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IoT-based Intelligent Monitoring & Control System Planning Using Project Management Method and Business Feasibility Analysis

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Abstract: Various PLTS systems have been installed in the Energy Laboratory of Politeknik Negeri Jakarta, ranging from on grid, off grid, and SHS systems, and various sources of PLTH, PLN, and Generator Set (Genset.) However, the problem that occurs there is that the hybrid system in the Lab. Solar System PNJ room cannot be monitored easily and controlled automatically. As a result of these problems, monitoring the performance of hybrid systems and learning in the PNJ Solar Systems Lab cannot be done optimally. The power source in the lab can be combined in a Hybrid PLTS system and generator with a switch method using the ATS switch control system and monitoring for student learning. The purpose of this research will be to analyze the economic value and use of ATS switches for various concepts in saving electricity in a certain period of time using project management analysis so that it can see the feasibility of this project to be implemented or not. The method in this study is to calculate the economic feasibility value, then find the value of Internal Rate of Return (IRR), NPV, Payback Period using Microsoft excel software and analyze project risks. The results obtained in this project are the IRR value> Interest rate, namely 6.51%> 5.75%. The NPV value obtained is Rp. Rp.572,252 with a payback period in year 12. From the results obtained, this project is declared feasible to continue.

Keywords: Control System; Internet of Things (IoT); Solar Hybrid Power Plant

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1. Introduction

New Renewable Energy (EBT) continues to be intensified to achieve the energy transition target in reducing greenhouse gas (GHG) carbon emissions and preventing global warming. The EBT mix target is 23% in 2025 while in 2022 it was still 12.3% [1]. One of the EBT mix targets is the spread of solar power plants (PLTS). PLTS is one of the EBT power plants that utilizes sunlight to be converted into electrical energy (procedures, villages, and regions n.d.) [2].

In previous research on Goring, Ramba Goring Village, Design of Portable Hybrid Power Plant Plts and Pltmh with Iot-Based Monitoring System conducted research on the design of a hybrid generation system between PLTS and PLTMH [3]. Then the research Analysis of Sensor Selection and Accuracy in Weather Station Design as a Weather Monitoring System for the Jakarta Polytechnic Area [4]. Analyzes the selection of sensors used as monitoring in the plts system. In research of Preliminary Study of Off-grid PLTS Systems as a Mobile SPBKLU Source [5]. Analyzing Calculations to determine the components selected in the Off grid PLTS system using theoretical calculations and comparing with the PVsyst application in order to reduce the risk of calculation errors. Research conducted by Techno-Economic Analysis of Solar Power Plants (PLTS) at PT Pertamina (Persero) processing unit IV Cilacap [6,7]. The calculation of investment feasibility carried out shows an NPV value of USD 2,128,717.24. PI value = 1.33, IRR value of 18.2%, and DPP value of 11 years. These conditions indicate that the construction of PLTS at PT Pertamina Processing Unit IV Cilacap is feasible. In research on Engineering Analysis and Economic Feasibility in the Design of Hybrid System Solar Power Plants Using analysis methods with PVSyst and RetScreen simulations, this PLTS produces electricity of 1,653.2 kWh / year [8,9]. With an initial investment of Rp 25,186,000, the net present value is Rp 1,210,272 and the pay back period is in the 24th year.

In this research, careful planning is needed so that the Hybrid Solar PV (PLTS) system project runs properly for real implementation [10-12]. The case use the PNJ Solar System Lab location. This research objective is to design the Hybrid Solar PV project with an additional Automatic Transfer Protocol (ATS). The paper compares several concept designs. Project Management which includes an explanation of the management team, stakeholder management, operational and maintenance management, and Business Feasibility Analysis including Financial Analysis, Risk Analysis, SWOT Analysis, and Load Analysis are discussed in this paper. Therefore, a suitable system design can be derived along with an economic analysis of the project on a series of IoT-based intelligent monitoring and control tools in the PNJ Solar System Lab.

2. Materials and Experiment Methods

This research is qualitative research that aims to analyze the economic value and feasibility of this research Hybrid PLTS system project. The focus of this research is to calculate the IRR NPV, Payback Period and Profitability Index values of the project. The system will be validated by clients or users to assess the level of feasibility and ease of use.

The stages of this research include problem identification by observation and discussion, information gathering to find the economic value and feasibility of the project based on the parameters mentioned above using formulas entered Microsoft Excel to facilitate the calculation process.

Before looking for NPV, IRR, Payback period and PI values, it is necessary to analyze the components in the system to see the suitability of specifications and the power generated with the load requirements to be installed through RETScreen software and Global solar atlas to find solar irradiation at the research location.

After finding the economic value, the risk analysis method is carried out with the probability and consequence table by assessing the risk from a scale of 1-5 and then adding mitigation to minimize the risk so that the previous value is reduced.

Formula for finding IRR [13]**:**

To find the NPV value, you can use the following formula:

$$\mathbf{NPV} = \sum_{t=1}^{N} \frac{Ci}{(1+i)^t} - Co \quad (1)$$

Ct : Cash Flow per year in period t

Co : Initial Investment Value at Year 0

r : Interest Rate

t : Investment Period

Formula for finding Payback period (PP)

$$\text{PBP} = 0 + \frac{Biaya\ investasi - net\ cash\ flow\ tahun\ ke-1}{cash\ flow\ tahun\ ke-2 - net\ cash\ flow\ tahun\ ke-1}\ x\ 1\ tahun \quad (2)$$

Formula for finding Internal Rate of Return (IRR)

IRR formula:

$$\text{NPV} = 0 = \frac{CF1}{(1+1)\text{^}1} + \frac{CF2}{(1+1)\text{^}2} + \frac{CF3}{(1+1)\text{^}3} + \ldots + \frac{CFn}{(1+1)\text{^}n} - \text{OI} \quad (3)$$

Ket: CF: Cash flow

i : Cost of capital/interest rate sought at discount rate NPV will be zero

n : Lifespan of the investment project

OI : Initial investment

3. Results and Discussion

Final Results

1. Product Design Concept.

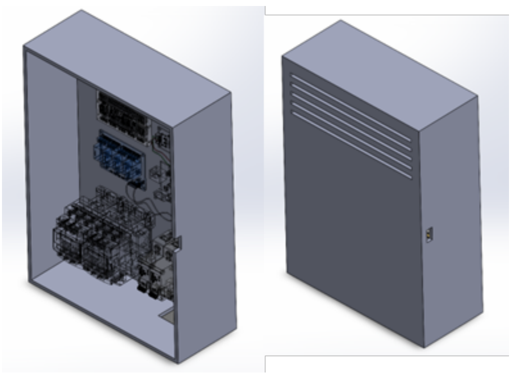
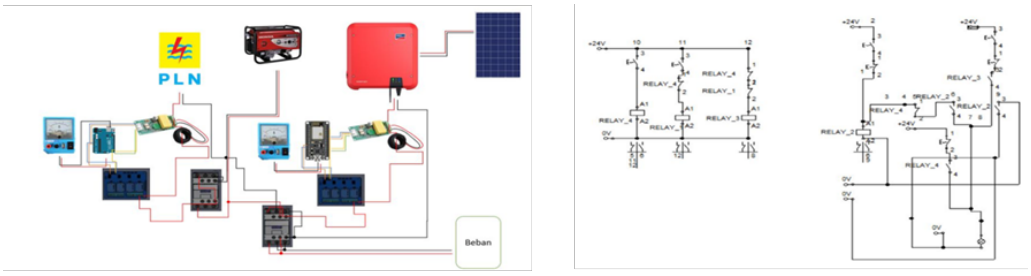


Figure 1. The revised draft of Product Design

In this research, the monitoring and control system will be incorporated into the control panel which is made of two concepts discussed in other subtitles as shown in Figure 1. Of these two concepts, Economic Analysis will discuss the second model which is more favorable according to the survey because with its larger size it will be easier to maintain and replace components later if needed.



(a) (b)

Figure 2. Hardware circuit of ATS control system shown in figure (a) diagram of ATS control system shown in figure (b).

The hardware circuit details as shown in Figure 2 illustrates the ATS/AMF intelligent control circuit arrangement. In the hardware design for the ATS/AMF control system, it is done by drawing the control and power circuit diagram of the ATS/AMF system. Furthermore, selecting / determining the components to be used such as MCBs, Contactors, Power Supplies, Relays based on the current capacity and performance of the component itself and equipped with monitoring components [14].

Financing project

Table 1. Funding for the Project Concept 1

No	Items	Units	Volume	Prices (Rp)	Total (Rp)
1	Arduino UNO	pcs	2	250,000	500,000
2	Relays	pcs	4	5,000	20,000
3	Contactor	pcs	3	87,000	261,000
4	AC voltage sensor	pcs	2	100,000	200,000
5	modem	pcs	1	125,000	125,000
8	NYM 1.5 power cable	meters	5	25,000	125,000
9	Electric cable NYM 3x2.5	meters	5	25,000	125,000
10	NYM 2025 power cable	meters	5	25,000	125,000
11	Skun (round/Y/feruless) colorful	pcs	30	5,000	150,000
12	Saldar MCB	pcs	2	50,000	100,000
14	Male female jumper cable	pcs	20	1,000	20,000
15	Routers	pcs	1	250,000	250,000
16	anti-lightning splitzen 60cm	pcs	1	145,000	145,000
17	filament	roll	2	210,000	420,000
18	loT module No de MCU ESP32	pcs	1	90,000	90,000
GRAND TOTAL				1,393,000	2,656,000

In this project, the preferred concept is shown in Table 1. The second panel box concept so that the cost is adjusted for the second concept, besides that this research carries 3 Solar Panel (PLTS) system concepts, namely:

In this research, 3 concepts are carried out to be selected conditionally for the client, namely:

Concept 1: Lightning-proof addition + router modem

Concept 2: Lightning-proofing + router addition

Concept 3: Addition of Modem + Router

The cost is adjusted for the concept of 1 solar system as shown in Table 2.

Table 2. Cost of Services

Fixed Service Fees		management fee applied
Design Fees	Rp.300000	Rp 30.000
System programming costs	Rp.250000	Rp. 25,000
Installation costs according to the concept chosen		optional*)
Concept Installation Costs 1	Rp.800.000	Rp.80.000
Concept Installation Cost 2	Rp.600.000	Rp.60.000
Concept Installation Cost 3	Rp. 450.000	Rp.45.000

Then the initial capital price is the cost price + service fee for concept 1 as shown in Table 1. so that the total initial capital for concept 1 is Rp.5,885,000. Then this value will be an input to find the value of NPV, IRR and determine the payback period on this project to determine the feasibility of the project.

Table 3. Total Project Cost

Items	**Prices**	**Notes**
Initial costs before using ATS	Rp.4.721.000	Fixed
Additional RAB Fees Monitoring tools and control	*) concept 1 Rp.2.921.600 *) concept 2 Rp.2.784.100 *) concept 3 Rp.2.613.600	*) Optional
Design service fee + programming	Rp.550.000	Fixed
Installment fee	*) concept 1 Rp.880.000 *) concept 2 Rp.660.000 *) concept 3 Rp. 495.000	*) Optional
Total Cost insstallment equipment	*) concept 1 Rp.4.351.600 *) concept 2 Rp.3.994.100 *) concept 3 Rp.3.658.500	*) Optional

Total investment costs (PLTS+addition tool)	*) concept 1 Rp.9.072.600 *) concept 2 Rp.8.715.100 *) concept 3 Rp.8.379.500	*) Optional

Table 3. above is made with Microsoft Excel so that the capital costs are obtained along with the estimated total operating costs and also the annual power generated from solar panels using the formula 0.8 KWp x 5 x 365 = 1460 Kwh / Year.

Table 4. PV Value of Net Cash Flow

IRR	9.32%	IRR	6.51%
NVP	1,358,644	NVP	572,252
Pay Back Period	9	Pay Back Period	12
RoI	5.8%	RoI	2.4%

Year	Net cash flow	Accumulatif	Year	Net cash flow	Accumulatif
0	-4,351,600	-4,351,600	0	-9,072,600	-9,072,600
1	487,789	-3,863,811	1	823,897	-8,248,703
2	487,789	-3,376,022	2	823,897	-7,424,806
3	487,789	-2,888,233	3	823,897	-6,600,909
4	487,789	-2,400,444	4	823,897	-5,777,012
5	487,789	-1,912,655	5	823,897	-4,953,115
6	487,789	-1,424,866	6	823,897	-4,129,218
7	487,789	-937,077	7	823,897	-3,305,321
8	487,789	-449,288	8	823,897	-2,481,424
9	487,789	38,501	9	823,897	-1,657,527
10	487,789	526,290	10	823,897	-833,630
11	487,789	1,014,079	11	823,897	-9,733
12	487,789	1,501,868	12	823,897	814,164
13	487,789	1,989,657	13	823,897	1,638,061
14	487,789	2,477,446	14	823,897	2,461,958
15	487,789	2,965,235	15	823,897	3,285,855
16	487,789	3,453,024	16	823,897	4,109,752
17	487,789	3,940,813	17	823,897	4,933,649
18	487,789	4,428,602	18	823,897	5,757,546
19	487,789	4,916,391	19	823,897	6,581,443
20	487,789	5,404,180	20	823,897	7,405,340

By using Excel, it is also obtained a comparison of IRR values before and after using the tool of 9.32% and 6.61% The amount of discount rate (i) used to calculate the present value in this study is 5.75% as shown in Figure 4. The determination of this discount rate refers to the Bank Indonesia lending rate as of March 15, 2023. Based on the simulation in Figure 4.3, it is known that the IRR value is> 5.75%, so the project is declared feasible to continue. In the payback period comparison, it can also be seen that the difference in the payback period before and after using ATS where if you don't use ATS. The payback value here means that clients who should pay electricity to PLN every year of Rp.2,108,240 / year with theoretical annual electrical energy production of 1460kWh / year by using PLTS without using ATS with an initial capital of Rp.4,721,600 will return capital in year 9 while if using ATS concept 1 then the return occurs in year 12. In addition, the NPV value of both shows a positive value before and after using the ATS tool, namely Rp.1,358,644 and Rp.572,252. It can be seen that the NVP value after installing the ATS is smaller than before installing the ATS because the initial capital required is greater and the payback period is also longer. In concept 1, although the payback value is longer, concept 1 offers a better safety aspect because there is a lightning rod and smooth data communication in the system so that there is no delay in data using routers and modems so that communication is smoother.

Table 5. Risk Assessment matrix table

		Assessment before measure				*Assessment after measures*			
Risk	**Risk description**	**P**	**S**		**Actions (multiple possible)**	**P**	**S**		**Decision**
1	Terjadi Kontak dengan sambaran petir	3	5	15	Memasang anti petir dan surge arrester pada sistem PLTS	3	2	6	
2	Shading pada PLTS	4	4	16	survey tempat yang cocok dipasang plts tanpa ada gangguan shading	2	2	4	Diambil
3	Cuaca yang tidak dapat diprediksi berdampak pada produksi daya plts	5	5	25	menambahkan sensor suaca atau berkordinasi dengan bmkg setempat	3	3	9	Diambil
4	Kebakaran Solar Panel	3	5	15	perhatikan saat ada kabel yang putus ataupun rusak, pastikan kebel tersebut diisolasi dengan bena	2	2	4	
5	Kualitas Komponen yang telah dibeli kurang baik	3	3	9	Pengawasan diperlukan selama tahap detail engineering	2	2	4	
6	Pembangkit tidak mencapai kinerja yang diinginkan	3	3	9	Menambahka n peralatan pendukung agar kinerja lebih baik	2	3	6	
7	Delay pada relay yang terlalu lama untuk switch	2	3	6	Mengoptimasikan Sistem baik pada programming maupun perangkat	1	2	2	
8	Keadaan Panel box yang kurang terisolasi dengan baik	3	5	15	tes terlebih dahulu untuk memastikan keadaan terisolasi dengan baik	2	3	6	
9	Muncul Kotoran di permukaan Panel Surya	4	4	16	membersihkan secara rutin/terjadwal	3	3	9	
10	Koneksi Internet untuk monitoring pada IOT bermasalah	4	4	16	Pilih provider yang baik dan pasang routerdan modem	2	2	4	
11	Setelan sensor yang kurang terkalibrasi	3	3	9	mengkalibrasikan sensor dengan alat ukur denan perocbaan beberapa kali hingga mendapat hasil yang akurat	2	2	4	

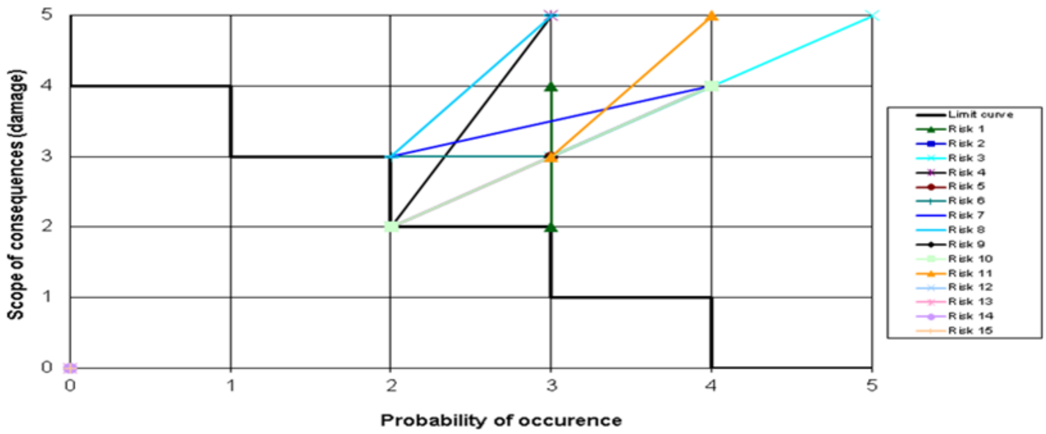


Figure 3. Risk Analysis Chart

Table 5. shows the analysis of risks that could potentially occur along with points on a scale of 1 - 5 for the amount of impact caused and the likelihood of the risk occurring. Then include mitigation actions that may be taken to prevent the risk from occurring.

Figure 3 shows the graph that occurs based on the assessment value given, if the trend position is getting up and to the right, the level of possibility of risk is getting bigger and the impact given is getting bigger. Vice versa, the more to the left and downward, the level of possibility of risk is getting smaller and the impact given is not too large.

In the graph, it can be seen that the biggest level of risk is from weather factors which cannot be predicted and greatly affects the amount of power generated from solar power plants and the benefits that can be taken, followed by uncalibrated sensor settings that can cause false alarms on the system. Then then the delay is too long on the switch where if the switch is too long it can disrupt the ongoing operational conditions if an emergency occurs and followed by other risks.

From the results of the risk analysis for lightning risk and internet connection, special devices are added to minimize these risks which have been grouped in the concepts offered in this study, namely concept 1, concept 2 and concept 3. Lightning-proof installation conditions are optional, especially for areas prone to lightning to improve safety aspects and maintain tool life. And for the addition of modems and routers is also optional where there is also an option to only install a router if you want to use the existing network at the location. If the network is not yet available, you can use a modem and also a router with a good provider as has been researched in the sub-title "Planning ATS and AMF Control System Design for PLT Hybrid Lab. Solar System PNJ" with the results of the best provider with the fastest upload and download rate is Telkomsel.

4. Conclusions

In the economic analysis in this research carries three concept offers, namely; concept 1, concept 2 and concept 3 for clients whose respective IRR values after installing ATS are compared with the investment value before using ATS with the three different concepts. The value of NVP, IRR is declared feasible to continue with the comparison of the level of electricity cost savings is saving Rp.2,108,240 / year with theoretical annual electrical energy production of 1460 kWh / year. Of the three concepts proposed, if you want a level of safety and comfort of data communication, the concept that should be taken is concept 1 because it includes using anti-lightning and routers and modems with the recommended provider is Telkomsel.

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