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Potential of using a Solar-Electricity Hybrid System in North-East of Thailand

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Abstract

We propose a new techniques system of sufficiency energy using solar cell created direct current (DC) and inverter system convert to alternative current (AC) for upon normal electric system. Simplify by a system consists of three phase and three inverter circuit for support electric system in office. Results of experimentally obtained have shown the potential of using such a save power electricity ~10% of normal electricity system. These properties make it very appropriate for routine monitoring of emitter region, including in-line process control. In near future we can the investment for solar energy is very economic in long term combination energy system 1 Mwatt.

***Keywords**:* Solar energy; Alternative energy; Hybrid energy system; Combination system; Sufficiency energy

1. Introduction

Recent technological progress opens new perspectives for *Integrated Solar Fossil Cycle Systems* (ISFCS). In the context of increasing global environmental concerns, these perspectives offer the possibility of accelerating fossil fuel substitution (even if only partial), and therefore reducing emissions, while ensuring an adequate power availability [1]-[3]. The solar power plant can also be used in hybrid by adding a small solar field to fossil fuel plants such as coal plants or combined-cycle natural gas plants in so-called *integrated solar combined-cycle plants* (ISCC) [4], concept of white light generation using a nano-waveguide for the solar radiation collection use [5], A contactless photoconductance technique to evaluate the quantum efficiency of solar cell emitters [6], solar-hydrogen/fuel cell hybrid energy systems for stationary applications [7], a hybrid solar system—solar air heater combined with solar cells [8]. As the solar share is limited, such hybridization really serves to conserve fuel. A positive aspect of solar fuel savers is their relatively low cost: with the steam cycle and turbine already in place, only components specific to solar power plant require additional investment. Such fuel savings,solar power plants in Swedish island, in Rajasthan of India, Brazil, Denmark and Turkey [9]-[14].

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The electric power generation accounts for 40 percent of human-generated carbon emissions. Solar energy can provide a material part of global low-carbon electricity needs at costs directly competitive with fossil alternatives, and can meet "utility grade" power quality, cost and reliability requirements [15]. In addition to significant emissions reduction and environmental benefits, solar offers sharply reduced supply and commodity risk. Three primary solar technologies – solar thermal electricity, photovoltaic solar (PV)[16], and solar heating are maturing rapidly , on a fast-declining cost curve.

The solar energy offers nearly unlimited potential to generate clean, carbon-free power. In this paper , about 3-5 percent of the North-East of Thailand areas, if devoted to solar power generation and linked to demand centers by the combination solar power plant [17], could be sufficient to meet total global electricity demand as forecast for near future.

2. Theory and Background

In Fig.1 show the solar radiation spectrum relation the spectral irradiance and wavelength. The solar energy most significant advantage over traditional energy sources is environmental. Concentrated solar plants (CSP) produce no CO2 or other emissions during operation; by contrast, the average 00 MW coal plant produces .7 million tons of CO2 annually, along with major releases of other greenhouse gases (GHG).

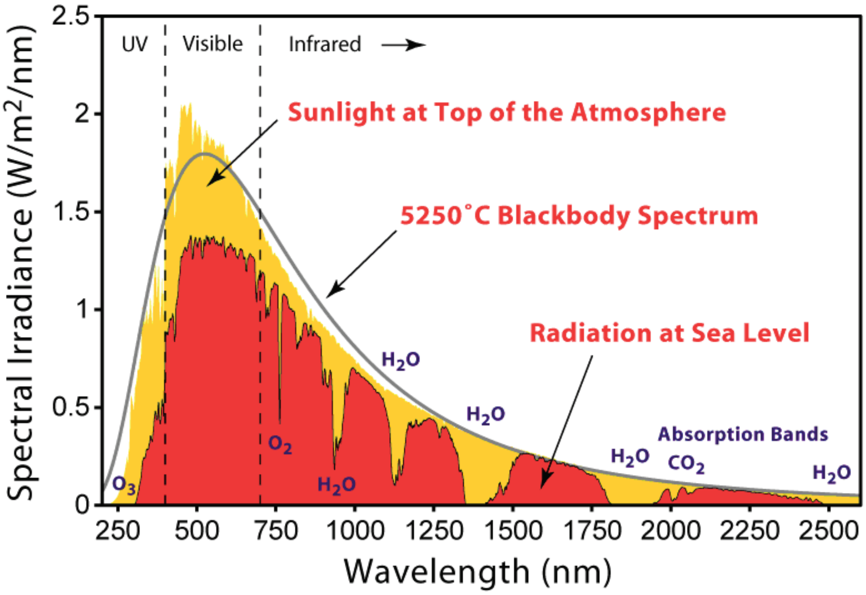

Fig. 1 Solar radiation spectrum [18]

Further, the construction carbon costs of solar plants, relative to the carbon savings, are not material over their lifetime. The Earth's atmosphere protects us from the higher-energy forms of light, such as ultraviolet rays. In fact, the existence of life on Earth would be far less likely if these more damaging forms of energy were more abundant. The terrestrial spectrum in Fig. 1 describes the light that actually reaches the Earth's surface after passing through the atmosphere.

2.1 Quality Factor

The quality factor (Q) is defined as the quotient of the real electric output energy measured at the system output (E_{load}), which is the system load (E_{demand}) and the theoretical output energy (E_{th}), which is defined as the output energy from the same system under ideal conditions, which is the Standard Test Conditions (STC).

$$Q = \frac{E_{Load}}{E_{th}} \tag{1}$$

Where Q is quality factor of the system, E_{Load} is real electric output energy [kWh] and E_{th} is theoretical output energy of the system [kWh].

The quality factor can be determined over any given time period. In most cases, a time period of one year is chosen to presize PV systems. The theoretical output energy (Eth) is defined as the energy output, which is produced by a PV array with an area of Aarray, the global radiation Eglob incident on a horizontal surface and efficiency η determined under STC:

$$E_{th} = \eta \cdot E_{glob} \cdot A_{array} \tag{2}$$

where E_{th} is theoretical output energy of array [kWh], η is efficiency of the PV array [decimal], E_{glob} is global radiation [kWh/m^2] and A_{array} is area of the PV array [m^2].

It is often difficult to obtain values like the efficiencies from manufacturers. Besides, the area of the array is frequently unknown. However, the peak power measured under STC is normally given (STC: I_{STC} = 1000 W/m^2; T_{STC} = 25 °C, AM = 1.5).

$$P_{peak} = \eta \cdot I_{STC} \cdot A_{array} \tag{3}$$

where Ppeak is peak power of the PV array [kWp], η is efficiency of the PV array [decimal] ISTC = global radiation under STC [1 kW/m^2].

Aarray is area of the PV array [m^2] According to the equations (3) and (4) after substitution of η· A_{array}:

$$E_{th} = P_{peak} \cdot \frac{E_{glob}}{I_{STC}} \tag{4}$$

According to the equations (2) and (5) the quality factor can be found out:

$$Q = \frac{E_{Load}}{E_{glob} \cdot P_{peak}} \cdot I_{STC} \tag{5}$$

With the quality factor formula (6) and the empirical quality factors of existing systems it is practical to use this quality factor (Q) to pre-size the PV array.

2.2 Sizing of PV System

From the quality factor (Q) in *(6)* , the PV array can be sized accordingly:

$$P_{peak} = \frac{E_{Load} \cdot I_{STC}}{E_{glob} \cdot Q} \tag{6}$$

where P_{peak} is peak power of under STC [kWp], E_{load} is real electric output energy [kWh/a], I_{STC} is solar radiation under STC [1 kW/m^2] , E_{glob} is annual global solar radiation [kWh/m^{2}a] and Q is quality factor of the system .

In the theory, supply and demand values are equivalent and the quality factor is therefore equal to one (Q = 1). A measured value of, for example, Q = 0.75 means that 75 % of the electric energy, which is converted from the incident solar energy, is used whereas 25 % of the electric energy is lost between the solar cell and the system output or it is not used [19].

3. Experimental

Electricity from solar power system is shown in the Fig. 2 system is also receiving (AC) electrical power systems produce electricity from solar energy and is the main distributor of electricity, which was continued through the second power systems are the first is solar energy to electricity distribution systems with main electrical power in the second power from the main electrical distribution alone. Fig. 3 shows the solar plant location of the North-East of Thailand and the combination system by inverter connection of electrical power system by the 3 phases, which the line is 220 V used in electrical system.

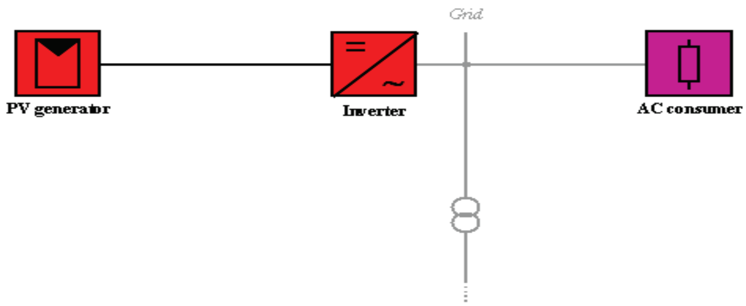

Fig. 2 shows the model solar installation for combination of electrical power system.

(a) (b)

Fig. 3 shows the solar plant real location (a) and the inverter for connect the electrical power system (b).

4. Results and Discussion

The data was recorded from 4:00 to 20:00 time, the information to the inverter is set because we designed the cell and panel 3 inverters set to pay liabilities of the three phase electrical engineering building. Data sets, each set including inverters. Total energy (E-total) measured in kilowatt hours. And total time (T-total) measured in the two-hour recorded information is beginning to connect to the grid system and the day progresses. The following is the AC power (*Pac*) measured in watts. AC voltages (*Uac*) measured in volts. Alternating current (*Iac*) measured in milliamps. Voltage of the cell panel (*Upv*) measured in volts. And electricity from the panel cells (*Ipv*) measured in milliamps. The information is information that occurs during periods of record. The result has been recording every 30 seconds.

Figure 4 shows the average energy per day of each month during the first years of electricity per day in each month, the highest value is 4.683 kWh in October 2009, in the winter. Electricity per day in each month is 3.239 kilowatt-hour charge in August 2010, which is in the rainy season. Of energy to designing the panels, each set of a 1 kW is 3.75 kWh (3.75 units) per day will see some day is lower than the power demand. But on the other is more than quite a lot. The average power of about 4 kWh per day is noted, which is higher than the minimum reasonable needs.

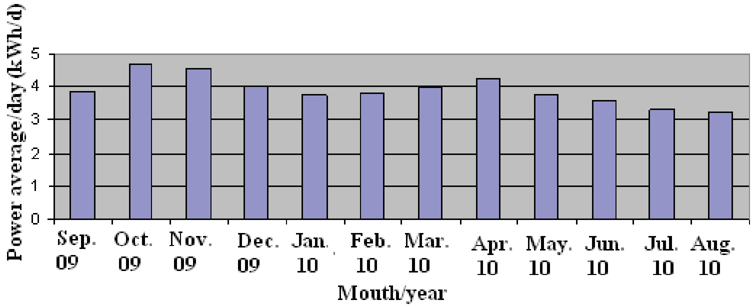

Fig. 4 shows the experiment of the average solar power for months.

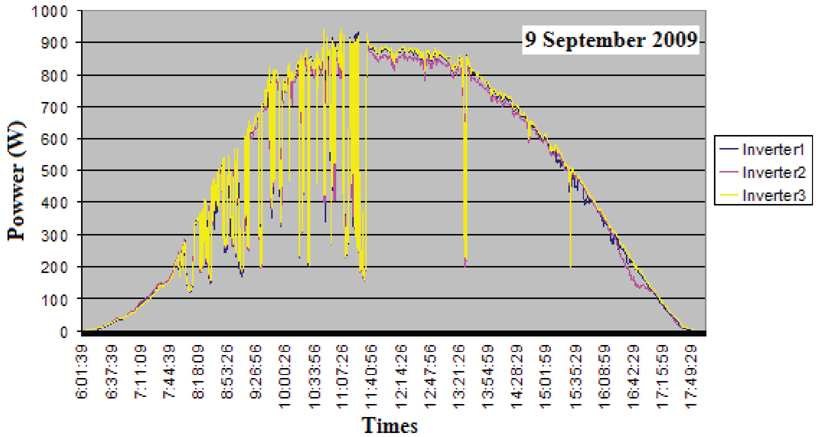

Fig. 5 shows the solar power in 3 lines of inverter on 9 September 2009.

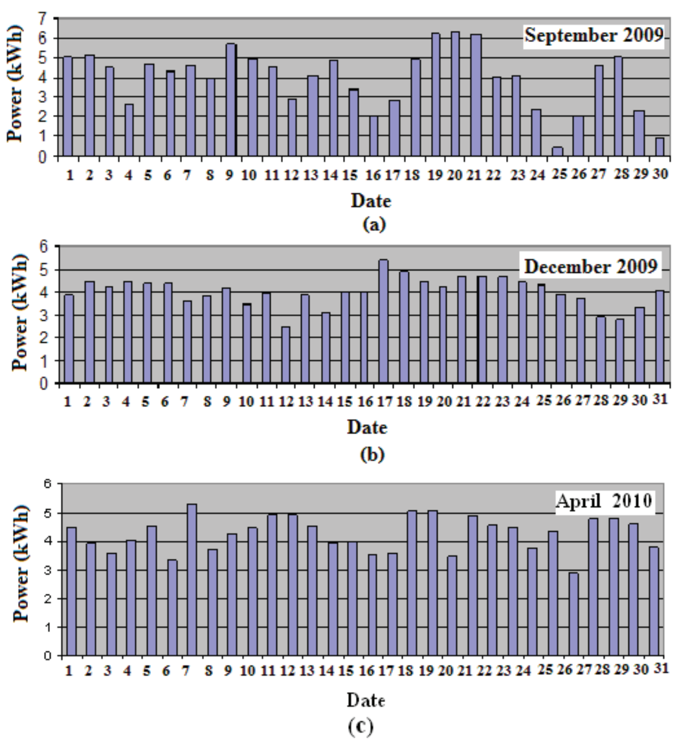

Fig. 6 shows the average solar power of September (a), December 2009 (b) and April 2010.

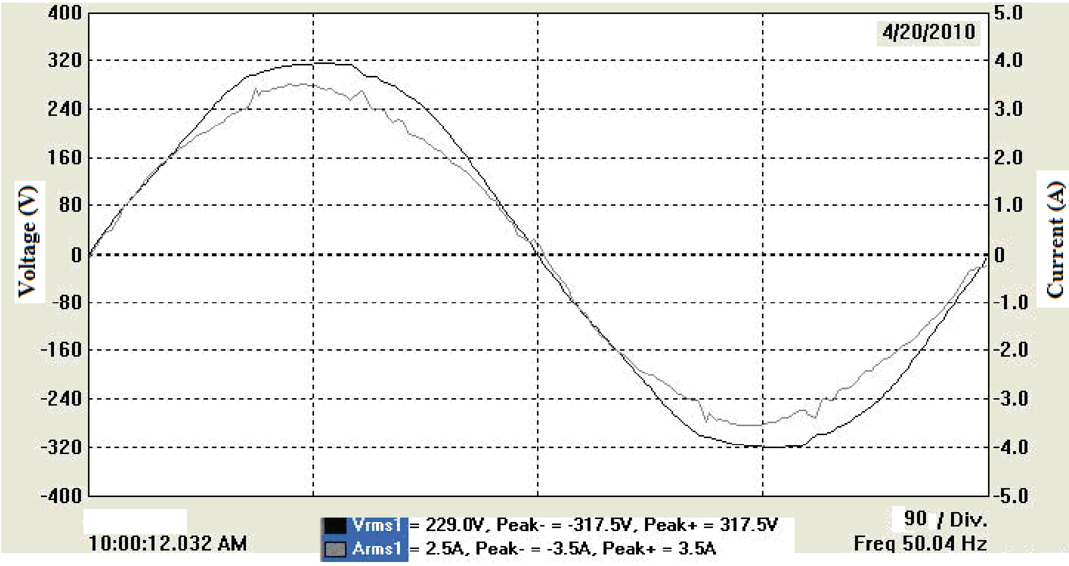

Fig. 7 show the voltage (V) and current (A) when combination in electrical power system to solar power system

In Fig. 5 shows the solar power in 3 lines of the inverter link for 3 phases of electrical power. The average solar power is 900 watt on 9 September 2009, which can be connecting the normal system and combination the electrical system. In Fig. 6 shows the average solar power of September 2009 in raining season, December 2009 in winter season and April 2010 in summer season , which the sufficiency power for small solar plant investment in future. Because the average power enough for the solar plant power 1 MW. The return on investment (ROI) of solar plant in the 6 – 7 years when compare the fossils fuel end of the world in near future. The North-East of Thailand area has potential of solar intensity very more other area of Thailand.

Fig. 7 shows the voltage (V) and current (A) when combination in electricity power system to solar power system. The solid line is the power of electrical power system 3 phases voltage level 320 Vp-p and the gray line is the current of solar power system 3 phases from inverter (V_{rms} : 200~220 V per line) and the current (I_{rms}) between 1.0-1.2 A. The solar power combination can be of electricity system approximate 10-15 % .That affect the compensation of the electrical current sufficient to the electricity power. The location for the research is the Phang Khon of Sakon Nakhon Province, Thailand, which is located in the northeast of Thailand, latitude 17 degrees 21 minutes north long optical amplitude 103, 42 minutes east as shown in Fig. 8. The electricity production from solar cells that used the electricity from solar systems connected to a grid. The size of the solar electric system is 1 kW and the solar panels that use is a form amorphous.

Fig. 8 The research location at the Phang Khon district of Sakon Nakhon province of Thailand by Google map.

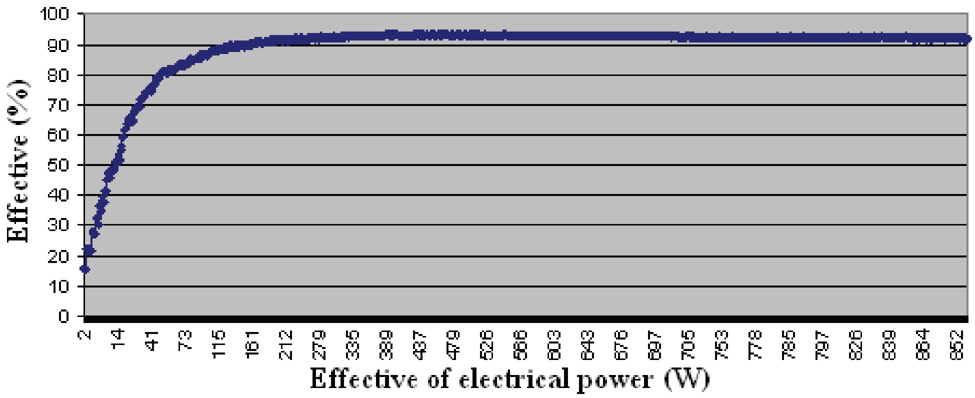

Fig.10 shows the Effective of inverter system.

Fig. 10 shows the inverter efficiency compared to the AC power system that pays out the most powerful 93.2 %. Solar technologies provide energy for heating, cooling, and lighting homes and heating water without any direct emissions; as a result, these technologies can help combination system and improve green energy for good quality of life. The use of solar energy systems on buildings displaces electricity generation from coal, natural gas, and oil power plants, which can reduce air pollutants such as nitrogen oxides, sulfur dioxide, and mercury; and greenhouse gas emissions such as carbon dioxide.

Finally, the high-efficiency approaches to solar energy conversion offer the potential in the extended time frame to produce devices that can convert much larger portions of the solar spectrum. Given the anticipated market growth, nearly all of these approaches will have to be investigated in parallel to meet the demand. The near future the solar cell will low cost when energy of fossils oil to be very expensive.

5. Concussion

In this paper present the effective of solar power plant 1 kilowatt in Sakon-Nakhon province, North-East of Thailand have been power potential is 4 kilowatt-hours. The productivity of the solar power plant of 1 megawatt can be support 4,000 units/day or 4,000 kilowatt-hours. Solar energy in a year is 1,427.6 kilowatt-hour. And average energy per day in each month, the highest value 4.683 kWh in October 2009, a winter.The average energy per day in each month low value 3.239 kWh in August 2010, a rainy season.

The investment income 103 millions Baht between 6.3 – 7.0 years for solar power plant in long term business 20 years for solar power plant of 1 megawatt. Which high potential of alternative power energy for management green energy and achieving efficient primary conversion of solar energy by fast long-lived charge separation will have a significant impact on the efficiency of energy conversion and storage in solar to fuel converting devices in the next future when the fuel end of the world.

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Reference

[1] J. Dersch, M. Geyer, U. Herrmann, S. A. Jones, B. Kelly, R. Kistner, W. Ortmanns, R. Pitz-Paal and H. Price, Trough integration into power plants—a study on the performance and economy of integrated solar combined cycle systems, Energy ,vol. 29,pp 947-959,2004.

[2] M. Kane , D. Larrain , D. Favrat , Y. Allani, Small hybrid solar power system, Energy, vol. 28,pp 1427–1443,2003.

[3] Allani Y, Favrat D, von Spakovsky M. , CO2 mitigation through the use of hybrid solar-combined cycles. Energy Conversion Mgmt., vol. 38, pp. 661–667, 1997.

[4] P.D. Lund, Optimization of stand-alone photovoltaic systems with hydrogen storage for total energy self-sufficiency, International Journal of Hydrogen Energy, vol. 16, ,pp 735-740,1991.

[5] P.P. Yupapin, N. Pornsuwancharoen, R. Sakulpong, B. Plangklang, A new concept of white light generation using a nano-waveguide for the solar radiation collection use Optik - International Journal for Light and Electron Optics, *(Article In Press)*, Corrected Proof, Available online 9 September 2009.
[6] A.Cuevas, R. A. Sinton, M. Kerr, D. Macdonald, H. Mäckel, A contactless photoconductance technique to evaluate the quantum efficiency of solar cell emitters, Solar Energy Materials and Solar Cells, vol. 71 ,pp 295-312,2002.
[7] A. Yilanci, I. Dincer, H.K. Ozturk , A review on solar-hydrogen/fuel cell hybrid energy systems for stationary applications, Progress in Energy and Combustion Science, vol. 35,pp 231-244,2009.
[8] A. K. Bhargava, H.P. Garg and R. K. Agarwal, Study of a hybrid solar system- solar air heater combined with solar cells, Energy Conversion and Management, vol. 31,pp 471-479,1991.
[9] A. Sundkvist, A. Jansson, A. Enefalk and P. Larsson, Energy flow analysis as a tool for developing a sustainable society—a case study of a Swedish island Resources, Conservation and Recycling , vol. 25 ,pp. 289-299,1999.
[10] K. S. Malhotra, P. B. Lal Chaurasia A plan for energy management in 110 villages of the Silora Block in Rajasthan, India Energy, vol. 6, pp 591-601,1981.
[11] Almeida M A, Schaeffer R, La Rovere E L. The Potential for electricity conservation and peak load reduction in the residential sector of Brazil, Energy, vol. 26,pp 413-429,2001.
[12] Lund H. , Implementation of energy-conservation policies: the case of electric heating conversion in Denmark. Applied Energy, vol.64, pp.117-127,1999.
[13] Mæng H, Lund H, Hvelplund F. , Biogas plants in Denmark: technological and economic developments, Applied Energy, vol. 64, pp. 195-206,1999.
[14] N. K. Salihoglu, V. Pinarli, G. Salihoglu, Solar drying in sludge management in Turkey, Renewable Energy, vol. 32, pp. 1661-1675,2007.
[15] D. K. Sidiras and E. G. Koukios, Solar systems diffusion in local markets , Energy Policy, vol. 32, pp. 2007-2018, 2004.
[16] K. L. Shum, C. Watanabe , An innovation management approach for renewable energy deployment—the case of solar photovoltaic (PV) technology , Energy Policy, vol. 37, pp.3535-3544, 2009 .
[17] Z. A. Hammou, M. Lacroix, A hybrid thermal energy storage system for managing simultaneously solar and electric energy, Energy Conversion and Management, vol. 47, pp. 273-288, 2006.
[18] W. Wobrock and R. Eiden , Direct solar radiation: spectrum and irradiance derived from sun-photometer measurements, Applied Optics, vol. 27,pp. 2253-2260,1988.
[19] J. Schmid, Photovoltaic systems Technology, teaching script, IEE-RE, University of Kassel, Germany, 2002.