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# **The Innovation Breakthrough in Digital and Disruptive Era**

## Smart Grid Study As Solution To The Challenges Of Electricity Transmission And Distribution In North Sulawesi

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**Abstract.** Electricity delivery in North Sulawesi faces many problems, such as inadequate supply, unreliable infrastructure, ineffective power transfer, and inadequate integration of renewable sources. This research is a literature study that provides a logical description in accordance with the study objectives. The results of this study show that Smart Grid Technology is considered a feasible solution to overcome the problem. Smart Grid can revolutionize the power grid in this region by monitoring and controlling superior power transmission by combining contemporary information and communication technology with conventional energy infrastructure. As this research shows, Smart Grid solutions can improve the efficiency and reliability of electric power transmission and distribution in North Sulawesi.

**Keywords:** *Smart Grid, renewable energy, transmission, and distribution*

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## 1 Introduction

To support the development and growth of a region, reliable and efficient electrical energy is needed. The ability to efficiently and reliably transmit and distribute electric power is essential to achieve sustainable development in a given area. Unfortunately, the smooth flow of electricity in North Sulawesi faces many obstacles including inadequate integration of renewable energy sources, poor efficiency, low reliability, and supply shortages. What is urgently needed are innovative measures that can not only overcome these hurdles but also improve existing infrastructure [1].

The electricity network in North Sulawesi faces transmission and distribution challenges, and this journal concentrates on utilizing Smart Grid to overcome them [2]. The Smart Grid approach integrates reliable information and communication technology systems into conventional electricity infrastructure, providing better control, Monitoring, and automation capabilities to manage the electricity grid more efficiently [3].

To overcome the challenges faced, this study aims to observe possible Smart Grid solutions that can be applied in North Sulawesi [4]. These efforts may include using a suite of modern applications to monitor the network, deploying high-tech sensors to detect problems early, deploying distributed energy storage systems, and implementing automated network control through intelligent algorithms [2].

Smart grid is a solution implemented to increase the reliability and efficiency of the electricity network in the North Sulawesi region. The hope is that this can provide an environmentally friendly, reliable, significantly efficient and sustainable electric power transmission and distribution system.

This journal is intended to provide stakeholders in the power industry with useful information and advice to help them develop and implement relevant Smart Grid solutions in North Sulawesi. Thus, it is expected that the transmission and distribution of electric power in the area can operate reliably, efficiently and sustainably.

## 2 Literature Review

This journal is based on important theoretical concepts to understand Smart Grid solutions to overcome the problems of distribution and transmission of electric power in North Sulawesi. Some of the ideas and theories underlying this journal are as follows:

### 2.1 Smart Grid

Smart Grid refers to the integration of information and communication system into traditional electricity infrastructure to create a more efficient, reliable, and sustainable electric power network. Smart Grid enables smarter monitoring, control, and management of the flow of electrical energy, both from traditional and renewable energy sources. Smart Grid enables smarter

and more efficient monitoring, control, and management of the electricity grid [5].

This journal uses Smart Grid as a possible solution framework to address the problem of distribution and transmission of electric power in North Sulawesi.



**Fig. 1** Smart Grid Power Flow Scheme.

### 2.2 Transmission and Distribution of Electric Power

In addition, this journal discusses the basic concepts of electric power transmission and distribution [6]. The transmission sends electrical energy from generators to transformer stations, while distribution sends electrical energy from transformer stations to end consumers [4]. In order to provide a successful Smart Grid solution, it is very important to understand the technical components and functions of electric power transmission and distribution [5].

### 2.3 Renewable Energy Sources

In the Smart Grid solution must be included Renewable energy resources. Smart grid to provide sustainable efficiency utilizing renewable energy sources such as geothermal energy, wind energy, solar energy and biomass. Theoretical foundations related to the use of renewable energy sources will be discussed in this study [7].

There is a lot of potential for renewable energy in Indonesia, especially in the province of North Sulawesi, which can be used to generate electricity. Therefore, to meet continuous load demand, an effective planning plan is required. As a result, to meet the demand for electrical energy in areas that have a lot of potential renewable energy sources, a hybrid system is designed that combines two or more renewable energy sources with conventional energy sources [8].

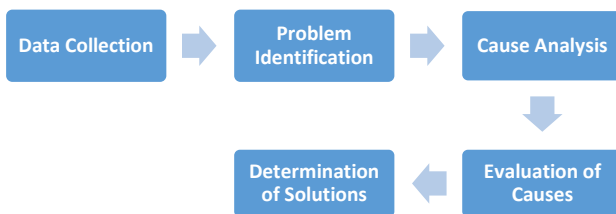
### 2.4 Information Communication Technology

To improve the efficiency and control of the electric power network, the application of information and communication technology is very important. This journal will focus on theories and concepts about ICT infrastructure, network monitoring systems, sensors, and intelligent algorithms. The application of technology communication and information (ICT) in

Smart Grid enables better monitoring, control, and communication between the various components of the electric power network. Sensor technology, communication networks, monitoring systems and intelligent algorithms are important theoretical foundations in the development of Smart Grid solutions [9].

### 3 Method

This research is a literature study that provides a logical description in accordance with the research objectives [10]. This analysis and interpretation are carried out with reference to the theory or research results research according to the problem of the challenges of transmission and distribution of electricity in North Sulawesi. Here are some steps that might be taken in the problem analysis:



**Fig. 2** Data Analysis Step

#### 3.1 Data Collection

The first step is to collect information on the distribution and transmission of electricity in North Sulawesi. Information on power supply, network reliability, system efficiency, integration of renewable resources, and other issues can be entered into this data.

#### 3.2 Problem Identification

At this stage, the main problems faced in the distribution and transmission of electric power in North Sulawesi are specifically identified.

#### 3.3 Cause Analysis

After the problem is found, the next step is to analyze the main factors that cause the problem to appear. This could include reviewing aspects such as inadequate infrastructure, ineffective policies or limitations of the technology used.

#### 3.4 Evaluation of Causes

At this stage, the impact of these problems on power transmission and distribution in North Sulawesi is assessed. These impacts can include poor power supply, high costs, or user dissatisfaction.

### 3.5 Determination of Solutions

The last step is to determine the right solution after understanding the problem and its source. Smart Grid solutions are the main focus of this study, which include the incorporation of information and communication technology into conventional electricity infrastructure [10].

## 4 Results And Discussion

Renewable energy integration systems, system efficiency levels, and network system reliability greatly affect the electricity supply in North Sulawesi. The results of this analysis include the following, which form the basis for the right solution for the development of Smart Grid in North Sulawesi:

#### 4.1 General Information

North Sulawesi is a province in Indonesia that is located in the northern part of the Sulawesi Islands. This province has unique geographical characteristics and consists of a number of islands. Geographically, this province is between 0°N-3°N and 123°E-126°E. Overall, North Sulawesi has stunning natural wealth and beauty, as well as a significant population. Geographical characteristics and the number of islands in this province affects infrastructure and accessibility, including in terms of providing adequate electricity for the entire North Sulawesi region [11].

In North Sulawesi very easily accessible Renewable energy such as water, wind and solar energy. However, due to the difficult geographical conditions and the dispersed population of the region, providing a reliable and efficient power supply is also a problem [8]. Thus, the development of Smart Grid solutions in North Sulawesi is expected to overcome these problems and increase the sustainability and efficiency of the electric power system in the area. [11].



**Fig. 3** Geographic Location of North Sulawesi

#### 4.2 Challenges of Smart Grid Solutions

The results of data analysis are aspects covering needs that arise in response to supply shortages, low

reliability, poor efficiency, and non-optimal integration of renewable energy [12], including:

#### 4.2.1 Lack of electricity supply

Improvement of power generation capacity in the area is needed to overcome the electricity shortage. One way to achieve this is by building new power plants or increasing the capacity of existing ones. Diversification of energy sources is also important to reduce dependence on one type of energy and ensure the availability of a more stable supply [13].

#### 4.2.2 Low reliability

Regular repair and maintenance of the electricity network infrastructure is carried out to increase the reliability of the electricity network [6]. Periodic maintenance, compensation of damaged or obsolete equipment, and development of better systems to monitor and correct outages. The use of intelligent technology and automation systems can also help detect outages quickly and shorten recovery time [13]

#### 4.2.3 Poor efficiency

Using the latest practices and technology is necessary to increase the efficiency of the electricity system in North Sulawesi [12]. For example, implementing a sophisticated control and monitoring system to reduce power losses and optimize energy distribution is a necessary step. In addition, it is necessary to consider strategies to save energy, such as using electricity-efficient equipment and setting tariffs that encourage the use of electricity during low-load hours [13].

#### 4.2.4 Less Optimal Renewable Energy Integration

In order to support increasing the integration of renewable energy sources, it is necessary to add additional supporting infrastructure. This includes building transmission and distribution networks capable of coping with changes in the amount of renewable energy. To encourage investment and development of renewable energy in the regions, it is also necessary to implement supportive policies and regulations. It is very important for stakeholders to be trained and trained on management and technology related to the integration of renewable energy [13].

### 4.3 North Sulawesi faces challenges in electricity supply

North Sulawesi faces challenges in electricity supply. This region consists of various islands with more dispersed populations, difficult topography, and limited accessibility [2].

The Smart Grid solution is an approach that can help overcome the electricity supply challenges in North Sulawesi. Through the implementation of Smart Grid, several solutions can be adopted to optimize electricity supply and improve the reliability,

efficiency and integration sources in this region [13]. Several solutions that can be implemented through Smart Grid in North Sulawesi include:

#### 4.3.1 Smart Grid

Information and communication technologies enable better monitoring, control and communication between different parts of the grid in a smart grid. Intelligent networking enables real-time network management, load monitoring and power checking [9].

#### 4.3.2 Renewable energy integration

Smart Grid enables better integration of renewable energy sources such as geothermal, water energy and wind into the electricity grid. Renewable energy can be optimally integrated and managed using smart technology and systems. This will reduce dependence on fossil energy sources and reduce greenhouse gas emissions [14]

#### 4.3.3 Intelligent load management

As a result, Smart Grid enables intelligent load management, which allows automatic regulation and modification of electricity usage according to needs. An intelligent load management system can properly manage the power supply, avoid overload and optimize power usage [14].

#### 4.3.4 Energy storage

On Smart Grid solutions is very important for Smart use of energy storage systems such as storage technologies, batteries and others. Energy storage systems allow renewable energy to be stored and used when needed, even when renewable resources are not available [15].

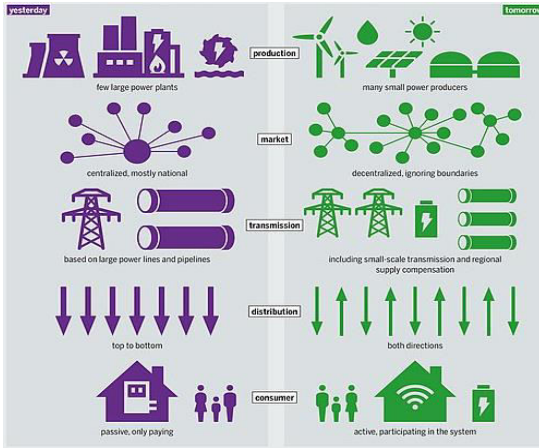
It is expected that a significant increase in electricity supply in North Sulawesi will be achieved through the implementation of the Smart Grid solution. These solutions can help address infrastructure issues, improve efficiency, leverage renewable energy, and provide better access to electricity for people in the area.

### 4.4 System Implementation

Referring to the conditions in North Sulawesi, both regional conditions, electricity conditions, and the availability of energy sources for power plants, a smart grid system that is suitable for application in North Sulawesi covers the generation and distribution of electricity. This is because most of the burden in North Sulawesi is in the form of non-industrial expenses such as household, commercial, and public sectors. Therefore, the implementation of Smart Grid solutions in North Sulawesi can provide significant benefits in increasing reliability of electricity supply, as well as

optimizing the integration of renewable energy sources [16].

On the generation side, Smart Grid can support better integration between conventional energy generation and renewable energy, such as geothermal and water energy. This enables more efficient management of multiple energy sources and minimizes greenhouse gas emissions [7].

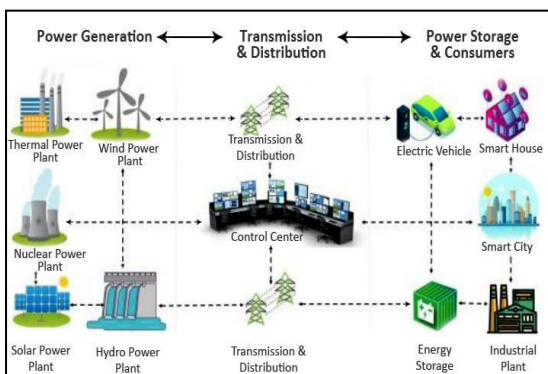


**Fig. 4** Characteristics of traditional systems (left) versus smart grids (right)

On the distribution side, Smart Grid enables more sophisticated network monitoring and control. Integrated information and communication technologies enable more efficient power delivery, faster power outages, and real-time fault detection. This will improve network reliability and speed up recovery time in the event of a disturbance [4].

In addition, Smart Grid can also facilitate the use of smart energy storage technologies, such as batteries, which can optimize the use of renewable energy [9]. By storing energy when there is excess supply and using it when supply is limited, Smart Grid can reduce dependence on conventional generation and increase the use of clean energy [13]

Overall, the application of Smart Grid in North Sulawesi will provide many benefits, including increased efficiency, reliability of electricity supply, and optimizing the use of renewable energy sources. This will support sustainable development and provide better access to electricity for communities in North Sulawesi.



**Fig. 5** Smart Grid Schematic

The Smart Grid electricity scheme involves the integration of information and communication technology into traditional electricity infrastructure [16]. The following main components in the Smart Grid electrical scheme are Power Generation, Transmission Network, Distribution central, Distribution Network, End User, and Technology of Communication and Information (ICT) [17]

With the integration of these components, Smart Grid enables real-time data collection, intelligent analysis, accurate monitoring, targeted control, and efficient management of electrical systems. This allows for increased reliability, efficiency, and integration of renewable energy in the transmission and distribution of electric power [18].

Distribution Line Carrier (DLC) or Power Line Carrier (PLC) is a technology used in Smart Grid implementation to transmit data communications through the electricity distribution network. The way DLC works involves the use of radio frequency (RF) signals or high frequency (HF) signals that are injected into the electricity distribution network [17].

Here are the general steps in how DLC works in a Smart Grid implementation:

#### 4.4.1 Signal injection

RF or HF signals are injected into the electrical distribution network through a device called a coupler. This signal injection is carried out at a different frequency from the frequency of the electric power contained in the network.

#### 4.4.2 Data transmission

This injected signal will run simultaneously with the flow of electricity through the distribution network. The signals carry data and information sent from various Smart Grid components, such as power plants, distribution central, distribution networks, and smart meters.

#### 4.4.3 Signal Reception

At specified points in the distribution network, DLC signals will be received using a receiving device called a coupler receiver. This device will separate the data signal from the electrical power signal.

#### 4.4.4 Data Processing

The data received from the DLC signal will be processed and analyzed by the Smart Grid system. This data may include information about load monitoring, network reliability, power outages, and so on. This data processing enables smarter decision-making in the management of distribution networks.

#### 4.4.5 Response and Control

Based on the received data, the Smart Grid system can respond and take necessary control measures. For

example, cutting power at a certain point to correct interference, optimize power flow, or dynamically adjust network loading.

By using DLC, Smart Grid implementation in North Sulawesi can transmit data and information efficiently through the existing electricity distribution network. This enables more accurate monitoring, more responsive control, and more efficient management of the electrical system [17].

On the control central side, data from all generators and substations will carry out the operation of the power system as a whole [17]. This includes generator scheduling, load forecasting, and remote plant control. Especially in renewable energy generators, which have intermittent energy sources [18].

In implementing the Smart Grid system, it is also possible to use secure and encrypted communication technologies, such as separate telecommunication networks or special communication protocols that ensure the security and confidentiality of the data sent [16]. This is important to protect system integrity, avoid tampering, and prevent unauthorized access to system data and controls. The use of this technology can also enable remote access to the electrical system, allowing operation and control of the system without having to be in a physical location [19].

With the use of advanced control and communication technology, a smart grid system can improve the efficiency, reliability, and operational management of the electricity system as a whole. In addition, with better monitoring and control, smart grid systems can also provide flexibility in integrating intermittent renewable energy sources into the network, thereby enabling the use of cleaner and more sustainable energy [14].

## 5 Conclusion

The Smart Grid system has many advantages over conventional networks. In addition to power flows, smart grids also have data or information flows that are used for remote monitoring and control, increasing the reliability of the electric power system. In addition, the smart grid system can enable the use of renewable energy to generate electricity, so it is very suitable for application in North Sulawesi Province because it has many potential sources of renewable energy that are spread throughout its territory. Some conclusions that can be drawn from the journal include:

- Smart Grid improves system reliability and efficiency by enabling better monitoring, control, and communication between different parts of the power grid.
- Various Information and Communication Technologies (ICTs) used in Smart Grid, such as intelligent algorithms, communication networks, monitoring systems, and sensors, are important theoretical foundations solutions.
- Smart Grid enables better integration of renewable resources into the electricity network, by enabling the use of cleaner and more sustainable energy.

- Development of better electricity infrastructure, such as transmission and distribution networks, is needed to achieve a smart grid solution.
- Policies and regulations that support the development of Smart Grid including investment incentives and training for management and technology stakeholders related to the integration of renewable energy.

By implementing the Smart Grid solution, it is expected that the electricity supply in North Sulawesi will be significantly improved, overcome infrastructure challenges, increase efficiency, utilize renewable energy, and provide better access for its residents.

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