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Design Smart Grid Hybrid in Faculty of Engineering Universitas Negeri Yogyakarta

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Abstract. The Faculty of Engineering, Universitas Negeri Yogyakarta (UNY), as one of the educational institutions in Engineering, still uses electrical energy from PT PLN, mainly generated from steam and gas power plants. Dependence on fossil energy can be reduced by utilizing renewable power plants, both solar and wind. For this reason, it is necessary to study the use of a Smart Grid system that can regulate electricity needs by optimizing renewable power plants. The Smart Grid components consist of solar power plants, wind power plants, batteries, inverters, and grid power sources from PLN integrated into the Smart grid system. We have designed the Smart Grid system through field observations and data processing with the HOMER Pro software to obtain an optimal hybrid power generation system and wind turbine. The study results indicate that the Faculty of Engineering, UNY has excellent potential to develop smart grids. The potential for solar energy is 418.393 kWh/year, and wind energy is 2.78 kWh/year. The Smart grid system is sufficient to meet the electricity consumption of only 205.5 kWh/year.

Keywords: Smart Grid, design, hybrid, UNY

1. Introduction
Electricity is an energy that has a vital role in modern human life. It has many advantages such as being practical, clean, easy to generate and distribute, reliable, safe, and environmentally friendly. As secondary energy, electricity is obtained through converting primary fuels such as oil, gas, coal, solar, geothermal, nuclear, and other direct energy [1], [2]. Power plants in Indonesia mainly use fossil fuels, gas, and coal, and some power plants use geothermal energy, water, photovoltaic, wind turbine, and waste. The need for electrical energy increases from year to year, prompting the Government to increase power generation. However, unfortunately, the policy of adding power plants uses coal-fired power plants. This condition creates potential energy crises, global warming, climate change, ecosystem damage, and acid rain [2], [3].

The Ministry of Energy and Mineral Resources has planned to increase the use of new and renewable energy in the future. Figure 1. shows the electrical energy mix plan until 2050. The use of new and renewable energy in 2016 was still deficient at less than 10%. Based on the long-term goal, the Government will increase renewable energy use to 23% in 2025 and 32% in 2050. This energy policy is very good in developing the electricity system in Indonesia, so it needs the support of all parties in the development of new and renewable energy [1], [3], [4]

	2016	2025	2050
NRE Mix	7.7 %	23%	31%
Energy Supply	169 MTOE	400 MTOE	1.012 MTOE
Generation Capacity	59 GW (NRE 8 GW)	136 GW (NRE > 45 GW)	443 GW (NRE > 167 GW)
Electricity/Capita	956 kWh	2.500 kWh	7.000 kWh
Electrification Rate	91%	~100%	~100%

Figure 1. Research Method Design Smart Grid System

Several renewable energy power plants continue to be developed, but the high investment costs and low economic value make renewable energy development less attractive [3]. The use of fossil energy sources, especially coal, is influenced by the abundance of coal reserves in Indonesia and the low price compared to other power plants, especially renewable power plants. The development of new renewable energy at the Faculty of Engineering, UNY, was initiated in 2010. Several studies related to renewable power plants have been carried out at the Faculty of Engineering, UNY. Some of the activities include the development of street lighting with solar panels and supercapacitors, micro-hydropower plants, electric power plants, wind, and renewable energy power plants integrated with the grid [1]. However, all of them are limited to small units used for learning in the laboratory.

Energy sustainability and environmental conservation are important issues of global concern due to climate change and the increasing energy demand. A technologically advanced area inevitably requires greater electrical energy consumption and continues to rise at a level that may no longer be manageable if left unattended. Smart grids offer one of the more sustainable technology shift solutions such as distributed generation and microgrids. General public awareness and adequate attention from potential researchers and policymakers are essential [5], [6].

One way to meet people's electrical energy needs is to maintain fossil energy reserves and prevent global warming. The Government has launched the development of New Renewable Energy power plants. One of the problems of developing new renewable energy power plants is the economic value and intermittent nature. Concerning the monetary value of new renewable energy, the Government has issued a subsidy policy for the public and businesses that use renewable energy. Meanwhile, it is necessary to modify the conventional electric power system into a Smart Grid to solve the intermittent nature of energy. The Smart Grid system is one of the technologies that can effectively and efficiently address the integration of New and Renewable Energy into the electricity system on a large scale [8], [9], [10].

Conventional electric power systems based on fossil generators need to be changed with a Smart grid system with renewable power plants [9], [12]. The Conventional electric power system is built based on the location of the energy source, then very long transmission and distribution lines are constructed to reach consumers. The weakness of the conventional electric power system is that the energy flow is only in one direction from the generator to the consumer. The traditional electrical system is very prone to disturbances that cause blackouts. Along with the development of technology and consumer needs, the electric power system must meet the needs of consumers who, at the same time, can function as producers. The power plant is supplied from the center, but each element can also produce electricity sent to the grid.

For this reason, this article will try to provide a review of hybrid Smart Grid planning by utilizing the potential of solar energy, wind energy, electrical energy storage, and conventional generation in a Smart Grid system. This research is expected to make a real contribution to the development and implementation of renewable energy. The impact of implementing renewable energy can reduce dependence on fossil energy and reduce global warming.

2. Method

The stages of designing the Smart Grid system of the Faculty of Engineering UNY can be explained as shown in figure 2.
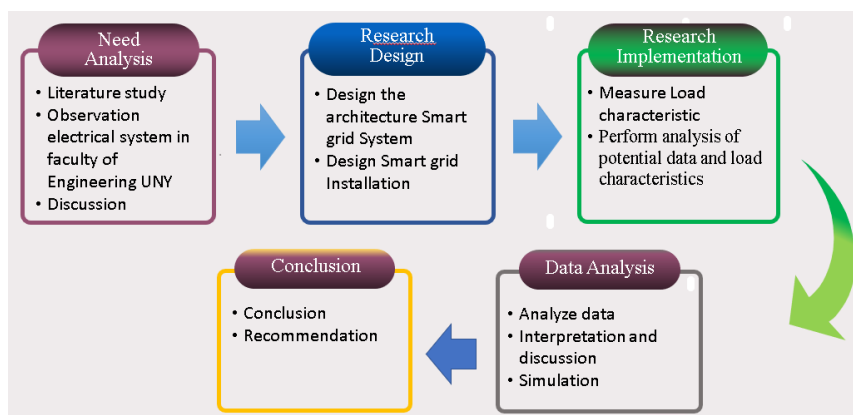

Figure 2. Research Method Design Smart Grid System

The first step is to analyze the need for developing a Smart Grid Hybrid at the Faculty of Engineering, UNY, through literature studies, observation, and discussions with related parties. The next stage is to design the architecture and installation of the Smart grid system in the Faculty of Engineering UNY. The third step is conducting research which consists of measuring load characteristics, identifying renewable energy, and measuring renewable energy potential at the Faculty of Engineering, UNY. The fourth step is to analyze the measurement data and conduct simulations and discussions. The final step is to draw conclusions and make recommendations to the parties concerned.

3. Results and Discussion

3.1. Smart Grid System Design

The Faculty of Engineering UNY is located at Karangmalang Campus, Special Region of Yogyakarta. The Faculty of Engineering has several buildings, including the Electrical and Electronic Engineering Education Department block, the Mechanical Engineering Education Department block, the Civil Engineering Education Department block, the culinary and fashion education department block, and the KPLT block. Planning for the development of a Smart Grid system at the Faculty of Engineering, UNY by optimizing New and Renewable Energy according to Figure 1 is as follows:

a. Solar Power Plant
    The solar panels used in the Smart Grid system are Canadian Solar MaxPower CS6U-340M with a capacity of 0.340 kW at US$279.50 (Solaris Shop, 2021) and maintenance costs of US$2,7950 (includes online ordering fees, shipping costs), and installation costs).

b. Wind Power Plant
    Wind turbines are also a significant component in this hybrid power generation system. The type of wind turbine that will be used for this simulation is AWS HC 3.3 kW with a purchase and replacement cost of US$25,000, operating and repair costs of US$250.

c.   Export and Import KWH meter system from PT. PLN
The EXIM (Export-Import) kWh meter device is a tool for calculating electrical energy consumption that is installed in PLN customer homes and has a function to record the amount of production (export) and consumption (import) of customers.

d.   Converter
The converter is a valuable component for converting DC electricity to AC. The converter type used in this simulation is REFUsol 46K-MV. The converter has an inverter and a rectifier section with an efficiency of 90% each. The converter fee is US$19,034.00.

e.   Battery
The battery used is a Trojan SSIG 12255 with a specification of 12V 259 Ah. The cost of all battery kits is US$425.20, and maintenance costs are US$4.2520.
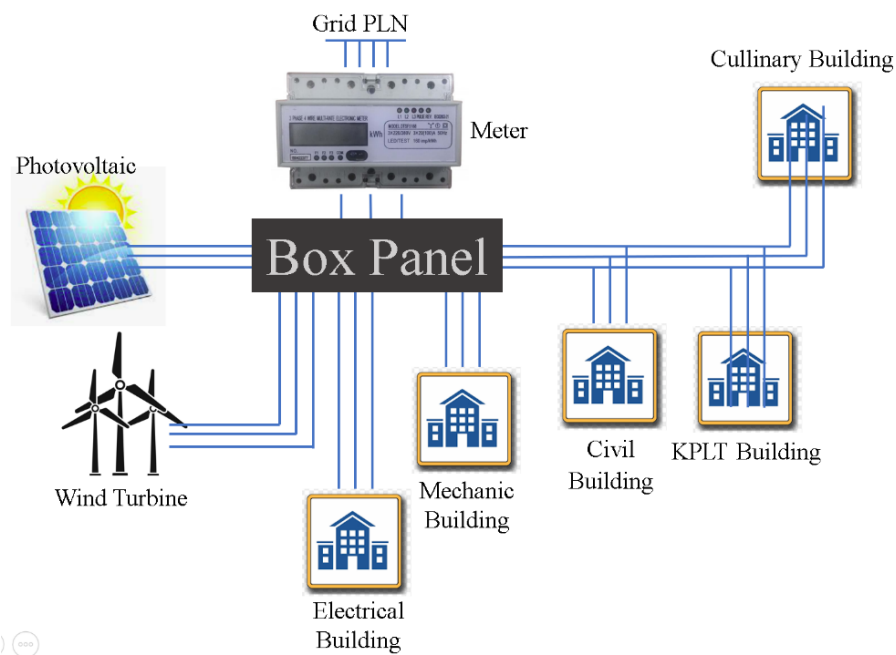

Figure 3. Design of Smart grid System at Faculty of Engineering UNY

Several renewable energy sources, such as water/hydro, photovoltaics, biomass, and wind/wind, need a study implemented into a power plant in the Faculty of Engineering Building.

Table 1. Renewable energy potential in Faculty of Engineering UNY

Energy sources	Location	Characteristic	Information
Water/Micro Hydro		No potential	The location is far from heavy water flows such as rivers, lakes, waterfalls, and other sources of water flow
Solar	Power House Faculty of Engineering Universitas Negeri Yogyakarta	Potential	The location is constantly exposed to sunlight throughout the day, and no buildings are blocking it so that it can be used for solar power generation
Biomass		No potential	The location is quite far from plantations, forests, and

		livestock, so the biomass potential is not optimal.
Wind	Potential	Wind at the Faculty of Engineering, UNY, has characteristics that change due to climate and seasons, so a more in-depth study of the utilization of wind power plants is needed.

The Smart grid design of the Faculty of Engineering UNY consists of two types of energy sources, namely fossil energy and new and renewable energy. Fossil energy consists of a grid component and a generator. Meanwhile, new and renewable energy consists of solar panels (PV) and wind turbines. Other components included in the hybrid power generation system are converters, battery storage, AC and DC buses. The following is the architectural design of the Faculty of Engineering UNY hybrid power plant system.
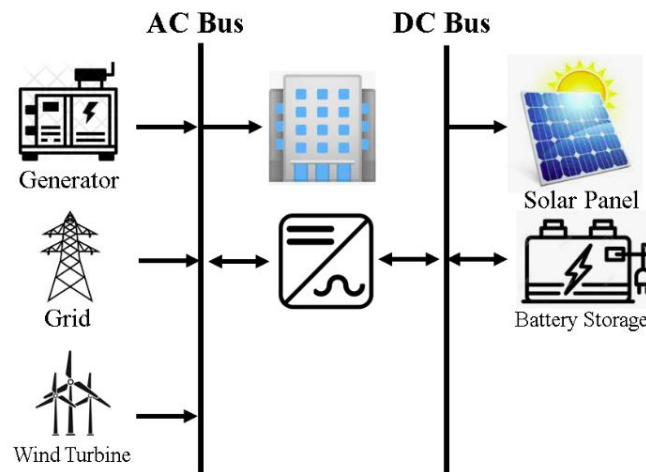

Figure 4. Hybrid Power Generation System Design

The architectural drawing of the Smart Grid system has two buses, namely the AC bus and the DC bus connected to the inverter. The DC bus is connected to the photovoltaic and battery storage system. The inverter functions to convert from DC electricity to AC and vice versa, as well as AC chargers and system performance regulators to regulate network voltage and frequency. For AC buses connected to the load or electrical load supplied, the grid, generator, and wind turbine.

4. Photovoltaic and Wind Turbin Energy Potential

Potential renewable energy sources consist of solar energy and wind energy. This data can be obtained from the NASA website database at https://eosweb.larc.nasa.gov/cgi-bin/sse by entering geographic information on the latitude and longitude of the FT UNY Building. Energy potential data in the form of radiation, sun clearness index, and wind speed for a year in tabular form. The average annual solar radiation obtained from the NASA database is 4.80 kWh/m²/s, and the yearly average wind speed is 4.2 m/s. The distribution of solar energy potential data can be seen in Figure 4, while the wind energy potential is in Figure 5.
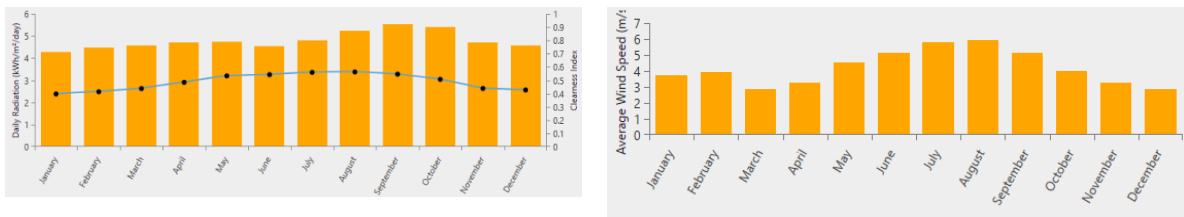
Figure 5. Photovoltaic and wind turbine Energy Potential

The daily load energy consumption per hour of the Faculty of Engineering UNY Building can be seen in Figure 6.
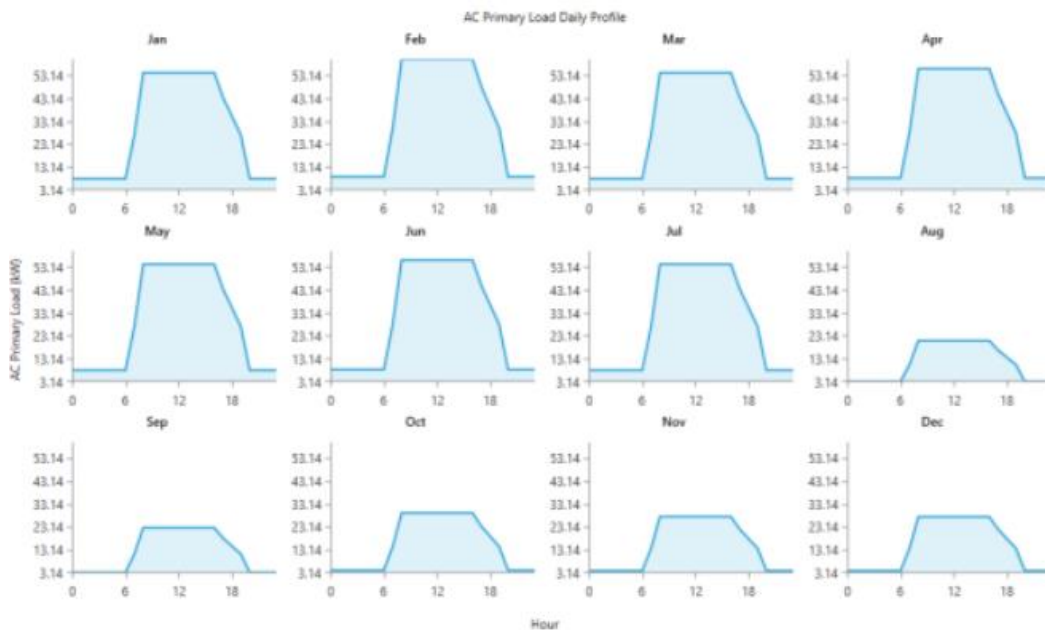

Figure 6. Annual Energy Profile

Figure 7 is the metric load of the UNY Faculty of Engineering Building with an average daily energy load of 562.98 kWh/d and average daily power of 23.46 kW. Peak power is 59.98 with a power factor of 0.79.
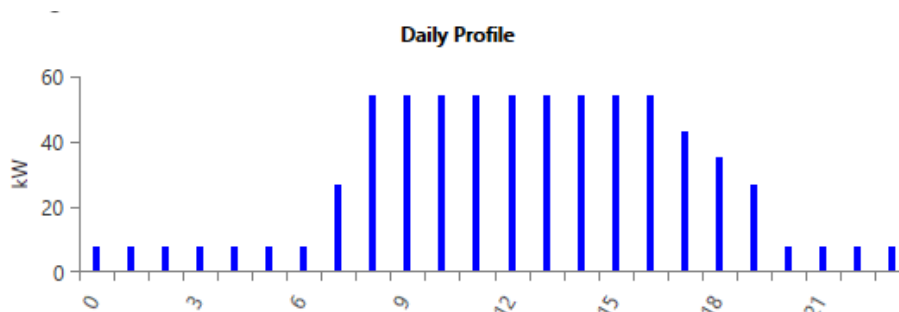

Figure 7. Daily Profile Electrical Load Faculty of Engineering UNY

From the sensitivity results of the Homer Pro simulation above, the results of the sensitivity case with wind speed (average) for wind turbines are 4.20 m/s. For optimization results with system, configurations are solar panels, wind turbines, generator sets, batteries, grids [11]. And inverters. The

results of the system configuration that the Homer Pro software has processed are 278 kWh solar panels, 1 unit of a wind turbine, 440 kW generator set, 500 units of battery, inverter with a capacity of 96.6 kW, and grid or PLN network.

Table 2. Potential of Renewable Energy Production

Component	Production (kWh)	Percentage (%)
Photovoltaic	403.12	96,30
Wind Turbine	2.78	0,66
Grid	12.50	2,99
Total	**418.39**	**100,00**

Table 3. Energy Consumption per year

Energy Consumption	Energy Per Year (kWh/yr)	Percentage (%)
AC Primary Load	205,489	100
DC Primary Load	0	0
Total	**205,489**	**100**

The total production of electrical energy from solar panels is greater than that of wind turbines because sunlight is terrific throughout the year. In contrast, wind speed is not stable due to changes in direction and speed influenced by air pressure, climate, seasons, and other influences. The Smart Grid configuration system can meet the electrical power needs of the Faculty of Engineering and has an excess of 186,379 per year. This condition shows that the Smart Grid system can be developed at the Faculty of Engineering, UNY.

Smart grid implementation at the Faculty of Engineering, UNY, is possible by optimizing solar power plants and wind turbines. The potential solar and wind power sources at the location can meet the Faculty of Engineering, UNY's electricity needs for an entire year. The Smart grid system requires a battery to overcome the problem of intermittent electrical energy so that the electrical power supply can be fulfilled continuously, safely, and reliably.

5. Conclusion

As an engineering higher education institution, the Faculty of Engineering of UNY needs to develop a Smart Grid on campus. The study results show that the Faculty of Engineering, UNY, has excellent potential to create smart grids. The potential for solar energy is 418.393 kWh/year, and wind energy is 2.78 kWh/year. The Smart grid system is sufficient to meet the electricity consumption of only 205.5 kWh/year. Implementing the Smart Grid Hybrid will improve the quality of the electric power system and reduce dependence on fossil fuels.

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