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Coordination of hybrid vehicles strategies to improve fuel consumption and reduce the economic cost

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ABSTRACT

To reduce fuel consumption and environmental pollution, this study focused on coordinating the use of a hybrid vehicle, that is, a bus type, powered by a diesel and electric engine. Solar cells have been added to the roof of the bus lighting, heating, and cooling, and fuzzy logic is applied to control the battery charge. Adding solar energy charge the battery by 25% of the total battery charge, thereby reducing fuel costs. The time was also calculated with the battery charge, and the battery is charge more. The aim of the research is to reduce environmental pollution and to use artificial intelligence to control the hybrid vehicle battery charge and speed.

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1. INTRODUCTION

In the last century, as a result of massive environmental pollution and oil and gas and automobile prices. Many researchers have sought to study environment and hybrid systems due to the pace of advances that have taken place in the area of energy and clean energy, via the exploration of issues in this field as well as used techniques. In these studies, the researchers applied four strategies to save battery charge, save fossil fuels, and smart control [1]. Energy management techniques have also emerged, including clean electric energy technologies[2], [3]. Moreover, designed a strategy for cost management, human resources, and in-kind risk management in the management of hybrid vehicles. They set a timetable for these strategies and obtained improved readiness and control on hybrid vehicles according to engineering quality and design construction [4]. So far, to highlight several technologies which have several goals to control more than one option. The example include: fuel consumption, electricity cost, battery charge status, shift frequency, exhaust emission temperature and associated gases, and problems of output engine torque, throttle position, gear shifting, powertrain dynamics, and fuel cost. The cost is calculated based on engine power and battery position. The performance of hybrid vehicles is improved through engine modeling (speed, angular velocity, and torque) additionally studied battery life and electricity cost [5]. Moreover, in this study researcher focuses examined the way to reduce the energy consumption of vehicles and congestion by making smart decisions from vehicles.

In the beginning, the problem of environmental guidance is discussion, and the best way for electric hybrid electric vehicles to reduce energy waste is examined. Then, many algorithms and simulations are proposed simulatously to plug-in hybrid electric vehicle reaching an optimal environmental road and control strategy. The powertrain is on this route, resulting in an inability to save power for vehicles with a near-instant execution time for algorithms [6]. Hence, this study used smart methods for energy management in hybrid electric vehicles the study plans a way to supply the battery with the required power and distributes a torque between energy sources to warm the battery and the hybrid drive system while considering, transmission and navigation systems. The researchers applied the neural network module design and training to learn the optimal state-oriented mechanisms of the state of charge (SOC), the researcher designed the fuzzy logic on the controller to track the direction of the SOC reference and compared the two methods. The results of fuzzy logic compared with the neural network module are better which reduce the fuel economy by 4.61-13.49% [7]. Additionally, the researchers studied the control strategies of hybrid vehicles in a mountainous area on a Toyota/Prius. The objective was to create good control strategies and methods through MATLAB simulation and build decision-making algorithms using fuzzy logic that provides many options. Including the possible use of global positioning system (GPS) in a mountainous logic. In a clear improvement in energy consumption, fuel consumption decreased by 16.16%, and the lowest percentage for electricity reached 14.36% [8].

The researchers studied the possibility of predictive control methods to reduce the cost of hybrid cars through an efficient design that covers energy requirements vehicle input system information (current location, time, 3D maps, and driving history) to determine the shape of the engine. The research aims to determine the size of the vehicle hybrid power train components and inverters, fuel tanks, and optimum vehicle operation. The study used a D-type hybrid vehicle with multi-wheel drive systems to operate independently, and optimized synchronization between online fuel consumption and forecasting the next step in a leadership role. This case allows forecasting of power distribution strategies and design optimization as part of the New European Drive Cycle (NEDC) [9], [10]. The researchers were interested in studying a hybrid car three different working modes, a pure engine, a four-wheel hybrid drive, and an electric drive using simulation in MATLAB software. Thus, the researcher developed a hybrid control strategy by applying the modular design method power strategy to manage parallel hybrid electric cars. This strategy is developed to improve the fuel consumption of hybrid electric vehicles. The results show that a dynamic programming DP-based energy management strategy (EMS) can reasonably and efficiently distribute engine torque to improve the fuel economy of hybrid electric vehicles and provide guidance on the control strategy [11].

The researchers focused on adapting control strategies to external road conditions and the need to install them more than others. The MATLAB program and fuzzy logic are applied to determine the ideal rules regarding the motor control strategy that already exists. And to prove its efficiency. Moreover, the researchers use strategies implemented to suit different types of uses with the need to maintain safety battery and maximum discharge state. This study presents an alternative approach to heavier control strategies that monopolize considerable computational power. This study also presents possibilities regarding situational and predictive algorithms based on route development [12]–[14]. Researchers have studied several strategies related to hybrid compounds to take advantage of uncontrolled charging (UC) and off-peak charging (OPC) charging methods. The maximum adjustable charge/discharge power over time was used and the original charging profile of electric vehicles was considered as the basis for estimating the elasticity the researchers found how to plan, manage and operate charging stations, and how to manage energy on demand and implement it in several different locations [15]. In this study, five different models were designed using the Simulink power-train blocket to obtain performance metrics that include acceleration, braking, driving range, fuel economy, and emission. Only one power train design that meets all performance goals was obtained. So the researchers tested five different designs using simulations and used energy management strategies in all designs [16]–[18]. The simulation results indicated that only one design was able to meet all criteria [19]. The researcher studies the conception and analysis the hybrid vehicle. In this study, the researchers studied and analyzed the concept of hybrid vehicles and explained the basic concepts involved in improving the control of hybrid vehicles using several methods (artificial intelligence, use of dynamic improvement and used MATLAB program virgin 2014).

2. PROBLEM STATEMENT

In this research, we study the problem of how to reduce fossil fuel consumption and environmental orientation are still important challenging, and also how to increase battery life. Also, in order to clarify our study by using our artificial intelligence and obtaining data from the University of Dhi Qar to determine the path of the hybrid vehicle. Choosing the best way to drive the vehicle and how to distribute charging stations within the university to facilitate vehicle operation and benefit from clean energy. Solar cells were added to the roof of the vehicle, and the results showed energy saving, increased battery life, and reduced environmental pollution.

3. WORK METHODOLOGY

Every project needs a methodology in order to be successful. It outlines the sequential actions that must be taken to produce the intended outcome. The technique was established following discussions with specialists and actual need requirements while considering the data being gathered [20], [21]. The methodology flow chart for the case study is shown in Figure 1.

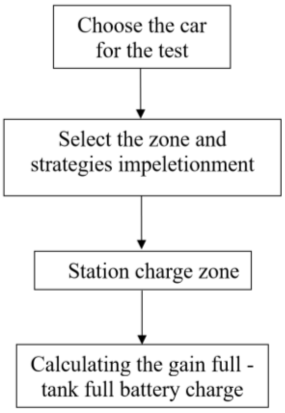


Figure 1. Flow chart of the steps of work experiment

3.1. Hybrid vehicle type

In this study, the researchers chose a hybrid car to highlight this technology, that is a type of bus, with a length of 8 m, containing an electric motor, drive system internal combustion engine (ICE), and a conventional combustion engine, which leads to lower fuel economy and better performance [22]. When barkers are used in a hybrid car, kinetic energy is converted into electrical energy, which is stored in a battery or super-capacity storage. The roof of the bus is made up of solar cells for interior and exterior lighting, in addition to cooling and heating. Table 1 shows the specifications of the bus. Energy consumption in vehicles depends on many different factors, including speed and acceleration.

Table 1. Specifications of the hybrid car

Motor	1PV5138-4W STYPE SIEMENS	AC 3Ø 85 KW
Solar type poly 250 w	1*646*1665 dimensions	1*640*960
Charge battery	Lithium iron phosphate	538 v 280 AH
Control system	SIEMENS	
Mange system	GPS/3G	

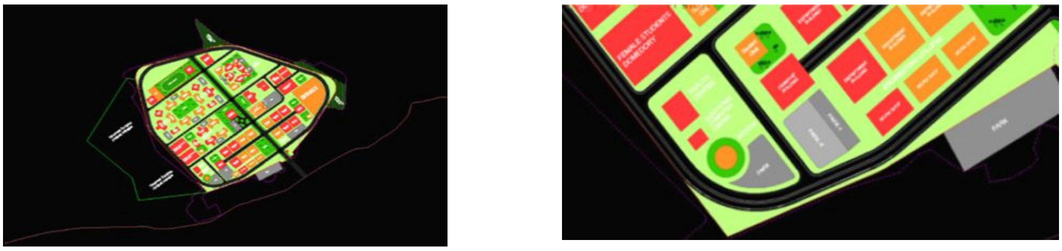
3.2. Selecting the zone

This research focuses on study of modern strategy was implemented at the Dhi QaR University, which is located to the west of Dhi Qar Governorate/Iraq. The area of the university is approximately 8 km^2 Figures 2(a) and 2(b) illustrate a map of Dhi Qar University. The path of the vehicle was determined from the main gate of the university and then to the departments affiliated with the university and the environmental orientation. The objective is to find the optimal way for the movement of the vehicle between two points and thus reduce the cost of fuel. This strategy reduces traffic congestion inside the university [23], [24]. The chart below represents a map of Dhi Qar University.

More than one energy storage device can be used to obtain good performance or increase fuel consumption and provide more efficient propulsion [25]. In addition, this case can prove e the fixed requirement of hybrid car (hybrid structure consisting a high component). Each energy storage device of a hybrid vehicle has different energy characteristic in a typical driving cycle or worst condition different energy characteristic. Energy density such as a rechargeable battery provides a middle ground and several energy storage systems. the energy storage device can be used for Leveraging the spatial versatility of vehicle-mounted battery storage devices (BSDs), they effectively bridge the gap between economically optimized planning in regular conditions and the provision of extra backup capacity in areas prone to extreme flooding hence a reduction of the total losses by Work on the adoption of Flywheels, Compressed air storage and superconductivity systems and Magnetic storage systems [26]–[28]. This research, used a type of lithium battery that bears the following specifications, as shown in Table 2.

Table 2. Specification of lithium battery

Parameter	Value
Battery	Lithium ion
Rate voltage	345.6
Control system	5.2 kwh
Rate energy capacity	15.04 h
Internal resistance	0.56104 Ω



(a) (b)

Figure 2. Overview of Dhi Qar University's campus: (a) provides an overall view showcasing the entire university campus and (b) offers a close-up image providing a detailed view of a particular street

3.3. Administration of direction coordination

The study represents the actual consumption of electric energy according to the specific path of the hybrid vehicle. Then, the real values of speed and battery charge can be measured, as shown in Figure 3. The costs of gasoline for a full tank, charging the battery, and the electricity consumed by the hybrid vehicle are calculate, as shown in Table 3.

In the beginning, we impose the movement of the hybrid vehicle from gate number 1 and passes through areas 2 and 3 sequentially. Then, the vehicle travels to the road of area 4 and then stops at station 1 to supply electrical energy. The vehicle continues toward the road 5, then 6-10 sequentially, the vehicle stops 5 minutes in each area to transport passengers (students). The vehicle’s travel speed ranges from (40 to 60 km/h) and we calculate the fuel spent from the vehicle’s running and time. We choose gate 1 and go to point 11, and the hybrid vehicle waits for a period of 5 minutes to transport students. The speed here is approximately 30 km/h. Then we choose the short path to reduce fuel consumption and maintain a longer rate battery charge. This path star form gate 1 and passes through the middle of the university until get 6 and 13–15. The hybrid vehicle can also use another lane to reduce traffic congestion, which is from gate 6 near station 2 to point 15. Through the middle road, the vehicle goes through points 15 and 14 and then returns to gate 1. Figure 4 shows the path of the vehicle.

Figure 3. Insulator bath in the Dhi Qar University

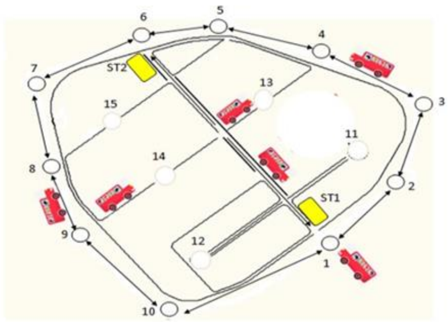


Figure 4. Path of the hybrid vehicle

Table 3. Calculate of hybrid vehicle

Total distance (km)	Km
Average speed (kph)	40 kph
Maximum speed(kph)	60 kph
State of battery charge	Full charge

We prove the validity of the study, by implementing the function of detecting the economic feasibility of the results based on diesel prices as of 11/2021. The average price globally is 1.12 dollars per liter. We use the following code 8. Strategies implemented can modify the transportation system, and through the equation that is shown in (1), the cost can be calculated and the best strategy can be determined.

$$G = \alpha\chi \ + \beta\Upsilon \tag{1}$$

G: the total price during the cycle in Iraq, α: the cost of gas in Iraq per liter, and β: the cost of electricity of battery in $. X and Y represent the gas economy during the cycle and economy during the cycle, expressed as % of battery gained. Table 4 shows the features of the driving courses used.

Table 4. Features of the driving courses used

Strategy	G (diesel)	G (electricity)	Battery charge	Strategy	G (diesel)	G (electricity)	Battery charge
1	1.16	0.04	2.2%	4	4.64	0. 16	1.9
2	2.32	0.08	2.4%	5	5.8	0. 20	0.95
3	3.48	0. 12	0	6	6.95	0. 24	0.85

4. RESULT

Via the exploration to highlight, this technology of application hybrid vehicle strategies, it appears to increase the savings of fossil fuels and increase the battery charge. The use of fuzzy logic in controlling battery charging has a significant impact on the ease of power deliver. Using solar energy for heating and cooling gradually until reaching the optimum level. We also found that it is possible to add many types of renewable energy.

Figure 5 shows the relationship between fuel and battery charging over time. Through the diagram, notably, when the hybrid vehicle starts, the fuel and battery charges are higher. Then both gradually decrease until at the peak of operation, and the battery charge reaches almost zero depending on the driving mode of the vehicle. Figure 6 illustrates the relationship between time and battery charge. The battery charge is highest at points 2, 4, 2, and 1.9, and then gradually decreases with time depending on fuel consumption.

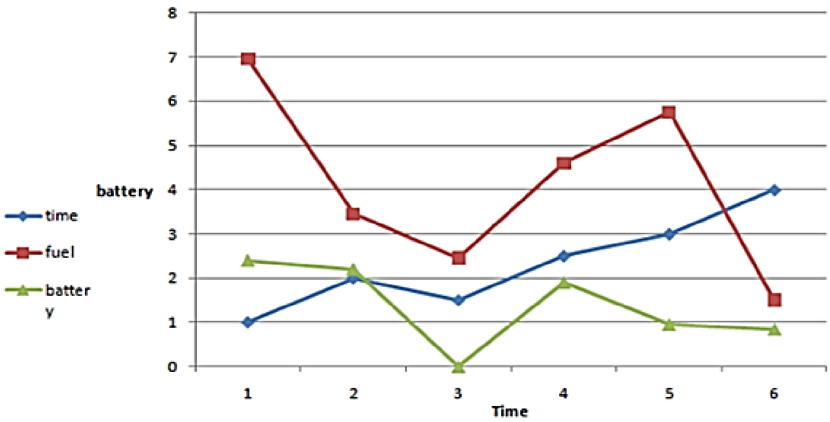


Figure 5. Relationship among fuel, battery, and time

In addition, the fuzzy Mamdani logic method illustrates that battery charges in three fuel inputs (solar, electric, and diesel) and one output charge battery. The method was used to control the battery charge. Diesel, electric, solar have three triangular membership functions in the range of [1-7], [0-1], and [0-1] gain respectively. The output battery charge has three member- ship functions in the range of [0 -2.4]. Moreover [h, mid, and low] represent the high, medium, and low charge battery respectively. Figures 7(a)-7(d) shows the membership function input diesel, electric, solar, and output battery charge.

In Figure 8 depicts the summation of the rules and the fuzzy logic of the fuel charge the battery. The state of charging the battery varies according to the variables of the fuel used. The battery can be charged by electricity or diesel. Figure 9 shows the surface among electric, diesel, and battery.

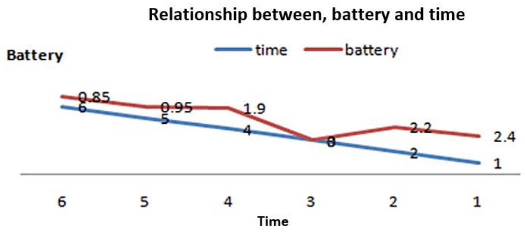


Figure 6. Relationship between battery and time

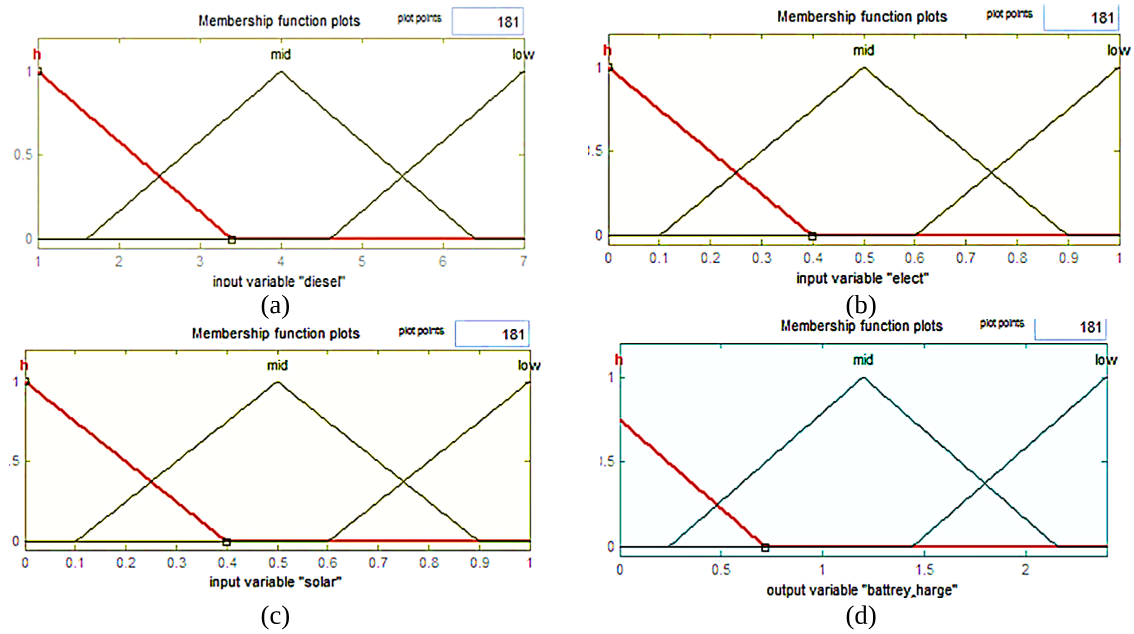


Figure 7. Membership functions for input and output parameters: (a) membership function for input diesel, (b) membership function for input electric, (c) membership function for input solar, and (d) membership function for output battery charge

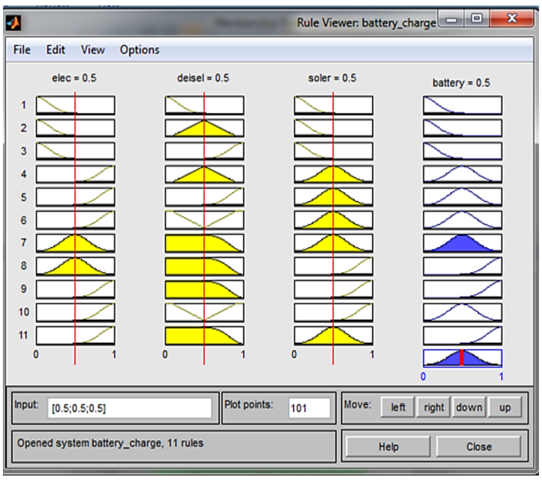


Figure 8. Control strategy of the logic rules

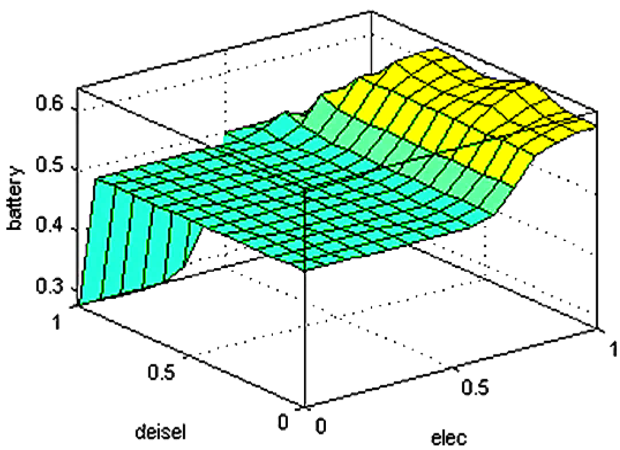


Figure 9. Surface among electric, diesel, and battery

5. CONCLUSION

This study mainly aims. To apply the strategy of hybrid vehicles in Dhi Qar University which has an area of 8 km^2. The study calculates the cost of diesel and electricity to charge a battery. Then, the study adds solar energy to charge the battery by 25% to reduce fuel costs. The time was also calculated with the battery charge, and notably, the battery was charge more. A simulation MATLAB of a hybrid vehicle a track was developed covering the university area. Fuzzy logic was used to control battery charge and reduce fuel consumption. The best way was to be in the middle near the charging stations (1,2) and reduce fuel expenditure. This strategy can be implemented in real time to determine the optimal path for a hybrid vehicle. Future studies can apply this work in Nasiryah City using algorithm to indicated optimal path. Hence, additional studies that extensively focus on also that it is possible to add many types of renewable energy, should be conducted.

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REFERENCES

[1] K. D. Huang, M.-K. Nguyen, and P.-T. Chen, "A Rule-Based Control Strategy of Driver Demand to Enhance Energy Efficiency of Hybrid Electric Vehicles," *Applied Sciences*, vol. 12, no. 17, 2022.

[2] M. İnci, M. Büyük, M. H. Demir, and G. İlbey, "A review and research on fuel cell electric vehicles: Topologies, power electronic converters, energy management methods, technical challenges, marketing and future aspects," *Renewable and Sustainable Energy Reviews*, vol. 137, 2021.

[3] S. T. Meraj, S. S. Yu, M. S. Rahman, K. Hasan, M. S. H. Lipu, and H. Trinh, "Energy management schemes, challenges and impacts of emerging inverter technology for renewable energy integration towards grid decarbonization," *Journal of Cleaner Production*, 2023.

[4] X. Hu, T. Liu, X. Qi, and M. Barth, "Reinforcement learning for hybrid and plug-in hybrid electric vehicle energy management: Recent advances and prospects," *IEEE Industrial Electronics Magazine*, vol. 13, no. 3, pp. 16–25, Sep. 2019, doi: 10.1109/MIE.2019.2913015.

[5] H. Tian, X. Wang, Z. Lu, Y. Huang, and G. Tian, "Adaptive fuzzy logic energy management strategy based on reasonable SOC reference curve for online control of plug-in hybrid electric city bus," *IEEE Transactions on Intelligent Transportation Systems*, vol. 19, no. 5, pp. 1607–1617, May 2018, doi: 10.1109/TITS.2017.2729621.

[6] S. S. Abosuliman and A. O. Almagrabi, "Routing and scheduling of intelligent autonomous vehicles in industrial logistics systems," *Soft Computing*, vol. 25, no. 18, pp. 11975–11988, Sep. 2021, doi: 10.1007/s00500-021-05633-4.

[7] S. Brouk, M. Buey, S. Ly, M. Pedron, and S. Burgalat, "Control strategies for hybrid vehicles in mountainous areas," in *Procedia Computer Science*, 2015, vol. 60, pp. 284–291.

[8] P. Dong *et al.*, "Practical application of energy management strategy for hybrid electric vehicles based on intelligent and connected technologies: Development stages, challenges, and future trends," *Renewable and Sustainable Energy Reviews*, vol. 170, Dec. 2022, doi: 10.1016/j.rser.2022.112947.

[9] Z. Dimitrova, "Predictive and holistic energy distribution for hybrid electric vehicles," *MATEC Web of Conferences*, vol. 133, Nov. 2017, doi: 10.1051/matecconf/201713302002.

[10] B. Xu *et al.*, "Parametric study on reinforcement learning optimized energy management strategy for a hybrid electric vehicle," *Applied Energy*, vol. 259, Feb. 2020, doi: 10.1016/j.apenergy.2019.114200.

[11] Y. Tian, J. Liu, Q. Yao, and K. Liu, "Optimal control strategy for parallel plug-in hybrid electric vehicles based on dynamic programming," *World Electric Vehicle Journal*, vol. 12, no. 2, Jun. 2021, doi: 10.3390/wevj12020085.

[12] H. Lin *et al.*, "Characteristics of electric vehicle charging demand at multiple types of location - Application of an agent-based trip chain model," *Energy*, vol. 188, Dec. 2019, doi: 10.1016/j.energy.2019.116122.

[13] E. Hossain, D. Murtaugh, J. Mody, H. M. R. Faruque, M. S. Haque Sunny, and N. Mohammad, "A Comprehensive Review on Second-Life Batteries: Current State, Manufacturing Considerations, Applications, Impacts, Barriers & Potential Solutions, Business Strategies, and Policies," *IEEE Access*, vol. 7, pp. 73215–73252, 2019, doi: 10.1109/ACCESS.2019.2917859.

[14] Y. Chen *et al.*, "A review of lithium-ion battery safety concerns: The issues, strategies, and testing standards," *Journal of Energy Chemistry*, vol. 59, pp. 83–99, Aug. 2021, doi: 10.1016/j.jechem.2020.10.017.

[15] J. P. Torreglosa, P. Garcia-Triviño, D. Vera, and D. A. López-García, "Analyzing the improvements of energy management systems for hybrid electric vehicles using a systematic literature review: how far are these controls from rule-based controls used in commercial vehicles?," *Applied Sciences*, vol. 10, no. 23, Dec. 2020, doi: 10.3390/app10238744.

[16] A. García, P. Carlucci, J. Monsalve-Serrano, A. Valletta, and S. Martínez-Boggio, "Energy management optimization for a power-split hybrid in a dual-mode RCCI-CDC engine," *Applied Energy*, vol. 302, Nov. 2021, doi: 10.1016/j.apenergy.2021.117525.

[17] W. Mo, P. D. Walker, and N. Zhang, "Dynamic analysis and control for an electric vehicle with harpoon-shift synchronizer," *Mechanism and Machine Theory*, vol. 133, pp. 750–766, Mar. 2019, doi: 10.1016/j.mechmachtheory.2018.11.018.

[18] R. Capata, "Urban and extra-urban hybrid vehicles: A technological review," *Energies*, vol. 11, no. 11, p. 2924, Oct. 2018, doi: 10.3390/en11112924.

[19] X. Lü *et al.*, "Energy management of hybrid electric vehicles: A review of energy optimization of fuel cell hybrid power system based on genetic algorithm," *Energy Conversion and Management*, vol. 205, Feb. 2020, doi: 10.1016/j.enconman.2020.112474.

[20] J. M. Jalil, G. A. Aziz, and A. A. Kadhim, "Experimental and numerical study to enhance of heat transfer coefficient in air flow using microchannel," *Journal of University of Babylon for Engineering Sciences*, vol. 26, no. 7, pp. 112–123, 2018.

[21] S. S. Gharehveran, S. G. Zadeh, and N. Rostami, "Resilience-oriented planning and pre-positioning of vehicle-mounted energy storage facilities in community microgrids," *Journal of Energy Storage*, vol. 72, p. 108263, Nov. 2023, doi: 10.1016/j.est.2023.108263.

[22] T. P. Barbosa, J. J. Eckert, V. R. Roso, F. J. P. Pujatti, L. A. R. da Silva, and J. C. Horta Gutiérrez, "Fuel saving and lower pollutants emissions using an ethanol-fueled engine in a hydraulic hybrid passengers vehicle," *Energy*, vol. 235, Nov. 2021, doi: 10.1016/j.energy.2021.121361.

[23] S. Jing, F. Hui, X. Zhao, J. Rios-Torres, and A. J. Khattak, "Cooperative game approach to optimal merging sequence and on-ramp merging control of connected and automated vehicles," *IEEE Transactions on Intelligent Transportation Systems*, vol. 20, no. 11, pp. 4234–4244, Nov. 2019, doi: 10.1109/TITS.2019.2925871.

[24] M. Li, Z. Cao, and Z. Li, "A reinforcement learning-based vehicle platoon control strategy for reducing energy consumption in traffic oscillations," *IEEE Transactions on Neural Networks and Learning Systems*, vol. 32, no. 12, pp. 5309–5322, Dec. 2021, doi: 10.1109/TNNLS.2021.3071959.

[25] D. D. R. Pena, "Railway infrastructure simulation software test and validation," Univesidad De Oviedo, 2018.

[26] O. Portugall, S. Krämer, and Y. Skourski, "Magnetic fields and measurements," in *Handbook of Magnetism and Magnetic Materials*, Cham: Springer International Publishing, 2021, pp. 1–70. doi: 10.1007/978-3-030-63101-7_24-1.

[27] K. Y. Huang, "The mechanical properties of Y-Ba-Cu-O and Gd-Ba-Cu-O / Ag bulk superconductor magnets," University of Cambridge, 2021. doi: 10.17863/CAM.79712.

[28] Z. Zhu *et al.*, "Rechargeable batteries for grid scale energy storage," *Chemical Reviews*, vol. 122, no. 22, pp. 16610–16751, Nov. 2022, doi: 10.1021/acs.chemrev.2c00289.

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