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Analysis of Electric Power Consumption in FTTH Network by Reducing Amount of Node HFC (A Case Study PT. Link)

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Abstract:- Using stable power in the infrastructure network of Hybrid Fiber Coaxial (HFC) NODEs is a major concern and a priority. A NODE is an active device that requires a supply of electrical energy to operate. The same applies to outdoor cabinets. This is where the active equipment of the Fiber-to-the- Home (FTTH) network is located. An outdoor cabinet as the location of active devices in the Fiber To The Home network becomes a system for efficient power consumption of the Fiber To The Home network in a hybrid fiber coaxial network. Electrical loads such as DC power systems, air conditioning (Aircond), optical line termination (OLT), and switches are the major electrical loads that require power in outdoor Fiber To The Home (FTTH) closets. Research suggests that FTTH networks are more energy efficient than HFC networks, using up to 70% less energy per user. This ongoing study focuses on demonstrating the impact of the network reconstruction conversion process on the power consumption efficiency of an existing network, Hybrid Fiber Coaxial (HFC), to his FTTH (Fiber To The Home) network. And the savings in monthly electricity bills with continued use of HFC technology are about 16% of the monthly bill.

Keywords:- *HFC, FTTH, Efficiency, Power Consumption, ElectricityBilling*

I. INTRODUCTION

The deployment of broadband networks such as Fiber to the Home (FTTH) and Hybrid Fiber Coaxial (HFC) networks has revolutionized the way people communicate and access information. However, these networks require significant amounts of energy to operate, and understanding their energy consumption is important for managing costs, reducing carbon footprints, and ensuring their long-term sustainability. While FTTH networks are generally considered to be more energy efficient than HFC networks due to the exclusive use of fiber optic cable, the energy consumption of both networks can vary depending on several factors. In this essay, we will delve deeper into the energy consumption of both FTTH and HFC networks, highlighting the factors that affect their energy efficiency and the innovations that can help to improve their sustainability.

PT Link, which is one of the internet service providers in Indonesia where it already has customers or customers who are served using hybrid fiber coaxial technology, does not want to miss out on adding more customers by making its service better. Business Competition in the internet and broadband TV provider service industries is getting higher, followed by a higher demand from customers for services that have the best quality and are also reliable in all conditions. One of them is rejuvenating the infrastructure network that still uses hybrid coaxial fiber technology into Fiber To The Home to significantly increase the number of customers.

The research carried out is based on the conditions conveyed in the background and refers to issues that occur in the field, where authors find them directly, including:

- Efficiency against other factors by using FTTH technology.
- Energy efficiency occurs due to technological changes that are benefited by the company.
- Adoption of technology 4.0 to network infrastructure implemented in the company as part of technology updates.

Khalil, *et al* [2] explain about the comparison and analysis of the impact of the HFC stand-alone to the FTTH technology migration process on both of the customers sides as well as the Network Availability and the percentage of uptime (connection to the ISP's) of customer devices are provided. In this case study, it is found that the infrastructure cost of the technology HFC system is cheaper about 53.93 percent than the technology FTTH system.

However, from a reliability perspective, FTTH is much better than HFC. It is found that theimpact of the migration from HFC to FTTH shows the yearly Network Availability was 98.635 percent with a downtime of 2,819,473 minutes. And it provides an increase of Network Availability after construction (during commissioning or acceptance test). In addition, it was found that the correlation between uptime/downtime before migrating during employed the about 10 percent, faster implementation for the schedule, andfewer cables maintain.

M. Zotkiewicz *et al* [11]. propose a method to reduce the costs of Fiber-to-the-Home (FTTH) networks by optimizing the deployment of splitters and Optical Line Termination (OLT) cards. The study uses a mathematical model to determine the optimal placement of splitters and OLT cards in a network, considering factors such as the number of subscribers, network topology, and deployment costs. The study finds that the proposed optimization method can lead to significant cost savings in FTTH network deployment while maintaining the desired level of service quality. The authors suggest that cost savings can be achieved by reducing the number of splitters and OLT cards required, and by optimizing their placement in the network. The findings of the study have practical implications for the deployment of FTTH networks, as it provides a method to reduce the costs associated with network deployment. The study highlights the importance of careful planning and optimization of network deployment, to achieve cost savings without compromising service quality. Overall, the study provides important insights into the optimization of FTTH network deployment and demonstrates the potential for cost savings through careful planning and optimization of network deployment.

H. S. Kim et al "Power Consumption Analysis and Optimization of Optical Network Units in Fiber-To-The-Home Access Networks" (2020) focuses on analyzing the

HFC technology, there were many problems caused by power supply problems and high losses of the coaxial cable. So, if the coaxial cable is replaced by the fiber optic cable, will be there an increase in the availability of the Network Availability during 2020 by 1.301 percent? Also, by takeout the FDT on the FTTH, it is predicted that a cost reduction of

power consumption of Optical Network Units (ONUs) in Fiber-to-the- Home (FTTH) networks and proposes an optimization method to reduce their energy consumption. The study uses both simulation and experimental methods to evaluate the power consumption of ONUs in different scenarios and proposes a new power management algorithm to optimize the ONUs' power consumption. The results show that the proposed optimization method can effectively reduce the power consumption of ONUs without compromising their performance. The study also highlights the importance of considering the dynamic changes in network traffic and adjusting the power management algorithm accordingly to achieve maximum energy savings. Overall, the paper provides valuable insights into the power consumption of ONUs in FTTH networks and proposes an effective optimization method to reduce their energy consumption, which can have significant economic and environmental benefits.

II. THEORITICAL BASES

A. First-Mile Concept

Figure 1 shows a simplified access network that allows the customer to subscribe to phone, video, and Internet services. In a PON a customer's premises are connected by means of a passive optical link to the central office, which interfaces to telecommunication services such as the public switched telephone network (PTSN), Internet service providers (ISPs), video-on-demand providers, or a storage area network (SAN).

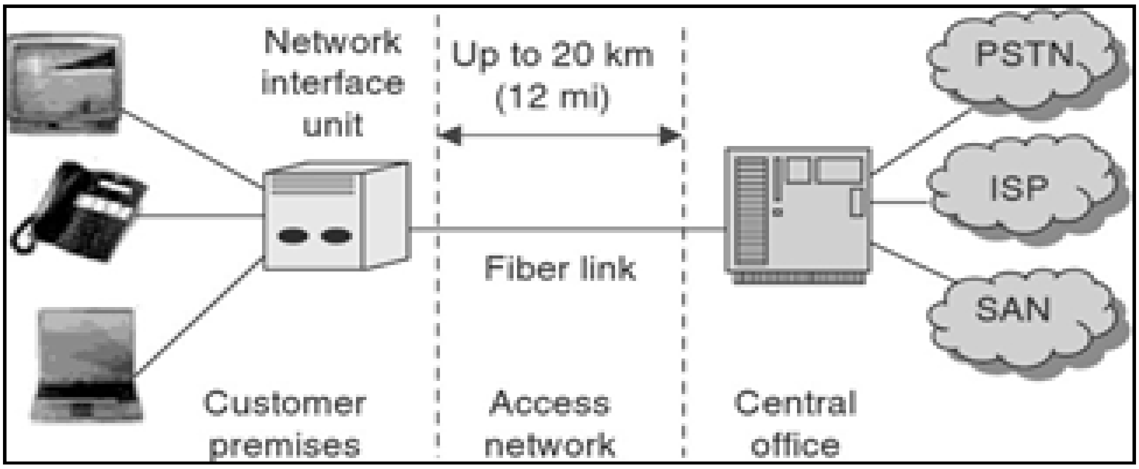

Fig 1 Simplified Access Network

The end user in a first-mile network can be either in a single-family dwelling, a single-business unit, or a building that houses multiple apartments, businesses, or other organizations. Figure 2 shows some of these premise types. The following acronyms are used to refer to variations on premises that contain multiple groups of users:

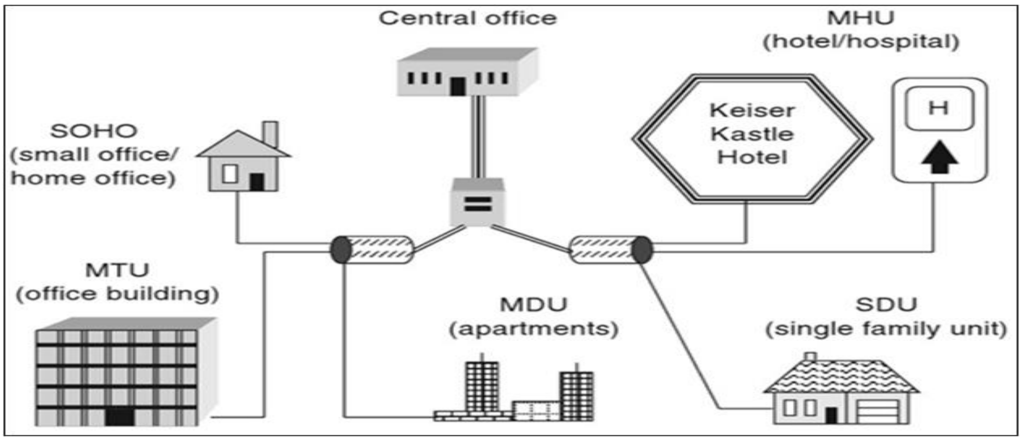

Fig 2 Acronyms Used for Various Types of Premises

- A multiple dwelling unit (MDU) refers to apartment complexes, condominiums, or dormitories.
- A multiple tenant unit (MTU) designates an office building, an office campus, or an industrial campus with different business tenants.
- A multiple hospitality unit (MHU) refers to premises suchas hotels, hospitals, airports, or convention centres.
- A single dwelling unit (SDU) is a premises occupied by asingle family.
- A single-family unit (SFU) is an alternative designation ofan SDU.
- A small office home office is referred to by the acronymsSOHO.

B. *Fiber Optics*

Fiber optics is one of the elements that will enable massive changes in the field of telecommunications. This is due to the ability of fiber optics to transmit very large amounts of information, the small volume of fiber, its resistance to outside interference and damage, and the relatively low cost.

Optical fiber is made of silica. Its ability to guide light waves is generated by its structure, which consists of a core and cladding. The core, which acts as a waveguide, is in the form of a cylindrical tube with very small spokes, between 1.5 microns and 25 microns. The casing is also cylindrical, covering the core, with spokes of 60 microns or more. The coreis made of the same material as the casing. They differ only in the doping mixture. For example, Ge in a certain concentrationcauses the index of refraction to be greater than the index of the coating. Besides that, the core also has a small light absorption capacity, so it allows the light that is channeled through the core not to experience a lot of loss in intensity or energy. With this fiber manufacturing method, absorption has been kept as small as possible, and loss yields of the order of 0.2 dB/km have been achieved. This allows the transmission of information over up to 120 km without repeaters, something that is not possible with electric or electronic transmission.

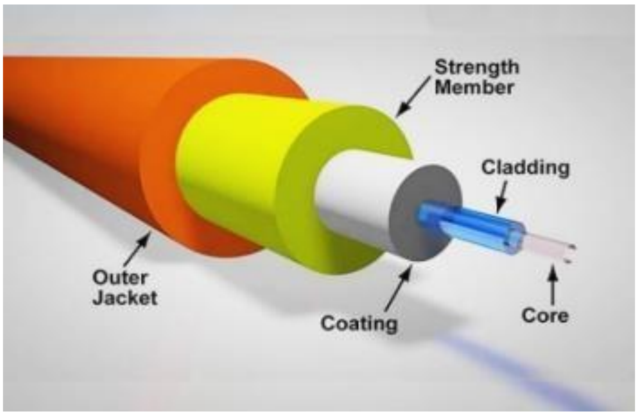

Fig 3 Structure of Fiber Optic

➢ *Advantages of Fiber Optics*

- Optical Fiber is lightweight and more compact.
- One of the most significant advantages of fibers is their ability to transmit enormous amounts of data in either digital or analogue form.
- The external disturbance is well-protected by optical fiber.
- Radar and other signals will not cause disruptions in the fiber. It has higher bandwidth.
- Disadvantages of Fiber Optics
- More complex transmitter and reception equipment are essential.
- Fiber is more vulnerable to fiber flux at greater optical power; consequently, the optical fiber may be broken.
- Splicing them is more difficult and complicated, and costly to maintain than splicing wires.
- It is an expensive investment for installation and maintenance.

C. *HFC Technology*

HFC technology is a combination of fiber optic and coaxial technology. A fiber-optic network is used as the backbone anda coaxial network as the customer distribution network. HFC technology is a development of cable TV networks that previously used only coaxial cable transmission. HFC technology is used to fix the weaknesses in coaxial cable transmission to get better performance. In the HFC system, thetelevision channels are dispatched from the cable system's distribution facility, the head-end/central office, to local communities by means of the optical fiber subscriber lines. While on the local community an optical node translates the signal from the light beam to the radio frequency (RF) as it is called fiber node, then it transmits the signal over the coaxial cable lines for the allocation to consumer residences, as illustrated in Figure 4.

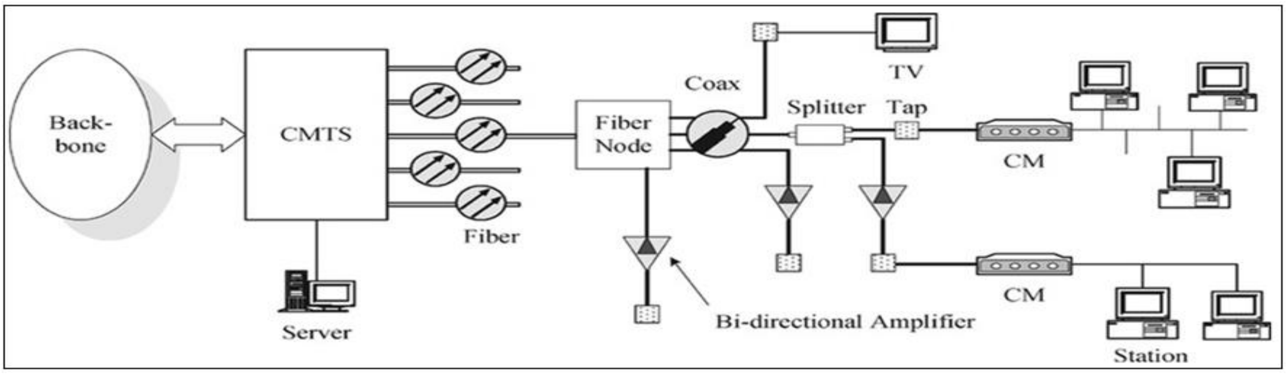

Fig 4 Architecture of HFC Network

In HFC systems the terms forward and reverse (or return) are used to refer to the downstream and upstream directions, respectively. The coaxial wires used in HFC networks allow the transport of broadband information over distances of several tens of kilometers. The cable attenuation over such distances is compensated for by the periodic use of inexpensive RF amplifiers. To attach a new user to the HFC system, the service provider uses a simple coaxial T-connector to tap into the main line in order to run a drop cable to the premises. To access the services on the top network, the customers use a relatively inexpensive modem that attaches to the drop cable and separates the TV and data signals internally.

D. HFC Homepass

HFC (Hybrid Fiber Coaxial) homepass refer to the number of households or buildings that can be connected to an HFC network. It represents the total number of homes or buildings that can be reached by a particular coaxial cable network.

The number of HFC (Hybrid Fiber Coaxial) homepass can also vary depending on the geographic location and the size of the service provider's network. According to a report by CableLabs, the average number of homes passed (HP) by an HFC network in the United States was approximately 500 in 2015. However, this number has likely increased since then as network operators have continued to expand their networks.

It's also worth mentioning that some HFC networks are being upgraded to support higher speeds and increased bandwidth capacity by replacing portions of the coaxial cable with fiber optic cable. This approach, known as DOCSIS 3.1, can significantly increase the number of homes passed by an HFC network and enable higher-speed broadband services to be delivered.

E. Passive Optical Networks

Given that network and service providers are seeking to reduce their operational costs, the concept of using a passive optical network (PON) is an attractive option. I an PON there are no active components between the central office and the customer's premises. Instead, only passive optical components are placed in the network transmission path to guide the traffic signals contained within specific optical wavelengths to the user endpoints and back to the central office. Replacing active devices with passive components provides cost savings to the service provider by eliminating the need to power and manage active components in the cable system of the access network. In addition, since the passive devices have no electrical power or signal-processing requirements, they have virtually an unlimited mean time between failures (MTBF). This obviously lowers the overall maintenance costs significantly for the services provider.

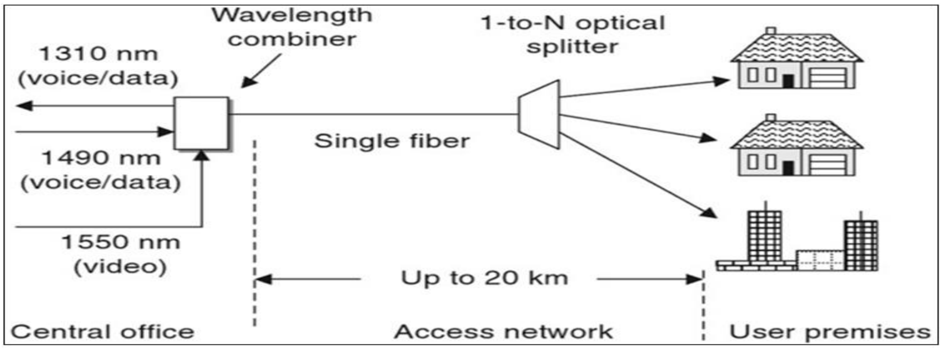

Fig 5 Architecture of a Typical Passive Optical Network

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There are several alternative PON implementation schemes. The three primary ones are broadband PON (BPON), Ethernet PON (EPON), and gigabit PON (GPON). In addition, occasionally there will be references to ATM PON (APON), a subset of the BPON category.

F. FTT-x System

The application of PON technology for providing broadband connectivity in the access network to homes, multiple occupancy units, and small businesses commonly is called fiber-to-the-x. This application is given the designation FTTx. Here x is a letter indicating how close the fiber endpointcomes to the actual user. Figure 6 illustrates some of these scenarios.

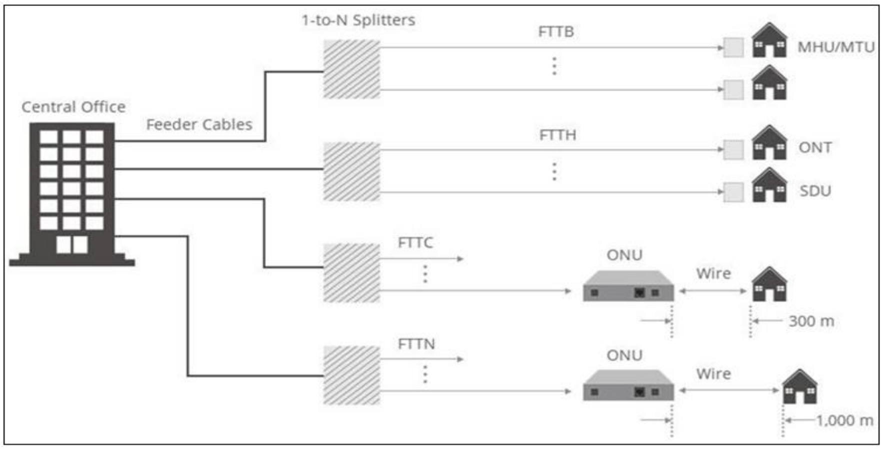

Fig 6 Some FTT-x Scenarios

Consists of an extensive collection of FTT-x optical transmission systems, and specifically the FTTH system by which the design and deployment of the proposed network in this project is based. Therefore, it describes the general operation of such networks, standards of architecture and operating structure, as well as the current situation in the world and the services that they offer, and soon will be able to offer. This will provide an overview of FTTH technology and in- depth knowledge of the circumstances of such networks.

G. FTTH Homepass

The homepass number is determined by the length of the fiber optic cable network, the density of the housing or building units, and the infrastructure necessary to deploy the network. A higher homepass number means that more homes or buildings can be connected to the network, increasing the potential customer base for service providers.

The number of FTTH homepass can vary depending on the geographic location and the size of the service provider's network. However, according to a 2018 report by the Fiber Broadband Association, the average number of FTTH homepass in the United States was approximately 3,000. This number has likely increased in the years since the report was published as more service providers have invested in expanding their fiber networks.

H. Comparison Between HFC and FTTH Network

FTTH (Fiber-to-the-Home) and HFC (Hybrid Fiber Coaxial) networks are two types of broadband network architectures used for delivering high-speed Internet and other communication services. HFC and FTTH networks differ in that HFC extends fiber to a node within a mile of the home or business, while FTTH extends fiber all the way to the home or business—typically terminating the fiber at a customer premises device, which then provides service to devices in the home over copper lines, coaxial cable, or wireless connections. As a result, FTTH networks have greater capacity and significant functional benefits over HFC networks. However, HFC can scale in capacity, both through the expansion of fiber and upgrading of electronics, and HFC provides a logical evolution path for the hundreds of millions of homes and businesses connected by the technology to gradually reachgigabit speeds.

I. Electricity Consumption between HFC and FTTH Network

The use of electricity in FTTH (Fiber to the Home) and HFC (Hybrid Fiber Coaxial) networks is crucial in ensuringthe quality and reliability of the services provided. Here are some theories regarding the use of electricity in FTTH and HFC networks:

- In FTTH networks, the use of electricity is concentrated ontwo devices, namely the Optical Line Terminal (OLT) and Optical Network Terminal (ONT). OLT is a device located on the operator's side and serves as a control centre and data flow regulator in the network. ONT, on the other hand, is located on the customer side and serves as a connector between the operator network and customer devices such as modems and routers. Both devices generally use lower power compared to devices used in HFC networks.
- In HFC networks, the use of electricity is concentrated on amplifiers and cable modems. Amplifiers are used to strengthen the signal passing through coaxial cables, and cable modems are used to convert digital signals into analogue signals that can be transmitted through coaxial cables. Both devices require more power compared to devices used in FTTH networks.

- The technology used in FTTH networks, such as Gigabit Passive Optical Network (GPON) or Next Generation Passive Optical Network 2 (NG-PON2), enables faster andmore energy-efficient data transmission compared to the technology used in HFC networks.
- The higher data transmission speed in FTTH networks can reduce energy consumption because the amount of data that can be transmitted at one time is more significant than inHFC networks.

III. METHODS

The research method used by the author is a quantitative method by looking at the statistical data obtained from PT.Link, Tbk. The parameters that will be used in this study toshow the comparison of HFC and FTTH technologies are:

- Efficiency, on the electricity consumption [8] required from each technology.
- Efficiency, against the costs incurred for operations and maintenance.
- Customer growth resulting from technological change.

By looking at the aspects mentioned above, conclusions canbe drawn regarding the effect of HFC technology change activities to FTTH on customer service and business continuityat PT. Link.

IV. RESULT AND ANALYSIS

A. Operational and Maintenance Costs

Operational costs incurred to carry out preventive and corrective maintenance, HFC network infrastructure requires very high costs due to the existence of 2 cable transmission media, namely coaxial and optical fiber.

Table 1 HFC Operation & Maintenance Cost

Preventive & Corrective HFC Technology (Covered one Node)			
Description	Cost (IDR)		
	Unit	Total	Grand Total
Preventive Maintenance			
1.1.HFC Acces Material	12	2,485,800	29,829,600
1.2 HFC Power Supply Material	12	5,750,000	69,000,000
Corecctive Maintenance			
1.1.HFC Acces Material	12	5,605,800	67,269,600
1.2 HFC Power Supply Material	12	15,850,000	190,200,000
Total Material Cost			**356,299,200**
Labour Maintenance			
2.1.Labour Preventive	2	16,000,000	32,000,000
2.1.Labour Corecctive	4	16,000,000	64,000,000
Total Labour Cost			**96,000,000**
Total Preventive & Corrective Maintenance Cost HFC			**452,299,200**

Fiber To The Home Infrastructure [11]in terms of operational costs is very little compared to HFC, where in FTTH most of the devices used are passive devices and also there is no internal interference from the Fiber Optic cable itself. Fiber To The Home attenuation [11] has a very small nature so that in its operation there are very few disturbances that arise. With fewer disturbances, there will also be less preventive and corrective maintenance that will occur on theFTTH network.

Table 2 FTTH Operation & Maintenance Cost

Preventive & Corrective FTTH Technology (Covered one ODC OLT)			
Description	Cost (IDR)		
	Unit	Total	Grand Total
Preventive Maintenance			
1.1.FTTH Acces Material	12	200,000	2,400,000
1.2 FTTH Power Supply Material	12	500,000	6,000,000
Corecctive Maintenance			
1.1.FTTH Acces Material	12	600,000	7,200,000
1.2 FTTH Power Supply Material	12	100,000	1,200,000
Total Material Cost			**16,800,000**
Labour Maintenance			
2.1.Labour Preventive	2	16,000,000	32,000,000
2.1.Labour Corecctive	4	16,000,000	64,000,000
Total Labour Cost			**96,000,000**
Total Preventive & Corrective Maintenance Cost FTTH			**112,800,000**

B. Electric Power

The need for electrical power capacity in the outdoor cabinet fiber to the home technology and HFC applied in this network can be formulated as follows:

$$P = V \; x \; I \; x \; \cos Q \qquad (1)$$

Table 3 Electric Power for Hfc

No.	Description	BTU hour
1	Equipment	769.05
2	Wall Heat loss	2,615.69
3	Roof heat loss	290.63
4	Infiltrasi heat loss	0.11
	Total	**3,675.47**
	Total in Watt	**1,077.22**
	Safety factor 10 %	**4,043.02**
	Total in Watt	**1,184.94**

AC Power Consumption Capacity Requirement

No.	Item	watt	Sys.	VA
1	DC Equipment	1,421.95	1 Phase	1,823.02
2	Environment	625.89	1 Phase	488.19
3	Air Cond	1.90	1 phase	398.72
				2,980.92

PLN CONNECTION	**3500**

In Table 3, Fiber Coaxial technology can be categorized as still very high where the use of active devices used in HFC technology requires electric current, the amount of electric current in the installed power supply requires a current of 3500 Watt. The power supply needed to serve 1 area is adjusted to the number of nodes installed to be able to serve services in that area which can only serve 1000 - 2000 home pass units.

Table 4 Electric Power for Ftth

No.	description	BTU hour
1	Equipment	2,006.57
2	Wall Heat loss	2,615.69
3	Roof heat loss	290.63
4	Infiltrasi heat loss	0.11
	Total	**4,913.00**
	Total in Watt	**1,439.92**
	Safety factor 10 %	**5,404.30**
	Total in Watt	**1,583.91**

AC Power Consumption Capacity Requirement

No.	Item	watt	Sys.	VA
1	DC Equipment	2,132.93	1 Phase	2,734.52
2	Environtment	625.89	1 Phase	488.19
3	Air Cond	2.54	1 phase	532.97
				4,131.25

PLN CONNECTION	**5500**

In Table 4, it can be explained as follows for the capacity of FTTH technology requires a total current 5500 Watt. While on Fiber To The Home technology because the use of active devices is only in an outdoor cabinet that is installed in a location to be able to service active devices and can serve as many as 5000 - 6000 home pass.

C. Electricity Billing

Billing for electricity for FTTH and HFC applied in this network can be formulated as follows:

$$Billing \; per \; day = (kW \; x \; 24 \; hours \;) \; x \; Tariff \; per \; kWh \qquad (2)$$

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Where, the cost of electricity used for B-2/TR. Based on the **Tariff Adjustment from PLN, B-2/TR** are charged at **Rp.** 1.444,70 / kWh**.**

After measuring in the field, the power output per monthfor each network is obtained as follows:

Table 5 Power Output FOR HFC AND FTTH Network

No	Month	System	
		HFC [kW]	FTTH [kW]
1	Jan-21	5.252,64	4.239,31
2	Feb-21	4.791,76	3.999,07
3	Mar-21	5.147,59	4.079,35
4	Apr-21	5.235,70	4.310,64
5	May-21	5.042,53	4.071,17
6	Jun-21	4.829,04	3.885,84
7	Jul-21	5.357,69	4.333,06
8	Aug-21	5.196,84	4.150,03
9	Sep-21	5.066,64	4.065,84
10	Oct-21	5.100,86	4.027,27
11	Nov-21	4.970,88	4.004,64
12	Dec-21	5.515,27	4.491,53

The author enters the power output per month into theformula as written above, and got the result:

Example: January 2021

5252,64 *KW*

$$Billing\ per\ month = (kW) x\ Rp1.444,70 \quad (3)$$

$$Billing\ per\ month = (5252{,}64\ kW) x\ Rp1.444,70 \quad (4)$$

$$\boldsymbol{Billing\ per\ month = Rp\ 7.588.489,01} \quad (5)$$

After the author gets billing per month, the author calculates and obtains the Electricity Billing during 2021, as shown in the table below.

Table 6 Electricity Billing During 2021 FOR HFC System

No	Month	Power Output [kW]	Electricity Billing [Rp.]
1	Jan-21	5.252,64	7.588.489,01
2	Feb-21	4.791,76	6.922.660,30
3	Mar-21	5.147,59	7.436.719,23
4	Apr-21	5.235,70	7.564.010,01
5	May-21	5.042,53	7.284.949,45
6	Jun-21	4.829,04	6.976.514,09
7	Jul-21	5.357,69	7.740.258,79
8	Aug-21	5.196,84	7.507.874,75
9	Sep-21	5.066,64	7.319.774,81
10	Oct-21	5.100,86	7.369.218,22
11	Nov-21	4.970,88	7.181.430,34
12	Dec-21	5.515,27	7.967.913,46
TOTAL			88.859.812,44

The same is true for FTTH technology.

Example: January 2021

4239,31 *KW*

$$Billing\ per\ month = (kW)x\ Rp1.444{,}70 \quad (6)$$

$$Billing\ per\ month = (4239{,}31\ kW)x\ Rp1.444{,}70 \quad (7)$$

$$\boldsymbol{Billing\ per\ month = Rp\ 6.124.534{,}05} \quad (8)$$

Table 7 Electricity Billing During 2021 FOR Ftth System

No	Month	Power Output [kW]	Electricity Billing [Rp.]
1	Jan-21	4.239,31	6.124.534,05
2	Feb-21	3.999,07	5.777.459,32
3	Mar-21	4.079,35	5.893.439,83
4	Apr-21	4.310,64	6.227.581,61
5	May-21	4.071,17	5.881.616,41
6	Jun-21	3.885,84	5.613.873,05
7	Jul-21	4.333,06	6.259.966,00
8	Aug-21	4.150,03	5.995.551,23
9	Sep-21	4.065,84	5.873.919,05
10	Oct-21	4.027,27	5.818.199,86
11	Nov-21	4.004,64	5.785.503,41
12	Dec-21	4.491,53	6.488.910,50
TOTAL			71.740.554,31

After doing the calculation as above, the author makes acomparison in the following graphic:

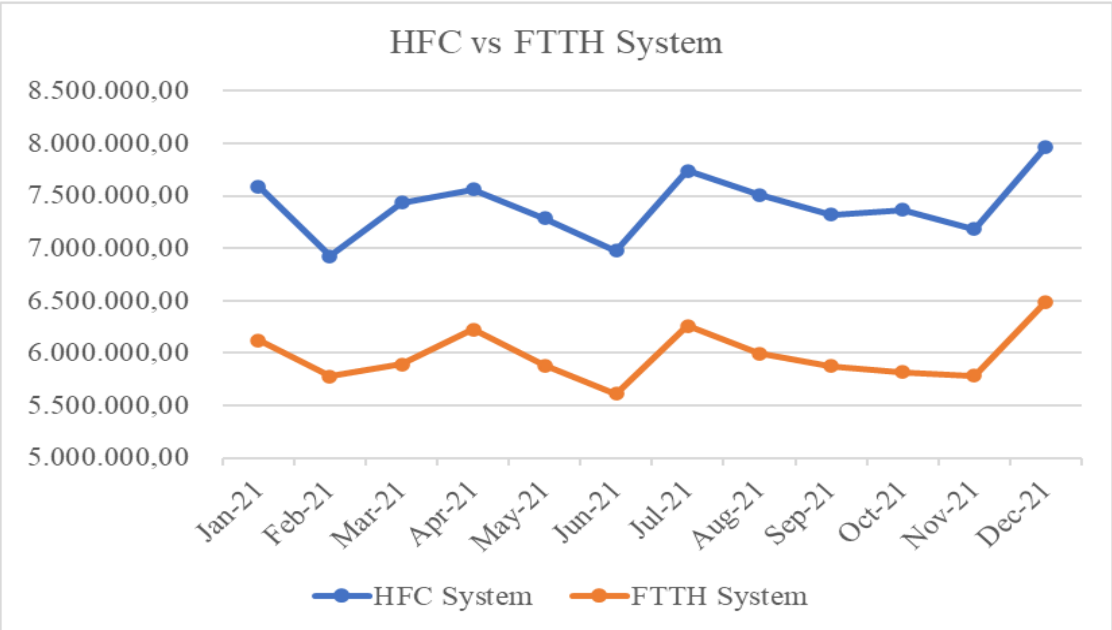

Fig 7 Comparison of Electricity Billing between HFC vs FTTH Networks

D. Customer Growth

By using fiber to the home network, the company has an annual customer growth target of 20-30%. As of the second quarter of 2021, PT Link has added an average customer growth of 18% from the 1 area where the network is being from hybrid fiber coaxial to fiber to the home technologyrejuvenated with the following data:

Table 8 Customer Growth

CONSTRUCTION STATUS	AREA	FTTH	FDT	NODE EKSISTING HFC INFRASTRUCTUR	BEFORE MIGRATION	FORCE MIGRATION	TODAY ACT CST	BEFORE VS TODAY	FORCE VS 2021	PRESENTAGE
DONE	PIK	OLT PIK	FDT 01 (FIK00100)	DPL00100,DPL00200,DPL3900	533	495	529	-4	34	7%
DONE	PIK	OLT PIK	FDT 02 (FIK00200)	DPL16100, DPL16200,DPL16300	502	471	551	49	80	17%
DONE	PIK	OLT PIK	FDT 01 (FBK00100)	DLK00100,DLK00300,DLK03600,DLK19600,DLK45500	490	441	522	32	81	18%
DONE	PIK	OLT PIK	FDT 02 (FBK00200)	DLK00500, DLK00600, DLK00300, DLK11000	326	284	329	3	45	16%
DONE	PIK	OLT PIK	FDT 03 (FBK00800)	DLK00500	210	191	251	41	60	31%
DONE	PIK	OLT PIK	FDT 04 (FBK00700)	DLK00700	242	192	241	-1	49	26%
DONE	PIK	OLT PIK	FDT 05 (FBK00300)	DLK00400, DLK45500	304	278	318	14	40	14%
DONE	PIK	OLT PIK	FDT 06 (FBK00900)	DLK00800, DLK47200	264	240	274	10	34	14%
TOTAL					2871	2592	3015	144	423	18%

V. CONCLUSION

Technological changes that occur have a major impact on efficiency, especially in terms of operations and maintenance as well as monthly electricity bill payments. [1] It can be seen in the table that is presented where the operational cost of maintenance on HFC technology is very large when compared to the operational costs of FTTH technology in the past year. Along with these technological changes, customer growth is also getting better with the rejuvenation of the infrastructure network.

A. Operational and Maintenance Cost

From the result the author get HFC network infrastructure requires very high costs due to the existence of 2 cable transmission media, namely coaxial and optical fiber. Fiber To The Home Infrastructure [11] in terms of operational costs is very little compared to HFC, where in FTTH most of the devices used are passive devices and also there is no internal interference from the Fiber Optic cable itself.

B. Electricity Power

The cost of electricity payments on Hybrid Fiber Coaxial technology can be categorized as still very high where the use of active devices used in HFC technology requires electric current, the amount of electric current in the installed power supply requires a current of 3500 VA. The power supply needed to serve 1 area is adjusted to the number of nodes installed to be able to serve services in that area which can onlyserve 1364 homepass units.

While on Fiber To The Home technology because the use of active devices is only in an outdoor cabinet that is installed in a location and also only requires a total current of 5500 VA to be able to service active devices and can serve as many as 5427 homepass units.

C. Electricity Billing

FTTH technology requires a smaller electricity bill than HFC technology, which is 19%.

D. Customer Growth

PT Link has added an average customer growth of 18% from the 1 area where the network is being from Hybrid Fiber Coaxial (HFC) to Fiber To The Home (FTTH) technology.

The key differences between FTTH and HFC networks are their transmission technology, network topology, bandwidth capacity, signal quality, equipment complexity, reliability, andcost. FTTH networks offer higher bandwidth, better signal quality, and greater reliability, but come at a higher cost. HFC networks offer a lower-cost alternative but with lowerbandwidth capacity and signal quality.

While FTTH networks are generally more energy efficient than HFC networks due to the exclusive use of fiber optic cable, the energy consumption of both networks can vary depending on several factors. Understanding the energy consumption of broadband networks is critical for managing energy costs, reducing carbon footprints, and ensuring their long-term sustainability. As the demand for high-speed broadband services continues to grow, it's essential to continue to innovate and find new ways to improve the energy efficiency of these networks.

A conclusion section is not required. Although a conclusionmay review the main points of the article, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

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