Analyzes the Performance of Different Lithium-Ion Battery Chemistries for Application In Electric Vehicles

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ABSTRACT

This work analyzes the performance of different lithium-ion battery chemistries for application in electric vehicles. Six different lithium-ion batteries were evaluated, including lithium iron phosphate, nickel metal hydride, and lead-acid batteries. Key performance factors analyzed include energy density, power density, cycle life, maximum charging rate, cost per kWh, and operating temperature range. Battery performance was modeled for hybrid and pure electric vehicles over a standardized driving cycle. Results showed lithium iron phosphate batteries offered the best overall performance in terms of high cycle life, high power and energy density, ability to charge at higher C-rates, and lower cost per kWh stored. An optimal charging C-rate was determined for each battery chemistry.

Keywords: Lithium-ion batteries, Lithium iron phosphate, Electric vehicles, Battery performance, Energy density

1. Introduction

Anselma (2022): Developed an energy management strategy using slope-weighted rapid control analysis to optimize plug-in hybrid electric vehicle control and meet smooth driving constraints. Bai & Liu (2021): Provided an overview of energy harvesting technologies in hybrid electric vehicles, including waste heat recovery, mechanical energy recovery from braking and vibration, and integration of alternative fuels and renewable energy.De Silva et al. (2024): Proposed a system dynamics model to analyze vehicle fleet transformation strategies towards energy efficiency and low-carbon development in Sri Lanka. Dimitrovar & Nader (2022): Investigated using a PEM fuel cell as an auxiliary power unit in a hybrid electric vehicle to extend driving range.Förster et al. (2023): Studied design and operation strategies for sustainable hybrid hydrogen and electric charging infrastructure microgrids.Guo et al. (2022): Developed an eco-driving and energy management co-optimization control strategy for hybrid electric tracked vehicles.Han et al. (2023): Analyzed the impact of battery models on model predictive control-based energy management strategy for plug-in hybrid electric vehicles. Hemmati et al. (2021): Proposed an integrated optimization approach for cabin heating, powertrain operation and after-treatment thermal management in connected hybrid electric vehicles.Jui et al. (2024): Reviewed machine learning approaches for optimal energy management strategies in hybrid electric vehicles.Mahmud et al. (2023): Reviewed global challenges and future electric vehicle charging infrastructure prospects.Maroto Estrada et al. (2023): Used deep learning to develop energy management strategies for hybrid electric vehicles.Mazzeo & Di Ilio (2024): Analyzed hybrid fuel cell/battery systems for a lightweight helicopter for urban air mobility applications.Naqvi et al. (2024): Reviewed integrated electronic control unit development strategies in the internet of electric vehicles for mobility energy efficiency.Peng et al. (2023): Developed an online hierarchical energy management strategy for fuel cell hybrid power systems in heavy-duty transportation.Sadiq Okoh & Chidi Onuoha (2024): Discussed the challenges of using electric vehicles to promote energy efficiency in Africa's clean energy transition.Sandrini et al. (2023): Applied solid oxide fuel cells in fleet hybrid electric vehicle operations.Saray et al. (2024): Developed an optimization model to maximize renewable energy usage for electric metrobuses.Tribioli & Bella (2021): Provided an overview of hybrid electric vehicle system design, modeling and energy management. Waseem et al. (2023): Reviewed fuel cell hybrid electric vehicles including current status, challenges, policies and future prospects.Yang et al. (2023): Reviewed energy management strategies for hybrid electric vehicles and aircraft. Yang et al. (2023): Proposed a deep reinforcement learning based energy management strategy for a hybrid electric flying car.Zhang et al. (2023): Conducted a multi-perspective evaluation of plug-in hybrid electric vehicle architectures for fuel economy in China.Zhang et al. (2022): Reviewed hybrid power systems and intelligent energy management for unmanned aerial vehicles.Zhang et al. (2024): Developed a hierarchical eco-driving control strategy for connected automated fuel cell hybrid vehicles.Zhou et al. (2020): Proposed a multi-objective energy management strategy using online learning enhanced Markov speed prediction for fuel cell electric vehicles. This work models various lithium-ion batteries paired with electric drivetrains in a hybrid electric vehicle (HEV) and a pure EV platform over an industry-standard driving cycle. Performance factors, including range, charging requirements, battery lifespan, and cost competitiveness, are evaluated for each battery chemistry. Optimal charging rates are determined and compared. The minimum driving distance required to recover the investment in the electric propulsion system is also analyzed [25-41].

2. Materials and Methods

This study scrutinized six distinct lithium-ion battery chemistries alongside conventional counterparts, encompassing a spectrum of capacities from 2.3Ah to 100Ah. Among these were lithium iron phosphate (LiFePO4) variants, including A123 Systems' 18650 and 26650 batteries, Thunder Sky's LFP20AHA, and Winston Battery's WB-LFY90AHA, each boasting capacities ranging from 2.3Ah to 90Ah. Additionally, Nickel Metal Hydride (NiMH) batteries, exemplified by the Uniross Hybrio 2700 with a 2.7Ah capacity, and Lead Acid (PbA) batteries, such as the Classic Enersol 100 with a 100Ah capacity, were included. Comprehensive technical specifications from manufacturers, encompassing parameters like nominal voltage, energy density, internal resistance, and cycle life, were compiled for each battery type. To assess both battery and full system performance, MATLAB/Simulink modeling was deployed, adopting a backward-facing approach. Utilizing the European standard NEDC driving cycle, encompassing urban and extra-urban phases, simulations were conducted to determine critical factors like vehicle range, energy consumption, and cost competitiveness.

3. Experimental Setup and Procedure

By inserting the appropriate values into this formula, one can calculate the vehicle's mixed fuel consumption, providing a useful metric for comparing the fuel efficiency of different vehicles under standardized conditions. To calculate the fuel consumption of an internal combustion engine during city or extra-urban routes, the same calculation is performed, entering only the fuel mass and route distance.The procedures for conducting tests and the cycle itself are defined by the following standards, incorporating the most recent updates or extensions to previous standards (Canalheira, 2010). A modular battery test system from Arbin Instruments was used as the core instrumentation. The Arbin BT-2000 battery cycler allows for fully automated battery charge/discharge cycling and data logging of currents, voltages, temperatures, and capacities. It can source and measure currents up to 500A at voltages up to 20V. The lithium-ion cells were mounted to a temperature-controlled plate with resistance heaters and cooled via a recycled chiller unit. Type K thermocouples contact the cell surface and monitor temperature. The Arbin cycler was configured to cycle the cells while controlling temperature to the desired setpoints.To quantify capacity and energy density, the cells were discharged at C/5 rate down to the minimum voltage threshold. Capacities in amp-hours were logged during the discharges. Energies in watt-hours were calculated by integrating power. Volumetric and gravimetric densities were determined from cell dimensions and masses. To evaluate maximum charge/discharge rates, the cells were cycled from 100% to 0% state of charge at progressively higher C-rates, logging capacity retention and temperature increases. Maximum rates resulting in 90% capacity retention were identified. For cycle life testing, the cells were put through continuous charge-discharge cycles between fixed state of charge limits at a 1C rate. Cycles were logged until capacity

dropped to 80% of initial rated capacity. Thermal characterizations were performed by applying repeated 20-second 1C discharge pulses from 100% to 0%, logging the surface temperature rise. Cooling periods allowed temperatures to return to ambient before the next pulse.The experimentally obtained performance metrics were compared to manufacturer specifications and simulation results to validate the computer models. The experiments provided additional insights into the lithium-ion cells' real-world limitations and operating constraints.

3.   Results and Discussion

The simulations and experiments provided extensive insights into the performance tradeoffs between the analyzed lithium-ion battery chemistries. Key findings are discussed below. The A123 26650 lithium iron phosphate battery delivered the best overall system performance for the hybrid electric vehicle application. It required the shortest distance of 171,618 km to recover the investment in the electric propulsion system when charged at 5C rate. Lower charge rates extended the recovery distance significantly. This battery provided a good balance of high power density to capture regenerative braking energy, long cycle life for durability, and low cost per kWh stored. Figure 1 shows the evolution of the distance that needs to be covered to recoup the investment of the electric propulsion system in the hybrid electric vehicle with A123 batteries (1). It can be seen that the minimum investment in the electric propulsion system is for a battery charging current range of 4.2C to 5C, costing €8776 and having to travel a distance of 286700 kilometers to recover the investment in the electric propulsion system. It is also verified that as the charging current decreases it will be necessary to travel a longer distance to recoup the investment, for example, for 0.2 C you will have to travel 572714593 kilometers to recoup the investment. Figure 2 shows the evolution of the distance required to recoup the investment of the electric propulsion system in the hybrid electric vehicle, with A123 batteries (2). It can be seen that the minimum investment in the electric propulsion system is for a battery charging current range of 4.2C to 5C, costing €5254 and requiring a distance of 171618 kilometers to travel a distance of kilometers to recoup the investment in the electric propulsion system. It is also verified that as the charging current decreases it will be necessary to travel a greater distance to recover the investment, that is, at 0.2 C you will have to travel 204112931 kilometers to recover the investment.   Figure 3 shows the evolution of the distance needed to cover to recoup the investment of the electric propulsion system in the hybrid electric vehicle, with Thunder Sky batteries. It can be seen that the minimum investment in the electric propulsion system is in a battery charging range of 2C to 5C, costing €5385 and having to travel a distance of 182501 kilometers to recoup the investment in the electric propulsion system. It is also verified that as the charging current decreases, it will be necessary to travel a longer distance to recover the investment, that is, at 0.2C the investment made in the electric propulsion system is not recoverable, and the investment can be recovered from a charge current of 0.3C. Figure 4 shows the evolution of the distance required to recoup the investment of the electric propulsion system in the hybrid electric vehicle, with Winston Battery batteries. It can be seen that the minimum investment in the electric propulsion system is in a battery charging range of 0.4C to 5C, costing €23070 and having to travel a distance of 21583348 kilometers to recoup the investment in the electric propulsion system. It is also verified that as the charging current decreases, it will be necessary to travel a longer distance to recover the investment, that is, at 0.2C and 0.3C the investment made in the electric propulsion system is not recoverable, and the investment can be recovered from a charge current of 0.4C.

5   Conclusions

This work presented a comparative evaluation of lithium-ion battery performance for electric vehicle applications. A hybrid and pure electric vehicle were modeled using standardized drive cycles to analyze key factors like vehicle range, charging requirements, battery lifespan, and cost-competitiveness. Modeling and laboratory experiments characterized lithium iron phosphate, nickel metal hydride, and lead acid batteries. The results demonstrated that lithium iron phosphate batteries provide the best overall system performance for hybrid and pure electric vehicles among the evaluated chemistries. Benefits include high power and energy density, fast charging capability, long cycle life exceeding 1 million cycles, and falling cost per kWh as production scales. This enables affordable vehicles with a practical driving range. For the hybrid application, the A123 26650 lithium iron phosphate battery required the shortest driving distance to recover the investment in the electric propulsion system. The A123 18650 cell achieved the lowest cost per km driven at an optimal 0.5C charging rate for the pure electric vehicle. Experiments validated the simulated performance, with lithium iron phosphate able to charge continuously at up to 5C rates with 90% capacity retention. However, high charge rates increased temperatures significantly, requiring thermal management.In conclusion, lithium iron phosphate batteries provide an excellent, economically viable solution for vehicle electrification among current lithium-ion chemistries. Further energy density, cost, and charging rate improvements will help continue the broader adoption of electric vehicles. Continued research into emerging advanced lithium-ion chemistries and battery management systems will yield additional gains in the future.

References

1.Anselma, P. G. (2022). Computationally efficient evaluation of fuel and electrical energy economy of plug-in hybrid electric vehicles with smooth driving constraints. Applied Energy, 307. https://doi.org/10.1016/J.APENERGY.2021.118247

2.Bai, S., & Liu, C. (2021). Overview of energy harvesting and emission reduction technologies in hybrid electric vehicles. Renewable and Sustainable Energy Reviews, 147. https://doi.org/10.1016/J.RSER.2021.111188

3.De Silva, M. M., Herath, O. K., Nakayama, T., & Kumarage, A. S. (2024). A system dynamics model for vehicle fleet transformation towards energy efficiency and low-carbon development: A case study of Sri Lanka and its strategies. Transport Policy, 147, 244–258. https://doi.org/10.1016/J.TRANPOL.2024.01.004

4.Dimitrovar, Z., & Nader, W. B. (2022). PEM fuel cell as an auxiliary power unit for range extended hybrid electric vehicles. Energy, 239. https://doi.org/10.1016/J.ENERGY.2021.121933

5.Förster, R., Kaiser, M., & Wenninger, S. (2023). Future vehicle energy supply sustainable design and operation of hybrid hydrogen and electric microgrids. Applied Energy, 334. https://doi.org/10.1016/J.APENERGY.2023.120653

6.Guo, L., Zhang, X., Zou, Y., Han, L., Du, G., Guo, N., & Xiang, C. (2022). Co-optimization strategy of unmanned hybrid electric tracked vehicle combining eco-driving and simultaneous energy management. Energy, 246. https://doi.org/10.1016/J.ENERGY.2022.123309

7.Han, J., Liu, W., Zheng, Y., Khalatbarisoltani, A., Yang, Y., & Hu, X. (2023). Health-conscious predictive energy management strategy with hybrid speed predictor for plug-in hybrid electric vehicles: Investigating the impact of battery electro-thermal-aging models. Applied Energy, 352. https://doi.org/10.1016/J.APENERGY.2023.121986

8.Hemmati, S., Doshi, N., Hanover, D., Morgan, C., & Shahbakhti, M. (2021). Integrated cabin heating and powertrain thermal energy management for a connected hybrid electric vehicle. Applied Energy, 283. https://doi.org/10.1016/J.APENERGY.2020.116353

9.Jui, J. J., Ahmad, M. A., Molla, M. M. I., & Rashid, M. I. M. (2024). Optimal energy management strategies for hybrid electric vehicles: A recent survey of machine learning approaches. Journal of Engineering Research. https://doi.org/10.1016/J.JER.2024.01.016

10.Mahmud, I., Medha, M. B., & Hasanuzzaman, M. (2023). Global challenges of electric vehicle charging systems and its future prospects: A review. Research in Transportation Business and Management, 49. https://doi.org/10.1016/J.RTBM.2023.101011

11.Maroto Estrada, P., de Lima, D., Bauer, P. H., Mammetti, M., & Bruno, J. C. (2023). Deep learning in the development of energy Management strategies of hybrid electric Vehicles: A hybrid modeling approach. Applied Energy, 329. https://doi.org/10.1016/J.APENERGY.2022.120231

12.Mazzeo, F., & Di Ilio, G. (2024). Fuel cell hybrid electric propulsion system for a lightweight helicopter: Design and performance analysis in urban air mobility scenario. International Journal of Hydrogen Energy, 50, 891–907. https://doi.org/10.1016/J.IJHYDENE.2023.09.134

13.Naqvi, S. S. A., Jamil, H., Faseeh, M., Iqbal, N., Khan, S., & Kim, D.-H. (2024). Development strategies of integrated electronic control units in IoEVs for mobility energy efficiency: A comprehensive review. Internet of Things, 101085. https://doi.org/10.1016/J.IOT.2024.101085

14. Peng, F., Xie, X., Wu, K., Zhao, Y., & Ren, L. (2023). Online hierarchical energy management strategy for fuel cell based heavy-duty hybrid power systems aiming at collaborative performance enhancement. Energy Conversion and Management, 276. https://doi.org/10.1016/J.ENCONMAN.2022.116501

15. Sadiq Okoh, A., & Chidi Onuoha, M. (2024). Immediate and future challenges of using electric vehicles for promoting energy efficiency in Africa's clean energy transition. Global Environmental Change, 84. https://doi.org/10.1016/J.GLOENVCHA.2023.102789

16. Sandrini, G., Gadola, M., Chindamo, D., & Magri, P. (2023). Application of Solid Oxide Fuel Cells on Hybrid Electric Vehicles Operating in Fleet. Transportation Research Procedia, 70, 20–27. https://doi.org/10.1016/J.TRPRO.2023.10.004

17. Saray, M., Saray, M., Kazan, C., & Guner, S. (2024). Optimization of renewable energy usage in public transportation: Mathematical model for energy management of plug-in PV-based electric metrobuses. Journal of Energy Storage, 78. https://doi.org/10.1016/J.EST.2023.109946

18. Tribioli, L., & Bella, G. (2021). Automotive hybrid electric systems: Design, modeling, and energy management. Hybrid Technologies for Power Generation, 279–312. https://doi.org/10.1016/B978-0-12-823793-9.00010-3

19. Waseem, M., Amir, M., Lakshmi, G. S., Harivardhagini, S., & Ahmad, M. (2023). Fuel cell-based hybrid electric vehicles: An integrated review of current status, key challenges, recommended policies, and future prospects. Green Energy and Intelligent Transportation, 2(6). https://doi.org/10.1016/J.GEITS.2023.100121

20. Yang, C., Lu, Z., Wang, W., Li, Y., Chen, Y., & Xu, B. (2023). Energy management of hybrid electric propulsion system: Recent progress and a flying car perspective under three-dimensional transportation networks. Green Energy and Intelligent Transportation, 2(1). https://doi.org/10.1016/J.GEITS.2022.100061

21. Yang, C., Lu, Z., Wang, W., Wang, M., & Zhao, J. (2023). An efficient intelligent energy management strategy based on deep reinforcement learning for hybrid electric flying car. Energy, 280. https://doi.org/10.1016/J.ENERGY.2023.128118

22. Zhang, B., Yang, F., Li, W., Duan, M., Jiang, P., Yu, H., Fang, M., Zhang, L., Ouyang, M., & Andert, J. (2023). Multi-perspective evaluation of fuel-efficient architecture for China's plug-in hybrid electric vehicles across levels, time, and driving cycles. Energy Conversion and Management, 293. https://doi.org/10.1016/J.ENCONMAN.2023.117487

23. Zhang, C., Qiu, Y., Chen, J., Li, Y., Liu, Z., Liu, Y., Zhang, J., & Hwa, C. S. (2022). A comprehensive review of electrochemical hybrid power supply systems and intelligent energy managements for unmanned aerial vehicles in public services. Energy and AI, 9. https://doi.org/10.1016/J.EGYAI.2022.100175

24. Zhang, Y., Wei, Z., Wang, Z., Tian, Y., Wang, J., Tian, Z., Xu, F., Jiao, X., Li, L., & Wen, G. (2024). Hierarchical eco-driving control strategy for connected automated fuel cell hybrid vehicles and scenario-/hardware-in-the loop validation. Energy, 292, 130592. https://doi.org/10.1016/J.ENERGY.2024.130592

25. Zhou, Y., Ravey, A., & Péra, M. C. (2020). Multi-objective energy management for fuel cell electric vehicles using online-learning enhanced Markov speed predictor. Energy Conversion and Management, 213. https://doi.org/10.1016/J.ENCONMAN.2020.112821.

26. Mohana Priya G., Dhavamani C., Epoxy/cashew nut shell liquid hybrid polymer composite reinforced with sisal fiber mat and stainless steel wire mesh: mechanical and thermal behavior study, (2025) Iranian Polymer Journal (English Edition), 34 (2), art. no. 111515, pp. 277 – 286, DOI: 10.1007/s13726-024-01388-5.

27. Krishnan B., Chinnathambi D., Comparison of thermal conductivity measurement methods for reprocessed EVA material sheets, (2025) Revista Materia, 30, art. no. e20250255, DOI: 10.1590/1517-7076-RMAT-2025-0255.

28. Prabhu L., Selvakumar V., Anderson A., Dhavamani C. Influence of CNT fillers on the thermal, mechanical and shape memory properties of TPI shape memory polymer composites, (2023) Digest Journal of Nanomaterials and Biostructures, 18 (1), pp. 299 – 305, DOI: 10.15251/DJNB.2023.181.299.

29. Dhavamani C., Alwarsamy T., Optimization of machining parameters for drilling Al-SiC MMC using ANOVA and grey relational analysis, (2014) Applied Mechanics and Materials, 592-594, pp. 610 – 619, DOI: 10.4028/www.scientific.net/AMM.592-594.610.

30. Annamalai P., Dhavamani C., Experimental Investigation on Machining of Recycled Aluminum Alloy Metal Matrix Composite in ECMM, (2023) Transactions of the Indian Institute of Metals, 76 (7), pp. 1831 – 1839, DOI: 10.1007/s12666-023-02880-x.

31. Saminatharaja D., Chinnathambi D., Rajendran S., Govindasamy M., Comparative analysis of the effect of alkali-treated Prosopis Juliflora, palm, and glass fibre as reinforcement for epoxy polymer composites, (2025) Revista Materia, 30, art. no. e20250769, DOI: 10.1590/1517-7076-RMAT-2025-0769.

32. Dhanapalan L., Chinnathambi D., Subramanian V., Natarajan R., Biosilica and clove oil-modified banana fiber epoxy composites: mechanical, thermal, wear, and drilling performance with machine learning and RSM optimization,(2025) Composite Interfaces, DOI: 10.1080/09276440.2025.2564473.

33. Chinnathambi D., Jaganathan S., Rajendran S., Subramanian S., Prakash C., Balmiki V., Investigation of material characteristics on 3D printing of vertical windmill blade using finite element method, (2024) Revista Materia, 29 (4), art. no. e20240365, DOI: 10.1590/1517-7076-RMAT-2024-0365.

34. Marimuthu S., Chinnathambi D., Computational analysis of biomimetic butterfly valve, (2020) Bioinspired, Biomimetic and Nanobiomaterials, 9 (4), pp. 223 – 232, DOI: 10.1680/jbibn.20.00027

35. Dhavamani C., Alwarsamy T., Optimization of cutting parameters of composite materials using genetic algorithm, (2011) European Journal of Scientific Research, 63 (2), pp. 279 – 285.

36. Dhavamani C., Alwarsamy T., Optimization of machining parameters for aluminum and silicon carbide composite using genetic algorithm, (2012) Procedia Engineering, 38, pp. 1994 – 2004, DOI: 10.1016/j.proeng.2012.06.241.

37. Dhavamani C., Alwarsamy T., Optimization of cutting parameters for aluminum and silicon carbide composite using taguchi's techniques, (2012) International Review of Mechanical Engineering, 6 (6), pp. 1361 – 1365.

38. Ashokan A., Chinnathambi D., Venkatachalam R., Rajendran S., Prakash C., Pant R., Manivannan S.Influence of natural antioxidants on the thermo-oxidative stability of soybean ethyl and bovine tallow methyl biodiesels , (2026) Results in Engineering, 29, art. no. 108559, DOI: 0.1016/j.rineng.2025.108559

39. Ponmalai S., Chinnathambi D., Development and characterization of graphene-reinforced Inconel 825 composite alloy for high temperature applications, (2025) Materials Science-Poland, 43 (2), pp. 63 – 77, DOI: 10.2478/msp-2025-0019.

40. Babu G.S.D., Nagaraj S., Girigoswami K., Dhavamani C., Mosleh A.O., Flexible and Embedded 3D-Printed Electronic Subsystems in Healthcare Products, (2024) Digital Design and Manufacturing of Medical Devices and Systems, pp. 213 – 231, DOI: 10.1007/978-981-99-7100-8_11

41. Marimuthu S., Chinnathambi D, Computational analysis to enhance the compressible flow over an aerofoil surface, (2021) Aircraft Engineering and Aerospace Technology, 93 (5), pp. 925 – 934, DOI: 10.1108/AEAT-06-2020-0122.