Article

Markov Chain and Techno-Economic Analysis to Identify the Commercial Potential of New Technology: A Case Study of Motorcycle in Surakarta, Indonesia

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Abstract: $LiFePO_4$ (LFP) or Lithium-ion battery with its advantages compared to common current motorcycle battery is an appropriate alternative in substituting wet and dry cell battery. Huge amount of demand of motorcycle along with the battery in Indonesia also make it an interesting product for business. In order to assess the commercial potential for such a new technology, market share needs to be estimated as well as the techno-economic feasibility. Hence, market share prediction using the residents of Surakarta Region and techno-economic analysis using NPV, IRR and PBP indicators have been conducted in this study. Calculation using markov chain method shows that LFP battery tends to dominate the market after certain period. Techno-economic analysis also figures out that the commercialization is feasible in three conditions - first mover, even with market leader and equilibrium point. Therefore, there is a great commercial potential for LFP battery especially in Indonesia.

Keywords: battery, commercialization, markov chain, new technology, techno-economic

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1. Introduction

There is an increasing trend of motorcycle sale in Indonesia for years. According to Indonesia Statistics Agency [1],the number of motorcycle sold in national level in 2010 were up to 61 million units and were increasing to 92 million of sold units in 2014. The facts are obviously indicated a growing amount of motorcycle as 52% in last five years. As a result, demand of motor accumulator or battery is also increasing. Two types of battery are common to be found in Indonesia market, which are: dry cell battery and wet cell battery. The dry cell holds for 80% of market share and the rest is for wet cell [2]. The demand volume for dry cell motorcycle was 48 million units in 2010 and grew up to 74 million in 2014 [1]. As the average price of dry cell in Indonesia is IDR 210,000 [3], it is able to generate revenue as much as 14 trillion rupiahs annually. Therefore, dry cell motorcycle battery business is hugely demanding in Indonesia market especially Lithium Ferro Phosphate battery [4]. However, until 2016 there is no any single manufacturer in Indonesia yet which produces an invented motorcycle battery technology – Lithium Ferro Phosphate (LFP) battery.

The lithium battery is one of the electrochemical battery system with promising technology with high power and energy densities characteristic with the increasing demand of alternative source of energy [5-6]. Since the introduction of the lithium type battery, many manufacturers and scientist has tried to develop the performance and utilization of lithium battery [7]. Ref [8] reveals that the behaviors of lithium type batteries are strongly related to the battery chemistry and technology. They compare four types of lithium-ion battery technologies which are NMC, LMO-NMC, NCA, and LFP

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in order to distinguish the performance of each type of chemistry related to the durability and energy storage. Not only limited to chemical composition, other study such as demonstrated by ref [9] was also aimed to progress the lithium ion battery technology by exploring various circuit models for lithium ion batteries. They proposed twelve circuit models which obtained from literature studies and test-data for the purpose of developing vehicle power management control and battery management system development.

The first ever type of motorcycle battery is wet cell or lead acid battery [10]. Along with development in motorcycle technology, battery technology in motorcycle also needs to be improved [11]. One of the technologies is Lithium-ion battery (LFP) which is very helpful for motorcycle battery development as it is maintenance-free and generally known as dry cell battery. Today's dry cell uses lead acid cathode with 12 V of full-charged capacity, 6 cells, 1-2 years of lifetime, 1.7 kilogram of weight and average price as much as IDR 210,000 [3]. As the LFP battery has been invented, previous dry cell is possible to be substituted [10]. A former study to identify replacement potential from wet cell to dry cell with LFP technology had been conducted by Research and Development team of PT Nipress Company in 2015. The result reveals that LFP battery is able to fulfill 12 V of motorcycle battery requirement – current requirement – with 14.4 V of full-charged capacity in 4 cells [12].

One of substantive benefits from LFP battery is the lifetime which is longer than usual dry cell battery [10-12]. Another study also shown that Li-ion batteries also has lesser life cycle cost compared to lead-acid batteries [16]. Thus, LFP cell has more advantageous specification which makes it possible to be substitution product of either wet or dry cell. Moreover, demand of LFP battery is predicted to grow up in Indonesia significantly due to government program to promote environmental-friendly technology in any circumstance [17]. However, LFP battery is 67% more expensive than recent dry cell battery. Hence, a market assessment is required to figure out market acceptance of LFP battery for motorcycle in Indonesia as well as economic feasibility study to determine whether the production the new technology is feasible to be executed or not.

The market study in this paper is conducted in order to predict the market share of Li-ion battery. Similar previous study shows that market penetration for battery technology product and utilization is not easy to be conducted as the product still unfamiliar to the market [15,16]. Whenever a firm wants to forecast the future demand of its product, it can use previous period selling data from the performance of existing products in order to estimate market demand [20]. On the other side, if the company tends to launch a new product, the company do a prediction in order to know the amount of product that will be absorbed by market due to lack past selling data [21]. Therefore, in this research was using markov chain to predict the market share of Li-ion battery. The markov chain is a mathematic technique in forecasting the change in particular variables base on knowledge of previous change [19-20]. This method merely needs data from one period before to predict future market share. Calculation in markov chain method is simple and provides result for the next periods.

There is no any previous study which construct market share prediction model of LFP motorcycle battery product in Indonesia. This model needs to be developed to be consideration especially in establish a business related to LFP battery specifically the commercial potential. The commercial potential is crucial specifically for new technology product in order to survive and success in dynamic market environment [24]. Therefore, the result of markov chain and the techno-economic analysis could lead to the success of new technology product introduction in order to gain and utilize the commercial potential of Li-ion battery products based. Moreover, the analysis from the result will give a decent impact to commercial studies of technology product in Indonesia in future time.

2. Materials and Methods

The processes of data collection in this research is illustrated in figure 1. The first step is survey consisting of two survey stages. First survey uses questionnaire 1 which aims to determine indicator influencing consumer in motorcycle battery purchase. Pareto chart is the tool used in this stage so that indicators considered important by customer can be developed to build the second questionnaire (questionnaire 2) in next survey. Questionnaire in the next survey is applied to reveal switching

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pattern of motorcycle battery consumer in Indonesia. The second questionnaire examines respondent profile, motorcycle battery currently used, type of battery that will be bought in future and several questions to indicate which consumer interested in LFP battery most. However, with the limitation of time and personnel, the scope of the respondents' location was limited only in Surakarta region. Nevertheless, the respondents from Surakarta Region is suitable to become one of the barometers for consumers preferences in Indonesia with major increasement in motorcycle ownership.

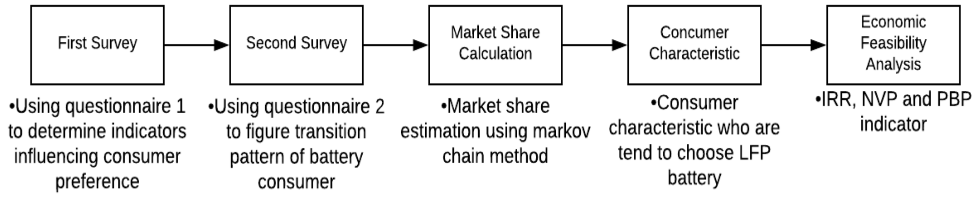

Figure 1. Research Method

2.1. Markov Chain Method

To predict market share of LFP battery, this study utilizes markov chain method. Markov chain method is a mathematic technique to forecast change of particular variables based on the knowledge of past changes [22-23]. This method was firstly introduced by Andrey Andreyevich Markov in 1906 [27]. The calculation process starts with the arrangement of prime algebra matrix, then continues with transition probability matrix and eventually estimate market share by multiplying transition probability matrices to market share matrices in "n" period of time.

In predicting the market share, markov chain use consumer's choice switching pattern in a certain period to forecast future market share [28]. Markov chain has been widely used in study regarding brand changing and market share prediction. In ref [29], markov chain method was utilized in order to discover changing pattern of GSM card user of a particular provider and prediction of the GSM card market share in the next two period as well as the interpretation of equilibrium period towards market share prediction. Markov chain method also has been conducted in purpose to test the brand loyalty of the sport-shoes consumer [26]. Another example of study using markov chain is conducted in order to forecast tourist characteristic pattern and country switching pattern to be chosen as tourism destination in 2009 and 2010 [30].

Basically, markov chain concept says that if a certain event in a series of experiment depends on several eventualities, that series of experiment is called as Stochastic Process. A markov chain is a sequence of random variables X_1, X_2, X_3, … with markov characteristic which is believe past and future condition is independent. Formally, markov formulation is expressed in equation (1) [31].

$$\Pr(X_{n+1} = x | X_1 = x_1, X_2 = x_2 \ldots, X_n = x_n) = \Pr(X_{n+1} = x | X_n = x_n) \qquad (1)$$

These are the steps in markov chain calculation:

1. Prime Algebra Matrices Construction

Algebra matrix is a matrix drawing transition of preliminary condition. This matrix illustrates situation in early time along with respective state shifting which being used as research object.

2. Transition Probability Matrices Construction

In accordance with markov chain definition, probability from state i to state j in a particular iteration (period n to n+1) can be formulated as equation (2).

$$P_{IJ} = P[X_{n+1} = j | X_n = i, X_{n-i} = i_{n-1,\ldots,} X_1 = i_{1,} X_0 = i_0] \qquad (2)$$

This probability states that probability in period or step of n+1 is only affected by step of n and there is no influence from previous steps. Conditional probability or so-called-as one step transition probability that condition xn+1 in period of n+1, formulated as:

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$P_{ij} = P\ [X_{n+1} = j \mid X_n = i],\ \forall\ state\ i,j = 0,1,2, \ldots$ where m and n ≥ 0 (3)

Abbreviations:

P_{ij} : Probability of battery-i consumer switchover to battery-j

$X_n = i$: Consumer using battery-i in period-n

$X_{n+1} = j$: Consumer using battery-j in period-n+1

1, 2, 3 ∈ i and j

Then, probability of m step is:

$P_{ij}^{(m)} = P[X_{n+m} | X_n = i]$ (4)

where $P_{ij}^{(m)} \geq 0, \forall$ i,j ∈ S and m = 0,1,2,...

Transitional probability matrix is a matrix which the elements are probability value of switching or transition from state i to state j. Transition from state i to state j for period t is defined as $P_{ij}(t)$. P_{ij} equation can be defined as:

$P_{ij} = \frac{n_{ij(t)}}{n_{i(t)}}$ (5)

As a matrix, one step transition probability can be illustrated as:

$$P = \begin{bmatrix} P_{11} & \cdots & P_{1j} \\ \vdots & \ddots & \vdots \\ P_{i1} & \cdots & P_{ij} \end{bmatrix}$$

3. Steady State Probability Calculation

The limit probability towards state-j after through several steps and independent towards early condition is called as steady state probability. In other words, after steps of transition, the transition probability value from one particular condition to another condition has reached the limit and remained unchanged. For example, if the system is already stead in step-j, it can be seen that transition probability to step-j does not depend on early condition. It will clearly illustrate by transition probability matrix from early step to step-j where the matrix possesses identical elements in every row.

4. Future Market Share Probability Prediction

Future market share probability especially for second period can be estimated by multiplying transition probability matrix to market share matrix (first period) [26].

$P \times Q^n = Q^{n+1}$ (6)

Q^{n+1} = market share prediction of period-n+1 from starting year

P = P_{ij} transition probability matrix with 1 column

Q^n = market share period-n

2.2. Techno-Economic Analysis

The analysis of techno-economic is intended to develop financial model of business activity by considering and calculating the financial payback period of business development. There are three indicators applied in techno-economic analysis in this study. Those are internal rate of return (IRR), net present value (NPV), and payback period (PBP).

Internal Rate of Return (IRR)

IRR shows minimum limitation of investment feasibility where it is compared to minimum acceptable rate of return (MARR). IRR is defined as the interest rate when NPV equals to 0 [32]. If only IRR > MARR, the investment will be considered feasible. MARR is minimum desirable interest rate of return. Equation (8) is used to calculate the IRR and the graphical result is drawn in figure 4. It is clearly in figure 3 that all alternatives are feasible.

$IRR = i_1 + \frac{NPV_1}{(NPV_1 - NPV_2)}(i_2 - i_1)$ (8)

IRR : Internal Rate of Return (%)

NPV_1 : Present worth from total investment

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NPV_2 : Present worth from profit in the end investment planning horizon period

Net Present Value (NPV)

The NPV is one of the financial tools which employed to reveals the level of profit gained from the business. It represents the number of rupiahs today equal to future cashflow. To be spesific, Net Present Value is one of analysis method in representing a value to be present value from net revenue cashflow [33]. A project will be granted whenever NPV > 0. Equation (7) shows the formula to calculate NPV and the result can be seen in Table 7 and Figure 2. According to Table 7, all alternatives has NPV > 0 which means that they are feasible to be executed.

$$NPV = \sum_{t=0}^{n} Ci(\frac{P}{F}, i\%, t) - C_o \qquad (7)$$

NPV : Net Present Value
C_i : business profit
i : interest rate
n : planning horizon

Pay-Back Period (PBP)

Techno-economic analysis also requires PBP assessment in order to identify how long it will take to payback the capital of a particular project beside its risk. Payback Period aims to examines how long (period) an investment will be paid back in breakeven point condition [34]. Investment become more interesting as the PBP is sooner and the investment is feasible if the PBP is sooner than desired payback time. In this study, payback period is targeted to approximately 4 years. Payback period is calculated by equation (9) and the result is illustrated as a graphic in figure 5.

$$PP = \frac{C_0}{C_i - D} \qquad (9)$$

PP : Payback Period
C_i : profit
C_0 : total investment
D : depreciation

This analysis combined with market share calculation reveals the commercial potential of Lithium-ion battery for motorcycle market in Indonesia.

3. Results

3.1. Market Share Prediction

The analysis of market opportunity in this begin with two process which consist of first survey which aims to discover consumer preference in choosing battery and second survey which aim to predict consumer interest in using lithium battery. In the first survey, the data obtained through the first questionnaire was processed using the pareto method to find the order of indicators that most considered by consumers. The pareto chart can be seen on the figure below:

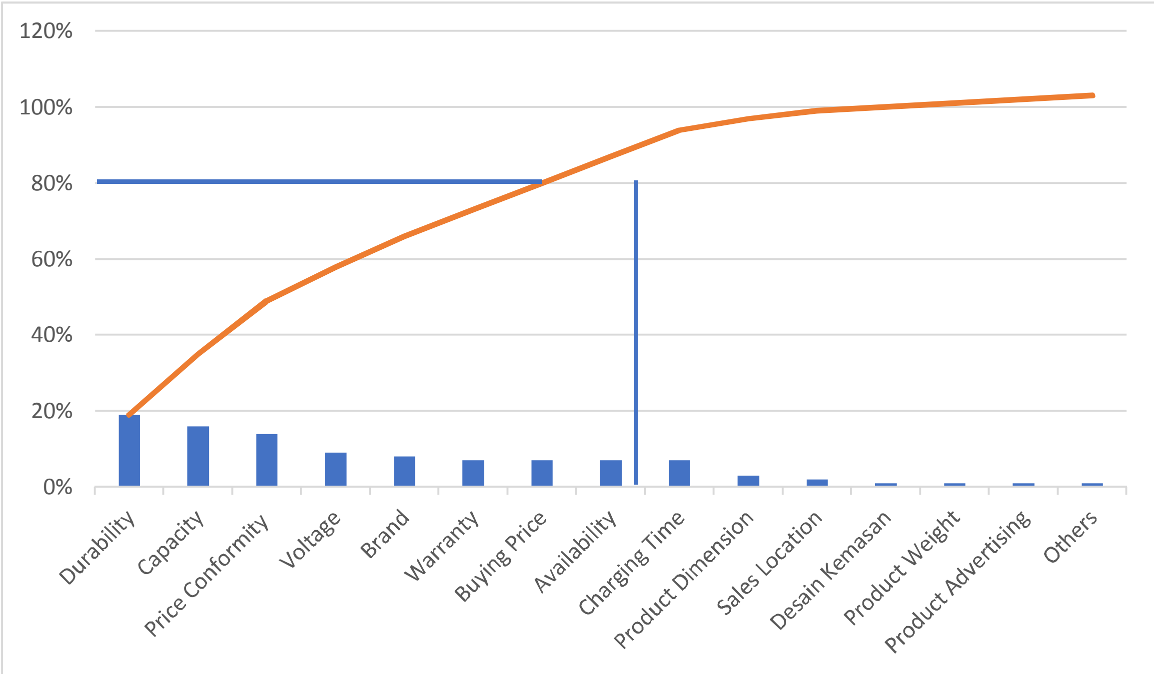

Figure 2: Pareto Chart for Consumer Preferences

Source: Kurniati (2017)[12]

From the pareto chart above, it indicated that there are several indicators that influencing the consumer preference in choosing battery which are: durability, capacity, price conformity, voltage, brand, warranty and buying price. The data from the first suvey then used in second survey in order to assess the motorcycle battery specification. However, not all of the indicator from the first survey was used in the second survey which are price conformality and and brand. This is because the price conformality with the benefit from the battery already represented by buying price and technical variable such as durability, capacity, and voltage. While the brand indicator was not used due to the product that still on development. Therefore, in order to assess the market share for lithium-ion based battery, the second survey is employed and then collected data being processed by using markov chain. In second survey, the prediction of market share uses primary data gained from questionnaires as many as 100 respondents from Surakarta Region. Three states are used in this research which are:

State 1 = consumer use wet cell battery (WB)
State 2 = consumer use dry cell battery (DB)
State 3 = consumer use Lithium-ion battery (LFP)

1. Prime Algebra Matrix

Algebra matrix is constructed to illustrate consumer behavior transition in consuming a certain product. Data from questionnaire can be arranged in a matrix in Table 1 as follows:

Table 1. Prime Algebra Matrix

Battery Type	Current Customer	Reduction to			Increase from			Future Customer
		WB	DB	LFP	WB	DB	LFP	
WB	17	7	6	4	7	1	0	8
DB	80	1	42	37	6	42	0	48
LFP	3	0	0	3	4	37	3	44
	100							100

2. Transitional Probability Matrix

Transitional probability matrix or switchover probability (P) matrix is a matrix which its elements is customer switching over probability value from a certain product or brand to another or keep choosing that product itself either. Supposed that $\{X_n, n = 0, 1, 2, \ldots\}$ is a stochastic process which

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satisfy markov chain characteristic, thus market share probability for certain period is expressed in equation (3).

Table 2. Type Transition Pattern of Battery Consumer

Current Choice	Future Choice			Current Customer
	WB	DB	LFP	
WB	7	6	4	17
DB	1	42	37	80
LFP	0	0	3	3
Future Customer	8	48	44	100

Table 3. Probability Transition

Current Choice	Current Market Share	Future Choice		
		WB	DB	LFP
WB	17%	0.4120	0.3530	0.2350
DB	80%	0.0125	0.5250	0.4625
LFP	3%	0	0	1

3. Market Share Prediction

To estimate market share in future period, this study uses expression as equation (6). The calculation result is shown in following matrices and Table 4.

$$P \times Q^0 = Q^1$$

$$\begin{bmatrix} 0,412 & 0,0125 & 0 \\ 0,353 & 0,525 & 0 \\ 0,235 & 0,4625 & 1 \end{bmatrix} \begin{bmatrix} 0,17 \\ 0,8 \\ 0,03 \end{bmatrix} = \begin{bmatrix} 0,08 \\ 0,48 \\ 0,44 \end{bmatrix}$$

$$P \times Q^1 = Q^2$$

$$\begin{bmatrix} 0,412 & 0,0125 & 0 \\ 0,353 & 0,525 & 0 \\ 0,235 & 0,4625 & 1 \end{bmatrix} \begin{bmatrix} 0,08 \\ 0,48 \\ 0,44 \end{bmatrix} = \begin{bmatrix} 0,04 \\ 0,28 \\ 0,68 \end{bmatrix}$$

$$P \times Q^2 = Q^3$$

$$\begin{bmatrix} 0,412 & 0,0125 & 0 \\ 0,353 & 0,525 & 0 \\ 0,235 & 0,4625 & 1 \end{bmatrix} \begin{bmatrix} 0,04 \\ 0,28 \\ 0,68 \end{bmatrix} = \begin{bmatrix} 0,02 \\ 0,161 \\ 0,819 \end{bmatrix}$$

Table 4. Market Share Prediction

Period	Battery Type			Total
	Wet Cell Battery	Dry Cell Battery	Lithium-ion Battery (LFP)	
1	8%	48%	44%	100%
2	4%	28%	68%	100%
3	2%	16%	82%	100%
4	1%	9.14%	89.86%	100%

3.2. Economic Feasibility Analysis

Economic feasibility analysis is intended to develop business financial model in accordance with payback period that will be earned in a business development. Three conditions of market share in this paper are considered as three alternatives chosen in this techno-economic analysis – 44%, 68% and 89% are respectively alternative 1, 2 and 3. The analysis used net present value (NPV), internal rate of return (IRR) and payback period (PBP) as indicators in determining the feasibility of the decision. In order to assess the economic feasibility, detail of required investment cost to commercialize LFP battery in Indonesia should be known as shown in Table 5 which referred and estimated from the 2015 annual report of PT. Nipress [11](Nirpress, 2015). Moreover, the cashflow for respective alternatives need to be calculated as well as shown in Table 6.

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Table 5. Total Investment Cost

Requirement	Quantity	Cost (IDR)	Total Cost (IDR)
Machine			
1. Cell Tester	4	162,000,000	648,000,000
2. Module Tester	1	540,000,000	540,000,000
Research and Development	1	1,016,806,004	1,016,806,004
Lithium-ion battery chamber	1	1,002,098,000	1,002,098,000
Chamber construction project	1	177,172,000	177,172,000
Machine installation	1	47,520,000	47,520,000
Total investment cost			3,431,596,004

Table 6. Cashflow

Year	Alternative 1 (IDR)	Alternative 2 (IDR)	Alternative 3 (IDR)
0	(3,431,596,004)	(3,431,596,004)	(3,431,596,004)
1	958,025,930	1,829,160,381	3,059,828,443
2	958,025,930	1,829,160,381	3,059,828,443
3	958,025,930	1,829,160,381	3,059,828,443
4	958,025,930	1,829,160,381	3,059,828,443
5	958,025,930	1,829,160,381	3,059,828,443
6	958,025,930	1,829,160,381	3,059,828,443
7	958,025,930	1,829,160,381	3,059,828,443
8	958,025,930	1,829,160,381	3,059,828,443

1. Internal Rate of Return (IRR)

The calculation of Internal Rate of Return (IRR) is appropriate and acceptable if the minimum attractive rate of return (MARR). The MARR in this research is referred to the investment interest level at 10.5% and with inflation level at 2.79% as regulated from central bank of Indonesia, and assumption of risk level on 5%. Below is the MARR calculation for the IRR:

$MARR = \{(1 + (i + a))(1 + inflation)\} - 1$

$MARR = \{(1 + (10.5\% + 5\%))(1 + 2.79\%)\} - 1 = 18.72\%$

After the MARR has been calculated, the IRR calculation then can be calculated given the alternative on Table 7 below.

Table 7: IRR Calculation

Year	IRR (1st alternative)		IRR (2nd alternative)		IRR (3rd alternative	
	Discount Rate 9%	Discount Rate 25%	Discount Rate 30%	Discount Rate 60%	Discount Rate 70%	Discount Rate 90%
1-8	Rp. 5.302.500.232	Rp. 3.189.183.403	Rp. 6.080.417.716	Rp. 3.384.304.460	Rp. 4.308.520.998	Rp.3.379.971.148

Thus, according to the given alternative IRR above, the calculation of IRR is shown below:

1st Alternative: $IRR = i_1 + \frac{NPV_1}{(NPV_1 - NPV_2)}(i_2 - i_1) = 9\% + \frac{\text{Rp.5.302.500.232}}{(\text{Rp.5.302.500.232} - \text{Rp.3.189.183.403})}(25\% - 9\%) = 23.16\%$

2nd Alternative: $IRR = i_1 + \frac{NPV_1}{(NPV_1 - NPV_2)}(i_2 - i_1) = 9\% + \frac{\text{Rp.6.080.417.716}}{(\text{Rp.6.080.417.716} - \text{Rp.3.384.304.460})}(60\% - 30\%) = 59.47\%$

3rd Alternative: $IRR = i_1 + \frac{NPV_1}{(NPV_1 - NPV_2)}(i_2 - i_1) = 9\% + \frac{\text{Rp.4.308.520.998}}{(\text{Rp.4.308.520.998} - \text{Rp.3.379.971.148})}(60\% - 30\%) = 88.88\%$

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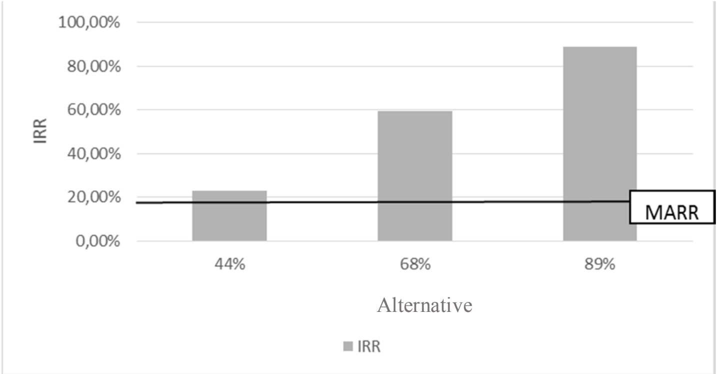

Figure 3. MARR to IRR Calculation Result

The calculation of the feasibility of the lithium ion battery business (LFP) in the viewpoint of the NPV calculation requires that income received in a certain future period be equal to or greater than the value of expenditure in the year commencement of investment. In this NPV calculation is also based on the assumption of market share control which consists of the first alternative with 44% market share, second alternative 68%, and third alternative 89%. Based on these assumptions, we find the NPV calculation with Table 8 below.

Table 8. NPV Calculation Result

Year	Alternative 1 (IDR)	Alternative 2 (IDR)	Alternative 3 (IDR)
0	(3,431,596,004)	(3,431,596,004)	(3,431,596,004)
1	866,991,792	1,712,362,335	2,769,075,514
2	784,607,957	1,549,649,172	2,505,950,692
3	710,052,450	1,402,397,441	2,267,828,680
4	642,581,402	1,269,137,956	2,052,333,647
5	581,521,631	1,148,541,136	1,857,315,518
6	526,263,920	1,039,403,743	1,680,828,523
7	476,256,941	940,636,872	1,521,111,786
8	431,001,756	851,255,088	1,376,571,752
Total	1,587,681,845	6,481,787,734	12,599,420,108

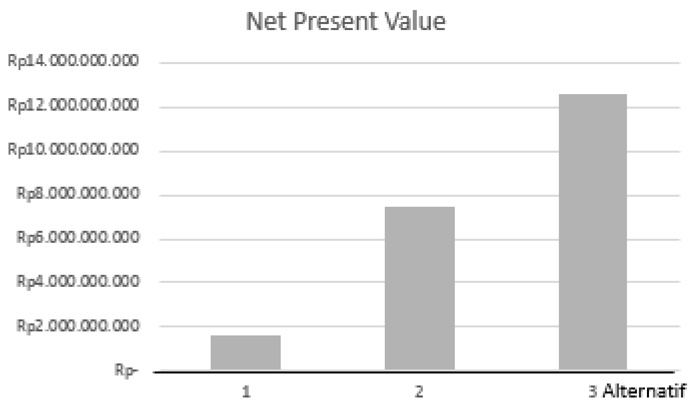

Figure 4. NPV Calculation Result

Next, to further refine the feasibility analysis of commercialization potential of lithium ion battery (LFP). Analysis using Payback Period (PP) method is used to find out how long the investment has been issued will be able to return. Keeping every alternative assumption of market share has different

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number of users, it will affect the time period required for the return of capital. The following is the calculation of Payback Period (PP) term for investment of lithium ion battery business (LFP).

Table 9: Payback Period

Year	1st Alternative		2nd Alternative		3rd Alternative	
	Yearly Income	Investment Return	Yearly Income	Investment Return	Yearly Income	Investment Return
0	-	3431596004	-	3431596004	-	3431596004
1	958025930	2473570074	1829160381	1602435623	3059828443	371767561
2	958025930	1515544144	1829160381	-226724758	3059828443	-2688060882
3	958025930	557518214	1829160381	-2055885139	3059828443	-5747889325
4	958025930	-400507716	1829160381	-3885045520	3059828443	-8807717768
5	958025930	-1358533646	1829160381	-5714205901	3059828443	-11867546211
6	958025930	-2316559576	1829160381	-7543366282	3059828443	-14927374654
7	958025930	-3274585506	1829160381	-9372526663	3059828443	-17987203097
8	958025930	-4232611436	1829160381	-11201687044	3059828443	-21047031540

$$1^{st}\ \text{Alternative PP} = 4 - \left(\frac{958025930-557518214}{958025930}\right) = 3\ years\ 7\ months$$

$$2^{nd}\ \text{Alternative PP} = 2 - \left(\frac{1829160381-1602435623}{1829160381}\right) = 1\ year\ 8\ months$$

$$3^{rd}\ \text{Alternative PP} = 2 - \left(\frac{3059828443-371767561}{3059828443}\right) = 1\ year\ 2\ months$$

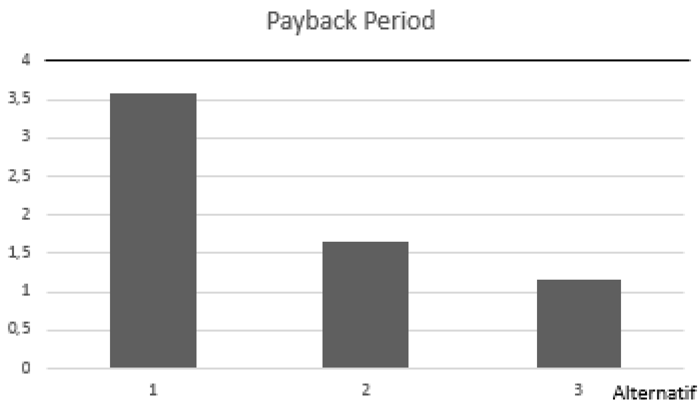

Figure 5. Payback Period Calculation Result

4. Discussion

According to Table 1, it can be perceived that most customer currently choose dry cell battery for their motorcycle accounted for 80% of respondents, 17% still uses wet cell battery and only 3% have tried Lithium-ion battery. However, this trend is supposed to change significantly based on respondent's answer. Only 7 current customers tend to keep choosing wet cell plus a new consumer from dry cell. Similar to dry cell in proportion, 42 out of 80 customers still choose dry cell to be purchased so do with 6 people from wet cell battery. On the contrary, 41 respondents are interested in new technology battery (LFP) and other three current respondents remain to choose LFP. In conclusion, only 8 respondents tend to choose wet cell in the future while dry cell and LFP battery will have similar customer in number, 48 and 44 respectively. Transition pattern of battery customer from one type to another is elaborated in Table 2. Meanwhile, Table 3 shows transition probability assuming that shifting customer between three battery types is stable. It is obvious in Table 3 that most customers for respective type of battery prefer the same type for next purchase. However, there is a tendency for non-LFP customer to choose either dry cell or LFP in similar probability.

This research takes three market share prediction conditions. First condition is market share in period 1 where the market share of first mover manufacturer of LFP battery is 44%. It assumes that

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market leader of battery in Indonesia does not launch any Lithium-ion-based battery yet. In this situation, the market leader still waits and sees if the Lithium-ion motorcycle battery has a good response in market. The second condition happens in second period with assumption that the first mover LFP battery manufacturer has an even business with the market leader. The last condition is in fourth period where the market share of LFP has reached equilibrium point. Market share of LFP battery is 89.86% and the product has dominated the market for motorcycle battery.

Related to the techno-economic analysis, MARR calculation results show that the minimum rate for rate of return is 18.72%. And based on the calculation of IRR on each alternative shows the results of 23.16% for the first alternative, 59.47% for the second alternative, and 88.88% for the third alternative. Each of these alternatives is structured and assumed under different discount rate conditions and different market share in each investment alternative which for the first alternative assumes a 44% market share for lithium ion batteries, a second alternative with a market share assumption of 68%, and a third alternative with assuming a market share of 89%. And yet, every alternative IRR calculation shows a positive result above the MARR value. Therefore, based on the calculation obtained, the lithium ion battery business plan (LFP) passes the business feasibility criteria to be developed in Indonesia as shown in Figure 3 above.

Based on the calculation of NPV in Table 8 and Figure 4, the number figures in the table show the bottom in each alternative has the same baseline investment value of Rp. 3,431,596,004-. However, with different market share assumptions, each alternative has a different NPV value. In the first alternative, the value of NPV is found at Rp. 1,587,681,845, the second alternative is Rp. 6,481,787,734, and the third alternative is Rp. 12,599,420,108. Therefore, because each alternative produces a calculation that has a value of more than Rp. 0, -, the feasibility of lithium battery business investment in the NPV calculation point of view is considered feasible to be executed and operated in Indonesia.

Based on the calculation results Payback Period (PP) above, the first alternative has a period of investment payback period for 3 years 7 months, the second period with a period of 1 year 8 months, and the third period with a period of 1 year 2 months. If it refers to the age of the motorcycle business and the length of the bank business loan which is generally 4 years in term, the business investment for lithium ion batteries (LFP) is feasible to be developed in Indonesia.

5. Conclusions

A massive demand of motorcycle in Indonesia results in high need of battery or accumulator. As the motorcycle technology is developing, the battery supposed to do so. $LiFePO_4$ or Lithium-ion battery (LFP) is an example of excellent invention in order to support the advancement of recent motorcycle. Longer lifetime and many other advantages show that it is a big opportunity to substitute common battery – wet and dry cell – with newest one and establish the manufacturing factory and business. However, as a most-recent technology product, there is still an absence of the company as well as the literature especially in Indonesia.

In order to assess the commercial potential of LFP battery, market share prediction and techno-economic analysis have been conducted. Markov chain method is selected to forecast the market share due to the simplicity, accuracy and characteristic of the battery as yet-launched product. Meanwhile, techno-economic analysis use NPV, IRR and PBP aspect to indicate feasibility of the business. Based on the result, there is a tendency of motorcycle battery consumer in Indonesia to switchover from wet and dry cell battery to LFP battery. LFP battery is estimated to dominate the market starts from third period and reach equilibrium point in next period. Techno-economic analysis also shows that LFP battery commercialization project is feasible in any condition – first mover, even with market leader and equilibrium. Therefore, there is a great commercial potential for Lithium-ion battery in Indonesia. Moreover, as a new invented product, a deep market study is inevitable for LFP battery. Future study may assess more aspects in market area for instance market strategy. In order to maintain commercial sustainability of the battery, it is essential to update information regarding market environment and expense identification for economic feasibility.

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