Suitable Alternative Energy in Bang Phra District Chonburi Thailand

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Abstract

The objective of this article is to study about the potential of wind and solar energy at the beach of the public park, Bang Phra District, Si Racha Amphur, Chonburi province, Thailand. The record data set of hybrid energy was installed for collecting the data at the beach of the public park. The record data set of hybrid energy consists of an anemometer, a wind turbine 200W 12V, a solar cell 120W 12V (Model: SP120E), a hybrid charger controller (Model: WWS02A-12-R-L-E), and a battery 12V 120Ah. The recorded data can be downloaded and displayed via WinPowerNet, which is a program from the record data set. The results show the recorded data from October 9, 2012 to November 7, 2012. It can be found that the wind velocity is fluctuated at all time. The maximum wind velocity was 8m/s and the average wind velocity was 0.94m/s. The wind turbine produced the maximum voltage at 13.55V. The solar cell can produce the maximum voltage and current at 16.7V and 9.8A, respectively. Obviously, the wind turbine can produce the electric power about 1 hour/day while the solar cell can produce the electric power about 10 hours/day. It implies that, in this area, the solar cell is suitable for producing the electric power more than the wind turbine.

1. Introduction

The energy problem is one of the major problems that affects to all countries in the world. While the energy consumption is increasing [1], the resources are decreased and some are extinct.

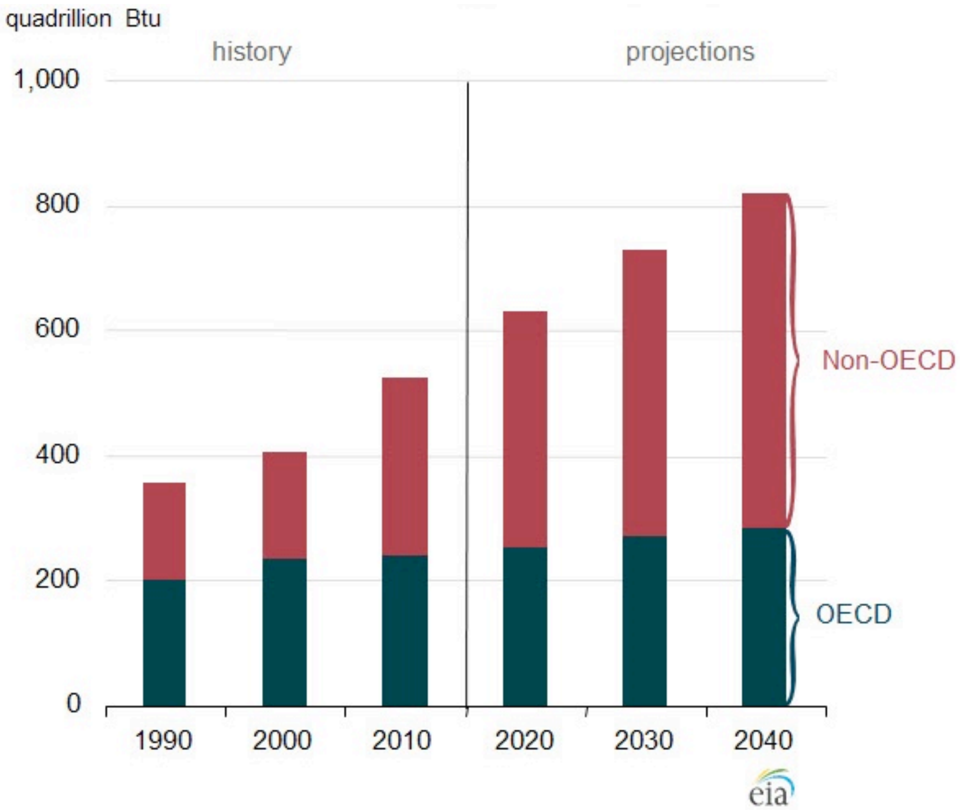

Figure 1. World total energy consumption, 1990 – 2040. [1]

From the figure 1, the *IEO2013* Reference case, world energy consumption increases from 524 quadrillion Btu in 2010 to 630 quadrillion Btu in 2020 and 820 quadrillion Btu in 2040, a 30-year increase of 56 percent. More than 85 percent of the increase in global energy demand from 2010 to 2040 occurs among the developing nations outside the Organization for Economic Cooperation and Development (non-OECD), driven by strong economic growth and expanding populations. In contrast, OECD member countries are, for the most part, already more mature energy consumers, with slower anticipated economic growth and little or no anticipated population growth. [1]

Electricity consumption grows faster than their use of other delivered energy sources in the Reference case, as has been true for the past several decades. Net electricity generation worldwide rises by 2.2 percent per year on average from 2010 to 2040. Renewable generation (including hydropower) is the interesting option to reduce the power using and pollution, so it is the world's fastest-growing source of electric power in the *IEO2013* Reference case, rising by an average of 2.8 percent per year. Government policies and incentives throughout the world support the rapid construction of renewable generation facilities as shown in figure 2. [1]

Figure 2. World electricity generation from renewable sources, 2010 – 2040. [1]

In Thailand, the renewable energy are used only 18.3 percent, while the crude oil has reached 81.7 percent [2]. There are many types of renewable energy, such as hydro power, solar, wind, etc. Each type is suitable for the different geography. So, the Bang Phra Municipality has an idea to initiate the renewable energy project to response the government's policy in dealing with the situation sustainable energy. The objective of this project is to study about the potential of wind and solar energy at the Bang Phra District to be a guide or tool for selecting the appropriate renewable energy that most effective in the Bang Phra Municipality.

2. Renewable Energy

2.1 Wind Energy

Surface wind is the wind blowing near the Earth's surface about 1 km above the ground. It is measured by an anemometer (speed) or wind vane (wind direction) at a standard height of 10 m above ground in an area. The changing of wind speed depends on the altitude and terrain as well as the wind direction as shown in figure 3. Performance of the wind turbine is based on these two variables. At the equal wind speed but the different wind direction, while the wind moving towards the axis of the wind turbines will largely affect to the torque of the wind turbine. The result is a different net force output from wind turbines. Thus, it can be concluded that the factors that determine the use of wind power is the speed and direction of the wind.

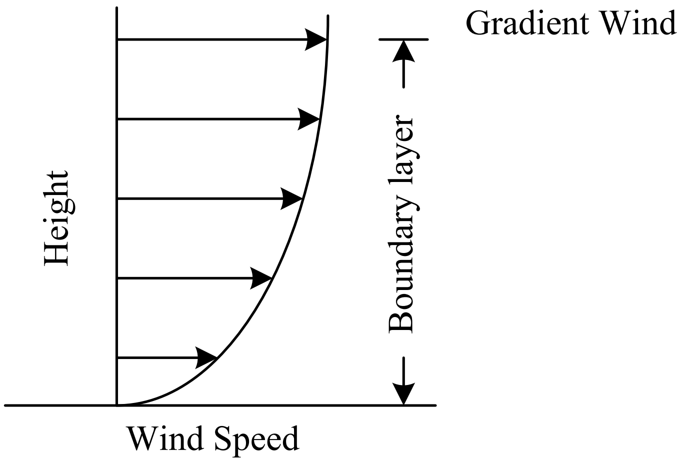

Figure 3. Characteristics of wind speed under the atmosphere.

Energy from wind turbines depends on wind speed as shown in figure 4. At very low wind speeds, there is insufficient torque exerted by the wind on the turbine blades to make them rotate. However, as the speed increases, the wind turbine will begin to rotate and generate electrical power. The speed at which the turbine first starts to rotate and generate power is called "the cut-in wind speed (3 - 4 m/s)". As the wind speed rises, the level of electrical output power rises rapidly as shown. However, at wind speed 12 - 17 m/s, the power output reaches the limit that the electrical generator is capable of. The wind speed at which it is reached is called "the rated/nominal wind speed". At higher wind speeds, the design of the turbine is arranged to limit the power to this maximum level and there is no further rise in the output power. In the range that wind speed climbs to the rated wind speed, the wind turbine operates with the maximum rotor efficiency as shown. Moreover, as the speed increases above the rate output wind speed, the forces on the turbine structure continue to rise and, at some point, there is a risk of damage to the rotor. As a result, a braking system is employed to bring the rotor to a standstill. This is called the cut-out speed and is usually around 25 m/s. [3]

Figure 4. Wind turbine power output variation with steady wind speed. [3]

The general principle of using wind energy is that while the wind blows against the blades of wind turbines, the wind power will be converting from kinetic energy to mechanical energy by the rotation of the blades. Force from the rotation of the blades will be passed to the spindle made of gears attached to the spindle rotation as well. Mechanical energy from the rotation of the gear can be applied to various practices, such as in the case of using wind turbines to generate electricity. It is connected to a generator. With this principle, the generator can produce the electricity. In the case of using windmills to pump water or rice mill, the mechanical energy of rotation of the gears can be taken for applications directly.

2.2 Solar Energy

A photovoltaic system (informally, PV system) is an arrangement of components designed to supply usable electric power for a variety of purposes, using the Sun (or, less commonly, other light sources) as the power source [4]. Todays, solar cell is more commonly used because it easy to installation and maintenance. Moreover, the lifespan is too long (about 20 years). The PV system can be divided into 2 types, such as off-grid and on-grid.

A solar cell is a solid state electrical device that converts the energy of light directly into electricity by the photovoltaic effect. It is made of the semiconductor, such as silicon, and through a process to make a thin-film. While the light is striking on the cell the photons in sunlight hit the solar panel and are absorbed by semiconducting materials. Then, if the absorbed energy has greater than the band gap in order to excite an electron from the valence band into the conduction band, the electron will be free and allowing them to flow through the material to produce electricity.

There are number of different types of solar cells. It can be classified according to the material used to produce 2 types:

1) Solar cells made from silicon, this type is most commonly used because the silicon is abundant elements in the world such as, in the sand, in the quartz. Solar cells made from silicon can be classified according to the crystal structure into 3 types.

1.1) Single crystalline silicon is the base material of the electronic industry. It consists of silicon in which the crystal lattice of the entire solid is continuous, unbroken (with no grain boundaries) to its edges. It can be prepared intrinsic, i.e. made of exceedingly pure silicon alone, or doped, containing very small quantities of other elements added to change in a controlled manner its semiconducting properties. Most silicon monocrystals are grown by the Czochralski process, in the shape of cylinders up to 2 m long and 45 cm in diameter (figure on the right), which, cut in thin slices, give the wafers onto which the microcircuits will be fabricated. The example of single crystalline silicon can be shown in the figure 5.

1.2) Polycrystalline silicon is developed to solve the problem of the production cost of single crystalline silicon. Polycrystalline silicon is composed of a number of smaller crystals or crystallites. It can be recognized by a visible grain, a "metal flake effect". The process to produce the polycrystalline silicon is short and simple than the single crystal. So, the production cost is cheaper and slightly lower efficiency than the single crystal. The example of polycrystalline silicon can be shown in the figure 6.

1.3) Amorphous silicon is the non-crystalline allotropic form of silicon. It can be deposited in thin films at low temperatures onto a variety of substrates. It offers some unique capabilities for a variety of electronics. The production method is use a siren gas (SiH_4) through the vacuum tube, which is placed on the plate and silicon is excited to dissociate from gas. Silicon is separated from the gas to be captured into each other on the plate. Silicon is formed by deposition and accumulation on the plate to be a silicon film while the boron gas (B_2H_6) is diffused into the plate for coating to be the p-type and phosphate compound gas is diffused to form n-type. The example of polycrystalline silicon can be shown in the figure 7.

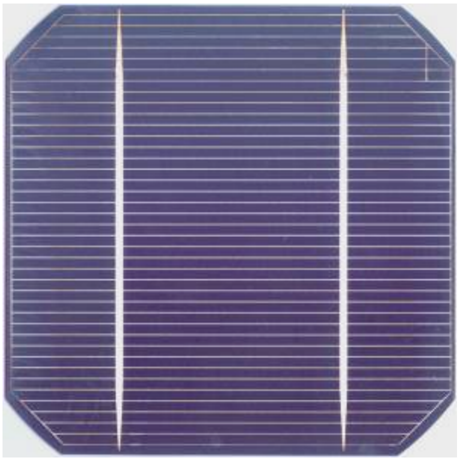

Figure 5. Single crystalline silicon [5]

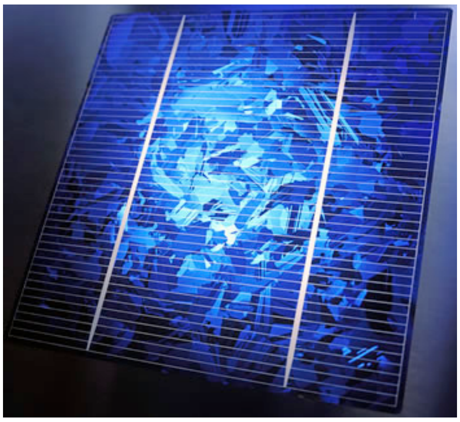

Figure 6. Polycrystalline silicon [6]

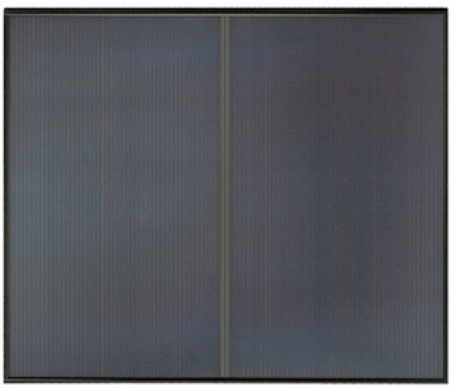

Figure 7. Amorphous silicon [7]

2) Solar cells made from compound such as Gallium Arsenide (GaAs), Cadmium Telluride (CdTe), Copper Indium Gallium Selenide (CIS), etc. It has both single and poly crystal. The most of this type has a high efficiency. The disadvantage is expensive. In addition, some of these types of solar cells made from substances that pollute and usually have a lifespan problem.

3. Methodology

3.1 Location

The most areas of Bang Phra District are the residence areas that are not suitable for installing the wind turbine. However, the west area of Bang Phra District has the Public Park which is the coast. Then, we decide to install the wind turbine and solar cell at the Bang Phra Public Park as shown in figure 8.

Figure 8. Satellite picture of recording data location

3.2 Equipment
- Wind turbine 200W 12V
- Solar cell 120 W Model: SP120E
- Hybrid controller Model: WWS02A-12-R-L-E
- Battery Deep Cycle 12 V 120 Ah
- Outdoor Cabinet (IP45)
- Anemometer

All equipment's are installed at the edge of Bang Phra Public Park. The wind turbine 200 W 12 V and solar cell 120 W 12 V are generates the electricity for charging into the battery 12 V. The hybrid controller has a function to control the battery charging and display the data on the screen. Battery is used to storage the electrical energy. It can be charged and discharged depends on the load. If the electrical energy is generated more than load, the rest energy is kept into the battery. On the other hand, if the electrical energy is generated less than load, the energy that storage in battery is taken to use for load. The system diagram can be shown in the figure 9 and the set of equipment's for recording wind and solar data is shown in the figure 10.

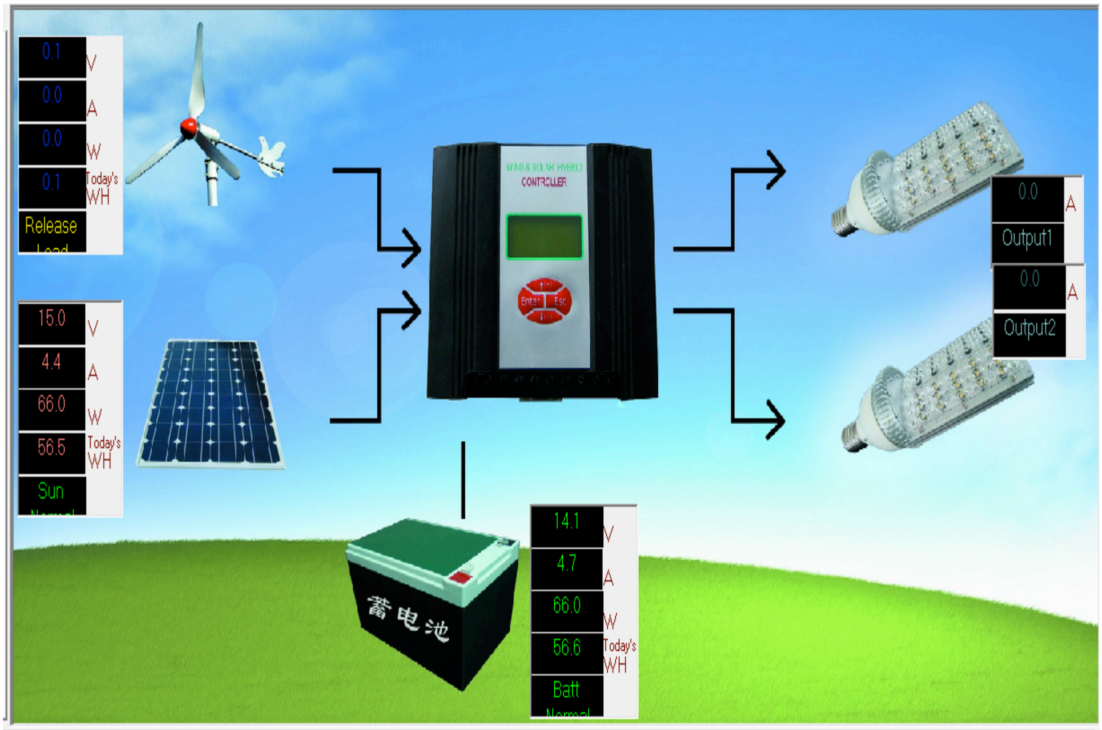

Figure 9. System diagram

a) Complete installation b) Equipment within the cabinet

Figure 10. Set of recording data for wind and solar energy

3.3 WinPowerNet

All data will be recorded to the SD card which can be downloaded or opened with WinPowerNet program. It can show the data into 3 types such as trend chart, table, and simulation graph. The details of each type can be shown bellows.

1) Trend chart

The values of voltage of battery, produced voltage from solar cell, produced voltage from wind turbine are shown. Moreover, the graph of electrical power varies with time and radar graph between voltage and current are shown in figure 11.

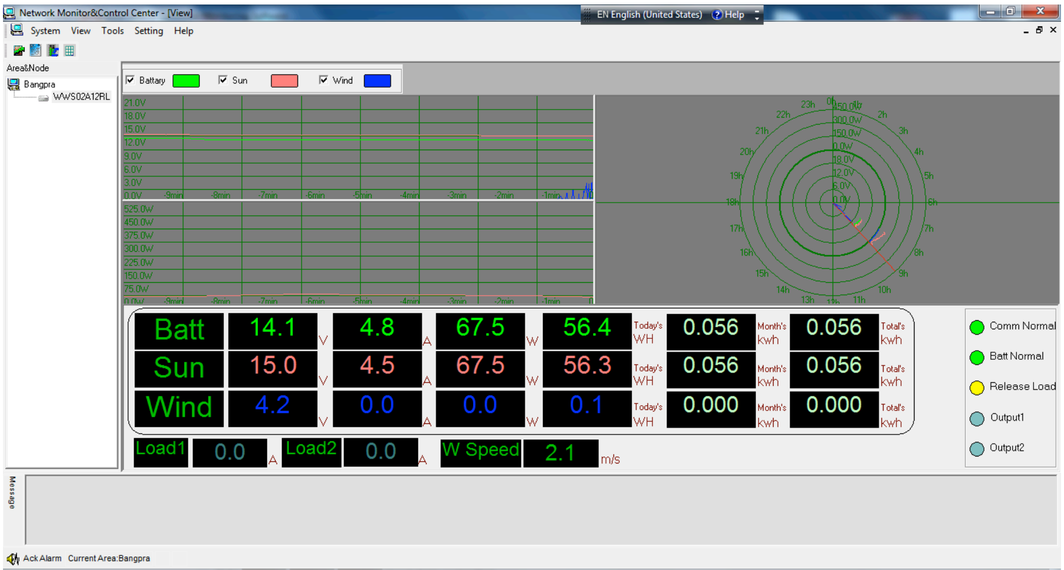

Figure 11. Example of the trend chart

2) Table

The real time data in 20 seconds will be shown in the table. The example of table can be shown in figure 12.

Figure 12. Example of the table data

3) Simulation graph

The data of battery, wind turbine, and solar cell will be shown in real time. The example of the simulation graph can be shown in figure 13.

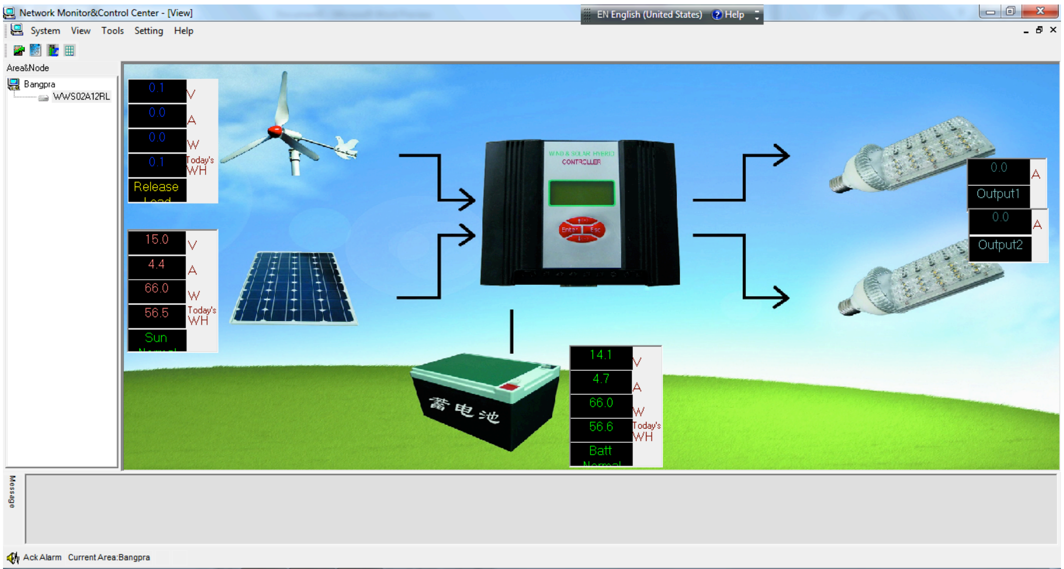

Figure 13. Example of the simulation graph

4. Results

The results can be divided into 2 parts: wind energy data and solar energy data.

4.1 Wind Energy Data

The data were recorded at every 1 minute. The example of daily wind speed can be shown in figure 14.

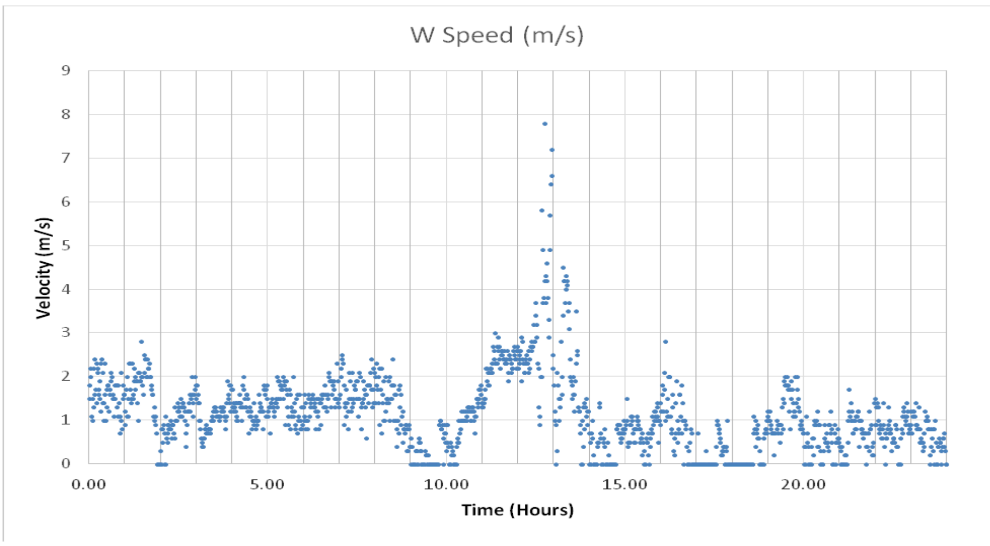

Figure 14. Daily wind speed on October 10, 2012

From the figure 14, it was found that the wind speed is fluctuated and the maximum wind speed is 8 m/s at 13.00 o'clock on October 10, 2012. The 30 days record data can be shown in the figure 15 – 18.

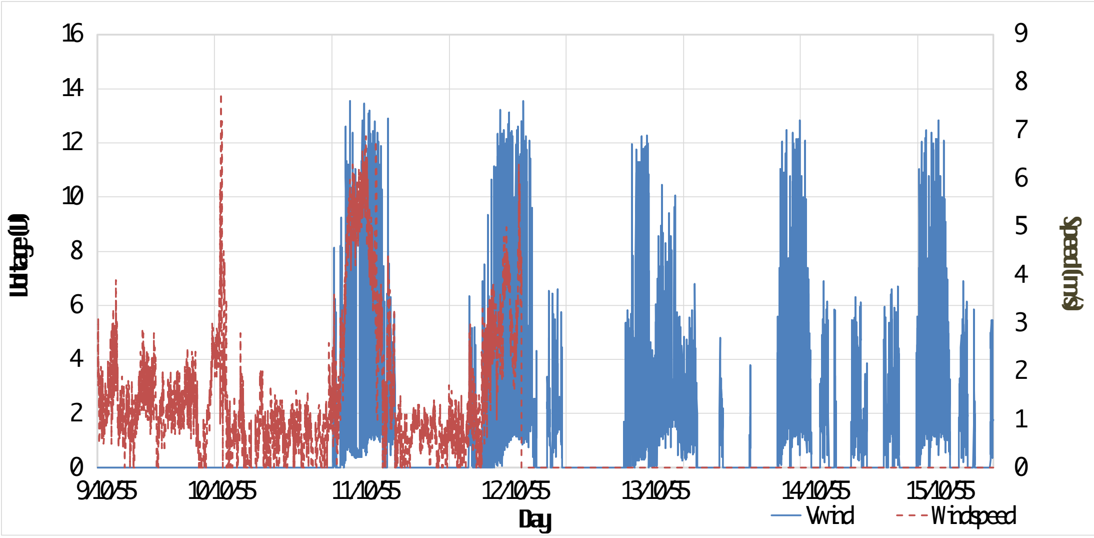

Figure 15. Wind speed and produced voltage on October 9 - 15, 2012

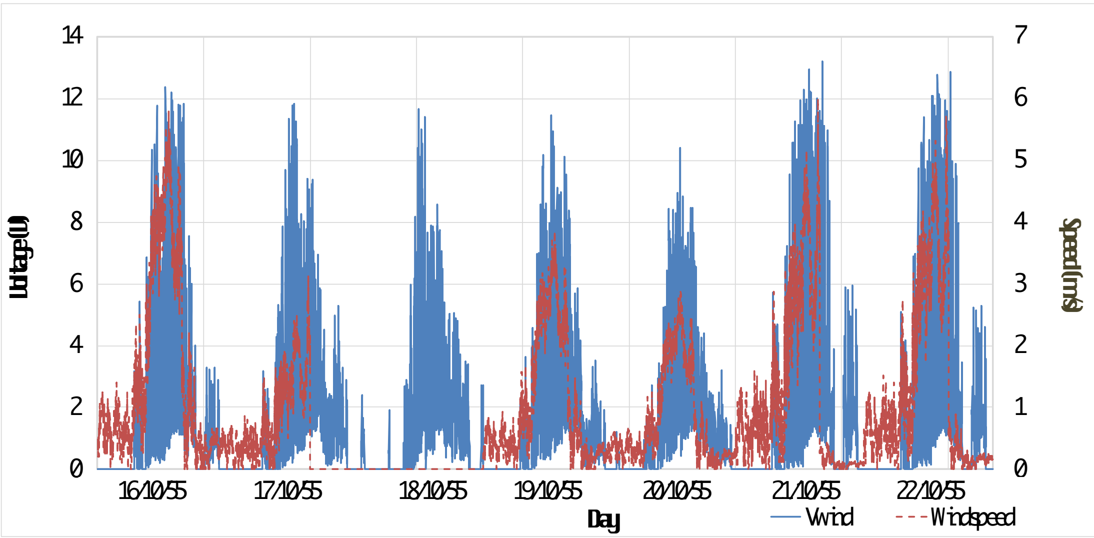

Figure 16. Wind speed and produced voltage on October 16 - 22, 2012

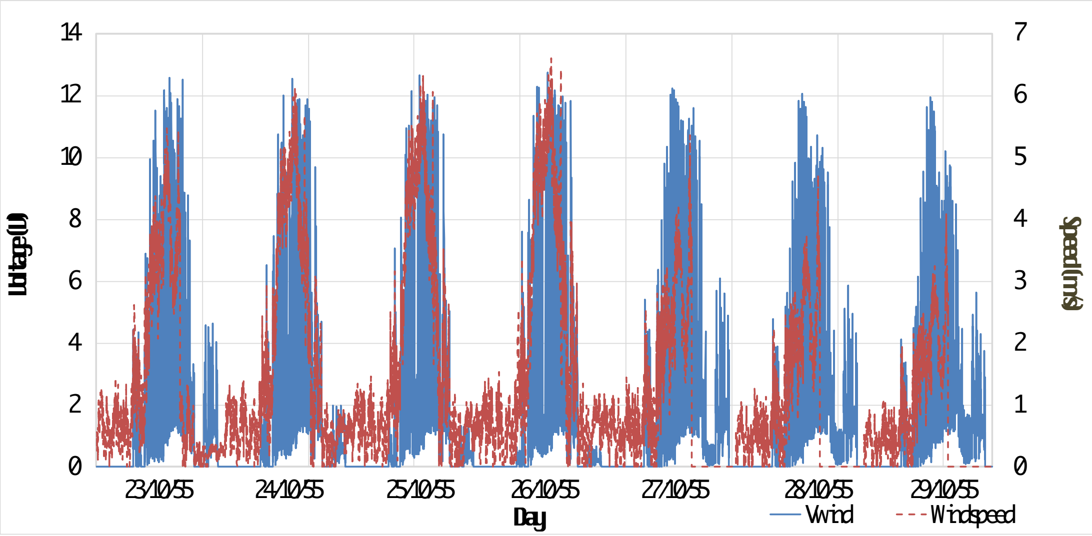

Figure 17. Wind speed and produced voltage on October 23 - 29, 2012

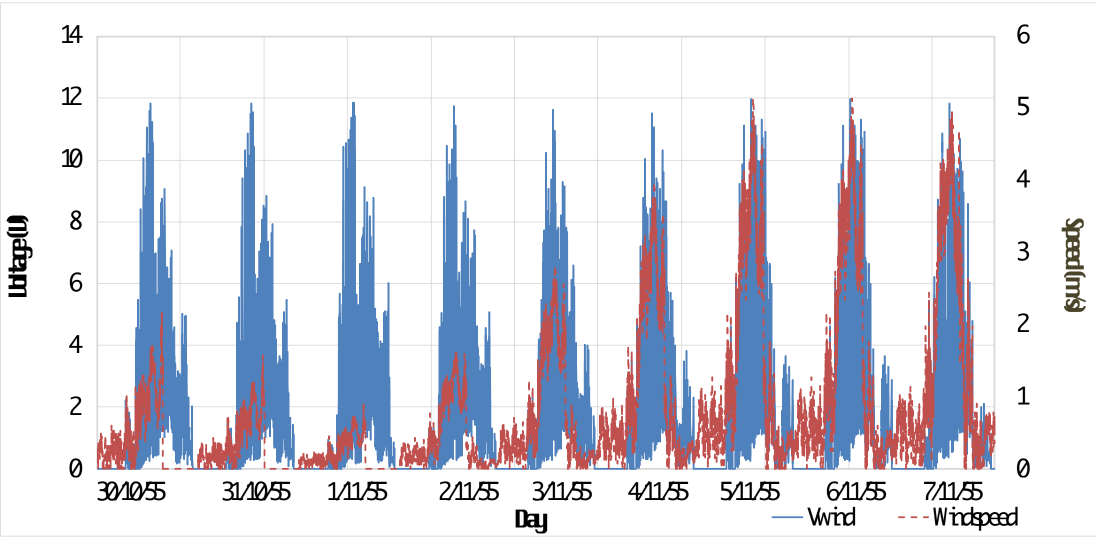

Figure 18. Wind speed and produced voltage on October 30 – November 7, 2012

From the figure 15 – 18, it was shown that the maximum produced voltage from wind turbine is 13.55 V at 5.4 m/s wind speed. The maximum voltage was happened on October 11, 2012 at 10.41 o'clock. Moreover, the average wind speed on 30 days is 0.94 m/s and the average produced voltage is 1.46 V.

4.2 Solar Energy Data

The example of daily produced voltage from solar cell can be shown in figure 19.

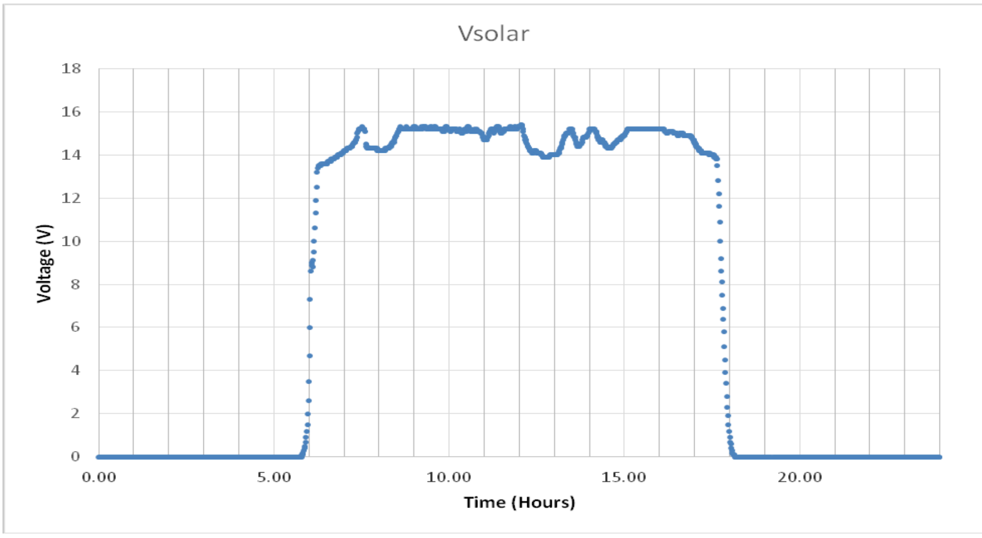

Figure 19. Daily produced voltage on October 10, 2012

From the figure 19, it was found that the produced voltage is quite constant from 6.00 – 18.30 o'clock. The average voltage is 15 V and the maximum voltage is 16 V. The 30 days record data can be shown in the figure 20 – 23.

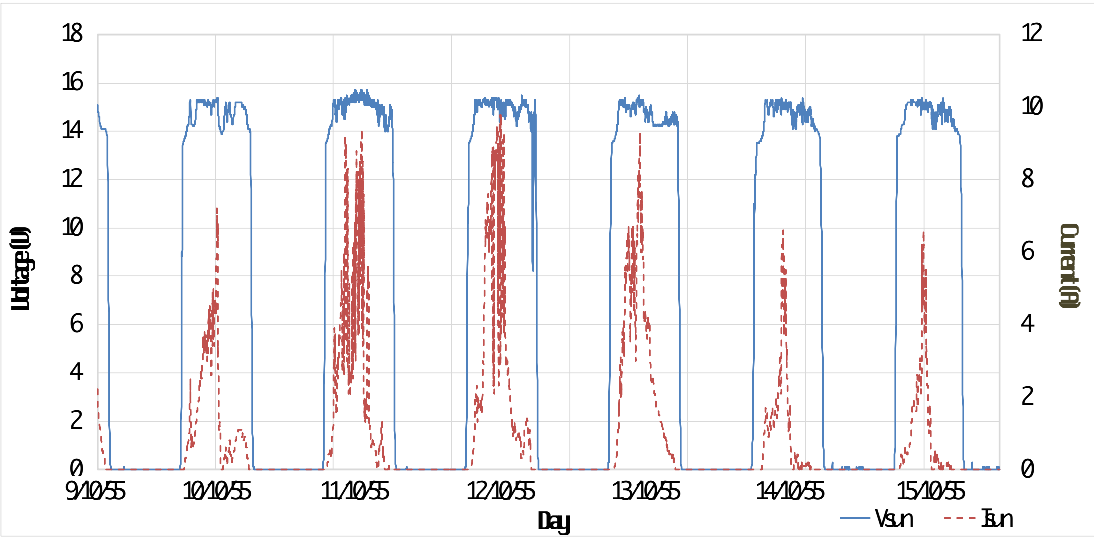

Figure 20. Produced voltage and current on October 9 - 15, 2012

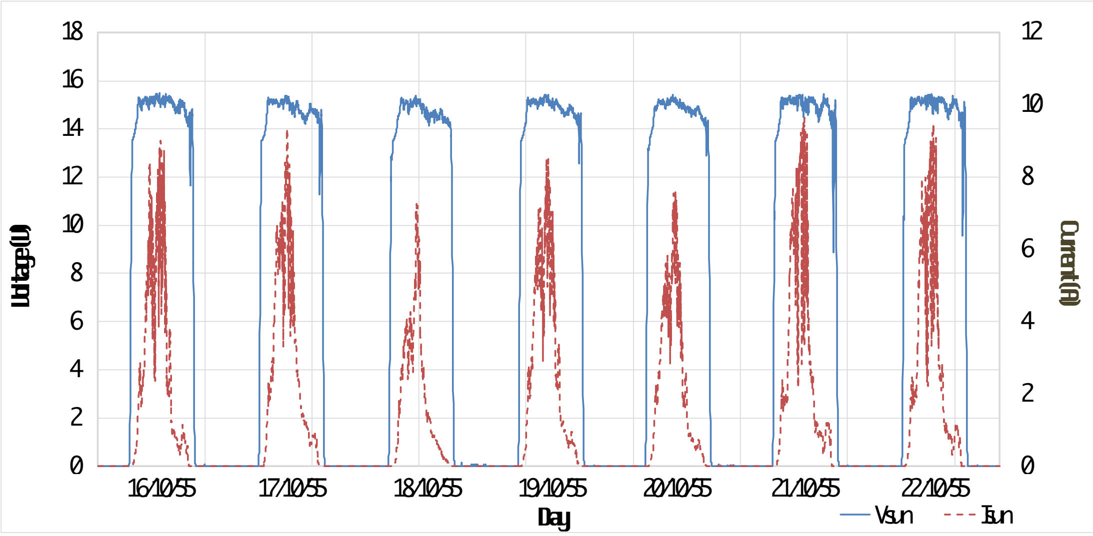

Figure 21. Produced voltage and current on October 16 - 22, 2012

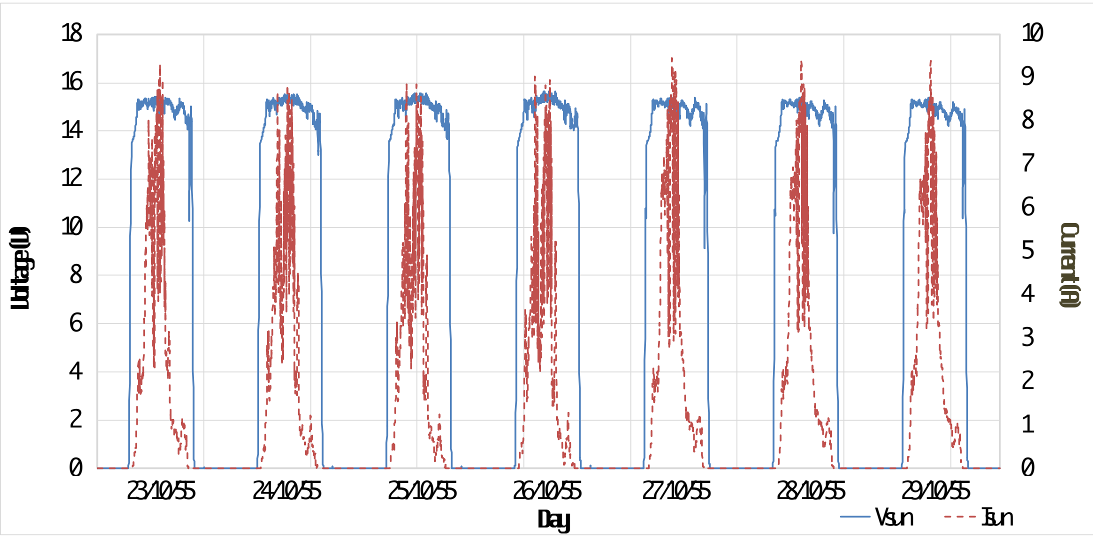

Figure 22. Produced voltage and current on October 23 - 29, 2012

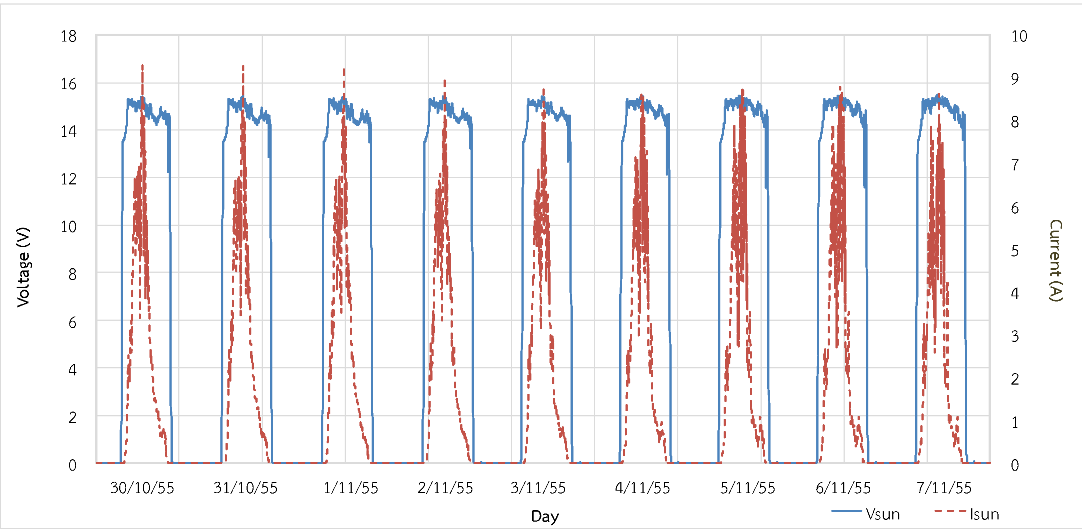

Figure 23. Produced voltage and current on October 30 – November 7, 2012

From the figure 20 – 23, it was shown that the sun rises on the 6.30 o'clock and fall on the 18.30 o'clock. However, the solar cell can be produced the energy only 10 hours per day. The current and power can be produced more than 3 A and 40 W in 9.30 – 12.15 o'clock. The maximum produced voltage is 15.7 V on October 11, 2012 at 11.24 o'clock.

5. Conclusion

This article presents the potential of wind and solar energy at the beach of the public park, Bang Phra District, Si Racha Amphur, Chonburi province, Thailand. The data such as wind velocity, produced voltage from wind turbine, and the electrical parameters from solar cells are recorded from October 9, 2012 to November 7, 2012.

From the record data, we found that the wind velocity is fluctuated at all time. The average wind velocity was 0.94 m/s which were the low rate and the average voltage produced from wind turbine was 1.46 V. Moreover, the maximum voltage was 13.55 V at 5.4 m/s wind speed on October 11, 2012.

Considering the data from solar cells, we note that the sun is rise and down on 6.30 and 18.30 o'clock respectively. However, the solar cell can produce the electrical energy only 10 hours per day. Especially on 9.30 – 12.15 o'clock, the solar cell can produce the current and electrical power much more than 3 A and 40 W. The maximum current was 9.8 A on October 12, 2012 at 11.43 o'clock.

The wind velocity is measured at the 10 m height from the ground. It is low rate (0.94 m/s) and not sufficient to produce the energy (3-4 m/s). Then, if we still need to install the wind turbine, it should be installed at the higher than 10 m. It implies that, in this area, the solar cell is suitable for producing the electric power more than the wind turbine. However, the only 30 days record data were not sufficient to decide for choosing the suitable renewable energy. It should be recorded more than 1 year.

References

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