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A Review on Performance of Various Energy Management Strategies for Hybrid Electric Vehicle

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Abstract: - This study offers a detailed examination of the (EMS) Energy Management System used in (HESS) Hybrid Energy Storage Systems for (EVs) Electric Vehicles. The system consists of a combination of a Battery, (FC) Fuel Cell, and Super- Capacitor(SC). The industry's top priority is to growth the battery method effectiveness and efficiency under protected working conditions. This demands for expansion in the operating conditions of the battery through resourceful EMS. There are several methodologies to achieve these objectives out of which, adaptive fuzzy logic control strategy is sturdy, robust, and environmentally friendly and have sparked a worldwide interest in the automotive industry. Energy management is consequently essential to extend battery life without compromising vehicle performance in hybrid electric vehicles. This study emphasizes the extensiveness of different control systems utilized for energy management including energy management system optimization.

Keywords: - Hybrid Energy Storage System, Energy Management System, FLC, Battery, Fuel Cell, Super-capacitor, Ultra capacitor, Hybrid Electric vehicle, Control Strategies

I. INTRODUCTION

In the recent enormous economic expansion and subsequent rise in living standards, now more cars are there on the roads. The transition from conventional (IC) internal combustion engine vehicles to (EV) electric vehicles is essential to overcoming the worldwide ecological disaster for example- environment pollution, the unexpected change in environment, and the sudden rise in earth environmental temperature [1,2]. This is because the transportation sector is expanding at a disturbing pace.

The advantages of EVs can also be better tapped into and sold for more than their conventional counterparts, with greater intensities of energy efficiency in power transmission. According to the economists, the electric vehicle (EV) market will soon grow significantly, and the global development is turning to electric cars or hybrid electric vehicles (HEV) [3,4]. The fuel for the EV system is electricity. HESS, an acronym for a collection of energy storage systems that includes batteries, SCs, and FCs, will serve as a conduit for converting electrical energy into kinetic energy using electrical motors. The battery is the most important part since it controls the driving range and has a significant effect on efficient performance of EV system [5]. But the most modern battery technologies can only retain good state of health (SoH) for a few hundred charging cycles before gradually losing charging and discharging capacity [6].

The supportive organization for hydrogen manufacture and transport must first be verified on a large scale in order to use (FC) fuel cell as a sole source of energy in HESS of EV. The development of FC technology costs outweighs through its small size and light weight. In the process of developing and implementing Fuel Cell Hybrid Electric Vehicle (FC-HEVs), the EMS must deal with a number of difficulties [7].

Since different sketch sizes allow collaboration between multiple energy sources, and this cooperation provides higher system efficiency in transportation system rather than a single energy source that’s why HESSs are now preferred [8]. The significance of (HESS) over the single ESS in EV is highlighted in [21]. Integration of several ESSs (such as SC, UC, battery, and FC) improves system stability, charging-discharging ratio, driving range, storage lifetime, and cost.

The aim of this paper is to raise consciousness about the importance of the HESS's in the sphere of transportation industry as well as reduces the challenges facing its long-term, practical implementation in EVs. This article also examines the basic advancements in EMS of HESS research that are currently running, as well as the necessity of modernizing old EMS paradigms to improve the state of the industry.

In this article section I is based on introduction. The problem statement is presented in section II. The significance of energy management system is given in section III and section IV deals with different methods of EMS. We have looked a pointed comparison of various methods of EMS in section V, section VI serving as the conclusion.

II. PROBLEM DISCLOSURE

A quick investigation revealed that while Rule Based approaches have low computational requirements & are extremely valid in real time, the result is not optimal. On the other hand, strategies focused on optimization can determine the best way to manage energy management. But in order to deliver solutions, complete information is needed, which is not permanently accessible. Additionally, the computing necessities are very high and take a long time.

III. SIGNIFICANCE OF EMS

Energy distribution between the SC & battery extends the battery pack's lifespan, however managing energy in battery-SC schemes has significant drawbacks. To reduce pressure on the battery, the battery pack's current must be restricted [1]. The battery pack's thermal equilibrium must be kept at normal area temperature. Each cell's voltage needs to be balanced and maintained consistently.

During HESS functioning, the EMS is estimated to provide these requirements. Therefore, EMS aims to identify the ideal operating situation for the efficient consumption of battery power or energy storage capacity. EMSs have been built using a variety of methodologies, including rule-based and optimization-based Due to the high computational and memory desires, they are not practical for actual apps.

Additionally, these tactics must be used throughout the predetermined driving cycle, which is typically challenging to do. Real-time implementation of rule-based techniques is possible, but the best outcomes cannot be guaranteed [15]. Real-time execution is possible with simplified EMS optimization technologies [16, 17], but some systems combine the two techniques. [18] For instance, [19,20] employed Dynamic Programming (DP) to build a rule-based methodology cantered on optimization.

In the same research project, one component was controlled by an EMS built on the basis of optimization, while alternative component was controlled by an EMS built on the basis of rules [19,20]. The fluctuation in the driving cycle affects the EMS performance regardless of the EMS method.

For EVs to achieve appropriate driving performance, power supply, energy storage systems, & additional refined controlling techniques are required. These includes FC, SC, & batteries. EMS for FC has the benefit of better energy distributes & reliability. The FC& SC in HESS is important in order to fulfil transient power necessities & provide vehicles with the essential energy and energy density [18,21].

IV. VARIOUS APPROACHES TO EMS

Various EMSs have been detailed in the literature for HESS based on fuel cell [22]. These approaches can be divided into four groups: rule-based methods, common energy storage based methods, HESS based methods, & optimization-based methods. Fuzzy logic, neural networks, and state equipment make up the majority of the rules' foundation [23,24].

For State Instrument Control, each rule or state must be specified or tested empirically [23], [25]. Additionally, to achieve the desired outcomes, rule-based fuzzy logic approaches integrate input and output membership functions. Some studies [09], [26], [27] utilized FL in a twin power source configuration with fuel cell and battery. The general objective is to increase the scheme's effectiveness and maintain a sizable amount of SOC battery. [28]. Fig.1 presents a complete categorization of the EMS.

A. RULE BASED

These techniques use "if-then" rules to define the activity and a control law that is already defined. This approach has the advantage of requiring less calculation. Rule-based systems are frequently employed in automobiles and have been taken into consideration in [29,30,31,32,62,63] for this benefit. These can be divided into: -

1) Deterministic Rule Based: -

These techniques are described in terms of regulations. The algorithm controls commands including engine shut-down, power division, and battery charging. The following categories apply to this [5].

a) Thermostat Management Approach: -

The control technique is based on how the vehicle's parts function. The key objective is to keep every component of the vehicle operating within defined limitations [33].

b) Power Follower Control Strategy: -

This approach provides another formulation for on/off control. Advanced method. The idea is based on 4 different cases control elements for energy management are defined based on: Battery charge level. This improves performance efficient, but not optimized for fuel economy.

c) Enhanced Power Flow Control Strategy: -

Adaptive RB: The method is carried out process by step, with an array of generate values established at the driver's need.

2) Fuzzy Rule Based Algorithms: -

The highest benefit of this control is the output performance for various operating conditions, the setting of fuzzy rules an easy and powerful way to model errors and incorrect measurement. This is explained below: -

a) Basic Fuzzy Logic

Here the controller calculates the fuzzy logic base are not. In this technique, the input is first dimmed according to then human based rules are used to determine the opacity output, finally the fuzzy result is reduced fuzzy at correlate with to the control signals. Use load balancing principles, it has been given in the energy management of HEV [34].

b) Adaptive Fuzzy Logic

Following this technique, functioning is improved if Control settings can adapt to present driving condition. This is an Intelligent Situational Awareness agent (IEMA) is fed into the fuzzy torque distribution process. This technique needs organization based on road type & driving performance. So training vector quantization is used to control the drive condition. Adapts extra effectively than basic dimming due to improved performance [35].

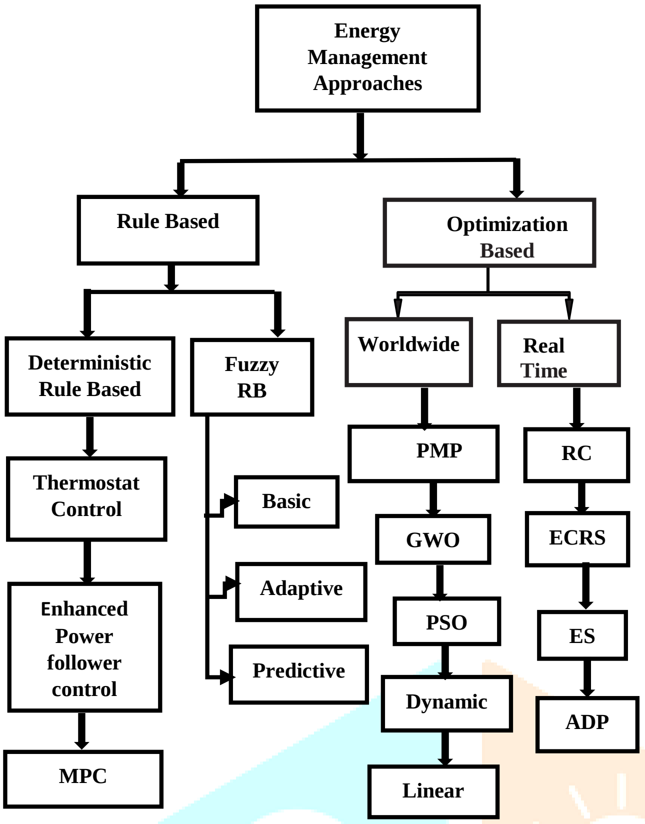

Fig1: -Categorization of Power Management Strategies

c) Predictive Fuzzy

In order to achieve the best result, we estimate the upcoming driving session that will be used by the fuzzy controller. For the purpose of forecasting future driving conditions, some data, such as the kind of road and traffic information, are collected. This method can also use state-of-health energy, however doing so results in significant fuel consumption. The development of the driving conditions is based on the degrees of traffic congestion. Results from this strategy demonstrated that it is more suitable in real time without the need for full driving cycle optimization [36, 37].

B. OPTIMIZATION BASED

Optimization techniques are nowadays receiving much extra importance as the results of these techniques are able to fulfill the limitations & in capable of smooth energy management in HEV. These techniques are divided into two parts: worldwide optimization & real time optimization. They are an explanation below: -

1) Worldwide Optimization

These strategies were created based on the predetermined learning of future driving conditions in order to have the overall best option for the entire journey. But due to the heavy computational load, its. However, these methodologies can be used as a standard for the analysis, adjustment, and assessment of other approaches. Static and dynamic optimization are the two main uses of these techniques. The goal of static optimization is to find an ideal value for each control parameter that produces a constant output under various operating conditions. Alternatively, we choose the control parameters in dynamic optimization. Through the use of backward calculations, the ideal values of each control parameter are investigated [38].

a) Linear Programming

Comparing all other optimization techniques, linear models are the simplest to compute. To reduce the complexity of the power management model, linear models can be linearized. These programming techniques can produce a nearly ideal result with minimal computing complexity and wait time. Irregular energy management difficulties can be transformed by maintaining consistent battery performance and reducing power bus voltage waves to achieve low fuel consumption. To increase fuel efficiency, non-linear convex optimization was used to manage the torque & gear ratio of the HEV sequence [39]. The plug in hybrid electric vehicle (PHEV) de-centralized EMS, which used a intemperate based procedure, was introduced to avoid this problem. The advantage of supply and demand was maximized using mixed integer nonlinear programming (MINLP). Because of the system's reduced complexity, the ultimate load has been reduced by 20%, [40].

b) Dynamic Programming (DP)

Through the application of mathematical models, dynamic programming can divide a multi-step decision-making difficulty into a number of simpler issues. If the powertrain model is believed to be uncomplicated, DP can attain global optimist when integrated, but as the control variable increases, its computational complexity rapidly rises, making it unsuitable for online control, [41,1,3]. Dynamic Programming will create a PHEV power cut system to cut down on fuel use & increase vehicle economy [42]. A GA-based strategy was suggested by [21] for reducing the aspect of energy source mechanisms [43]. Future, DP was utilized for fuel-efficient power control. [22] proposed a DP-centered energy management technique that took temperature noise effects into account. Under the same driving conditions and driving patterns, it has been observed that temperature variations cause variances in fuel economy, pollution, and energy management [44].

c) Particle Swarm Optimization (PSO)

This population-wide random optimization method uses a population of particles as the finding substance and the particle positions as the solution. Since the result parameters are already provided in this case, the goal function's minimum value is determined. The particle movement in this scenario can be divided into two categories: speed and position. Then, these are adjusted to provide the optimal results for individual particle and the swarm as a whole. These particles are moving in a path that the organized group believes to be the best one. This technique can use numerous iterative stages, which requires significant computational time, to determine the best power [45].

d) EMS based on Grey Wolf Optimization

A Grey Wolf Optimizer (GWO)-based EMS for HESS with FC and SC is described in [46]. The procedure's name refers to a grey wolf's search conduct, & a design resembling this is reproduced. The GWO mimics the Grey Wolves' common structure and basic hunting techniques, such as first encircling and then attacking. Wolves approach their prey by changing their positions to put themselves in the greatest possible attacking stance. In a similar vein, the GWO informs the situation vector, an average of the group's highest ranking position. [47,28,27,26]. Finding the best management reference that maximizes driving performance while minimizing response time and SoC constraints is the responsibility of the GWO. GWO is well-liked for its remarkable convergence efficiency while solving constrained situations. The purpose of this method is to find the best energy adjustment by reducing the energy consumption of the method's parts. As indicated in equation

(1), an objective purpose JGWO that considers the energy inaccuracy of DC-bus & SCs is presented. [48]

$$JGWO = \lambda 1\ \Delta c\ SC\ k + \Delta c\ Bus + \lambda 2 TS\ \Delta c\ SC\ k - + \Delta c\ Bus\ k - \quad (1)\ [48]$$

Where,

$\Delta c = c - c$ is SCs energy fault, Bus Reference Bus $\Delta c = c - c$ is the Energy fault for DC Bus, SC k is the energy stored in SC & SCs Bus is the energy stored in DC Bus, λ1 & λ2 are the increment coefficients & TS is the sample time K is the term used for the iteration procedure. Three stages make up GWO's design process [46]. the number of iterations is used in the first step, "Encircling," to evaluate all of the hunting options. The three best options are picked in the next step, "Hunting," which evaluates the attacking contender. The best option out of the three options is then utilized to "attack" after the attacking candidate has been verified for the last stage, known as "Occurrence."

e) Pontryagin's Minimum Principle (PMP)-based EMS

The concept of the optimal EMS, which is derived from optimum control concept, is proposed in [47] and is based on PMP. This control technique creates the greatest situations for quickly resolving difficulties, and because to its EMS-based PMP capabilities, it is one of the greatest capable method for the energy management of the vehicle. Due to their foundation in optimal control theory, the fuzzy logic strategy and the DP techniques have drawbacks. Consumption time is shorter in PMP. This technique objective to minimize energy use while instantaneously maximizing the battery's cycle life. Fig. 2 presents a flowchart diagram illustrating the suggested PMP-EMS architecture. The PMP approach was selected because it can be utilized to find the local solution for each horizon, producing PMP-MPC, and because it can increase the computing effectiveness of MPC [65].

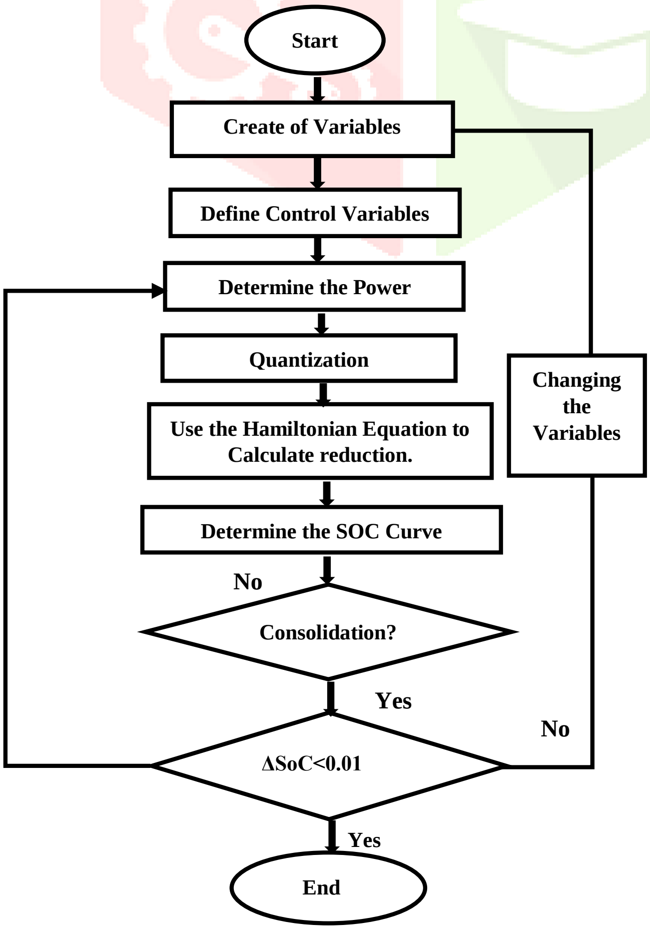

Fig: -2 Flow Chart PMP [52]

2) EMSs BASED ON REAL-TIME OPTIMIZATION

Real-time EMS-based optimization relies on knowledge about upcoming driving rather than particular driving circumstances. (ECMS), Energy Consumption Minimization Strategy, (PCM) Predictive Control Models are used in real-time optimization-based EMS.

a) Re-Energy Consumption

As a feature of device performance & finite metrics on board in operational method, Strategy-ECMS measures fuel equivalent. It lowers worldwide optimization to an immediate minimization result and is self-regulating of specific information of driving configurations. Suggested ECMS for HEV in charge of the supporting mode, which reduces fuel use & polluting emissions [49]. The key difficulty with this approach is estimating equivalent factors that take into account the transient dynamics of each power source and the efficiency of all of the vehicle's components.

b) Adaptive Dynamic Programming (ADP)

This adaptive approach shortens the computing time required to solve a DP, reconstructing and simplifying it in the process. Even if the answer offered by the simplified and rebuilt version is almost suboptimal, it nevertheless outperforms several real-time approaches. Additional technique, known as iterative DP, uses irregular grids for control and state paths to identify the best approaches for forthcoming iterations. The grids are cleaned up by iterative refinement to reach the worldwide optimum in order to save fuel with fewer calculations & less memory usage. A less-than-ideal outcome can be used to bring this procedure to real-world use. This method's drawback is that information of the driving cycle is necessary. Even variations in the traffic must be observed, as well as anything else that can have an impact on the drive cycle [27].

c) Extremum Seeking (ES)

This approach differs from an established control example where formation lacks a defined stability. We may investigate the gradient and also determine the minimum & maximum at zero gradient regions based on the restoration of unknown plants using periodic excitation inputs and system outputs. [51,52].

d) Robust Control (RC)

This control technique is utilized to systems with unpredictability, disturbing inputs, unclear or inaccurate measurements in order to assure system reliability and elasticity. It depends on an arrangement of variables to provide the desired result while limiting the system's ability to react to the multiple effects induced by unknown inputs.

The discharge of SoC battery in expressions of power & reactive energy as well as the energy used are specified for the energy management of a hybrid electric vehicle using robust control. A reduction in difficulty can be calculated by keeping the input close to the required power when the input is expressed as electric power. The outcomes of this methodology are static inferior to those of the ECMS or DP method. The key drawbacks are that the problem is complex, which makes calculation difficult and makes it impossible to discover an ideal solution when needed [53,54].

C. COMMON ENERGY STORAGE METHODS FOR EVs

The three most prevalent types of energy storage strategies are battery, FC, & SC. When utilized in hybrid mode, they are sometimes used in EVs as major energy sources and other times as backup sources. The sources utilized are described in detail below along with their general ideal.

a) Battery

The battery is an excellent & usually used energy source that can be create on every single electronic device. It works as an important power source even for HEVs [24,44]. HEV batteries are connected to a DC bus via a DC-DC converter, & their voltage is the same as the voltage of the DC bus. Battery SoC illustrates an essential conception that controls the performance of the hybrid vehicle system. The battery provides quick peak power response during increasing & restores power during braking, much like SC [50,33]. The many batteries that are common of HEVs are shown in Figure 3.

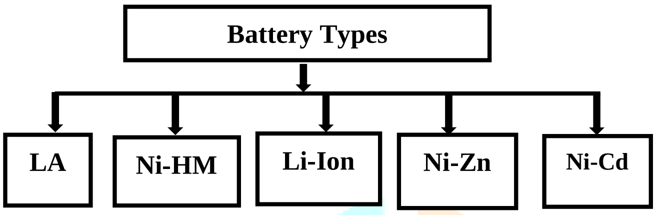

Fig: -3 Common Types of Battery [50,62]

Where,

LA - Lead Acid
Ni-HM - Nickle Metal Hydride
Li-Ion - Lithium Ion
Ni-Zn - Nickle Zinc
Ni-Cd - Nickle Cadmium

b) Supercapacitor/Ultracapacitor

In the HEV system, SC and UC are regarded as well-known energy sources, although their electrode length and storage capacity are different. This source was pointed out in some research papers as UC, while others utilized SC in place of UC. For every research work, authors express UC and SC in an objective way. The purpose of both the battery and the SC is to store charge, however the SC can store and discharge & charge more quickly than the battery [54]. A positive electrode stores negative ions, while the negative electrode stores positive ions when an external voltage is supplied to it. While SC delivers transient power throughout acceleration & recovers power during braking, additional energy sources feed the HEV with steady-state power [55,61,62,63].

c) Fuel Cell

The FC is the major power source in HEVs, converting chemical energy into electrical energy. Although FC delivers a continuous steady-state power supply to the HEV, it cannot supply transient power throughout acceleration and deceleration that is supplied by other sources [56,64]. FC points out its efficiency as an emission-free energy source. The many batteries that are common of HEVs are shown in Figure 4.

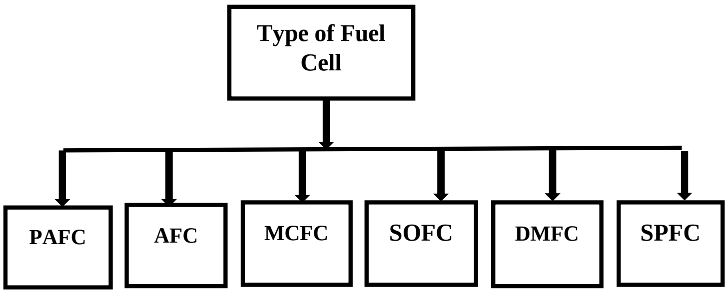

Fig: -4 Types of FC [56,33,27]

Where,

PAFC - Phosphoric Acid Fuel cell
AFC - Alkaline Fuel cell
MCFC - Molten-Carbonate Fuel cell
SOFC - Solid Oxide Fuel cell
SPFC - Solid Polymer Fuel cell
DMFC - Direct Methanol Fuel cell.

D. BASED ON HYBRID ENERGY STORAGE SYSTEM FOR EVs

Hybrid electric vehicles are vehicles that use two or more energy sources or storage systems, at least one of which delivers electrical energy. A conventional HEV, for example, consists of an electric motor with a battery and an engine with a fuel tank. Based on the ESSs, HEV configuration can be divided into 4 types, which are detailed below.

a) Battery-Fuel Cell-Ultra-capacitor

The purpose of such technology is the correct management of energy distribution amongst its multiple resources in order to meet the power requirement at any operation demanded [57]**.**

Because all of the sources are available, the arrangement significantly decreases hydrogen uses and offers a resourceful performance during restive operation across a long driving range. The key issue of the composition is the battery current variations, battery SoC level, & storage capacity [58,43].

b) Fuel Cell-Ultracapacitor

In this method, FC & UC are the sources of energy. Voltage is at its maximum when zero current flow in FC. It decreases as current increases due to stimulation overvoltage & ohm resistance losses in the membrane.

When the transportation of the reacting gases cannot keep up with the volume of the reaction, a sharp voltage drop occurs at high current. FC should supply a limited amount of current. To preserve the defined performance of EV, the measured power response of FC can be balanced by the quick power response of UC [59,43,61.65].

c) Battery-Ultracapacitor

The battery & ultracapacitor arrangement illustrates a feasible and acceptable EV energy arrangement that decreases costs, improves system reliability, and permits for load-leveling. The configuration decreases energy losses & increases battery life. Ultracapacitor helps the battery reduce pressure at peak hours [54,57,58,43].

d) Battery-Fuel Cell

This method illustrating fuel cell as the main power source and the battery as a backup solution. Because of its improved energy density, FC can handle larger load demand to charge the connected battery module. If the quantity of fuel gets near to the allowable subordinate limit, the battery steps in to help the system maintain a stable performance. As a result, efficiency improves [59,60,61].

The schematic illustration of the four hybrid energy storage system mentioned above is shown in below VI section Table. Comparison between FC-UC-Battery, FC-UC, UC-Battery, and FC-Battery configuration. The table representation a relative comparison of different relations: important factors, transient response, battery SoC, driving cycle, initial load demand.

V. PERFORMANCE&COMPARISON-BASED EVALUATION

The management of HESS, which includes the battery, Super-capacitor, and fuel cell, is examined in this study based on a number of research publications, and conclusions are drawn for the succeeding criteria based on the effectiveness of the various strategies, as presented in Table 1 & Table 2 determines a parameter comparison between FC-UC-Battery, FC-UC, UC-Battery, and FC-Battery structure. The table lists various factors that are taken into account when each strategy is implemented.

Table-1 Different EMS approaches are evaluated based on all of the parameters [2,14].

Method	CoS	CT	ToS	RoPK
FL	Negative	Compact	worldwide	Yes
PSO	Negative	Average	worldwide	Negative
PMP	Negative	Compact	City	Yes
GWO	Negative	Average	worldwide	Negative
DP	YES	Average	worldwide	Yes
MPC	Negative	Compact	worldwide	Negative
NN	YES	Compact	worldwide	Yes

Where,
CoS - Complication of Structure
CT - Calculation Time
ToS - Type of Solution
RoPK - Requirement of Prior Knowledge
PSO - **Particle Swarm Optimization**

Table-2 Comparison & performance evaluated based on all of the parameters [58,59,60].

Specification	Battery-FC-UC	Battery-FC	FC-UC	Battery-UC
Setup of the System	Main Source-FC Secondary-Battery & UC	Main Source-FC Secondary-Battery	Main Source-FC Secondary-UC	Main Source-Battery Secondary-UC
Primary Load Demand	Managed by FC& Battery	Managed by Battery	Managed by FC	Managed by Battery
Implementation Process	Difficulties	Simple	Simple	Simple
Fuel Consumption	Very high	High	High	High
Dynamic Performance	Superior	Acceptable	Acceptable	Acceptable
Battery Load	Decrease by UC&FC	Decrease by FC	Decrease by UC	Decrease by UC
Battery Life-span	Very Long	irrelevant	Long lasting	Long lasting
Emission	Small	Small	Small	No
Availability	Low price accessible	Low price accessible	Low price accessible	Low price accessible
Flexibility & Reliability	Very Good	Good	Good	Good

VI. CONCLUSION

It has been noted that rule-based and optimization-based methods are both frequently utilized for real-time power management.

This report introduced the most recent, cutting-edge trends in this industry. Advantages and disadvantages for each strategy were highlighted. The study's findings show that while Rule Base approaches are simple to use in real time, they don't always produce the best results and an analytical study into several HEV control schemes & energy management system systematically for four arrangements: - Battery-UC, FC-UC, FC-Battery, and FC-Battery-UC. For known real-time driving patterns under set operational conditions, rule-based techniques are found to be quite effective.

When compared to previous approaches, the rule-based methodology reduces the battery current cost by 2%. But rule-based techniques like FL controller need the real-time information to be connect. If the typical, recognizable driving cycle is taken into description, the optimization method expressively extends the life of the HESS. But, they do not take into account the ambiguous driving cycles.

In overall, enhanced battery life is greatly subjective by optimized controller methods, but very resourceful fuzzy-based solutions are presented for varying drive cycles. Moreover, GWO in energy storage systems utilizing FC eliminates changes in currents and guards in contradiction of the difference of the battery's SoC. The reimbursements of fuzzy-based control and optimization methodologies are collective in the PMP technique, and the RMS current of the battery in HESS is significantly reduced. Several attempts have been made to combine the various ways in order to mitigate the drawbacks of each methodology for EMS, such as rule basis techniques using optimization methodology, both of which are in the early phases of research. The development of the strong and trustworthy strategy taking into account cost reduction and life cycle enhancement is still ongoing. Finally, strategies for achieving various goals are suggested.

REFERENCES

[1] A. Panday and H. O. Bansal, "A Review of Optimal Energy Management Strategies for Hybrid Electric Vehicle," vol. 2014, 2014.

[2] B. Vulturescu, R. Trigui, R. Lallemand, and G. Coquery, "Implementation and test of a hybrid storage system on an electric urban bus," Transp. Res. Part C, vol. 30, pp.55–66, 2013

[3] T. Gnann, T. S. Stephens, Z. Lin, P. Plötz, C. Liu, and J. Brokate, "What drives the market for plug-in electric vehicles? - A review of international PEV market diffusion models," Renewable and Sustainable Energy Reviews. vol.2018.

[4] M. Ali, Ahmed & Söffker, D (2018). Towards Optimal Power Management of Hybrid Electric Vehicles in Real-Time: A Review on Methods, Challenges, and State-Of-The-Art Solutions.Energies.vol 2011.

[5] A. Castaings, W. Lhomme, R. Trigui, and A. Bouscayrol, "Comparison of energy management strategies of a battery/supercapacitors system for electric vehicle under real-time constraints," Appl. Energy, vol. 163, pp. 190–200, 2016

[6] M. Hashem and N. C. Wang, “Modelling and Control of Fuel Cells Distributed Generation Applications.” vol. 163, pp. 190–210, 2018

[7] K. Alobeidli and V. Khadkikar, “A new ultracapacitor state of charge control concept to enhance battery lifespan of dual storage electric vehicles,” IEEE Trans. Veh. Technol., vol. 67, no. 11, pp. 10470– 10481, 2018

[8] R.Amin, T. Bambang, A. S. Rohman, C. J. Dronkers, R. Ortega, and A. Sasongko, “Energy management of fuel cell/battery/supercapacitor hybrid power sources using model predictive control,” IEEE Trans. Ind. Informatics, vol. 10, no. 4, pp. 1992–2002, Nov. 2014.

[9] F. R. Salmasi, “Control strategies for hybrid electric vehicles: Evolution, classification, comparison, and future trends,” IEEE Trans. Veh. Technol., vol. 56, no. 5 I, pp. 2393–2404, 2007.

[10] A. Tani, M. B. Camara, and B. Dakyo, “Energy Management Based on Frequency Approach for Hybrid Electric Vehicle Applications:” vol. 61, no. 8, pp. 3375–3386, 2012.

[11] Z. Song, H. Hofmann, J. Li, X. Han, and M. Ouyang, “Optimization for a hybrid energy storage system in electric vehicles using dynamic programing approach,” Appl. Energy, vol. 139, no. Dc, pp. 151–162, 2015.

[12] Y. Hung and C. Wu, “An integrated optimization approach for a hybrid energy system in electric vehicles,” Appl. Energy, vol. 98, pp. 479–490, 2012.

[13] P. P. J. Van Den Bosch and D. B. Kok, “Hybrid Electric Vehicles,” vol. 57, no. 6, pp. 3428–3440, 2008.

[14] A. M. Ali and D. Söffker, “Towards optimal power management of hybrid electric vehicles in real-time: A review on methods, challenges, and state-of-the-art solutions,” Energies, vol. 11, no. 3, pp. 1–24, 2018

[15] J. Peng, H. He, and R. Xiong, “Rule based energy management strategy for a series–parallel plug-in hybrid electric bus optimized by dynamic programming,” Appl. Energy, vol. 185, pp. 1633–1643, Jan. 2017.

[16] M. Kandidayeni, A. O. Macias Fernandez, A. Khalatbarisoltani, L. Boulon, S. Kelouwani, and H. Chaoui, “An Online Energy Management Strategy for a Fuel Cell/Battery Vehicle Considering the Driving Pattern and Performance Drift Impacts,” IEEE Trans. Veh. Technol., vol. 68, no. 12, pp. 11427–11438, 2019.

[17] A. Santucci, A. Sorniotti, and C. Lekakou, “Power split strategies for hybrid energy storage systems for vehicular applications,” J. Power Sources, vol. 258, pp. 395–407, 2014.

[18] F. Zhang, X. Hu, R. Langari, and D. Cao, “Energy management strategies of connected HEVs and PHEVs; Recent progress and outlook,” vol. 73, pp. 235–256, 2019.

[19] S. Zhang and R. Xiong, “Adaptive energy management of a plug-in hybrid electric vehicle based on driving pattern recognition and dynamic programming,” Appl. Energy, vol. 155, 2015.

[20] A. Tahri et al., “Management of fuel cell power and supercapacitor state-of-charge for electric vehicles,” Electr. Power Syst. Res., vol. 160, pp. 89–98, 2018.

[21] K. Ettihir, L. Boulon, and K. Agbossou, “Optimization-based energy management strategy for a fuel cell/battery hybrid power system,” Appl. Energy, vol. 163, pp. 142–153, 2016

[22] X. Zhang, L. Liu, and Y. Dai, “Fuzzy state machine energy management strategy for hybrid electric UAVs with PV/Fuel cell/battery power system,” Int. J. Aerosp. Eng., vol. 2018, 2018.

[23] N. Chettibi, A. Mellit, G. Sulligoi, and A. Massi Pavan, “Adaptive Neural Network-Based Control of a Hybrid AC/DC Microgrid,” IEEE Trans. Smart Grid, vol. 9, no. 3, pp. 1667–1679, 2018.

[24] S. Njoya Motapon, L. A. Dessaint, and K. Al-Haddad, “A comparative study of energy management schemes for a fuel-cell hybrid emergency power system of more-electric aircraft,” IEEE Trans. Ind. Electron., vol. 61, no. 3, pp. 1320–1334, 2014

[25] L. Sun, K. Feng, C. Chapman, and N. Zhang, “An adaptive power-split strategy for battery-supercapacitor powertrain-design, simulation, and experiment,” IEEE Trans. Power Electron., vol. 32, no. 12, pp. 9364– 9375, 2017.

[26] P. Thounthong, L. Piegari, S. Pierfederici, and B. Davat, “Nonlinear intelligent DC grid stabilization for fuel cell vehicle applications with a supercapacitor storage device,” Int. J. Electr. Power Energy Syst., vol. 64, pp. 723–733, 2015

[27] A. Djerioui, A. Houari, S. Zeghlache, and G. Wolf, “ScienceDirect Energy management strategy of Supercapacitor / Fuel Cell energy storage devices for vehicle applications,” Int. J. Hydrogen Energy, no. xxxx, 2019.

[28] R. Zhang and J. Tao, "GA-Based Fuzzy Energy Management System for FC/SC-Powered HEV Considering H2 Consumption and Load Variation," in IEEE Transactions on Fuzzy Systems, vol. 26, no. 4, pp. 1833-1843, Aug. 2018

[29] Q. Xu, X. Luo, X. Jiang and M. Zhao, "Research on double fuzzy control strategy for parallel hybrid electric vehicle based on GA and DP optimization," in IET Electrical Systems in Transportation, vol. 8, no. 2, pp. 144-151, 6 2018.

[30] Navale and T. C. Havens, "Fuzzy logic controller for energy management of power split hybrid electrical vehicle transmission," 2014 IEEE International Conference on Fuzzy Systems (FUZZ-IEEE), Beijing, 2014, pp. 940-947.

[31] S. A. Zulkifli, S. Mohd, N. Saad and A. R. A. Aziz, "Influence of Motor Power and Efficiency on Fuel Consumption of RetrofitConversion Split-Parallel Hybrid Electric Vehicle," 2013 IEEE Vehicle Power and Propulsion Conference (VPPC), Beijing, 2013, pp. 1-5.

[32] A.R. Sahu, B.S. Kumar, “A Review of Various Power Management Schemes in HEV” vol.198, pp. 978-1-7281-7016-9,20202

[33] Y. Zeng, "Research on the parameter matching and

CVT's target speed ratio optimization of plug in hybrid electric vehicle*," 2017 IEEE Transportation Electrification Conference and Expo, Asia-Pacific (ITEC Asia-Pacific), Harbin, 2017, pp. 1-6.

[34] Navale and T. C. Havens, "Fuzzy logic controller for energy management of power split hybrid electrical vehicle transmission," 2014 IEEE International Conference on Fuzzy Systems (FUZZ-IEEE), Beijing, 2014, pp. 940-947.

[35] Y. Wang and X. Zhu, "Hybrid Fuzzy Logic Controller for optimized autonomous parking," 2013 American Control Conference, Washington, DC, 2013, pp. 182-187.

[36] Q. Xu, X. Jiang, J. Sun and S. Cui, "Comparison analysis of power management used in hybrid electric vehicle based on electric variable transmission," 2016 UKACC 11th International Conference on Control (CONTROL), Belfast, 2016, pp. 1-7

[37] Q. Ali, H. Z. Butt and S. A. A. Kazmi, "Integration of Electric Vehicles as Smart Loads for Demand Side Management in Medium Voltage Distribution Network," 2018 International Conference on Computing, Electronic and Electrical Engineering (ICE Cube), Quetta, 2018, pp. 1-5

[38] E.Tate, S.Boyd, Finding ultimate limits of performance for hybrid electric vehicles. In: Proceedings of Society of Automotive Engineers 2000 Future Transportation Technology Conference, (2001).

[39] A.Mehrabi, H. Nunna, A.Dadlani, S.Moon, K.Kim, “Decentralized Greedy-Based Algorithm for Smart Energy Management in Plug-in Electric Vehicle Energy Distribution Systems.” IEEE Access 8, 75666-75681, (2020)

[40] O.Sundstróm, L.Guzella, “A generic dynamic programming MATLAB function.” In: Proc. 18th IEEE Int. Conf. Control Appl., Saint Petersburg, Russia, pp. 1625–1630, (2009).

[41] Y.Li, N. Kar, “Advanced design approach of power split device of plug-in hybrid electric vehicles using dynamic programming.” In: Proceedings of the 7th IEEE Vehicle Power and Propulsion Conference (VPPC ’11), pp. 1–6, Chicago, Ill, USA, (2011).

[42] A. Ravey, R. Roche, B. Blunier, A.Miraoui, “Combined optimal sizing and energy management of hybrid electric vehicles”. In: Proceedings of the IEEE Transportation Electrification Conference and Exposition (ITEC ’12), pp. 1–6, Dearborn, Mich, USA, (2012).

[43] M. Shams-Zahraei, A.Kouzani, S.Kutter, B. Baker, “Integrated thermal and energy management of plug-in hybrid electric vehicles”. Journal of Power Sources 216, 237–248, (2012).

[44] Teng Liu; Amir Khajepour, "Reinforcement Learning-Enabled Intelligent Energy Management for Hybrid Electric Vehicles," in Reinforcement Learning-Enabled Intelligent Energy Management for Hybrid Electric Vehicles, Morgan & Claypool, 2019, vol.234 pp1-8

[45] M. Panda and B. Das, “Grey Wolf Optimizer and Its Applications: A Survey,” in Lecture Notes in Electrical Engineering, 2019, vol. 556, pp. 179–194.

[46] C. Zheng, W. Li, and Q. Liang, “An Energy Management Strategy of Hybrid Energy Storage Systems for Electric Vehicle Applications,” IEEE Trans. Sustain. Energy, vol. 9, no. 4, pp. 1880–1888, 2018.

[47] G.Paganelli, M.Tateno, A.Brahma, G. Rizzoni,Y.Guezennec,”Control development for a hybrid-electric sportutility vehicle: strategy, implementation and field test results.” In: Proceedings of the American Control Conf. pp. 5064–5069, Columbus, Ohio, USA, JuneJuly (2001)

[48] P.R. Chaudhary, K.P. Schenider,” Smart Energy Profile Application Protocol," in IEEE Std 2030.5-2018 (Revision of IEEE Std 2030.5-2013), vol., no., pp.1-361, 21 Dec. 2018

[49] C. Zhu, F. Lu, H. Zhang, J. Sun and C. C. Mi, "A Real-Time Battery Thermal Management Strategy for Connected and Automated Hybrid Electric Vehicles (CAHEVs) Based on Iterative Dynamic Programming," in IEEE Transactions on Vehicular Technology, vol. 67, no. 9, pp. 8077-8084, Sept. 2018

[50] V. Lakshminarayanan, V. G. S. Chemudupati, S. K. Pramanick and K. Rajashekara, "Real-Time Optimal Energy Management Controller for Electric Vehicle Integration in Workplace Microgrid," in IEEE Transactions on Transportation Electrification, vol. 5, no. 1, pp. 174-185, March 2019

[51] A. Alsabbagh, H. Yin and C. Ma, "Distributed charging management of multi-class electric vehicles with different charging priorities," in IET Generation, Transmission & Distribution, vol. 13, no. 22, pp. 5257-5264, 19 11 2019

[52] B. Bose and Ruchira, "Power Spectrum Estimation of PMU using Digital Signal Processing Techniques," 2019 3rd International Conference on Recent Developments in Control, Automation & Power Engineering (RDCAPE), NOIDA, India, 2019, pp. 373-377

[53] N. Sulaiman, M. A. Hannan, A. Mohamed, P. J. Ker, E. H. Majlan, and W. R. Wan Daud, “Optimization of energy management system for fuel-cell hybrid electric vehicles: Issues and recommendations,” Appl. Energy, vol. 228, no. May, pp. 2061–2079, 2018.

[54] Z. Yuan, L. Teng, S. Fengchun, and H. Peng, ‘‘Comparative study of dynamic programming and Pontryagin’s minimum principle on energy management for a parallel hybrid electric vehicle,’’ Energies, vol. 6, no. 4, pp. 2305–2318, Apr. 2013

[55] M. Yilmaz and P. T. Krein, ‘‘Review of battery charger topologies, charging power levels, and infrastructure for plug-in electric and hybrid vehicles,’’ IEEE Trans. Power Electron., vol. 28, no. 5, pp. 2151–2169, May 2013.

[56] S. Habib, M. M. Khan, F. Abbas, L. Sang, M. U. Shahid, and H. Tang, ‘‘A comprehensive study of implemented international standards, technical challenges, impacts and prospects for electric vehicles,’’ IEEE Access, vol. 6, pp. 13866–13890, 2018.

[57] Y. Ligen, H. Vrubel, and H. H. Girault, ‘‘Mobility from renewable electricity: Infrastructure comparison for battery and hydrogen fuel cell vehicles,’’ World Electr. Vehicle J., vol. 9, no. 1, pp. 3–14, 2018.

[58] A. Khaligh and Z. Li, ‘‘Battery, ultracapacitor, fuel cell, and hybrid energy storage systems for electric, hybrid electric, fuel cell, and plug-in hybrid electric vehicles: State of the art,’’ IEEE Trans. Veh. Technol., vol. 59, no. 6, pp. 2806–2814, Jul. 2010

[59] S. G. Wirasingha and A. Emadi, ‘‘Classification and review of control strategies for plug-in hybrid electric vehicles,’’ IEEE Trans. Veh. Technol., vol. 60, no. 1, pp. 111–122, Jan. 2011.

[60] A. Ostadi, M. Kazerani, ‘‘A comparative analysis of optimal sizing of battery-only, ultracapacitor-only, and battery–ultracapacitor hybrid energy storage systems for a city bus,’’ IEEE Trans. Veh. Technol., vol. 64, no. 10, pp. 4449–4460, Oct. 2015.

[61] Y. Shekhar, A. Uddin Ahmad ‘‘A Performance Comparison study of Hybrid Electric Vehicle Between Type-1 and Type-2.0 FLC,’’ IEEE Trans. vol.23, pp.979-8-3503-9976-9/23, May-2023.

[62] E.R. Shukla, A. Uddin Ahmad, K. Sahay, ‘‘Fuel Cell and Solar Power Based Hybrid Electric Vehicle Using Fuzzy Controller,’’ IEEE Trans. vol.22, pp. 978-1-6654-5883-2/22, May-2022.

[63] V.K. Yadav, A. Uddin Ahmad, K. Sahay, ‘‘Performance Improvement of Hybrid Electric Vehicle Using Supercapacitors Energy Storage System,’’ JES. vol.233-245, pp. 18-2 (2022): 233-245, 2022.

[64] Y. Shekhar, A. Uddin Ahmad ‘‘A Novel Control Strategy of Electric Vehicle with Hybrid Energy Storage System using Interval Type 2.0 Fuzzy Logic Controller,’’ IJMTST. vol.22, pp. 8(09): 245-262, Sep-2022.

[65] Shaobo Xie , Xiaosong Hu ,Zongke Xin , James Brighton ‘‘Pontryagin’s Minimum Principle based Model Predictive Control of Energy Management for a Plug-In Hybrid Electric Bus,’’ Elsevier. vol.032, pp. 10.1016/j.apenergy.2018.