CHAPTER I Introduction

1.1 Background

The fast advancement of technology has resulted in increased power demand, particularly in the city of Bandung; the increased number of electricity usage is due to the use of the Industrial 4.0 era. Industry 4.0 creates wonderful technology that can help human labor while also making it simpler to produce output that is rapid and precise. Furthermore, because inhabitants live side by side and utilize devices or senses that need the origin of electrical power, electricity is already a major necessity for general citizens.

Behind its higher function, its availability also goes through a difficult process, beginning with the generation process and ending with the synchronization process, which is also difficult. Even the organizers must prepare primary standard materials for the generation of electricity, which results in a price that is not cheap in relation to the electrical energy itself. Electric power is utilized in residential residences for a variety of electronic device demands ranging from water pumps, lighting, rice cookers, and smartphone charging. To avoid the possibility of use surpassing the payment due date, it is preferable to monitor power usage and temporarily disconnect the electricity genre.

Because the Internet of Things carries a wireless communication method, which can cause this system to be connected according to the user to the server without human intervention, as a result it can optimize the monitoring & disconnection process, this Internet of Things technology is also very possible to monitor the amount, as well as the cost of electricity used. As a result of this research, a smart kWh meter system capable of disconnecting and monitoring power use was developed.

PT PLN will install smart meters to improve customer service quality. This is shown in the company's decision to provide smart meter services in order to enhance the accuracy of power bills by recording meters in every electrical energy transaction. On the client side, smart meters will supplement the digitization of PLN services. Previously, PLN has encouraged and continues to foster digital transformation beginning with generation, transmission, and distribution. PLN agrees that a digital-based network infrastructure is required for energy transformation and energy transition to be more efficient and responsible.

In this case, with the implementation of smart meters in Indonesia, customers can find out the load profile as well as electricity bills running in real time via the PLN mobile application, eliminating the need to wait for the bill at the end of the month. Customers can thus control energy use and electricity bills as needed. That is, everything is simpler because it can be operated with just one hand.

The deployment of smart meters also makes service patterns more flexible because clients can select between postpaid and prepaid services. Furthermore, because PLN may be recognized in real time by the system, it helps speed up recovery time in the event of a power outage. Electricity meter reading, which was done manually (door to door) by police before to the development of this technology, may now be done digitally, making it more accurate and protecting consumer privacy.

Officers will only visit the customer's home to do maintenance or physical checks if anomalous data or interference is discovered in the communication media and smart meters. Then, this smart meter product can be produced for businesses other than electricity, such as new renewable energy, electric vehicles, internet, agricultural technology, smart home gadgets, and smart prepayment.

LoRaWAN (Long Range Wide Area Network) is a wireless communication protocol intended primarily for low-power, wide-area networks (LPWANs). It allows for long-distance communication between low-power devices, such as those used in Internet of Things (IoT) applications, and a central network infrastructure. LoRaWAN works in the unlicensed spectrum, making it simple to deploy and scale.

LoRaWAN's capacity to deliver long-range connection, spanning distances of several kilometers in rural regions and up to several hundred meters in urban situations, is one of its primary features. This enhanced range makes it perfect for wide-coverage applications such as smart cities, agribusiness, asset tracking, and environmental monitoring.

LoRaWAN is based on the LoRa physical layer, which employs a modulation approach to achieve low power consumption and high interference immunity. LoRa radio-equipped devices may transfer short packets of data at low data rates, consuming little energy and extending battery life. As a result, LoRaWAN is well-suited for battery-powered devices that must operate over months or even years without having regular battery replacements.

Devices communicate data to gateways in a LoRaWAN network, which operate as intermediates between the devices and the network server. The signals are received by the gateways and forwarded to the network server using regular IP connections. The data is subsequently processed and managed by the network server, which routes it to the appropriate apps or cloud services.

LoRaWAN networks provide several device classes, providing flexibility in fulfilling a variety of application requirements. Class A devices are the most prevalent and energy-efficient, working in a bi-directional fashion in which devices transmit data and then wait for network downlink signals. Class B devices feature scheduled receive windows, allowing for more exact downlink communication time, whereas Class C devices have continuous receive windows, sacrificing some energy efficiency for increased responsiveness.

LoRaWAN, in general, offers a cost-effective, scalable, and energy-efficient option for connecting IoT devices across long distances. Its durability in harsh settings, paired with its low-power operation and broad coverage, make it a popular choice for a wide range of IoT applications across sectors.

Long Range Wide Area Network, or LoRaWAN, is a wireless communication protocol intended primarily for low-power, long-range applications. It is a critical technology in the Internet of Things (IoT), allowing objects can connect and communicate across large distances while using minimal energy.

LoRaWAN runs in the unlicensed Industrial, Scientific, and Medical (ISM) radio frequencies, offering IoT devices with long-range wireless communication. It employs a low-power, wide-area modulation system known as LoRa (short for Long Range), which allows devices to achieve exceptional coverage even in difficult urban or rural situations.

One of LoRaWAN's key advantages is its ability to accommodate a high number of devices on a single network. It communicates with gateways, which operate as intermediates between the devices and the network server, thanks to its unique star-of-stars network architecture. This design enables scalability and efficient connectivity, making it appropriate for applications involving dozens or even millions of IoT devices scattered across large geographical areas.

Another important feature of LoRaWAN is its low energy consumption. LoRaWAN-enabled devices can operate on batteries for extended periods of time, ranging from months to years, depending on usage patterns and power-saving measures used. Because of its low power consumption, it is perfect for Internet of Things applications such as smart agriculture, asset tracking, smart cities, and environmental monitoring, where devices may be put in remote or inaccessible locations.

LoRaWAN addresses security concerns in IoT applications using end-to-end encryption and authentication techniques. It ensures that data communicated over a network is secure and is not vulnerable to unauthorized access or modification.

Overall, because of its long-range capabilities, low power consumption, scalability, and comprehensive security features, LoRaWAN has garnered substantial interest in the IoT industry. It has transformed many industries by enabling the efficient and cost-effective deployment of IoT solutions, allowing organizations and individuals to realize the full potential of connected devices and drive innovation in a wide range of applications.

The state of the art is a type of affirmation of the authenticity of the work generated so that it can be accounted for, and as a result, there is no act of plagiarism being a form of piracy of other people's work, in addition to inventing new ideas in the global technology that is currently developing.

The evolution of traditional power meters can be traced back to the origins of smart metering. Historically, utility companies relied on electromechanical meters that required manual reading and gave rudimentary energy consumption statistics. However, these meters have limits in terms of accuracy, frequency of data collection, and ability to deliver real-time information.

As a result of these restrictions and the growing need for more efficient energy management, the notion of smart metering evolved. Smart meters are sophisticated digital devices that monitor and record electricity consumption in real time or at regular intervals. They have communication capabilities, allowing two-way communication between the meter and the utility company.

The adoption of smart meters serves numerous purposes. Its primary goal is to give accurate and timely information regarding energy consumption, allowing consumers to gain a better understanding of their own energy consumption patterns. This information enables them to make more educated decisions about energy conservation and cost management.

Utility firms profit from smart metering as well, as it provides extensive insights into energy demand and load characteristics. They can use this data to optimize energy generation, distribution, and grid management, resulting in increased efficiency and lower operational costs. It also makes it easier to develop demand response programs, in which consumers can modify their energy consumption in response to pricing signals or grid circumstances, boosting energy saving.

Furthermore, smart metering provides additional features such as remote connection and disconnection, which eliminates the need for actual visits to households or companies for utility operations. It also allows for speedier identification of power outages, allowing for quicker reaction and restoration of services.

Smart metering deployment has been aided by developments in communication technologies such as wireless networks, cellular connectivity, and the emergence of protocols such as Zigbee and Wi-Fi. These technologies make data transmission between smart meters and utility providers more frictionless, allowing for real-time monitoring and analysis.

Globally, smart metering efforts have been developed due to a variety of considerations such as energy efficiency aims, environmental concerns, regulatory obligations, and the possibility for greater customer participation and satisfaction. Governments and regulatory agencies have frequently played a substantial role in supporting and mandating utilities' implementation of smart metering.

Overall, the backdrop of smart metering illustrates the energy sector's continual shift toward a more data-driven and efficient system. Smart metering has the potential to alter the way we consume and manage energy by giving accurate information, improving energy management, and enabling a smarter grid, resulting in a more sustainable and resilient energy future.

The origins of smart metering can be traced back to the demand for more efficient and precise energy usage assessment. Mechanical or electromechanical utility meters, for example, required manual reading and had limited functionality. The creation of smart metering systems was prompted by the advancement of advanced technologies and the growing demand for energy efficiency.

Smart metering originated in the late twentieth century as a result of a desire to update utility infrastructures and enhance energy management. Smart meters are electronic devices that record and send energy consumption data in real time or at predetermined intervals. These meters have communication capabilities, allowing them to talk with utilities and provide two-way communication.

The installation of smart metering systems has various advantages. For starters, it gives precise and timely energy usage information, eliminating the need for manual meter reading and decreasing human errors. This data helps consumers to monitor their energy consumption habits and make informed decisions to manage energy usage, thereby saving money and benefiting the environment.

Smart metering improves load control and planning for utilities. Smart meter data in real time helps utilities understand energy demand patterns, spot anomalies, and respond swiftly to grid failures or irregularities. It also permits time-of-use pricing and demand response programs, which encourage consumers to shift their energy consumption to off-peak hours and reduce grid pressure during peak periods.

Smart metering systems are frequently integrated into broader smart grid programs. Smart grids use advanced technology such as sensors, communication networks, and data analytics to improve the electrical grid's efficiency, dependability, and sustainability. Smart meters are an important component because they provide detailed energy consumption data, facilitate demand-side management, and allow for the integration of renewable energy sources.

Several reasons have contributed to the broad use of smart metering. Government laws and regulations, energy efficiency targets, the demand for more accurate billing, the necessity for grid modernisation, and the growing emphasis on sustainability are among these. To attain these goals, many governments and areas around the world have begun large-scale smart meter rollouts.

Overall, smart metering represents a dramatic shift in the measurement and management of energy usage. It provides a more transparent and efficient energy ecosystem by providing actionable data to customers, utilities, and grid operators to encourage energy savings, increase dependability, and pave the path for a smarter and more sustainable future.

According to Gunawan Wibisono et al.'s research, LoRa WAN technology is the best LPWAN technology that PLN Bali can use as a two-way smart meter [1].

Based on the results of the implementation tests, the two types of LoRaWAN-based smart meters can be operated for both pre-paid and post-paid clients. According to the implementation test results, customer satisfaction is 100% and meter reading success rate is 100%. He suggested that the two-way smart meter, which is part of the PLN Bali Smart Metering system, be continued to be implemented throughout Bali [2].

As part of their network modernization initiatives, many utilities are using advanced metering covered infrastructure events (AMI). Smart Metering automatically collects interval smart meter data by customer location and delivers it to the utility. As a result, a massive volume of data is generated that must be examined for various objectives. This data allows poly utilities to use data analytics to potentially improve their operations in terms of efficiency.

Meter data, for example, can be utilized to improve voltage rating and optimization, evaluate distribution line losses, identify and quantify power theft, and enable better load assumptions and distribution system analysis.

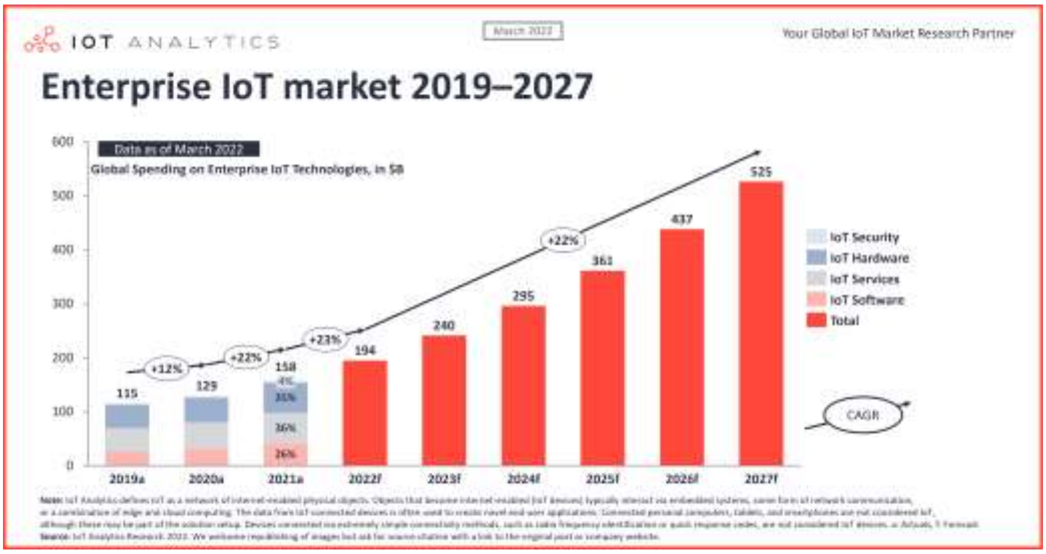

Figure I.1 Graph Global Market Value Internet of Things

In the digital era, IoT has many opportunities, and interest in IoT is growing as more devices are connected to the internet. IoT deployment is fast developing and has the potential to become a business opportunity due to the large market, therefore traffic will continue to rise. The expansion of the Indonesian IoT sector is expected to produce Rp444.2 billion [4].

Because IoT connectivity solutions have grown and span a wide range of use cases that service a wide range of purposes, no single communication method is suited for all applications. By considering the fundamental technology of each, IoT connectivity technology can be divided into two categories based on transmission distance: short distance and long distance, with licensed and unlicensed spectrum as alternatives. Because the Smart Metering system is supported by various sensors and control devices in the communication infrastructure system, connection plays a critical role in supporting the Smart Metering service system [5].

IoT connectivity technology is evolving and includes a wide range of services that meet a variety of needs, and each connectivity technology has its own set of characteristics and advantages, necessitating a comparative analysis of feasibility studies on the feasibility of connectivity technologies suitable for Smart Meter planning in the Bandung area.

In this study, researchers will examine the viability of IoT network technology based on LPPWAN, of course, using LoRaWAN in the Bandung area. Bandung City is characterized by a burgeoning industry. This is where energy use management is required, hence Smart Meter is deemed appropriate in managing energy use management. The feasibility study for building an IoT network is then analyzed using the TEA approach, which is designed to support decision-making and evaluate the success and viability of a technology.

The approach with the TEA method will be divided into three segments in this study, including regulatory, technical, and economic, such that the outcome of the research will be whether or not LoRaWAN technology is employed for Smart Metering services, particularly on kWH meters in Bandung City.

1.2 Statement of the Problem

The formulation of the case in this research is as follows.

a. How to analyze the use of smart metering using LoRaWAN based on the TEA model?

b. How to design a LoRaWAN network for smart metering users in the Bandung area?

c. How to analyze the cost structure for smart metering users in the Bandung area?

d. How to analyze regulations related to the design of LoRawan networks for smart metering users in the Bandung area?

1.3 Objectives

Based on the background & case formulation, the objectives based on the study were influenced as follows.

a. Analyzing LoRaWAN connectivity technology using the TEA model which is divided into three segments, namely technical, economic, and regulatory.

b. Analyzing LoRaWAN-based connectivity network for smart metering based on Coverage and Capacity planning.

c. Analyzing the cost structure planning (Capex, Opex, Revenue, NPV, IRR, PP and PI) of the LoRaWAN network.

d. Analyze regulations related to LoRaWAN network planning for smart metering use based on laws and regulations in Indonesia. d. Analyze regulations related to LoRaWAN network planning for smart metering use based on laws and regulations in Indonesia.

1.4 Scope and Delimitation

The author places certain case limits into the following based on the discretion based on the formulation of the case that was listed before for this research.

a. The IoT network deployment area in this study is the Bandung area, West Java.

b. Analysis of the selection of IoT technology for Smart Metering services based on the use of electrical energy not for other energy such as water, gas and fuel.

c. This IoT technology is non-3GPP listed, namely LoRaWAN, not compared to 3GPP technology, namely Nb-IoT.

d. The scope of discussion for the implementation of IoT technology for smart meters will be carried out only on the network connectivity side.

e. Feasibility study for IoT network deployment based on technical, economic and regulatory analysis.

f. Because this study solely analyzes if LoRaWAN is practical as a Smart Metering service provider for telecoms operators, the business case utilized in this study is an example of a business becoming an IoT provider.

1.5 Hyphothesis

IoT connectivity technology necessitates connectivity with wide-area coverage, long battery life, and low device cost. LPWAN-based connectivity technology is seen as a solution to the connectivity issue, particularly for smart meters.

AMI systems are made up of smart meters that are fixed in densely populated regions and necessitate frequent communication, low latency, and high data rates [6]. However, because LoRaWAN operates on unlicensed airwaves, it cannot deliver the same level of service as licensed technologies[7]. However, it has the advantage of requiring less capital than licensed technologies. Furthermore, the coverage and gateway capacity of licensed and unlicensed services differ.

Capacity, Coverage, QoS/Data Rate/Latency, Battery Life, Security, Ecosystem, Business Model, Time to Market, and Total Cost are the primary factors influencing the performance of IoT applications."[7] However, according to the LoRaWAN study, no single technology can meet the needs of all applications[8].

1.6 Research Metodology

The research methods used in the study are as follows:

a. Literature study

Learning theories linked to IoT connectivity technology, such as the notion of IoT, LPWAN, and design both technically and economically, is required through numerous references, including books, journals, and past research that supports the running of this research.

b. Data collection

Data is collected from telecommunications service providers, national utility companies, and/or other parties involved in smart metering applications and LPWAN-based technology installation.

c. Calculation of Technical Requirements

Potential customer identification, device and application requirements, customer growth predictions, traffic capacity, pathloss, and coverage calculations.

d. Feasibility Study Analysis

The examination of feasibility studies is divided into three categories: technical, economic, and regulatory feasibility analysis.

e. Conclusion

The feasibility study analysis results are completed to provide recommendations or ideas for regulators or decision makers in assessing whether or not LoRaWAN technology should be used, particularly for smart meters