Comparative Analysis of Developing Innovation Products on Electric Motorcycle Conversion: Lesson Learned to Commercialization

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Abstract

Electric motorcycle conversion is a new technology in Indonesia. Electric motorcycle conversion as one of the results of the innovation system. There are several parts related to electric motorcycle conversions such as a battery, brushless direct current motor (BLDC), and controller as a conversion kit, then public electric charging station (SPLU) and battery swap for its supporting infrastructure. To develop it as a successful business, then technopreneurship and commercialization technology systems must be considered. This paper provides a study of a technopreneurship model suitable for a technological basis based on comparative research of some parts innovation of electric motorcycle conversion products in Indonesia. Meanwhile, aspects that will be reviewed include technology development, whether included in the market pull or technology push. This paper also analyzes the types of innovation and degree of product innovation, whether classified as closed innovation or open innovation. Next, the product development process models are also considered, so this product innovation does not fall in the valley of death. The findings of the study could be developed lessons learned in the success of technology commercialization. Future research, including quantitative studies, will help examine the conclusions and understand more in-depth of technopreneurship and innovation systems.

Keywords
Electric Motorcycle Conversion, Innovation Product, Commercialization.

1. Introduction

Electric motorcycle conversion is a new technology in Indonesia. Electric motorcycle conversion as one of the results of the innovation system. This product designed because of the higher carbon emissions. It can be seen from the increasing of the Internal Combustion Engine (ICE) motorcycle in Indonesia, reaching almost 300% from 2007 to 2017. For that reason, it automatically will also increase carbon emissions. Now, all countries' governments are trying to reduce carbon emissions from the transportation sector (Bonilla and Donald, 2010). The transportation sector is one of the most carbon emissions source in the global (Andler, 2012).

The Indonesian government also gives special attention to reducing carbon emissions. Trough Presidential Regulation Number 61 of 2011, the targets a reduction of CO2 from the transportation sector by 0.038 up to 0.056 gigatons during 2010-2020. The government also issued Presidential Regulation Number 55 of 2019 for the electrification; all vehicles can be accelerated in Indonesia.

The fundamental innovation idea for electric motorcycle conversion is to reduce carbon gas emissions by replacing engines in ICE motorcycle by an electric power source. This innovation will make customers easier because the customers do not need to buy a new motorcycle if they want to use an electric motorcycle. They can just convert their old motorcycle, and they can use an electric motorcycle. They must replace the engine with a conversion kit, namely battery, BLDC, and controller (Habibie and Sutopo, 2019). There are several parts that must be known about electric motorcycle conversion, and it is shown in Table 1.

Table 1. Electric Motorcycle Conversion Innovation Part

No	Product	Description	Inventor
1	Item	Electric Motorcycle Conversion	Pusbangnis UNS
2	Conversion Kit	Battery	Pusbangnis UNS
3	Conversion Kit	Brushless Direct Current Motor (BLDC)	PT Wiksa Daya Pratama (WDP)
4	Conversion Kit	Controller	PT Wiksa Daya Pratama (WDP)
5	Support Infrastructure	Public Electric Charging Station (SPLU)	PT Perusahaan Listrik Negara (PLN)
6	Support Infrastructure	Battery Swap	PT LG Chemical

Electric motorcycle conversion is one of the results of innovation management. Innovation management comes from creativity and has a final destination as competitiveness (Carayannis et al., 2015). Innovation management is determined by five basic activities (Drejer, 2002). There are: technological integration regards the relation between technologies and the company's products, the process of innovations involves functions creating and preserving innovations, strategic planning refers to the plan of innovation-related technologies, organizational change encompasses the disruptive nature of innovations related to requirements for knowledge and skills, new markets, new employees, etc., and the development of an enterprise refers to the creation of new markets for the products of innovations.

However, not all technological innovations can be successful in the market. There are some products innovation which cannot be present in the market; even many products innovations are only limited to ideas and have fallen into "the valley of death". The valley of death is a gap between research and industrial commercialization. This will not contribute and count as an innovation measurement. This failure also has an impact on the competitiveness of the company. Thus, an improvement is needed by presenting technopreneurship and innovation systems in electric motorcycle conversion. This paper aims to analyze the innovation technology of electric motorcycle conversion to be successful in the market.

There are several previous papers studied about technopreneurship and innovation systems. Yuniaristanto et al. (2015) identified of incubation scheme by the incubator in the university innovation center to develop the Indonesian economy. The roles of industrial engineering education for promoting innovations and technology commercialization in the digital era ware presented by Sutopo (2019). Sutopo et al. (2019) also studied about accelerating technology commercialization, with a discussion on the relation between technology transfer efficiency and

open innovation. Ades et al. (2013) showed that implementing open innovation is the case of Natura, IBM, and Siemens. This paper gives a technopreneurship and innovation system framework of electric motorcycles conversion, those related to them, and their commercialization in Indonesia.

2. A Comparative Study Approaches

This paper will conduct a comparative analysis of electric motorcycle conversion technology development in Indonesia. Six products will be compared in this paper, such as electric motorcycle conversion, battery, BLDC, controller, SPLU, and battery swap. A technopreneurship and innovation system approach will be used to understand the technology innovation process for electric motorcycle conversion, its conversion kit, and its supporting infrastructure. Meanwhile, aspects that will be reviewed include technology development, whether included in the market pull or technology push. It will also be analyzed to the types of innovation and degree of product innovation, whether classified as closed innovation or open innovation. Next, the product development process model and the innovation management model are also considered, so this product innovation does not fall in the valley of death.

2.1 The Concept of Technological Innovation

Technological innovation is often interpreted by the introduction of a new technological product in the market (Carayannis et al., 2015). Technological innovation also is defined as a situationally new development through which people extend their control over the environment. Essentially, technology is a tool of some kind that allows an individual to do something new. So, technology transfer amounts to communication of information, usually from one organization to another (Tornatzky and Fleischer, 1990). In particular, technological innovation is defined as an introduction in the market of a technologically new or significantly improved product or the application of a technically new or significantly improved production process, successfully responding to market demand. It is the outcome of the interplay of market conditions on the one hand and of the possibilities to utilize the stock of technological and scientific knowledge (Schumpeter, 1934).

2.2 Innovation Process

The innovative process is determined through the correlation of its research constituent parts (Nelson, 1977). Inventions can be measured, while the process of research and development can also be determined or constitute an object of research. Most of the innovation models are based on three basic ideas (Drejer, 2002). Firstly, the organization can act in a suitable way in order to create or choose its environment. Secondly, the strategic options of managers shape the structure and the processes of organizations. Thirdly, the selected structures and processes highlight a strategy. Organizations are influenced by innovations in many ways. Creativity is driven by competition, change, learning, climate, communications, processes, social interaction between individuals and other external factors. Despite the fact the application of innovation constitutes an act with a predetermined purpose, uncertainty is its main attribute (Nelson, 1977).

2.3 Innovation Management

Innovation management is the result of the management of knowledge and education. Given that innovations do not constitute a purely technological project, the experience required for their successful management cannot be solely covered by science and engineering. Innovations can be divided into two sectors. Technology management offers technical knowledge and transfer of knowledge and in learning regarding administrative methods (Bohn, 1994; Jelinek, 1979). Knowledge management is defined as the systematic, clear, and premeditated creation, renewal, and knowledge application to enhance as much as possible the knowledge-related company's performance and the revenues derived from the elements of knowledge (Wiig, 1993). defines knowledge management as the art of creating value from an organization's intangible assets (Sveiby, 1998). There are some types of innovation and classified into three groups; it is shown in Figure 1.

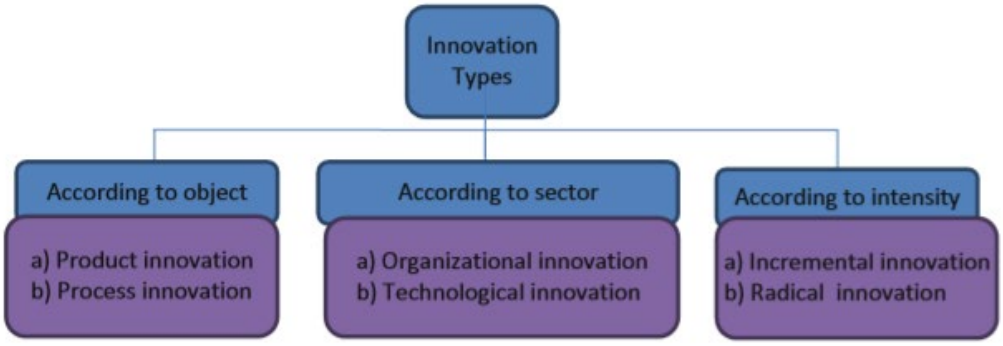

Figure 1. Types of Innovation
Source: Carayannis et al., (2015)

3. Result and Analysis

3.1 Technology Innovation Process

Electric motorcycle conversion is one solution for reducing carbon emission from the transportation sector. That is the reason for the basic idea of this technology innovation. It is also supported by Presidential Regulation Number 55 Indonesian government push to accelerate the electrification of all vehicles in Indonesia. The Indonesian government's target is the number of electric vehicles in Indonesia, reaching 2,5 billion in 2025. The government is also preparing regulations to legalize this electric motorcycle conversion. Based on figure 2, now electric motorcycle conversion is still in a prototype product. Electric motorcycle conversion has passed the identified ideas phase and concept validation phase. This innovation product already in the demo plan phase, where several prototypes are being made and which ones are the chosen best. There is no official company in Indonesia that has been launched electric motorcycle conversion, and the patent right also does not exist. The government also has invited Original Equipment Manufacturer (OEM) of Internal Combustion Engine (ICE) motorcycle to develop this innovative product.

Battery for electric motorcycle conversion is now manufactured in Indonesia. This battery is a lithium-ion battery and produced by Sebelas Maret University (UNS). Initially, UNS was

appointed as one of the universities in Indonesia to support the National Electric Car (Molina) program from the government in 2012. UNS was assigned to make a battery for this Molina. In 2018, UNS succeeded in producing batteries for the first time in Indonesia. The target production quantity for this factory is 1.000 batteries per day. UNS issued two types of batteries, namely LFP 18650 and NCA 18650, with a voltage of 3.2 volts and 3.7 volts, as well as capacities of 1400 mAH and 2700 mAH. Using LFP technology, this battery has high security because it does not cause an explosion in the event of a short circuit. In addition to being recharged and also economical, this battery has a long usage life of up to 3000 usage cycles and is longer than current commercial products (500 cycles) and is able to withstand relatively high temperatures, up to 70° C. This battery was developed by Center for Business Development (Pusbangnis) UNS. Pusbangnis is a center for Technology Transfer Office (TTO) in UNS. This center serves as a facilitator for students and lecturers to develop products and commercialize them.

BLDC and controller actually have been produced in Indonesia. Both components are produced by PT. Wiksa Daya Pratama (WDP). WDP is a company that was born from the Prospective Beginner to Technology-Based Company Program (CBPPT). CBPPT is one of the programs from the Ministry of Research and Technology Indonesia, which is useful to support technology-based companies that want to grow. CBPPT will give funding to those companies. Now, WDP is still developing a competitive product for BLDC and controller. Going forward, these products will be used for the electric motorcycle in Indonesia. Meanwhile, BLDC and controller still have to be imported from other countries to meet domestic needs.

Public Electric Charging Station (SPLU) is one of the infrastructures supporting electric motorcycle conversion. SPLU is similar to a gas station if the gas station provides gasoline for public needs, and SPLU provides electricity for public needs. Gas stations in Indonesia are under the responsibility of PT Pertamina, the provider company for gasoline in Indonesia. SPLU is under the responsibility of PT PLN, the provider company for electricity in Indonesia. As of September of 2019, PLN has manufactured 7.000 SPLU in Indonesia. If the electric vehicle is highly developed in Indonesia, PLN must be forecast electricity power requirement in Indonesia, whether it lacks in power or not. This is because electrical power automatically needs will rise.

Battery swap technology is still on the development of ideas in Indonesia. Electric motorcycle conversion consumers only have to swap their empty battery with a full battery. This battery swap must be integrated with SPLU in Indonesia. The government also makes a standard for battery and its housing, so the battery swap program runs smoothly. Indonesia can emulate other countries that have implemented a battery swap, one of which is Taiwan. Until 2020, there are nine companies interested in developing battery swap technology, namely PT LG Chemical form South Korea, PT Wijaya Karya, PT Triangle Motorindo, PT Juara Bike, PT Migo Ebike Success, PT Green City Traffic, PT Terang Dunia Internusa, PT Tomara Jaya Perkasa, and PT Volta Indonesia Semesta.

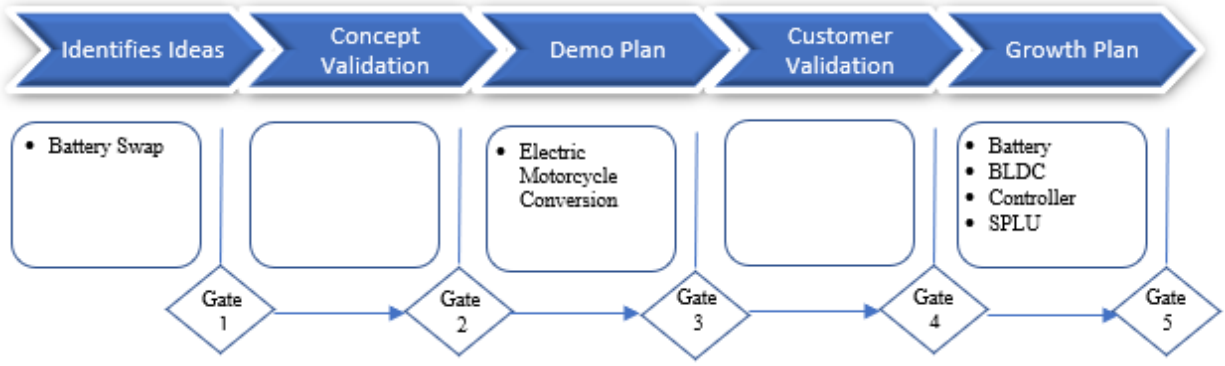

Figure 2. Technology Innovation Process of Electric Motorcycle Conversion

3.2 Innovation Types

According to the object, there are two types of innovation, namely product innovation and process innovation. Product innovation is when a company introduces a new product to the market. In this case, electric motorcycle conversion, battery, BLDC, controller, and SPLU are included in the product innovation category because all of them is product object. Otherwise, process innovation refers to when a company introduces a new process in its product. The battery swap is one technology that changes a person's process when he wants electricity from charging their battery to swap their battery. They don't need to wait a long time to charge their battery and just swap their empty battery to full battery.

According to the sector, innovation is divided into two categories, namely organizational innovation and technological innovation. Corporate or administrative innovation is when a company tries to changes its regulatory system for its innovation. Technological innovation refers to when a company introduces its new product. It could be the raw materials or finished product. In this paper, the six innovation products are included in technological innovation because all of that is the result of technological innovation.

Based on intensity, there are two categories of innovation, namely incremental innovation and radical innovation. Incremental innovation usually makes a small deviation from the existing product. This innovation does not introduce a new product. Electric motorcycle conversion, battery, BLDC, controller, and SPLU are included in incremental innovation. Electric motorcycle conversion just changes the power source of ICE motorcycle from gasoline to electric motorcycles that use electricity. Battery for electric motorcycle conversion changes the raw material form lead oxide to a lithium-ion battery to be more durable and has a longer usage life. BLDC and controller have been on the public, and the changes lie in its capacity to match the battery used and power produced. SPLU is an innovation from gas stations. If gas station provides gasoline for public needs and SPLU provides electricity for public needs.

On the contrary, radical innovation brings fundamental changes in the product and usually introduces a new product. The battery swap is radical innovation because this product did not exist before. People just only swap their empty battery to full battery to get electricity.

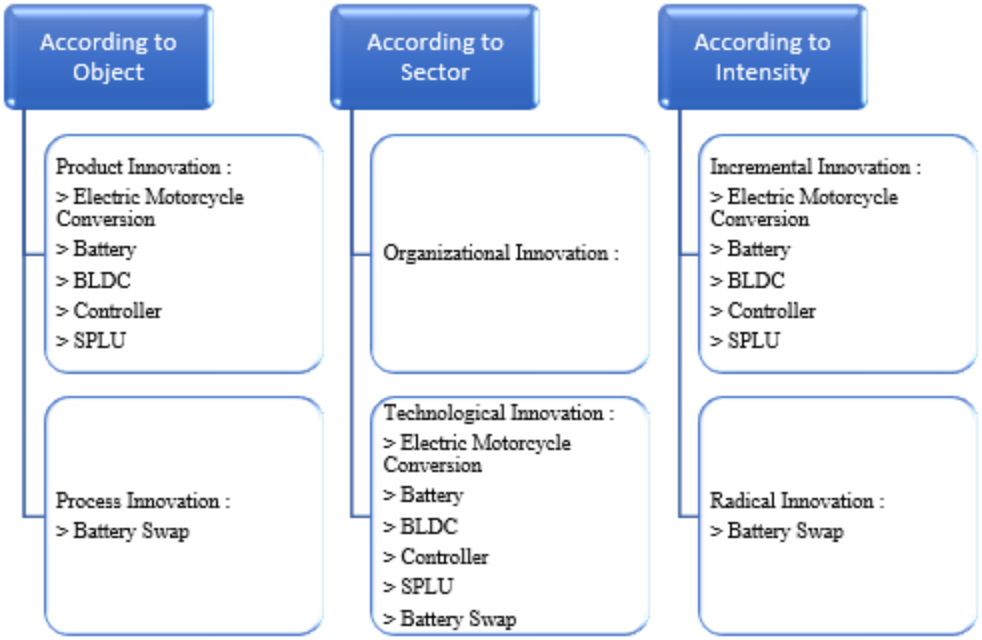

Figure 3. Innovation Type of Electric Motorcycle Conversion

3.3 Market Pull vs. Technology Push

Market pull and technology push is one of model that can be used to differentiate the innovation product when viewed from the customer side. Technology push comes from research and development products, then product manufacturing and launches to the market. Technology push product is very close to radical innovation. The market pull is the reciprocity of customers, shortcomings from previous products, and customer input are an essential point for this side. Customer needs and input will be researched and developed by the company. The product will be manufactured by the company and then launch to the market. Market pull product is very related to incremental innovation.

In this paper, electric motorcycle conversion, battery, BLDC, controller, and SPLU are classified into technology push products. Electric motorcycle conversion is an innovation product from ICE motorcycle. The main replacement focuses on its power source; ICE motorcycle uses gasoline as a power source, and electric motorcycle conversion uses electricity as a power source. Battery for motorcycle already existed before, and the old battery is called a lead-acid battery. The innovation focuses on the raw material. The old battery uses lead oxide as raw material, and the new one uses lithium-ion. Lithium-ion batteries produce more durable power than a lead-acid battery. BLDC and controller have also been on the market before, and it's just changing specifications in order to match the lithium-ion battery used. SPLU is very similar to the gas station. The gas station provides gasoline for ICE motorcycle, and SPLU provides electricity as a power source for electric motorcycle conversion. Battery swap technology is classified to market pull products. The battery swap is a new technology in Indonesia. Before using a battery swap, the government must standardize specification battery and battery housing at the motorcycle. An empty cell will just have to be swapped for a full battery.

3.4 Degree of Product Innovation

In developing an innovative product, two ways can be used by companies. The old companies usually use closed innovation to develop their product. Closed innovation assumes that companies themselves must develop innovations, and the innovation process must be exclusively in companies. Innovation is impossible to be opened in public. Generally, companies have to provide a great budget for their research and development. Otherwise, open innovation can open their innovation process beyond company boundaries. One company can discuss with the other company and make collaborate to develop new innovative products. Consumers also can give input and suggestions to their innovative products. In this paper, all of the innovation products are included in open innovation because at this time the product was also being developed by other companies. Several companies jointly developed even the product. For example, a battery swap in Indonesia is being developed by one South Korea Company and nine local companies. Open innovation also can reduce the great budget for research and development of a new product. However, open innovation does not mean free access to all company's knowledge and technology. Pusbangnis UNS developed electric motorcycle conversion. In its development, Pusbangnis UNS also paid attention to several inputs from the others. Pusbangnis UNS considered a conversion kit that is on the market today. Battery, BLDC, and controller must be in accordance with the electric motorcycle conversion that is being developed. So, several aspects and inputs from others must be considered, including from consumers who will later use it. Lithium-ion battery designed by UNS, also considering technology development from the others. The raw material of this battery is nickel, cobalt, aluminum, copper, and manganese. The availability of the raw material in Indonesia must be seen before further development. Fortunately, Indonesia has the largest nickel reserves in the world. Based on Mineral Commodity Summaries 2019 from the United States of Geological Survey (USGS) in 2019, Indonesia had 21 million tons of nickel equivalent in 2018. The level of mining production in that year was 560,000 tons of equivalent nickel. The development of salt as a raw material for batteries is also being researched, so UNS must pay attention to the development of other products related to batteries and battery as product innovation can run successfully.

3.5 Lesson Learned

There are many products of technological innovation in Indonesia; one of those products is electric motorcycle conversion. As explained in the previous chapter, there are five gates before technological innovation can be successfully commercialized. The first gate is idea identification; some of the ideas must be evaluated before proceeding further. This evaluation can be done in terms of the number of target markets, availability of raw materials, and the complexity of production. A suitable business model must be well planned because a business model cannot be applied to all products. That business model also depends on who the target market is. Electric motorcycle conversion originated from ideas to reduce carbon emissions. The target market of this product is people who use ICE motorcycle and concern about reducing carbon emissions. Some conversion kits are imported from other countries, but in the future, all conversion kits will be produced domestically by some inventors. As a country with the largest nickel reserves, Indonesia can also strengthen it because the primary raw material of lithium-ion batteries for electric motorcycles is nickel.

The second gate is a concept validation. In this gate, a feasibility study must be sought by the inventors. They must determine the investment needed, who will invest in this product, how long

the period is for returning the investment, and the competitive advantage of this product. The third gate is the demonstration development plan. Prototypes products must be made and tested in this gate. For the project start, the product can be used and tested with non-paying consumers. One of the strong reasons for developing electric motorcycle conversion is the Indonesian government supporting this program by issuing several laws. Pusbangnis UNS has made an electric motorcycle conversion prototype in Indonesia as an inventor. Some of the prototypes have been given to some consumers to test the product and provide feedback.

The fourth gate is customer validation. In this gate, the predetermined target market must be validated, whether the target market is appropriate and will buy this product. Feedback from customer testing also must be considered, so electric motorcycle conversion can be the best product according to customer needs. The last gate is a growth plan – the commitment to commercializing. The production scale at the start may not be too large to reduce the risk, but it will increase automatically by business development.

Similar to the explanation above, Osawa and Miyazaki (2006) give five critical points in commercialization technology for technopreneurship. The first critical point is research and development, the second is technology transfer, the third is a product launch, the fourth is a success as a new product, and the last one is successes as a business. In passing these five critical points, an inventor must be careful not to fall in the valley of death. Based on Figure 4, the valley of death is shown as the extent of investment incurred. The greater investment spent from the first critical point to the fifth critical point will make a greater change a product fall in the valley of death. The longer investment reaches the fifth critical point. It will also make a greater change in a product fall in the valley of death.

Battery swap technology is still on the development of ideas in Indonesia. There are many things that still need to be prepared to make a battery swap successful in business. The main thing to do is to standardize battery shape, battery size, and battery housing. Later if there are several battery manufacturers, they will make the battery as required, and it can be swapped with the other cell. If the battery swap is launched, this innovative product will likely be successful in the market because consumers do not have to wait a long time by charging their battery. The consumers just need to swap their empty battery with a full charging battery and use their electric motorcycle again. Based on Figure 4, the constraints that may be faced by battery swap are a scientific risk, technical risk, the high research & development cost, and feasibility study. Research and development about any aspect of the battery swap must be clarified well, so battery swap technology can be successful and can trough the valley of death. Investment planning must also consider whether sufficient capital comes from personal inventors or need additional from other parties such as banks.

An electric motorcycle conversion prototype has been produced. Based on Figure 4, the constraint of electric motorcycle conversion at this point is prototype testing. Feedback from consumers testing must be considered to make electric motorcycle conversion better. Product validation is important at this point, whether the product is already well accepted by the customers. The product can also be introduced initially to the market. The next stage after the prototype is commercialized the product.

Battery, BLDC, controller, and SPLU has been launched the product. Based on Figure 4, those products can be categorized as success as a new product. It means that the inventors have managed to sell at least one product and get first commercialization. At this point is the deepest point in the valley of death. The investment made is the most significant. It is the turning point in the valley of death, and the graph has started to grow up even though it has not yet returned all investments. The constraints at this point are market rollout and market uncertainty. The inventors of battery, BLDC, controller, and SPLU must be the focus on marketing strategy first at this point. The right demand forecasting must be considered so the production can match the demand. The investors must work out how to increase sales until the return on investment. After the focus on sales increases, then the critical point is about licensing. The inventors must register and get the license for their products so the competitor cannot copy this innovation product. If the inventors successful in increasing sales until the return on investment, then it can be said that those products are a success as a business and through the valley of death. In the last point, the inventors must focus on quality assurance and quality improvement to keep market loyalty and then continue to increase sales.

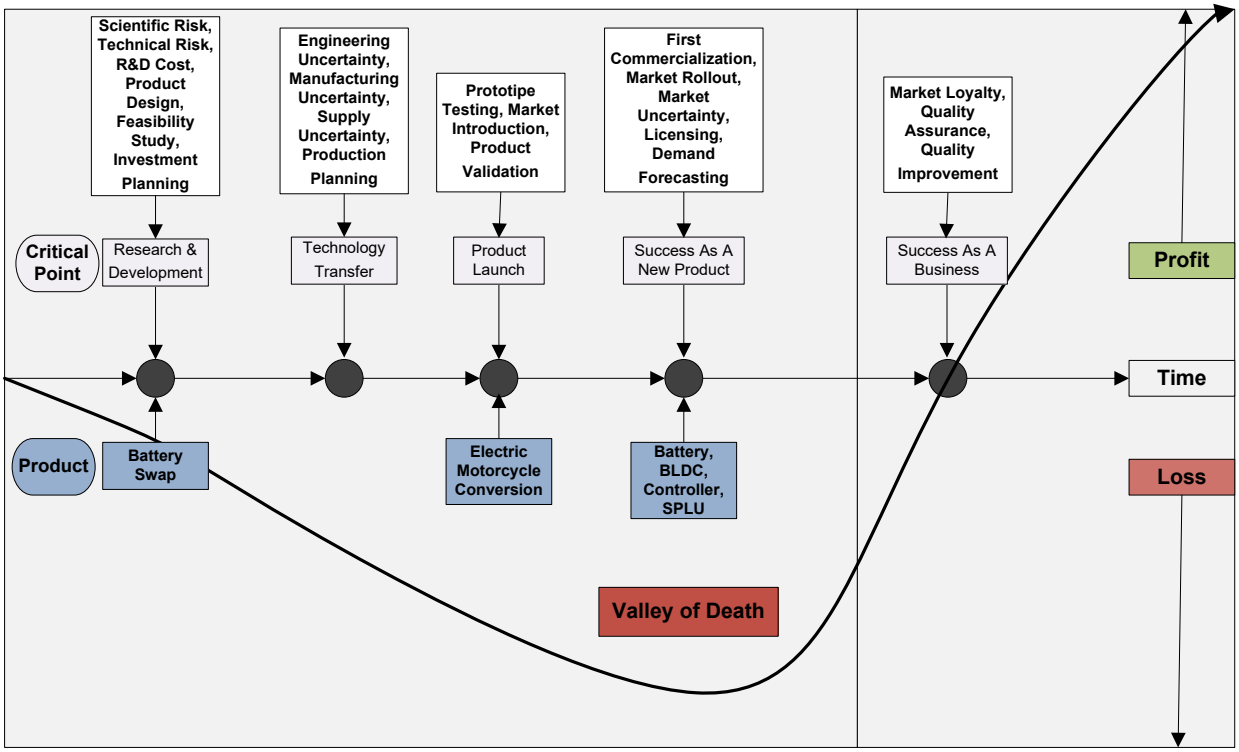

Figure 4. Valley of Death on Electric Motorcycle Conversion

4. Conclusion

There are several parts related to electric motorcycle conversions such as a battery, brushless direct current motor (BLDC), and controller as a conversion kit, then public electric charging station (SPLU) and battery swap for its supporting infrastructure. The comparative study and analysis of all products have been explained. This paper provided a technology innovation process of electric motorcycle conversion, the innovation type, and the degree of product innovation. Battery swap

still in the idea development stage. Electric motorcycle conversion has released a prototype and is being tested. Battery, BLDC, controller, and SPLU has been launched the product even though it has not been successful as a new business. This paper is a step forward in filling the literature gap about technopreneurship and innovation systems with some definite implications for technology commercialization. A lot is written about the collaboration between technopreneur and innovation systems, but the technology commercialization's perspective has been left unexplored. This paper also provided a critical point for product innovation as electric motorcycle conversion to avoid falling in the valley of death.

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