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Power Requirement Study of Bus KITe PHEB in Kuala Terengganu

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ABSTRACT

Air pollution and the depletion of fossil fuel are both made worse by the increasing number of vehicles on the road. Conventional vehicles never fulfil future regulations for emission and fuel usage. In addition to this, diesel-powered vehicles are quickly becoming one of the most significant sources of particulate matter (PM) and nitrogen oxides (NOx) in the atmosphere. Electric vehicles (EV), hybrid electric vehicles (HEV), and plug-in hybrid electric vehicles (PHEV) are only a few examples of the innovative vehicle topologies that have emerged in recent years. The battery pack in a PHEV is more substantial than that of a HEV. Plus, it gets the same mileage as regular cars while using a combination of fuel and electricity as its propulsion source. The power requirement for the BUS KITe plug-in hybrid electric bus (PHEB) powertrain has been determined in this work by employing a steady-state velocity and the Kuala Terengganu driving cycle in accordance with the bus parameter, specification, and performance requirement. The power requirements of the bus can be used to determine the appropriate dimensions for the electric machine, internal combustion engine, and energy storage system that make up the BUS KITe PHEB model in MATLAB/SIMULINK environment.

1. Introduction

Many automobile manufacturers have indicated that the traditional gasoline vehicle would be replaced by the new energy vehicle around 2025 [1]. Therefore, it is crucial to build upon the existing methods for energy management strategy in new energy vehicles and make them even better. There has been some progress made in increasing the range of new energy vehicles due to the advancement of battery technology [2]. Unlike pure electric vehicles, which are limited in range due to their batteries' poor energy density, plug-in hybrid electric vehicles (PHEV) are completely tail-gas emission-free while operating only on the power of their motors, making them a prime example of a

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new type of energy vehicle [3,4]. The PHEV's fundamental technology relies heavily on the efficient distribution of its multiple power sources [5,6].

One of the most effective ways to cut back on greenhouse gas emissions from the transportation industry is to switch to electric vehicles (EV) [7]. Electric vehicles reduce both fuel use and carbon dioxide emissions. In a typical internal combustion engine vehicle (ICEV), only 75% of the fuel goes into propulsion while the other 20% is lost to heat and friction. In contrast, EVs have an average efficiency of 80%. [8].

A bus that combines an internal combustion engine (often powered by diesel or petrol) with an electric propulsion system is known as a plug-in hybrid electric bus (PHEV bus). PHEV buses can operate in electric mode for a limited distance before switching to the combustion engine or a hybrid mode thanks to a battery that can be charged by plugging it into an external power source. In truth, PEH buses have a number of significant advantages than completely electric buses, including smaller batteries, greater operational flexibility, and the ability to operate as full hybrid vehicles when the batteries are not charged. Due to the excellent flexibility PEH buses provide, controlling the distribution of the two driving modes along the route presents an extra problem [9].

A successful PHEV design needs to have the right size for its essential mechanical and electrical components [10]. The majority of the manual and analytical work involved in the PHEV component sizing studies that can be found in the open literature is done by the designer. Simpson [11] and Termica [12] used the Parametric Analytical Model of Vehicle Energy Consumption (PAMVEC) model to analyze the component sizes. An automatic sizing procedure was created by Sharer *et al.*, [13]. Powertrain System Analysis Toolkit (PSAT), a simulation tool, determines the engine, motor, and battery size based on the vehicle performance criteria. For component sizing in PHEVs, Golbuff [14] developed an analysis-based design optimization. A systemic design utilizing an optimization method has not, however, been released.

The main objective of this paper is to study the BUS KITe plug-in hybrid electric bus (PHEB) to decrease the fuel consumption and emissions for road transportation. There is only one electric machine (EM) in the PHEB powertrain, and it can operate as either a motor or an electric generator at various times determined by a specially developed energy management strategy that regulates the power flow in accordance with the desired operating mode. The PHEB uses a hybrid energy storage system (ESS) that combines batteries and ultracapacitors because they can function well together to increase drive performance and energy efficiency. Since the internal combustion engine (ICE) is only used in a few specific operating modes, its size can be decreased.

This paper used a steady state velocity to study theoretical research on the power requirement for PHEB powertrain. The parameters, requirements, and specifications for the bus are used to calculate the power requirements for the PHEB powertrain.

2. Methodology

Parameters such as the weight of the bus, the aerodynamic coefficient, the rolling resistance, the constant acceleration, the drag coefficient, the frontal area of the bus, the air density, and the gravitational force are needed in order to determine the power need of the BUS KITe PHEB. The specifications and parameters for the BUS KITe PHEB are listed in Table 1.

The power requirement is essential to determine the component sizing of PHEB. The design variables that characterize the powertrain are responsible for determining the powertrain model's parameters. On the other hand, the vehicle dynamics model's parameters need to be altered in a way that is both practical and effective to obtain equal outcomes [15].

Table 1
BUS KITe PHEB parameter and specification

Parameter	Specifications
Bus Mass, m_{bus} (kg)	14838
Rolling Coefficient, f_{ri}	0.01
Gravitational Force, g (ms^{-2})	9.81
Frontal Area (m^2)	2.499
Acceleration, a_{cons} (ms^{-2})	0.01
Air Density, p (kgm^{-3})	1.17
Drag coefficient, C_d	0.6

2.1 Theoretical equations

To fulfil the requirements and specifications of the BUS KITe PHEB powertrain design, the component sizes of the EM, ICE, and ESS were adjusted accordingly. Using the steady state velocity as a reference, the power demand for the BUS KITe PHEB powertrain was sized with reference to the vehicle's parameters, specifications, and performance requirements. After that, the dimensions of the individual components were determined by carefully considering each requirement and specification. Table 2 summarizes all the equations involve for to calculate the power requirement for BUS KITe PHEB powertrain.

Table 2
Equations for power requirement of BUS KITe PHEB powertrain.

Variable	Equation	Definition
Aerodynamic force	$P_{aero} = 0.5_{\rho} C_d A v^2$ Where, p is density of air, C_d is drag coefficient of the vehicle, A_v is frontal area of vehicle and V is velocity.	When a vehicle is driven, the friction it generates with the environment it is travelling through causes further friction. The force of this friction is referred to as the aerodynamic drag. Both the vehicle's speed and its frontal area contribute to an increase in aerodynamic drag resistance.
Rolling resistance force	$P_{roll} = \mathrm{mgC_{\pi}} \cos\theta$ Where, m is the rolling resistance, g is the gravitational acceleration due to gravity, C_{π} is rolling resistance and θ is gradient of road.	Rolling resistance is connected to the deformation that occurs in the tyres because of rotation. When a tyre rotates, it strikes a portion of the road, which is then loaded by the weight of the vehicle. This section of the road is then unloaded as the automobile continues to travel forward, and a new section of the road is struck.
Gravitational force	$P_{grav} = \mathrm{mg} \sin\theta$ Where g is the gravitational acceleration due to gravity and θ is gradient of road.	The force that arises because of gravity is referred to as grade. The force that can be attributed to grade is the component of gravitational force that acts along a gradient. In most cases, grades are expressed as a percentage. It is less difficult and more straightforward to calculate the grade by using an angle.
Acceleration force	$P_{accel} = mav$ Where m is mass of vehicle, a is acceleration and v is velocity.	The second law of Newton states that the amount of force required to change the velocity of an object with a fixed mass is proportional to the amount of force that is applied. This is the same thing as multiplying the mass of the object by its acceleration.

Power requirement	$P_{req} = P_{aero} + P_{roll} + P_{grav} + P_{accel}$ where P_{aero} is aerodynamic force, P_{roll} is rolling resistance, P_{grav} is gravitational force and P_{accel} is acceleration force.	Power requirement for BUS KITe PHEB can be estimated using this equation.

2.2 Component sizing

Figure 1 shows the power requirement graph of the BAS Kite, where the sizes of the ESS, ICE, and EM components were determined. After the sizing procedure, the key components are selected based on the qualities and specifications of the finished product [16].

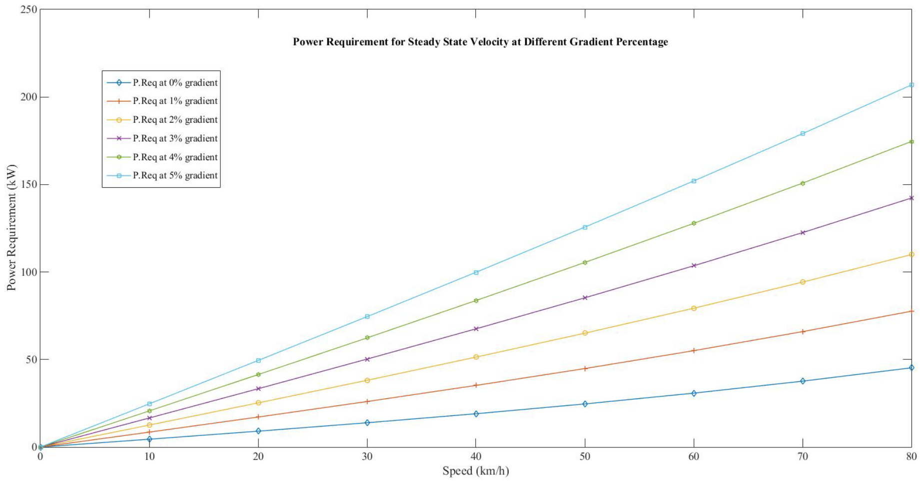

Fig. 1. Power requirement of BUS KITe PHEB against speed

Bus power requirements for constant speed were used to determine the specifications for the primary PHEB powertrain components such electric machine, energy system storage, and internal combustion engine [17].

2.2.1 Electric machine (EM)

The ability to transform electrical energy into mechanical energy is EM's underlying principle [18]. The power demand of the electric propulsion engine is determined by the maximum gradient that can be traversed at this pace as well as the top speed. The quantity of power that must be supplied by the electric propulsion engine is determined by the maximum speed as well as the maximum gradient at that speed [19]. The gradient will eventually approach its maximum of 5%. Based on the graph shown in the Figure 1, the maximum design speed is set at 80 kilometres per hour.

$$\mathrm{P_{EM}}\,(5\%, 80\,\mathrm{km/h}) = 206.9\,\mathrm{kW} \tag{6}$$

When the required speed is reduced, both the size of the motor and its cost can be reduced. When a crawling lane for trucks is installed on a road with a gradient of 5% or higher, the speed restriction is normally set to less than 110 kilometres per hour (km/h). If the vehicle is designed to move at 60 kilometres per hour while climbing at a grade of 5%, it is still capable of meeting the requirements, even though its propulsion motor can be scaled down:

$$\mathrm{P}_{\mathrm{EM,continuous}} = \mathrm{P}_{\mathrm{EM}}\ (5\%, 60\ \mathrm{km/h}) = 152.0\ \mathrm{kW} \tag{7}$$

2.2.2 Internal combustion engine (ICE)

Most hybrid and plug-in hybrid vehicles are built around internal combustion engines. Powertrains for commercial HEVs and PHEVs typically include an ICE in addition to the EM [20]. In the series HEV idea, the requirements for the internal combustion engine (ICE) are determined by the average power requirements. In the worst-case scenario, it is assumed that the average capacity is defined by driving at the maximum speed allowed on highways, which is 110 kilometers per hour (km/h), and there is no incline. The requirements for constant ICE output power are as follows:

$$\mathrm{P}_{\mathrm{ICE,continuous}} = \mathrm{P}_{\mathrm{EM}}\ (0\%, 80\ \mathrm{km/h}) = 45.3\ \mathrm{kW} \tag{8}$$

Given that the power of the electric output is 45.3 kW, and the efficiency is predicted to be 85%, the power of the mechanical input must be 55 kW. This is the minimum amount of continuous power that the ICE requires:

$$\mathrm{P}_{\mathrm{ICE,continuous}} = 55\ \mathrm{kW} \tag{9}$$

2.2.3 Energy storage system (ESS)

Lead (Pb), nickel cadmium (NiCd), nickel metal hydride (NiMH), sodium nickel chloride (NaNiCl), and lithium (Li-ion) are just some of the commercial batteries available for the HEV. Li-ion batteries are favoured due to their superior safety features, specific energy, power, durability, and lifespan [21]. The two most crucial requirements for energy storage are the maximum power and the availability of energy. In the mode of driving that uses just electric power, the available energy needs to be sufficient for travel of 10 kilometres within an urban environment. Around 30 kilometres per hour is the standard speed in urban areas. Assume the vehicle is moving at a speed of 10 kilometres per hour for the purposes of measurement. This is to account for the fact that the average speed is centred on a faster plateau, yet there are regular starts and pauses during the journey. To move the vehicle at a speed of 10 kilometres per hour, the engine needs to have a power output of:

$$\mathrm{P}_{\mathrm{EM}}(0\%, 10\ \mathrm{km/h}) = 4.47\ \mathrm{kW} \tag{10}$$

With a 60% overall drivetrain performance, the required battery storage capacity is at least:

$$\mathrm{E}_{\mathrm{ESS,min}} = (10\ \mathrm{km}/10\ \mathrm{km/h}) \times (4.47\ \mathrm{kW}/0.6) = 7.45\ \mathrm{kWh} \tag{11}$$

It is expected that the battery will be able to power the propulsion motor to its highest possible output. The maximum motor power is equivalent to 1.5 times the continuous motor power.

$$\mathrm{P}_{\mathrm{ESS,max}} = \left(1.5\ \times \mathrm{P}_{\mathrm{EM,continuous}}\right) - \ \mathrm{P}_{\mathrm{ICE,continuous}} = 173\ \mathrm{kW} \tag{12}$$

To achieve full performance, a maximum discharge of 3C (3 times the rated capacity) was assumed. The battery storage capacity is determined by this requirement, provided it also meets the criteria for pure electric range:

$$E_{ESS} = P_{ESS,max}/3 \times h = 57.7 \text{ kWh} \quad (13)$$

The estimated primary components of the PHEB powertrain are listed in Table 3, and they are the EM, ICE, and ESS. These estimates are based on the specifications and requirements of each component during the sizing process. The value is around 100 kW for ICE, 210 kW for EM, and 173 kW for ESS, according to the estimations.

Table 3
Component sizing of EM, ICE and ESS for BUS KITe PHEB

Component	Specifications
ICE	100 kW
EM	210 kW
ESS (P_{ESS}, E_{ESS})	173 Kw, 57.7 kWh

3. Results and discussions
3.1 Component sizing for KT driving cycle.

The total distance travelled during a driving cycle in Kuala Terengganu is 27 kilometres. Due to various external factors like traffic lights, bad roads, driver behaviour, and other environmental factors, the driving cycle's pattern is erratic. Using the KT driving cycle displayed in Figure 2, the PHEB powertrain is used to conduct the analysis on the impact of the actual developed driving cycle on the individual components that make up the overall structure.

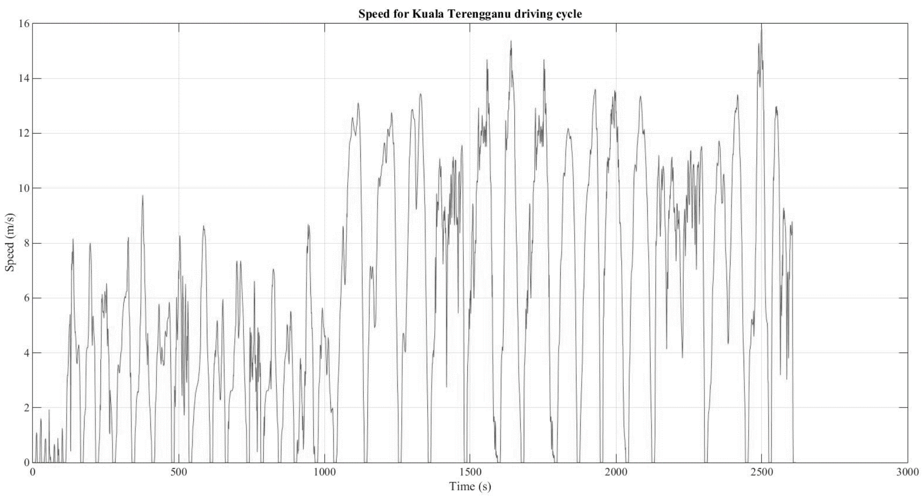

Fig. 2. KT driving cycle

The pattern of power demand during the KT drive cycle has an uneven pattern illustrated in Figure 3. It is because of a circumstance with frequent starts and stops. The amount of time spent with the vehicle idling during the KT driving cycle is 7.21% [22]. It also shows that the requirement for constant acceleration is not nearly as high as it was previously thought. More power is required to propel the vehicle in situations with frequent stops and starts. When compared to traditional buses, BUS KITe PHEB can achieve lower levels of fuel consumption and emissions because it covers 70% of the whole powertrain using just electricity.

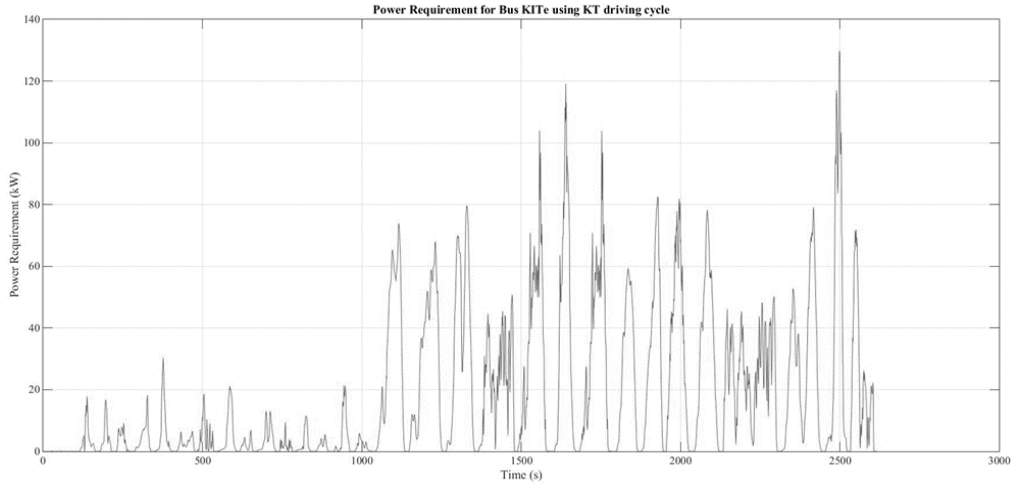

Fig. 3. Power requirement for KT driving cycle.

From the power requirement, the component sizing based on KT driving cycle can be estimated using power flow analysis using equation 6 – 13. Table 4 lists the component sizing using KT driving cycle based on Figure 2 and Figure 3 respectively.

Table 4
Component sizing for KT driving cycle.

Driving cycle	Kuala Terengganu
EM	
P_{EM} (kW)	129.80
$P_{EM,continuous}$ = P_{EM} (kW)	71.90
ICE	
$P_{ICE,continuous}$ = P_{EM} (kW)	34.56
$P_{ICE, continuous}$ (kW)	40.00
ESS	
P_{EM} (kW)	13.76
$E_{ESS, min}$ (kWh)	22.93
$P_{ESS, max}$ (kW)	67.85
E_{ESS} (kWh)	22.62

The PHEB powertrain components' sizing and selection represent the most important task to complete to meet the vehicle's design requirements and specifications. To validate the proposed PHEB components, the KT driving cycle is used. If the proposed PHEB component falls within the desired range, it can be concluded that the proposed components are appropriate. The individual parts that make up the overall structure of the PHEB powertrain are selected as necessary based on the vehicle parameters, requirements, and performance standards. Once the components have been defined, modeling of each component in the MATLAB/Simulink environment can start.

3.2 Fuel consumption and emission analysis

After all the components were sized, the fuel consumption and emission analysis of PHEB can be analyzed using ADVISOR software. ADVISOR is based on MATLAB/SIMULINK. The user of ADVISOR can analyze the efficiency, emissions, and performance of conventional, electric, and hybrid vehicles

[23]. These analyses using component sizing for Bus KITe PHEB in ADVISOR using KT driving cycle is displayed in Table 5. Table 5 shows the analysis of hydrocarbon (HC), carbon monoxide (CO), and nitrogen-dioxide (NOx) and fuel consumption.

Table 5
Fuel consumption and emissions for KT driving cycle.

Driving cycle	Kuala Terengganu
Fuel consumption (L/100 km)	
30.9	
Emission (g/km)	
CO	7.005
HC	8.824
NOx	0.06

4. Conclusions

In conclusion, the power requirement study is necessary to establish the appropriate dimensions for the EM, ESS, and ICE. According to the findings, the appropriate power levels for the EM, ICE, and ESS are respectively 210 kW, 100 kW, and 173 kW. These analyses using component sizing for Bus KITe PHEB in ADVISOR using KT driving cycle are 7.005 g/km for CO, 8.824 g/km for HC, and 0.06 g/km for NOx. It can be concluded that PHEB is the best powertrain in order to sustain the green environment with lowest fuel consumption and emission. For the future work, the scaling of the model of BUS KITe PHEV that was developed through this research can be utilised as a reference when building models in MATLAB or SIMULIK environments.

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References

[1] Hannan, Mahammad A., F. A. Azidin, and Azah Mohamed. "Hybrid electric vehicles and their challenges: A review." *Renewable and Sustainable Energy Reviews* 29 (2014): 135-150. https://doi.org/10.1016/j.rser.2013.08.097

[2] Lee, Byung-Gwan, and Seung-Hwan Lee. "Application of hybrid supercapacitor using granule Li4Ti5O12/activated carbon with variation of current density." *Journal of Power Sources* 343 (2017): 545-549. https://doi.org/10.1016/j.jpowsour.2017.01.094

[3] Fathabadi, Hassan. "Utilization of electric vehicles and renewable energy sources used as distributed generators for improving characteristics of electric power distribution systems." *Energy* 90 (2015): 1100-1110. https://doi.org/10.1016/j.energy.2015.06.063

[4] Borba, Bruno Soares MC, Alexandre Szklo, and Roberto Schaeffer. "Plug-in hybrid electric vehicles as a way to maximize the integration of variable renewable energy in power systems: The case of wind generation in northeastern Brazil." *Energy* 37, no. 1 (2012): 469-481. https://doi.org/10.1016/j.energy.2011.11.008.

[5] Jiang, Bingnan, and Yunsi Fei. "A PHEV power management cyber-physical system for on-road applications." *IEEE Transactions on Vehicular Technology* 66, no. 7 (2016): 5797-5807. https://doi.org/10.1109/tvt.2016.2642836

[6] Dong, Qiumin, Dusit Niyato, Ping Wang, and Zhu Han. "The PHEV charging scheduling and power supply optimization for charging stations." *IEEE Transactions on Vehicular Technology* 65, no. 2 (2015): 566-580. https://doi.org/10.1109/tvt.2015.2399411.

[7] Richardson, David B. "Electric vehicles and the electric grid: A review of modeling approaches, Impacts, and renewable energy integration." *Renewable and Sustainable Energy Reviews* 19 (2013): 247-254. https://doi.org/10.1016/j.rser.2012.11.042.
[8] Perujo, Adolfo, and Biagio Ciuffo. "The introduction of electric vehicles in the private fleet: Potential impact on the electric supply system and on the environment. A case study for the Province of Milan, Italy." *Energy Policy* 38, no. 8 (2010): 4549-4561. https://doi.org/10.1016/j.enpol.2010.04.010.
[9] Ruiz, P., J. M. Aragón-Jurado, M. Seredynski, J. F. Cabrera, D. Peña, J. C. de la Torre, A. Y. Zomaya, and B. Dorronsoro. "Optimal battery management strategies for plug-in electric hybrid buses on routes including green corridors." *Sustainable Cities and Society* 94 (2023): 104556. https://doi.org/10.1016/j.scs.2023.104556
[10] Wu, Xiaolan, Binggang Cao, Xueyan Li, Jun Xu, and Xiaolong Ren. "Component sizing optimization of plug-in hybrid electric vehicles." *Applied energy* 88, no. 3 (2011): 799-804. https://doi.org/10.1016/j.apenergy.2010.08.018
[11] Simpson, Andrew. *Cost-benefit analysis of plug-in hybrid electric vehicle technology*. No. NREL/CP-540-40485. National Renewable Energy Lab.(NREL), Golden, CO (United States), 2006.
[12] de Almeida, S. C. A., and F. L. A. Vieira. "Modeling and Analysis of an Electric Vehicle using PAMVEC." *Revista de Engenharia Térmica* 17, no. 2 (2018): 37-40. https://doi.org/10.5380/reterm.v17i2.64129
[13] Sharer, Philip, Aymeric Rousseau, Paul Nelson, and Sylvain Pagerit. "Vehicle simulation results for plug-in HEV battery requirements." *EVS22* (2006). https://doi.org/10.4271/2007-01-0295
[14] Golbuff, Sam. "Optimization of a plug-in hybrid electric vehicle." PhD diss., Georgia Institute of Technology, 2006. https://doi.org/10.4271/2007-01-1545
[15] Angerer, Christian, Sebastian Krapf, Alexander Buß, and Markus Lienkamp. "Holistic modeling and optimization of electric vehicle powertrains considering longitudinal performance, vehicle dynamics, costs and energy consumption." In *International Design Engineering Technical Conferences and Computers and Information in Engineering Conference*, vol. 51784, p. V003T01A024. American Society of Mechanical Engineers, 2018. https://doi.org/10.1115/detc2018-85430.
[16] Norbakyah, J. S., and A. R. Salisa. "A study on PHERB powertrain modeling and analysis." *International Journal of Electrical and Computer Engineering (IJECE)* 8, no. 3 (2018): 1822-1829. https://doi.org/10.11591/ijece.v8i3.pp1822-1829
[17] Haezah, M. N., J. S. Norbakyah, W. H. Atiq, and A. R. Salisa. "A conceptual design of main components sizing for UMT PHEV powertrain." In *IOP Conference Series: Materials Science and Engineering*, vol. 100, no. 1, p. 012036. IOP Publishing, 2015. https://doi.org/10.1088/1757-899x/100/1/012036.
[18] Kivanc, Omer Cihan, Ozgur Ustun, Gurkan Tosun, and Ramazan Nejat Tuncay. "On regenerative braking capability of BLDC motor." In *IECON 2016-42nd Annual Conference of the IEEE Industrial Electronics Society*, pp. 1710-1715. IEEE, 2016. https://doi.org/10.1109/iecon.2016.7793608
[19] Hovgard, Mattias, Oscar Jonsson, Nikolce Murgovski, Martin Sanfridson, and Jonas Fredriksson. "Cooperative energy management of electrified vehicles on hilly roads." *Control Engineering Practice* 73 (2018): 66-78. https://doi.org/10.1016/j.conengprac.2017.12.010.
[20] Dawody, Aryan. "Characterization of Emissions from Hybrid and Plug-in Hybrid Medium-Duty Electric Vehicles." (2014).
[21] Nitta, Naoki, Feixiang Wu, Jung Tae Lee, and Gleb Yushin. "Li-ion battery materials: present and future." *Materials today* 18, no. 5 (2015): 252-264. https://doi.org/10.1016/j.mattod.2014.10.040.
[22] Anida, I. N., J. S. Norbakyah, M. Zulfadli, M. H. Norainiza, and A. R. Salisa. "Driving cycle development of BAS KITe in Kuala Terengganu city to optimize the energy consumption and emissions." In *IOP Conference Series: Materials Science and Engineering*, vol. 469, no. 1, p. 012112. IOP Publishing, 2019. https://doi.org/10.1088/1757-899x/469/1/012112.
[23] Norbakyah, J. S., and A. R. Salisa. "Modelling, Simulation and Analysis of PHERB Powertrain." *Journal of Telecommunication, Electronic and Computer Engineering (JTEC)* 10, no. 2-5 (2018): 15-19. https://doi.org/10.11113/jt.v76.5633