Journal of Economics and Business UBS e-ISSN: 2774-7042 p-ISSN: 2302-8025
Vol. 12 No. 2 Maret-April 2023

RISK ASSESSMENT OF PUBLIC ELECTRIC VEHICLE BATTERY SWAPPING STATION (SPBKLU)

Azkal Fata Herzasha
Institut Teknologi Bandung
azkal_fata@sbm-itb.ac.id

Abstract

The use of Electric Vehicles (EVs) in recent years has become an alternative for people to switch to environmentally friendly technology. Exhaust emissions from Internal Combustion Engines (ICE) vehicle which play a big role in air pollution are one of the strong reasons for people to switch. However, one of the main challenges faced when using EVs widely is the limited range and long battery charging times. The existence of limited electric vehicle infrastructure is also an obstacle to the sustainability of the use of EVs for daily activities. Public Electric Vehicle Battery Swapping Station/Stasiun Penukaran Baterai Kendaraan Listrik Umum (SPBKLU) are one of the potential solutions to this problem that allow EV owners to quickly swap out their depleted batteries for fully charged ones. This research study aims to determine the potential risks that can arise in the development process of the Public Electric Vehicle Battery Swapping Station (SPBKLU) as a solution to the limited range and charging time of battery – based electric motor vehicles. The data collection method was carried out through interviews and surveys to 3 respondents from divisions/units who are owners of business processes related to the SPBKLU project. A comprehensive risk assessment through risk management assessment is carried out on the strategic, financial, operational, project and compliance aspects of this technology. The risks that have been identified are then evaluated and prioritized to then be able to make a mitigation plan in reducing the level of risk to reach the level of corporate risk appetite. The results of the risk assessment identified 16 (sixteen) risks with different levels of risk as follows, there is 2 (two) risks at the Extreme level, 3 (three) risks at the Very High level, 9 (nine) risks at the High level, and 2 (two) risks at the Moderate level. Based on the Risk Appetite level of PT PLN (Persero), only 2 (two) risks that are at the Moderate level will be accepted. Meanwhile, for the other 14 (fourteen) risks, a mitigation plan will be carried out to lower the risk level to a Moderate/ Low level. The mitigation plan that will be carried out is prepared in the form of an action plan that the implementation process will be monitored according to the scheduled timeline.

Keywords: company performance; competitive advantage; brand equity.

Introduction

Increased public awareness of environmentally friendly energy has prompted a change in public behavior toward fossil-based energy consumption (Al-Marri, Al-Habaibeh, & Watkins, 2018). The transport sector is one of the biggest contributors to the increase in CO_2 emissions that are starting to change to renewable energy. This change is marked by an increasing number of manufacturers in the field of transportation starting to produce electric vehicle to meet the public's need for green energy-based vehicle (Zhang & Da, 2015).

According to benchmark study with global consultant, the projected total sales volume of two-wheeled battery–based electric motor vehicle/Kendaraan Bermotor Listrik Berbasis Baterai Roda 2 (KBL BB R2) in Indonesia is estimated to reach 3% of the total national motorcycle sales volume (projection is based on sales volume of ICE based motorcycles in Indonesia) and will increase to 16% in 2030. Using this assumption then the projected number of KBL BB R2 in Indonesia in 2030 is estimated to reach 4.6 million (Yeh, 1979).

Figure 1 Projection of the number of EV motorcycles until 2030 in Indonesia (Source: *PT PLN (Persero) business development study with global consultant*)

To fulfil the increase in electric vehicle users it is necessary to add a large amount of electric vehicle infrastructure (Hardman et al., 2018). Several things have been done by the government, such as issuing Presidential Regulation of the Republic of Indonesia No. 55 of 2019 and Regulation of the Minister of Energy and Mineral Resources No. 13 of 2020 to encourage the acceleration of the KBL BB program as a transportation vehicle. Based on data from the ministry of transportation, the directorate general of land transportation, the number of EV motorcyles users in July 2022 has reached 19,698 users.

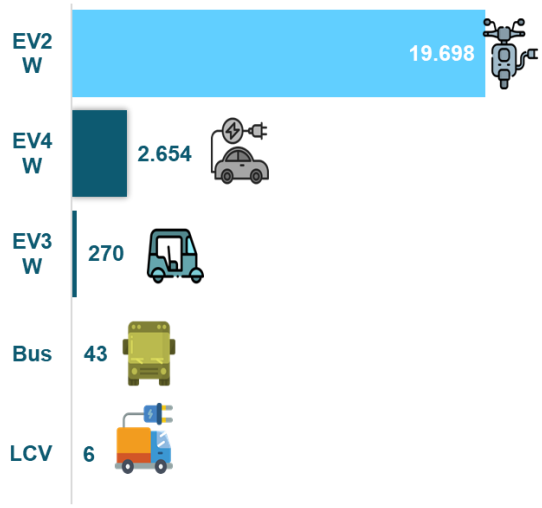


Figure 2 Population of Electric Vehicles in Indonesia, Juli 2022
Source: *The Ministry of Transportation*)

However, the increasing number of battery – based electric motor vehicle users has not been accompanied by an increase in the number of battery swapping stations/Stasiun Penukaran Baterai Kendaraan Listrik Umum (SPBKLU). PLN as an enabler was specifically mandated by the government to develop the electric vehicle ecosystem, specifically entering the upstream sector (supply) and the downstream sector (demand). So, the provision of adequate electric vehicle infrastructure will be one of the key factors to the growth of the electric vehicle ecosystem while increasing public confidence to switch from ICE–based motor vehicle into battery–based electric motor vehicle.

Business Issue

In accordance with Presidential Regulation of the Republic of Indonesia No. 55 of 2019, PLN was specifically given the mandate to develop an electric vehicle ecosystem. One of the developments of the electric vehicle ecosystem by PLN is the development of cooperation with fleet management and electric motorcyles manufacturer (Questera, Aziz, & Purwadi, 2022). PLN continues to build Public Electric Vehicle Battery Swapping Station (SPBKLU) because it is what the community needs most in the midst of the proliferation of electric motorcycle, especially online motorcycle taxi drivers. Based on a study of PLN's business development with consultants related to the roadmap for the development of battery–based motor vehicles, the electric motorcycles can cover a distance of 60 kilometers with full battery (Perujo, Van Grootveld, & Scholz, 2012). Meanwhile, online motorcycle taxis travel around 120 until 150 kilometers every day. So, they have to replace the depleted batteries 2–3 times a day. While the number of existing battery swapping stations is still inadequate. Insufficient supply of charging infrastructure has become a serious issue which hinders the development of electric vehicles (Wu, Song, Li, & Xu, 2018).

In the pilot project stage, PLN collaborating with online transportation operators (fleet management) and electric motorcycle manufacturers. The business scheme carried

out is PLN as a provider of electricity supply, fleet management as a provider and owner of SPBKLU and a manufacturer as a provider of electric vehicles used by fleet management. Fleet management is given a special service tariff for its electricity supply by PLN and waived the rental fee for the SPBKLU location at the PLN office (Yang, Long, Li, & Rehman, 2016). Based on the SPBKLU development pilot project report, with the business scheme as mentioned above, it is still not enough to attract partners to cooperate with PLN in developing SPBKLU. This is due to the large amount of investment that must be spent by business entities to do SPBKLU business and the low level of utilization. And in its implementation, there are still major issues related to technical matters. So, PLN still have to analyse the risks that will arise in the future by developing the public electric vehicle battery swapping station (SPBKLU) for the commercial phase where the business model must be profitable and sustainable for both PLN and partners.

The research questions are: 1. What are the risks in providing Public Electric Vehicle Battery Swapping Station (SPBKLU)? 2. What is the risk level of risks that has been identified and its priority regarding the development of Public Electric Vehicle Battery Swapping Station (SPBKLU)? 3. What are the mitigation plans that can be implemented regarding the development of Public Electric Vehicle Battery Swapping Station (SPBKLU)?

Metode

The research method and techniques chosen in this study are qualitative method. This method is used to identify, analyse, evaluate, and mitigate the risks that could occur in the development of Public Electric Vehicle Battery Swapping Station (SPBKLU). Qualitative methods are carried out by interview, group discussion, and desktop study to determine the best mitigation plan to be applied to the development of Public Electric Vehicle Battery Swapping Station (SPBKLU).

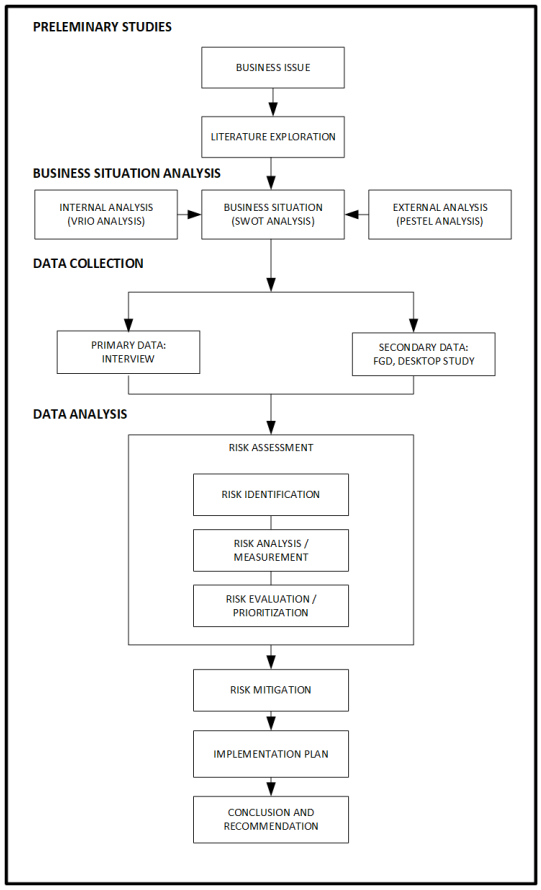


Figure 3 Research Design
(Source: *Author*)

Data Analysis Method

After collecting data, the next step is to apply the Risk Management Process based on ISO 31000:2018. First, establish the context by define the risk management context, including the objectives and the stakeholders who are affected by the risks. Then the next step is doing Risk Assessment (Wang & Wang, 2020). There are three subprocesses, begin with Risk Identification, Risk Analysis, and Risk Evaluation that can be seen below:

a. Risk identification is made by analysing the primary data and secondary data that has been done in data collection process. The result from Risk Identification about the risk that arise when development of Public Electric Vehicle Battery Swapping Station (SPBKLU) started then will be validated by experts from the Corporate Risk Management Unit.
b. Risk analysis is carried out by analysing the risks to determine their significance and to prioritize them for further action. This involves assessing the likelihood and impact of each risk, as well as any potential interactions or dependencies between risks. The level of likelihood and level of impact for the identified risks are prepared based on the criteria of the degree of probability and impact on to the General Guidelines for PLN Integrated Risk Management in the Regulation of the Board of Directors of PT PLN (Persero) No. 0071.P/DIR/ 2021.

c. Then risk evaluation will be carried out to evaluate the risks to determine whether they should be accepted, treated, or avoided. This involves comparing the costs and benefits of different risk treatment options and selecting the most appropriate one.
d. After carrying out the Risk Assessment, there will be a Risk Prioritization to choose the the main risks to be mitigated or to be treated. The Risk Treatment or Mitigation Stage taken by company by reducing the impact or likelihood of the risk. From interviews and group discussions with business process owner and related stakeholders, there will be several alternatives that can be used to reduce the impact of the risks that occur and the probability of the risks. Then several priority alternatives are suggested to be implemented in business processes in the company (Valipour et al., 2015)

Results and Discussion

In this chapter, the results of the risk assessment obtained from the collection of main data from interviews and secondary data discussions, literature review, project reports and other supporting data from reliable sources. Analysis of the risks identified from various data inputs in the risk assessment will then be measured the level of risk and the priority of handling it. A mitigation plan is then drawn up to lower the level of risk on priority risks. The mitigation plan is then broken down into an action plan that can be implemented by the company in the development of the Public Electric Vehicle Battery Swapping Station (SPBKLU) project.

Analysis

Internal and External Analysis

External Environment Analysis: PESTEL Analysis

PESTEL analysis shows 6 external environmental factors that affect the development of SPBKLU. Each influencing factor is described in detail along with its category as an opportunity or threat.

Political

a. Presidential Regulation of the Republic of Indonesia Number 55 of 2019 and Regulation of the Minister of Energy and Mineral Resources Number 13 of 2020 encourage the acceleration of the KBL BB program as a transport vehicle and mandate PLN to develop an electric vehicle ecosystem. *(Opportunity)*
b. The regulations made by PLN are strongly influenced by government policies. So that regulatory changes very often occur when there is a change from government regulation. *(Threat)*

Economic

a. Global economic conditions that have begun to improve after the Covid-19 Pandemic have made people's purchasing power also increase. Because people's financial condition is also getting better. *(Opportunity)*
b. Exchange rate fluctuations that are the reference for determining investment costs will have an impact on the uncertainty of the cost of making and developing a SPBKLU business. *(Threat)*

Sociocultural

a. Battery swapping systems can be particularly beneficial for fleet vehicles, such as delivery trucks, buses, and taxis as it can reduce downtime and increase efficiency. *(Opportunity)*
b. The growing electric vehicle market today will create more demand for battery exchange systems to support the use of battery-based electric motorcycles. *(Opportunity)*
c. People still have a high level of doubt about switching from using an Internal Combustion Engine (ICE) based motor vehicle into electric motor vehicle. Due to the limited availability of electric vehicle infrastructure. *(Threat)*

Technology

a. Battery swapping technology is more efficient than charging station technology. *(Opportunity)*
b. The development of battery technology with more advanced technologies, such as long-lasting batteries, can make battery swapping less necessary and reduce the demand for systems. *(Threat)*

Environment

a. The use of electric motor vehicles can reduce the level of air pollution due to exhaust gases. *(Opportunity)*
b. The increasing use of battery-based electric vehicles poses an increased risk of battery waste. Improper handling of battery waste has the potential to pollute the environment. *(Threat)*

Legal

a. The process of developing an internal payment gateway that has been hampered due to the non-issuance of license from the Otoritas Jasa Keuangan (OJK) as a regulator. Because special permits are needed for non-banking institutions to carry out financial transactions. *(Threat)*
b. There is a dispute between PLN and partners regarding the established cooperation contract so that it can cause lawsuits. *(Threat)*

e. Internal Environment Analysis: VRIO Analysis

Furthermore, business situation analysis is carried out by measuring and evaluating the internal environmental conditions of PLN and its capabilities to generate value. VRIO analysis aims to find out how well PLN's resources and capabilities are used in providing services to consumers.

Table 1 VRIO analysis

Resource, capability, or competency	Valuable	Rare	Inimitable	Organized
Competitive Parity				
State-owned enterprises that manage energy resources	√			
Telecommunications business processes	√			
Temporary Competitive Advantages				

Resource, capability, or competency	Valuable	Rare	Inimitable	Organized
Have experts from various scientific fields, especially related to the use of energy resources	√	√		
Development of electric vehicle charging station	√	√	√	
Development of electric vehicle battery swapping station	√	√	√	
Unexploited Competitive Advantages				
PLN Mobile App	√	√	√	
Transmission network infrastructure that is spread to remote areas	√	√	√	
Sustained Competitive Advantages				
Strong brand image as an Electricity Company that becomes the customer's first choice for energy solutions	√	√	√	√
Large assets and infrastructure	√	√	√	√
Strategically playing a role in national economic growth as the largest electricity provider	√	√	√	√

Source: *(Author)*

Table 1 above contains the key resources, capabilities or competencies possessed by PLN as a business entity evaluated through the VRIO framework. The results of the analysis of all key resources, capabilities or competencies are described as follows.

Competitive Parity

The resources under the group of competitive parity are because several other competitors have similar types of resources.

Temporary Competitive Advantages

With existing resources and competencies, PLN should be able to manage business processes outside the electricity provider's business more optimally.

Unexploited Competitive Advantages

One of the steps taken to increase engagement with customers is to provide the best service to customers by creating a PLN Mobile application that integrates all PLN products. In addition, PLN's electricity transmission infrastructure spread to remote areas should be able to be used to distribute other PLN products, namely the internet network.

Sustained Competitive Advantages

As one of the largest state-owned enterprises engaged in energy and has large assets, large infrastructure and customers spread nationwide, being the main point that distinguishes PLN from other companies.

Business Situation Analysis: SWOT Analysis

Risk Assessment of Public Electric Vehicle Battery Swapping Station (SPBKLU)

From the internal and external results above, the Strength, Weakness, Opportunities and Threats (SWOT) owned by PLN as a business entity that develops Public Electric Vehicle Battery Swapping Station (SPBKLU) are as follows.

Table 2 PLN SWOT Analysis

Internal Analysis			
Strength		**Weakness**	
Convenience for users	Battery swapping systems allows users to quickly replace their battery without having to wait for charging, making it more convenient than traditional charging methods.	Limited battery options	With battery swapping, users are limited to the battery options provided by the system, which could restrict their ability to choose the best option for their needs.
Cost effective solution	Battery swapping can be a cost-effective solution for users, as it eliminates the need for them to purchase and maintain their own battery.	Dependence on battery swapping infrastructure	Battery swapping system requires a well-established infrastructure, which is not yet widely available. It also means that it's less flexible in terms of location and availability.
Reduced downtime for vehicles	By allowing for quick battery replacement, battery swapping can reduce downtime for vehicles.	High investment costs	The battery is one of the investment components that must be provided in large quantities and the price is quite expensive

External Analysis			
Opportunity		**Threat**	
Expansion of electric vehicles market	As the electric vehicle market continues to grow, there will be more demand for battery swapping systems to support these vehicles.	Competition from other charging methods	Battery swapping system faces competition from other charging methods, such as fast charging stations and home charging, which could make it less attractive to users.
Greater adoption	Battery swapping	Battery	Advancements in battery

in fleet vehicles	systems can be particularly beneficial for fleet vehicles, such as delivery trucks, buses, and taxis as it can reduce downtime and increase efficiency.	technology advancements	technology, such as longer-lasting batteries, could make battery swapping less necessary and reduce demand for the system.
Providing environtmentally friendly transportation options	The use of electric vehicles also helps reduce the level of air pollution due to exhaust gases from motor vehicles	Low rate of technological conversion in society	Inadequate electric vehicle infrastructure makes people hesitate to switch from internal combustion engine (ICE) based motor vehicles to electric vehicles

(Source: *Author*)

From the results of the business situation analysis above, the development of a Public Electric Vehicle Battery Swapping Station (SPBKLU) by PLN is still very possible. It's just that PLN must mitigate things that can hinder it as early as possible.

Risk Identification

Risk identification is carried out by interviewing relevant stakeholders based on risk categories in PLN's risk taxonomy. In this study the business process owner who acts as a stakeholder is Strategic, Finance and Human Capital Risk Division, Commerce Product Development Division and Electricity Maintenance Center with the mapping of each risk category as follows.

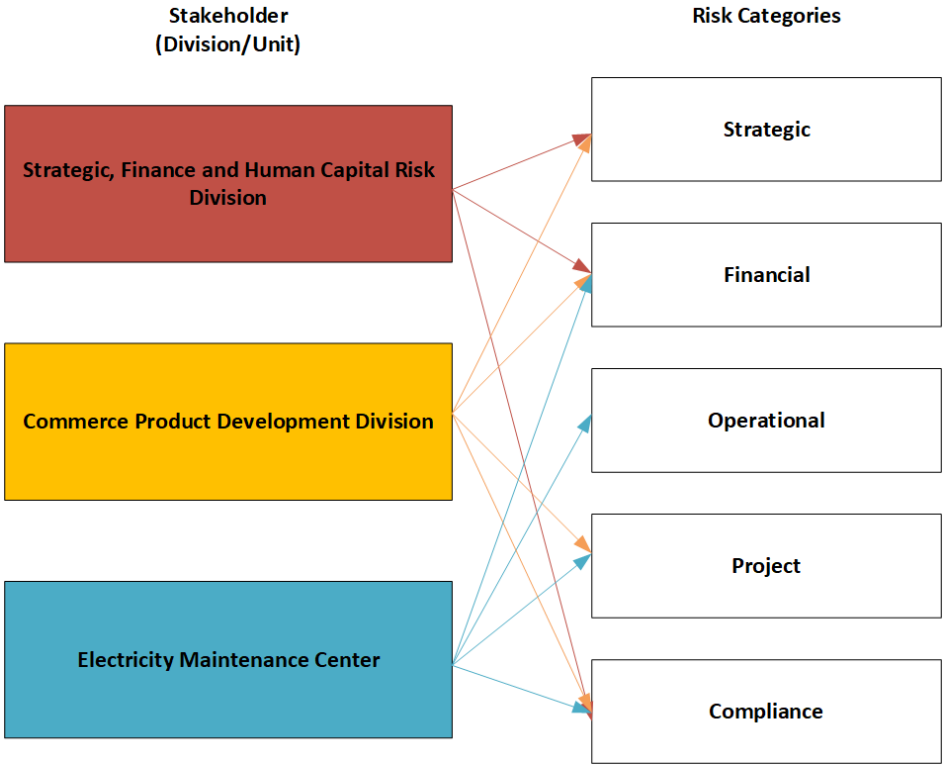


Figure 1 Risk Identification Mapping

(Source: *Author*)

Based on previous study, internal and external analysis, and the interview, all identified risks are listed with the categorization based on PLN's risk taxonomy as seen in table 2 below:

Table 3 Risk Identification

Risk Category	Risk ID	Risk Description	Risk Cause
Strategic (S)	S.1	Government regulatory changes	Changes in global issues related to climate change and net zero emission commitments have also influenced the policies taken by the Indonesian government
Strategic (S)	S.2	Permits for payment systems not issued	Incomplete supporting documents for licensing to be reported to the central bank as regulator (Bank Indonesia)
Strategic (S)	S.3	There is no regulation that sets the basic battery swapping tariff	Ministerial Regulation related to electric vehicles have not regulated the tariffs for battery swapping process
Strategic (S)	S.4	The product development plan is not mature	Battery Swapping Station is still in the pre–commercialization stage
Financial (F)	F.1	Changes in	Global economic conditions

Risk Category	Risk ID	Risk Description	Risk Cause
		interest rates	affected by the Russia-Ukraine conflict
Financial (F)	F.2	Insufficient operation incomes	Battery swapping fees is not enough to cover the cost of electricity production for charging the battery
Financial (F)	F.3	Low investment rating	Excessive investment costs and low return on investment make investments for SPBKLU projects not a top priority
Operational (O)	O.1	Battery swapping process failed	Batteries not registered
Operational (O)	O.2	Inadequate system interconnection technology	Synchronization between Battery Swap System (BSS), back end and payment point is not perfect
Operational (O)	O.3	Battery not compatible with swapping cabinet	Electric motorcycle manufacturers don't want to change the size of the battery to fit the existing cabinet because it will increase production costs
Operational (O)	O.4	Electric motor vehicles battery is broken	There is no battery usage history
Operational (O)	O.5	Force majeure	Damage from natural disasters and other unforeseen events
Project (P)	P.1	There is no standardization of battery models	Electric vehicle manufacturers have their own battery designs and have not yet agreed to make batteries with standardized dimensions
Project (P)	P.2	The Swapping Battery Cabinet Development Project is delays	The development process that involves the type of battery from several manufacturers requires a longer synchronization process
Compliance(C)	C.1	Lawsuits from business partner	Cooperation with several partners can lead to lawsuits if there is an article in a contract that is detrimental to one of the parties
Compliance (C)	C.2	Delays in the adaptation of the latest government regulations	The PLN Internal Regulation review process that requires a long Good Corporate Governance (GCG) process

(Source: *Author*)

Risk Measurement and Prioritization

In determining risk prioritization, the risk rating score is measured and calculated first. The risk rating score is obtained by multiplying the probability level by the risk impact level. Risk rating for each of the risks identified are as follows.

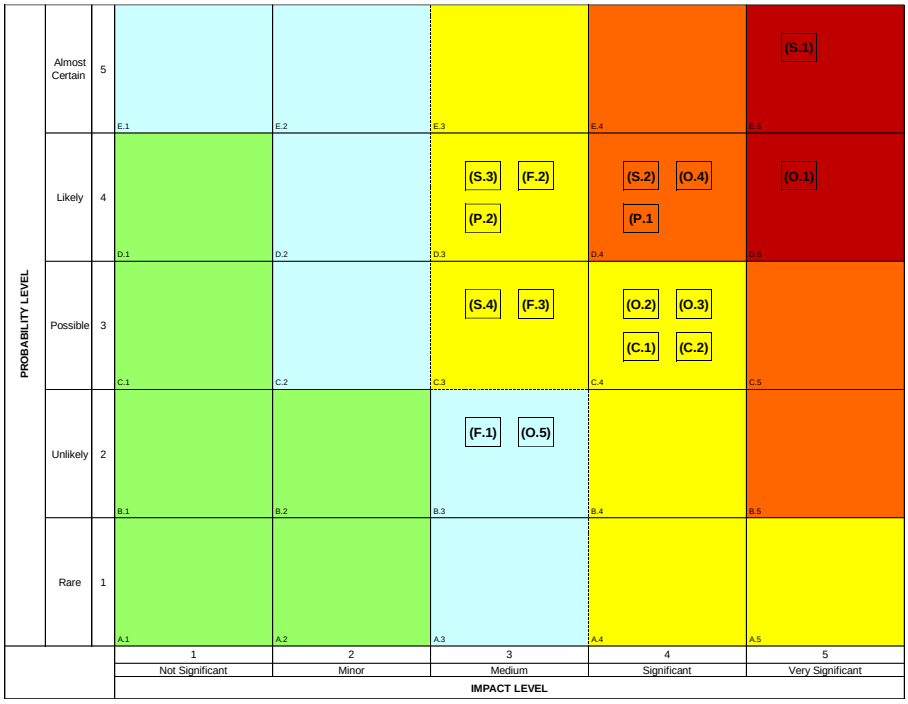
Table 4 Measurement of Risk Level

Risk ID	Risk Description	Likelihood Level	Impact Level	Risk Rating
S.1	Government regulatory changes	Almost Certain	Very Significant	Extreme
S.2	Permits for payment systems not issued	Likely	Significant	Very High
S.3	There is no regulation that sets the basic Swapping Battery tariff	Likely	Medium	High
S.4	The product development plan is not mature	Possible	Medium	High
F.1	Changes in interest rates	Unlikely	Medium	Moderate
F.2	Insufficient operation incomes	Likely	Medium	High
F.3	Low investment rating	Possible	Medium	High
O.1	Battery switching process failed	Likely	Very Significant	Extreme
O.2	Inadequate system interconnection technology	Possible	Significant	High
O.3	Battery not compatible with charger cabinet	Possible	Significant	High
O.4	Electric motor vehicles battery is broken	Likely	Significant	Very High
O.5	Force majeure	Unlikely	Medium	Moderate
P.1	There is no standardization of battery models	Likely	Significant	Very High
P.2	The Swapping Battery Cabinet Development Project is delays	Likely	Medium	High
C.1	Lawsuits from business partner	Possible	Significant	High
C.2	Delays in the adaptation of the latest government regulations	Possible	Significant	High

Source: (*Author*)

The results of the risk rating score will then be mapped into the risk matrix. The risk appetite limit is indicated by a dotted line Mapping risk rating score for all identified risks are shown in table 4 below.

Table 5 Risk Matrix



Source (*Author*)

After measuring the risk rating, the risks above will then be prioritized. Risk prioritization aims to develop a treatment or mitigation plan for the priority risks that can reduce the level of risk to a predetermined risk appetite. Priority risks are risks with a high–risk rating score and above the company's risk appetite. PT PLN (Persero)'s risk appetite is at a low and moderate level, so priority risks are risks that are extreme at high, very high and extreme levels.

Table 6 Risk Prioritization

Rank	Risk ID	Risk Description	Risk Rating
1	S.1	Government regulatory changes	25
2	O.1	Battery swapping process failed	20
3	S.2	Permits for payment systems not issued	16
4	O.4	Electric motor vehicles battery is broken	16
5	P.1	There is no standardization of battery models	16
6	O.2	Inadequate system interconnection technology	12
7	O.3	Battery not compatible with swapping cabinet	12
8	C.1	Lawsuits from business partner	12
9	C.2	Delays in the adaptation of the latest government regulations	12
10	S.3	There is no regulation that sets the basic tariff for swapping battery	12
11	F.2	Insufficient operation incomes	12
12	P.2	The battery swapping cabinet development project is delays	12
13	S.4	The product development plan is not mature	9
14	F.3	Low investment rating	9
15	O.5	Force majeure	8
16	F.1	Changes in interest rates	6

Source (*Author*)

From the results of the calculation of the risk rating in table 4.6 above, there are 4 levels of risk rating. For the Extreme level there is 2 risks, for the Very High level there is 3 risks, for the High level there are 9 risks, and for the Moderate level there are 2 risks. According to PT PLN (Persero)'s Risk Appetite, only 2 risks that are at the Moderate level will be accepted. Meanwhile, for the other 14 risks, risk treatment will be carried out to reduce the risk rating to a Moderate level. The risk treatment carried out is by carrying out a mitigation plan that can reduce the level of possibility or level of impact of the 14 risks that are at the High, Very High and Extreme levels. Each mitigation plan for the priority risks above will then be prepared for an implementation plan.

Conclusion

From the results of the risk priorities above, 7 (seven) risks with the highest level of risk were selected for mitigation. Mitigation plans that can be carried out regarding the construction of a Public Electric Vehicle Battery Swapping Station (SPBKLU)

BIBLIOGRAPHY

Al-Marri, Wadha, Al-Habaibeh, Amin, & Watkins, Matthew. (2018). An investigation into domestic energy consumption behaviour and public awareness of renewable energy in Qatar. *Sustainable Cities and Society*, *41*, 639–646.

Hardman, Scott, Jenn, Alan, Tal, Gil, Axsen, Jonn, Beard, George, Daina, Nicolo, Figenbaum, Erik, Jakobsson, Niklas, Jochem, Patrick, & Kinnear, Neale. (2018). A review of consumer preferences of and interactions with electric vehicle charging infrastructure. *Transportation Research Part D: Transport and Environment*, *62*, 508–523.

Perujo, Adolfo, Van Grootveld, Geert, & Scholz, Harald. (2012). Present and future role of battery electrical vehicles in private and public urban transport. *New Generation of Electric Vehicles*, 3–25.

Questera, Niko, Aziz, Mochamad Vicky Ghani, & Purwadi, Agus. (2022). Preliminary Design to Overcome Range Anxiety in Indonesia Using the Quest Motors Electric Vehicles Ecosystem. *2022 7th International Conference on Electric Vehicular Technology (ICEVT)*, 210–213. IEEE.

Valipour, Alireza, Yahaya, Nordin, Md Noor, Norhazilan, Kildienė, Simona, Sarvari, Hadi, & Mardani, Abbas. (2015). A fuzzy analytic network process method for risk prioritization in freeway PPP projects: an Iranian case study. *Journal of Civil Engineering and Management*, *21*(7), 933–947.

Wang, Xinan, & Wang, Jianhui. (2020). Economic assessment for battery swapping station based frequency regulation service. *IEEE Transactions on Industry Applications*, *56*(5), 5880–5889.

Wu, Yunna, Song, Zixin, Li, Lingwenying, & Xu, Ruhang. (2018). Risk management of public-private partnership charging infrastructure projects in China based on a three-dimension framework. *Energy*, *165*, 1089–1101.

Yang, Tong, Long, Ruyin, Li, Wenbo, & Rehman, Saif U. R. (2016). Innovative application of the public–private partnership model to the electric vehicle charging infrastructure in China. *Sustainability*, *8*(8), 738.

Yeh, Yeong Tein. (1979). *A new surface-wave inversion method for determining lateral variations in Crust-mantle structure with application to China*. The Pennsylvania State University.

Zhang, Yue Jun, & Da, Ya Bin. (2015). The decomposition of energy-related carbon emission and its decoupling with economic growth in China. *Renewable and Sustainable Energy Reviews*, *41*, 1255–1266.