SPEKTRA fast and smart software for renewable energy management

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Abstract. Nowadays, many countries prefer to use renewable energy and increase the capacity of power generations. One method to increase the capacity power uses a hybrid system. The aim of this paper is to introduce a software for simulating a hybrid power generation included renewable energy, which combines solar and wind power generations. This software is named as SPEKTRA. In order to represent the actual system, there are some editable variables to show exchange of solar and wind power outputs. This simulation is used to increase the understanding of the power generation in the hybrid system for users and to estimate the spending cost of the power generation on hybrid system. The SPEKTRA is developed using Visual Basic. Functional and developed simulation is analysed using the black box method. the result show that the output graph is similar to the theoretical review.

1. Introduction
Currently, the usage and diversification of renewable energy to decrease dependency on fossil fuels become a major issue in many countries; the goal is to maintain the sustainability of energy. The renewable energy studies on diversification of energy, integration opportunities, challenges, and implications of using biomass, geothermal, hydropower, solar resources, wind-powered system and ocean technologies for generation technology improvement, electric system operational constraint, and electricity demand [1]. Indonesia has a large new and renewable-energy potential as explained by the Director General of Electricity and Energy Conservation at the Focus Group Discussion on the Supply and Demand of New and Renewable Resources [2]. However, the utilization of renewable and alternative energy is very low compared to the existing potential. The alternative energy is still limited to electrical power generator, where total of electrical energy is about 25.3TWh or 15% of total electrical resources in 2010 [3]. On the other hand, the energy consumption continues to rise along with economic growth.

Electricity is one of important points affecting to the economy of the countries. Electricity is the main energy source for housing, industrial sector, and public facilities. Electrical consumption growths in line with the population growth and regional development, so the needs should be balanced with the ability of electricity production [4]. Furthermore, the usage of power energy should be monitored and controlled [5]. Nowadays, increasing renewable energy as alternate energy production has been increased, using geothermal power plants (1.3 GW), hydropower (5.1 GW), while solar, wind, landfill, mini-hydro, biomass with a total capacity of 96MW [6]. Considering the potential usage of renewable

energy, the developed simulation is proposed to be used for educational purposes such as represent the actual system of hybrid system.

The aim of this paper is to describe a simulation consisted of software called SPEKTRA. The software part of SPEKTRA will calculate the most potential renewable energy to be used according to the environment condition towards the capability of electricity result. There are some editable variables to show the exchange of solar and wind power outputs and it is also accomplished completed with financial review. The purposes of this simulation are to increase the understanding of making a power plant with hybrid system planning. This software was developed using visual basic because there are many features available as a data processor and has a great user interface so that users can easily learn independently. Including in this software, there are learning materials, the way data retrieval based on the parameters provided, see the parameter output, and the concept of management power plants renewable energy wind power and solar to review the calculation of the cost of the investment. The simulation will be able to give user an experience to understand the real condition without use the real power plant generator. It used to keep the users safely and minimalizing the accident while the users analyse the environment potential for sustaining the renewable energy.

2. Software Development of SPEKTRA

The proposed system is developed using Systems Development Life Cycle (SDLC) method consisted of planning, analysing, designing, implementing, and maintaining processes [7]. The simulation is used to show the real effect of the parameters inserted by user. These parameters represent the environmental conditions to apply the hybrid system. Meanwhile, the software section is used to calculate and analyse the electricity result which will be transmitted to the consumer. Based on the result shown in the software section, users could plan the most suitable renewable energy to be used and estimate the power generation on hybrid system. The detail of the proposed system is described on figure 1.
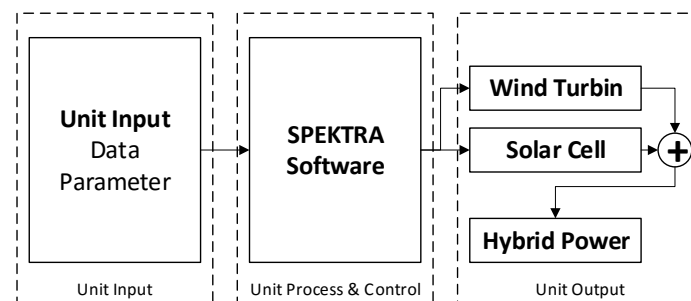
Figure 1. Block Diagram of SPEKTRA.

The software of SPEKTRA is developed using Visual Basic. Here, the software application is a desktop program which can be used easily using the computer. The software SPEKTRA is used to know the calculation of electricity result based on the parameter inserted by user which change the solar and wind power output and it also accomplished with financial review. Each power plant panel such as solar power generation, wind power generation, and hybrid generation have the different input of parameters to be analysed.

The calculation process of the software simulation is divided into three kinds of power plants. Those are solar power generation, wind power generation, and hybrid system included the wind and solar power generation. Input parameters of each power plant are shown in figure 2.
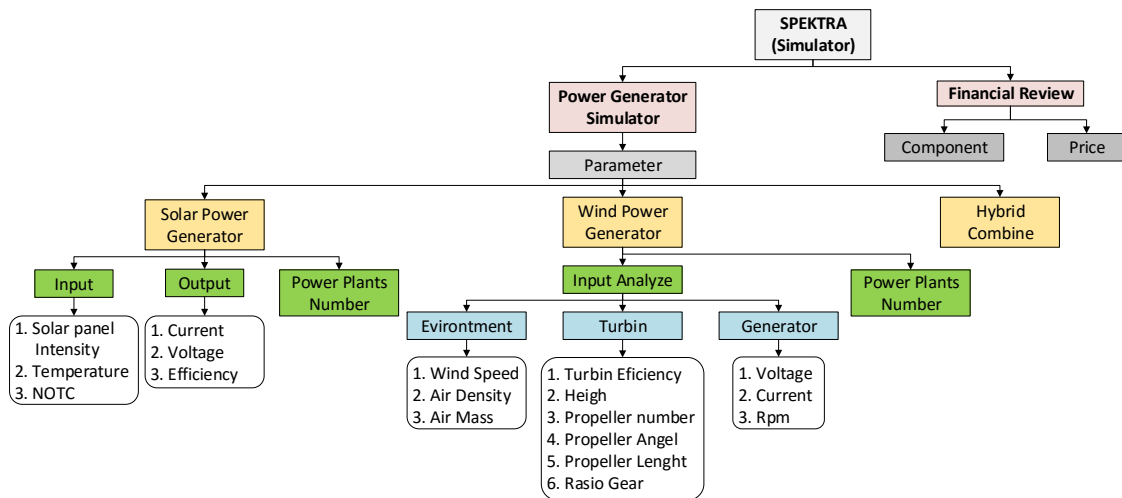
Figure 2. Hierarchy Concept of Software SPEKTRA.

2.1. Solar Power Generation

Solar power generation is a renewable energy generation utilizing the solar power resource. In order to calculate the solar power plant result based on the parameter input by user, the software simulation is developed using the formula (1). While to know the maximum power result, the software simulation is developed using the formula (2). Each solar panel has the threshold of temperature to work properly. If the temperature of the sun or environment condition is higher than the threshold, the power result will be reduced automatically by NOTC (Normal Operation Temperature Coefficient) percent set by user.

$$P = V \cdot I \tag{1}$$

$$P\max = Lux\max \tag{2}$$

2.2. Wind Power Generation

Wind power generation is a renewable energy generation utilizing the wind power resource. In order to calculate the wind result based in the parameter input by user, the software simulation is developed using following formula i.e. (3) is used to calculate the speed of the wind on the height represented by z, (4) is used to calculate power density of the wind parameter, and (5) is used to calculate the final power result created by wind power generator. The percentage of power result is equal with power generator calculated by formula (6) which is also equal to Rpm (rotation per minute) percent calculated by formula (7).

$$v = vref \ln(\frac{z}{z0}) \Big/ \ln(\frac{Zref}{z0}) \tag{3}$$

$$WPD = \frac{P}{A} = \frac{1}{2} p \cdot v^3 \tag{4}$$

$$Pm = Cp(\lambda \cdot \beta)\frac{\rho \cdot A}{2} v^3 \tag{5}$$

$$Pgen = V \cdot I \cdot Rpm\% \tag{6}$$

$$Rpm = P = V \cdot I \tag{7}$$

2.3. Hybrid Power Generation

Hybrid power generation is a combination of solar and wind power generation. The power result of the hybrid power plant is a total value between both of power plant as shown by formula (8). Contrasted

to the previous power generation as a stand-alone power plant, the hybrid system allows the solar and wind power plants. The Advantage of the hybrid power plant is having stability, continuity, reliability more than the stand-alone power plant. A hybrid power plant can decide the type of power plants that produce maximum electricity in accordance with the environmental conditions.

$$Phybrid = Psolar + Pwind \qquad (8)$$

3. Result and Testing of SPEKTRA

In the testing stage, the functionality of simulation are tested using Black Box testing method [8]. The experiment is done to ensure the simulation, which will show the output according to the actual system on the field based on environment parameter inserted by user. The test is carried out to avoid any errors when the system is executed.

3.1. Description of Software SPEKTRA

SPEKTRA, the developed software has a section of the parameter block that enables users to better understand how to perform simulation analysis. In this software, there are blocks of input parameters, blocks of output parameters, graphical display and circuit drawing tutorial for implementation. In the mater block the inputs of solar power plants contain input columns Voltage (V), Flow (A), Number of solar panels (Unit), NOCT (Normal operation Coefficient temperature), Solar panel power, Sun Light Intensity (Lux), temperature (oC). The outputs determine a voltage, current and power generated by the solar power plant. Wind turbine input parameters include columns covering area type, air mass (kg / m), air density, turbine coefficient, turbine height (m), turbine sweep area, (m), vane angle, generator voltage (V), Current Generator (I), Rpm speed minimum-maximum of generator and number of generators. Here the Figure 3 shows the specification of software simulation.
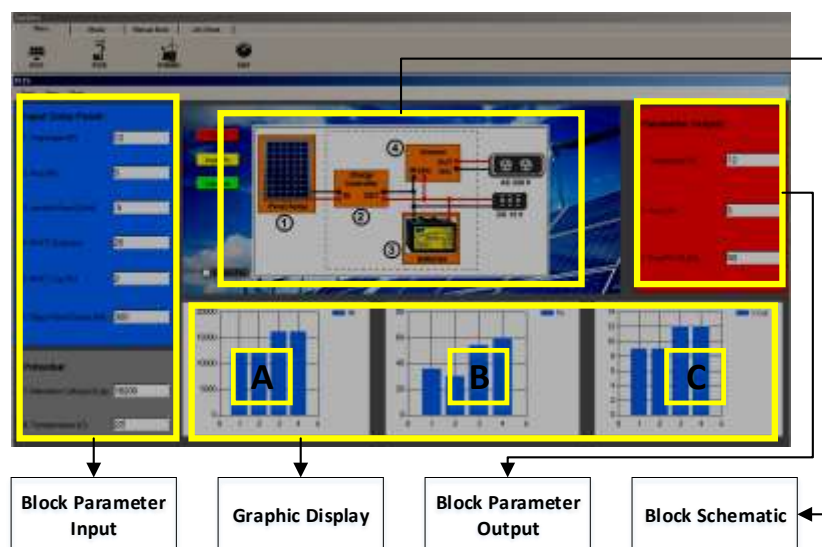
Figure 3. The Display and Specification of SPEKTRA.

3.2. Black Box Testing

The test has been done to software simulation. in the testing stage, the simulation was tested using the same parameter for each type of power plant. The same parameter was inserted in the software simulation to show the result calculation and the effect physically. The testing result confirmed that all parts of software simulation are running well. The testing of calculation function in the software simulation is done for each different power plant generator. The result follows to show that the calculation is equal with the theoretical calculation.

3.2.1. Solar Power Generation Testing. In the testing, the usage of power capacity is 100 Wp with variable data usage shown in table 1 and the Sun temperature usage is 25 degrees Celsius. In this calculation, the power peaks are getting out from the equation the ideal performance of the solar panel toward the sun light intensity in absorbency on solar panels.

Table 1. Solar Power Generation Result.

No	Solar Panel (Wp)	Sun Light (Lux)	Temperature (ºC)	P Out (Watt)	P Theoretical Calculation (Watt)
1	100	51500	25	44.32	44.32
2	100	62300	25	53.61	53.61
3	100	94000	25	80.90	80.90

3.2.2. Wind Power Generation Testing. In the testing, the specification usage of power plant capacity is 3KW with the mechanics of A (cross-sectional area) is 5 meters, the angle of slope of the propeller blades is 30 degrees, and the number of propeller blades is 3 units. On the 15 meter height above ground level at the level of rudeness/roughness Beach area has wind speeds ranging from 2-25 Km/h. Based on the result, cut on minimum rpm generator and is cut off is the maximum rpm generator. The wind power generation result is shown in table 2.

Table 2. Wind Power Generation Result.

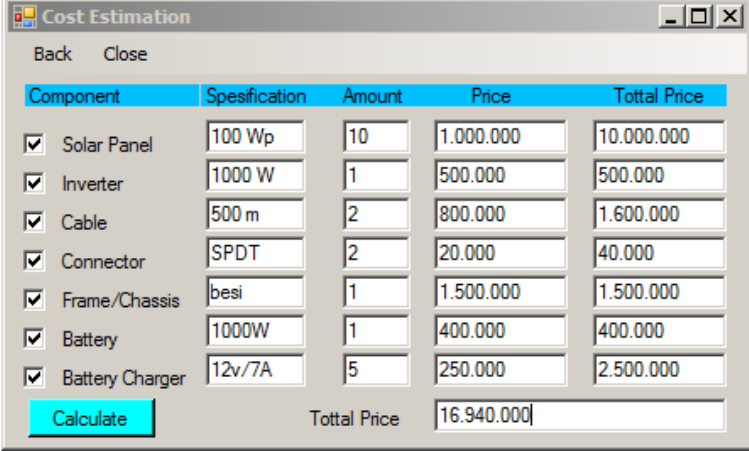| No	Sweep Area Turbine (m)	air velocity (m/s)	height (m)	P Out (Watt)	P Theoretical Calculation (Watt)
1	5	3	15	79.65	79.65
2	5	5	15	368.75	368.75
3	5	7	15	1011.85	1011.85

3.2.3. Hybrid Power Generation Testing. The estimation of hybrid system uses the previous result based on the solar and wind power generation. The combination result is shown in table 3.

Table 3. Hybrid Power Generation Result.

No	Solar Power (Watt)	Wind Power (Watt)	Hybrid (Watt)	P Theoretical Calculation (Watt)
1	44.32	79.65	123.97	123.97
2	53.61	368.75	422.36	422.36
3	80.90	1011.85	1092.75	1092.75

3.3. Financial Review

In order to know the financial review, users have to select the appropriate set of electronic materials displayed on the software based on the type of the selected power plant. Followed by entering the required amount and the price in accordance with catalog purchases. The system will display the calculation estimates the funds needed in the development of renewable electricity generation. Here Figure 4 shows the estimation of building cost of developing power plants.

Figure 4. Display of Financial Review of SPEKTRA

4. Conclusion

In this paper, the simulation system has developed which aim to increase the understanding of power generation in hybrid system for users and to estimate power generation on hybrid system using the software simulation. The presence of this simulation will give the users an experience to know the actual system of renewable power generation utilizing the solar and wind resources. The testing has been done with functionality test using black box method. The testing result shows that the system worked properly, confirming that software of simulation and its financial review can work well and ready to be implemented.

5. Acknowledgments

6. References

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