEEE Trans. Smart Grid, vol. 3, no. 1, pp. 526–534, Mar. 2012.

[17]. W. Kempton and J. Tomić, “Vehicle-to-grid power fundamentals: Calculating capacity and net revenue,” Elsevier J. Power Sources, vol. 144, pp. 268–279, Jun. 2005.

[18]. W. Kempton and J. Tomić, “Vehicle-to-grid power implementation: From stabilizing the grid to supporting large- scale renewable energy,” Elsevier J. Power Sources, vol. 144, pp. 280–294, Jun. 2005.

[19]. J. Tomić and W. Kempton, “Using fleets of electric-drive vehicles for grid support,” Elsevier J. Power Sources, vol. 168, pp. 459–468, Jun. 2007.

[20]. A. Y. Saber and G. K. Venayagamoorthy, “Optimization of vehicle-to grid scheduling in constrained parking lots,” in Proc. Power and Energy Society General Meeting (PES’ 2009), pp. 1–8.

[21]. C. Pang, P. Dutta, and M. Kezunovic, “BEVs/PHEVs as dispersed energy storage for V2B uses in the smart grid,” IEEE Trans. Smart Grid, vol. 3, no. 1, pp. 473–482, Mar. 2012.

[22]. G. Strbac, Quantifying the System Costs of Additional Renewables in 2020, DTI Report, Oct 2002.

[23]. D.G.W.M. Report, Electrical Energy Storage Systems—A Mission to the USA, Dec. 2006.

[24]. N. Jayawarna, N. Jenkins, M. Barnes, M. Lorentzou, S. Papthanassiou, and N. Hatziagyriou, “Safety analysis of a MicroGrid,” in *Proc. Int. Conf. Future Power Syst.*, 2005, pp. 1–7.

[25]. R. M. Tumilty, M. Brucoli, G. M. Burt, and T. C. Green, “Approaches to network protection for inverter dominated electrical distribution sys- tems,” in *Proc. 3rd IET Int. Conf. Power Electron., Mach. Drives*, 2006, pp. 622–626.

[26]. Dinesh, L., Sesham, H., & Manoj, V. (2012, December). Simulation of D-Statcom with

hysteresis current controller for harmonic reduction. In 2012 International Conference on Emerging Trends in Electrical Engineering and Energy Management (ICETEEEM) (pp. 104-108). IEEE

[27]. Manoj, V. (2016). Sensorless Control of Induction Motor Based on Model Reference Adaptive System (MRAS). International Journal For Research In Electronics & Electrical Engineering, 2(5), 01-06.

[28]. V. B. Venkateswaran and V. Manoj, "State estimation of power system containing FACTS Controller and PMU," 2015 IEEE 9th International Conference on Intelligent Systems and Control (ISCO), 2015, pp. 1-6, doi: 10.1109/ISCO.2015.7282281

[29]. Manohar, K., Durga, B., Manoj, V., & Chaitanya, D. K. (2011). Design Of Fuzzy Logic Controller In DC Link To Reduce Switching Losses In VSC Using MATLAB-SIMULINK. Journal Of Research in Recent Trends.

[30]. Manoj, V., Manohar, K., & Prasad, B. D. (2012). Reduction of switching losses in VSC using DC link fuzzy logic controller Innovative Systems Design and Engineering ISSN, 2222-1727

[31]. Dinesh, L., Harish, S., & Manoj, V. (2015). Simulation of UPQC-IG with adaptive neuro fuzzy controller (ANFIS) for power quality improvement. Int J Electr Eng, 10, 249-268

[32]. Manoj, V., Swathi, A., & Rao, V. T. (2021). A PROMETHEE based multi criteria decision making analysis for selection of optimum site location for wind energy project. In IOP Conference Series: Materials Science and Engineering (Vol. 1033, No. 1, p. 012035). IOP Publishing.

[33]. V. Manoj, P. Rathnala, S. R. Sura, S. N. Sai, and M. V. Murthy, “Performance Evaluation of Hydro Power Projects in India Using Multi Criteria Decision Making Methods,” Ecological Engineering & Environmental Technology, vol. 23, no. 5, pp. 205–217, Sep. 2022, doi: 10.12912/27197050/152130.

[34]. V. Manoj, V. Sravani, and A. Swathi, “A Multi Criteria Decision Making Approach for the Selection of Optimum Location for Wind Power Project in India,” EAI Endorsed Transactions on Energy Web, p. 165996, Jul. 2018, doi: 10.4108/eai.1-7-2020.165996.

[35]. Kiran, V. R., Manoj, V., & Kumar, P. P. (2013). Genetic Algorithm approach to find excitation capacitances for 3-phase smseig operating single phase loads. Caribbean Journal of Sciences and Technology (CJST), 1(1), 105-115.

[36]. Manoj, V., Manohar, K., & Prasad, B. D. (2012). Reduction of Switching Losses in VSC Using DC Link Fuzzy Logic Controller. Innovative Systems Design and Engineering ISSN, 2222-1727.

[37]. Manoj, V., Krishna, K. S. M., & Kiran, M. S. Photovoltaic system based grid interfacing inverter functioning as a conventional inverter and active power filter.

[38]. Vasupalli Manoj, Dr. Prabodh Khampariya and Dr. Ramana Pilla (2022), Performance Evaluation of Fuzzy One Cycle Control Based Custom Power Device for Harmonic Mitigation. IJEER 10(3), 765-771. DOI: 10.37391/IJEER.100358.

[39]. Manoj, V., Khampariya, P., & Pilla, R. (2022). A review on techniques for improving power quality: research gaps and emerging trends. Bulletin of Electrical Engineering and Informatics, 11(6), 3099-3107.

[40]. V. Manoj, R. Pilla, and V. N. Pudi, “Sustainability Performance Evaluation of Solar Panels Using Multi Criteria Decision Making Techniques,” Journal of Physics: Conference Series, vol. 2570, no. 1, p. 012014, Aug. 2023, doi: 10.1088/1742-6596/2570/1/012014.

[41]. V.Manoj, R. Pilla, and S. R. Sura, “A Comprehensive Analysis of Power Converter Topologies and Control Methods for Extremely Fast Charging of Electric Vehicles,” Journal of Physics: Conference Series, vol. 2570, no. 1, p. 012017, Aug. 2023, doi: 10.1088/1742-6596/2570/1/012017.