A Using of Solar Roof Top for Electrical Energy Conservation in Educational Organization

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Abstract. This research presents solar roof top for electrical energy conservation. The case study is implemented in educational building in a campus of university in Thailand. To get the goal of electricity cost reducing under limited budget, the solar roof top is used in some building. This research uses surveys the electrical load data and considers the selecting of building following on the budget. The chosen building is the building of accounting department which the majority of electrical loads are air conditioner and lighting system. From the data, it is observed that electrical load consisted of 27000 W of air condition or about 74%, 4536 W of lighting or 12%, 3850 W of computer or 11% and other about 1160 W or 3% which including refrigerator, kettle and so on. The total load is 36546 W. Therefore, the 12 kW solar roof top is installed. Solar cell in type of crystalline silicon is used. The system consists of the 300 W solar panel amount 17 panels amount 2 sets the total of 34 panels, 2 commercials on grid inverter 6 kW. From the experimental results, it is found that the electrical consumption decreased 20.46% approximately 49103 kWh a year or about 5,729 dollars a year. The payback period is 4.01 years.

1. Introduction
Presently it is clearly that the electrical energy is an important thing for all people on the world. The electricity is the energy source which used for running the many activity; factory, business, transportation, healthy and so on. That means it is needed for country development [1]. According to Statistics of Electricity domestic consumption, it is found that electricity is consumed much more than the past [2]. However, the main source for electricity production still be the fossil energy; coal gas oil and etc. From the energy situation, it is investigated that the fossil energy is used rapidly so in a short period becoming energy crisis [3]. A choice way to solve this problem is using the energy effectively. Not only that but also the alternating energy should be used more. This way is correspondent with [4] which presents both energy conservation and developing the renewable energy continuously.

Presently many countries around the world focus on energy conservation. Thailand is an awareness country for energy situation. It can be seen that Thailand declared Energy Conservation Act 1992 which the designed building and factory have needed to do energy conservation [5]. For the ways of electrical energy conservation, they are several solutions, for example building energy management system (BMS), automatic light control, system control only peak demand period and so on. The interesting another solution is using of solar cell for energy saving.

According to Power Development Plan [6], it is found that the goal of solar cell energy is approximately 10,000 MW while the data in [7] shows that it is used just 1419 MW in 2015. Therefore, Thai government promotes home-use solar panels. Nowadays the cost of solar cell is more reduced than 40% in 5 years ago [8]. Hence the reasons why several factories and organizational building with
greater energy consumption interest in installing solar panels for energy saving and solar self-generating energy [9, 10]. However, some organization cannot install completely all system because it needs the high budget but it need not instead all building in the area. Another choice it system can replace just some building. By this way, the cost of investment can limit and the cost for electrical energy still reduces. Moreover, several building can do it following budget. Although it is that, the electrical load need survey and carefully design system.

Therefore, this research presents the applying solar roof top for electrical energy conservation. The case study focuses on the building of college. The location is in Nakhon Phanom Province, Thailand.

2. Experimental Setup
The research is done in a college. The policy for energy conservation is using solar roof top for one building from several building because of budget limitation. So the data of electrical loads is needed. After that the design is considered. The research results would head to find benefit from this policy.

2.1. Location
The location is set in an educational organization; a college in Nakhon Phanom province, North East of Thailand. The location refers to Latitude 17°37'33.2"N and longitude 104°15'10.0"E. In this area has average temperature of 16 – 35 °C. The location is near the equator which provides uniform solar intensity throughout a year. The peak density of direct radiation in area is approximately 1,350 – 1,400 kWh/m²–year. The area receives an average of 8 sunshine-hours per day. The area of plant covers 40,000 m² (9.88 acre). The transformer 250 kVA is installed. The building in this area is about 9 building. The 2 floor building is considered. In considered building consists of 8 class rooms, 6 office rooms, an electrical control room, 2 toilets and 1 broadcasting room. The working time is 6 days a week; Monday to Saturday. It is close on Sunday. But the lighting outside building is turn on every in the night.

2.2. The electrical loads in observed building
To design the solar roof top system, the electrical loads were surveyed. The details all of load is shown in table 1 and figure 2. The most load is air conditioner about 27000 W or 74%. The next are lighting, computer and other at approximately 4536 W (12%), 3850 W (11%) and 1160 W (3%) respectively. Therefore, the total load is 36546 W.

| The List of Load | Power  |
|-----------------|--------|
| Air conditioner | 27000  |
| Lighting        | 4536   |
| Computer        | 3850   |
| Other           | 1160   |
| Total           | 36546  |

Table 1. The Electrical Loads in Observed Building.

Figure 1. The location of experiment.  
Figure 2. The proportion of electrical loads.
2.3. Specification of device

Nowadays, the silicon solar cells have 2 types; thin film and crystalline silicon solar cell. In this research the crystalline type was chosen because its characteristic is suitable for Thai climate. Moreover, the efficiency of module (watt per area) of crystalline is higher than thin film. So the space needs for installation is less a half of thin film. The crystalline is use by considering from Tier 1 manufacturing certified by PV Tech. It is warrantee the degradation percentage is decreased not over 20% for 25 years.

The inverters presently have two types; central solar inverter and string solar inverter. String solar inverters of 5 kW amount 2 sets were chosen in this research. String solar inverter is small inverter which is suitable of office and home. Because of 2 sets installation, if some inverters fail, the rest can still generate sufficient power required.

The 17 solar panels amount 2 sets (total of 34 solar panels) were installed on the building. They are placed heading to South direction. They were used as pole supporting for solar panel by angle 15° to south as shown in figure 3. The structure made of steel with hot dip galvanizing. The devices to stick made of stainless.

2.4. System diagram

The 10 kW solar roof top was installed on the building. The diagram of system is shown in figure 4. The system consists of 5 kW solar module amount 2 sets. Each set of solar module includes 300W 17 solar panels in type of crystalline. They are connected with grid tie inverter thought out protection sets (fuse and circuit breaker). After that they is connected to main distribution board. The monitoring and data logger is used to get the power generated by VSD (inverter) which they have software.

2.5. Test procedure

The research aims to apply solar roof top for electrical energy conservation. The period of research is succeeded for 2 years. The experiment started since October 2015 to September 2017. The monthly electricity costs were gotten for 2 years. The cost of 12 first months is before performance of solar roof top installation. After installation, the cost of electricity is gotten again to comparing for 12 next months. The solar roof top is stand alone for only one building and no has storage battery. Hench, it distributes the electricity just only on daylight. While in night, the building used electricity form PEA (Provincial Electricity Authority) which is regional seller organization of Thailand. Therefore, analysis in this research is done from real information and economic analysis is performed from the real data at that research time run.

3. Experimental Results

3.1. The Monthly Expense for Utility

Considering monthly expense in 2016 as shown in figure 5, it is found that the college expense for electricity is the highest approximately 86%. The next is water, internet and phone expense at about 8%, 5% and 1% respectively. It is shown that the main expenses for utility in this case is electricity. Therefore, when this cost of electricity is reduced, the money spend is low.
To understand the idea for energy conservation, it can be observed by figure 6. It is found that the total cost varies on the cost of electricity clearly. While another expenses; phone, water and internet is very lower than once. Moreover, they are quite constant. Therefore, to reduce cost, the electrical energy should be focused.

![Proportion of Monthly Expenses](image)

![The Cost of Monthly Utility](image)

**Figure 5.** The diagram of solar pump systems.  
**Figure 6.** The diagram of solar pump systems.

### 3.2. The cost of electricity saved

For the cost of electricity in a period which in this research did 2 years. From the figure 7, it can be seen that the electrical consumption in the month for before and after perform is difference outstanding. The electrical consumption of after run project is lower clearly than before. Considering the data, it is the results of performance. It is found that the average the used electricity after installed the solar roof top is less than before. The used electricity is reduced from 239959 kWh to 190856 kWh which is conserved result is about 49,103 kWh. The cost of electricity is decreased from 27995$ to 22266$ which saved cost is about 5,729$.

![The Expenses for Monthly Electricity](image)

| The List  | Before | After | %Saving |
|----------|--------|-------|---------|
| Cost per year ($) | 27995  | 22266 | 20.46   |

**Figure 7.** The cost of utility for each month.

### 3.3. The Economic Analysis

To understand investment, the economic analysis is needed. The details are shown in table 2. The investment cost in this project is limited 700,000 Bath or. Therefore, by the cost, the 2 sets of 5 kW solar roof top were chosen. From in formation form electricity bills all 2 years, it shows the consumed units (kWh) is decreased about 49103 kWh a year. It is found that the saved electricity cost is
171585.61 Bath a year. Therefore, this organization would get payback form this investment in 4.08 years. In conclusion, it can be said that this project is interested.

4. Discussion
From the research results, it is found that policy of electrical conservation by using solar roof top is get target well. The way to use this policy, personnel responsible for energy needs understand the behaviour of electricity consumption. Considering this case study, the policy is done in building of educational organization. Generally main expense is electricity cost which it is approximately 86% of all expense. Therefore, it can be seen that if the electricity cost is reduced, the monthly expense is more decreased. Moreover, the next important point should be focused is the type of load. For the educational organization, the majority of electrical loads are air condition and lighting and at 74% and 12% of all loads. For general educational building, these loads are run in daylight. So it is corresponding to solar cell run. However, some load of lighting is turn on in night hence the conventional source of electricity still needed. Although some load run in night, majority of loads run on the day light. The next interesting point, this research aims to present the solution of conservation by replacing solar cell instead some part. Really it should be replaced completely, but it is difficult because the budget is limited. However, this research shows it can save the cost of electricity 20.46% years while investment is just some expensed only. The payback period is just 4.01 years.

Table 2. The Economic Analysis.

| The List          | The Value       |
|-------------------|-----------------|
| Investment (I)    | 23000 $         |
| The Saved Energy  | 49103 kWh       |
| The Saved Cost    | 5,729 $         |
| Payback Period    | 4.01 Years      |

5. Conclusion
From the results presented in this paper, it is concluded as following.

1. The main expense in educational organization is electricity cost which it is approximately 86% of all expense.
2. The majority of electrical loads in educational organization are air condition, lighting and computer at 74%, 12% and 11% of all loads respectively.
3. The policy of solar roof top can save the electrical cost and energy is about 20.46%.
4. The investment cost is 23000 $. The solar roof top is 10 kW. The project has payback period in 4.01 years.

In conclusion, the solar roof top project is saved energy and the cost therefore this way is interested.

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