Comparison of Design and Technology Electric Buses Between Malaysia and Thailand

Perbandingan Reka Bentuk dan Teknologi Bas Elektrik antara Malaysia dan Thailand

Corina Lee
Muhammad Zulhilmi Zakaria
[1]Wan Fathul Hakim W Zamri

Jabatan Kejuruteraan Mekanikal dan Pembuatan
Fakulti Kejuruteraan dan Alam Bina
Universiti Kebangsaan Malaysia

Correspondence email: [1]wfathul.hakim@ukm.edu.my

ABSTRAK

Pada masa kini, operasi pengangkutan merupakan sumber utama pelepasan gas rumah hijau(GHG). Ia juga menyumbang kepada pencemaran udara di bandar utama serta seluruh dunia dalam bentuk zarah (PM), karbon monoksida (CO), dan karbon dioksida (CO2). Bas elektrik adalah penyelesaian yang menjanjikan untuk mengurangkan pelepasan karbon dan pencemaran udara dalam sektor pengangkutan. Malaysia dan Thailand adalah dua negara Asia Tenggara yang telah menunjukkan minat yang semakin meningkat untuk menggunakan bas elektrik untuk menangani kebimbangan alam sekitar. Oleh itu, kajian ini bertujuan untuk membandingkan reka bentuk dan teknologi bas elektrik di Malaysia dan Thailand. Berdasarkan reka bentuk, bas elektrik Malaysia mempunyai rupa yang lebih moden dan anggun dengan badan yang diperkemas dan cermin depan berpanorama yang besar. Sebaliknya, bas elektrik Thailand cenderung mempunyai penampilan seperti bas yang lebih tradisional dengan bentuk kotak dan cermin depan rata. Berdasarkan teknologi, kedua-dua Malaysia dan Thailand telah giat melaksanakan bas elektrik dengan ciri canggih seperti brek regeneratif, keupayaan pengecasan pantas dan sistem pengangkutan pintar. Bagaimanapun, Malaysia baru-baru ini memperkenalkan teknologi pengecasan tanpa wayar untuk bas elektrik, yang membolehkan bas mengecas semasa menunggu di perhentian bas tanpa memerlukan sambungan fizikal kepada pengecas. Teknologi ini masih belum dilaksanakan secara meluas di Thailand. Secara keseluruhan, kedua-dua Malaysia dan Thailand mengorak langkah dalam menggunakan bas elektrik untuk mengurangkan pelepasan karbon dan meningkatkan kualiti udara. Walaupun terdapat perbezaan dalam reka bentuk dan teknologi, kedua-dua negara sedang berusaha ke arah matlamat bersama pengangkutan mampan.

***Keywords**: rekabentuk, teknologi, bus elektrik, laluan*

ABSTRACT

Nowadays, transportation operations are a major source of greenhouse gas (GHG) emissions. It also contributes to air pollution in major cities throughout the world in the form of particulate matter (PM), carbon monoxide (CO), and carbon dioxide (CO2). Electric buses are a promising solution to reduce carbon emissions and air pollution in the transportation sector. Malaysia and Thailand are two Southeast Asian countries that have shown a growing interest in adopting electric buses to address environmental concerns. Therefore, this study aims to compare the design and technology of electric buses in Malaysia and Thailand. In terms of design, Malaysian electric buses have a more

modern and sleeker look with a streamlined body and a large, panoramic windshield. On the other hand, Thailand electric buses tend to have a more traditional bus-like appearance with a boxy shape and a flat windshield. In terms of technology, both Malaysia and Thailand have been actively implementing electric buses with advanced features such as regenerative braking, fast-charging capability, and intelligent transportation systems. However, Malaysia has recently introduced wireless charging technology for electric buses, which allows buses to charge while waiting at bus stops without the need for a physical connection to the charger. This technology is not yet widely implemented in Thailand. Overall, both Malaysia and Thailand are making strides in adopting electric buses to reduce carbon emissions and improve air quality. While there are differences in design and technology, both countries are working towards a common goal of sustainable transportation.

***Keywords**: design, technology, electric bus, route*

1. Introduction

In addition to industrial activity and electricity generation, the transportation industry is regarded as one of the most energy-demanding sectors globally. According to the International Energy Agency (IEA), the global transportation industry utilized roughly 31,310 kWh of total energy consumption in 2015, accounting for approximately 14% of global greenhouse gas (GHG) emissions. Malaysia's transportation accounted for 40% of total energy consumption and 22.9% of GHG emissions in 2010.

In response to the urgent need to mitigate climate change and reduce emissions, Malaysia has set ambitious targets under the Paris Agreement. The government aims to reduce GHG emissions intensity by 45% by 2030. To achieve this target, a key strategy involves the introduction of electric buses (EBs) into the transportation sector. The plan is to deploy 2000 electric buses, which will not only contribute to reducing GHG emissions but also help decrease reliance on fossil fuels and improve air quality.

Similarly, Thailand has also recognized the significance of the transportation sector in terms of energy consumption. In 2017, the country's final energy consumption was 80,752 kWh, with the transportation sector accounting for approximately 40.1% of the total. Following closely behind was the industrial sector at 35.2%, followed by the residential, commercial, and agricultural sectors. The high energy demand in the transportation sector highlights the need for sustainable solutions to address environmental concerns and reduce dependence on non-renewable energy sources.

Considering these factors, the adoption of electric buses emerges as a viable solution for both Malaysia and Thailand to achieve their energy efficiency and emission reduction goals. Electric buses offer numerous advantages, including lower greenhouse gas emissions, reduced reliance on fossil fuels, and improved air quality. Moreover, the development of a robust electric bus infrastructure can stimulate economic growth, create job opportunities, and enhance the overall quality of life for citizens.

This study is to conduct a comparative analysis of the design, technology, and performance of electric buses with respect to different routes. The subsequent section will provide an overview of the electric bus innovations in Malaysia and Thailand. This will be followed by the technology of electric buses in both countries. Lastly, the performance of electric buses in relation to specific routes will be discussed in the final section.

2. Electric bus innovations in Malaysia and Thailand

This section focuses on the design innovations of electric buses in Malaysia and Thailand. In Malaysia, there are some companies, including Sync R&D, the Malaysian Automotive Institute (MAI), and Go Auto-Higher, working with the Malaysian government to create a more sustainable public transportation system. In Thailand, SIKOR Co., Ltd., was a local electric bus company and Electric Vehicles (Thailand) Co., Ltd. (EVT) is a local manufacturer that works with the National Electronics and Computer Technology Center (NECTEC) to perform research and development on a wide range of electric vehicles.

2.1 Electric Bus Innovation Malaysia (EBIM)

The Electric Bus Innovation Malaysia (EBIM) is a Malaysia product developed by Sync R&D. EBIM vehicle that is approved design following United Nations Economic Commission for Europe (UNECE) standards offered by Automotive Engineering of Transport Department Malaysia. As shown in Figure 1, the prototype of EBIM.

FIGURE 1. Electric Bus Innovation Malaysia (EBIM)
Source: (*Malaysian-Made EV Buses with German, Chinese DNA*, 2016)

2.2 Putra-NEDO

DRB-Hicom Defence Technologies (DEFTECH), a wholly owned subsidiary of DRB-Hicom, has been appointed as the manufacturer of Malaysia's first Super Quick Charge (SQC) Electric Vehicle (EV) Putra-NEDO EB project, which aims to replace fossil-fuel-powered buses with faster-charging electric buses, has been launched in Malaysia and Japan. As shown in Figure 2, the Putra-NEDO electric bus.

FIGURE 2. Putra-NEDO electric bus
Source: (*Kuching to Begin Electric Bus Service Early next Year - Paultan.Org*, 2018)

2.3 PEA Zero Emission

The electric bus prototype's propulsion technology, known as the PEA Zero-emission, is intended for public transportation in Thailand. PEA Zero-emission has introduced numerous innovative technologies, including a 12-meter-long Li-phosphate battery bus for light weight, swap battery pack and plug in for charging strategies and the next generation of facility choice, two hub motors drive for better torque, and a low floor entry bus for wheelchairs. As shown in Figure 3, the PEA-Zero Emission electric bus.

FIGURE 3. PEA-Zero Emission electric bus
Source: (*University, Utility Unveil Electric Bus They Helped Develop | Coconuts*, 2014)

2.4 Edison Motor

The Edison Motor electric bus is a collaborative partnership between Korea and Thailand, led mostly by Korean carmaker Edison Motors, which now delivers eco-friendly buses for public transportation at Namsan in Seoul and on Jeju Island. Eleven institutions from both sides are involved in the project, including Korea's Industry Ministry and Korean Energy Technology Evaluation and Planning. Bangkok Mass Transit Authority, Electricity Generating Authority of Thailand, and King Mongkut's University of Technology Thonburi are among the Thai partners. As shown in Figure 4, the Edison Motor electric bus.

FIGURE 4. Edison Motor electric bus
Source: (*Thailand and South Korea Partner on Development of Electric Buses | Thaiger*, 2019)

2.5 Comparison design specification electric buses

Based on the observation specification electric bus between Malaysia and Thailand, Table 1 showed the design specifications of four electric buses Malaysia and Thailand.

TABLE 1. Design specification of four electric bus Malaysia and Thailand

	Malaysia		Thailand	
	Putra-NEDO	EBIM	PEA Zero Emission	Edison Motor
Length (mm)	12 000	12 000	12 000	11 030
Passenger	65	66	43	23
Max speed (km/h)	80	80	100	85
Energy storage (kWh)	270	-	196	-
Battery (V)	633	-	650	-
Travel (km)	200	200	-	174

3. Technology of electric bus

In this section, we will see the technology of electric buses in Malaysia and Thailand. Then, we can make a justification and comparison between the two models of electric buses for each country.

3.1 Technology of electric buses in Malaysia

Malaysian firm for product development, Sync R&D, was founded in 2006. This start-up, known as Electric Bus Innovation Malaysia, unveiled an EB prototype (EBIM). There are many technologies and features included in these electric buses. The intelligent driver assists (IDA) system functions to reduce human mistakes in driving and make driving safer are the six crucial components that we want to draw attention to. The supervisory controller is the next step in fault handling control methods and diagnostics. Third, is the motor controller, which converts the electric vehicle's battery energy into motion. Next, is a composite monocoque body, which has a reduced mass and prevents rust in electric buses. The body control module system, which integrates all electrical work through vehicle buses, comes in fifth. The electric axle, which serves as a power source for electric buses, is the final one. Additionally, it restores energy lost during braking to the battery.

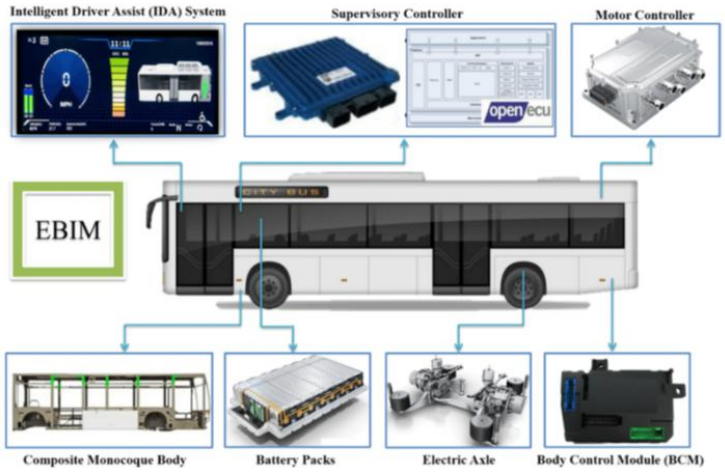

FIGURE 5. EBIM (Electric Bus Innovation Malaysia)
Source: (Saadon Al-Ogaili et al., 2020)

3.2 Technology of electric buses in Thailand

Electric buses in Thailand are using the PEA zero-emission electric bus model. The purpose of electric buses in Thailand is to reduce the air pollution problem in Thailand. The four important features of this electric bus are highlighted. The first one is the vehicle control unit (VCU). This VCU serves as the bus's command centre, translating the driver's commands such as those for accelerating and braking to the bus, determining the appropriate torque for either driving or braking, and detecting sensors. Next is the vehicle hydraulic system. Using a pump with excellent efficiency. An electric controller controls pump speed to alter pump pressure and flow, giving steering efforts for various driving scenarios. Third is the vehicle air compressor system. By possessing pneumatically operated features, such as pneumatically operated doors, pneumatic suspension, and pneumatic braking. Lastly is the battery management system. It is designed to determine the maximum charge or discharge current, and duration based on an assessment of the battery pack's state of charge (SOC) and state of health (SOH).

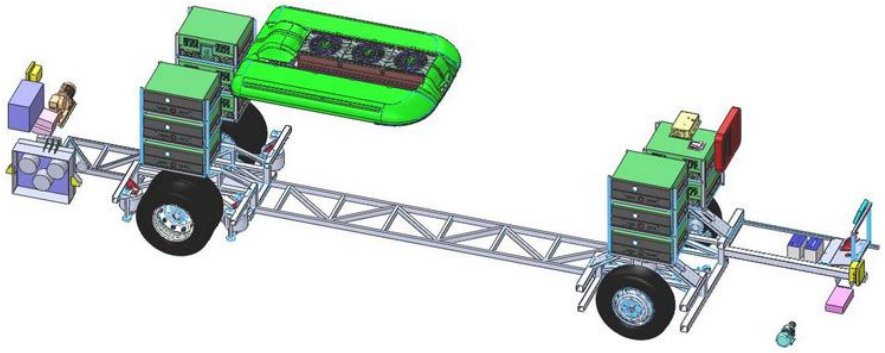

FIGURE 6. Component in PEA zero-emission electric bus
Source: (Punpaisarn, 2018)

3.3 Comparison between two buses technology

Based on the observation between two buses, the electric buses in Malaysia basically focused more on safety of driver and passenger on the bus. Besides, the electric buses in Malaysia are designed for durability and efficiency. Meanwhile, the electric buses in Thailand focus on implementing more technologies for convenient use. The design of electric buses in Thailand is more on a biological-circular-green economic model because Thailand wants to produce electric buses that can reduce air pollution.

4. Route of electric buses in Malaysia and Thailand

The purpose of route research is because we want to see how far the electric bus can travel in a day when the bus is in full charge.

4.1 Route map in Malaysia

In Sarawak, Kuching Metro is the brand name for the first electric city bus. Sarawak's first electric city bus was inaugurated in December 2018 by The Right Honourable Datuk Patinggi (Dr) Abang Haji Abdul Rahman Zohari Bin Tun Datuk Abang Haji Openg, Chief Minister of Sarawak, and the official operation ceremony was inaugurated in March 2021 by The Honourable Dato Sri Haji Abdul Karim Rahman Hamzah, Minister of Tourism, Arts & Culture Sarawak, and Minister of Youth & Sports Sarawak. This electric bus operates from Sarawak State Legislative Assembly to Semenggoh Wildlife Centre. The bus will bring people to visit around the place.

TABLE 2. Route map bus in Kuching, Sarawak

Route number	Bus route	Number of bus stop	Trip duration (min)	Distance (km)
103	Sarawak State Legislative Assembly - Semenggoh Wildlife Centre	54	120	30

Sourc : (Dason, 2022)

4.2 Route map in Thailand

In Thailand, RTC City bus, Chiang Mai is usually used by people near Chiang Mai. The bus provides people with a convenient environment of transportation; besides it provides a cheaper bus fee.

TABLE 3. Route map bus in Chiang Mai, Thailand

Route	Number of bus stop	Trip duration (min)	Distance (km)
R1-CEN	Central festival - Zoo	30	30
R1-Zoo	Zoo - Central Festival	38	30
R2	Promenada	52	45
R3	Airport – Nimman – Thapae	44	20
R3-Y	Airport – Thapae - Nimman	48	30

Source: (Citylife, 2017)

5. Conclusion

In conclusion, the comparison of the design and technological features of electric buses in Malaysia and Thailand reveals some critical discoveries and insights. As part of their sustainability ambitions, both nations have made a major commitment to adopting electric buses into their transportation sector.

Malaysia and Thailand have taken unique approaches to the development of electric buses in terms of design. Malaysia has prioritised the integration of efficient battery systems, charging infrastructure, and smart technologies, which has contributed to the expansion of electric bus fleets while lowering carbon emissions. Thailand has prioritised lightweight materials, innovative battery technology, and the incorporation of renewable energy sources in order to improve the environmental sustainability of its electric bus systems.

Both nations have achieved substantial technological advances in areas like as regenerative braking, battery technology, charging infrastructure, and the integration of smart technologies. Malaysia has used regenerative braking systems to maximise energy utilisation, whilst Thailand has looked at using artificial intelligence and data analytics to improve bus operations and passenger experience. These technical developments help to improve energy efficiency, lower operational costs, and improve overall performance.

Furthermore, comparing electric bus performance along distinct routes demonstrates the significance of route factors in impacting energy consumption, charging needs, and operating efficiency. Road conditions, traffic congestion, and route length all have an influence on electric bus performance, necessitating specific tactics for optimised fleet management and charging infrastructure implementation.

The findings of this comparison study might assist policymakers, urban planners, and transportation authorities in Malaysia, Thailand, and other nations considering the adoption of electric buses. Moving forward, continued research and collaboration between Malaysia and Thailand, as well as other countries, can further enhance the design and technology of electric buses.

Acknowledgement

We would like to extend our sincere gratitude and appreciation to Universiti Kebangsaan Malaysia for their support and contribution to this research. Furthermore, we extend our thanks to the following grants: Fundamental Research Grant Scheme (FRGS) under grant number FRGS/1/2022/TK09/UKM/02/31 and TAP-K016102. The financial support given by these grants has been instrumental in the successful execution of this study.

References

Al-Ogaili, A. S., Al-Shetwi, A. Q., Babu, T. S., Hoon, Y., Abdullah, M. A., Alhasan, A., & Al-Sharaa, A. (2021). Electric Buses in Malaysia: Policies, Innovations, Technologies and Life Cycle Evaluations. *Sustainability 2021, Vol. 13, Page 11577*, *13*(21), 11577. https://doi.org/10.3390/SU132111577

Boonraksa, T., Sakulphaisan, G., Marungsri, B., Boonraksa, T., Boonraksa, P., Sakulphaisan, G., & Marungsri, B. (n.d.). Strategic Planning of Charging Stations for Electric Public Transportation Bus Systems: a Case Study Analysis of Flashover Induced by Transient Current During Multiple Lightning Strokes on a Train and Transient current behaviour during multiple lightning strokes on multiple unit trains View project optimization of hybrid renewable energy source in distribution system View project SEE PROFILE

Strategic Planning of Charging Stations for Electric Public Transportation Bus Systems: a Case Study. *International Review of Electrical Engineering (I.R.E.E.)*, *15*(6). https://doi.org/10.15866/iree.v15i6.18764

Citylife. (2017). *Chiang Mai bus routes in English - Chiang Mai Citylife*. https://www.chiangmaicitylife.com/clg/living/getting-around/chiang-mai-bus-routes-in-english/

Dason, C. (2022). *Kuching e-bus service by Kuching Metro: All you need to know | KuchingBorneo*. KuchingBorneo. https://kuchingborneo.info/kuching-e-bus-service-1st-in-malaysia-and-its-free/

Duangsrikaew B, Mongkoltanatas J, Karin P, Hanamura K, & Benyajati C. (n.d.). *Energy consumption analysis for electric campus tram design based on real university driving cycle pattern in Thailand*.

Gabriel, N. R., Martin, K. K., Haslam, S. J., Faile, J. C., Kamens, R. M., & Gheewala, S. H. (2021). A comparative life cycle assessment of electric, compressed natural gas, and diesel buses in Thailand. *Journal of Cleaner Production*, *314*, 128013. https://doi.org/10.1016/J.JCLEPRO.2021.128013

Hasan, M. K., Mahmud, M., Ahasan Habib, A. K. M., Motakabber, S. M. A., & Islam, S. (2021). Review of electric vehicle energy storage and management system: Standards, issues, and challenges. *Journal of Energy Storage*, *41*, 102940. https://doi.org/10.1016/J.EST.2021.102940

Janjamraj, N., Changsarn, N., & Hiranvarodom, S. (2021). Design of Traction Motor and Battery for the Modification of Old BMTA Public Bus to E-Bus. *Proceeding of the 2021 9th International Electrical Engineering Congress, IEECON 2021*, 101–104. https://doi.org/10.1109/IEECON51072.2021.9440335

Janjamraj, N., Changsarn, N., & Hiranvarodom, S. (2021). Design of Traction Motor and Battery for the Modification of Old BMTA Public Bus to E-Bus. *Proceeding of the 2021 9th International Electrical Engineering Congress, IEECON 2021*, 101–104. https://doi.org/10.1109/IEECON51072.2021.9440335

Kammuang-lue, N., & Boonjun, J. (2021). Energy consumption of battery electric bus simulated from international driving cycles compared to real-world driving cycle in Chiang Mai. *Energy Reports*, *7*, 344–349. https://doi.org/10.1016/J.EGYR.2021.07.016

Kuching to begin electric bus service early next year - paultan.org. (2018). https://paultan.org/2018/12/13/kuching-to-begin-electric-bus-service-early-next-year/

Lim, L. K., Muis, Z. A., Ho, W. S., Hashim, H., & Bong, C. P. C. (2023). Review of the energy forecasting and scheduling model for electric buses. *Energy*, *263*, 125773. https://doi.org/10.1016/J.ENERGY.2022.125773

Malaysian-made EV buses with German, Chinese DNA. (2016). https://www.nst.com.my/news/2016/07/157685/malaysian-made-ev-buses-german-chinese-dna

Ng, C. W., & Yossapong, L. (2020). Comparison of Electric Bus Power Consumption Modelling and Simulation Using Basic Power Model, ADVISOR and FASTSim. *2020 2nd International Conference on Smart Power and Internet Energy Systems, SPIES 2020*, 414–419. https://doi.org/10.1109/SPIES48661.2020.9243058

Punpaisarn, S. (2018). *DEVELOPMENT OF AN ELECTRIC BUS PROTOTYPE USING LITHIUM-ION BATTERY FOR THAILAND*. http://sutir.sut.ac.th:8080/jspui/bitstream/123456789/8110/2/Fulltext.pdf

Saadon Al-Ogaili, A., Ramasamy, A., Juhana Tengku Hashim, T., Al-Masri, A. N., Hoon, Y., Neamah Jebur, M., Verayiah, R., & Marsadek, M. (2020). Estimation of the energy consumption of battery driven electric buses by integrating digital elevation and

longitudinal dynamic models: Malaysia as a case study. *Applied Energy*, *280*, 115873. https://doi.org/10.1016/J.APENERGY.2020.115873

Teoh, L. E., Khoo, H. L., Goh, S. Y., & Chong, L. M. (2018). Scenario-based electric bus operation: A case study of Putrajaya, Malaysia. *International Journal of Transportation Science and Technology*, *7*(1), 10–25. https://doi.org/10.1016/J.IJTST.2017.09.002

Thailand and South Korea partner on development of electric buses | Thaiger. (2019). https://thethaiger.com/news/world/asia/thailand-and-south-korea-partner-on-development-of-electric-buses

University, utility unveil electric bus they helped develop | Coconuts. (2014). https://coconuts.co/bangkok/news/university-utility-unveil-electric-bus-they-helped-develop/