The Economic Analysis Consider Carbon Credit from Hybrid Solar Rooftop System

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***Abstract*— This paper presents an economic analysis consider carbon credits from hybrid solar rooftop systems. The objective of this research is to determine the cost effectiveness of hybrid solar rooftop installations compared with the analysis combined with the carbon credit assessment. Installation of photovoltaic systems is prevalent today. Because it is clean energy and suitable for the climate of Thailand. The power generation of the hybrid solar rooftop system was simulated with PVsyst program. The analysis was based on a 149.80 kW hybrid solar rooftop system. The results of the research are a presentation of the concept of economic analysis that considers carbon credits.**

Keywords—economic, carbon credit, hybrid solar rooftop system

I. INTRODUCTION

Greenhouse Gas (GHG) is mainly composed of carbon dioxide (CO_2), mainly caused by the combustion of fuels and industrial processes [1]. Greenhouse gases in the atmosphere are H_2O, CO_2, CH_4 , O_3, and N_2O, but CO_2, CH_4, and N_2O have a significant effect on global warming [2]. The carbon dioxide net zero emissions are achieved when CO_2 emissions are counterbalanced by CO_2 removal by companies. from the atmosphere in a process called "Removing Carbon Dioxide" [3]. The concept of net zero greenhouse gas emission is shown in Figure 1.

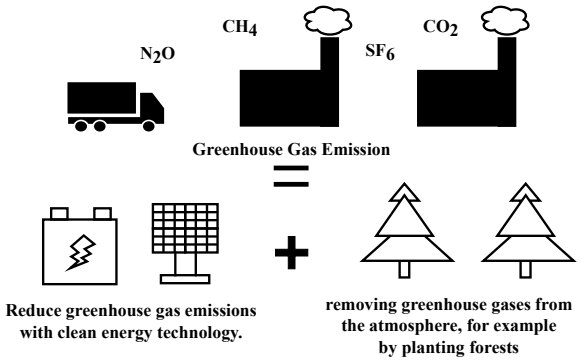

Fig. 1. The concept of net zero greenhouse gas emission.

Figure 1 shows the net zero greenhouse gas emission concept. A net zero greenhouse gas is an emission equal to the reduction and removing a greenhouse gas.

The way to reduce greenhouse gas emissions and find replacements for greenhouse gas emissions is called "Carbon Credit". Carbon credits are like certificates showing the reduction of greenhouse gases in the atmosphere from projects that prevent or reduce greenhouse gas emissions. Countries that can reduce greenhouse gas emissions are entitled to sell carbon credits to countries whose greenhouse gas emissions exceed standards [4].

Thailand has an emission reduction program by Thailand Greenhouse Gas Management Organization. (Public Organization) to promote and encourage all sectors to participate in a voluntary reduction of greenhouse gas emissions in the country [5]. The concept of a volunteer carbon market is shown in Figure 2.

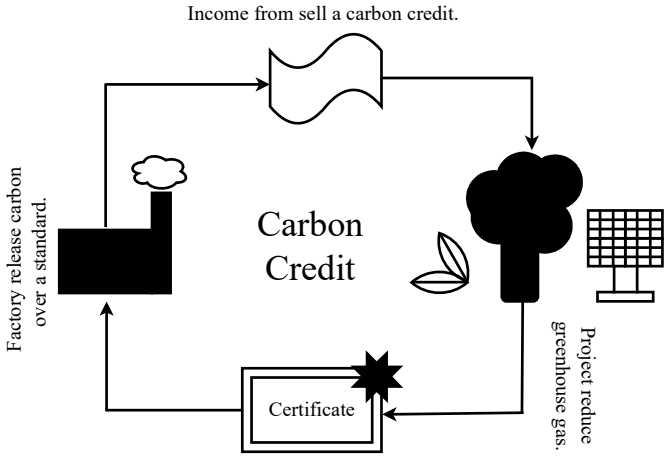

Fig. 2. The concept of a volunteer carbon market.

Rakesh Naskar, et al. (2017) estimated & real time analysis of a 5 kWp solar photovoltaic power plant at JIS College of Engineering, Kalyani. The objective is to evaluate the true value cost analysis of a 5 kWp solar photovoltaic power plant. By evaluating the carbon credits that power plants produce in 25 years. Compare payback with and without considering carbon credits. The payback period is reduced to nearly 4 years when carbon credits are traded [6]. Dhanaji Kale (2019) studied the overall performance and economic analysis of a 6 kW off grid solar photovoltaic system from February 2017 to January 2018. The payback period is 9 years. The system can reduce approximately 5.6 tones of CO_2 per year and 112 tones over its lifetime. When considering carbon credits as payback, the period drops to 4 to 5 years [7]. R. Ahshan, et al. (2020) design and economic analysis of a solar power generation system for a university sports complex located at Sultan Qaboos University (SQU) in Oman. The results show that the solar power generation system satisfies the energy demand (78.568 MWh/year), the system can sell energy (56.065 MWh/year) back to the grid. The payback period is 10 years, The net present value is 120,755 dollars. Internal Rate of Return is 10% [8]. Hemant M. Bhadke, et al. (2022) design and evaluation of solar PV power plants and carbon credits earned by Government College of Engineering Amravati. The designed 650 kWp system uses 1,477 modules. Each module capacity 440 Wp. Each array having 17 modules. The plant energy payback time (EPBT) is 8.24 years. Carbon credits received from the facility resulted in 20,574.07 tCO_2e valued at $12,489 at $0.61/credit [9]. Kwame Asante, et al. (2023) comprehensive technological economic analysis of power generation from solar power generation systems at the University of Environment and Sustainable Development (UESD) in Ghana using net present value (NPV), internal rate of return (IRR), payback period at There is a discount (DPP) and profitability index (IP). The results showed NPV is 15,148,100.88. IRR is 21%. IP is 1.6. DPP at GHS is 8 years [10].

Therefore, this paper presents an economic analysis together with the assessment of carbon credits from rooftop solar hybrid power systems.

II. Data of Factory

The factory is located in Pathum thani Province, receiving electricity from the Provincial Electricity Authority Thailand through an 800 kVA transformer, voltage 22/0.4 kV. Installation location of solar panels on the roof is shown in Figure 3.

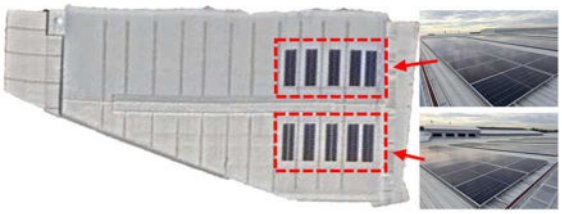

Fig. 3. Installation location of solar panels on the roof.

Figure 3 shows before installing a hybrid solar rooftop system, the plant load was measured by the Provincial Electricity Authority Thailand. The results showed that the average plant load was 145.54 kW, the RMS currents A, B and C were 90.67, 82.16 and 84.85 A, respectively.

III. Thailand Energy Policy

Thailand prioritizes reducing carbon dioxide emissions in the energy sector, which is the main cause of greenhouse gas emissions. Therefore, Thailand has a plan in 2023-2027. The plan is National Economic and Social Development Plan. The Thirteenth Plan Milestone 10: Thailand is a circular economy and low carbon society [11]. Target 3 to establish a low carbon sustainable society. In target 3 has a proportion of renewable energy in the final energy consumption increases by no less than 24 percent by 2027.

Thailand has drafted Thailand integrated energy blueprint (TIEB) to guide relevant agencies to transition to a clean energy system and achieve carbon neutrality by 2050, and net zero emissions by 2065 [12].

Thailand integrated energy blueprint viz Thailand power generation development plan, energy conservation plan, renewable energy and alternative energy development plan, natural gas management plan, and fuel management plan.

IV. Calculation a Greenhouse Gas Emission Reduction

The amount of greenhouse gases reduced in terms of carbon dioxide equivalent (CO_2eq) can be calculated as equation (1).

$$ER_y = BE_y - PE_y \quad (1)$$

ER_y is amount of GHG emission reduction from project implementation in year y (tCO_2eq/year).
BE_y is base year emissions y (tCO_2eq/year).
PE_y is release of the project in year y (tCO_2eq/year).

From equation (1), calculation method based on the Thailand Voluntary Emissions Reduction Program is used.

The power generation from solar energy in this research is within the scope of calculation based on the method of electricity generation from renewable energy to replace the use of electricity from the transmission or distribution system [13]-[14] can be calculated in equation (2).

$$BE_y = BE_{EG,y} = \left(EG_{pj,y} \times 10^{-3}\right) \times EF_{grid} \quad (2)$$

$BE_{EG,y}$ is amount of greenhouse gas emissions from the grid power generation in year y (tCO_2eq/year).
$EG_{PJ,y}$ is amount of electricity produced from photovoltaic systems in a year y (kWh/year).
EF_{grid} is GHG emissions from grid power generation (tCO_2eq/MWh).

EF_{grid} in equation (2) for solar power project, it is 0.4401 tCO_2/MWh (refer to value of greenhouse gas emissions from electricity generation/consumption for projects and activities to reduce greenhouse gas emissions 2022) [15].

The price of carbon credits from solar energy. The information as of June 29, 2023. The average price of solar energy is 30.31 baht [16].

V. Case Study

In this paper divided into two parts viz assessment a carbon credit from hybrid solar rooftop system and analysis economic consider and not consider carbon credit. The case study divided two cases as follow:

Case 1: analysis economic not consider carbon credit.

Case 2: analysis economic consider carbon credit 14 years.

From case 2 Thailand greenhouse gas reduction program allows trading of carbon credits for 7 years and can be extended for another 7 years. Therefore, total trading of carbon credits in case 2 use 14 years.

VI. Results

Greenhouse gas emission reduction in the first year is calculated as follows.

$$BE_y = (200{,}378 \times 10^{-3}) \times 0.4401$$

$$= 88.1864\ tCO_2eq\ per\ year$$

$$ER_y = 88.1864 - 0 = 88.1864\ tCO_2eq$$

$$The\ return\ of\ carbon\ credit = 88.1864 \times 30.3100$$

$$= 2{,}672.9297\ Baht$$

The results of assessment amount and valuation of carbon credits from hybrid solar rooftop systems is shown in Table I.

TABLE I. The Results of Assessment Amount and Valuation of Carbon Credit from Hybrid Solar Rooftop System

Year	Energy generated (kW)	Amount of carbon credit (tCO_2eq)	Valuation of carbon credit (Baht)
1	200,378.0000	88.1864	2,672.9297
2	199,275.9210	87.7013	2,658.2274
3	198,173.8420	87.2163	2,643.5263
4	197,071.7630	86.7313	2,628.8252
5	195,969.6840	86.2463	2,614.1241
6	194,867.6050	85.7612	2,599.4230
7	193,765.5260	85.2762	2,584.7219
8	192,663.4470	84.7912	2,570.0208
9	191,561.3680	84.3062	2,555.3197
10	190,459.2890	83.8211	2,540.6185
11	189,357.2100	83.3361	2,525.9174
12	188,255.1310	82.8511	2,511.2163
13	187,153.0520	82.3661	2,496.5152
14	186,050.9730	81.8810	2,481.8141
15	184,948.8940	81.3960	2,467.1130
16	183,846.8150	80.9110	2,452.4119
17	182,744.7360	80.4260	2,437.7108
18	181,642.6570	79.9409	2,423.0097
19	180,540.5780	79.4559	2,408.3086
20	179,438.4990	78.9709	2,393.6075
21	178,336.4200	78.4859	2,378.9064
22	177,234.3410	78.0008	2,364.2053
23	176,132.2620	77.5158	2,349.5042
24	175,030.1830	77.0308	2,334.8030
25	173,928.1040	76.5458	2,320.1019
Total	4,678,826.3000	2,059.1515	62,412.8806

Table I shows the total amount of carbon credit in 25 years is 2,059.1515 tCO_2eq. The total valuation of carbon credit in 25 years is 62,412.8806 baht. The results compare of amount and valuation of carbon credits from hybrid solar rooftop system is shown Figure 4.

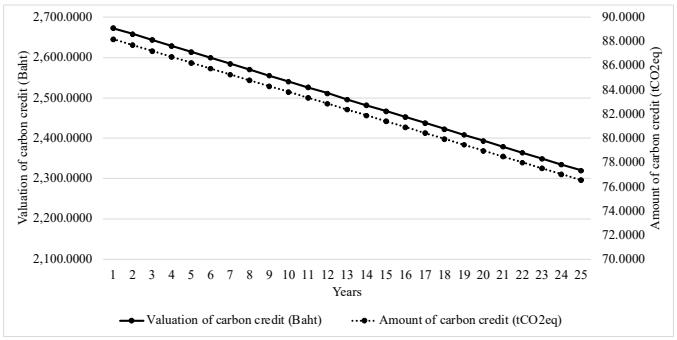

Fig. 4. The results compare of amount and valuation of carbon credits from hybrid solar rooftop systems.

The results of electricity cost reduction and payback evaluation is shown in Table II.

TABLE II. The Results of Electricity Cost Reduction and Payback Evaluation

Year	Reduction electricity cost (Baht)	Payback not consider carbon credit (Baht)	Payback consider carbon credit 14 years (Baht)
1	735,693.3068	-5,091,526.6932	-5,088,853.7646
2	731,646.9937	-4,359,879.6995	-4,354,548.5436
3	727,600.6805	-3,677,219.0190	-3,669,244.3368
4	723,554.3673	-2,998,604.6517	-2,988,001.1444
5	719,508.0541	-2,324,036.5976	-2,310,818.9662
6	715,461.7409	-1,653,514.8567	-1,637,697.8023
7	711,415.4277	-987,039.4290	-968,637.6527
8	707,369.1145	-324,610.3145	-303,638.5174
9	703,322.8013	333,772.4869	357,299.6036
10	699,276.4882	988,108.9750	1,014,176.7103
11	695,230.1750	1,638,399.1500	1,666,992.8027
12	691,183.8618	2,284,643.0118	2,315,747.8808
13	687,137.5486	2,926,840.5604	2,960,441.9446
14	683,091.2354	3,564,991.7958	3,601,074.9941
15	679,044.9222	4,199,096.7180	4,235,179.9163
16	674,998.6090	4,829,155.3270	4,865,238.5254
17	670,952.2958	5,455,167.6229	5,491,250.8212
18	666,905.9827	6,077,133.6055	6,113,216.8039
19	662,859.6695	6,695,053.2750	6,731,136.4733
20	658,813.3563	7,308,926.6313	7,345,009.8296
21	654,767.0431	7,918,753.6744	7,954,836.8727
22	650,720.7299	8,524,534.4043	8,560,617.6026
23	646,674.4167	9,126,268.8210	9,162,352.0193
24	642,628.1035	9,723,956.9245	9,760,040.1229
25	638,581.7903	10,317,598.7149	10,353,681.9132

Table II show, the condition estimate maintenance is free in the first two years of installation, after the two years is worth 44,940 baht. The value of the ability to reduce electricity costs for a period of 25 years is 17,178,438.7149 baht. The results compare of reduction electricity cost and energy generated from hybrid solar rooftop systems is shown Figure 5.

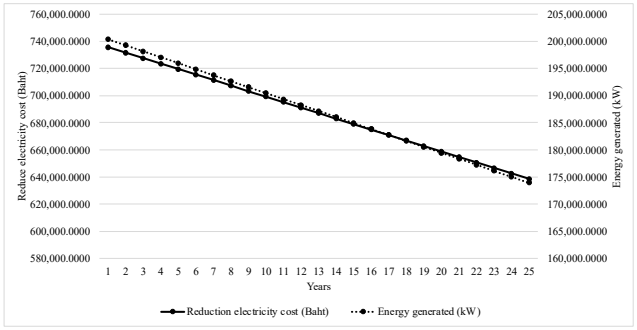

Fig. 5. The results compare of reduction electricity cost and energy generated from hybrid solar rooftop systems.

The results compare payback isn't consider and consider a carbon credit from hybrid solar rooftop system is shown in Figure 6.

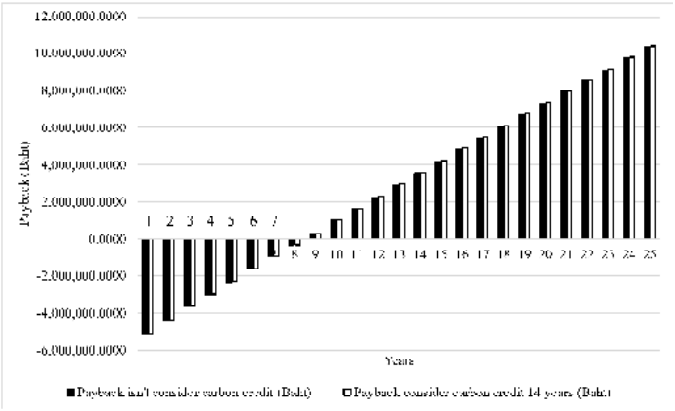

Fig. 6. The results payback isn't consider and consider a carbon credit from hybrid solar rooftop system.

Figure 6 shows the payback period consider carbon credit is 8 years and 6 months or 102 months. In year 9 the payback cost is 357,299.6036 baht, which can pay back 11 days faster than not considering a carbon credits.

VII. Conclusion

This paper presents an economic analysis consider carbon credits from hybrid solar rooftop systems. This research presents a technique for calculating the payback of a hybrid solar rooftop system with carbon credits to shorten the payback period. The results show that the payback method of hybrid solar rooftop systems with carbon credits can achieve faster payback than without considering carbon credits. In this research article, the value for money is not high because the production capacity of the hybrid solar power generation system is not large. But if applied to high capacity of solar farms, solar floating and solar rooftop. It will be another option for faster return on investment. is another option for faster payback.

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