Techno-Economic Analysis of Investment in Specific Absorption Rate Test System at Telecommunication Equipment Testing Laboratories in Indonesia

Muhammad Ikhwan[1]*, Fitri Yuli Zulkifli[2]
[1,2] Department of Electrical Engineering, Universitas Indonesia, Depok, West Java 16424, Indonesia
Email: [1]muhammad.ikhwan21@ui.ac.id , [2]yuli@eng.ui.ac.id*

ARTICLE INFORMATION

Received 30 March 2024
Revised 13 June 2024
Accepted 30 September 2024

Keywords:
Cellular Phone
Laboratory
Specific Absorption Rate
Techno Economic
Telecommunication

ABSTRACT

The use of mobile devices has become a primary necessity for Indonesian society. The benefits of mobile devices are increasingly abundant. However, it is essential to consider the impact of electromagnetic exposure on health. Recently, the government regulated Specific Absorption Rate (SAR) limits for mobile phones and computer tablets. The government strives to ensure that devices circulating in Indonesia comply with these SAR limits. Unfortunately, the number of laboratories in Indonesia capable of testing SAR is quite limited. This situation presents a business opportunity for telecommunications testing laboratories to invest in SAR test systems. The author analyzes the techno-economic aspects of investing in the SAR test system using parameters such as Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period (PP). The author compares two options: the first option involves investing in two complete SAR test systems, while the second option involves investing in one test system with a backup probe. Both options allow for full operation of the SAR test system, enabling consumers to request testing whenever needed. The calculations reveal that both options yield an NPV greater than zero, an IRR exceeding the specified interest rate, and the ability to recoup the investment within a six-year payback period. Consequently, this investment is deemed viable for implementation at present with current conditions.

1. Introduction

The rapid advancement of telecommunications technology has made mobile devices an integral part of our daily lives. The use of mobile devices allows us to communicate, access information and run various applications with ease. However, behind this convenience and ease lie important health and safety considerations (Abdul-Al M, 2022).

In Indonesia, where mobile phone ownership has reached 67.88% of the population (Badan Pusat Statistik, 2023), the need to ensure the safety and compliance of telecommunications equipment with international standards is becoming increasingly important. One aspect that needs to be considered is the Specific Absorption Rate (Varshney, 2018). SAR quantifies the energy that human body tissues absorb from electromagnetic radiation from mobile devices.

The Indonesian government has just issued a regulation on SAR limits for mobile phones (Keputusan Menteri Kominfo No. 177, 2024). The regulation mandates the testing of mobile phones and tablet computers for SAR. These devices must be tested because they are used at less than 20 cm from the user's body and have a radiation emission of more than 20 mW. This regulation will be implemented in phases. In the first phase, the SAR limit to the head will be tested, and then the SAR limit to the body will become mandatory for certification of mobile phones and tablet computers.

DOI : 10.17933/bpostel.v22i2.389

Cellular telephone market penetration is accelerating in Indonesia (Meilita Tryana Sembiring, 2019). According to the Ministry of Communication and Information, Directorate of Sumber Daya dan Perangkat Pos dan Informatika (SDPPI), the number of certifications for mobile phones and tablet computers reaches 300 devices per year. As shown in Table 1, the number of certifications for mobile phones is twice that of tablet computers. Both are devices that must be tested for SAR values based on Kepmen Kominfo No. 177 of 2024, which comes into effect on April 1, 2024.

Tabel 1. Number of Certificates Issued for Telecommunications Equipment and Devices based on The Designation Period 2020 - 2022

Devices	Year		
	2020	2021	2022
Cellular Phone	221	233	206
Tablet Computer	92	61	86

Source: (Direktorat Jenderal Sumber Daya Perangkat Pos dan Informatika, 2023)

The implication of Kepmen Kominfo Number 177 of 2024 is the increasing need for SAR testing in Indonesia. Currently, the only telecommunications equipment testing laboratory in Indonesia that has a SAR test system is BBPPT (Balai Besar Pengujian Perangkat Telekomunikasi). BBPPT has two SAR test systems that can test 2G, 3G, 4G, 5G FR1 technologies as well as Wireless Local Area Network (WLAN) and Bluetooth. The other one can only test 2G, 3G and 4G.

There are currently 17 frequency bands used by mobile devices in Indonesia, including 14 cellular bands and 5 WLAN and Bluetooth bands. Head SAR testing takes approximately 50 hours. The test method used is to find the parameter configuration that produces the highest power from the mobile phone (Federal Communications Commission Office of Engineering and Technology Laboratory Division, 2015).

Under current conditions, additional laboratories capable of performing SAR testing are needed. This is to meet the high demand for certification of mobile phones and tablet computers for each year. Of course, this is necessary to ensure that the mobile devices circulating in Indonesia meet the SAR limits set by the government. It is also necessary to provide society with a sense of safety and comfort when using mobile devices in everyday life.

The objective of this study is to conduct a techno-economic analysis of the investment in SAR test systems in telecommunications equipment testing laboratories in Indonesia. The economic aspects will be analysed using Net Present Value (NPV), Internal Rate of Return (IRR) and Payback Period (PP) parameters. In this way, it will be possible to determine whether the investment in the SAR test system in the telecommunications equipment test laboratory will be able to generate profits or vice versa.

2. Literature review

2.1. *Specific Absorption Rate*

Specific Absorption Rate (SAR) is a measure used to evaluate the rate of absorption of electromagnetic radiation energy by a given biological tissue or body system. SAR is expressed in units of watts per kilogram (W/kg). SAR is primarily concerned with non-ionizing radiation because ionizing radiation, such as X-rays or gamma rays, has energy high enough to directly ionize atoms or molecules (L. E. Amrani, 2018).

Non-ionizing radiation, such as radio, micro, infrared, and visible light, does not have enough energy to ionize atoms or molecules in biological tissues. However, although there is no direct ionization, non-ionizing radiation can cause energy absorption by human body tissues, primarily in the form of heating.

SAR is used to measure the rate of energy absorption by biological tissues when exposed to non-ionizing electromagnetic radiation (Bindhu Christopher, 2021). This helps to assess the potential effects of heating on body tissues due to excessive exposure to non-ionizing radiation. SAR limits set by organizations such as International Commission on Non-Ionizing Radiation Protection (ICNIRP) and Institute of Electrical and Electronics Engineers (IEEE) are designed to ensure that the level of energy absorption by the human body remains within limits that are considered safe and do not cause excessive heating or adverse effects.

2.2. *SAR Calculation Mechanism*

Mathematically, SAR is a measure used to quantify the amount of electromagnetic radiation absorbed by human body tissues when using electronic devices such as mobile phones. The mechanism for calculating SAR involves several basic steps. Here is an overview of how SAR calculations are performed.

a. Radiation measurement: First, the electromagnetic radiation emitted by the electronic device is measured. This is usually done using specialized equipment called SAR dosimeters or computer simulation techniques.
b. Human body model: Next, SAR calculations involve the use of a human body model that represents the physical characteristics of the human body. This model includes different tissues and organs of the body.
c. Energy absorption simulation: In this step, electromagnetic radiation emitted by electronic devices is directed at the human body model. Computer simulation techniques are used to predict how this electromagnetic energy is absorbed and interacts with the tissues of the human body.
d. SAR calculation: Once the energy absorption simulation is complete, SAR calculations are performed by measuring the amount of energy absorbed by a unit volume of human body tissue. This is expressed in units of watts per kilogram (W/kg).

The general formula for calculating the SAR (A K M Fazlul Hoque, 2013) is shown in Equation 1.

$$SAR = \frac{\sigma|E|^2}{\rho} \quad \text{...1)}$$

Where:

SAR is the Specific Absorption Rate, which is the amount of electromagnetic radiation energy absorbed by biological tissue per unit mass in a unit time (expressed in watts per kilogram, W/kg).

σ is the electrical conductivity of biological tissue exposed to radiation (expressed in Siemens per meter, S/m).

E is the strength of the electromagnetic field (expressed in volts per meter, V/m)

ρ is the density of biological tissue (expressed in kilograms per cubic meter, kg/m^3)

2.3. *SAR Standards and Limit*

The SAR standard establishes acceptable limits for the amount of electromagnetic radiation absorbed by the human body, expressed in units of watts per kilogram (W/kg). These limits are based on current scientific reviews and epidemiological research to ensure that radiation exposure levels remain below the threshold considered safe for human health.

SAR standards are developed by international agencies and research institutions with expertise in non-ionizing radiation, such as the ICNIRP, the Federal Communications Commission (FCC), and the International Electrotechnical Commission (IEC). SAR testing is performed using a phantom, a model of the human body that mimics the radiation absorption characteristics of the human body. It is important to note that SAR standards may vary from country to country or region to region. Therefore, electronic devices must meet the requirements of the SAR standards applicable in that country or region before they are sold or used.

Some of the bodies and organizations that publish standards related to SAR testing include ICNIRP, IEEE, FCC, Health Canada, and World Health Organization (WHO). ICNIRP, as an international body, is widely accepted worldwide and is used as a reference by other regulatory bodies. IEEE develops technical standards including SAR testing for wireless devices. The FCC refers to ICNIRP or IEEE standards to ensure that devices meet limits that are considered safe. Health Canada issues SAR standards based on ICNIRP guidelines and adapted to the Canadian context. WHO provides guidance and recommendations on non-ionizing radiation protection based on ICNIRP guidelines and is involved in research and evaluation of health risks related to electromagnetic radiation.

The regulations related to SAR limits are divided into two parts. Devices used in the workplace (occupational) and devices used by the general public. The limits for work-related devices have higher limits than those for devices commonly used by the general public, as shown in Table 2.

Table 2. Limits for Exposure to Electromagnetic fields from 100 kHz to 300 GHz, with Mean Intervals ≥ 6 Minutes

Exposure Scenario	Frequency Range	Whole-body average SAR (W kg^{-1})	Local Head/Torso SAR (Wkg^{-1})	Local Limb SAR(Wkg−1)	Local S_{ab} (Wm^{-2})
Occupational	100 kHz to 6 GHz	0.4	10	20	NA
	> 6 to 300 GHz	0.4	NA	NA	100
General Public	100 kHz to 6 GHz	0.08	2	4	NA
	> 6 to 300 GHz	0.08	NA	NA	20

Source: (ICNIRP, 2020)

Government regulate the SAR limits for Indonesia are contained in Kepmen Kominfo No. 177 of 2024. Where the regulation refers to international SAR rules, namely the ICNIRP Guideline 1998 (ICNIRP, 1998) and ICNIRP Guideline 2020 (ICNIRP, 2020). The obligation to comply with SAR limits is imposed first on mobile phone devices and tablet computers.

2.4. *SAR Testing Method*

SAR test methods refer to international standards. Some of the most recent standards referenced in SAR testing are as follows. The first is IEC/IEEE 62209-1528: 2020, which is the latest method from IEC for conducting SAR tests on hand-held and body-worn wireless devices with a frequency of 4 MHz - 10 GHz (IEC/IEEE 62209-1528, 2020). This is followed by Knowledge Database (KDB) 941225 D05 (FCC Office of Engineering and Technology Laboratory Division, 2015) and KDB 941225 D05A (Federal Communications Commission Office of Engineering and Technology Laboratory Division, 2015), which guide how to test LTE devices.

The main components of the SAR testing process are as follows:

a. SAR test system

   A special instrument that can measure the amount of electromagnetic energy absorbed by a phantom or simulated human body. This instrument can produce SAR data in the form of numerical values. The SAR test system is divided into two, wet and dry methods. This method is used for pre-testing. As for the wet method, it is a common method used for full compliance testing.

b. Shielded Room

   SAR testing requires a special room that is isolated from external electromagnetic signal interference. This is to ensure that the measured value is the value of the tested device. Can be used shielded room with or without additional absorber.

c. Phantom

   A model or simulated body used as a substitute for human tissue. A phantom is made of material that has characteristics similar to human tissues, such as liquids that contain salt or artificial tissues.

d. Base Station Simulator (BSS)
   BSS is an Radio Frequency (RF) signal generator as an input from the device to be tested. It can be 2G, 3G, 4G and 5G mobile signals as well as WLAN and Bluetooth.

2.5. *Techno-Economic*

Techno Economics is a method used to analyze the costs, benefits, and risks associated with an investment project over a certain period of time. This method measures financial performance based on the cash flow of the financial report. Financial performance assessment parameters can use Net Present Value (NPV), Internal Rate of Return (IRR) and Payback Period (PP) (Haotian Dai, 2022).

a. NPV
   Net Present Value (NPV) is used to analyze the value of future investments. NPV calculates the difference between the current value of cash inputs and the present value of the cash outputs on an investment (Shou, 2022). The formula used to calculate NPV is shown on equation 2 (Haotian Dai, 2022).

$$NPV = \sum_{t=1}^{n} \frac{CFt}{(1+i)^t} \quad \text{……………………………………..2)}$$

   Where:
   NPV: Net Present Value
   CFt: Cash Flow period t
   i: interest rate
   t: Year of t
   n: number of years
   NPV value 0 means that the investment is capable of returning capital. Whereas if the NPV is negative, then that investment is detrimental and not worthy of being executed. So the expected NPV was positive value, where the investment means that it can generate a profit.

b. IRR
   Internal Rate of Return (IRR) is used to measure how quickly an investment value can increase its value. The IRR is calculated when the NPV is zero (Yushan Chen, 2022), as in the 3 equation.

$$0 = \sum_{t=1}^{n} \frac{CFt}{(1+IRR)^t} \quad \text{……………………………………..3)}$$

   Where:
   IRR: interest rate
   Here it can be concluded that if the value of the IRR is greater than the interest rate, then the investment is profitable.

c. PP
   Investment requires measurement of how long it takes to make a profit. PP is used to see how long it takes for an investment to reach the Break Even Point (BEP). The formula of PP can be seen on equation 4 (Haotian Dai, 2022).

$$PP = t + \frac{(a - CCFt)}{CCF_{(t+1)} - CCFt} x\, 1\, year \quad \text{……………………………..4)}$$

   Where:
   PP: Payback Period
   t: year in which the cash flow has not yet been able to cover the value of the investment

a: investment value
CCFt: cumulative value of cash flow in the t-year

2.6. *Benchmarking Telecommunications Device Testing Laboratory*

The certification of telecommunications devices can be submitted to the Ministry of Communications and Informatics. Currently the service process is organized by the Directorate of Postal Standardization and Information Technology, Directorate SDPPI. As for this certification process, the device can be tested in ten domestic laboratories as listed in Table 3 (SDPPI, 2024).

Table 3. List of Domestic Laboratories for Certification of Telecommunications Devices in Indonesia

Laboratory	SAR Test System	Price	Information
Balai Besar Pengujian Perangkat Telekomunikasi (BBPPT)	SPEAG	Rp. 7.000.000/band/technology	(Peraturan Pemerintah No. 43 , 2023)
Balai Besar Standardisasi dan Pelayanan Jasa Industri Bahan dan Barang Teknik (B4T)	-	-	-
Balai Standardisasi dan Pelayanan Jasa Industri (BSPJI)	-	-	-
Quality Assurance - Divisi Digital Connectivity Service (Telkom Test House) PT. Telekomunikasi Indonesia	-	-	-
PT. Bureau Veritas Consumer Products Services Indonesia	SPEAG	-	Hongkong
PT. Hyundai Calibration and Certification Technologies Indonesia	SPEAG	-	South of Korea
PT. TUV Rheinland Indonesia	ART-FI	-	Europe
PT. Qualis Indonesia	-	-	-
PT. Sucofindo (Persero)	-	-	-
PT. Hartono Istana Teknologi, Sub Lab Electronic & RF	-	-	-

From ten laboratories in Table 3, only one laboratory already has a test system for SAR testing, namely BBPPT. Currently the laboratory has two SAR test systems for devices with 2G, 3G, 4G, 5G, WLAN and Bluetooth technologies. While one test system can only test devices with cellular technology 2G, 3G and 4G.

However, for the SAR test price, it is not given in detail. Because the cost of SAR testing is influenced by several factors such as the type of device, the number of technologies and frequencies used and the complexity of the device's usability. In Indonesia, the cost of SAR testing for a single cell phone with complete technology can be calculated as in table 4. There are 17 frequency bands in total, so the test cost for a cell phone device is up to Rp. 119 million.

Table 4. SAR Test Estimates Price for Cell Phones based on Technology Band in Indonesia

Technology	Frequency	Price
2G	900 MHz, 1800 MHz	Rp 14,000,000
3G	-	-
4G	850 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz	Rp 35,000,000

Technology	Frequency	Price
5G	850 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz	Rp 35,000,000
WLAN	2.4 GHz, 5.1 GHz, 5.2 GHz, 5.8 GHz	Rp 28,000,000
Bluetooth	2.4 GHz	Rp 7,000,000

3. Method

This research method will compare the techno-economic value of investing in a SAR test system. There will be two variation options for the investment model as shown in Table 5.

Table 5. SAR Test System Investment Model Options

Option	CAPEX	OPEX
#1	SAR Measurement System: SPEAG Dasy 8 (2 set) BS Simulator: Rohde & Schwarz CMX500 & CMW500 (2 set) Shielded room dimension (12 x 5 x 3) m Air Conditioner & Dehumidifier	2 tester engineers Electrical Bill Calibration measurement system SAR Liquid Maintenance
#2	SAR Measurement System: SPEAG Daisy 8 (1 set) BS Simulator: Rohde & Schwarz CMX500 & CMW500 (1 set) Back-up Probe (1 set) Shielded room dimension (7 x 5 x 3) m Air Conditioner & Dehumidifier	1 tester engineer Electrical Bill Calibration measurement system SAR Liquid Maintenance

First option is an investment in two complete test systems, with one shielded room. So that testing can be carried out without being hampered by test system calibration. Meanwhile, the second option only provides one test system by adding a backup probe. Due to the special nature of this probe, currently it can only be calibrated in its country of origin, Switzerland. Meanwhile, for the base station simulator, because it is a supporting tool, the calibration option is not included.

The two options will be compared for their techno-economic value consisting of the Net Present Value (NPV), Internal Rate of Return (IRR) and Payback Period (PP) parameters. Next, it will be determined which option can produce greater profits by looking at the largest NPV, largest IRR and smallest Payback Period.

The service life of a SAR test system can reach 20 years (SPEAG, Schmid & Partner Engineering AG, 2024). However, you need to pay attention to spare parts and maintenance support. Apart from that, cellular technology, which continues to develop every ten years, also needs to be taken into consideration. So here the investment value of the test system is limited to being evaluated within a period of ten years to see whether it has reached BEP. So, in the future we will see whether this investment is feasible or not if analyzed from a techno-economic perspective.

4. Results and Discussion

4.1. *Estimated Investment Costs*

Investment costs were obtained from interviews with authorized distributors for the SPEAG and Rohde & Schwarz brands. Meanwhile for AC and Dehumidifier as secondary data. The estimated costs were obtained as presented in Table 6.

Table 6. Estimated Investment Costs

Option	CAPEX	Volume	Price
#1	SAR Measurement System: SPEAG Daisy 8	2 set	Rp 28,578,350,000
	BS Simulator: Rohde & Schwarz CMX500 & CMW500 (2 set)	2 set	Rp 17,845,304,600
	Shielded room dimension (12 x 5 x 3) m	1 set	Rp 2,000,000,000
	Air Conditioner & Dehumidifier	1 set	Rp 10,000,000
	Total		**Rp 48,433,654,600**
#2	SAR Measurement System: SPEAG Daisy 8	1 set	Rp 14,289,175,000
	BS Simulator: Rohde & Schwarz CMX500 & CMW500	1 set	Rp 8,922,652,300
	Back-up Probe	1 set	Rp 1,627,650,000
	Shielded room dimension (7 x 5 x 3) m	1 set	Rp 2,000,000,000
	Air Conditioner & Dehumidifier	1 set	Rp 10,000,000
	Total		**Rp 26,549,477,300**

4.2. *Estimated Operational Costs*

Operational costs are obtained from market analysis. The tester engineer's salary is calculated based on twice the 2024 regional minimum salary or Upah Minimum Regional (UMR) in Jakarta. For electricity rates, premium class calculations are used. The calculation of electricity needs is shown in Table 7. Effective working days in a year are 240 days with 8 hours of working hours per day. For information, the room needs to be maintained at a temperature of around 20-25^{o}C to keep the fluid in the SAR on the phantom from changing.

Table 7. Electrical Power Requirement in a Year

Option	Electrical power	Work Hour	Work Day	Power (kW)	Total Power in a Year (kW)	Base Price (Rp/kWh)	Total Price
#1	SAR TS	8	240	15.77	30,289.92	1,644.52	Rp 89,245,338
	BSS	8	240	4.90	9,408		
	AC	24	365	1.58	13,840.80		
	Dehumidifier	8	240	0.38	729.60		
#2	SAR TS	8	240	7.89	15,144.96	1,644.52	Rp 56,603,326
	BSS	8	240	2.45	4,704		
	AC	24	365	1.58	13,840.80		
	Dehumidifier	8	240	0.38	729.60		

Probe calibration costs were obtained from interviews. Meanwhile, maintenance costs are an estimate of 5% of the SAR test system investment value. Estimated inflation is also included in operational costs at a rate of 5% per year. Meanwhile, Indonesian inflation data from 2022 to 2023 has reached a maximum of 6% with an average value of 4%.

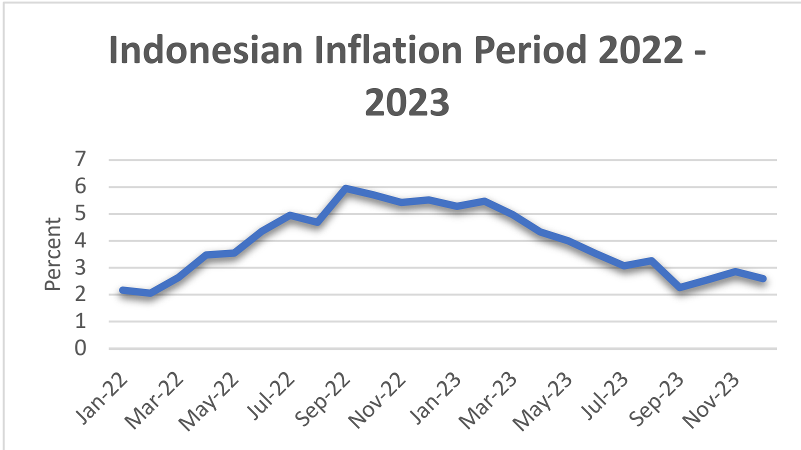

Figure 1. Inflation Rate in Indonesia 2022-2023 (Bank Indonesia, 2023)

The total operational costs in the first year are shown in Table 8. Furthermore, the value of operational costs will increase by 5% in line with the inflation estimates that have been set. The year in which the investment was made is included in the previous year.

Table 8. Estimated Operational Costs for the First Year After Investment

Option	OPEX	Year	Price
	Salaries	1st	Rp 256,484,640
	Electrical bill	1st	Rp 89,245,338
#1	Calibration	1st	Rp 1,406,000,000
	SAR Liquid	1st	Rp 366,280,400
	Maintenance	1st	Rp 1,428,917,500
	Total		**Rp 3,546,927,878**
	Salaries	1st	Rp 128,242,320
	Electrical bill	1st	Rp 56,603,326
#2	Calibration	1st	Rp 703,000,000
	SAR Liquid	1st	Rp 183,140,200
	Maintenance	1st	Rp 714,458,750
	Total		**Rp 1,785,444,596**

4.3. *Revenue*

The cost of testing one cellular device with a total of 17 frequency bands is Rp. 119 million. The total working time in one year is 240 days and the testing time for one cell phone device is six days. So, one test system in one year can complete testing of 40 devices. Added here is an estimated 3% increase in testing prices each year. Likewise, testing capabilities are also increased every year by 3%. So, we get the calculations in Table 9.

Table 9. Estimated Revenue for Ten Years

Year	Estimation Price	Target Device per Station	Total Revenue Yearly per Station
1	Rp, 119,000,000	40	Rp 9,520,000,000
2	Rp, 122,570,000	41	Rp 10,050,740,000
3	Rp, 126,247,100	42	Rp 10,604,756,400

Year	Estimation Price	Target Device per Station	Total Revenue Yearly per Station
4	Rp 130,034,513	43	Rp 11,313,002,631
5	Rp 133,935,548	44	Rp 12,054,199,355
6	Rp 137,953,615	45	Rp 12,829,686,180
7	Rp 142,092,223	46	Rp 13,640,853,436
8	Rp 146,354,990	47	Rp 14,489,144,009
9	Rp 150,745,640	48	Rp 15,376,055,248
10	Rp 155,268,009	49	Rp 16,303,140,932

4.4. *NPV, IRR and PP*

The first step in getting the NPV, IRR and PP values is to calculate the investment cash flow for ten years. In Table 10, cash flows are shown in ten years plus one year of investment time. From this cash flow, we will then see what the NPV, IRR and PP values are.

Table 10. Estimated Cashflow for Ten Years

Year	Option #1		Option #2	
	Cashflow	Cumulative Cashflow	Cashflow	Cumulative Cashflow
Invest	-Rp 48,433,654,600	-	-Rp 26,549,477,300	-
1	Rp 7,401,989,622	-Rp 41,031,664,978	Rp 3,689,014,154	-Rp 22,860,463,146
2	Rp 6,503,812,122	-Rp 34,527,852,855	Rp 3,239,925,404	-Rp 19,620,537,742
3	Rp 7,057,828,522	-Rp 27,470,024,333	Rp 3,516,933,604	-Rp 16,103,604,138
4	Rp 7,766,074,753	-Rp 19,703,949,579	Rp 3,806,039,463	-Rp 12,297,564,675
5	Rp 8,507,271,477	-Rp 11,196,678,102	Rp 4,107,719,533	-Rp 8,189,845,141
6	Rp 9,282,758,303	-Rp 1,913,919,799	Rp 4,422,468,072	-Rp 3,767,377,069
7	Rp 10,093,925,558	Rp 8,180,005,759	Rp 4,750,797,675	Rp 983,420,606
8	Rp 10,942,216,131	Rp 19,122,221,890	Rp 5,093,239,933	Rp 6,076,660,539
9	Rp 11,829,127,370	Rp 30,951,349,260	Rp 5,450,346,109	Rp 11,527,006,648
10	Rp 12,756,213,054	Rp 43,707,562,314	Rp 5,822,687,839	Rp 17,349,694,487

From the cash flows above, the NPV, IRR and PP values are obtained in Table 11. The NPV values are obtained from calculations using equation 2. The interest rate uses the average Indonesian interest rate in 2023 of 5.81% (Bank Indonesia , 2023). Meanwhile, IRR is obtained from calculations using equation 3. And PP is obtained from calculations using equation 4.

Table 21. Value of NPV, IRR & PP in Ten Years

Option	NPV	IRR	PP
#1	Rp 16,704,133,419	12.09 %	6 Years
#2	Rp 4,829,858,522	9.31 %	6 Years

Based on the NPV and IRR calculations, it was found that option 1 had greater NPV and IRR values. The NPV value of Option 1 is approximately three times greater than option 2. Meanwhile, the IRR value of option 1 is 2.78% greater than option 2. So, as can be seen in Figure 2, Option 1 has better NPV and IRR values compared to Option 2, within ten years of investment. Meanwhile, for PP, both options have the same time to reach BEP of six years.

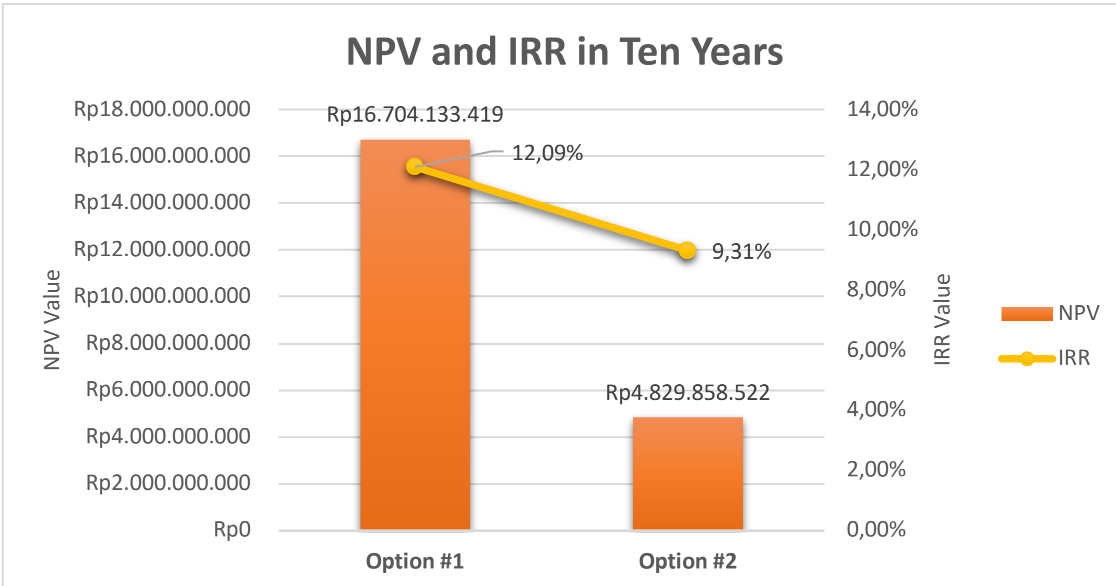

Figure 2. Result NPV and IRR in Ten Years

5. Conclusion

Based on the analysis that has been carried out, investment in SAR testing test system is feasible. Especially after the government issued regulations regarding the SAR limit values that mobile phone device manufacturers must meet. The current domestic testing capacity is only capable of testing approximately 100 devices each year. This means that the demand for SAR testing can only be met by 1/3 of the total devices that are usually certified each year. In fact, in the future, not only cellular telephone devices and tablet computers will need to be tested, but smart devices that use cellular or WLAN and Bluetooth technology will also need to be tested if the transmit power of the device exceeds the predetermined limit of 20mW. Of course, this is an opportunity for telecommunications equipment testing laboratories to invest in meeting domestic SAR testing needs. This will help the government in protecting consumers from electromagnetic exposure that exceeds the limits. As well as to support the growing telecommunications industry in developing safe technology for society.

6. Acknowledgements

The author would like to thank all parties who have helped complete this study, especially BBPPT, and the Ministry of Communication and Information of the Republic of Indonesia.

References

A K M Fazlul Hoque, M. S. (2013). A Study on Specific Absorption Rate (SAR) Due to Non-Ionizing Radiation from Wireless/Telecommunication in Bangladesh. American Journal of Physics and Applications, 104-110.

Abdul-Al M, A. A.-Y. (2022). Wireless Electromagnetic Radiation Assessment Based on the Specific Absorption Rate (SAR): A Review Case Study . Electronics.

Badan Pusat Statistik. (2023). Statistik Telekomunikasi Indonesia 2022. Retrieved from https://www.bps.go.id/id/publication/2023/08/31/131385d0253c6aae7c7a59fa/statistik-telekomunikasi-indonesia-2022.html

Bank Indonesia. (2023). BI-Rate. Retrieved from https://www.bi.go.id/id/statistik/indikator/BI-Rate.aspx

Bank Indonesia. (2023). Data Inflasi. Retrieved from https://www.bi.go.id/id/statistik/indikator/data-inflasi.aspx

Bindhu Christopher, S. M. (2021). Empirical study on specific absorption rate of head tissues due to induced heating of 4G cell phone radiation. Radiation Physics and Chemistry.

Direktorat Jenderal Sumber Daya Perangkat Pos dan Informatika. (2023). Retrieved from Data Statistik 2022: https://www.postel.go.id/publikasi-data-statistik-44

FCC Office of Engineering and Technology Laboratory Division. (2015). SAR Evaluation Considerations For LTE Devices.

Federal Communications Commission Office of Engineering and Technology Laboratory Division. (2015). REL. 10 LTE SAR TEST GUIDANCE AND KDB INQUIRIES.

Haotian Dai, N. L. (2022). The Analysis of Three Main Investment Criteria: NPV, IRR and Payback Period. International Conference on Financial Innovation and Economic Development (ICFIED 2022). Atlantis Press.

ICNIRP. (1998). ICNIRP GUIDELINES FOR LIMITING EXPOSURE TO TIME-VARYING ELECTRIC, MAGNETIC AND ELECTROMAGNETIC FIELDS (UP TO 300 GHZ).

ICNIRP. (2020). ICNIRP GUIDELINES FOR LIMITING EXPOSURE TO ELECTROMAGNETIC FIELDS (100 KHZ TO 300 GHZ).

IEC/IEEE 62209-1528. (2020). Measurement procedure for the assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-worn wireless communication devices - Human models, instrumentation and procedures (Frequency range of 4 MHz - 10 GHz).

Keputusan Menteri Kominfo No. 177. (2024). Batasan Specific Absorption Rate pada Perangkat Telekomunikasi Telepon Seluler dan Komputer Tablet.

L. E. Amrani, T. M. (2018). The Specific Absorption Rate induced in human organs due Ionizing and Non Ionizing Radiations exposure. 2018 6th International Conference on Wireless Networks and Mobile Communications (WINCOM), (pp. 1-4). Marrakesh.

Meilita Tryana Sembiring, C. (2019). Peninjauan Prospek Smartphone Global: Studi Pustaka. TALENTA Conference Series: Energy & Engineering. Medan: Talenta Publisher.

Peraturan Pemerintah No. 43 . (2023). Jenis dan Tarif Atas Jenis Penerimaan Negara Bukan Pajak yang Berlaku pada Kementerian Komunikasi dan Informatika.

SDPPI. (2024). Balai Uji Dalam Negeri. Retrieved from Postel: https://sertifikasi.postel.go.id/balai-uji/balai-uji-dn

Shou, T. (2022). A Literature Review on the Net Present Value (NPV). International Conference on Enterprise Management and Economic Development (ICEMED 2022). Atlantis Press.

SPEAG, Schmid & Partner Engineering AG. (2024). PRODUCT LIFETIME. Retrieved from https://speag.swiss/products/dasy8/m-sar-apd/product-lifetime/

Varshney, S. &. (2018). Specific Absorption Rate (SAR) value of mobile phones: An awareness study among mobile users. Indian Journal of Community Health. 30, 156-162.

Yushan Chen, Z. D. (2022). Various Methods Aim to Solve the Limitation of IRR . International Conference on Financial Innovation and Economic Development (ICFIED 2022). Atlantis Press.