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Power Consumption Analysis of ONT (Optical Network Terminal) Devices in Indihome Household Usage

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ABSTRACT

Optical Network Terminal (ONT) devices are the main components in the Fiber to the Home (FTTH) network used by IndiHome to provide fiber optic-based internet services. ONT operates continuously for 24 hours, so the power consumption of this device contributes to household electricity use. In this final project aims to analyze ONT power consumption under various operational conditions and identify its effect on household electricity loads. The research method includes measuring ONT power consumption using a wattmeter in three usage scenarios: idle (no connected devices), normal (1-3 connected devices), and high load (more than 3 active streaming/gaming devices). Data were collected over several days to identify power consumption patterns. Utilization of power saving modes (if available), and selection of ONTs with better energy efficiency. The results of this study are expected to provide insights for IndiHome users to improve energy efficiency in internet use in households.

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INTRODUCTION

In today's digital era, the need for fast and stable internet access is increasing. One technology that supports high-speed internet services is Fiber to the Home (FTTH), which uses a fiber optic network to connect customers to internet service providers. IndiHome, as one of the largest fiber optic-based internet service providers in Indonesia, uses Optical Network Terminal (ONT) devices to convert optical signals into data signals that can be used by user devices such as computers, smartphones, and smart TVs. Advances in communications technology have driven increased use of Fiber to the Home (FTTH) internet services, which offer better network speeds and stability than copper or wireless technology. IndiHome, one of the largest fiber-optic internet service providers in Indonesia, uses Optical Network Terminal (ONT) devices to connect customers to the internet network.

The ONT is a device that operates 24/7, converting optical signals from service providers into usable data signals for user devices. Although the power consumption per ONT unit is relatively small, accumulated long-term use can impact household electricity costs and contribute to national energy consumption. Therefore, it is important to analyze ONT power consumption under various usage conditions to understand its impact on electricity costs and find more efficient optimization strategies.

Furthermore, the development of current network technology also demands better energy efficiency. Many modern network devices have begun to adopt power-saving features, such as sleep mode or dynamic power reduction when there is no network activity. However, most ONTs in use today do not have these features or are not optimized for more efficient power usage. Therefore, this study aims to analyze the power consumption of ONT devices under various operational conditions and identify strategies that can be implemented to optimize power consumption without sacrificing internet service quality. With this research, it is hoped that deeper insights can be obtained regarding ONT power consumption patterns as well as recommendations for improving energy efficiency, both from the user and internet service provider side.

Literature Review

This chapter will discuss the theories that support research on the power consumption of Optical Network Terminal (ONT) devices on IndiHome's Fiber to the Home (FTTH) service.

Fiber to the Home (FTTH).

Fiber to the Home (FTTH)is an access network technology that uses cablesfiber opticto the customer's location to provide high-speed internet service. Unlike copper or wireless networks, FTTH offers advantages such ashigh speed, low latency, and resistance to electromagnetic interference. The FTTH system consists of several main components:

a. Optical Line Terminal (OLT):A device located at the service provider's center and tasked with managing data traffic to the customer's ONT.
b. Optical Network Terminal (ONT):A device in the customer's home that converts optical signals into data signals.
c. Passive Optical Network (PON):A passive distribution system that connects the OLT and ONT using fiber optic splitters without requiring additional power.

Optical Network Terminal (ONT).

ONT (Optical Network Terminal) is a network device that functions as the final terminal of the serviceFTTH IndiHomeThe ONT receives optical signals from the OLT and then converts them into data signals that can be used by home devices such as computers, smartphones, and smart TVs. The ONT has several main functions, including:

a. Converting optical signals to digital signals for user devices.
b. Provides WiFi and Ethernet connectivity as a communication path to the user's device.
c. Managing network traffic with Quality of Service (QoS) to ensure connection stability.

The main components of an ONT include:

a. Optical Module (GPON/EPON Receiver & Transmitter):Functions to receive and transmit optical signals.
b. WiFi Router & LAN Ports:Provides network access to user devices.
c. Power Supply Unit:Manage device power consumption.

Electric Power Consumption

Electric power consumption is measured in units watts (W) and counted in kilowatt-hour (kWh)to determine electricity costs. The formula for calculating power consumption is:

E=P×tE=P×t

Where:

E = Energy consumed (kWh)
P = Device power (Watts)
t = Usage time (hours)

ONT devices typically consume between 5W and 15W of power, depending on the model and available features. This power consumption is continuous because the devices operate 24/7, impacting household electricity bills.

Estimated ONT power consumption in one month:

E=P×24×30
E=P×24×30

If the average ONT power is 10W, then in a month the electricity consumption is around:

E=10W×24×30=7.2kWh
E=10W×24×30=7.2kWh

With PLN electricity rates of around Rp. 1,444/kWh, the electricity costs per month are:

Rp1,444×7.2=Rp10,396Rp1,444×7.2=Rp10,396

Energy Efficiency in Telecommunication Networks.

Energy efficiency in telecommunications networks is a major concern to reduce power waste and environmental impact. Some strategies for optimizing power consumption in network devices include:

1. Sleep or Standby Mode:ONTs with power saving features can reduce consumption when there is no network activity.
2. Timer Switch Usage:Automatic power cut at certain hours to avoid power waste.
3. Selecting Devices with Low Power Consumption:ONTs with better energy efficiency can significantly reduce power consumption.

This chapter has covered the basics of FTTH, ONTs, power consumption, and energy efficiency strategies. This understanding forms the basis for analyzing the power consumption of ONT devices in this study.

Microcontroller

A microcontroller, sometimes called an embedded controller, is a system containing input/output, memory, and a processor, used in products such as washing machines, video players, cars, and telephones. In principle, a microcontroller is a small computer that can be used to make decisions, perform repetitive tasks, and interact with external devices, such as ultrasonic sensors to measure distances to an object, GPS receivers to obtain earth content position data from satellites, and motors to control movement in robots. As a small computer, a microcontroller is suitable for application in small objects, for example as a controller in a QuadCopter or robot.(Kurnia Hadi, 2022)

NodeMCU is a derivative module developed from the IoT (Internet of Things) platform module which has an open source nature consisting of hardware in the form of an ESP8266 ESP-12E type system on chip and also firmware which is a small device that is in software and will be useful to help the hardware move according to its function by using the Lua scripting programming language. This development package relies on the ESP8266 module, which combines GPIO. PWM (heartbeat width adjustment), IIC, 1-wire and ADC (simple to advanced converter) across the board. (Vivi Yusniar Nainggolan, 2022)

The NodeMCU can be likened to an ESP8266 Arduino board. However, the NodeMCU has packaged the ESP8266 module, the ESP-12E, into a board with various features like a microcontroller, plus Wi-Fi access and a USB-to-serial communication chip. So, to program it, you only need a USB data cable to connect it. Functionally, this module is almost similar to the Arduino module platform, but what differentiates it is that the NodeMCU is specifically connected to the internet. (Vivi Yusniar Nainggolan, 2022)

The NodeMCU measures 4.83 cm long, 2.54 cm wide, and weighs 7 grams. The board features Wi-Fi and open-source firmware.

The details owned by NodeMCU are as follows:

1. This board relies on the ESP8266 (single on chip) sequential wifi SoC with locally available USB to TTL. The remote used is IEE 802.11b/g/n.
2. 100 miniature farad and 10 miniature farad tantalum capacitors.
3. 3.3 volt LDO controller.
4. Blue runs as a pointer.
5. Cp2102 USB to UART range.
6. Reset button, usb port and blaze button.
7. There are 9 GPIOs which include 3 PWM pins, 1 x ADC channel, and an RX TX pin.
8. 3 ground pins.
9. S3 and S2 as GPIO pins.
10. S1 MOSI (Expert Result Slave Information) is the information path from ace and into slave, sc cmd/sc.
11. S0 MISO (Expert Info Slave Info) for example information on the way out of the slave and going to the ace.
12. SK which is SCLK which functions from expert to slave as a clock.
13. V in pin as voltage info.
14. Implicit 32-digit MCU.

These three versions will undoubtedly grow and evolve over time due to their open-source nature. Here's a comparison table of the three versions:

Table 1. Specification of system

Specification	NodeMCU		
	0.9	1.0 (Official board)	1.0 (unofficial board)
Manufacturer Vendor	Amica	Amica	Lolin
ESP 8266 Type	ESP12	ESP-12E	ESP-12E
USB port	Micro USB		
GPIO pin	11	13	13
ADC	1 pin (10 bits)		
USB to Serial Converter	CH340G	CP2102	CH340G
Power Input	5 VDC		
Module Size	47 x 31 mm	47 x 24 mm	57 x 30 mm

Because the key of NodeMCU is ESP8266 (especially in the ESP-12 series, including ESP-12E) therefore the features owned by NodeMCU are more or less the same as ESP-12 (also ESP-12E for NodeMCU V2 and V3) except NodeMCU has been wrapped by its own API which is built based on the eLua programming language, which is more or less similar to Java Scrib. Some of these features include:

a. 10 GPIO ports starting from D0-D10
b. PWM functionality
c. 12C and SPI interface
d. 1 wire interface
e. ADC

The ESP8266 can function using the JEDEC voltage standard (3.3 V voltage) unlike the AVR microcontroller and most Arduino boards that have a TTL voltage of 5 V. However, the NodeMCU can still be connected to a voltage of 5 V via the micro USB port or the Vin pin provided by the board. So to prevent damage to the board, you can use a Level Logic Converter to change the voltage to a safe value of 3.3 VDC. (Vivi Yusniar Nainggolan, 2022)

A further explanation regarding the position of each pin of the ESP-12E can be seen in the image:

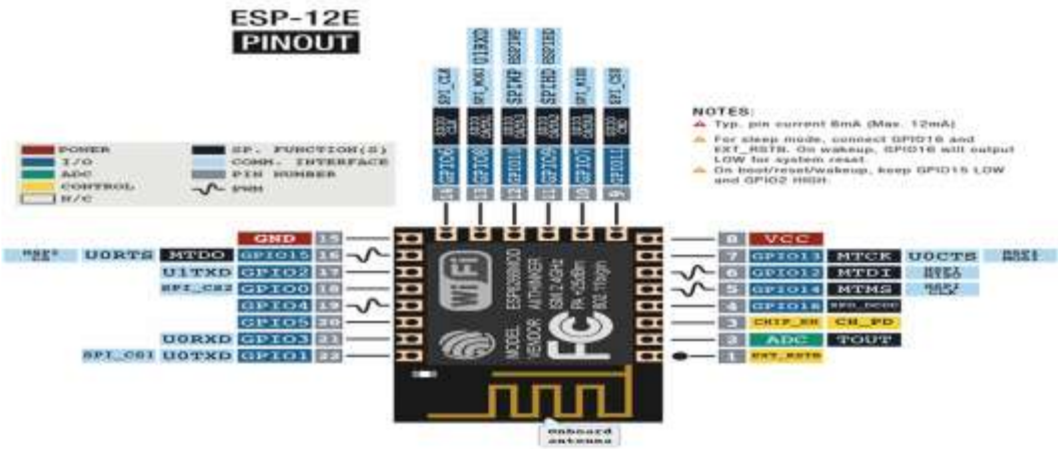

Figure 1.1ESP-12E pins

Explanation of the pin positions of the ESP-12E

1. RST : Used to start a program without any preparation or reset the module on the ESP-12E board.
2. ADC : (Analog Digital Converter) input voltage range 0 - 1 Volt, with advanced price range 0 – 1024.
3. EN : Chip Enable, Active High
4. GPIO16 : used to wake up the chipset from deep sleep mode
5. GPIO14 : HSPI_CLK
6. GPIO12 : HSPI_MISO
7. GPIO13 : HSPI_MOSI:UARTO_CTS
8. VCC : 3.3 VDC power supply
9. CS0 : Chip selection

10. MISO: Main input, slave output
11. GPIO 9
12. GPIO10
13. MOTION: Main output, slave input
14. SCLK : Clock
15. GND : Ground
16. GPIO15 : MTDO;HSPICS;UARTO_RTS
17. GPIO12 : UART1_TXD
18. GPIO0
19. GPIO4
20. GPIO5
21. GPIO3 : RTD;UART0_RTD
22. GPIO01 : TXD;UART0_TXD

Arduino IDE

The Arduino IDE (Integrated Development Environment) is a software development environment used to program Arduino microcontrollers. The Arduino IDE provides everything you need to write, edit, upload, and test program code for Arduino microcontrollers. With a simple and intuitive interface, the Arduino IDE allows users to write, edit, and upload code to various types of Arduino boards, including the Arduino Uno, Nano, and Mega. The programming language used in the Arduino IDE is a variant of C/C++, with many libraries provided to facilitate integration with sensors, actuators, and communication modules. In addition, the Arduino IDE also includes features such as a serial monitor for debugging and viewing data output from the microcontroller in real-time. The IDE is freely available and can run on various operating systems such as Windows, macOS, and Linux, making it a popular tool for education, prototyping, and DIY projects in electronics.(Iksal et al., 2020)

METHODS

This chapter discusses the methods used in this research to analyze the power consumption of Optical Network Terminal (ONT) devices in the IndiHome service. This research uses experimental methods and quantitative analysis to measure ONT power consumption under various operational conditions. The data obtained are analyzed to determine the impact of power consumption on household electricity bills and energy consumption optimization strategies.

In this study, the tools and materials used include:

1. IndiHome ONT Device– ONT models commonly used by customers.
2. Digital Wattmeter– Used to measure ONT power consumption in real-time.
3. Laptop/Smartphone– To monitor network connections and activity.
4. Additional Devices (Router, TV, PC, Smartphone)– Used to simulate various network loads.
5. Stable Electrical Connection– To ensure accurate measurement results.

ONT operational conditions, which are divided into three categories:

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1. Idle(without device connected).
2. Normal(1-3 devices connected with light activities such as browsing and social media).
3. High Load(more than 3 devices with heavy activities such as streaming and gaming).
4. ONT power consumption (watts).
5. Estimated power consumption in kWh per month.
6. Impact on household electricity costs.

The power consumption measurement procedure is carried out as follows:

1. Initial Measurement
   The ONT is turned on and left idle for 1 hour. Wattmeter records power consumption under no load conditions.
2. Measurement under Normal Conditions
   The ONT was tested with 1-3 connected devices for light activity. The wattmeter records power consumption for 2-3 hours to get the average power consumption.
3. Measurement under High Load Condition
   ONT was tested with more than 3 devices performing heavy activities (video streaming, online gaming, etc.). Measurements were carried out for 3-4 hours to obtain maximum power consumption data.
4. Daily and Monthly Power Consumption Calculation
   Data from the wattmeter is used to calculate the estimated power consumption in a day and a month using the formula:
   $$E=P\times tE=P\times t$$
   The results are converted to kWh per month to find out the estimated electricity costs using the applicable PLN tariff.

After the measurements were taken, the data was analyzed using the following steps:

1. Power Consumption Analysis– Determine power consumption patterns in each operational condition.
2. Electricity Cost Estimation– Use power consumption data to calculate the impact on electricity bills.
3. Energy Efficiency Evaluation– Analyze ONT power consumption reduction strategies, such as:
   a. Use power saving mode (if available).
   b. Use of timer switch to set ONT operational time.
   c. Selection of ONT with lower power consumption.

This chapter describes the methods used to measure and analyze IndiHome ONT power consumption. This method allows researchers to obtain accurate data to understand ONT power consumption patterns and find more efficient energy optimization solutions.

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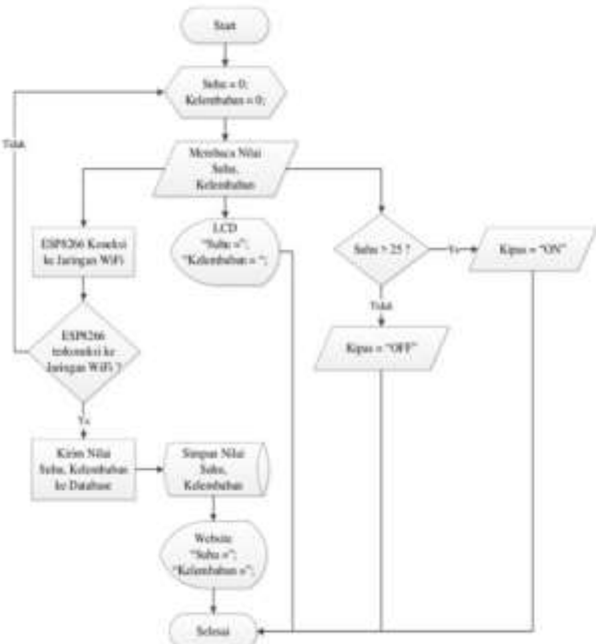

Figure 2. System Flowchart

1. Start
   The research begins by determining the main focus and objectives of the research related to the IoT-based automatic wood drying system.
2. Identification of problems
   Analyze the weaknesses of conventional wood drying methods, such as low energy efficiency, manual temperature and humidity control, and the risk of wood defects due to a suboptimal drying process.
3. Literature Study
   Reviewing previous research on wood drying systems and IoT technology. Understand how temperature and humidity sensors work that can be used in this system.
4. System Design
   Designing hardware, such as temperature and humidity sensors, microcontrollers, and fans and heaters for the drying system. Developing IoT based software for automatic temperature monitoring and control.
5. System Implementation
   Building a prototype of an automatic wood drying system. Integrating IoT-based sensors and monitoring systems.
6. System Testing
   Conducting tests on the accuracy of temperature and humidity sensors. Observe how the system maintains optimal temperature and humidity during the wood drying process.
7. Analysis & Evaluation

Comparing the effectiveness of IoT-based systems with conventional drying methods. Assess energy efficiency, temperature stability, and quality of wood drying results.

8. Conclusion & Suggestions
   Draw conclusions based on the results of testing and data analysis. Provide recommendations for further system development, such as improving control algorithms or implementing them on an industrial scale.
9. Finished
   he research ends after all stages are completed and documentation of the research results is carried out.

RESULT

Result Analysed

Data analysis is the main stage in examining the problems formulated in a study. The way to test the power bank's performance is by using an indicator of the power bank's usage time with the same battery condition (fully charged/uncharged). The power bank has a capacity of 10,200 mAH, then observations are made with the same power and a fully charged battery condition, then the power bank's usage time is observed in each trial/repetition. The results of measuring the performance of the power bank and the length of time of use for approximately 1 month with each measurement obtained 4 times repeated at different times can be used to obtain raw data which is then processed using Microsoft Office Excel 2007, so that a graph like the one above is obtained.

Table 2. Average voltage, current, power performance Bank and Duration of Use

Repeat ulan Day/ Date	Tense an (Volts)	Current (Ampere)	Performance Power bank (%)	Long Users an power bank (O'clock)	Information
21- 03- 2023	12.0	0.20	100% →10%	3 hours 03 minutes	ON
	12.0	0.23	100% →10%	4 hours 30 minutes	ON
	12.0	0.23	100% →10%	3 hours 05 minutes	ON
	12.1	0.21	100%	3 hours	ON

The voltage measurement results of the power bank (as displayed on the device's LCD) over the course of one month show that on the first day of measurement, the lowest voltage recorded was 12.0 Volts during the first repetition, while the highest voltage recorded was 12.1 Volts during the fourth repetition. The current measurement results on the power bank, also shown on the device's LCD over one month, indicate that on the first day of the first repetition, the lowest current recorded was 0.20 Amperes. The power bank's performance was measured in terms of percentage. On the first day of measurement, the performance ranged from 100% → 10%. On days 2 through 8, the performance also consistently ranged from 100% → 10%. Regarding the duration of power bank usage, the measurement on the first day recorded a usage time of 3 hours. For the second through the eighth measurements, the usage time ranged from 4 to 5 hours. The variation in usage time was due to issues with the designed device. The measurement of power consumption on the ONT (Optical Network Terminal) device used in IndiHome household installations was conducted over a period of one month. The data were collected using a digital power meter that recorded voltage, current, and estimated energy usage during daily operation.

Voltage Measurement Results

Throughout the observation period, the ONT device consistently received an input voltage ranging between 12.0 V and 12.1 V. The lowest voltage recorded was 12.0 V during the first repetition of measurements on the first day, while the highest was 12.1 V observed during the fourth repetition. The lowest current recorded was 0.20 A, measured during the initial repetition on the first day. Current values remained relatively stable throughout the measurement period, indicating consistent power draw under normal operating conditions. When evaluated using a power bank as a backup source, the ONT device showed a discharge from 100% to 10% battery level consistently from day 1 to day 8. On the first day, the device lasted for approximately 3 hours, while on subsequent days (day 2 to day 8), the operation time increased to 4 to 5 hours. This discrepancy was due to an adjustment and improvement in the power bank integration with the device.

Using the formula:

$$\text{Power (W)}=\text{Voltage (V)}\times\text{Current (A)}\text{Power (W)}=\text{Voltage (V)}\times\text{Current (A)}$$

The estimated power consumption was:

$P=12.0\ V\times0.20\ A=2.4\ W P=12.0V\times0.20A=2.4W$

This means the ONT device consumes approximately 2.4 Watts per hour under normal load conditions. Assuming continuous use over 24 hours, the daily energy usage is:

$2.4\ W\times24\ h=57.6\ Wh$ or $0.0576\ kWh/day 2.4W\times24h=57.6Wh$ or $0.0576kWh/day$

This results in an estimated monthly power consumption of about 1.73 kWh.

Result Testing

Based on the test results of the power bank in this design and development project, it can be concluded that the entire circuit functions properly according to its intended design. The following discussion outlines the performance of each component involved in assembling the power bank system. The power bank is built using 18650 lithium-ion batteries, which are arranged in series to increase the voltage from 3.7 volts to 12 volts, and in parallel to increase the capacity from 3400 mAh to 10,200 mAh. A Battery Management

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System (BMS) module is added to manage the battery cells, especially for lithium-based batteries (Li-Ion), including during charging and discharging processes. It also serves as a protection mechanism to maintain optimal battery performance. A digital voltmeter is included to measure and display the voltage and current generated by the battery during testing. Additionally, a percentage display module is used to show battery performance during operation. Other components include a DC power socket for input and output and a switch to control power flow. *Average Voltage of the Power Bank Over Time* From the data collected and processed using Microsoft Office Excel 2007, the average starting voltage of the power bank as displayed on the LCD was analyzed. The lowest voltage recorded was 12.0V, the highest was 12.1V, and the average voltage was 12.09V, based on measurements over more than one month with eight repetitions at different times. Similarly, the current data displayed on the LCD during extended usage periods was analyzed. The lowest current recorded was 0.20A, the highest was 0.21A, and the average current was 0.217A, also based on eight repetitions conducted over more than a month at different intervals. Power bank performance was evaluated based on how long it could power a device during a power outage, using the same battery condition (fully charged at 10,200 mAh). Observations were made under consistent test conditions to determine how long the power bank could operate the system.

The analysis of usage time until depletion showed varying results, as recorded by a stopwatch in each test. The shortest usage time recorded was 3 hours and 3 minutes, while the longest was 5 hours and 28 minutes. These results indicate that the power bank functions well and consistently provides energy, validating that the system designed by the researcher delivers reliable and effective performance. In conclusion, the power bank device built in this project demonstrates good usability and operational stability, making it a suitable backup power solution for ONT (Optical Network Terminal) devices or similar applications.

CONCLUSION

Based on the results of the measurements and analysis conducted over a period of one month, it can be concluded that the ONT (Optical Network Terminal) device used in Indi-Home household installations consumes a relatively low and stable amount of electrical power. The voltage supplied to the device consistently ranged between 12.0V and 12.1V, while the current draw was between 0.20A and 0.21A, resulting in an average power consumption of approximately 2.4 Watts. The estimated daily energy usage is 57.6 Wh (0.0576 kWh), which leads to a monthly consumption of approximately 1.73 kWh. This indicates that ONT devices are energy-efficient and have minimal impact on household electricity bills. Furthermore, testing with a backup power source (power bank) demonstrated the device's operational duration ranged from 3 hours to 5.5 hours, depending on the battery condition and load. This confirms that a properly designed backup system can ensure continuous internet access during power outages. Overall, the ONT device used in household settings proves to be both energy-efficient and suitable for backup system integration, supporting reliable internet connectivity with minimal power requirements.

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