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# Renewable Energy Cost Estimation on Smart on Grid Actuator Innovation for the Development of Alternative Rural Electricity

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**Abstract**

Indonesia's target for using the energy mix through Renewable Energy (RE) is 22.5 percent in 2025. The steps taken are to optimize local energy use for electricity generation and select more efficient technologies that can reduce the cost of electricity supply. One of the pioneers carried out in the city of Magelang is the Smart on Grid Actuator (SOGA) system that converts sunlight into electrical energy. This study aims to calculate and analyze estimated costs by using the sun using SOGA System innovations. The research location in the Research and Development Agency of the City of Magelang focused on cost efficiency testing based on solar energy harvesting with SOGA. The survey on the use of SOGA innovation was conducted during October 2018 to obtain primary data. The approach to the results of previous research and theoretical approaches is intended as a reference, and secondary data complete the analysis of this study. Study analysis uses the Financial and Economic Benefits Photovoltaic Grid-Tied System projection (Utility-Based Rebate Formula). As a result, the SOGA system can reduce installed electricity costs by ± 330 USD per year and can be used for alternative rural energy development.

Keywords: cost; innovation; rural; smart on-grid actuator

## 1. Introduction

Carbon emissions have a big influence in creating climate change. Therefore, mitigation of climate change, especially those caused by increased carbon emissions, needs to be done as anticipation. In response to climate change, innovation in the use of low carbon energy needs to be carried out, one of which is through budgeting. However, in developing countries, this poses a significant challenge. However, investment in renewable energy (RE) continues to be dwarfed by investment in fossil fuels. From 2013 to 2014, investment in fossil fuels in the electricity sector directly competitive with NRE electricity increased by 7%, while RE received less than USD 260 billion in investment and only represented 16% of the total energy sector investment of USD 1.6 trillion. The transition to low-carbon energy requires significant attention, primarily to obtain sufficient funding to direct investment towards NRE because fossil fuels still dominate energy investment (Mazzucato & Semieniuk, 2018).

Provision of RE has positive externalities and negative externalities. However, what needs to be anticipated is the emergence of negative externalities, significantly negative externalities that arise during the manufacturing stage of equipment from materials used in renewable facilities. However, the cost of damage caused by renewable energy is much lower than burning fossil fuels (greenhouse gas emissions, climate change, and global warming).(Cedrick & Long, 2017).

In another research, Cedrick & Long (2017), RE consumption highly influences economic growth. These have significant potential in providing socio-economic benefits in certain areas as one of the efforts in sustainable development. Renewable energy expansion positively impacts direct (Blanco & Rodrigues,

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2009) and indirect employment (Del Rio & Burguillo, 2009). In Indonesia, it starts with the regulation on RE explained that Presidential Regulation No. 22 of 2017 concerning the General Plan of National Energy (RUEN) was enacted on March 13, 2017. The government prepared the RUEN as the basis for technical plans such as the General Plan for the Provision of Electric Power by State Electricity Company (PLN), drafting plan of State and Regional Revenue and Expenditure Budget plan (APBN/APBD), as well as guidelines for the drafting of strategic plans by the Ministry and Regional General Plan of Energy by local governments (Anindhita, 2018). The utilization of electricity continues to grow due to the rapid growth of innovation in electricity-based technology. It is used in almost all sectors, especially in the household and commercial sectors. Electricity demand increases by an average of 6.0% per year until 2050 or to 7.4 times the consumption in 2016 (Anindhita, 2018).

The high increase in electricity consumption then needs to be prepared for efforts to achieve it. Therefore, this scientific paper tries to actively fulfill the need for electricity by absorbing sunlight as an energy source. This study aims to calculate and analyze cost estimates with solar sources using SOGA System innovations. The research location in the Research and Development (R&D) Agency of the City of Magelang focused on cost efficiency testing based on solar energy harvesting with SOGA. The survey on the use of SOGA innovation was conducted in October 2018 to collect primary data. The approach to the results of previous research and theoretical approaches is intended as a reference, and secondary data complete the analysis of this study. Study analysis uses cost projections in confidence limits.

The smart grid by Milchram, Hillerbrand, van de Kaa, Doorn, & Künneke (2018) is often used as a general term to describe the digitization of power systems focusing on distribution networks to facilitate the transition to more sustainable energy systems. Sub-systems include smart metering, generally considered the cornerstone of smart grids, smart home energy management systems (HEMS), demand-side response (DSR), household storage, and vehicle-to-grid (EV) (Tuballa & Abundo, 2016), electric vehicle integration, and network-to-vehicle solutions (Colak, Fulli, Sagiroglu, Yesilbudak, & Covrig, 2015).

Smart grid is an emerging and widely implemented system. In addition, smart grid technology is constantly evolving and thus constantly changing. However, to create a sustainable energy system, the use of ICT is a combined factor. The interaction between technology, institutions, and social actors is a significant variable in determining the performance of a smart grid system. The distribution network has changed from a physical copper network to a network supported by ICT infrastructure with advanced communication technology. However, this advance in communication technology also raises new questions, especially regarding data ownership and market access rights. Institutions in this case are laws and regulations regarding smart networks that form the rules governing development and recognition. (North, 1991). Changing roles and increasing the diversity of actors is one of the differences between smart grid and other networks. In this case, the most prominent is the changing role of consumers, which can develop from mostly passive energy consumers to active energy citizens and are actors involved in the energy transition (Goulden, Bedwell, Rennick-Egglestone, Rodden, & Spence, 2014).

## 2. Methods

The research location in the Research and Development Agency of the City of Magelang focused on cost efficiency testing based on solar energy harvesting with SOGA. The survey on the use of SOGA innovation was conducted during October 2018 to obtain primary data. The approach to the results of previous research and theoretical approaches is intended as a reference, and secondary data completes the analysis of this study. Study analysis uses the Financial and Economic Benefits Photovoltaic Grid-Tied System projection (Utility-Based Rebate Formula).

## 3. Result and Discussion

### 3.1 Model Financing Estimates for Renewable Energy

Vassileva, Dahlquist, Wallin, & Campillo (2013) and Goulden et al. (2014) suggest that realizing their true economic potential can be done by promoting renewable energy and increasing access to energy and promoting energy security for countries. Decentralized renewable energy generation helps address energy access challenges in rural areas while conserving the environment. Also, according to the ARE by Balta-Ozkan, Amerighi, & Boteler (2014), populations in urban areas benefit from increased economic activities that impact development. Michaels and Parag (2016) and Raimi and Carrico (2016) show that sustainable economic development can be promoted through renewable energy by providing employment, while Bager & Mundaca (2017) and Taebi & Kadak (2010) show that access to energy in remote areas can also be done by promoting renewable energy. According to Miller, Iles, & Jones (2013), this can alleviate energy poverty and increase the quality of life for people.

According to Sovacool, Heffron, McCauley, & Goldthau (2016), to spur economic development, various models and mechanisms have been developed to reduce the challenges of financing RETs. Sovacool & Dworkin (2015) stated that the prevailing economic conditions in the implementing countries are the success factors of the models and mechanisms to be implemented. Scholars stated that more accessible access to finance REPs is determined by the stability of capital markets in developed countries.

### 3.2 Alternative Rural Electricity

Developing alternative rural electricity can be done to help create a sustainable environment. However, it is also necessary to consider regulations and financial markets that support project financing with low transaction costs. Feed-in tariffs or electricity purchase agreements that have been made in many countries are an important prerequisite in project financing and are one of the certainties in revenue streams. As scholars and policymakers consider increasing the re-risk of mature renewables by enticing them to risk investors again. Caution is needed in designing policies, the goal is that the projects carried out can meet the project financing requirements

SOGA results from community creativity and innovation screening called KRENOVA, held regularly by the Research and Development (R & R & R & R&D) Agency of Magelang City in 2018. This work belongs to Patra Agung Wirayuda, a resident in Magelang City who focuses on RE. SOGA was very simple at first. After developing the R & D Agency in collaboration with universities, it could be created in a prototype and already installed in the R & D Agency. The innovation shown at SOGA is the ability to keep up with the availability of sunlight every day. The panel will follow the source of sunlight from morning to evening. The panel is not static but dynamic, to follow the sun using a programmed actuator.

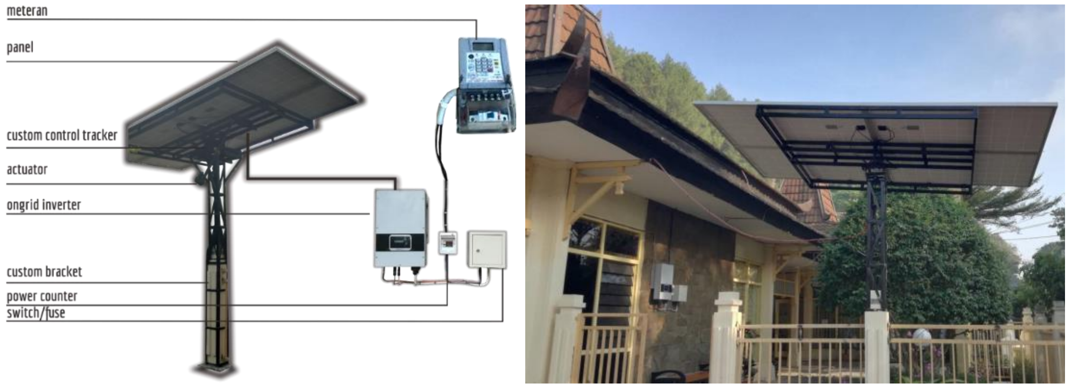


Figure 1. Smart on Grid Actuator Installation.

SOGA products that have been registered as Patents with number S00201709095 (see figure 1) have the main specifications: (1) Panel 1000 WP Max. Power (Pmax) 250W, Max. Power Voltage (Vmp) 31.4V, Max. Power Current (Imp) 7.96A, Open Circuit Voltage (Voc) 37.6V, Short Circuit Current (Isc) 8.53A, Max. System Voltage 1000Vdc, Max. Series Fuse 15A, Dimension (mm) 1645x995x50, as much four-panel; (2) On-grid Inverter Model 1K-SM, Maximum PV array open-circuit voltage 500 Vdc, Maximum total PV array short circuit current 11 A, Nominal input voltage 360 Vdc, PV input operating voltage range 80 Vdc-450 Vdc, Nominal output voltage 230 Vac, Nominal output frequency 50 Hz, Maximum continuous output current 5 A, Nominal active power Pn 1000 W, Power factor (Cosphi) >0,99, Ingress protection IP65, Protect class I; (3) Cable 4 mm; (4) Custom Bracket Panel; (5) Custom Control Tracker; (6) Actuator/Gearbox; (7) Switch / Fuse; and (8) Box Panel/Power Counter.

The parameters surveyed are the values listed on the power counter (Table 1), containing information on the value of Cosphi, Hour, and Kwh. The survey results were conducted during October 2018, with the sampling time divided randomly, as in the following table. The table of the Result of the power counter can explain that the average kWh obtained every day is 4-5 Kwh with the intensity of harvest time for 7 hours starting at 8 am to 3 pm. For the value of Cosphi, it is only informative about the power factors that exist in the electrical installation of the R & D Agency in the City of Magelang. For the clock showing the length of the SOGA function since it was installed, the number at that hour functions to divide how many Kwh is obtained per hour since it was installed. The calculation of electrical energy is obtained by dividing the number of Kwh by the number of hours. The average per hour of electricity obtained is 155.801717 watts or 0.155801717 Kwh. The value of electrical energy is then used to calculate the effectiveness of the estimated costs needed. This value can be increased or the same if installed in rural areas because the installation of SOGA currently resembles rural characters.

### 3.3 Cost Estimation

This tool was adopted from sites from: http://extension.colostate.edu/ on November 12, 2018. such as a calculator can be used to determine the financial and economic benefits (or costs) of installing a gridvoltaic photosystem to a residence. This is only related to solar photovoltaic systems that are tied to a grid without a battery system. This calculator is used to decide whether or not to buy and install a photovoltaic grid-bound system. Estimated costs can be known by variables and sub-variables, such as variable Installation Costs with sub-variables Size of System, Installation Price, Tax Incentive, Incentive Rate, Expected Life of System, Cost of Installation and Net Installed cost. Variable Annual Benefits, with sub-variables such as Amount of Electricity Produced, Amount of Electricity Used, Cost Savings by Generating Electricity, Electricity Savings, Rate, Revenues from Sales of Excess Electricity, Amount Sold, Rate and Net Annual Benefits. The following variable is Cost/Benefit Analysis (life of the system) with sub-variables such as Net Installation Costs, Maintenance Costs, Percent of Initial System Cost, Additional (Home) Insurance Premiums, Rate of Inflation, Total Interest Paid on "Loan," Total Costs, Total Benefits, Rate of Inflation and Net Financial Benefits. Finally variable is Annual Cash Outflows, and sub-variables such as Change In (Home) Insurance Premiums, Rate, Debt Payments (or Opportunity Costs), Amount Borrowed, Interest Rate, Term (Years), Monthly Payment, Total Annual Cash Outflows. The estimation results of cost calculation can be seen in the following Figure 2 and Figure 3.

Table 1: Result of Power Counter

| Date | Time | Cosphi | Hour | Kwh |
|---|---|---|---|---|
| 09-Oct | 15.16 | 0,814 | 57,45 | 9,295 |
| 10-Oct | 07.52 | 0,581 | 74,23 | 9,779 |
| 10-Oct | 15.25 | 0,823 | 81,58 | 14,115 |
| 11-Oct | 07.12 | 0,731 | 97,41 | 14,497 |
| 11-Oct | 10.48 | 0,984 | 101,23 | 16,634 |
| 11-Oct | 15.42 | 0,862 | 103,53 | 17,834 |
| 12-Oct | 07.01 | 0,711 | 119,08 | 18,214 |
| 12-Oct | 11.20 | 0,972 | 123,35 | 20,877 |
| 13-Oct | 16.15 | 0,4 | 146,35 | 26,19 |
| 14-Oct | 16.54 | 0,175 | 169,42 | 30,498 |
| 16-Oct | 18.09 | 0,174 | 215,54 | 32,93 |
| 17-Oct | 19.28 | 0,177 | 241,15 | 36,751 |
| 18-Oct | 12.45 | 0,985 | 258,35 | 39,987 |
| 18-Oct | 17.22 | 0,172 | 262,22 | 40,674 |
| 20-Oct | 13.37 | 0,958 | 326,43 | 48,573 |
| 21-Oct | 19.36 | 0,166 | 330,51 | 51,123 |
| 22-Oct | 18.38 | 0,166 | 352,56 | 55,421 |
| 23-Oct | 18.54 | 0,164 | 372,48 | 57,965 |
| 24-Oct | 19.23 | 0,161 | 397,21 | 61,886 |

**INSTALLATION COSTS**

| | |
|---|---|
| Size of System (Watts) | 1.000 |
| Installation Price ($/Watt) | $ 4,00 |
| Rebate ($/Watt) | $ - |
| Federal Incentive Rate | 1% |
| Expected Life of System (years) | 20 |
| Cost of Installation | $ 4.000 |
| Rebate | $ - |
| Federal Tax Incentive | $ 40 |
| Net Installed cost | $ 3.960 |

**ANNUAL BENEFITS**

| | | |
|---|---|---|
| Amount of Electricity Produced (kWH) | 431 | |
| Amount of Electricity Used (kWH) | 425 | |
| Cost Savings by Generating Electricity | | $ 208 |
| Electricity Savings (kWH) | 425 | |
| Rate ($/kWH) | $ 0,4900 | |
| Revenues from Sales of Excess Electricity | | $ 2 |
| Amount Sold (kWH) | 6 | |
| Rate ($/kWH) | $ 0,0900 | |
| Net Annual Benefits | | $ 211 |

Figure 2. Installation Costs and Annual Benefits

The estimated system size is 1000 watts, Installation Price ($ / Watt) is $ USD, Rebate ($ / Watt) does not exist, Federal Incentive Rate is 1%, Life System Expected for 20 years. Installation fee of 4,000 USD, Net Installed Cost of 3,960 USD (assumed to get no tax incentives). Furthermore, it can be calculated that the amount of electricity produced for one year is 431 (kWH), while the calculation for one year is the amount of electricity used at 425 (kWH). (kWH). Net Annual Benefits obtained amounted to 211 USD.

**ANNUAL CASH OUTFLOWS**

| | | |
|---|---|---|
| Change In (Home) Insurance Premiums | | $ - |
| Rate | 0,0000% | |
| Debt Payments (or Opportunity Costs) | | $ 890 |
| Amount Borrowed | $ 3.333 | |
| Interest Rate | 12,00% | |
| Term (Years) | 5 | |
| Monthly Payment | $ 74,14 | |
| Total Annual Cash Outflows | | $ 890 |

**COST/BENEFIT ANALYSIS (life of system)**

| | | |
|---|---|---|
| Net Installation Costs | | $ 3.960 |
| Maintenance Costs | | $ 80 |
| Percent of Initial System Cost | 2,00% | |
| Additional (Home) Insurance Premiums | | $ - |
| Rate of Inflation | 3,00% | |
| Total Interest Paid on "Loan" | | $ 1.290 |
| Total Costs | | $ 5.330 |
| Total Benefits | | $5.660 |
| Rate of Inflation | 3,00% | |
| **Net Financial Benefits** | | **$330** |

*This amount shows the return on investment over the system's useful life.*

Figure 3. Annual Cash Outflows and Cost/Benefit Analysis

Based on the above calculation, then with the Annual Cash Flow in the table, the Cost / Benefit Analysis obtained is 330 USD. This value is still low because SOGA is still in the process of development. If it has become an expected result, it is believed that the value of benefits will increase.

## 4. Conclusion

The models and mechanisms developed by the R & D Agency add references to the region in reducing the challenges of RET financing to increase adoption of RE and spur economic development. The government can apply these models and mechanisms as an alternative to promote economic development. In this context, innovative financing models and mechanisms need to be developed, especially for the convenience of RET end users. The results of this study after an analysis of the Grid-Tied System Financial and Photovoltaic Advantages were concluded that the SOGA system was able to reduce installed electricity costs by ± 330 USD per year and could be used for the development of RE in rural areas, this based on the installation of SOGA conducted in the R & D Agency of the City of Magelang in its environment such as the rural environment.

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