A Manufacturer Opening Decision of Electric Motorcycle Conversion Kit Due to Tax Reduction Policy: A Case Study

Achmad Habibie[1], Wahyudi Sutopo[1,2] and Muhammad Hisjam[1]
[1]Master Program of Industrial Engineering Department
Universitas Sebelas Maret Surakarta, Indonesia
[2)] National Center for Sustainable Transportation Technology, Bandung, Indonesia
achmad.habibie.mail@student.uns.ac.id, wahyudisutopo@staff.uns.ac.id, hisjam@staff.uns.ac.id

Abstract

The increasing in the number of Internal Combustion Engine (ICE) motorcycle will have an impact on increasing carbon emissions in Indonesia. One of the solutions is to convert ICE motorcycle to electric motorcycle conversion. The Indonesian government will give a tax reduction to a manufacturer involved in vehicle electrification in Indonesia. This paper will explain the supply chain costs of the center of electric motorcycle conversion kit whether as a trader or opening a manufacturer with tax reduction. This study develops a mathematical model for making decision of electric motorcycle conversion kit manufacturer opening by mixed integer linear programming model (MILP). This paper also gives breakeven analysis as a second stage to make a decision. The result shows that the model can be decision making tool for opening manufacturer of electric motorcycle conversion kit due to tax reduction and opening manufacturer is more effectively than becomes a trader.

Keywords
Electric motorcycle conversion, Mixed integer linear programming, Break even analysis.

1. Introduction

Based on Potsdam Institute for Climate Impact Research, yearly carbon emissions Indonesia is 2.4 billion tons of CO2 and the biggest in Southeast Asia (Dunne, 2019). One of the biggest pollution sources in the world is transportation sector (Andler, 2012). In Indonesia, Internal Combustion Engine (ICE) motorcycle continues to grow each year. From 2007 until 2017 increase almost three times as much. The conversion program of ICE motorcycle to electric motorcycle conversion will reduce carbon emissions (Tuayharn et al., 2015). ICE motorcycle can be converted to electric motorcycle conversion by replace the engine with some parts of conversion, such as Balance Direct Current Motor (BLDC), controller, Battery Management System (BMS), battery, and steel for replace the motorcycle swing arm (Nizam, 2019; Habibie and Sutopo, 2019). Electric motorcycle conversion is new technology for Indonesia so the right commercialization should be applied (Sutopo et al., 2018). The prototype of electric motorcycle conversion has been made and ready to be adopted (Utami et al., 2020). The consumers also ready to change their ICE motorcycle to electric motorcycle conversion (Jodi et al., 2019).

This study was held in Central Java province, Indonesia. Central Java has 6 residencies and 35 cities. The center of electric motorcycle conversion located in Semarang City. From Figure 1 shows that the center of electric motorcycle conversion can be whether as a trader or as a manufacturer. Now, the center becomes a trader, the center just buys parts of electric motorcycle

conversion from the supplier and sells it to the workshops around Central Java. Otherwise, if the center becomes a manufacturer, the center must assembly some parts of electric motorcycle conversion to conversion kit and sells this conversion kit to the workshops. Then the workshops can just install that conversion kit to ICE motorcycle. There are two types of supplier in this study. The first supplier is overseas supplier, the center buys BLDC, controller, and BMS from this supplier. The second supplier is local supplier, the center buys battery and steel for motorcycle swing arm.

The Indonesian government very concern about carbon emission reducing from transportation sector by issued Presidential Regulation Number 55 of 2019 for accelerate the electrification all vehicle in Indonesia. Based on initial regulation, the center has to pay custom duty tax for purchases from overseas supplier if the center becomes a trader. Otherwise, the Indonesian government will give tax reduction for manufacturer that support government electrification program. It is stated in the Regulation of The Finance Ministry Number 150 of 2018.

This paper will explain the supply chain costs of the center of electric motorcycle conversion kit in Central Java whether as a trader or a manufacturer. Costs from two scenarios will be compared in this study. The main objective of this study is developing mathematical model for making decision of electric motorcycle conversion manufacturer opening by mixed integer linear programming model (MILP). We have also considered the effect tax reduction from government comparing with existing model. This paper also gives breakeven analysis to make a decision. The initial hypothesis of this study is tax reduction can cover manufacturer opening and operational costs.

There are several papers studied about opening facility location in the supply chain. Wu et al. (2006) studied about decision to hypermarket site selection (Wu et al., 2006), Rentizelas and Tatsiopoulos (2010) explained facility location decision on bioenergy case, Yuniaristanto et al. (2010) selected the terminals of rattan industry, and Mathirajan et al. (2011) presented opening warehouse decision on electronic industry in India. Habibie et al. (2012) and Hisjam et al. (2013) studied about supply chain model in furniture industry.

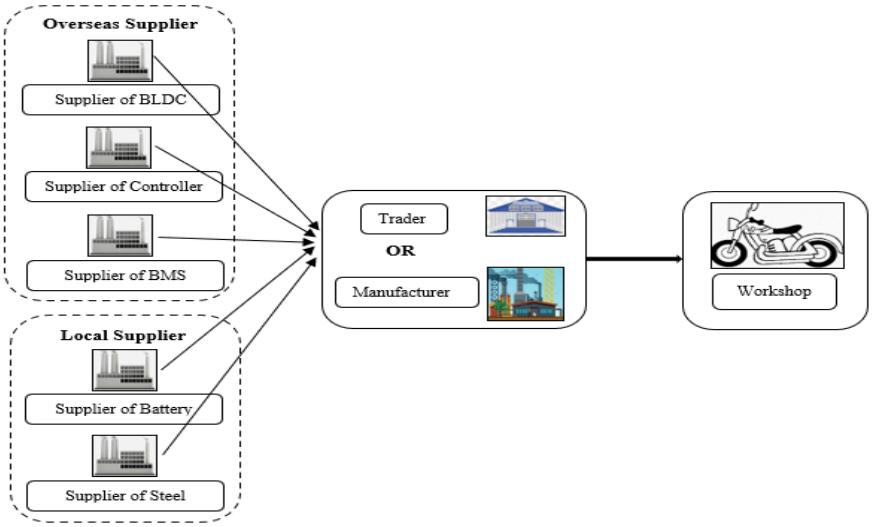

Figure 1. Supply Chain Network of Electric Motorcycle Conversion

2. Problem Description

The main problem of this paper observes whether the tax reduction is appropriate for open a manufacturer or not. The existing cost as a trader are local purchase cost, overseas purchase cost, transportation cost, and custom duty tax. If the center opens a manufacturer, the government will give custom duty tax reduction. However, as a consequence as a manufacturer new costs will arise namely investment cost, fixed operational cost, production cost with considering costs in the previous model. It shown at Figure 2.

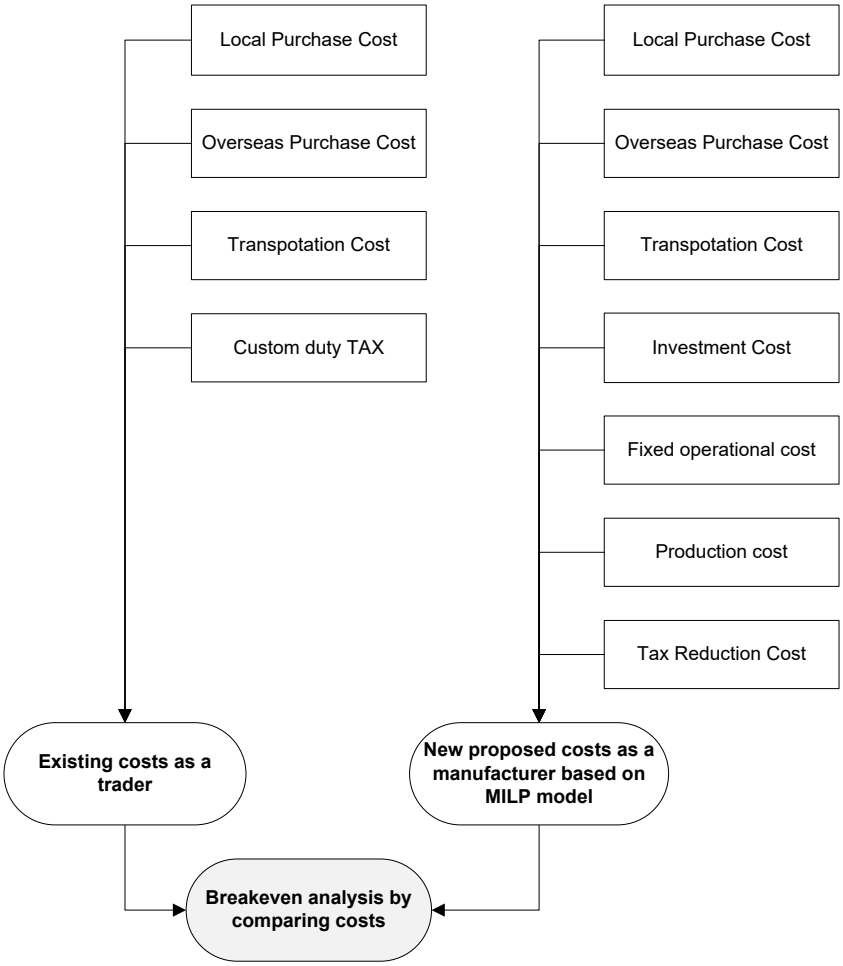

Figure 2. Costs Flow for Breakeven Analysis

Figure 3 explains influence diagram of this model. From this diagram, it can be seen that the objective is cost minimization in the manufacturer of electric motorcycle conversion kit. Seven costs are considered in this model, such as total overseas purchase cost, total local purchase cost, total production cost, total investment cost, total operational cost, total tax reduction, and total transportation cost. There are 13 parameters and 3 decision variables are considered in this model. The optimal solution will be calculated with MILP.

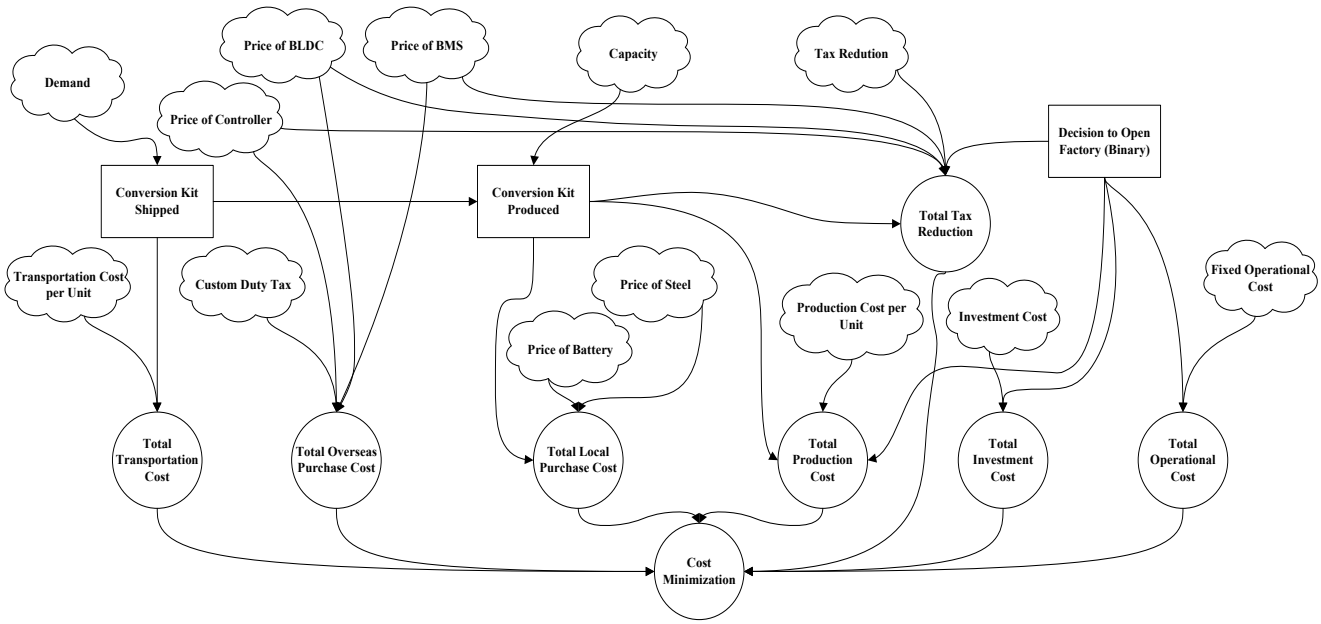

Figure 3. Influence Diagram

3. Result and Discussion

3.1 Mathematical Modelling

Based on the above description, the objective function of this paper is total cost minimization in the manufacturer of electric motorcycle conversion kit using MILP. The notations of parameters, decision variables, and objective function used for formulating the MILP in this model are:

Sets
i : Manufacturer
j : Workshop

Parameters
TMC_i : Total cost in manufacturer i (IDR)
IC_i : Investment cost for opening manufacturer i (IDR)
FC_i : Operational fixed cost in manufacturer i (IDR)
PRC_i : Production cost in manufacturer i (IDR)
PBL : Price of BLDC (IDR)
PC : Price of controller (IDR)
PBM : Price of BMS (IDR)
PB : Price of battery (IDR)
PS : Price of steel (IDR)
TX : Percentage of custom duty tax
DTX : Percentage of tax reduction
TC : Transportation cost (IDR)
CAP_i : Capacity in manufacturer i (Pcs)
D_j : Demand in workshop j (Pcs)

Decision variables

Y_i : Binary decision for opening manufacturer
1, if manufacturer *i* is opened
0, if manufacturer *i* is not opened and run as a trader

XP_i : Conversion kit produced in manufacturer *i* (Pcs)

XS_{ij} : Conversion kit shipped from manufacturer *i* to workshop *j* (Pcs)

Objective function

$$\sum_{i=0}^{I} TMC_i = \sum_{i=0}^{I} (IC_i * Y_i) + \sum_{i=0}^{I} (FC_i * Y_i) + \sum_{i=0}^{I} \sum_{j=1}^{J} (PRC_i * XP_i * Y_i) + \sum_{i=0}^{I} \sum_{j=1}^{J} (PBL + PC + PBM) * TX * XP_i) - \sum_{i=0}^{I} \sum_{j=1}^{J} (PBL + PC + PBM) * DTX * XP_i) + \sum_{i=0}^{I} \sum_{j=1}^{J} (PB + PS) * XP_i) + \sum_{i=0}^{I} \sum_{j=1}^{J} (TC_{ij} * XS_{ij}) \quad (1)$$

Subject to

$$\sum_{i=0}^{I} \sum_{j=1}^{J} XP_i \leq CAP_i \quad (2)$$

$$\sum_{i=0}^{I} \sum_{j=1}^{J} XS_{ij} \geq D_j \quad (3)$$

$$\sum_{i=0}^{I} \sum_{j=1}^{J} XP_i = \sum_{i=0}^{I} \sum_{j=1}^{J} XS_{ij} \quad (4)$$

$$XP_i \geq 0 \quad (5)$$

$$XS_{ij} \geq 0 \quad (6)$$

$$Y_i \epsilon \{0,1\} \quad (7)$$

The objective function is to minimize total cost (1). Constraint set (2) is the capacity constraint of the manufacturer. It ensures that the total quantity of conversion kit produced is less than capacity of the manufacturer. Constraint set (3) is the demand constraint from the workshop. It ensures that the conversion kit demand from workshop can be fulfilled by the total quantity of conversion kit shipped. Constraint set (4) ensures that all the conversion kit produced in the manufacturer is shipped to the workshop. Constraint set (5) and (6) are non-negativity constraint for the respective decision variables. The last constraint set (7) is binary constraint for decision variable. It ensures that whether the manufacturer is opened or not.

3.2 Numerical Example and Results

In order to illustrate the capabilities of the proposed-model, a numerical example has been done. All parameter cost used for the computational study is presented in Table 1. The price all of parts needed can be seen in Table 2. The percentage of custom duty tax and tax reduction is shown in Table 3. The capacity of manufacturer and conversion kit demand from the workshop is presented in Table 4.

Table 1. Parameter Costs

Parameter	Quantity	Units
Investment cost	4,000,000,000.00	IDR
Operational fixed cost	10,000,000.00	IDR/year
Production cost	1,450,000.00	IDR/pcs
Transportation cost	120,000.00	IDR/pcs

Table 2. Price of Parts

Part	Price	Units
BLDC	1,350,000.00	IDR/pcs
Controller	850,000.00	IDR/pcs
BMS	350,000.00	IDR/pcs
Battery	8,500,000.00	IDR/pcs

Table 3. Percentage of Tax

Description	Percentage	Units
Custom duty tax	35%	Percent
Tax reduction	20%	Percent

Table 4. Capacity and Demand

Description	Percentage	Units
Manufacturer capacity	24,000	Pcs/year
Conversion kit demand	20,000	Pcs/year

Table 5. Results

Decision Variables	Quantity	Units
Conversion kit produced	20,000	Pcs
Conversion kit shipped	20,000	Pcs
Opening manufacturer	1 (Open)	Binary
Total Cost	272,060,000,000	IDR

The result of this MILP model can be seen in Table 5. From Table 5 shows that manufacturer should be opened for conversion kit of electric motorcycle. The total cost for 20,000 pcs of demand is IDR 272,060,000,000 if running as a manufacturer and IDR 278,250,000,000 if running as a trader. From this result, it shows that being a manufacturer can save as much as IDR 6,190,000,000 rather than being a trader.

3.3 Breakeven and Sensitivity Analysis

Once the result of MILP model shows that the manufacturer must be opened, the second stage in this study is breakeven point (BEP) analysis. This breakeven analysis can make another view for making decision how profitable it is to open the manufacturer. The procedure developed for breakeven analysis in this model involves comparison existing costs as a trader and proposed model costs as a manufacturer, it is shown in Figure 2. The existing costs includes local purchase cost, overseas purchase cost, transportation cost, and custom duty tax. Those costs will be compared with adding investment cost, fixed operational cost, production cost, and tax reduction cost as consequence for manufacturer.

When the manufacturer is opened, this study will calculate the breakeven point. Breakeven point is defined as the time that the costs of proposed model will be equal to the existing costs. Breakeven period is obtained from total investment cost divided by net gain (8). Net gain can be calculated from existing costs reduced by proposed model costs.

$$Breakeven\ Period = \frac{Total\ investment\ cost}{Net\ gain} \tag{8}$$

The result of breakeven point is shown in Figure 4. From Figure 4, it shows that breakeven point is 7,683. It means that if the demand of electric motorcycle conversion kit is 7,683 pcs, the total cost if becomes a manufacturer will be the same as being a trader. The total cost is IDR 109,390,441,176.

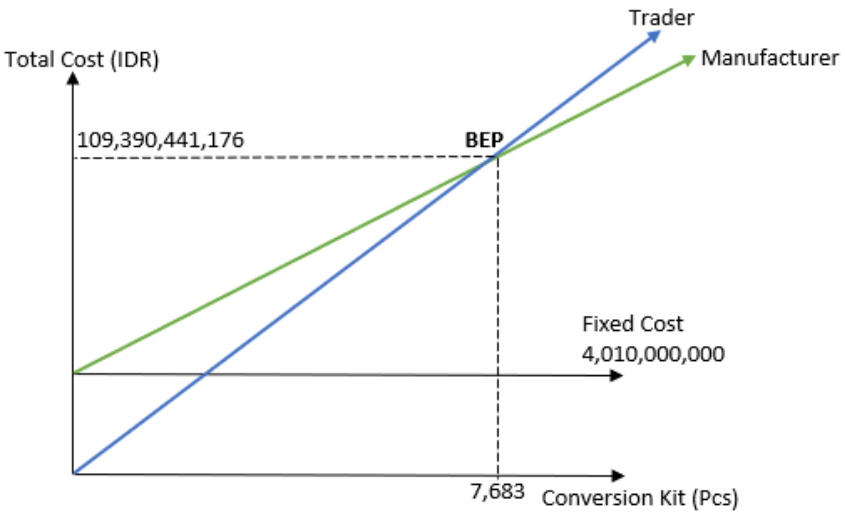

Figure 4. Breakeven Chart

The sensitivity analysis of this model will be presented to determine the effect of changes that will occur in the decision variables caused by parameter changes. The parameter to be changed are demand, percentage of tax reduction, and investment cost. The sensitivity analysis due to demand changes is presented in Table 6. Table 7 shows the sensitivity analysis because the changes of tax reduction percentage. Last, the sensitivity analysis due to the changes of investment cost is shown in Table 8.

Table 6. Sensitivity Analysis for Demand Changes

Demand	Opening Manufacturer	Total Cost
1,000	Not open	17,412,500,000
5,000	Not open	71,022,500,000
10,000	Open	138,035,000,000
15,000	Open	205,047,500,000

Table 7. Sensitivity Analysis for Tax Reduction Changes

Tax Reduction	Opening Manufacturer	Total Cost
0%	Not open	282,260,000,000
5%	Not open	279,710,000,000
15%	Open	274,610,000,000
25%	Open	269,510,000,000
35%	Open	264,410,000,000

Table 8. Sensitivity Analysis for Investment Cost Changes

Investment Cost	Opening Manufacturer	Total Cost
1,000,000,000	Open	269,060,000,000
5,000,000,000	Open	273,060,000,000
10,000,000,000	Open	278,060,000,000
15,000,000,000	Not open	283,060,000,000
20,000,000,000	Not open	288,060,000,000

Table 6 shows that demand changes give the effect to decision variables of opening manufacturer. If the demand of electric motorcycle conversion kit just 1,000 pcs or 5,000 pcs, the manufacturer does not need to be opened and becomes a trader is more effectively. Then if the demand changes 10,000 pcs ad 15,000 pcs, the manufacturer should be opened and this will be more effectively than become a trader. If it is associated with BEP, it can be concluded that if the demand lower than 7,683 pcs the manufacturer should be opened and otherwise if the demand is greater than or equal to 7,683 pcs the manufacturer should be opened.

Table 7 presents that tax reduction affects the decision to open a manufacturer. If the government does not give a tax reduction and give a tax reduction of 5%, it will make a decision that the manufacturer should be not opened. Then if the tax reduction become 15%, 25%, or 35%, the manufacturer should be opened and more effectively. From this table, it can be concluded that the greater tax reduction provided by the government, the total cost will be smaller and more likely to open the manufacturer.

The effect of investment cost on the decision to open a manufacturer shown in Table 8. This table shows that if the investment cost can be reduced to 1 billion, 5 billion, and 10 billion, the manufacturer should be opened. Then if the investment cost changes to 15 billion and 20 billion, it will change the decision that the manufacturer is not effectively to be opened. It can be concluded that if the investment cost can be reduced, the possibility to open manufacturer will be greater.

3.4 Further Research

This research is a preliminary study to develop supply chain network design for electric motorcycle conversion. The further model is shown in Table 9. The next model or the second model is location-allocation model and warehouse opening decision. The entity in this model is three as developing from first model. The second model uses mixed integer linear programming with single objective. Coverage area is considered in this model but sustainability aspects are not yet considered. The last model or the third model is supply chain network design model for electric motorcycle conversion with sustainability consideration. This model uses goal programming with multiple objectives. In this model coverage area and sustainability aspects will be considered.

Table 9. Further Research

Aspect	Model in This Research	The Second Model	The Third Model
Objective	A manufacturer opening decision	Location-allocation model and warehouse opening decision	Supply chain network model with sustainability consideration
Model Formulation	Mixed Integer Linear Programming	Mixed Integer Linear Programming	Goal Programming
Entity	Two entities	Three entities	Three entities
Objective Function	Single objective	Single objective	Multiple objectives
Coverage area	Not yet considered	Considered	Considered
Sustainability	Not yet considered	Not yet considered	Considered

4. Conclusion

The aim of this study is to develop a mathematical model for making decision of electric motorcycle conversion kit manufacturer opening by mixed integer linear programming model (MILP). From this model, it was found that the manufacturer of electric motorcycle conversion should be opened and more effectively than becomes a trader due to tax reduction effect. The second stage of this model is breakeven analysis. It means that if the demand of electric motorcycle conversion kit is equal to the breakeven point, the total costs if becomes a manufacturer will be the same as being a trader. In another sense if the demand lower than the breakeven point, the manufacturer should not be opened and otherwise if the demand is greater than or equal to the breakeven point, the manufacturer should be opened.

Acknowledgements

This research was partially supported by the LPPM (Institute for Research and Community Service) Universitas Sebelas Maret Program FY 2020 (Contract No.: 453/UN27.21/PN/2020, April 23, 2020).

References

Andler, S, The Contribution of Transport to Air Quality –TERM 2012: Transport Indicators Tracking Progress, *European Environment Agency*, 2012.

Dunne, D, The Carbon Breif Profile: Indonesia, https://www.carbonbrief.org/the-carbon-brief-profile-indonesia, 2019.

Habibie, A. and Sutopo, W., A Literature Review: Commercialization Study of Electric Motorcycle Conversion in Indonesia, *Proceedings of The 2nd International Conference On Materials Technology And Energy (ICMTE 2019)*, 2019.

Habibie, A., Hisjam, M., Sutopo, W., and Widodo, K.H., A relationship model between supplier and manufacturer for securing availability of teak log in export oriented furniture industry with sustainability considerations, *Lecture Notes in Engineering and Computer Science*, vol. 2196, pp. 1292-1297, 2012.

Hisjam, M., Habibie, A., Sutopo, W., and Widodo, K.H., A supplier-manufacturer model for procurement plan in export oriented furniture industry with sustainability considerations, *Lecture Notes in Electrical Engineering*, vol. 186, pp. 247-260. 2013.

Jodi, M.N.A., Sutopo, W., and Zakaria R., Markov Chain and Techno-Economic Analysis to Identify the Commercial Potential of New Technology: A Case Study of Electric Motorcycle Conversion in Surakarta, Indonesia, *Proceedings of the 5th International Conference on Industrial, Mechanical, Electrical and Chemical Engineering 2019 (ICIMECE 2019),* 2019.

Mathirajan, M., Kumar, M., and Ramachandran, V., A design of distribution network and development of efficient distribution policy, *Int. J. Logistics Systems and Management*, vol. 9, no.1, pp.108-137, 2011.

Nizam, M., Comparative Study of Electric Vehicles in Urban Areas in Indonesia, *Proceedings of the 5th International Conference on Industrial, Mechanical, Electrical and Chemical Engineering 2019 (ICIMECE 2019)*, 2019.

Presidential Regulation Number 55 of 2019 the Republic of Indonesia concerning Acceleration of Electric Vehicle Program Based on Battery for Road Transportation (Peraturan Presiden No. 55 Tahun 2019 tentang Percepatan Program Kendaraan Berbasis Listrik (KBL) Berbasis Baterai untuk Transportasi Jalan) in Bahasa Indonesia, 2019.

Regulation of The Finance Ministry Number 150 of 2018 concerning about Giving Tax Reduction Facilities for Corporate Income Tax (Peraturan Menteri Keuangan No. 150 Tahun 2018 tentang Pemberian Fasilitas Pengurangan Pajak Penghasilan Badan) in Bahasa Indonesia, 2018.

RentizelasIlias A.P. and Tatsiopoulos, T.P., Locating a bioenergy facility using a hybrid optimization method, *International Journal of Production Economics*, vol. 123, no. 1, pp.196–209, 2010.

Sutopo, W., Kurniyati, I., and Zakaria, R., Markov Chain and Techno-Economic Analysis to Identify the Commercial Potential of New Technology: A Case Study of Motorcycle in Surakarta, Indonesia, *Technologies*, vol. 6, no. 73; pp. 1-18, 2018.

Tuayharn, K., Kaewtatip, P., and Limthongkul, P., ICE Motorcycle and Electric Motorcycle: Environmental and Economic Analysis, *SAE Technical Paper*, 2015.

Utami, M.W.D., Yuniaristanto, and Sutopo W., Adoption Intention Model of Electric Vehicle in Indonesia, *Jurnal Optimasi Sistem Industri*, vol. 19, no. 1, pp. 70-81, 2020.

Wu, W.Y., Bai, C.J., and Gupta, O.K., A hypermarket site selection model using the grey multi-objective decision method, *Int. J. Logistics Systems and Management*, vol. 2, no. 1, pp.68–77, 2006.

Yuniaristanto, Sutopo, W., and Aisyati, A., Pemodelan Lokasi-Alokasi Terminal Bahan Baku untuk Meminimasi Total Biaya Rantai Pasok pada Industri Produk Jadi Rotan, *Jurnal Teknik Industri*, vol. 12, no. 1, pp.17-24, 2010.

Biography / Biographies

Achmad Habibie is Student at Master Program of Industrial Engineering of Universitas Sebelas Maret, Surakarta, Indonesia. He is also an assistant of System Logistic and Business Laboratory at Universitas Sebelas Maret. He received his Bachelor degree from Universitas Sebelas Maret in 2012. His research interests are in supply chain, logistics, business, techno economy, and sustainability. He has published some papers in his research area.

Wahyudi Sutopo is a professor in industrial engineering and coordinator for the research group of industrial engineering and techno-economy (RG-RITE) of Faculty Engineering, Universitas Sebelas Maret (UNS), Indonesia. He earned his Ph.D. in Industrial Engineering & Management from Institut Teknologi Bandung in 2011. He has done projects with Indonesia endowment fund for education (LPDP), sustainable higher education research alliances (SHERA), MIT-Indonesia research alliance (MIRA), PT Pertamina (Persero), PT Toyota Motor Manufacturing

Indonesia, and various other companies. He has published more than 130 articles indexed Scopus, and his research interests include logistics & supply chain management, engineering economy, cost analysis & estimation, and technology commercialization. He is a member of the board of industrial engineering chapter - the institute of Indonesian engineers (BKTI-PII), Indonesian supply chain & logistics Institute (ISLI), society of industrial engineering, and operations management (IEOM), and institute of industrial & systems engineers (IISE). His email address: wahyudisutopo@staff.uns.ac.id.

Muhammad Hisjam is with Department of Industrial Engineering, Faculty of Engineering, Universitas Sebelas Maret, since 1998. He received his Bachelor degree from Universitas Gadjah Mada in 1986, and a Master degree from Institut Teknologi Bandung in 2002. He received his Ph.D. in Environmental Science from Universitas Gadjah Mada in 2016, with his dissertation title is "Sustainable Supply Chain Model in Export Oriented Furniture Industry in Indonesia (Case in Perum Perhutani)". His research interests are in supply chain, logistics, business and sustainable development. He has published some papers in his research area. He and his colleagues have initiated and maintain some collaborations between his institution with some abroad universities, such as Ehime University, Japan and Universiti Teknologi Malaysia.