Economical valuation for measuring renewable energy efficiency as the implementation of smart city concept at Surabaya City

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Abstract. Energy is the most important part of supporting human necessity. For this while, the crude oil energy which is mostly needed at Indonesia are fuel oil and electricity. Unfortunately, the domestic crude oil reserves are diminishing and global crude oil’s price has always fluctuated. Thus, the development of renewable energy is necessary. However, the alternative energy development in Indonesia still relies on fossil energy, which is not environmental friendly yet. Smart energy is one of the existed approaches in the concept implementation of smart city. Surabaya city has already had a number of innovations in smart energy implementation of alternative uses in utilizing renewable energy for particularly public services, such as solar cell, garbage power plant, and the application of wind turbine. Some of the mentioned alternative energy have been tried at government’s buildings, other government’s facilities, and public street lighting. There are some occurrences of problems such as the lack of readiness of the supporting facility, the energy production made a few trial project slowed down to be implemented. This study is trying to economically valuate about the efficiency level of renewable energies which have been tried. This study aims to offer an advantage of choosing the best alternative energy to be mass implemented. Thus, the smart city concept, especially smart energy, can be thoroughly implemented using the most efficient type of energy.

Keywords: Smart city, Smart energy, Economical valuation, Energy efficiency

1. Introduction

Energy is the most important part of human life because almost all of the human activity always need energy. Most energy used in Indonesia comes from fossil energy in the form of crude oil and natural gas. If it was examined from development segment, the energy system in Indonesia since shows that the fossil energy source still be the main source in fulfilling the domestic energy necessity. The favorable fossil energy is crude oil, natural gas, and charcoal. For many years, crude oil dominates the energy supply and utility domestically as fuel oil and electricity.

The most useful for crude oil is gasoline and diesel fuel, meanwhile for household necessity, people tend to choose kerosene. However, because of the program of kerosene to LPG (Liquid Petroleum Gas) conversion, kerosene’s price becomes too high and rarely existed which makes people substitute it with LPG for their energy needs. Unfortunately, the particular program is not solving the fuel problem in
society. It is because the society’s worriedness of a severe blown potential which caused by the package’s leaking, also the distribution of LPG is not thoroughly yet which cause rarity in some areas.

Fuel oil is a form of energy which has an important role in the activities of industrial sector, transportation sector, also household sector. The diminishing of domestic crude oil and the increasing of domestic fuel oil consumption leads to the rarity of fuel oil in some areas in Indonesia. This condition forces Indonesia to imports fuel oil from other countries and unable to rely on the global crude oil source because of its fluctuated price, which will deplete country’s foreign exchange and threatening national energy security.

The diminishing of domestic crude oil reserves, the fluctuated price of global crude oil, and the availability of various domestic alternative energy potencies become a background of consideration that the alternative energy development is necessary. However, according to Presidential Regulation No. 5 of 2006 concerning National Energy Policy, this day the developing portion of alternative energy still rely on fossil energy which aims in increasing the supply and utility of natural gas and charcoal. Meanwhile, the renewable alternative energy development which is environmentally friendly still get relatively limited portion even though it has already increased.

Energy has ever been separated from the environmental issue. The most globally trending issue of environmental nowadays is global warming and climate changes. Since before, fossil fuel oil is issued as the cause of global warming [1]. Fossil fuel oil which is incompletely combusted will cause the CO$_2$ gas rising to the earth’s surface and obstructing the earth heat’s reflection. This occurrence leads to high temperature on the earth surface.

The development of renewable and environmentally friendly alternative energy are relevant matters to issues about energy and environment nowadays. This happens because of the energy sector has a strong relation toward the environment, in which the energy sector is affecting the environment while on the energy production period until its utility by changing the environment state.

The development of renewable alternative energy which is environmentally friendly and available for local structure can be a multi-advantages instrument, as a substitute in order to make people will reduce their dependence on fossil energy, realizing the sustainability of the environment, and supplying energy which is accessible to local people for its quantity, quality, and value. There are a lot of kind of renewable alternative energy which is environmentally friendly and locally available which can be developed.

Surabaya city is the second biggest city in Indonesia and is a trade and service city by becoming the central interconnection to the east part of Indonesia. This fact means that the economic growth and development of Surabaya City are affecting its citizen’s mobility. The high mobility leads to the citizen’s consumption of fuel oil escalate too. Besides that matter, the centralized economic activities of Indonesia’s east part at Surabaya City is increasing the electricity consumption.

Thus, it is necessary to conduct a study about the potential of alternative energy development for public necessity at Surabaya City. This should be done in order to prevent the rapid activities which are happening to not interrupt the existing supply of energy source.

2. Research method

2.1 Research type

This study is included to comparative study which is done in order to compare the similarity and difference of two or more facts and characteristics of a study’s object based on particular framework. There are few main steps of comparative study, which are: 1) to formulate and define the problem; 2) to explore and analyze the existing literature 3) to formulate the theoretical framework and hypotheses, also any other assumptions which are used; 4) to create a research design by determining the subject using the chosen data collection technique, then categorized the characteristics, attributes, or other matters which is corresponding with the study’s problem in order to ease the analysis of cause and effect; 5) to test the chosen hypotheses, create an interpretation about the correlation using suitable statistic
The method used in this study is quantitative and qualitative method. The quantitative method is calculating the data using formulas, meanwhile the qualitative method is analyzing the calculating result and comparing them to the existing standards.

2.2 Data collection technique
The data collection technique in this study is using secondary survey. The data collected by secondary survey is done through a study of related literature, also by collecting data from public service agency or related institutions, they are Bappeda Kota Surabaya (development planning agency for Surabaya City) and BPS (central bureau of statistics) in this study. The used data in this study are:
1. The general pictorial of Surabaya City, including administration profile, geography, also the physical condition of the city base
2. The electricity usage for Surabaya City’s government buildings
3. The electricity usage for PJU (Penerangan Jalan Umum, public street lighting)
4. The electricity usage for buildings or areas which are financed by Surabaya City’s government
5. The examples of utilization of alternative energy source at Surabaya City.

2.3 Data analysis
The data analysis in this study is done in the form of qualitative and quantitative analysis. The qualitative analysis is implemented to gain the pictorial of the potential of alternative energy development at Surabaya City by using comparative analysis.

Meanwhile, the quantitative analysis is implemented for determining the priority in choosing the later to be developed alternative energy source at Surabaya City by using Benefit Cost Ratio method. Benefit Cost Ratio is one of the investment feasibility methods to evaluate a project or investment by comparing its economic benefits toward its economic cost [3]. As for the criteria to determine the single decision is by examining the value of B/C which will show resulting values are greater or equal to one, or less than one. The following are the valuation criteria of benefit cost ratio [4]:

If B/C≥1, thus the alternative investment or project is feasible, approved (1)

If B/C<1, thus the alternative investment or project is not feasible (2)

3. Result and discussion
3.1 PLTS (Solar System Power Plant)
3.1.1 PLTS Analysis for Building Utility
In evaluating the efficiency of Solar System Power Plant usage for building, three schemas of valuation are done, as follows:
A. Valuation Schema of the Usage of 100% from PLN (State Electricity Company)
This valuation’s aim is to understand the public facility’s electricity charge if only using power from PLN without using solar system power at all.

Below is the result of valuation of the electricity charge annually, using 100% power from PLN. This valuation is retrieved from invoice data from PLN monthly for several government building which is chosen as study’s sample.
### Table 1. The valuation schema of using 100% power from PLN

| No | Public Facility | Annual Charge |
|----|----------------|---------------|
| A  | KANTOR JIMERTO |               |
| 1  | Pemda Tk. II / Puskesmas Ketabang | Rp 65.682.018,00 |
| 2  | Kota Praja / Rumah Dinas Walikota | Rp 214.216.317,00 |
| 3  | YYS Kas Pembangunan / Rumah Dinas Wawali | Rp 44.527.800,00 |
| 4  | Kota Praja / Balai Kota Surabaya | Rp 55.419.520,36 |
| 5  | Gedung Keuangan T2 KMS / Kantor Pemkot Surabaya (6 lantai) | Rp 2.046.115.791,00 |
| 6  | Kota Madya Dati II Sby / Komplek Kantor Pemkot Surabaya (kantor balaikota) | Rp 1.862.063.949,82 |
| B  | KANTOR BAPPEKO | Rp 269.812.923,00 |

### B. Valuation schema of the usage of 50% power from PLN and 50% power from PLTS

This valuation is used to understand the amount of savings made by government if reducing the power usage from PLN to 50% and simultaneously increasing the power usage from solar system to 50%. The investment valuation is included in the following schema.

The following is the valuation result of electricity charge annually by utilizing both powers from PLN and solar system in 50% part of each. By using PLTS, the expenses of investment, operational, and maintenance should be considerate.

### Table 2. The valuation schema of using 50% power from PLN and 50% power from PLTS

| No | Public Facilities               | MIXED (50% PLN + 50% PLTS) |
|----|--------------------------------|-----------------------------|
| A  | KANTOR JIMERTO                  |                             |
| 1  | Pemda Tk. II / Puskesmas Ketabang | Rp 260.898.275,67           |
| 2  | Kota Praja / Rumah Dinas Walikota | Rp 124.031.847,39           |
| 3  | YYS Kas Pembangunan / Rumah Dinas Wawali | Rp 260.904.611,11 |
| 4  | Kota Praja / Balai Kota Surabaya | Rp 220.716.426,85           |
| 5  | Gedung Keuangan T2 KMS / Kantor Pemkot Surabaya (6 lantai) | Rp 1.031.367.495,50 |
| 6  | Kota Madya Dati II Sby / Komplek Kantor Pemkot Surabaya (kantor balaikota) | Rp 940.263.077,94 |
| B  | KANTOR BAPPEKO                  | Rp 158.391.394,83           |

The cost from the city government’s electricity charge is able to be diminished to 97.15%. In this valuation, the cost of the PLTS procurement investment is omitted. This valuation’s goal is to understand the PLTS role which is aiming in reducing the electricity charge from using the power from PLN, as an existing or projection matter.

### Table 3. The saving percentage of the valuation schema of using 50% power from PLN and 50% power from PLTS

| No | Public Facility | Saving Percentage (without investment cost) |
|----|----------------|---------------------------------------------|
| A  | KANTOR JIMERTO |                                             |
| 1  | Pemda Tk. II / Puskesmas Ketabang | 94,44%                                      |
| 2  | Kota Praja / Rumah Dinas Walikota | 99,87%                                      |
| 3  | YYS Kas Pembangunan / Rumah Dinas Wawali | 91,43%                                   |
If considering investment cost, thus the city government will reach BEP (Break Even Point) in 17 years, when the percentage will be on the positive value.

C. Valuation Schema of the Usage of 100% Power from PLTS
This valuation is used to understand the amount of savings made by government if only utilize the power usage from PLTS 100%. The required energy to have the electricity is retrieved 100% from the sun. The investment valuation is included in the following schema.

The following is the valuation result of electricity charge annually by utilizing 100% power from PLTS. By using PLTS, the expenses of investment, operational, and maintenance should be considerate. Using 100% power from PLTS means not using any power from PLN at all.

Table 4. The valuation schema of using 100% power from PLTS

| No | Public Facility | SOLAR CELL |
|----|----------------|------------|
|    |                | Investment Cost | Maintenance/year |
| A  | KANTOR JIMERTO | Rp 456.114,533 | Rp 7,297,833 |
| 1  | Pemda Tk. II / Puskesmas Ketabang | Rp 33,847,378 | Rp 541,558 |
| 2  | Kota Praja / Rumah Dinas Walikota | Rp 477,281,422 | Rp 7,636,503 |
| 3  | YYS Kas Pembangunan / Rumah Dinas Wawali | Rp 386,013,333 | Rp 6,176,213 |
| 4  | Kota Praja / Balai Kota Surabaya | Rp 16,619,200 | Rp 265,907 |
| 5  | Gedung Keuangan T2 KMS / Kantor Pemkot Surabaya (6 lantai) | Rp 18,462,206 | Rp 295,395 |
| 6  | Kota Madya Dati II Sby / Komplek Kantor Pemkot Surabaya (kantor balaikota) | Rp 46,969,867 | Rp 751,518 |

The able-to-diminished cost from the existing electricity charge of city government is 94.29%. In this valuation, the cost of the PLTS procurement investment is omitted.

Table 5. The Saving Percentage of the Valuation Schema of Using 100% Power from PLTS

| No | Public Facility | Saving Percentage (without investment cost) |
|----|----------------|-------------------------------------------|
| A  | KANTOR JIMERTO |                                           |
| 1  | Pemda Tk. II / Puskesmas Ketabang | 88,89% |
| 2  | Kota Praja / Rumah Dinas Walikota | 99,75% |
| 3  | YYS Kas Pembangunan / Rumah Dinas Wawali | 82,85% |
| 4  | Kota Praja / Balai Kota Surabaya | 88,86% |
| 5  | Gedung Keuangan T2 KMS / Kantor Pemkot Surabaya (6 lantai) | 99,99% |
Considering investment cost, thus the city government will reach BEP (Break Even Point) in 17 years, when the percentage will be on the positive value.

3.1.2 PLTS analysis for PJU (Public Street Lighting) usage

The usage of public street lighting is costed by the PLN and should be paid by local government. For this payment interest, the PJU will be listed as a must be paid component in monthly electricity invoice. PLTS at Surabaya City is utilized for PJU. The PJUs which have been using power from PLTS are: PJU Jembatan Surabaya dan Air Mancur, PJU Jalan Raya, PJU Tanggul, PJU THP Kenjeran, PJU THP Kenjeran Parkir, Lampu Taman THP Kenjeran. The following is the analysis of investment cost and the savings percentage by utilizing PLTS for PJU.

### Table 6. The investment cost and saving rate

| No | PJU (Public Street Lighting) | Solar Module Needs | Battery Needs | Investment Cost kbps13.600,00 | Probability | Savings |
|----|-----------------------------|--------------------|--------------|-----------------------------|-------------|---------|
| 1  | PJU Jembatan Surabaya dan Air Mancur | 1.875,90 WP | 16 buah | 36 buah | Rp 255.122.400,00 | 99% |
| 2  | PJU Jalan Raya | 0,06 WP | 1 buah | 1 buah | Rp 8.012,97 | Too Small |
| 3  | PJU Tanggul | 258,15 WP | 3 buah | 1 buah | Rp 35.108.587,16 | 55% |
| 4  | PJU THP Kenjeran | 0,06 WP | 1 buah | 1 buah | Rp 8.547,17 | Too Small |
| 5  | PJU THP Kenjeran Parkir | 951,93 WP | 8 buah | 1 buah | Rp 129.462.915,14 | 57% |
| 6  | Lampu Taman THP Kenjeran | 0,03 WP | 1 buah | 1 buah | Rp 4.056,28 | Too Small |

Based on the above valuation analysis, thus the government is able to save 70% off from the electricity charge by utilizing the solar system power for powering PJU.

3.2 PLTB (Wind Power Plant)

The development of Wind Power Plant at Surabaya City is adopting the Wind Power Plant on Nusa Penida Island because the average wind speed in this area is lower than 5m/s. A WES80 turbine is chosen accordingly as its used for low rate of 3.0m/s wind speed. Each WES80 turbines gives average electricity power as much as 135,000 kWh (kilowatt an hour) annually. 1 billion rupiahs is needed to build up each turbine, which means every kWh, it will cost US$ 10-15 cents. The valuation of the electricity usage by utilizing power from PLTB at Surabaya City shown in the table below:

### Table 7. The valuation of electricity usage by utilizing PLTB at Surabaya City

| Description | Amount |
|-------------|--------|
| Average Electricity Requirement per Month | 3.436.025,65 kWh |
| Average Electricity Needs per Year | 41.232.307,78 kWh |
From the previous valuation, it is known that for supply the public electricity needs, it will require 305 units of WES80 turbines with the buildup investment cost is 305 billion rupiahs. The total charge of electricity usage by utilizing PLTB for public affair is 56,075,938,581.00 rupiahs. This amount is more efficient 4,411,856,932.00 rupiahs than using power from PLN, or can save around 7.29%.

### 3.3 PLTSa (Garbage Power Plant)

According to the existing data, it can be understood that the production result of PLTSa Benowo for the year 2017 is 6,349,298 kWh and the selling potential to PLN is 15,847,847,808.00 rupiahs, which means can be counted that the savings in garbage maintenance for the year 2017 is 16%. The complete information is shown in the table below:

**Table 8. The cost saving of garbage maintenance of 2017**

| No. | Month  | Garbage Maintenance Cost 2017 | Production Result of PLTSa Benowo 2017 | Saving Cost of Garbage Maintenance 2017 |
|-----|--------|------------------------------|----------------------------------------|----------------------------------------|
| 1   | Desember | 46500 Tonage | Rp 7.253,302,500.00 Total | 672,148.00 kWh | Rp 1.677,681,408.00 Selling Potential to PLN | 23% |
| 2   | Januari | 127600 | Rp 19.903,686,000.00 Total | 692,164.00 kWh | Rp 1.727,641,344.00 Selling Potential to PLN | 9% |
| 3   | Februari | 44800 | Rp 6,988,128,000.00 Total | 873,550.00 kWh | Rp 2,180,380,800.00 Selling Potential to PLN | 31% |
| 4   | Maret | 49600 | Rp 7,736,856,000.00 Total | Rp - | Selling Potential to PLN | 0% |
| 5   | April | 48000 | Rp 7,487,280,000.00 Total | Rp - | Selling Potential to PLN | 0% |
| 6   | Mei | 49600 | Rp 7,736,856,000.00 Total | 1,028,666.00 kWh | Rp 2,567,550,336.00 Selling Potential to PLN | 33% |
| 7   | Juni | 48000 | Rp 7,487,280,000.00 Total | 1,101,736.00 kWh | Rp 2,749,933,056.00 Selling Potential to PLN | 37% |
| 8   | Juli | 49600 | Rp 7,736,856,000.00 Total | 1,142,240.00 kWh | Rp 2,851,031,040.00 Selling Potential to PLN | 37% |
| 9   | Agustus | 49600 | Rp 7,736,856,000.00 Total | 838,794.00 kWh | Rp 2,093,629,824.00 Selling Potential to PLN | 27% |
| 10  | September | 48000 | Rp 7,487,280,000.00 Total | Rp - | Selling Potential to PLN | 0% |
| 11  | Oktober | 49600 | Rp 7,894,089,600.00 Total | Rp - | Selling Potential to PLN | 0% |
| 12  | November | 48100 | Rp 8,028,082,400.00 Total | Rp - | Selling Potential to PLN | 0% |

**TOTAL** 659000 Tonage | Rp 103,476,552,500.00 Total | 6349298 kWh | Rp 15,847,847,808.00 Selling Potential to PLN

And by understanding the above analysis table, the average savings in the garbage maintenance cost for the year 2017 is 16%.

In order to know the savings for the year 2018, a projection of production result at PLTSa Benowo is valuated. Thus, the projection of production result of PLTSa Benowo for the year 2018 is 10,884,511 kWh with the selling potential to PLN reach 27,167,739,099.43 rupiahs. And as for its saving amount, this projection for the year 2018 is 26%. Further information can be seen on the next table:
### Table 9. The projection of garbage maintenance cost of 2018

| No | Month   | Projection of Garbage Maintenance of 2018 Sampah 2018 Tonage | Projection of Production Result of PLTSa Benowo 2018 Total KWh | Selling Potential to PLN | Saving Cost of Garbage Maintenance 2018 |
|----|---------|-------------------------------------------------------------|---------------------------------------------------------------|-------------------------|-----------------------------------------|
| 1  | December| 52700                                                       | 907.042,57                                                   | Rp 2.263.978.258,29    | 26%                                     |
| 2  | January | 52700                                                       | 907.042,57                                                   | Rp 2.263.978.258,29    | 26%                                     |
| 3  | February| 49300                                                       | 907.042,57                                                   | Rp 2.263.978.258,29    | 28%                                     |
| 4  | March   | 52700                                                       | 907.042,57                                                   | Rp 2.263.978.258,29    | 26%                                     |
| 5  | April   | 51000                                                       | 907.042,57                                                   | Rp 2.263.978.258,29    | 27%                                     |
| 6  | May     | 52700                                                       | 907.042,57                                                   | Rp 2.263.978.258,29    | 26%                                     |
| 7  | June    | 51000                                                       | 907.042,57                                                   | Rp 2.263.978.258,29    | 27%                                     |
| 8  | July    | 52700                                                       | 907.042,57                                                   | Rp 2.263.978.258,29    | 26%                                     |
| 9  | August  | 52700                                                       | 907.042,57                                                   | Rp 2.263.978.258,29    | 26%                                     |
| 10 | September| 51000                                                     | 907.042,57                                                   | Rp 2.263.978.258,29    | 27%                                     |
| 11 | October | 52700                                                       | 907.042,57                                                   | Rp 2.263.978.258,29    | 25%                                     |
| 12 | November| 51000                                                       | 907.042,57                                                   | Rp 2.263.978.258,29    | 25%                                     |
|    | TOTAL   | 622200                                                      | 10884511                                                    | Rp 27.167.739.099,43   |                                         |

### 4. Conclusion

According to this study, thus it can be concluded that by utilizing the renewable energy, Surabaya City’s government are able to manage some amount of cost savings. Meanwhile, the saving rate of each type of alternative energy is concluded as follows:

a. PLTS for buildings, the saving rate of this project reaches 97.15% (50% power from PLN and 50% power from PLTS), 94.29% (100% power from PLTS)

b. PLTS for PJU, the saving rate of this project reaches 70%

c. PLTSa, the saving rate of this project reaches 26%

d. PLTB, the saving rate of this project reaches 7.29%.

### 5. References

[1] Wahyuni, S. 2013. *Biogas Energi Alternatif Pengganti BBM, Gas, dan Listrik* (Jakarta Selatan : PT. Agro Media Pustaka) p 3-4

[2] Nazir, Mohammad. 1988. *Metode Penelitian* (Jakarta : Ghalia Indonesia) p 69-70

[3] Shively, Gerald. 2012. *An Overview of Benefit-Cost Analysis*.

[4] Subagyo, Ahmad. 2007. *Studi Kelayakan Teori dan Aplikasi* (Jakarta: PT. Elex Media Komputindo) p 33