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FEASIBILITY STUDY ON SOLAR POWER GENERATION IN ISLAMIC UNIVERSITY OF RIAU PEKANBARU CAPACITY 1 MW

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Abstract

Currently electricity power supplies have limited resources because of most power generation from diesel engine and others limited resources. Solar power is one of alternative energy resources that having in tropical region especially in Indonesia. This research conduct on feasibility and capacity that potential be generate in Islamic University of Riau. Method use is based on survey and data collected in area of campus Islamic University of Riau. Results shows within as space on open area that available as 2 Hectare in Islamic University of Riau, potential to generate electricity power by installing solar photovoltaic as much as 1 MW. This capacity have potential to replace electricity usage in campus daily in day time and night time will be less because not much activity compare to daytime. With this solar photovoltaic power generation will be reduce University expenses in monthly electric bill as well in night time power is surplus then can be sell to resident that get extra income for University.

Keywords*: Solar Power, Feasibility Study, UIR*

1. INTRODUCTION

This diesel based energy has several problems that need to be taken into consideration. Firstly, the CO2 emissions due to fuel for generators were 569.000 tons in 2012. Secondly, oil spills and pollution (both chemical and acoustic) are especially important in the arctic region. The pristine characteristics of this environment, like the low temperatures that regulate the climate or the inability of the habitat of cleaning itself, make the problems mentioned above even worst. Thirdly, the transportation of fuel to remote areas can be dangerous and highly cost, especially during winter. An interesting approach to solve this problem could be the introduction of stand-alone

PV systems. This kind of systems has the possibility of reducing fuel consumption and noise level of the area. The election of Photovoltaic (PV) energy as the substitute of the fuel generators comes from an analysis of the characteristics that make the arctic environment a unique place. The relatively high irradiances, long day lights and the low ambient temperature are key factors that increase the efficiency of the solar energy production. In addition, PV systems require almost no maintenance, which make it an important aspect in a

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country where no technicians, tools and equipment are easily available.

When it comes to our energy needs, there are three main problems. We have confused needs and desires, cheap energy and not educated ourselves enough on understanding energy. Need is a word that gets used out of context all the time, it falls into the category of words like have to, should, got to and must. When we hear those words, we feel as if our choice is taken away and we are presented with something we have to do or else. The reason is what is it we need in our homes that require energy, people say all the time to me, but I need a dryer, air-con and else. When in reality they are just desires. Things we would like to have to make our days easier so we can get more done in a day. So that we can go to work to pay for our electricity bills in reality, more people on earth live without electricity than with, so we don't need it at all to survive. Have a think about how much excess electrical load you have in your home just because it saves you time or helps you do something faster.

The next part of the problem is cheap energy, what has made us go out and buy a lot of electrical devices that save us time. That way we can go to work and make more money as it's cheaper to have the electricity work for us at home while we go work. This has helped a lot of desires become needs. Cheap energy has helped bad building designs to get built because we don't need to insulate or think about solar aspect anymore. We just put the air-con on, and that will heat and cool the house at the touch of a button, cheap fossil fuels have had an enormous part in making renewable energy seem expensive. Fossil fuels receive a huge chunk of currency from governments to keep the energy coming so that we don't get upset when there is no energy at the power points. If they charged us the true cost of what it takes to get energy to our power points, I guarantee that would instantly help reduce the need for energy in our homes. The math is simple, multiply your energy bill by 10 times, and that's how much of a discount the government is paying for you every month right now to subsidies fossil fuels and that is worldwide.[1]

2. LITERATURE REVIEW

Solar PV technology converts energy from solar radiation directly into electricity. Solar PV cells are the electricity-generating component of a solar energy system. When sunlight (photons) strikes a PV cell, an electric current is produced by stimulating electrons (negative charges) in a layer in the cell designed to give up electrons easily. The existing electric field in the solar cell pulls these electrons to another layer. By connecting the cell to an external load, this current (movement of charges) can then be used to power the load (e.g., a light bulb) as shows in figure 1.

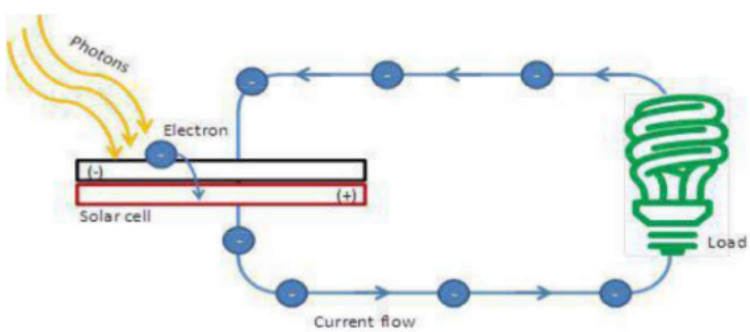

Figure 1. Generation of electricity from a PV cell

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PV cells are assembled into a PV panel or modules, PV modules are then connected to create an array. The modules are connected in series and then in parallel as needed to reach the specific voltage and current requirements for the array. The direct current (DC

electricity generated by the array is then converted by an inverter to useable alternating current (AC) that can be consumed by adjoining buildings and facilities or exported to the electricity grid. PV system size varies from small residential (2–10 kW), to commercial (100–500 kW), to large utility scale (10+ MW). Central distribution plants are also currently being built in the 100+ MW scale. Electricity from utility-scale systems is commonly sold back to the electricity grid.

A typical PV system is made up of several key components, including:

- PV modules
- Inverter
- Balance-of-system (BOS) components.

These, along with other PV system components, are discussed in turn below in figure 2.

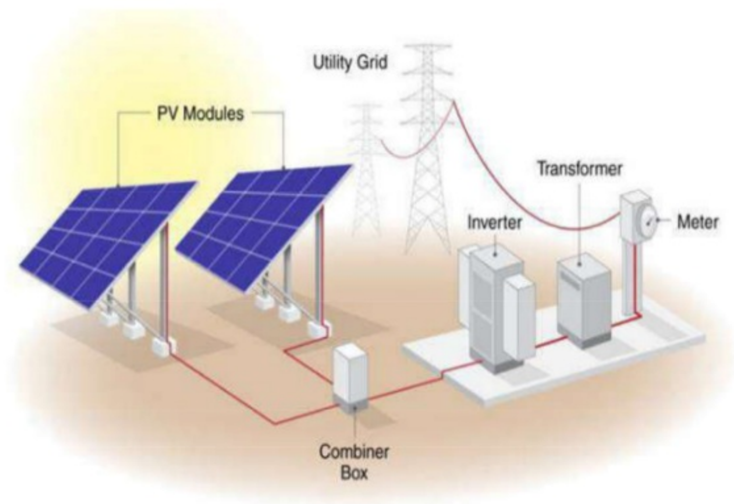

Figure 2. Ground-mounted array diagram

Module technologies are differentiated by the type of PV material used, resulting in a range of conversion efficiencies from light energy to electrical energy. The module efficiency is a measure of the percentage of solar energy converted into electricity.

Two common PV technologies that have been widely used for commercial- and utility-scale projects are crystalline silicon and thin film. Traditional solar cells are made from silicon. Silicon is quite abundant and nontoxic. It builds on a strong industry on both supply (silicon industry) and product side. This technology has been demonstrated to be functional for over 30 years in the field. The performance degradation, a reduction in power generation due to long-term exposure, is under 1% per year. Silicon modules have a lifespan in the range of 25–30 years but can keep producing energy beyond this range.

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Typical overall efficiency of silicon solar panels is between 12% and 18%. However, some manufacturers of mono-crystalline panels claim an overall efficiency nearing 20%. This range of efficiencies represents significant variation among the crystalline silicon technologies available. The technology is generally divided into mono- and multi-crystalline technologies, which indicates the presence of grain-boundaries (i.e., multiple crystals) in the cell materials and is controlled by raw material selection and manufacturing technique. Crystalline silicon panels are widely used based on deployments worldwide. Figure 3 shows two examples of crystalline solar panels: mono and multi silicon installed on tracking mounting systems

.

Figure 3. Mono and multi crystalline solar panels.

3. METHODOLOGY

The research focuses on two cases, an internet café with existing solar panels and an upcoming school facility. In the field study measurements were done on the solar panels of the internet café, to get accurate data, valid for the location. Laboratory work with solar PV has been done at Chalmers to see how angles and reflectors affect the power output. Different sources of climate data for Universitas Islam Riau (UIR) campus has been studied and compared, in order to evaluate which data to use. A literature study was done within the field of stand-alone power systems. Scientific articles were studied to evaluate equations and methods for the dimensioning of solar power systems. Since climate data varies between different sources, the field study includes measurements of the actual generation from solar panels in UIR campus. From these results, which was compared with literature concerning solar radiation, conclusions could be drawn, of which data source that should be used in the research, for the dimensioning of the energy systems. Measurements were also done to evaluate the importance of maintenance of solar panels. The generation by the panels at the internet café was measured before and after cleaning the panels. To evaluate if it is economic to use reflectors the expected increased generation from attached reflectors has been calculated. The reflections from a metal surface were analyzed in a laboratory test. The attachment of the reflectors was designed to suit the panels and the solar path throughout the year, as shows in Figure 4. The required size and cost of the reflectors was evaluated for the cost-comparison.

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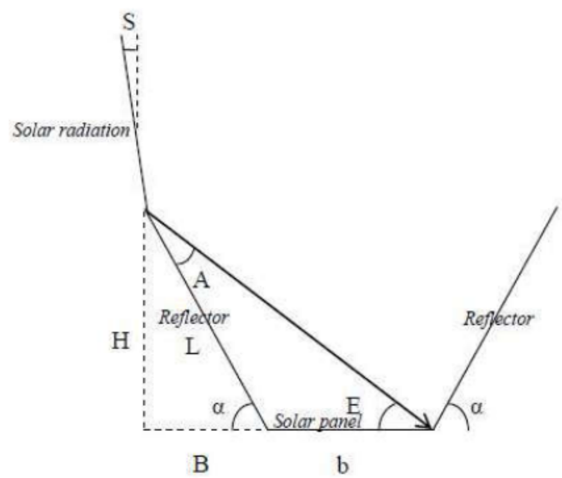

Figure 4. The proposed attachment of reflectors.

Geometrical theory was used to evaluate Equation 1, which was used to calculate the expected increased generation for different solar paths.

$$E = 2 * \alpha - S - 90 \quad (1)$$

The angle E means that the reflections will add as an extra light source with the incoming angle E. The increased radiation (R), during solar noon, was calculated with Equation 2.

$$R = \cos(90 - E) * \eta r * \eta surf \quad (2)$$

The reflection efficiencies (ηr) are evaluated from the results of an experiment by (4). When the increased generation over one full day should be estimated, the solar height and the varying generation over the day are included. Equation 3 was evaluated to estimate the increased generation over one full day (RF).

$$RF = R * \eta 6r + R * \eta 5r + R * \eta 0r \quad (3)$$

$\eta 6r$ is the part of the total daily generation that occurs during the time when all the six panels fully can absorb reflections. $\eta 5r$ is the part of the generation that occurs when five of the panels are affected by the reflectors. $\eta 0r$ is the part of the generation that occurs when none of the panels are affected by the reflections.

Reflectors lead to an increased temperature, which results in decreased efficiency. The estimated increased temperature (ΔT) and the decreased efficiency per ΔT gives the decreased efficiency. In order to recommend and present a cost-effective energy system, based on solar panels, a few alternative systems have been designed and compared. The systems are designed by estimating the power consumption throughout the year and adapting the power generation to the load. The month with lowest values of insolation was used for dimensioning the generation, in order to cover the electricity demand for every month of the year. Attached reflectors were included in some of the alternatives to give conclusions if reflectors should be recommended to solar power systems. Some of the alternatives use a Maximal Power Point Tracker (MPPT) charge controller, while other uses a regular Pulse Width Modulations (PWM) controller. This gives a conclusion of which investment is preferred.

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The dimensioning of the energy storage differs for the two cases. For the case of the internet café, the energy system mainly works as a backup system during power blackouts. The energy storage was dimensioned to cover the energy demand during one day with a generation at a low level. The low level is defined as the tenth lowest daily irradiation that occurs during one year of climate data. The dimensioning for the school case is based on the expected generation during a *single-day scenario* and a *five-day scenario*. The *single-day scenario* is the lowest expected daily irradiation from one year climate data and the *five-day scenario* is the lowest expected insolation during a period of five days. For the school facility the energy storage was dimensioned to cover the demand at all times, but some of the loads are allowed to be reduced during periods of low generation. This is regulated by reducing the lighting when the battery capacity reaches a level of 70 % and by turning off the charge of two third of the computers when the battery capacity reaches a level of 60 %. The consumption during periods of low generation is therefore dependent of the capacity of the energy storage, since the loads will be reduced at a certain capacity level. The required capacity is in its turn dependent of the consumption.

The expected annual generation and the supply of power, to the loads, during periods of low solar radiation, have been analysed and used as a value of performance for the alternative systems. In case of a period of low insolation, the alternative energy systems, designed for the school facility, will supply the loads with power during different periods of time. The Matlab calculations are used to calculate how long time the computers in the school can be fully used during the *five-day scenario*. This gives a value of performance for the alternative systems. Sensitivity analyses were done to evaluate the robustness of the alternative systems. The robustness of the alternative systems is checked by calculating the Depth of Discharge (DOD) of the battery bank, during periods with low generation, when both the generation and the battery capacity are reduced with 20 %.

To see if the alternative systems, designed for the school facility, can withstand the *single-day scenario* and the *five-day scenario*, with a 20 % decreased insolation and a 20 % decreased battery capacity, the Matlab calculations was used. For the *single-day scenario* the required capacity was calculated, with the decreased insolation and reduced capacity. The result was compared with the capacity of the dimensioned energy storage. The expected DOD for the *five-day scenario,* with the decreased insolation and reduced capacity, was received directly from the Matlab calculations. For the economic point of view an investment analysis was done for both cases. The payoff time and the Net Present Value (NPV) were used. The economic and expected lifetime of the system affects the result. A lifetime of 25 years was used for the NPV calculation. The expected interest rate and future electricity price affect the results a lot. The investment analysis was done with interest rates of 10 and 20 % and with an increased electricity price of 5 or 10 % per year.

4. RESULTS

Pekanbaru city located in Riau Province continues to grow along with the economic progress, so it is estimated the growth of Pekanbaru City energy consumption will increase. In the assessment of a solar power source, the elevation angle is measured from the angular height of the sun from the horizontal position. Figure 5 shows a map of Pekanbaru city in Riau Province.

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Figure 5. Map of Pekanbaru in Riau.

Both height and latitude is measured from sea level. 0 degree elevation occurs at sunrise and 90 degree elevation occurs at midday. The elevation angle varies daily and depends on the latitude of the location which happens every year. The most important of the photovoltaic system parameters is the maximum elevation angle, which is the maximum angle on the horizon at every year. Table 1 shows total of energy generate from sun irradiance in Universitas Islam Riau.

Table 1. Total irradiance of energy

Month	POA irradiance beam after shading and soiling | (kWh/mo)	POA irradiance beam nominal | (kWh/mo)	POA irradiance total after shading and soiling | (kWh/mo)	POA irradiance total nominal | (kWh/mo)	PV array DC energy | (kWh/mo)	System AC energy | (kWh/mo)
Jan	291,891.0	310,201.0	1,106,210.0	1,165,210.0	141 623.0	134 856.0
Feb	287,792.0	302,909.0	1,024,700.0	1,079,370.0	131 471.0	124 026.0
Mar	470,827.0	496,397.0	1,355,180.0	1,427,400.0	171 901.0	161 980.0
Apr	522,494.0	549,994.0	1,399,630.0	1,474,190.0	177 423.0	166 438.0
May	830,770.0	874,495.0	1,751,120.0	1,844,280.0	217 771.0	201 057.0
Jun	729,168.0	767,567.0	1,632,260.0	1,719,130.0	207 482.0	191 094.0
Jul	809,969.0	852,600.0	1,756,750.0	1,850,200.0	221 139.0	204 299.0
Aug	881,714.0	928,120.0	1,800,750.0	1,896,540.0	228 161.0	209 264.0
Sep	820,977.0	864,185.0	1,682,650.0	1,772,170.0	213 616.0	196 184.0
Oct	746,300.0	785,673.0	1,625,290.0	1,711,800.0	206 724.0	190 811.0
Nov	519,566.0	546,933.0	1,356,530.0	1,428,800.0	173 579.0	164 030.0
Dec	262,588.0	276,400.0	1,075,930.0	1,134,410.0	141 288.0	134 228.0

Average annual irradiation long-term, there are two main sources data of solar resources, i.e. data derived from satellites and land-based measurement. Therefore both sources have advantages respectively, and then the selection of data sources will depend on the location PLTS. Land-based location measurement can be used for calibrate data resources from other sources, such as satellites or stations meteorological, to improve accuracy and certainty. Figure 6

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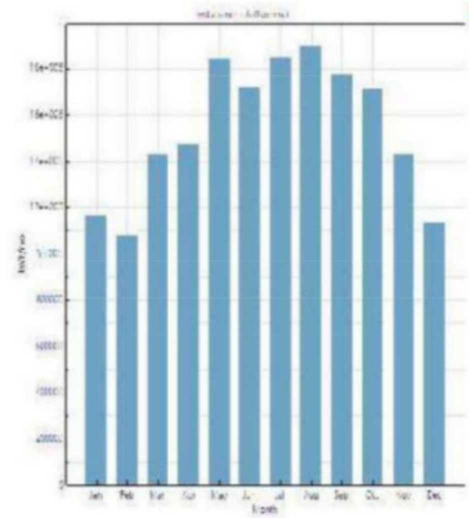
shows an estimate monthly potential energy generate by solar photovoltaic.



Bulan	Total nominal Irradiant (kWh/mo)
Jan	1,165,240.00
Feb	1,079,370.00
Mar	1,427,400.00
Apr	1,474,190.00
May	1,844,280.00
Jun	1,719,130.00
Jul	1,850,230.00
Aug	1,896,540.00
Sep	1,772,170.00
Oct	1,711,800.00
Nov	1,428,800.00
Dec	1,134,410.00

Figure 6. Estimated monthly graph of energy produced

In general, data for 10 years is needed to provide variations at the level reasonable belief. Data used in energy calculations sun for Photovoltaic Power Generation (PLTS) Universitas Islam Riau is the data coming from NASA NREL (National Renewable Energy Laboratory) United States. These data sources have varying quality and resolution. It takes the right skills to interpret the data. Figure 7 shows estimated monthly energy loss due to inconsistence sun light

POA shading loss	0.059070
POA soiling loss	4.999990
DC module modeled loss	13.530000
DC inverter MPPT clipping loss	0.040101
DC mismatch loss	1.973420
DC diodes and connections loss	0.493356
DC wiring loss	1.973420
DC tracking loss	0.000000
DC nameplate loss	0.000000
DC power optimizer loss	0.000000
DC performance adjustment loss	0.000000
AC inverter power clipping loss	2.124610
AC inverter power consumption loss	0.214144
AC inverter night tare loss	0.004279
AC inverter efficiency loss	3.544150
AC wiring loss	1.000000
Transformer loss percent	0.000000
AC performance adjustment loss	0.000000
Total Losses	29.956539

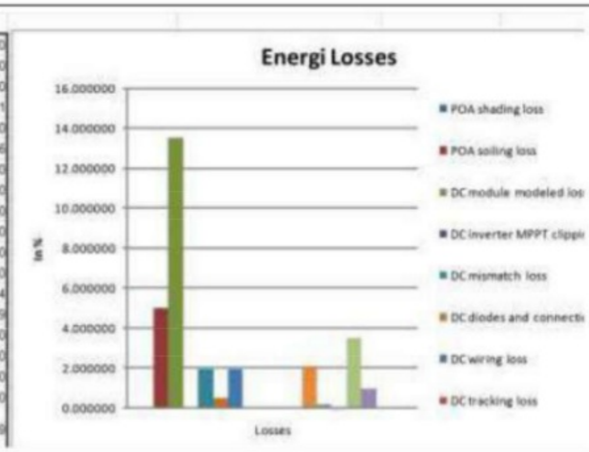


Figure 7. Estimated monthly energy losses

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5. CONCLUSION

This feasibility study to find on how much power is able to generate using solar panel photovoltaic in Universitas Islam Riau as shown in results. In order to achieve power generation as much 1 Mega Watt (MW) then 2 hectare of land or empty area is required. Potential to generate as much 1 MW of electricity is benefit for University to reduce expenses or cost of monthly electricity billing, possibility of expand power generate by solar photovoltaic to share to other consumer such as resident, street lighting and other. The feasibility have been done based on environmental of Riau province especially in Pekanbaru City, some of number sun irradiance and duration of sub rise is calculated to achieve accurate data of potential power to generate.

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