

Policy and Economy Analysis on the Application of the Smart on Grid Actuator to Public Road Lighting in Magelang City

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ABSTRACT

Magelang City with limited natural resources encourages its regional government to be able to develop its existing potential from renewable energy. One of the works that has been produced, namely Smart on Grid Actuator (SOGA) is the result of the development of the Research and Development Agency for renewable energy. Meanwhile Public Street Lighting in the City of Magelang still uses electricity from the National Electricity Company. This study aims to analyze the policy and economy due to the application of SOGA on public street lighting in the city of Magelang. The primary data source was obtained from SOGA, while the secondary source was the amount of Public Street Lighting in Magelang City. The analysis was carried out with qualitative and quantitative descriptive. The results obtained from SOGA data are predicted to be 10-20% for the efficiency of electricity use. If it is applied to public street lighting in the city of Magelang, the efficiency of the economy is significant, but the implementation of SOGA is very conducive to regional policies.

Keywords: policy, economy, SOGA model, public road lighting renewable energy

1. INTRODUCTION

Energy has an important and strategic role for the achievement of social, economic and environmental goals in sustainable national development. Energy demand is estimated to continue to increase as a consequence of economic growth and population growth. Therefore, Energy Management is carried out as well as possible in order to meet the guarantee of Energy supply both for current and future needs. Magelang City since 2018 has initiated a model called SOGA as a way to create energy management through harvesting sunlight, although it is still in the form of a prototype in the Research and Development Agency of the City of Magelang. But in the process of harvesting sunlight is able to produce electricity that can be used for energy activities in that place. Energy activity in the area is able to produce an average estimate of 3.3 Kwh per day, while in the City of Magelang night activities require public road lighting. In 2016 data, there were at least 16,000 public street lighting points spread across the city of Magelang. This study seeks to discuss the potential use of SOGA in improving the efficiency of public street lighting that can be intervened in policy and economic terms. As explained that SOGA is a Smart On Grid Actuator, this technology is as stated in The "smart grid" in [1] a modernized electrical grid allowing for two way digital communication about energy demand and availability is

critical infrastructure for reducing cost and environmental impacts of electricity systems worldwide. This technology has the potential to deliver improvements in transmission efficiency, integration of renewable energy, and demand reduction; and is a gatekeeper for expanding technologies such as electric vehicles and distributed solar power. Estimates suggest that the smart grid could reduce greenhouse gas (GHG) emissions by 0.9–2.2 gigatons per year, roughly 2–5% of global emissions. The smart grid encompasses a wide range of technologies including advanced sensors and energy storage. One critical component of the smart grid is smart meters (SMs) digital electricity meters attached to homes and businesses that enable remote meter reading and two-way communication. This functionality can provide consumers detailed information about their energy use and the ability to program appliances to reduce energy consumption and cost per kWh. Utilities may also utilize SMs to moderate peak loads by interfacing with smart appliances or through variable pricing. Although aspects of the smart grid can be implemented without SMs, they are integral to realizing its full potential. Consumer willingness to adopt and utilize SMs could greatly affect the scale and pace of smart grid deployment. This study aims to analyze the policy and economy due to the application of SOGA on public street lighting in the city of Magelang. The primary data source was obtained from SOGA, while the secondary source was the amount of Public Street Lighting in Magelang City. The analysis was carried out with qualitative and quantitative descriptive.

2. LITERATURE REVIEW

2.1. Policy Energy

Energy is the ability to do work which can be in the form of heat, light, mechanics, chemistry, and electromagnetics, an energy source is something that can produce energy, both directly and through a process of conversion or transformation [2]. Energy Resources are natural resources that can be utilized, both as Energy Sources and as Energy. Renewable Energy Sources are Energy Sources that are produced from Sustainable Energy Resources if managed properly, including geothermal, wind, bioenergy, sunlight, flow and waterfall, as well as the movement and temperature differences of the sea layer. Independence of Energy Management is the quality of Energy Management that is fully oriented to the national interest to ensure that Energy, Energy Sources, and Energy Resources are managed as well as possible for the greatest prosperity of the people, by prioritizing as much as possible the ability of human resources and domestic industries. National energy policy is an Energy Management policy that is based on the principles of fairness, sustainability and environmental insight in order to create national energy independence and energy security. Energy availability for national needs is fulfilled by: a) increase the exploration of resources, potential and / or proven reserves of Energy, both from fossil types and New Energy and Renewable Energy; b) increasing domestic Energy and Energy Production and / or from foreign sources; c) improve the reliability of the production system, transportation and distribution of energy supply; d) reduce exports of fossil energy gradually, especially gas and coal and set a time limit to start stopping exports; e) realize the balance between the rate of addition of fossil energy reserves with the maximum production rate; and f) ensure the guaranteed carrying capacity of the environment to ensure the availability of water and geothermal energy sources. In line with the regulation, energy policy studies have been carried out in several existing studies for example Study [3], which highlights energy intensification means that energy-intensive services can be consumed to a greater extent, over a longer period of time, or during peak periods when the grid faces supply constraints. Each of these conflicts with the goal of social management or a system to reduce energy demand or change peak demand. The impact of Smart Home Technologies (SHT) on energy demand ultimately depends on how developers, manufacturers, and retailers design and market SHT, and on how users configure and use it. For example, an SHT that includes an energy optimization algorithm to reduce or shift demand, or to notify users if the request exceeds a predetermined threshold, can result in a reduction in net demand. SHT which allows energy-intensive user preferences without algorithmic constraints may have the opposite effect. Then by [4] It has become clear that the Building integrated photovoltaics (BIPV) sector crosses national boundaries, and should therefore be reviewed and developed from an international perspective. In policy implementation, management aspects are an important part in encouraging policy operations, the complexity of energy policies requires a wise and

sustainable management architecture as stated [5] the analysis of architects approaches and views, perceived as bound by established structures of management and deeply embedded project workflows. Initial insights suggest challenges lie within particular perceived established organizational hierarchies and structures. Much remains to be explored about the way in which organizations within the built environment within the UK and internationally navigate complex technological design environments. Management architecture also needs to be supported by the use of facilities and infrastructure in order to obtain efficiency as concluded by [6] which states that simplified computer simulations emerge as tools that produce results that are more accurate than those obtained with prescriptive methods, and whose use is more accessible and faster than complex software used conventionally. These tools can be used to help the early stages of an architectural project or as a means to evaluate the level of energy efficiency.

2.2. Economic Energy

In [7], the current energy and economic community remains strong polarized review of whether phosphorus resources are used ultimately available to society declining and, if so, potential the impact of community satisfaction and economic growth. Many of these documents are used by the energy community around the concepts of "clean energy" and "energy investment returns" (EROI). For example, when most scientific experts accept, the fog argument also does not exist in the background and around it higher prices will encourage extraction and production, they also show that when money is required more or more is needed too, and here admit to how maybe I can pay for that to happen when someone converts using related items to expose other items. Energy return on investment (EROI) is a name for measurement the quality of various fuels by calculating information to get energy delivered by the community's special fuel and the energy invested in capturing and sending this energy. The economic function in energy is also assessed by [8] which focuses on buildings occupied by many families giving the result that the building is high performing in Iran-Shiraz and in all climatic conditions similar can be achieved with sophisticated energy systems, average levels of thermal insulation, heat collectors solar and with a large number of PV panels (on-site energy production from renewable sources is the most effective measure), although the optimal level of costs is directly dependent on appropriate financial subsidies and government policies on renewable electricity prices. The power sector is at a phase of shifting from a conventional distribution system to the smart grid system with the integration of renewable energy resources. By substituting fossil fuels in energy production with renewable energy, reduction of carbon emissions is achieved. At the same time, diversification of energy production ensures security of energy supplies. This increases power system resilience and reduces its vulnerability. In this case, vulnerability can be defined as a condition or a process resulting from a given (natural or man-made) hazard and can be defined as the joint conditional probability of disruption in an energy system

due to hazard likelihood, hazard potential impact and system capacity [9].

3. METHOD

The analysis was carried out with qualitative and quantitative descriptive. [10] The comparison method which has been developed represent a rather promising starting point to develop a methodology by which the ratings produced by different systems can be compared, allowing them to communicate. The method is designed to allow its application to a larger set of rating systems for sustainability, in order to perform a further validation of the results which have been obtained. Limiting complex calculations of an enormous number of indicators should stimulate the construction industry to focus more on the relevant performances of sustainability, by enhancing both the competition based on these features and a wider diffusion of rating systems for sustainability applications within the market. In other studies, for example [11] Maturity matrix with solutions specifically designed to increase the stock of this building. This approach facilitates the reuse of methodologies for other building typologies. The development of this showcase highlights that in-depth analysis is needed to identify adequate solutions that apply to historic housing typologies that will later contribute to the success of increasing their energy efficiency.

4. RESULTS AND DISCUSSION

Most of the rooftop solar PV installations use Hybrid PV systems. The hybrid solar PV system binds energy from PV and the electricity network at the building's main electricity distribution points. This energy distribution model works best when the grid is stable, and an energy repurchase program is available. SOGA also has similarities with studies conducted by [12], with the term Smart Energy Switching Platform (SESP) consisting of two main components: 1) Smart Switch (es) and 2) Central Coordinator (CC). There is only one CC in the installation that connects several Smart Switches to themselves. Using a Smart Switch (a diamond-shaped symbol), the device chosen inside the building is connected to two energy sources, namely solar PV and a grid. Smart Switch is placed with one electrical device or a group of devices to control energy sources. Such as the study of [13] with the Home Energy Management (HEM) model, will enable a balance between demand and generation, by controlling the burden that can be deferred, reducing energy consumption for example by using natural light for as long as possible, exchanging excess energy produced between neighbors instead of taking energy from the tissue.

SOGA has an advantage in the form of an actuator that moves with the sun, in contrast to as stated by [14] in his study Photovoltaic (PV) modules applied to buildings form a unique surface at the same roof inclination, replacing the tiles. Such PV systems are affected by thermal and mechanical stresses, and remarkable dirt. Another issue is the partial shading with possible failure of bypass diodes. Or study from [15] Semi Transparent Photovoltaic (STPV)

products installed as technical elements of the building envelope, these could be used, in place of absorbing, tinted glass or ceramic frits, to respond to multiple building requirements, such as: solar shading in summer to reduce cooling loads; solar gain and thermal insulation in winter to lower heating loads; daylighting to reduce artificial lighting loads. However, SOGA can also be developed by allowing users to use telephone or internet applications (APP) as conveyed by [16] to find out household electricity consumption directly has an important impact on increasing household electricity efficiency and changing user habits in using electricity. Summarizes advanced research on visualization techniques of home energy systems and analyzes their values and shortcomings.

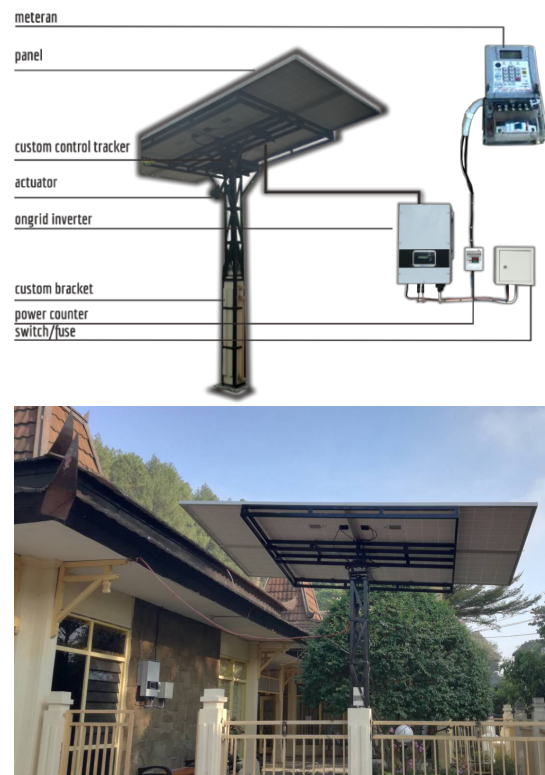


Figure 1 Smart on grid actuator installation [17]

The results of observations on SOGA since it was installed in October 2018 until the end of October 2019, recorded at 1220 Kwh has been harvested, or an average of 101 Kwh per month and the average per day gets energy of 3.48 Kwh. This value when viewed from an economic standpoint by multiplying the price of state electricity generates IDR 27,885,- or in one month reaches IDR 836,571,-. In the electricity financing standard regulated by the state electricity company, it is divided into several groups, including business, industry, offices, households and social. Table 1 explains the amount of the bill issued to pay for public street lighting that must be borne every month by the community, according to the provisions of 10 percent of the total electricity use bill in the month concerned. The cost of electricity bills for public road lighting in April 2016 was IDR 523,028,360.

Table 1 Magnitude of electricity costs for public street lighting in the city of Magelang in 2016

Groups	Sum of Public Street Lighting Costs	Sum of Electricity User Charges	Total
B1	36,492,221	445,971,924	407,468,724
B2	172,165,281	2,127,788,861	1,952,293,580
B3	40,525,274	490,842,100	450,280,826
I1	1,271,782	43,838,494	42,392,712
I2	12,525,092	430,211,189	417,503,097
I3	49,025,818	1,683,243,735	1,634,193,917
LB2	104,565	1,272,396	1,161,831
P1	-	353,282,027	352,631,027
P2	-	201,785,670	201,773,670
P3	-	455,846,276	451,883,309
R1	182,586,056	2,237,560,872	2,050,594,816
R2	18,106,169	227,331,162	208,318,993
R3	5,299,610	168,318,739	148,298,866
S2	4,013,622	611,379,058	606,348,436
S3	912,870	11,061,870	10,143,000
Grand Total	523,028,360	9,489,734,373	8,935,286,804

Source: Magelang State Electricity Distribution Company, April 2016

The application of SOGA to public street lighting is one alternative that can be used to encourage energy efficiency and have an impact on economic functioning, but requires more preparation and identification, in line with studies from [18] to build protocols and working principles of new utilities. First, the provisional simulation results show the importance of considering the same distribution of thermal mass in the structure of the facility to have the same dynamic response on both the ground floor and the first floor. The second result shows a good level of comparison for certain test cells, but as a measurement protocol, absolute tests coupled with simulations will be used, to avoid the influence of lateral walls.

Table 2 Electricity usage (electricity units per group)

Groups	Count of public street lighting	Sum of Kwh
B1	1.779	401.715
B2	409	1.437.755
B3	6	416.798
I1	48	38.147
I2	33	374.111
I3	4	1.568.100
LB2	1	847
P1	229	271.384
P2	2	189.740
P3	190	332.882
R1	23.523	2.953.594
R2	281	153.098
R3	50	109.037
S2	785	696.337
S3	1	13.800
Grand Total	27.341	8.957.345

Source: Magelang State Electricity Distribution Company, April 2016

Furthermore, in table 2 it is shown the number of points in the city of Magelang for public street lighting, which is as many as 27,341 points, this number can be streamlined by using SOGA at each point, certainly with a process that needs to be carefully considered, especially at the policy level with complete the economic level of SOGA utilization, for example by identification of GIS. The policy

and economic context that intersects with SOGA in its efforts to use as public street lighting should also be supported by GIS, which is in line with research conducted in Germany by [19] GIS is very useful in exploring the spatial relationships of complex problems such as policy effects as shown and using tools this helps in estimating the maximum solar PV potential by applying four technical criteria: solar radiation, slope, altitude and orientation. However, the implementation of SOGA in mapping the use of renewable energy still requires high commitment from policy makers. In line with research conducted by [20] Urban Energy Use Mapping can be used not only to visualize energy use and what comes from energy use (evaluation of emissions and pollution) but also to visualize energy quality, namely entropy through thermodynamic indicators that are developed, generations to achieve rational cities. energy saving solution. Therefore, evaluating energy and environmental retrofit options to find a compromise between city forms, energy and / or mobility infrastructure, thus an important instrument for the definition of urban policy, is possible.

SOGA also still needs improvements in its use, such as the need to adopt a way of regulation with the study of [21] namely Monet Platform, as an Energy Management System for Microgrid, covering: 1) Table of different energy rates, to consider energy costs, time slots of production and energy consumption as input for optimization algorithms; 2) Management of complex refill islands, with many generating units, differs for typology and size, and with different types of charging stations, with a set of optimization algorithms that can be used. this study is a preliminary study that needs to be continued at least to collect more data and make it possible to see what changes in energy consumption can be related to what factors - technology, climate, energy prices (primary and changing), population in the test household, behavior consumers, or others. Further analysis will make it possible to adapt business strategies for more effective deployments of market-based energy efficiency solutions related to smart home technology [22].

5. CONCLUSION

The results obtained from SOGA data are predicted to be 10-20% for the efficiency of electricity use. However, in the implementation of SOGA an initial mapping is required for each public road lighting point that can be intervened with SOGA, the public road lighting point is prioritized at the point where the level of electricity usage per month is below 100 Kwh. Improving SOGA with technological interventions is also an important element given the rapid growth of technology today, for example with information technology and GIS interventions. Government policy is a crucial starting point so that the economic efficiency of the use of renewable energy in the City of Magelang can be achieved. The use of SOGA can also support government programs in pushing Magelang City to become Smartcity. If it is applied to public street lighting in the city of Magelang, the efficiency of the economy is significant, but the implementation of SOGA is very conducive to regional policies.

REFERENCES

- [1] K. T. Raimi and A. R. Carrico, "Understanding and beliefs about smart energy technology," *Energy Res. Soc. Sci.*, vol. 12, pp. 68–74, 2016.
- [2] Government of the Republic of Indonesia, Government Regulation Number 79 of 2014 concerning Energy Policy. 2014, p. 36.
- [3] C. Wilson, T. Hargreaves, and R. Hauxwell-Baldwin, "Benefits and risks of smart home technologies," *Energy Policy*, vol. 103, pp. 72–83, 2017.
- [4] F. J. W. Osseweijer, L. B. P. Van Den Hurk, E. J. H. M. Teunissen, and W. G. J. H. M. Van Sark, "A Review of the Dutch Ecosystem for Building Integrated Photovoltaics," *Energy Procedia*, vol. 111, pp. 974–981, 2017.
- [5] S. Oliveira, E. Marco, B. Gething, and C. Robertson, "Exploring Energy Modelling in Architecture Logics of Investment and Risk," *Energy Procedia*, vol. 111, pp. 61–70, 2017.
- [6] M. Da Silva Garcia and R. V. G. De Souza, "Reflections about the Use of the Tool S3E for the Evaluation of Energy Efficiency Level in Commercial Buildings in Brazil," *Energy Procedia*, vol. 111, pp. 131–140, 2017.
- [7] C. A. S. Hall, J. G. Lambert, and S. B. Balogh, "EROI of different fuels and the implications for society," *Energy Policy*, vol. 64, pp. 141–152, 2014.
- [8] M. Alvand, Z. Gholami, M. Ferrara, and E. Fabrizio, "Assessment of Cost Optimal Solutions for High Performance Multi-family Buildings in Iran," *Energy Procedia*, vol. 111, pp. 318–327, 2017.
- [9] M. Mola, M. Feofilovs, and F. Romagnoli, "Energy resilience: Research trends at urban, municipal and country levels," *Energy Procedia*, vol. 147, pp. 104–113, 2018.
- [10] S. Politi and E. Antonini, "An Expeditious Method for Comparing Sustainable Rating Systems for Residential Buildings," *Energy Procedia*, vol. 111, pp. 41–50, 2017.
- [11] A. G. González, M. Á. G. Zotano, W. Swan, P. Bouillard, and H. Elkadi, "Maturity Matrix Assessment: Evaluation of Energy Efficiency Strategies in Brussels Historic Residential Stock," *Energy Procedia*, vol. 111, pp. 407–416, 2017.
- [12] Q. Khalid, J. Ikram, and N. Arshad, "A Collaborative Approach to Operate High Powered Devices on Small-scale PV systems," *Energy Procedia*, vol. 111, pp. 895–903, 2017.
- [13] F. Chekired, Z. Smara, A. Mahrane, M. Chikh, and S. Berkane, "An Energy Flow Management Algorithm for a Photovoltaic Solar Home," *Energy Procedia*, vol. 111, pp. 934–943, 2017.
- [14] F. Spertino, J. Ahmad, A. Ciocia, and P. Di Leo, "Techniques and Experimental Results for Performance Analysis of Photovoltaic Modules Installed in Buildings," *Energy Procedia*, vol. 111, pp. 944–953, 2017.
- [15] M. Morini and R. Corrao, "Energy Optimization of BIPV Glass Blocks: A Multi-software Study," *Energy Procedia*, vol. 111, pp. 982–992, 2017.
- [16] X. Fan, B. Qiu, Y. Liu, H. Zhu, and B. Han, "Energy Visualization for Smart Home," *Energy Procedia*, vol. 105, pp. 2545–2548, 2017.
- [17] A. Prasetyo, Renewable Energy Cost Estimation on Smart on Grid Actuator Innovation for the Development of Alternative Rural Electricity. Magelang: Regional Planning, Research, and Development Board Jawa Tengah Province, Indonesia, 2018.
- [18] L. Bianco, P. Schneuwly, E. Wurtz, and A. Brun, "Design of a New Full-scale Facility for Building Envelope Test: FACT (FACade Tool)," *Energy Procedia*, vol. 111, pp. 256–266, 2017.
- [19] B. B. Kausika, O. Dolla, and W. G. J. H. M. Van Sark, "Assessment of policy based residential solar PV potential using GIS-based multicriteria decision analysis: A case study of Apeldoorn, the Netherlands," *Energy Procedia*, vol. 134, pp. 110–120, 2017.
- [20] M. G. Baldi and G. Giuseppe, "The Second Law and the Energy Use Mapping for Sustainability Planning," *Energy Procedia*, vol. 111, pp. 730–739, 2017.
- [21] M. Bigoloni and S. Filipponi, "Monet: An Innovative System to Manage Energy Services," *Energy Procedia*, vol. 111, pp. 846–855, 2017.
- [22] R. Aboltins and D. Blumberga, "In search for market-based energy efficiency investment in households: Smart home solutions as an option for optimized use of energy and reduction of costs for energy," *Energy Procedia*, vol. 147, pp. 1–6, 2018.