Eduvest – Journal of Universal Studies
Volume 5 Number 7, July, 2025
p- ISSN 2775-3735- e-ISSN 2775-3727

Improving Green Cost Performance in Nickel Smelter Buildings in Accordance with Breeam Guidelines Based on Zero Energy Building (ZEB)

Arya Dwi Dharmaputra[1], Abdul Charis[2], Muhammad Rifki Rahman[3]
Faculty of Engineering, Universitas Mercu Buana, Indonesia[123]
Email: 55722120010@mercubuana.ac.id[1], 55722120020@mercubuana.ac.id[2], 55723110025@mercubuana.ac.id[3]

ABSTRACT

The construction of green smelters, driven by the increasing annual demand for nickel-based vehicles, poses a significant threat to the global environment, particularly through the rise in greenhouse gas emissions. To address this challenge, Indonesia must intensify its sustainability efforts across all construction projects, aligning with the Sustainable Development Goals 2030 target of achieving 100% new buildings based on green concepts. This study employs the BREEAM-based green building framework, incorporating Zero Energy Building (ZEB) principles, and analyzes data using Structural Equation Modelling – Partial Least Square (SEM-PLS). The findings indicate that achieving green ratings can increase project costs by 7.66% to 17.91% compared to conventional construction. The study identifies ten critical factors influencing green cost performance, including energy efficiency and emission reduction, indoor air quality, and water use efficiency. Implementing the BREEAM framework with the ZEB approach demonstrates cost efficiency, with certification levels ranging from PASS to OUTSTANDING, and reveals potential cost savings between 4.67% and 7.96%, depending on the certification achieved.

KEYWORDS *Smelter; ZEB; Green Cost, Energy; BREEAM*

INTRODUCTION

In recent years, market interest in electric vehicles (EVs) and lithium batteries has seen a significant surge globally. The demand for electric vehicles and lithium batteries is increasing worldwide due to rising CO_2 emissions, fluctuating fossil fuel costs, and growing public awareness of the need to shift to eco-friendly technologies (Chandran et al., 2021; Chen et al., 2019; Feng et al., 2018; Illa Font et al., 2023; Speirs et al., 2014; Walvekar et al., 2022; Zeng et al., 2019). Global demand for electric vehicles is projected to rise from 5.3 million units in 2019 to approximately 40 million units by 2030 (Duan et al., 2020; Harper et al., 2019; S. Rangarajan et al., 2022; Zhang et al., 2022).

Nickel plays a crucial role in electric vehicles due to its use in battery production, and its supply must be increased to support the effective deployment of high numbers of electric vehicles (Nguyen et al., 2021). According to data from the *US Geology Survey* in 2020, Indonesia was identified as the country with the largest nickel reserves globally, comprising 52% or 72 million tons of nickel.

The development of nickel smelters faces various obstacles, particularly environmental challenges. Based on the *Environmental Performance Index* (EPI), the latest data from 2022 places Indonesia at 164th out of 180 countries, with an index score of 28.20. These results indicate that Indonesia must urgently implement green construction development across various sectors.

The concept of green building has become an integral component of the evolving construction landscape, serving as a solution to issues such as high energy consumption, negative environmental impacts, and inefficient resource utilization in the construction sector (Atabay et al., 2020). According to the *United States Green Building Council*, green buildings can reduce operational costs by 8–9% and increase total asset value by 7.5%.

Zero Energy Building (ZEB) represents a multidimensional strategy that integrates various technologies and approaches to optimize cost performance and achieve net-zero energy balance. ZEB structures incorporate energy-saving technologies and practices with renewable energy generation systems to minimize energy consumption to a level that can be fully met by locally available renewable energy sources (Pranit B Perane, 2022).

The *Building Research Establishment Environmental Assessment Method* (BREEAM) is the leading global standard for assessing a building's environmental performance, with a focus on sustainability throughout the building lifecycle—from design to construction and operation. BREEAM evaluates a variety of sustainability factors, including energy consumption, water management, material use, and ecological impact (Laurinavičiūtė & Tupėnaitė, 2018).

This study aims to analyze the most influential factors in improving green cost performance based on BREEAM and ZEB principles in smelter buildings, to implement the ZEB concept for enhancing green cost performance, and to assess the outcomes of these implementations in meeting green building criteria for smelter facilities.

The rapid growth of the electric vehicle industry has created unprecedented demand for nickel, positioning Indonesia's vast reserves as strategically important yet environmentally challenging. As the world's largest nickel producer, Indonesia faces increasing pressure to balance industrial expansion with environmental protection, particularly given its poor performance in global sustainability rankings. The surge in smelter construction exemplifies this tension, where economic priorities often conflict with ecological concerns, necessitating innovative approaches to sustainable industrial development.

Current research on green building practices demonstrates significant environmental and economic benefits but remains largely focused on commercial and residential sectors. While studies such as those by Hwang et al. (2017) establish the financial viability of green construction, their findings offer limited guidance for heavy industries with unique operational requirements. This gap is especially pronounced in nickel smelting facilities, where energy intensity and environmental impact far exceed those of typical building projects, highlighting a critical knowledge gap.

The lack of comprehensive studies integrating BREEAM standards with ZEB principles for smelters represents a significant research deficiency. Existing frameworks do not adequately address the unique challenges of industrial-scale operations, where conventional green building metrics may fall short. This limitation becomes increasingly problematic as global sustainability standards evolve and industrial operators seek practical pathways to decarbonization.

Indonesia's dual role as both environmental steward and industrial developer creates urgent demands for sustainable smelting solutions. The nation's international climate commitments and domestic development goals require immediate action to transform polluting industries into models of green production. Without such transformation, Indonesia risks both environmental degradation and exclusion from increasingly sustainability-conscious global markets.

This investigation seeks to establish practical benchmarks for green smelter construction by identifying cost-performance optimization strategies under BREEAM certification. By focusing specifically on nickel processing facilities, it aims to develop tailored sustainability metrics that account for industrial-scale energy demands while ensuring economic viability. The research particularly examines how ZEB implementation can mitigate the cost premiums typically associated with green industrial projects.

The study's novelty lies in its specialized focus on heavy industry applications of green building principles, moving beyond the conventional boundaries of sustainable construction research. By adapting BREEAM criteria to smelter operations and quantifying ZEB benefits in this context, it offers new perspectives on industrial sustainability and challenges prevailing assumptions about the limitations of green technologies in energy-intensive sectors.

Practical implications extend across multiple stakeholders, from smelter operators seeking to reduce environmental liabilities to policymakers crafting industrial regulations. The findings promise to inform more accurate cost-benefit analyses for green industrial projects and provide certification bodies with industry-specific assessment tools. Such applications could significantly accelerate the adoption of sustainable practices in emerging markets.

Emerging results highlight the disproportionate impact of ecological management factors on overall project viability, suggesting that conventional energy-focused approaches may need rebalancing. The data reveal unexpected correlations between certification levels and long-term savings, potentially reshaping investment strategies for industrial developers and challenging traditional cost paradigms in heavy industry sustainability projects.

Ultimately, this research bridges theoretical sustainability principles with practical industrial requirements, offering a replicable model for green heavy industry development. Its findings contribute to broader discussions on decarbonizing industrial processes while maintaining economic competitiveness. As global attention shifts toward sustainable supply chains, this work provides timely guidance for resource-rich nations navigating the transition to green industrialization.

By establishing evidence-based frameworks for sustainable smelter design, the study supports Indonesia's strategic position in the global nickel market while addressing critical environmental concerns. Its industry-specific approach offers a template for other resource-intensive sectors seeking to align production with sustainability goals, marking a significant step toward reconciling industrial development with environmental stewardship in emerging economies.

RESEARCH METHOD

This study uses a quantitative method with the Structural Equation Modeling - Partial Least Square (SEM-PLS) approach to analyze the relationship between variables. The research population consists of 185 experts and professionals involved in smelter construction projects in Southeast Sulawesi, including directors, consultants, contractors, subcontractors, and other related parties.

The number of samples was determined using the Slovin formula with a 95% confidence rate and a 5% margin of error:

$n = N / (1 + N(e)^2)$

Where n = sample, N = population (185), e = margin of error (0.05). Based on calculations, a sample of at least 125 respondents was obtained. To anticipate the failure of data collection, 175 questionnaires were distributed and 143 valid questionnaires (81.7%) were successfully collected.

The questionnaire was compiled based on a literature study that included the main variables: Smelter (X1), Green Cost (X2), and Zero Energy Building/ZEB (X3) as independent variables, and Cost Performance (Y) as dependent variables. Each variable consists of several sub-variables with a total of 213 indicators. The questionnaire used a Likert scale of 1-6 to avoid central tendency bias.

The data was analyzed using SmartPLS 3.2.7 software with the following stages:

1. Evaluation of the outer model (validity and reliability)
2. Evaluation of the inner model (hypothesis test and path coefficient)
3. Interpretation of results and discussion

The assessment criteria included loading factor >0.7, composite reliability >0.6, Average Variance Extracted (AVE) >0.5, and discriminant validity using Fornell-Larcker criteria.

RESULT AND DISCUSSION

Respondent Characteristics

The study respondents consisted of 143 experts and professionals involved in smelter construction projects in Southeast Sulawesi. The distribution of respondents based on education level showed that 85% had a minimum educational background of S1 and 15% had a S2 education. The composition of respondents' positions includes project manager (25%), site engineer (20%), quantity surveyor (18%), planning consultant (15%), contractor (12%), and others (10%). Respondents' work experience varied between 5-20 years with an average of 12 years in construction and project management.

The validity of the sample was strengthened by strict respondent selection criteria, where all respondents had direct experience in industrial construction projects and a minimum of 5 years of work experience. The geographical distribution of the respondents covers the areas of Kendari, Kolaka, and its surroundings which are the development areas of the nickel smelter industry in Southeast Sulawesi. The diversity of respondents' backgrounds provides a comprehensive perspective in assessing the implementation of green building in smelter buildings.

Evaluation of Measurement Models (Outer Model)

The results of the external model evaluation showed that all research constructs met the validity and reliability criteria required in the SEM-PLS analysis. Cronbach's Alpha values for all constructs range from 0.8240 to 0.9936, which indicates excellent internal consistency. The Green Cost construct (X2) has the highest Cronbach's Alpha value of 0.9936, followed by the Smelter construct (X1) with a value of 0.9931, Cost Performance (Y) of 0.9213, and ZEB (X3) of 0.8240.

The composite reliability of all constructs shows values above 0.8, with a range of 0.8954 to 0.9937. This value indicates an excellent level of reliability and indicates that the indicators used consistently measure the same latent construct. The Average Variance

Extracted (AVE) for all constructs is above the minimum value of 0.5, with a range of 0.6191 to 0.8633. The highest AVE value was found in the Innovation construct (0.8633), indicating that the variance of the indicator can be explained very well by its latent construct.

Table 1. Main Construct Reliability Evaluation Results

Construct	Cronbach's Alpha	rho_A	Composite Reliability	AVE
Green Cost (X2)	0,9936	0,9939	0,9937	0,6518
Smelter (X1)	0,9931	0,9933	0,9933	0,6799
Cost Performance (Y)	0,9213	0,9240	0,9373	0,6822
ZEB (X3)	0,8240	0,8255	0,8954	0,7408

The validity of the discriminator is tested using the Fornell-Larcker criterion, where the square root of the AVE of each construct must be greater than the correlation of that construct with the other construct. The test results showed that all constructs met the criteria for discriminant validity, indicating that each construct had unique characteristics and was different from the other constructs in the model.

The loading factor for all indicators shows values above 0.5, with the majority of indicators having a loading factor above 0.7. The indicators with the highest loading factor were "Site selection" (0.9551), "Ecological risks and opportunities" (0.9700), and "Energy monitoring" (0.9647). This high loading factor value indicates that these indicators are a strong representation of their latent constructs.

Evaluation of Structural Models (Inner Model)

An internal evaluation of the model shows the predictive power of the model is excellent. The R^2 value for the Cost Performance (Y) variable is 0.9276 with the adjusted R^2 is 0.9261, indicating that 92.61% of the cost performance variability can be explained by independent variables in the model. This high R^2 value indicates that the model has very strong predictive capabilities and is relevant to industrial practice.

The Green Cost construct (X2) has the highest R^2 value of 0.9804 with an adjusted R^2 of 0.9803, indicating that the Smelter and ZEB variables are able to explain 98.03% of the variability in Green Cost. This indicates that the characteristics of the smelter and the implementation of ZEB are the main determinants in determining the green cost of the smelter construction project.

Table 2. Results of R^2 Evaluation of Structural Model

Construct	R^2	R^2 Adjusted	Category
Green Cost (X2)	0,9804	0,9803	Strong
Cost Performance (Y)	0,9276	0,9261	Strong
ZEB (X3)	0,8742	0,8735	Strong

The f^2 value is used to measure the effect size or strength of the effect of an exogenous variable on an endogenous variable. The results of the analysis showed that the relationship between Smelter → Green Cost had an f^2 value of 11.510 (large effect), Green Cost → ZEB of 17.184 (large effect), and Green Cost → Cost Performance of 0.105 (small to medium effect). A high f^2 value in the relationship between the Smelter → Green Cost indicates that the characteristics and requirements of the smelter have a very significant influence on the green cost.

Path Coefficient and Significance Analysis

Path coefficient analysis showed a significant relationship between all the main variables with a T-statistic value of >1.96 and a p-value of <0.05. The strongest relationship was found between the Green Cost and Cost Performance variables with a path coefficient of 0.987 and a T-statistic of 465.935. This value indicates that the implementation of the green building concept has a very strong and positive influence on cost performance.

The path coefficient of the Smelter → Green Cost shows a value of 0.823 with a T-statistic of 156.742, indicating that the characteristics and requirements of the smelter have a very significant influence on the green cost. The relationship between Green Cost → ZEB shows a path coefficient of 0.891 with a T-statistic of 198.634, showing that the effective implementation of green cost encourages the adoption of Zero Energy Building technology.

Analysis of Influential Factors

Based on the analysis of outer loading T-statistic with a threshold of >1.96, this study succeeded in identifying the 10 most influential factors in improving the performance of green costs in BREEAM-based smelter buildings with ZEB:

Table 3. The Ten Most Influential Factors

Ranking	Sub Factor	Code	T-Statistic	Loading
1	Ecological risks and opportunities	X2.8.2	163,1589	0,9700
2	Ecological change and enhancement	X2.8.4	151,2159	0,9679
3	Managing impacts on ecology	X2.7.4	139,9561	0,9655
4	Energy monitoring	X2.8.4	175,1639	0,9647
5	Sustainable transport measures	X2.8.3	175,6288	0,9634
6	Energy efficient equipment	X2.4.2	155,2954	0,9607
7	Low carbon design	X2.6.1	152,8641	0,9600
8	Environmental impacts from construction products - LCA	X2.4.3	152,7095	0,9580
9	Road transport	X2.8.1	129,3433	0,9573
10	Site selection	X3.10.4	196,3569	0,9551

These results show the dominance of ecological and energy factors in influencing the performance of green costs. Ecological risks and opportunities occupy the top position with a T-statistic of 163.1589 and a loading factor of 0.9700, indicating the importance of identifying and managing ecological risks in the construction of green smelters. These factors include impact assessments on local biodiversity, animal habitat, and ecosystems around the smelter area.

Energy monitoring occupies the fourth position with a T-statistic of 175.1639, showing the criticality of the energy monitoring system in optimizing green cost performance. The implementation of an effective monitoring system allows the identification of energy consumption patterns, the detection of inefficiency, and the optimization of energy use in real-time.

Implementation of BREEAM with ZEB

The implementation of the BREEAM concept with the ZEB method in smelter buildings showed significant variations in cost efficiency based on the targeted level of certification. Cost-benefit analysis shows the trade-off between the initial investment and long-term operational savings.

Table 4. Cost Efficiency Based on BREEAM Rating

Rating BREEAM	Initial Green Cost (Rp)	Green Cost with ZEB (Rp)	Savings (Rp)	Efficiency (%)
PASS	18.127.431.955	16.684.443.155	1.442.988.800	7,96%
GOOD	24.517.431.955	22.990.385.555	1.527.046.400	6,23%
VERY GOOD	32.247.306.955	30.552.145.355	1.695.161.600	5,26%
EXCELLENT	38.323.362.455	36.576.904.455	1.746.458.000	4,56%
OUTSTANDING	42.359.942.455	40.381.560.455	1.978.382.000	4,67%

The PASS rating shows the highest efficiency of 7.96% with absolute savings of IDR 1.44 billion. The high efficiency of the PASS rating is due to the focus on the cost-effective implementation of ZEB's basic technology without complex additional requirements. The implementation of basic technologies such as solar panel systems, energy-efficient lighting, and basic building automation systems provides optimal return on investment.

In contrast, the OUTSTANDING rating shows the lowest efficiency of 4.67% despite the absolute savings reaching IDR 1.98 billion. This phenomenon occurs because to achieve an OUTSTANDING rating, investment in cutting-edge technology and integrated systems that have a high initial cost is required. Technologies such as advanced building management systems, high-performance building envelopes, and renewable energy storage systems require substantial investment.

Analisis Cost Structure

The green cost structure with the implementation of ZEB shows a different distribution compared to conventional development. Key cost components include:

1. Material Cost (35-40%): The use of eco-friendly materials and high-performance building materials increases material costs but provides long-term durability.
2. Energy System Cost (25-30%): Investment in renewable energy systems, energy storage, and building automation systems.
3. Technology Integration Cost (15-20%): The cost of integrating various green technology systems and commissioning.
4. Certification and Compliance Cost (5-10%): The cost of BREEAM certification, energy audits, and compliance with environmental regulations.
5. Contingency and Others (5-10%): Unexpected costs and other components.

Payback Period Analysis

Analysis of the payback period shows that investments in green building with ZEB have a period of return that varies based on the BREEAM rating:

1. PASS: 8-10 years
2. GOOD: 10-12 years
3. VERY GOOD: 12-15 years
4. EXCELLENT: 15-18 years old
5. OUTSTANDING: 18-22 years old

The shorter payback period on the PASS rating is due to high cost efficiency and relatively low initial investment. However, it's worth considering that higher ratings provide more significant long-term benefits in terms of brand value, regulatory compliance, and future-proofing.

Implications for the Smelter Industry

The findings of this study have strategic implications for the smelter industry in Indonesia. The implementation of BREEAM with ZEB not only provides cost efficiency benefits but also compliance with increasingly stringent environmental regulations. With Indonesia's position as the world's largest nickel producer, the adoption of green building has become a competitive advantage in a global market that increasingly prioritizes sustainability.

The ten influential factors identified can be a priority framework in the implementation of green building. Focusing on ecological aspects and energy monitoring provides a solid foundation for sustainable smelter development. This is in line with Indonesia's commitment to the Paris Agreement and the Sustainable Development Goals.

Comparison with Previous Studies

The results of this study are consistent with the findings of Hwang et al. (2017) which show a premium cost of 5-15% for green building, but make a new contribution with a specific focus on the smelter industry and ZEB implementation. The cost efficiency of 4.67-7.96% found in this study is lower than the USGBC's claim of 8-9%, which can be due to differences in industry context and geographic location.

This study also expands on the findings of Sutikno et al. (2023) on green building in Indonesia by providing a more detailed quantitative analysis and application to the heavy industry sector. The use of SEM-PLS in this study provides more in-depth insight into the causal relationship between variables compared to previous descriptive studies.

CONCLUSION

This study identified ten key factors that significantly enhance green cost performance in *BREEAM*-certified smelter buildings utilizing the *Zero Energy Building* (ZEB) approach, highlighting ecological risks and opportunities as the most critical influences. The integration of BREEAM standards with ZEB principles demonstrated measurable cost efficiencies, with savings ranging from 4.67% to 7.96% depending on the certification level achieved—where the *PASS* rating yielded the highest efficiency at 7.96% and the *OUTSTANDING* rating provided 4.67%. These results offer actionable guidance for stakeholders in the smelter industry to adopt sustainable and economically viable green building practices, advancing progress toward the *Sustainable Development Goals 2030* and supporting Indonesia’s efforts to reduce greenhouse gas emissions through green infrastructure. For future research, it is recommended to conduct longitudinal studies assessing the long-term operational and environmental impacts of BREEAM-ZEB implementation in heavy industrial sectors, and to explore the scalability of these frameworks across different industrial contexts for broader sustainability outcomes.

REFERENCES

Atabay, S., Gurgun, A. P., & Koc, K. (2020). Incorporating BIM and green building in engineering education: Assessment of a school building for LEED certification. *Practice Periodical on Structural Design and Construction, 25*(4), 1–11. https://doi.org/10.1061/(asce)sc.1943-5576.0000528

Chen, M., Ma, X., Chen, B., Arsenault, R., Karlson, P., Simon, N., & Wang, Y. (2019). Recycling end-of-life electric vehicle lithium-ion batteries. *Joule, 3*(11). https://doi.org/10.1016/j.joule.2019.09.014

Chandran, V., Patil, C. K., Karthick, A., Ganeshaperumal, D., Rahim, R., & Ghosh, A. (2021). State of charge estimation of lithium-ion battery for electric vehicles using machine learning algorithms. *World Electric Vehicle Journal, 12*(1). https://doi.org/10.3390/wevj12010038

Duan, J., Tang, X., Dai, H., Yang, Y., Wu, W., Wei, X., & Huang, Y. (2020). Building safe lithium-ion batteries for electric vehicles: A review. *Electrochemical Energy Reviews, 3*(1). https://doi.org/10.1007/s41918-019-00060-4

Feng, X., Ouyang, M., Liu, X., Lu, L., Xia, Y., & He, X. (2018). Thermal runaway mechanism of lithium ion battery for electric vehicles: A review. *Energy Storage Materials, 10*. https://doi.org/10.1016/j.ensm.2017.05.013

Harper, G., Sommerville, R., Kendrick, E., Driscoll, L., Slater, P., Stolkin, R., Walton, A., Christensen, P., Heidrich, O., Lambert, S., Abbott, A., Ryder, K., Gaines, L., & Anderson, P. (2019). Recycling lithium-ion batteries from electric vehicles. *Nature, 575*(7781). https://doi.org/10.1038/s41586-019-1682-5

Hwang, B. G., Zhu, L., Wang, Y., & Cheong, X. (2017). Green building construction projects in Singapore: Cost premiums and cost performance. *Project Management Journal, 48*(4), 67–79. https://doi.org/10.1177/875697281704800406

I.B. Komang Surya Werdiyasa. (2020). A journey to be eco-tourism destination: Bali prepared to shift into electric-based vehicle. *Bali Tourism Journal, 4*(3). https://doi.org/10.36675/btj.v4i3.48

Illa Font, C. H., Siqueira, H. V., Machado Neto, J. E., Santos, J. L. F. dos, Stevan, S. L., Converti, A., & Corrêa, F. C. (2023). Second life of lithium-ion batteries of electric vehicles: A short review and perspectives. *Energies, 16*(2). https://doi.org/10.3390/en16020953

IEA. (2021). *Global energy review: CO2 emissions in 2021*. IEA, Paris.

Laurinavičiūtė, R., & Tupėnaitė, L. (2018). Civil engineering. *Civil Engineering, 10*, 1–9.

Nguyen, R. T., Eggert, R. G., Severson, M. H., & Anderson, C. G. (2021). Global electrification of vehicles and intertwined material supply chains of cobalt, copper and nickel. *Resources, Conservation and Recycling, 167*, 1–33. https://doi.org/10.1016/j.resconrec.2020.105198

Perane, P. B. (2022). Zero energy building. *International Journal for Science Technology and Engineering, 10*(1), 9. https://papers/zero-energy-building-1w1nc8fq

Rangarajan, S., Sunddararaj, S. P., Sudhakar, A. V. V., Shiva, C. K., Subramaniam, U., Collins, E. R., & Senjyu, T. (2022). Lithium-ion batteries—the crux of electric vehicles with opportunities and challenges. *Clean Technologies, 4*(4). https://doi.org/10.3390/cleantechnol4040056

Speirs, J., Contestabile, M., Houari, Y., & Gross, R. (2014). The future of lithium availability for electric vehicle batteries. *Renewable and Sustainable Energy Reviews, 35*. https://doi.org/10.1016/j.rser.2014.04.018

Sutikno, Husin, A. E., & Iswidyantara, A. M. (2023). Indonesia MICE green building project with value engineering and its influential factors: An SEM-PLS approach. *Sinergi (Indonesia), 27*(1), 101–110. https://doi.org/10.22441/sinergi.2023.1.012

Walvekar, H., Beltran, H., Sripad, S., & Pecht, M. (2022). Implications of the electric vehicle manufacturers' decision to mass adopt lithium-iron phosphate batteries. *IEEE Access, 10*. https://doi.org/10.1109/ACCESS.2022.3182726

Zeng, X., Li, M., Abd El-Hady, D., Alshitari, W., Al-Bogami, A. S., Lu, J., & Amine, K. (2019). Commercialization of lithium battery technologies for electric vehicles. *Advanced Energy Materials, 9*(27). https://doi.org/10.1002/aenm.201900161

Zhang, X., Li, Z., Luo, L., Fan, Y., & Du, Z. (2022). A review on thermal management of lithium-ion batteries for electric vehicles. *Energy, 238*. https://doi.org/10.1016/j.energy.2021.121652