CHAPTER I
INTRODUCTION

1.1 Background

The twenty-first century, the world must face the phenomenon of global warming which is getting worse. Global warming occurs due to increasing greenhouse gas emissions in the atmosphere caused by human activities such as burning fossil fuels which results in the formation of carbon pools in the atmosphere. Fossil fuel-derived energy is responsible for over 75% of worldwide greenhouse gas emissions and around 90% of all carbon dioxide emissions, which significantly contributes to climate change [1]. This collection of carbon causes sunlight that should be reflected from the earth out of the atmosphere to be reflected back into the earth, causing a greenhouse effect. The most abundant greenhouse gas in the atmosphere is CO2 [2]. The solution that can be done is to carry out an energy transition to renewable energy.

Solar power plants are among the most promising solutions in the energy transition endeavor among the several renewable energy sources that are now accessible. Solar power plant is one of the renewable energy plants that uses solar irradiation as its energy source. Compared to fossil fuel power plants, solar power plants are the fastest growing, most cost-effective to generate because the energy source is free, and have the most favorable impact on the environment. Compared to wind energy, biomass, hydropower, and geothermal energy. Solar power has seen a significant drop in price and is the least expensive renewable energy source [1]. Solar irradiation is an important source of energy conversion for solar photovoltaic (PV) systems [3]. However, the unpredictability of the amount of sunshine received is a hurdle for solar power plants, which depend on solar irradiation as their primary energy source.

Weather factors like clouds, which frequently reduce the quantity of solar energy that reaches the solar panels, further increase this uncertainty. During the day the amount of solar irradiation that hits the solar panel is affected by clouds. When clouds block solar irradiation, the power generated will decrease. Furthermore, The electrical grid may experience an imbalance between supply and demand when solar systems' power production decreases. This might cause the grid's frequency to drop, endangering its ability to function as intended. The daily and seasonal fluctuations of renewable energy sources, such wind and solar, and the requirement to store energy in order to maintain equilibrium between the supply and demand for power sometimes restrict their ability to become widely used in the energy market [4]. To overcome this problem, a forecasting using artificial intelligence is needed because It has been demonstrated that applying artificial intelligence to forecast renewable energy can improve the use of renewable energy resources and boost efficiency by 97.32%, assisting in overcoming obstacles such limited energy management and shifting demand patterns [5].

In the past, intricate and computationally demanding numerical weather models have been used to forecast sunshine or solar radiation. However, because these systems rely on numerous meteorological assumptions that frequently change in the near term, they have limitations in terms of accuracy.For forecasting renewable energy, artificial intelligence (AI) offers a higher degree of accuracy than conventional empirical techniques for estimating solar irradiation [6]. This is because it can more efficiently handle vast volumes of data and identify intricate patterns [7]. Consequently, AI will be used in this study to make the forecasting. Forecasting renewable energy, including solar energy, has advanced significantly in recent years due to advancements in processing technology and the availability of vast amounts of data. Numerous research have used conventional models like random forest and linear regression to forecast weather and energy output. However, when it comes to managing sequential data with significant time correlations, like sunshine data, deep learning techniques in particular, Long Short-Term Memory (LSTM) have demonstrated advantages [6].

Based on research in a journal entitled All sky imaging-based short-term solar irradiance forecasting with Long Short-Term Memory networks in 2024, it shows that using LSTM which has been adjusted in various weather conditions for a period of 0 to 20 minutes ahead gets a forecast score of 39% in sunny conditions and 25% in partly cloudy conditions [8]. In addition, research in a journal entitled Combined K-Means Clustering with Neural Networks Methods for PV Short-Term Generation Load Forecasting in Electric Utilities in 2024 showed forecasting using LSTM by combining data clustering using K- means for the next 168 hours resulted in a mean absolute error of 5.7%. [9]. In this research, we used solar irradiation data for a year, data used for at least a year to determine trends and patterns of irradiation in all seasons in a particular area. For this research, we used the West Kalimantan area. In previous research LSTM has been used for forecasting cloud movement using solar irradiation data and proven to optimize the performance of solar power plants. According to G. Etxegarai et. al at 2022 using artificial neural networks to forecast short-term period solar irradiation, specifically the next 10 minutes provides accurate forecasts, with less than 4% error in 82% of the days tested. From previous studies always using short-term periods, therefore this study aims to develop a forecasting model that can predict solar irradiation with a period of 72 days or 20% of the dataset and a forecasting accuracy of more than 90% and a square error below 5.7%. With the hope of improving and optimizing the use of solar power plants [10].

The application of deep learning to forecast solar irradiation is becoming more and more significant in the age of fast information technology growth, particularly in aiding the renewable energy industry. The effectiveness of solar power plants and other companies that depend on this green energy source depend on accurate forecasts of sunshine intensity. The intricacy of atmospheric data, which encompasses weather, time variability, and other environmental elements, is a significant obstacles to this forecasting process. High-precision solar forecasts may be produced by optimizing forecasting systems using deep learning algorithms that can uncover hidden patterns in vast amounts of historical data. Deep learning is therefore a possible answer for future sustainable energy demands as it provides a more precise and adaptable method.

1.2 Problem Identification

The increase in world temperature due to global warming encourages humans to make an energy transition. Solar power plant as a renewable energy generator is growing rapidly due to its advantages of cost-effectiveness, environmental friendliness, and unlimited availability of energy sources. However, accurate forecasting of solar irradiation is essential to optimize the performance of solar power plants. Based on previous research, there are several problems that need to be identified to improve the effectiveness of forecasting and use of Solar power plants including forecasting periods that exist in previous studies still use a short period of accuracy that is still low below 40% by identifying these problems researchers will focus on developing forecasting models so as to increase the efficiency of Solar power plants.

1.3 Objectives

The objectives of this study are:

1. Making long-term solar radiation forecasting using Long Short Term Memory (LSTM) based on one year of solar radiation data from West Kalimantan.
2. Creating input scenarios for disruptions to the power system using the results of solar irradiation forecasting for West Kalimantan over a one year period.
3. Analyzing the impact of decreased solar radiation on the frequency stability of the power system in West Kalimantan through simulation using DigSILENT software.

Based on the problem formulation, there are the following problem restrictions:

1. The data used is limited to historical data on solar irradiation in West Kalimantan over a period of one year.
2. The prediction model was developed using the Long Short-Term Memory (LSTM) algorithm and was not compared with other prediction methods.
3. The electrical power system simulation was conducted using DigSILENT software, focusing on frequency stability analysis due to decreased solar radiation..

1.4 Expected Results

1. A long-term solar irradiation forecasting model based on the Long Short-Term Memory (LSTM) algorithm has been developed, demonstrating high accuracy based on evaluation metrics such as MSE, RMSE, MAE, and MAPE.

2. The development of realistic and representative solar irradiance disturbance scenarios based on forecasting results, which can be used to test the resilience of the power system against solar energy fluctuations.
3. The acquisition of an understanding of the impact of reduced solar irradiance on the frequency stability of the power system, through simulations using the DigSILENT software.

1.5 Research Methodology

In this thesis, In this thesis, artificial intelligence is used to forecast solar irradiation using solar irradiation data for a year. The research method is as below.

1. Acquisition of Secondary Solar Irradiation Data
2. Data Preprocessing
3. Forecasting Model Development
4. Model Evaluation
5. Disturbance Scenario Construction
6. Power System Simulation
7. Simulation Analysis