CHAPTER 1
INTRODUCTION

1.1 Background

Sumatra, as one of the largest islands in Indonesia, has significant potential to generate energy from renewable sources. The island has abundant natural resources including hydro, solar, wind and geothermal energy, which have not been fully exploited. Sumatra's strategic geographical position, combined with its wealth of renewable energy sources, provides a great opportunity to support national and global efforts towards a cleaner and more sustainable energy transition. Sumatra can be at the forefront of Indonesia's green energy initiatives, with the potential of how energy is produced and used in the region and in the future can become one of the sources of state revenue from renewable energy production.

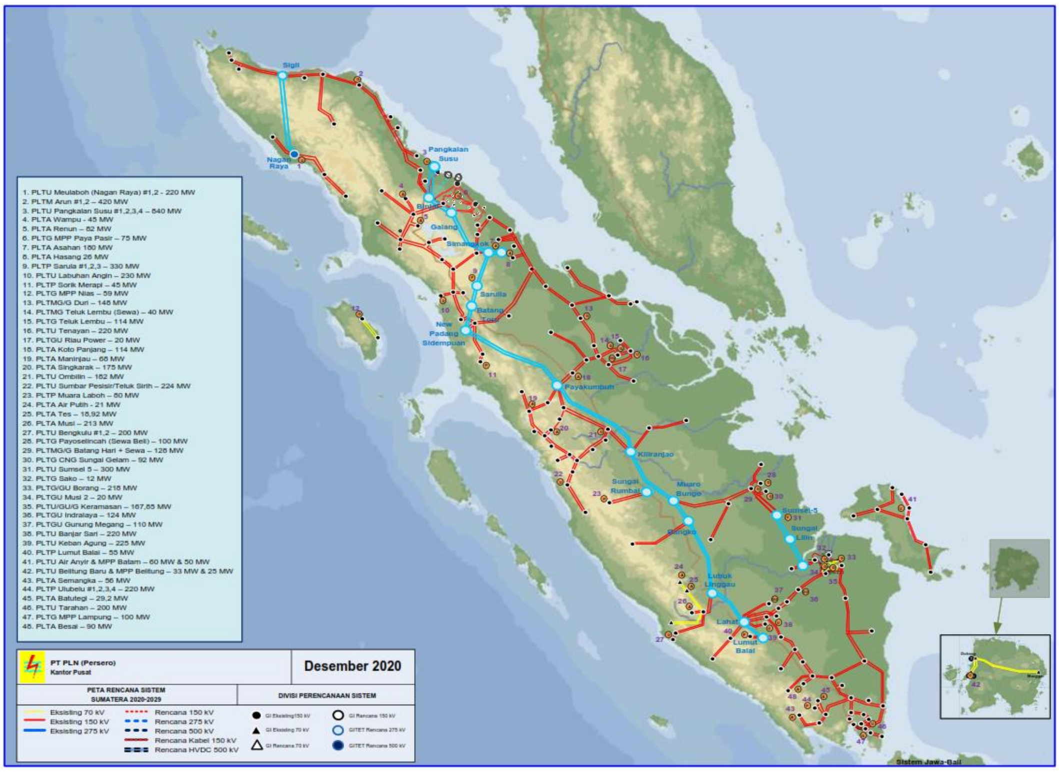

Figure 1.1 Sumatra Power Plants and Grids [6]

On November 11, 2022, PT. Pertamina (Persero), Keppel Infrastructure, and Chevron signed a Joint Study Agreement (JSA) to explore green hydrogen and green ammonia development projects in Indonesia [23].

The project is planned to be located on the island of Sumatra and will utilize renewable energy, namely geothermal and solar power, as its main energy sources. In the initial stage, this facility is targeted to have a production capacity of at least 40,000 tons of hydrogen per year, supported by 250MW of renewable energy sources, with the potential to increase capacity to 160,000 tons per year or equivalent to 400MW of electricity supply depending on energy availability and market demand [23].

This collaboration combines the expertise of PT. Pertamina (Persero) as one of the largest energy companies in Indonesia, Keppel Infrastructure as a leading energy infrastructure solutions provider headquartered in Singapore, and Chevron as a multinational energy company committed to providing clean and reliable energy [23]. Indonesia, which has around 40% of the world's geothermal energy potential, has a great opportunity to utilize geothermal energy as a reliable and stable source to produce green hydrogen and green ammonia [9]. The development of green hydrogen and green ammonia production plants plays an important role in Indonesia's roadmap to Net Zero Emissions. With the potential of Sumatra Island, Indonesia has the opportunity to become a major producer of green hydrogen in Asia. Ammonia can also function as a hydrogen transport medium and has the potential to replace petroleum-based fuels in the shipping industry as a low-carbon solution to global needs.

Figure 1.2 Transmission Gas Pipeline [19]

This strategic collaboration between PT. Pertamina NRE (New and Renewable Energy), Keppel Infrastructure, and Chevron is expected to support

Indonesia's energy transition efforts and investment in the renewable energy supply chain in Asia. By utilizing the existing natural gas pipeline network to send hydrogen to Singapore. This plan is an effort by PT. Pertamina to modernize the existing energy infrastructure and transform it into a means to support the production and delivery of renewable energy. With this hydrogen production capacity, at least 400MW of electrical energy from renewable energy sources is needed. Furthermore, the plan to build a hydrogen plant in Kuala Tungkal includes a plan to utilize and develop energy sources from geothermal, solar energy, and hydroelectric power plants based on the RUPTL (Electricity Supply Business Plan). This scheme plan uses a combination of geothermal, solar energy, and hydro energy sources with the power swap and REC (Renewable Energy Certificate) methods so that it can be declared to produce green hydrogen. The plan to build a Solar Power Plant will be built around Kuala Tungkal as one of the sources of electricity supply and will be the closest renewable energy source to the hydrogen plant, so that the hydrogen production process is expected to run optimally.

The hydrogen product will be transported using the existing natural gas pipeline network from the PT Transportasi Gas Indonesia (TGI) Station in Kuala Tungkal which is part of the Sub Holding Gas of Pertamina to be sent to Singapore. The plan also includes the transfer of natural gas supplies from Grissik in South Sumatra to Java and North Sumatra to the Special Economic Zone (KEK), which shows a strategic reorientation in the management of energy resources in Indonesia [23].

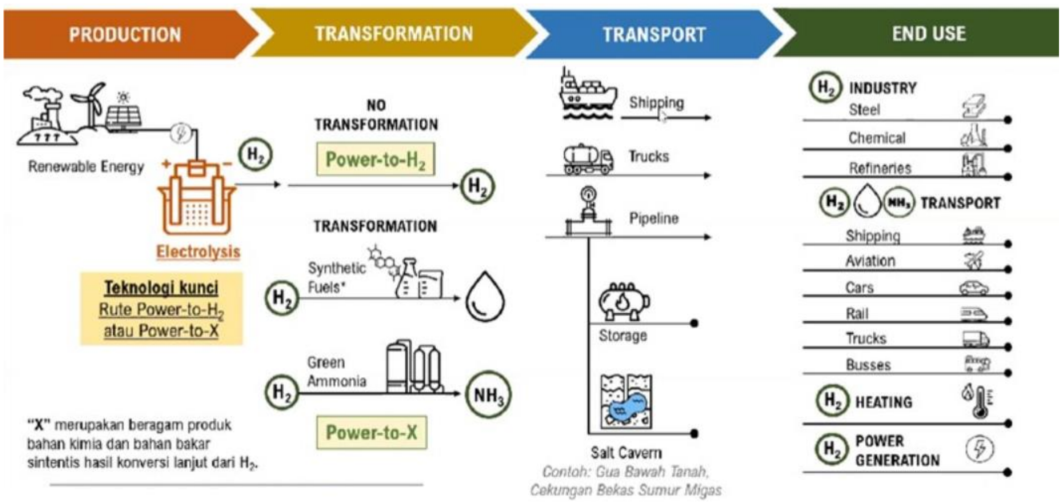

Figure 1.3 Green H2 Value Chain [23]

This thesis aims to analyze the reliability and risks associated with a renewable energy power system that is a source and integrated for hydrogen production. This analysis will include an evaluation of the performance of existing energy infrastructure, potential operational risks, and the impact of integration using the power swap system method. This study is expected to provide insight into the optimization of infrastructure and technology needed to support the sustainable energy transition in Indonesia, as well as recommendations to minimize hidden risks. This analysis includes geographical and environmental considerations for Jambi Province. Meanwhile, the peak electricity load of Jambi Province at night is assumed in 2030 when the hydrogen plant operates, which is 1085 MW, with the supply capacity at that time assumed to reach 1168.7 MW [6].

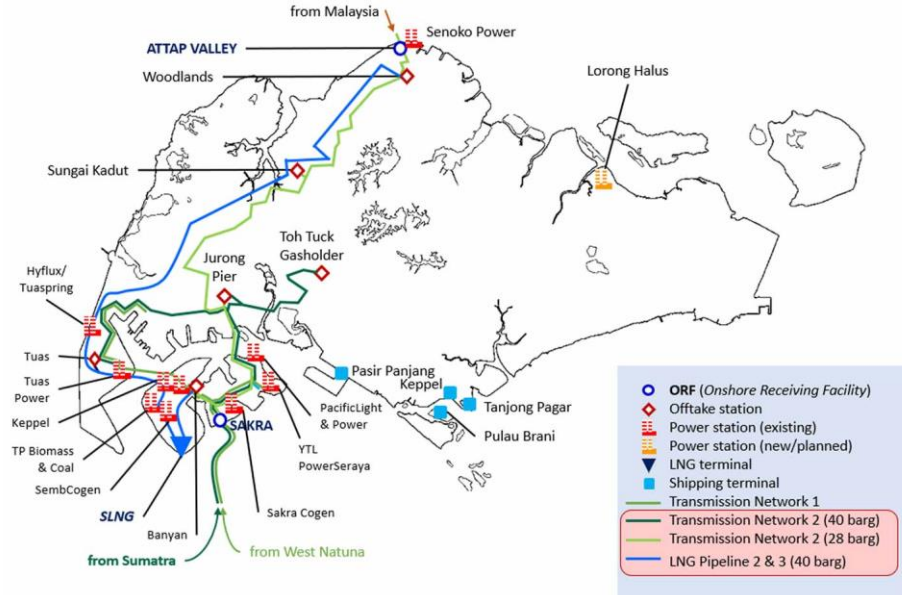

Figure 1.4 Singapore Gas Transmission Pipeline [26]

1.2 Problem Identification

The problem formulation covers aspects of reliability and risk in the context of renewable energy operations in Sumatra, with a particular focus on the integration and sustainability of hydrogen production. The reliability of electricity supply from Geothermal Power Plants (PLTP), Hydroelectric Power Plants (PLTA) and Solar Power Plants (PLTS) connected to the PLN (State Electricity Company) grid in Jambi Province is evaluated to determine its impact on the capacity and reliability of hydrogen production. Furthermore, the risks associated with the implementation of a power exchange system are analyzed, particularly in terms of how this system affects the overall reliability of energy supply for the electrolysis process in a hydrogen plant, also considers the risk to investment feasibility. In addition, the effect of fluctuations in energy production from renewable sources such as solar power sources on the reliability of energy supply for electrolysis is also assessed. The impact of integrating the power exchange system with the local PLN grid in Kuala Tungkal is also studied, particularly regarding its effect on the reliability of the electricity grid in handling variations in load and energy sources. This comprehensive problem formulation aims to explore how generator reliability and risks associated with the power exchange system can be managed to support the implementation and operation of an effective and sustainable hydrogen plant in Sumatra.

1.3 Objectives

The purpose of this study is to answer the following questions:

1. Evaluating the reliability of electricity supply from geothermal, hydro, and solar power plants connected to the PLN grid in Jambi Province, Kuala Tungkal area, with a focus on their capacity to support consistent hydrogen production.
2. Identify and analyze potential risks associated with the power swap system, especially its impact on the reliability of energy supply for hydrogen plant in Sumatra and the financial risks of investment.
3. Investigate the Impact of Energy Source Fluctuations by studying the impact of fluctuations in renewable energy production (geothermal, hydroelectric, and solar power plants) on the reliability of energy supply for hydrogen plant.

1.4 Scope of Work

In order for the research to be carried out properly, the problems in the research are limited as follows:

1. Collecting data on renewable energy power plants, namely geothermal, hydro, and solar, as well as power transmission systems in Jambi
2. The power swap plan between Pertamina and PLN through an agreement and Renewable Energy Certificate
3. Conducting load flow simulations from transmission in Jambi with system simplification

4. Analyzing the Reliability of electricity supply through EENS calculations for renewable energy power plants, namely geothermal, hydro, and solar
5. Analyzing Risks starting from possible scenarios of plant failure conditions to investment feasibility for hydrogen plants and solar power plants.

1.5 Expected Results

The expected outcomes of this thesis are on the integration of renewable energy for hydrogen production in Sumatra which will be crucial in the green energy initiative program in Indonesia.

First, this thesis is expected to provide an evaluation of the reliability of grid-connected geothermal, hydro, and solar power supply in Kuala Tungkal. In this case, this thesis covers the existing electricity supply system to consistently support hydrogen production, highlighting any potential weaknesses or areas for improvement.

Second, this thesis aims to identify and thoroughly analyze the risks associated with the power swap system. This analysis will focus on the impact of the system on the reliability of the energy supply which is essential for hydrogen electrolysis, providing insights in proposing mitigation strategies. In addition, this thesis is expected to conduct an in-depth examination of the impact of fluctuations in renewable energy production on the reliability of the energy supply for electrolysis. This thesis will assess how variations in the output of renewable energy sources affect the overall reliability of the system and will develop strategies to effectively mitigate these impacts. This study will also offer recommendations to mitigate the identified risks, which will further support the investment, implementation and operation of effective and sustainable hydrogen production facilities in Sumatra. These findings are expected to provide a valuable framework for policy makers and industry stakeholders in enhancing energy resilience and sustainability in the region.

1.6 Research Methodology

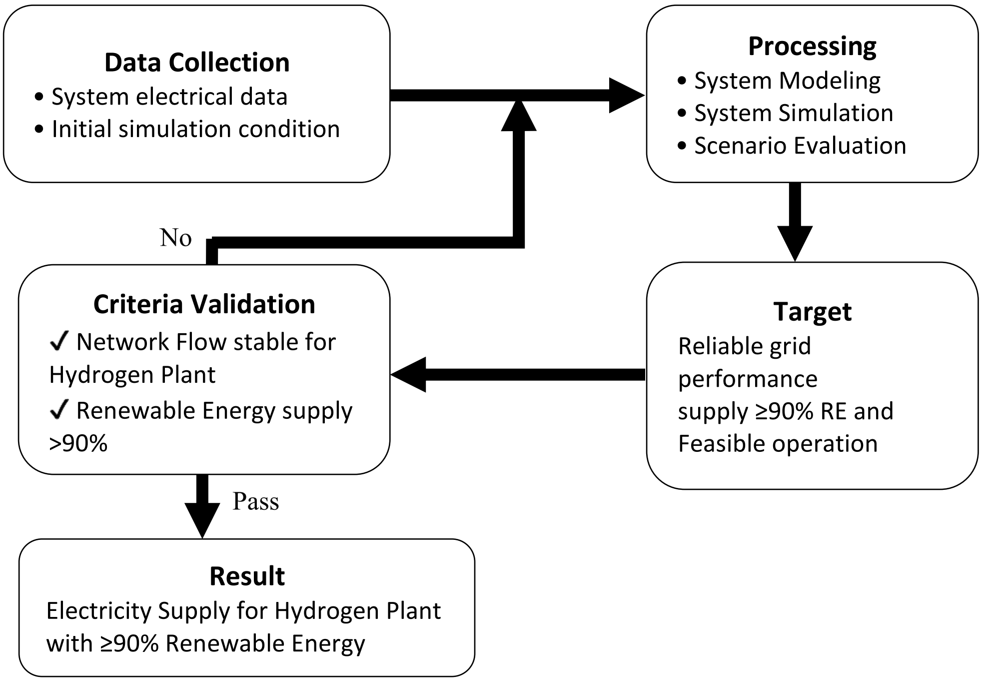

Figure 1.5 Methodology Flow Diagram

These are the following a flowchart explanation for this thesis:

1. Data Collection:

   This stage collects the necessary electrical system data and determines the initial conditions for the simulation. This stage is the basis for subsequent modeling and analysis steps.

2. Processing:

   In this phase, the following processes are carried out:

   - System Modeling: Creating a representative model of the power grid and its components with minor simplifications.
   - System Simulation: Running simulations to assess behavior under various scenarios.
   - Scenario Evaluation: Exploring alternative scenarios including variations in renewable energy generation and load profiles.

3. Target:

   The purpose of the analysis is to achieve

   - Reliable power supply performance for hydrogen plant
   - Renewable energy (RE) contribution ≥90%

- Operational feasibility and reliability for hydrogen production.

4. Criteria Validation:

   After simulation, the system results are validated against the main performance criteria:

   - Grid flows that can meet the sustainable operation of the hydrogen plant.
   - Renewable energy supply reaches or exceeds 90% of the total supply.

   If the target is not met, the process returns to the Processing step for refinement

5. Model Validation:

   Present initial findings to industry experts for feedback and validation, ensuring the model accurately reflects real-world conditions and predictions.

6. Result:

   Once the validation criteria are met, the end result is a reliable electricity supply for the hydrogen plant with a contribution of ≥90% from renewable energy sources..