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Economic analysis of CO_2 emission reduction from large scale photovoltaic power plant in Thailand

Prapita Thanarak[a]*, Kanda Sae-Eir[b]

[a]*Lecturer, School of Renewable Energy Technology, Naresuan University, Phitsanulok 65000, Thailand*

[b]*MS student, Graduate School, Naresuan University, Phitsanulok 65000, Thailand*

Abstract

The present technology of the photovoltaic is still highly costing and the efficiency can improve to maximize efficiency, so the investor need to collect and study the return of project. In general the photovoltaic module has life time about 25 years and the almost of Photovoltaic Power Plant costing modules about 70% of portion. Hence, the degradation of photovoltaic module has an effect to the energy yield and benefit of project. The return of the project also depend on many factors such as the temperature, moisture content, the damaged of modules, government subsidy, CDM benefit and etc.

This paper is considered the effecting about the degradation of 2.16MW amorphous photovoltaic power plant that the energy yield output is directly affect the capital and cost of project. The return of the investment when the solar module was degrade of the efficiency 10%, 20%, 30% by using NPV, BCR, IRR and PB to find out though the breakeven point of project and the degradation percentage that unacceptable to investment. This paper output applicability to determine to others amorphous photovoltaic power plant project by adjustment some information and factors appropriate to each project site.

Keywords: economic analysis; CO2 emission reduction; photovoltaic power plant

1. Introduction

Nowadays the electricity consumption situation is critical because electricity is one of the necessities in our life. People need the benefits of using electricity for daily activities 24-hours a day. Today, almost all of the electricity productions in Thailand are sourced from natural gas, coal, gasoline and so on. The growth rate of energy supply not only limited to the sourcing quantities but also to the energy sources emissions of the toxic as carbon dioxide that cause the global warming. The methane gas released to the atmosphere has increased and impact the environment that has an effect to the climate change issue. The

* Corresponding author. Tel.: +66-55-96-3193; fax: +66-55-96-3182.
E-mail address: prapitat@nu.ac.th

fossil combustion from oil, coal and other gasses are the causes of the carbon dioxide emissions; the ocean, atmosphere and soil absorb the toxic waste by half-and-half and the rest of the carbon dioxide will be trapped in the atmosphere for over a century. The twenty percent of fossil fuel pollution from 2007 is reckoned to be trapped in the atmosphere over thousands of years. According to the information from the scientific evaluation of the international climate change committee, the methane level in the atmosphere has increased for the first time last year since 1998. The methane increase has strengthened the greenhouse effect more than the carbon dioxide by 25 times. The global increase of carbon dioxide was dense in 2007, in year 2005 which represent third-time rise of carbon dioxide peak according to the atmosphere measurement data collection. Currently there is electric-power farms that operates as private businesses in Thailand from solar energy, almost all are amorphous photovoltaic (PV) power plants. Investors are interested in the innovation of PV cell and also invested in the research and development for it. This is due to the fact that PV can generate unlimited clean energy from the sun. Furthermore, this technology can be applied and installed in any place that the sun radiations can reach and requires only low maintenance. However, the Amorphous PV module has limitation life cycle and the standard capacity specification to produce the electricity from production line from the manufacturing was authenticated by use the standard testing and provide information in order to marketing and commerce aspect to investor for consideration and project assessment. In the actual use under operating condition, PV module has the degradation factor of power generation and this issue was affected to final yield production which continuing effect to the economic aspect and CO_2 emission reduction.

1.1. Amorphous PV degradation

The characterization of degradation in amorphous PV module performance parameter is related to the project investment in PV Power. The estimate of life cycle of PV array is about 25 years and the warrantee of PV array performance is ≥80% electricity generation of PV life (warranty the degradation ≤20% to PV life 25 years), this factor to effect to final yield per year to decreasing and also extension payback time of time of project investment. This issue was caused of increasing cost of project which the investor need to consideration. The following fig. 1 presents the result of simulation for what if PV module degradation 10% - 30% and using to be parameter for next scenarios.

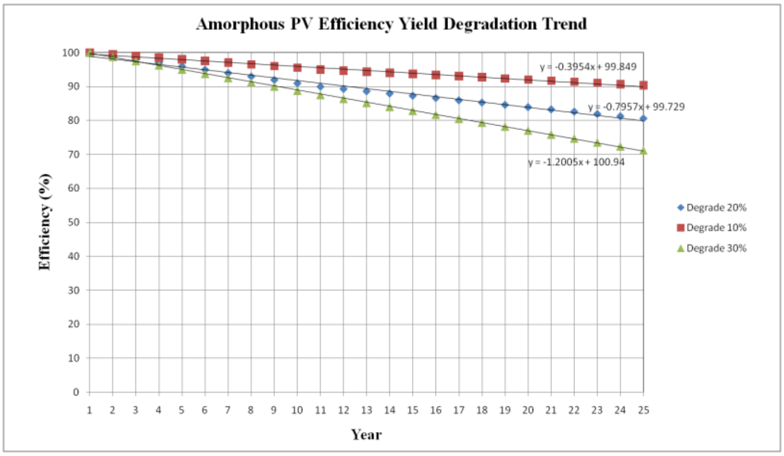

Fig. 1. Simulation of Amorphous PV efficiency Yield Degradation Trend 10-30%

Nipon Ketjoy, et al. [1] has did research about effect natural parameter on outdoor performance of amorphous silicon photovoltaic module in actual field conditions for long term performance and found that the effect of the natural parameters an a-Si performance under actual conditions such as the irradiance was effect on current of a-Si and array temperature was effected on voltage of a-Si, and relation between the irradiance and array temperature could be correctly predict power output of photovoltaic array and array yield of a-Si array.

Nattawut Khaosaad and Nipon Ketjoy [2] had did research about solar spectrum investigation in Phisanulok province and found that the radiation come to the world, the specification of solar spectrum was absorbed for first time by atmosphere and absorbed again by clouds, stream and all gas before arrive to the earth surface. The solar spectrum in earth the area is valuable rough as result of but the area has will the weather is opposite make the solar spectrum. SERT has did research about solar spectrum investigation about behaviour of solar spectrum in Phisanulok province during each season. The result is during rainy season has solar spectrum season will valuable least regarding to crisis makes the sky has very the clouds rather make the solar spectrum was absorbed more than other season.

Nattawut Khaosaad and Nipon Ketjoy [3] had did research about degradation of maximum peak power of photovoltaic under the operating condition in long term installed by studies on 3 types of PV module behaviour such as Amorphous Silicon, Poly Crystalline and Hybrid Crystalline Silicon by captured to Current (A), voltage (V), power (W), array temperature (°C), ambient temperature (°C) and solar irradiation (W/m2) were measured by PV analyzer. The results of research found that the degradation rate of Pmax of three different types is 2.22, 2.17 and 3.75 respectively. It can conclude that, HIT has the most degradation rate.

Nattawut Khaosaad, Thitiporn Jorjong and Nipon Ketjoy [4] has present about the Investigation of Annual Photovoltaic Array Yield under Actual Application by studies on 3 types of photovoltaic module as amorphous silicon solar cell (a-Si), polycrystalline silicon solar cell (p-Si) and hybrid silicon solar cell (HIT). The arrays are installed in a 10 kWp PV - AC power plant at the School of Renewable Energy Technology (SERT). The annual yield outcomes were collected during July 2005 to December 2008. The a-Si, p-Si and HIT modules are respectively found as 2005: 885, 739 and 798 kWh/kWp, in 2006: 1,891; 1,676 and 1,779 kWh/kWp, in 2007: 1,761; 1,604 and 1,703 kWh/kWp, and in 2008: 1,670; 1,496 and 1,583 kWh/kWp.

1.2. Environmental impact and CO_2 Emission

Sergio Pacca, et al. [5] has presented about assessment of modeling parameter that affect the environmental performance of two state of the art PV electricity generation technologies: the PVL136Thin film laminates and the KC120 multi-crystalline modules by three metrics to assess the module's environment performance. The net energy ratio (NER), the energy payback time (E-PBT) and the CO_2 emissions are calculated using process based LCA methods. The result reveal some of parameters such as the level of solar radiation conversion, the position of the modules, the module's manufacturing energy intensity and its corresponding fuel mix and the solar radiation conversion efficiency of modules which effect the final analytical results. The most effective way to improve the module's environment performance is to reduce the energy input in the manufacturing phase of the modules. The NER of PV is the key to the success of the performance of this scheme. The results show that the NER base on PV system can be 3.7 times higher than the NER base on electricity supplied by the traditional grid mix and CO_2 emission can be reduced by 80%

F.Pietrapertosa, et al. [6] studied about the impact of the integrated activities system to Life Cycle Assessment (LCA), External of Energy (Extern E) and comprehensive analysis to evaluate the whole environmental burden of productive processes and to indentify the best recovery strategies from both environment and economic point of view. The framework of an analytical methodology base on the integration of LCA, Extern E and comprehensive analysis was developed to perform an in-depth investigation of energy systems aimed to better characterize the environmental impact of the energy system. These scenario analysis shows the efficiency increase and energy saving are privileged tools for driving a steady reduction of energy consumption, whereas renewable energy sources have a key role in supply system but need an in depth characterization of the construction and dismantling phase that may contribute heavily to environment damage, the eco-taxes are important to estimate fair price of resource and to promote the use of eco-compatible technologies and resources including the environmental component in the cost of goods and services, its possible to reduce the cost gap among traditional and innovative technologies.

Vasilis Fthenakis, et al. [7] studied about the land use and electricity generation to emphasize on a life cycle analysis. To compare the land transformation and occupation matrices within a life cycle framework across fuel cycles, effect on land use including contamination and disruption of the ecosystems of adjacent lands and land disruptions by fuel cycle related accidents.

Annette Evans, et al. [8] studied about the assessment of sustainability indicators for renewable energy technologies were price of generated electricity, greenhouse gas emission during full life cycle of the technology, availability of renewable energy sources, efficiency of energy conservation, land requirements, water consumption and social impacts. The cost of greenhouse gas emissions and the efficiency of electricity generation were found to have a very wide range of technology, mainly because the variations in technological options. The social impact were assessed qualitatively base on the major individual impacts. Each indicator was assumed to have equal importance to sustainable development and used to rank the renewable energy technologies against their impact. It was found that the ranking revealed that wind power is the most sustainable, followed by hydropower, photovoltaic and the geothermal.

S.M. Shaahid, et al. [9] studied about the burning and depleting fossil fuel for power generation detrimental impact on human life and climate. The photovoltaic (PV)-diesel hybrid system technology promises a lot of opportunities in remote areas which are far from utility grid and are driven by diesel generators. The PV-diesel hybrid system meets the energy needs, reduces diesel fuel consumption and minimize atmospheric pollution. The simulation result indicate that for a hybrid system composed of 2.5MWp capacity of PV systems together with 4.5MW diesel systems (three 1.5MW units) and a battery storage of 1hr of autonomy (equivalent to 1h of average load). It has been found that for a given PV-diesel hybrid system decrease in diesel runtime will further enhance by inclusion of battery storage. The percentage fuel saving using hybrid PV-diesel-battery system is 27% as compared to diesel-only situation. The percentage decrease in carbon emission by using the above hybrid system has been found to be 24% compared to the diesel-only scenario. More importantly with the use of the above hybrid system about 1,005 tons/year of carbon emission can be avoided entering into the local atmosphere.

2. Analysis method

This paper used the following parameter condition as default to starting and adjustments of the parameter to predict each scenario.

Table 1. Standard default condition

Description	Revenue Baht (25 Years)	Condition
Electric Base Income	214,806,816	3 THB / Unit / Year
Adder Income	236,476,800	8 THB / First 10 Years

CERs Trade Income	23,124,412	CERs 1 TON : 10 EUR (1EUR : 45.6166 THB @ 9 Feb.2010)
Loan Instalment	81,600,000	40 % of Total Project Investment
Loan Interest Expense / Year	24,786,000	6.75% / Year
Land Rental Cost / Year	85,800,000	5,000THB /Rai /Year (55 Rai) x 26 Years
O&M	26,500,000	O&M 0.1% per year, and repair inverter at year 10 and 20 with 30% of inverter cost

Sensitivity analysis also applied total 45 scenarios with different rate of PV module degradation (10%, 20% and 30% of 2.16 MW), percentage of degradation efficiency at 0.1%, 0.5%, 0.8% and 1% each year, PV performance (1,450kWh/kWp and 1,500kWh/kWp), discount rate (3.25%, 5.25%, 7.25% and 9.25%) and adder cost (6.50 THB/kWh to 8 THB/kWh) by using NPV, IRR, MIRR and PB.

3. Results analysis and discussion

2.16MW amorphous PV power plant project sensitivity analysis presenting the relationship of PV degradation to economic aspect as the follows:

- The increasing of discount rate ratio will make the economic indicators as NPV, IRR, BCR to decrease and payback time to extend in the same aspect.
- Adder value relate to cash-flow to NPV, IRR and BCR value to increase the benefit and project earning influential to project investment. In case the solar power plant project without adder support NPV and IRR of project will be in negative value since the first year earning and return of investment will be negative in value, although the PV array no degradation value the benefit still uncover to the project investment and payment time & PB over 25 years.
- Refer to each scenarios, this analysis to found that the optimum adder under each condition about adder, loan interest, discount rate, inflation rate should be not lower 6 baht otherwise if adder lower 6 baht/kWh then PV array performance should not over 10% as the scenario for adder 4 baht/kWh 10 years with 90% performance to generate electric (10% degradation) project it's not be negative NPV but the payback time is too long nearly the end of project life which not interesting to investor.
- Increasing ratio of adder will directly relate to payback time period to deduction and be efficiency of ROI.
- Discount rate to relate with NPV, IRR, and BCR value, more discount rate will be more reduce their indicators reduction.
- PV module decreasing efficiency will affect to the annual yield outcome and CO_2 emission reduction by decrease the benefit site of project and also decreasing CO_2 emission trade.
- 70% portion of PV Power Plant Project is PV module so; if PV array price were decreased it will make the high efficiency to return of investment and payback period to reduction, as above mentioned NPV, IRR, BCR will increase and influence to the investors to investment to amorphous PV power plant.

Regarding to PV module cost decreasing based on the global PV price's trend and increasing efficiency by technology of each vendor research and development to their product, new model of PV Power Plant to produce higher energy yield and increase benefit, so the PB will be shorter and more revenue from CO_2 emission reduction. Even we have more CO2 emission to trading; we should have the backup plan to keep stock of some CO_2 emission to be trade and to increase value for the future if Thailand will join Kyoto Protocol Program.

Recommendation

Additional comment for this analysis, the project cost reduction to the most material portion of project as PV arrays is one of solution to support to project, in case the government has planning to decrease adder support by extend support time. In addition, to determine the optimum adder value and support time condition to optimization, also need to influence for the investor because the beyond the scenarios, project may have other risk factors apart from scenario to consideration. CO_2 emission reduction is also has high volume for all Thailand if the government set up PV power plant target as 500 MW or 3,000 MW as REDP within 15 years.

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