

Techno Economic Analysis of LPWAN Smart Meter Project To Escalate Company Performance & Fairness Concern (Case Study: PT PGN Tbk)

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Abstract – The government's strategic program, gas network for households (Jargas), aims to connect 4.7 million households to gas by 2025. This creates new challenges for PT PGN Tbk, because the large number of customers owned contrasts with PGN's revenue from household customers. There are numerous operational issues, such as a high error rate, a high receivables rate, etc. PGN must find a way to make household operations more efficient by utilizing new technology in order to improve company performance and fairness. In this study, we evaluate various smart meter technologies, such as prepaid smart meters, wired communication smart meters (fiber optic connection), and wireless smart meters as well as focus on LPWAN smart meters. The LPWAN communication modes we studied included Lora WAN, NB IoT and Sigfox. We evaluate the best smart meter technology based on technical & economic evaluation and cost-benefit analysis. Lora WAN provides the most appropriate cost benefit among LPWAN communications, based on an economic evaluation that estimates recovery from uncollectible at 100%, Lora WAN smart meters outperform conventional meters in terms of calculating total cost of ownership in year 7. PGN should use smart meters, especially if the target reaches up to 1 million/year household customers per year, because it will provide benefits in terms of CAPEX and OPEX meters, as well as eliminate potential risk of account of receivable up to 32.25 billion rupiah if PGN household customer up to 4.7 million.

Keywords - smart meter; LPWAN; household gas network; cost benefit analysis; technology

I. INTRODUCTION

Based on the RUEN (*Rencana Umum Energi Nasional*) target for construction of a household gas network (2020-2025) is 4.7 million household gas connection. One of the government's strategic steps to replace the use of petroleum is to increase the use of natural gas for the home sector and small customers. It is called the gas network for household or city gas. A gas network for households means passing the gas through a pipeline to the house stairs. Distribution network development for household is one of the national priority programs that aims to diversify energy, reduce subsidies, provide clean energy at a low cost, and complement programs that convert kerosene to Liquefied Petroleum Gas (LPG) to accelerate the reduction of oil use. Through this program, the community expected to get fuel cleaner, safer, and cheaper.

Related to this, the Ministry of Energy and Mineral Resources (ESDM) got a supply assignment for natural gas network infrastructure for households from the Government through Presidential Decree Number 19 of 2010 concerning Government Work Plan 2011 and Presidential Instruction Number 1 Year 2010 concerning Acceleration Implementation of Development Priorities National Year 2010 as well as through hearings meeting with the Commission VII DPR. In this case, the Ministry of Energy and Mineral Resources has the mandate to provide natural gas network for homes stairs free of charge to public. Development program natural gas distribution network for this household is built in the city or areas close to natural gas sources and has a natural gas transmission network. There are several problems currently encountered in the implementation of conventional meter systems in household customers in PGN, including customer arrears, high cost of recording meters, difficulty in recording meters due to access constraints and so on. To solve this problem, in 2014, testing of prepaid meter technology based on Integrated Circuit Card (ICC) was carried out by PGN, then in 2017 it was continued with testing for prepaid meter technology based on STS Token and along with the development of current technology, it was continued with a study of smart meter technology. Prepaid meter technology based on Integrated Circuit Card (ICC), STS tokens and smart meters has its own advantages and disadvantages. In 2017, IoT-based smart meter technology with LORA WAN communication, NB-IOT for gas meter applications is still not mature. But the development of radio communication technology in the world is growing rapidly. By 2020, it is estimated that more than 50 billion devices will be connected via radio communication. Low Power Area Network (LPWAN) has become a popular low-level radio communication technology in the world today. NB-IoT, LORA and Sig fox are three of the leading LPWAN technologies competing for IoT deployments on a large scale.

STS-based prepaid meter technology has several advantages over Integrated Circuit Card (ICC), including more flexibility for centralized and distributed customers, safer because the numeric token generated can only be accepted by the intended meter, can be used for all types of meter brands (multi-vendor), in contrast to Integrated Circuit Card (ICC), most of which are vending

machines/card readers, are proprietary and cannot be used for different brands. However, STS-based prepaid meters have drawbacks, including not being able to provide customer gas usage data. This is because STS uses one-way communication. If the number of household customers is large enough to reach millions or more, then this can be a problem related to the data requirement for calculating the gas balance or unaccounted gas ("UAG"). The STS prepaid system has been implemented nationally by PT PLN (Persero). As happened in PLN, where the number of prepaid household customers using STS has reached tens of millions, they have difficulty knowing the real amount of electricity required for the planning of the power plant production process.

PGN faces several problems with operating household meters as follows:

1. Business: The number of household customers will increase to 4.7 million according to the National Energy General Plan.
2. Operational: Over 200 thousand household customers and 2000 Industrial Commercial customers were manually recorded. High error rates and error findings at reconciliation, the customer's meter recording has been discovered to be inaccessible.
3. Finance: From the data, during 2020, PGN experienced a loss of income from 13,021 inactive customers. In April 2020, there was a notice in the local electronic news about customer complaints about an increase in gas bills, fraud and an inefficient payment process
4. Safety: Household gas explosions

To determine which technology is most appropriate and optimal for overcoming the problems and challenges listed above, a comprehensive and comparative study of the LPWAN smart meter technology is required, both from a technical and commercial standpoint, including risk assessment of all the alternative schemes and recommendation to PGN for best schemes LPWAN smart meter technology. This study limited analysis of the LoRa Wan, NB-IoT & Sigfox type of LPWAN smart meter in household gas customer of PT PGN Tbk. This study only discusses a business strategy, financial and technological review if it is implemented in PT PGN Tbk's household gas customers. This study focused primarily on qualitative analysis; however, for quantitative analysis, data on performance LPWAN smart meter was only for LoRa Wan, NB-IoT, and Sigfox communication; data on other LPWAN communication was not analyzed. The main question that should be answered in this study is what the findings of technical and economic analyses of all LPWAN smart meter technology are, including risk and recommendations for implementation in PGN.

II. LITERATURE REVIEW

A. LPWAN Technology

TABLE 1.
LIST OF LPWAN TECHNOLOGY ABBREVIATION

No.	Abbreviation	Definition
1.	ICC	Integrated Circuit Card
2.	LAN	Local Area Network
3.	LoRaWAN	Low Range Wide Area Network
4.	LPWAN	Low Power Wide Area Network
5.	LTE	Long-Term Evolution
6.	NB-IoT	Narrowband Internet of Things
7.	OFDM/FDMA	Orthogonal Frequency Division Multiple/ Frequency Division Multiple Access
8.	SRD	Short Range Device

The IoT system is a concept that aims to expand the benefits of continuously connected internet connectivity. Through the internet, you can share data, remote control, and various other things such as convenience. IoT works by translating programming languages that have been included in the tools of the IoT. This tool is also known as a microcontroller. In gas meter applications, the IoT system is very useful as a medium for sending data and paying for gas usage by customers. The IoT system can be applied to both prepaid and postpaid meters, it depends on customer needs. Media interfaces used in IoT systems include LoRa WAN / Sigfox / NB-IoT networks. Many in various countries have used LoRa WAN as a media interface.

The development of radio communication technology in the world is growing rapidly. By 2020 it is estimated that more than 50 billion devices will be connected via radio communications. The growth of the IoT and LPWAN markets has become a popular low-energy radio communication technology in the world today. NB-IoT, LoRa WAN and Sigfox are the three leading LPWAN technologies competing in IoT deployments at scale. To determine which technology is the most appropriate and optimal in overcoming the problems and challenges that will be faced by PGN in the future, a comprehensive and comparative study of the technology is required.

Many factors must be considered when selecting the appropriate LPWAN technology for IoT applications, including quality of service, battery life, latency, scalability, payload length, range, deployment and cost. In the following, Sigfox, LoRa and NB-IoT are compared in terms of these factors and their technical differences.

Service quality

Unlicensed spectral brands and asynchronous communication protocols are used by Sigfox and LoRa. They can reflect interference, multipath, and fading. However, they cannot offer the same Quality of Service that NB-IoT provides. NB-IoT uses licensed spectrum and LTE-based synchronization protocols, which are optimal for Quality of Service at expense. Due to the Quality of Service and cost trade-offs, NB-IoT is preferred for applications requiring service quality assurance, while

applications that do not have these constraints prefer LoRa or Sigfox.

Battery life and Latency

In Sigfox, LoRa, and NB-IoT, the end device most of the time is in sleep mode outside of the operating state. It aims to reduce the amount of energy consumed, for example, to extend the life of the device. However, NB-IoT end devices will consume additional energy for communication for synchronization and Quality of Service handling, and OFDM/FDMA access modes will require more peak currents. This additional energy consumption reduces the life of the NB-IoT end device compared to Sigfox and LoRa. However, NB-IoT offers the advantage of low latency.

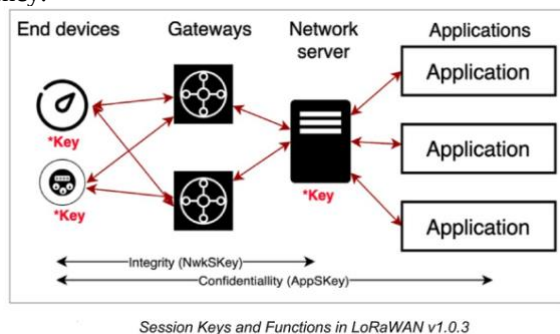


Fig 1. Session Keys and Function in Lora WAN [1]

Scalability and payload length

Support from a large number of devices is one of the main features of Sigfox, LoRa, and NB-IoT. This technology works well as the number and density of connected devices increases. Several techniques are thought to overcome these scalability features, such as efficient exploitation of diversity in channels, as well as in time and space. NB-IoT offers a much higher scalability advantage than Sigfox and LoRa. NB-IoT enables connectivity of up to 100,000 end devices per cell compared to 50,000 per cell for Sigfox and LoRa.

Network coverage and coverage

The main advantage and utilization of Sigfox is that the entire city can be reached by a single base station (range can reach > 40 km). In Belgium, a country with a total surface area of about 30,500 km², only requires the deployment of the Sigfox network's 7 base stations to cover the entire country.

Placement model

NB-IoT specifications which have been released in June 2016; it will take some additional time before the network is established. However, the Sigfox and LoRa ecosystems are mature and are now being commercialized in various countries and cities. LoRa has advantages that allow it to be used currently in 42 countries versus 31 for Sigfox. However, the deployment of LoRa and Sigfox worldwide is still underway, with LoRa having an edge in Indonesia

with the easy deployment of LoRa communication equipment.

In addition, one of the significant advantages of the LoRa ecosystem is its flexibility. Unlike Sigfox and NB-IoT, LoRa offers local network deployments, i.e., LANs using LoRa gateways as well as public network operations via base stations. In the industrial sector, the hybrid operating model can be used by deploying the local LoRa network in the factory area and using the public LoRa network to cover areas outside the local LoRa range.

The LPWAN device developed uses a Short-Range Device (SRD) frequency slot with the frequencies regulated in Ministerial Regulation number 35 of 2015 where the frequency band used is in the range 923-925 MHz. The LPWAN module installed on each smart meter is called a node. Each of these nodes will be connected to a concentrator device that functions as a data gateway using LPWAN communication technology. This gateway will connect the node with the server system. This device will function as a switch that will direct an order from the server to the target node and send response data back to the server.

Each node will send data packets to the gateway in the form of small data packets that are encapsulated in a symmetric encrypted packet, where each node will have a key with the gateway called the network key. The data from the node is then re-encapsulated to be sent to the server using an application key. Generally, LPWAN uses the AES-128 encryption system which is tough enough to be cracked.

In one transmission, the power required by the device is very small with wide transmission coverage and long signal ranges, by utilizing a small bandwidth. This bandwidth limitation is not a problem for data communication in LPWAN, because the data packet to be sent is also very small (in bytes), so the power required is ultimately very small (in micro amperes). Thus, the installed node device will be able to have a high resource lifetime, even up to 10 years of usage.

LPWAN Gateway

The LPWAN gateway device is between the node/smart meter and the server. This device functions as a bridge and data collector/concentrator from several connected nodes. One gateway will be able to connect with many nodes and can work simultaneously to receive data from nodes and servers and send it to relate devices

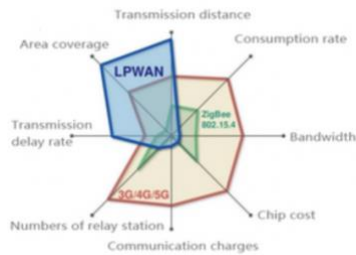


Fig 2. Comparison of LPWAN VS Zigbee vs 3G/4G/5G [5]

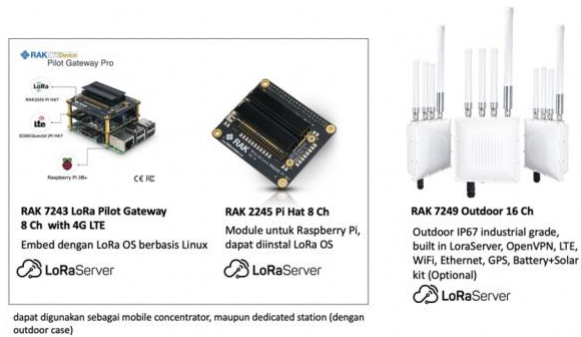


Fig 3. LPWAN Gateway [9]

B. Cost Benefit Analysis

Cost benefit analysis (CBA) is a systematic approach to estimating the strengths and weaknesses of alternatives used to determine options which provide the best approach to achieving benefits while preserving savings (for example, in transactions, activities, and functional business requirements) [2]. A CBA may be used to compare completed or potential courses of actions, or to estimate (or evaluate) the value against the cost of a decision, project, or policy.

III. METHODOLOGY

In this study, the evaluation begins with learning the policy's objective, the implementation strategy, the government's effort to achieve the goal (Jargas Project) and locating the ideal conditions for the gas network project in PT PGN Tbk. The expected result of the evaluation is to find the causes of gas network operational problems in PT PGN Tbk. so the strategies for addressing, reducing, or eliminating the gas network operational problem can be developed. The alternatives solution is analyzed using technology and economical reviews.

The following is how the conceptual framework is implemented:

- Business issues explain PT PGN's business challenges and problems with the national strategic program for the household gas network.
- Root cause analysis explain the process of determining the underlying causes of business issue in order to find appropriate solutions.
- Comparison alternative solution explains alternative technologies based on industrial development outside

- where household gas network business could be optimized through selected smart meter technologies.
- Design explanation selected alternative solution from point c to evaluate more thoroughly in terms of:
 - Techno evaluations explain analysis of qualitative and quantitative comparisons between smart meter technologies in general and specific applications.
 - Economic evaluation explains the tangible and intangible analysis that will be carried out when PT PGN implements smart meter technology.
- Risk assessment explains the risk and mitigation analysis when PT PGN implement smart meter technology.

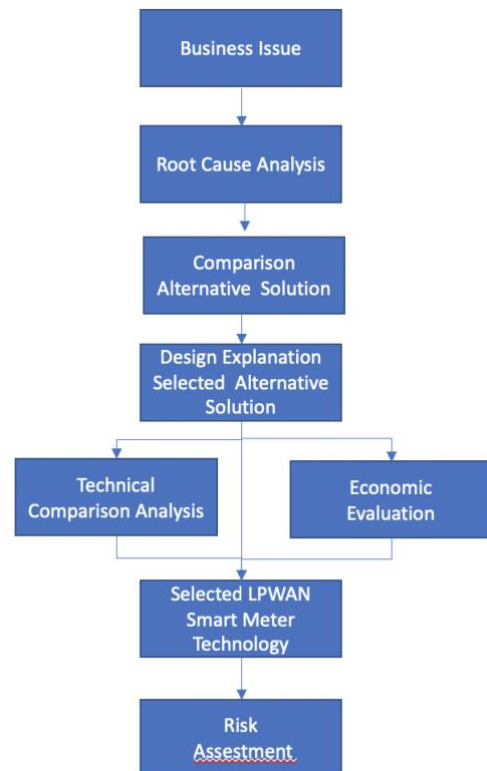


Fig 4. Conceptual Framework

According to the above conceptual framework, research methodology is being established. Primary & secondary data are both used.

a. Primary Data Acquisition & Analysis

Primary data acquisition is being done through Focus Group Discussion (FGD), participant observation. Participant observation involved visiting and observing PGN's household gas network in Jabodetabek and surrounding areas. Accompanied by the related operations and sales team, monitoring the operation of the household gas network was carried out, starting from the pipe connection to the house, the gas meter and piping system as well as the installation pipe connection to the stove.

There are two FGDs, which are as follows:

FGD 1: Confirmation of secondary data analysis and finding of possible problem's root cause. Related responsible person are invited, such as the operational team, commercial team, ICT team, project team and subject of expert to deliver expert judgments for further analysis.

FGD 2: Analysis of FGD 1 result and possible solution of agreed problem's root cause, especially through technology. Related responsible people are invited as the operational team, revenue assurance team, ICT team, project team and subject of expert to deliver expert judgments for further analysis.

b. Secondary Data Acquisition & Analysis

Consist of both external and internal data collection.

External: Data from smart meter vendors & manufactures as a highlight of the development of smart meter technology, and data from telecommunication providers as a highlight of the development of LPWAN communication in the global and Indonesian markets.

Internal: Revenue assurance report, household gas network operational report.

c. Proposed Business Solution

This phase identifies proposed models of business solution implementation, particularly for household gas network projects and operational

d. Recommendation of Technology Adoption & Development

Adaption and development of the recommended LPWAN smart meter technologies implementation plan is summarized (including timeline).

customers. It is also equipped with a shut off valve which can be closed automatically when the credit runs out.

c. Using smart meter FO connection system (Alternative 3)

Smart meter which uses FO connection as main communication to MDMS (Meter Data Management System). It supports both prepaid and postpaid scheme and has a 2-way communication system. It also has a shut off valve that can be opened and closed automatically by the server. It has high telecommunication costs since using fiber optics, if not accompanied by other service sales such as internet or smart home service to optimize fiber optic capacity.

d. Using retrofitted conventional meter system (Alternative 4)

Retrofitting a conventional meter system entails taking an existing conventional meter and retrofitting it with a

TABLE 2.
COMPARISON ALTERNATIVE SOLUTION

No	Parameter	Req.	Alternative 1	Alternative 2	Alternative 3	Alternative 4
1	Cost	Low	Medium capital cost & low operational cost	High capital & operational expenditure cost	High capital cost & high operational cost	Low capital & operational expenditure cost
2	Time Efficiency	No	It takes time for trial testing	Existing operational in subsidiary	It takes time for trial testing	Has been tested before
3	Impact	Increase meter accuracy Efficiency cost, eliminate risk of receivable	Increase meter reading accuracy, efficiency operational cost, account receivable problem solution	Increase meter reading accuracy, efficiency cost, account receivable problem solution	Increase meter reading accuracy, efficiency cost (except combined internet product bundling), account receivable problem solution	Increase meter reading accuracy, efficiency operational cost, can't be account receivable problem solution
4.	Technical & Operability comparison from literature	High recommendation	High recommendation	Medium recommendation	Medium recommendation	Low recommendation
5.	Reference Implementation	Worldwide	Worldwide	Worldwide	Restricted	Limited
Conclusion			SELECTED	NO	NO	NO

IV. FINDINGS AND ARGUMENT

Alternative of business solution

There are several solutions to reduce high manual reading cost and improve metering system accuracy, including the following:

a. Using smart meter LPWAN system (Alternative 1)

Smart meter that communicates via LPWAN (Low Power Wide Area Network) and can be used in both prepaid and postpaid schemes. It will increase meter reading accuracy since data will be automatically sent to MDMS (Meter Data Management System) and has a 2-way communication system. It also has a shut off valve that can be opened and closed automatically by the server.

b. Using prepaid meter system /STS Token or IC card (Alternative 2)

Prepaid meter which has 2 types, using STS Token or IC card. It can only be used as a prepaid scheme and has a 1-way communication system for STS token type and a 2-way communication system for IC card type (not directly). PGN will not know the gas consumption of

communication module that sends meter data reading to the server via LPWAN or GSM. It only utilizes a postpaid system and has 1-way communication system. It is not equipped with a shut off valve since it uses an existing conventional meter. It will increase meter reading accuracy but cannot automatically stop the gas flow when the customer does not pay gas bills.

Table 2 shows a comparative analysis of alternative solutions among the identified alternatives. Alternative 1 or smart meter LPWAN system is chosen as the selected alternative solution because it provides the best option that meets PGN's needs and can be the solution to problems in PGN's household gas network.

Design Explanation of Selected Alternative Solution

A. Techno Analysis Smart Meter LPWAN

1. LPWAN technology selection

The communication specifications required for implementation in household gas metering at PGN include:

- Communication frequency is not very frequent.
- The latency or time lag required in sending data packets is low where the minimum data is obtained once a month.
- Low data rates as well as communication requires low energy consumption in order to prolong battery life because gas meters are not like electric meters which have a continuous power source.
- PGN does not require real time monitoring to maintain gas distribution, considering that the total flow and pressure of household customers does not have the potential to disrupt network pressure, i.e., such as high-pressure transmission or distribution.
- High efficiency costs. This is because the use of household gas is small compared to the investment that must be spent.
- Low payload length, because it only sends customer gas usage flow data.

TABEL 3.
 COMPARISON OF THE COMMUNICATION
 IMPLEMENTATION OF LORAWAN, NB IOT AND SIGFOX IN
 THE PGN GAS METER APPLICATION

No	Parameter	PGN's Requirement	LORA-WAN	NB-IoT	Sigfox
1.	Cost efficiency	High	High	Low	Medium
2.	Latency performance	Low	Low	High	Low
3.	Battery Life	Long time	Long time	Medium	Long time
4.	Payload length	Low	Medium	High	Low
5.	Skalability	High	Medium	High	Medium
6.	Range	High	Medium	Low	High

- High scalability, because it requires high connectivity so that operational & investment costs are low.

Broad network coverage and coverage, considering that household customers are spread all over Indonesia, from remote areas to big cities.

In accordance with the above requirements and Figure 2, a comparison table can be made of the implementation of LORAWAN, NB-IoT and Sigfox communication in the PGN gas meter application as follows:

From the table 3, NB-IoT can be considered over-spec for applications in PGN's household gas meters, because of its low-cost efficiency, high latency, and limited deployment range for LTE BTS. On the other hand, LORA and Sigfox are more suitable for these applications where only low data speeds, infrequent communication and high efficiency costs are required. Considering that there is no provider yet that offers Sigfox communication alternatives to PGN, and its application is still very limited in Indonesia, LORA is currently the most suitable type of communication for the gas smart meter application at PGN.

2. Smart Meter LPWAN Architecture

The LPWAN smart meter device applies the same principles set out in the LPWAN architecture, where the device that will become the node is a gas meter that has been equipped with an LPWAN communication module. The device will communicate with the gas meter via a magnetic sensor which will read the rotation of the totalizer and translate it into customer usage figures. The data will be sent to the server via LPWAN Gateway to be processed into customer billing data. During the process of sending data, LPWAN will also carry out a capturing command process from the server, so that commands from the server can be executed by the meter device, where the command is in the form of a valve opening/closing process.

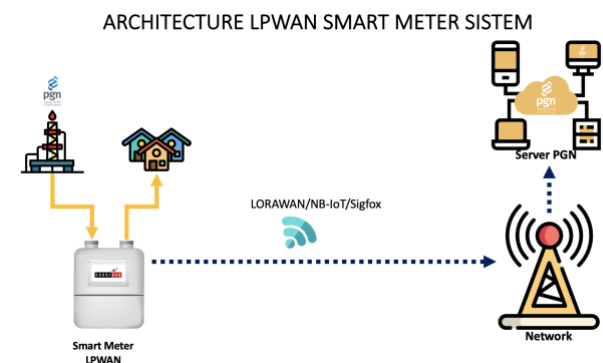


Fig 5. Architecture LPWAN Smart Meter System

B. Economic Evaluation

Parameters and assumptions

The parameters and assumptions used to carry out this study are as follows:

- Jargas program scale is 10 million customers in 10 years.
 - Assuming 1 million customers per year.
 - Smart meter price: IDR 1,000,000 per unit
 - Conventional meter price: IDR 400,000 per unit
- Customer usage data
 - Gas consumption volume: 14 m3 per month
- OPEX data for infrastructure O&M
 - IOT communication fee : IDR 2,000 / customer / month (for two-way smart meter communication - server via Lora WAN)

A. Tangible Aspect

The tangible aspect is calculated by combining investment and operating costs, yielding the total cost of ownership.

From a tangible aspect, the advantage of using a smart meter is the reduction in OPEX costs. In terms of Total Cost Ownership over the useful life of the meter 10 years, the savings of conventional vs smart meters can be seen in the fig.6.

Based on the price assumptions in points a-c and

assuming a 100% recovery from uncollectible, the graph above shows that smart meter savings will begin to be felt in the 6th or 7th year. By using a smart meter, the data received is more accurate, the quantity is greater, saving operational cost and eliminate risk of account receivable (for prepaid scheme) which is up to 35.25 billion rupiah per month if PGN household customer about 4.7 million.

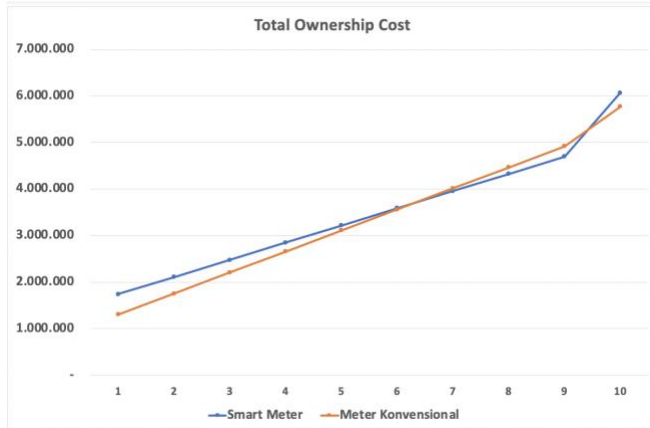


Fig 6. Graph of Total Cost Ownership Smart Meter vs Conventional Meters

TABEL 4.
ELIMINATE RISK OF ACCOUNT RECEIVABLE
(FOR PREPAID SCHEME)

Parameter	Cost (IDR)	Unit
Data rate	15%	customer/month
Total customer (RJPP target)	4.700.000	Customers/month
Assumption receivable bills	50.000	IDR/month
Prognosis of customer in arrears	705.000	Customers/month
Prognosis of total customer bills	35.250.000.000	IDR/month

B. Intangible Aspect

Based on the tangible and intangible aspects in table 4, the following conclusions can be drawn:

- PGN's decision to enter the smart meter era is more due to intangibles (Table 3 above) than tangible, because the current meter recording costs have been reduced to around Rp 4,500 per customer (tangible will be felt in the following year 7).
- PGN has the moment to enter the smart meter to coincide with the Jargas program for 5 million customers in 2026, which allows capex meter prices to benefit from an economy of scale.
- Smart meter vendor validation and IoT communication are obtained by optimizing the procurement, design, logistics, and clustering of

potential customers of Jargas, which allows the level of efficiency to achieve the required assumptions.

TABEL 5.
COMPARISON OF THE BENEFITS OF INTANGIBLE ASPECTS
OF USING SMART METERS VS CONVENTIONAL METERS

Intangible Aspect	Conventional Meter	Smart Meter
Sistem flexibility	Postpaid	Postpaid or Prepaid
Gas consumption reading	Once a month with the possibility of lock access	At any time and at the same time
Potential default (arrears)	Yes (almost 1-10 times from 2019 to 2020 both active & non active customer)	No
Closure of flow	PGN officers must visit to the field	This can be done by remotely
Customer information	Waiting for bill recap	Can be at any time
Data analysis	There is no database	The database is available at all times for prediction of future plans

TABEL 6.
RISKS AND MITIGATION OF SMART METER
IMPLEMENTATION

No	Topic	Challenges & Risk	Impact	Risk Level	Contingencies & Mitigation
1	Commercial	This recommendation is based on the following assumptions: • Smart Meter prices range from IDR 900.000 • The operating price ranges from Rp. 2500,- / meter / month	The total cost of ownership of smart meters with conventional meters will converge in the 7th year, which will allow for the replacement period for smart meters	High	a. Validate and update meter prices b. Market pricing to reduce the price of the smart meter c. Doing technology shopping to other vendors in the market
3	Operational	Smart meters are currently only a few manufactures specific and are not compatible between manufactures	A damaged smart meter cannot be replaced with a new smart meter due to a different brand	High	The smart meter chosen is LoRa based (one type)
4	Operational	The lifespan of the smart meter only lasts 5 to 7 years	The investment costs are greater and the calibration time is faster than conventional meters which have a 10 year lifespan	High	a. Guarantee b. Pilot testing Keep up with the latest updates on smart meter technology and design
5	Legality	Unlicensed Services	Prone to disturbing the frequency of the license frequency that will be turned off if it is proven that it does not use the required specifications There is a possibility that the transaction data will leave the territory of Indonesia (loss of data sovereignty)	High	The non-mobile LPWA gateway must have the ability to ensure that customer data flow does not leave the territory of Indonesia, among others by making easily configurable firmware or other techniques deemed necessary so that the data remains transparent and does not flow outside the territory of the Republic of Indonesia
6	Security	a. Theft on physical gateways and sensors b. Unauthorized modification of application access control and configuration. c. Unauthorized modification of API configuration and access control. d. Unauthorized modification of the security settings on the cloud server. e. Manipulation and data leakage on sensors, servers, gateways f. Damage due to inexperience customers.	a. Manipulation and leakage of customer privacy data. b. Potential malware	High	a. The communication between the various nodes on the Smart Meter must be encrypted b. Accurate verification of the data source is very important for consumers and Smart Meters must validate legal customers. 3. The Non-Cellular LPWA Gateway must have the ability to ensure that customer data flow does not leave the territory of Indonesia, among others by making easily configurable firmware or other techniques deemed necessary so that the data remains transparent and does not flow outside the territory of the Unitary State of the Republic of Indonesia.

C. Risk Assessment

Considering that the smart meter with the LPWAN communication module is a new asset that will be owned by the PGN Group, here are the qualitative risks and risk mitigation if the smart meter is implemented in PGN. Based on qualitative risk evaluation and risk mitigation in table 5, if the smart meter is implemented at PGN, the

contingency and mitigation plans required for high-level risk are as follows:

- a. Commercial, market pricing, validation and updating of meter prices and technology shopping to other vendors in the market.
- b. Operations, choose one type of smart meter and keep providing the latest updates on smart meter technology and design.
- c. Legality requires that the non-cellular LPWAN gate be capable of ensuring transparency and that customer data flows do not leave the territory of the Unitary State of the Republic of Indonesia.
- d. Security, communication between various nodes must be encrypted, validate customers legally and ensure that customer data flow does not leave the Republic of Indonesia.

V. CONCLUSION

This study illustrates how the application of technology tailored to the needs of the gas case/application at PGN produces results that differ from several references of the LPWAN technology literature in other applications, which is influenced by the development of LPWAN technology and different technical requirements in other countries.

Based on a technical evaluation Lora WAN provides the most appropriate cost benefits when compared to NB-IoT and Sigfox, which can provide high-cost efficiency, performance latency and battery life in accordance with the needs for gas meter applications at PGN. This study does not recommend Sigfox because of its proprietary technology, not based on an open platform. As for Nb-IoT, although technically it is the best of all because it allows the device to be connected real time and saves battery, the real time capability of Nb-IoT is not needed (over-spec) for smart meter communication on household gas networks. The choice fell on the communication mode Lora WAN. Lora WAN provides the most appropriate cost benefit, as attached in the technical comparison table and is widely used in Indonesia with its open platform.

Based on an economic evaluation by estimating recovery from uncollectible at 100%, Lora WAN smart meters are superior for calculating total cost of ownership in year 7 when compared to conventional meters.

Based on qualitative risk evaluation and risk mitigation, if the smart meter is implemented at PGN, the contingency and mitigation plans required for high-level risk for commercial, market pricing, operation, legality and security.

PGN should use smart meters, especially if the target reaches up to 1 million household customers per year, because it will provide benefits in terms of CAPEX and OPEX meters, as well as eliminate potential risk of account of receivable up to 32.25 billion rupiah if PGN household customer up to 4.7 million.

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