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Technical Feasibility for Commercialization of Lithium Ion Battery as A Substitute Dry Battery for Motorcycle

Indah Kurniyati[1, a)], Wahyudi Sutopo[2], Roni Zakaria[3], and Evizal Abdul Kadir[4, 5]

[1]*Laboratory of Business and Logistic System, Departement of Industrial Engineering, Faculty of Engineering, Sebelas Maret University, Surakarta, Indonesia*
[2]*Industrial Engineering and Techno-economics Research Group, Departement of Industrial Engineering Faculty of Engineering, Sebelas Maret University, Surakarta, Indonesia*
[3]*Departement of Industrial Engineering, Faculty of Engineering, Sebelas Maret University, Surakarta, Indonesia*
[4]*Wireless Communication Centre, Faculty of Electrical, Engineering, Universiti Teknologi Malaysia, Johor Bahru, 81310 Malaysia*
[5]*Faculty of Engineering, Universitas Islam Riau, Pekanbaru, Riau 28284 Indonesia*

a) Corresponding author: indahkurniyati.ia2@gmail.com

Abstract. Dry battery on a motorcycle has a rapid rate of voltage drop, life time is not too long, and a long charging time. These are problems for users of dry battery for motorcycle. When the rate in the voltage decreases, the energy storage in the battery is reduced, then at the age of one to two years of battery will be dead and cannot be used, it makes the user should replace the battery. New technology development of a motorcycle battery is lithium ion battery. Lithium ion battery has a specification that has been tested and possible to replace dry battery. Characteristics of lithium ion battery can answer the question on the dry battery service life, the rate of decrease in voltage and charging time. This paper discusses about the technical feasibility for commercialization of lithium ion battery for motorcycle battery. Our proposed methodology of technical feasibility by using a goldsmith commercialization model of the technical feasibility and reconfirm the technical standard using the national standard of motorcycle battery. The battery has been through all the stages of the technical feasibility of the goldsmith model. Based on the results of the study, lithium ion batteries have the minimum technical requirements to be commercialized and has been confirmed in accordance with the standard motorcycle battery. This paper results that the lithium ion battery is visible to commercialized by the technical aspect.

INTRODUCTION

Indonesia is a developing country which is highly consumptive. Especially in a motor vehicle. According to Badan Pusat Statisika Indonesia, The sales of motor vehicle in Indonesia increased from year to year [1]. The data of motor vehicle's sales in Indonesia of the last ten years is shown in Figure 1.

It can be seen that sales of motorcycles in Indonesia are greater than the sale of the car. Increased demand for motorcycles in Indonesia are accompanied by increased demand for motorcycle battery. So the business opportunities motorcycle battery is quite large. One the technology aspect which is becoming a main discussion in Indonesia is the battery industry [2]. A battery is an electrochemical device which converts electrochemical energy to electrical energy [3]. Energy storage and energy conversion has become the basic need as well as the key issue concerning with our daily life [4].

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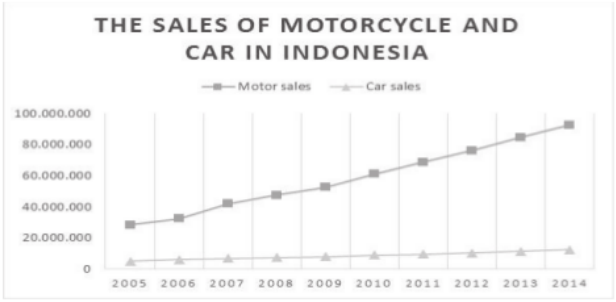

FIGURE 1. Motorcycle and Car Sales

Source: [1]

The first function of a battery is to starter [5]. At the time of ignition is off and will be turned, it takes the initial driving force to rotate the crankshaft, so the piston can move up and down, then there was a burning in the combustion chamber, and the engine came to life. Once the engine is on, the starter is turned off by disconnecting the starter switch relationships. To run the starter system in particular dynamo starter used power supply, and the supply of electricity is supplied by a battery. From these functions, it is known that the battery is a major component in a motorcycle. Therefore, this study examines the motorcycle battery.

Battery technology is always developing over time. Indonesia is one of country who developed battery technology. Lead acid battery is the first type of rechargeable battery. It is a battery that has long been used by the whole world [6]. Dry battery on a motorcycle has a rapid rate of voltage drop, life time is not too long, and a long charging time. These are problems for users of dry battery for motorcycle. When the rate in the voltage decreases, the energy storage in the battery is reduced, then at the age of one to two years of battery will be dead and can not be used, it makes the user should replace the battery. New technology development of a motorcycle battery is lithium ion battery. Lithium ion battery has a specification that has been tested and possible to replace dry battery.

Rechargeable lithium which are names by Sony Corp., Commercialized for the first time in 1991 which a relatively affordable price [7]. The developed motorcycle battery based on $LiFePO_4$ for cathode material. Lithium-ion (Li-ion) is one type of rechargeable batteries [8]. Lithium-ion batteries are one of battery technology with the best energy storage ratio [9] and it has a relatively low self-discharge [10]. Battery with lithium material are able to store three times energy more than other materials, it gives a competitive advantage and makes the key element for batteries. Moreover, The advantages of lithium–ion batteries are higher energy density to weight ratio, longer life time, and no memory effects [11]. Lithium ion batteries for motorcycles has the disadvantage that the size of the battery terminals do not match when paired with a motorcycle that has a long clamp. Furthermore, the material of lithium ion battery material of lithium ion batteries are not available in Indonesia as well as production scale is limited, so the price of lithium ion batteries are more expensive compared to lead acid batteries so it takes a technical feasibility testing to determine how the technical quality of lithium ion batteries.

The advantage of lithium ion battery makes Indonesian battery company develop lithium ion batteries and want to commercialize that battery in Indonesia. Moreover, the market for motorcycle batteries are widely available, so the availability of markets for lithium ion batteries motorcycle certainly provided. In the development of new products required the identification of the technical aspects, market aspects, and environmental organizations [12].

According to [13], in making investment each company will find a way to get the maximum benefit for the company's survival. Because of this, the feasibility analysis is needed [14]. The term feasibility study is frequently used in state of product development processes. There are two primary examination aspects: economic feasibility and technical feasibility. While the economic sense the term "feasibility study" is clearly defined, in a technical sense the term is used in very different ways [15]. Feasibility studies aim to show the risks and opportunities of an investment that is being planned or already in process. There are five areas of feasibility, it consists technical, operational, legal, scheduling, and economic [16].

Business feasibility study is a study of a business plan that not only analyze feasible or not feasible business is built, but also when operated on a regular basis in order to achieve maximum benefit for an unspecified time [17]. The feasibility study was instrumental in the investment decision-making process. From the definition above can be concluded that the feasibility study is an attempt to analyze an investment plan using some aspects of the investment plan with regard to the outcome and sacrifice in order to predict the degree of success of these investments.

In an attempt to analyze the feasibility of lithium ion battery for motorcycle, it is important to conduct feasibility analysis from a technical aspects. This study discusses about the technical feasibility of lithium ion battery for motorcycle as a substitute dry battery.

RESEARCH METHOD

The problem in this paper is how the technical feasibility of lithium ion battery for motorcycle. Fig. 2 is a description of the process of evaluation the technical of lithium ion battery for motorcycle. The product is lithium ion battery based Lithium Ferro Phosphate ($LiFePO_4$) 12 V 3 Ah. $LiFePO_4$ as cathode material [31]. The researcher conducted a study of feasibility study and commercialization model to learn about how to evaluate the feasibility.

The first step to develop the technical feasibility of the product based on the Goldsmith commercialization model. In developing the technical feasibility, there are five steps such as test technical features, develop working models, assess preliminary manufacturability, and finalize the design of the technology. Fig 3 shows the explanation of research approaches to develop technical feasibility. In establishing the technical feasibility has been constructed, this research method uses the concept of Technical Readiness Level (TRLs). The technology is said to fulfill the indicators for each stage of TRL if it has the minimum value of 80%.

The second stage is comparing the technical specifications of lithium ion battery for motorcycle with the technical standardization of motorcycle battery. The standard that is used in this research is motorcycle battery standard of national standard Indonesia.

The output of this study be used for future research which analyze the feasibility of investment products.

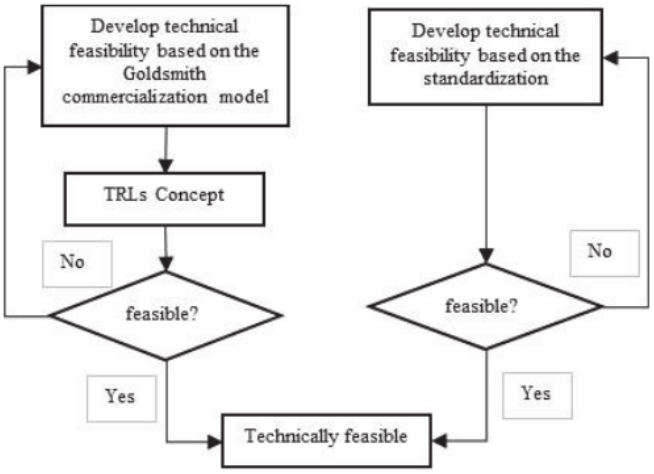

FIGURE 2. Research Approach

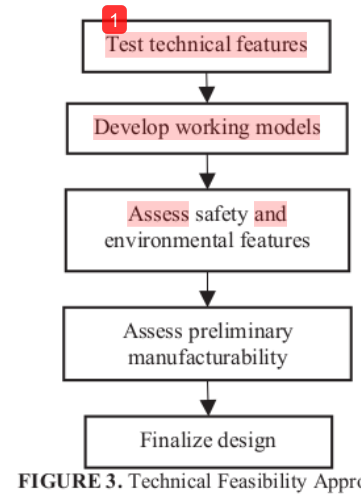

FIGURE 3. Technical Feasibility Approach

Source: [18]

RESULT AND DISCUSSION

Technical evaluation was conducted to determine the feasibility of the project are used to answer whether the project in question is quite reliable, secure, and reliable [19]. The technical evaluation of the lithium ion battery for motorcycle has a main focus the value of technical specification the lithium ion battery for motorcycle and evaluation system according to standard.

Test Technical Features

Test technical features are aimed to prove that the technology can work as a standard. In this research, there are two parts in this stage: technical specifications and technical test research according to standard.

Technical Specification

Regarding the evaluation of the comparison, technical specification of motorcycle battery will be as shown in Table 1. There are two types of batteries that are now used for motorcycles in Indonesia, namely wet and dry battery

TABLE 1. Comparison Between Lead Acid Battery And Lithium Battery

Criteria	Battery (*Lead Acid*)	*Maintenance Free*	
		Lead Acid	*Lithium Ion*
Battery/ Capacity	*Lead acid* / 12 V 3,5Ah	*Lead acid* / 12 V 3,5Ah	$LiFePO_4$ / 12 V 3,5Ah
Voltage	12,1 V	12,4 – 12,6 V	14,4 V
Battery cell	6 cells (@2V / cell)	6 cells (@2, 1V / cell)	4 cells (@3, 2V / cell)
Life Time (years)	1 – 1,5	1,5 – 2	4 - 5
Charging time	5 h	5 h	1,5 h
Weight (kg)	1,7	2	0,5
Size (L X W X H) (mm)	150 x 87 x 93	114 x 71 x 94	68,53 x 42,5 x 52

accumulator. The battery uses lead acid materials. Dry battery has the same characteristics with the lithium ion battery that is equally not require treatment or so-called maintenance free. From Table 1. It can be seen that the lithium ion battery has a technical specification that is better than the wet and dry battery.

The cells of lithium ion battery in the battery are less than lead acid battery. That is because of lithium can store more energy than the lead acid. Then lithium ion battery charging time is faster than the lead acid batteries. That is

because the lithium ion batteries have no memory effect. Memory effect is a situation where charging is done by two stages. The stages are completely discharged and re-charging. The process of charging the lithium ion battery only adds energy storage or re-charging. So that the charging time lithium ion batteries are shorter. Batteries lighter weight due to the atomic mass of lithium is much smaller than the atomic mass of lead, tin, IE 6.939 for the atomic mass of lithium and 207.19 for the atomic mass of tin.

Technical Test Research According To Standard

Regarding the evaluation of the evaluation system according to standard as shown in Table 2. This evaluation shows the result of lithium ion battery test. The test results compare with the SNI requirement. SNI is Indonesian National Standard.

Table 2 presents the list of evaluation criteria and the test result of lithium ion battery. The prerequirement in that table is based by Indonesian national standard of motorcycle accumulator type BTX-4. It is because the capacity of BTX-4 as same as lithium ion battery for motorcycle. Based on the above table shows that test results of lithium ion batteries meet the criteria of SNI.

TABLE 2. The Result of Performance of Lithium Battery for Motorcycle

Criteria	Prerequirement	Result	Explanation	Source
Nominal voltage	12 V	14,4 V	Passed	SNI 4326:2013[a]
Capacity	3 Ah	3,5 Ah	Passed	SNI 4326:2013[a]
Dimension	85 X 70 X 113 (mm)	52 X 42,5 X 68,53 (mm)	Passed	SNI 4326:2013[a]
Life Cycle	275	2000	Passed	SNI 4326:2013[a]

[a]SNI for vehicles accu

Develop Working Model

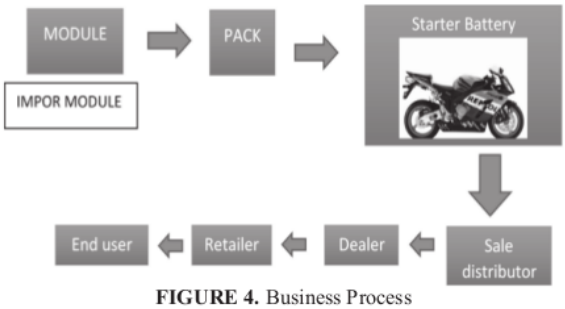

FIGURE 4. Business Process

Develop a working model in this research is the identification of business processes of lithium ion batteries for motorcycles. Here is the business process of lithium ion battery in Indonesia.

Lithium ion batteries for motorcycles imported from aboard, then tested in the company's technical feasibility in Indonesia. Lithium ion battery specifications adapted to the standard specification battery in Indonesia. After qualifying for a technical test, then the battery wrapped and sold through wholesalers, etc.

Safety and environmental features

Checking the potential safety and environmental hazards carried out to identify the potential harmful effects of the new product development and environmental hazards that may occur on the commercialization undertaken.

A process undertaken in the development of lithium batteries is to check the technical performance of the battery. In the process, the workers doing potentially dangerous are the direct contact of chemicals that the risks of irritation to eyes, skin, and respiratory, doing the packaging manually and mechanical handling, batteries are explosive, flammable, and corrosive so when testing the potential of the explosion, fire and electrical hazard [20].

The identification of waste of the lithium ion battery. The waste of battery production can be classified as non hazardous waste. Hazardous waste from the battery only in case of leakage. The leakage of the battery may pose risks such as fire, explosion, release of hydrogen fluoride gas and the risk of exposure to irritant ingredients contained within the battery.

Assess Preliminary Manufacturability

The initial assessment of manufacturing an assessment effort undertaken for planning the manufacturing of a technology. In assessing initial manufacturing, some assessment done by looking at the factor contribution to the value-added chain and availability of raw materials [21]. Identification of the value-added chain made because of the added value of a new product development efforts are important factors.

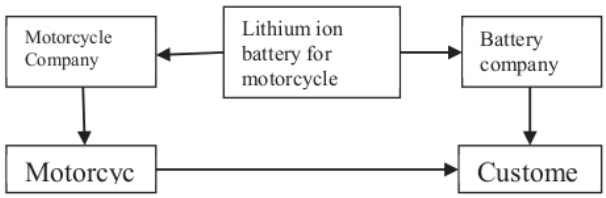

FIGURE 5. The Value Added of Lithium Ion Battery for Motorcycle

Sales of lithium ion batteries for motorcycles currently dominated by Taiwan, China, USA, and Canada. In Indonesia lithium ion battery has not commercialized officially yet. There are no companies that commercialize lithium ion battery for motorcycles. Parallel importation occurs when an importer is entering the genuine goods in parallel, then together with the licensee is authorized to sell the goods at a cheaper price than the same goods by authorized licensees of the brand owner [22]. The value added of the product is shown in fig. 5.

Battery manufacture in particular a motorcycle battery to get a review of evaluation to develop a new type of motorcycle batteries is that lithium ion batteries. Where it is known that lithium ion batteries for motorcycles yet formally commercialized by the company in Indonesia. This makes the business opportunities for the battery company to commercialize the battery. Motorcycle companies may consider using a lithium ion battery for their bike. It could be a value added to the motorcycle used batteries with new technology.

The material of lithium can not be founded in Indonesia yet. Most of the lithium market is dominated by four main suppliers. At 2011, the US Geological survey estimated 70% of the 34,000 tonnes' world lithium production was dominated by Chile (37%) and Australia (33%).

Sales of lithium ion battery is not yet officially available in Indonesia, it makes market opportunities for the company that will commercialize lithium ion battery in Indonesia.

Finalize Design

Finalize design is done to determine the use of lithium battery components. Cathode material is an important part of the research. The cathode material of lithium ion batteries is widely explored today are $LiCoO_2$, $LiNiO_2$, $LiMn_2O_4$ [23].

Among the above cathode materials, $LiCoO_2$ is toxic and very expensive. Pure $LiNiO_2$ could not be commercialized because of safety concerns subsequent to exothermic oxidation of the organic electrolyte with the collapsing delimited Li_xNiO_2. The cathodes $LiCoO_2$, $LiNiO_2$, $LiMn_2O_4$ have higher open circuit voltage, but have lower capacities [24-25]. $LiFePO_4$ suits well because of its low cost, on-toxicity, and environmental benignity. Due to this advantage, $LiFePO_4$ is attracting greater than attention as a promising new cathode electrode material for lithium-ion batteries. LiFePO4 consists of lithium as a single ion that serves as energy storage, Fe as conjugates, and PO_4 as salt or weak acid. The result of the component of material on show in Figure 6.

TABLE 3. Comparison of The Properties of Different Cathodes

Property	$LiNiO_2$	$LiCoO_2$	$LiMn_2O_4$	$LiFePO_4$
Avg. Voltage (V)	3.65	3.84	3.86	3.22
Theo. Capacity (mAh g^{-1})	265	274	117	170
True density (g cm^{-3})	4.73	5.05	4.15	3.6
Specific energy (Wh kg^{-1})	219.8	193.3	154.3	162.9
Energy density (Wh L^{-1})	598.9	557.8	418.6	415
Materials cost	1.628	1.824	1.159	1.219
Energy cost (Wh US$$^{-1}$)	6.08	5.05	5.97	6.31

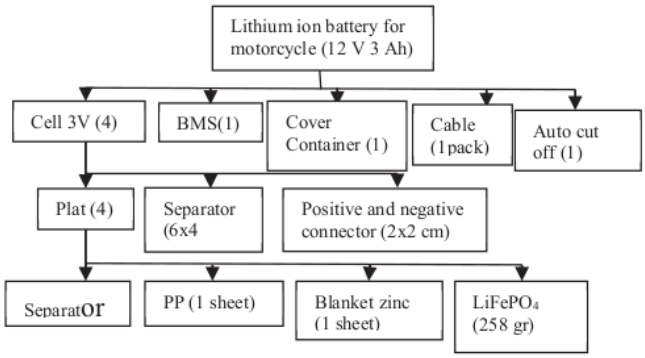

FIGURE 6. The bill of material

$LiFePO_4$ is attracting greater than other attention as a promising new cathode electrode material for lithium-ion batteries. Besides that, we would give comparison between $LiFePO_4$ battery and Ca-ion battery. Calsium-ion batteries are a new uses for larger scale energy storage system [27]. Ca-ion batteries have attracted much attention a next-generation batteries to replace lithium ion batteries. Ca-ion has a lower cost and higher safety than Li-ion because Ca is more abundant than Li. Ca-ion battery has lower voltage than lithium ion battery, but it has higher capacity than the lithium ion battery. There is one hindrance to the application of Ca. There is no appropppriate electrode material in which calcium ions can be put on and extracted reversible because of the roundly substantial iconic radius of calcium ion [28].

TABLE 4. Comparison of Li-ion Battery and Ca-ion Battery

Property	Li-ion	Ca-ion
Voltage (V)	3.22	3.0
Capacity (mAh g^{-1})	170	288
Applicability	Portable and stationary needing high load currents and endurance	Portable and stationary needing high load currents and endurance

Source : [29]

TRLs Assessment

This research uses the concept of TRLs as an approach to determining the technical feasibility which has been constructed. There are readiness indicators that can present a value of TRL. Each of the indicators rated according to the degree of readiness (Scales 0%, 10%, 40%, 60%, 80% and 100%). This research assesses the level of readiness of lithium ion battery for motorcycle by mapping the correlation of technical feasibility and the TRLs concept has been developed by [26].

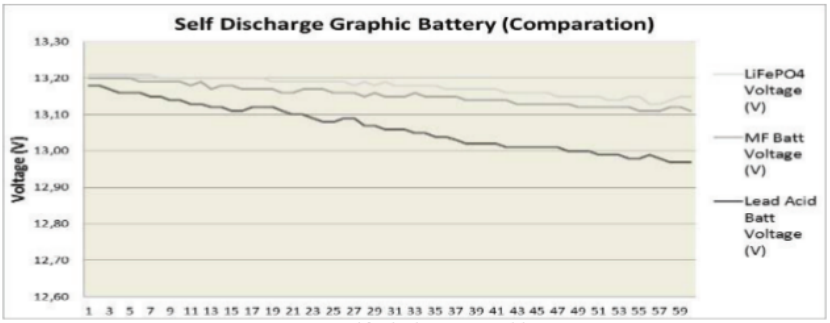

FIGURE 7. Self Discharge Graphic Battery

According to the calculation of TRL, it was found that the lithium ion battery for motorcycle occupied on the TRL 6. The TRL results are 80%. The indicator level indicator 6 is the last level of the design group applied, which states that the test results prove technically feasible. There are six indicators on level 6 is the condition of the operating environment had actually known, the investment needs for equipment and fabrication processes are identified, M & S performance technology systems in the operating environment, parts manufacturing or fabrication approve and accept the results of laboratory testing, the prototype has been tested with an accuracy of laboratory high on a simulated operational environment (which is actually outside the laboratory), and the test results prove technically feasible.

Lithium ion batteries for motorcycles has been tested on a simulated operational environment. The test 10 e carried out on several types of motorcycles. Motorcycle used in the test is Yamaha Mio Sport, Yamaha Mio J, Honda Beat CW, Honda CB 150 R, Honda Scoopy Sport, Yamaha Jupiter MX, Honda Supra X, Yamaha V-Ixion, Suzuki Satria F. From the test results showed that lithium ion batteries for motorcycles can be used on all motorcycles were tested unless Yamaha Mio Sport and Yamaha Mio J. that is because the size of the lithium ion battery terminals do not match the size of the clamp motorcycle. The tests are also conducted to measure the self-discharge of lithium ion batteries. Results of testing the battery self-discharge is shown in Fig. 7. The lithium ion battery has self-discharge is longer than the lead acid batteries and battery MF.

These products do not meet the indicator level 7 because, some aspects have not been made in full and the product is not yet ready to do the initial production.

From the results of this paper, battery manufacture in particular a motorcycle battery to get a review of evaluation to develop a new type of motorcycle batteries is that lithium ion batteries. Where it is known that lithium ion batteries for motorcycles yet formally commercialized by the company in Indonesia. This makes the business opportunities for the battery company to commercialize the battery.

Motorcycle companies may consider using a lithium ion battery for your bike. It could be an added value for the motorcycle used batteries with new technology. Consumer motorcycle battery users can determine battery performance comparison between wet batteries, dry batteries and lithium ion batteries. From these data, the consumer may consider the purchase of a motorcycle battery that fit their needs.

CONCLUSION

This paper analyze the technical feasibility of lithium ion battery for motorcycle. In assessing the technical feasibility of product evaluate the technical specification of the product and compare it with the standard of motorcycle battery. Lithium ion battery for motorcycle has superior specifications compared with the dry battery. The advantages are higher energy, long life, lighter and smaller than dry battery, and no memory effect. Based on this research show that the performance oh this battery in accordance with the standard of motorcycle battery in Indonesia. The lithium ion battery for motorcycle occupies on the TRL 6, which states that the test results prove technically feasible. These are signs of lithium ion batteries for motorcycles technically feasible

According to the specification owned by the battery and sales of lithium ion battery is not yet officially available in Indonesia, it makes market opportunities for the company that will commercialize lithium ion battery in Indonesia. Suggestion for further research will be more about how the market opportunity of the lithium ion battery for motorcycle in Indonesia.

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