FEASIBILITY ANALYSIS OF FLOATING SOLAR FARM BASE ON PVSYST SOFTWARE

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ABSTRACT

Solar energy is a form of renewable energy that plays a very important role in replacing fossil fuels in the future. In order to exploit and use solar energy efficiently, this study uses PVsyst software to analyze the pre-feasibility of floating solar farm and investigate the heat island phenomenon of solar farm impacted on the local environment. The simulation results of a 50 MW floating solar farm with a total investment of 40.9 million USD, the project will produce 74,115 MWh/yr, reduce greenhouse gas emissions by 22,744 tonCO_2/yr and payback in 6.5 years. Comparing the ambient temperature at the existing project shows that the PV panel temperature is about 20 ^oC higher than the ambient temperature, however, this temperature has a negligible impact on the surrounding areas due to the very low thermal conductivity of the atmosphere. The research results show that the project has high feasibility and the "Heat Island" phenomenon has a small impact on the surrounding environment.

Keyword: *Solar power, floating solar farm, PVsyst software, heat Island effect.*

1. INTRODUCTION

Solar power is defined as "clean energy", "green energy", which does not cause noise, greenhouse gases, the global climate change, environmental pollutants. If using solar power instead of using traditional fossil fuel sources, solar power also helps to reduce emissions.

According to literature review solar projects around the world, this technology has been confirmed to be safe for humans, animal life and the environment during operation.

Researchers have pointed out 32 effects of solar power plants, of which 22 are beneficial, 4 are neutral and 6 need in-depth studies to be evaluated. There are no negative effects of solar power plants like traditional power plants. If 32 effects are classified according to priority criteria based on large or small impacts on human and natural life, the top priority effects are all beneficial effects [1]. We know that solar energy is inexhaustible and no other energy source can compare. According to the theory, solar energy is enough to meet the world's electricity needs. Solar energy is not only a sustainable energy source but also a clean energy [2]. Power plants (especially coal burning) are a major source of greenhouse gas (GHG) emissions, emitting about 25% of all anthropogenic emissions [3].

As a result, GHG emissions associated with solar power generation (including production, installation, operation and maintenance) are minimal [4]. CO_2 emissions per kWh generated from coal, natural gas and solar power are estimated to be 0.64~1.63, 0.27~0.91 and 0.03~0.09 kg (18:9.5:1 emission ratio), respectively. Thus, this comparison once again confirms the friendliness of solar power compared to other types [5]. Therefore, solar energy has become one of the most viable solutions to reduce global warming today, without a solution, it will be extremely expensive to overcome the consequences. To mitigate global warming through replacing coal and gas power sources with solar energy will bring huge environmental, economic and social benefits for sustainable development. Emissions from fossil fuel plants are accused of causing nerve damage, heart attacks, breathing problems, cancer, and more.

Previous research has shown that replacing fossil fuels with renewable energy can reduce premature mortality and reduce overall health care costs [6]. To evaluate the feasibility of the solar power plant, Yu Pan and his colleagues used RETScreen software to simulate and evaluate the feasibility of wind and solar power projects [7].

In the study [8], the author compared 3 software RETScreen, PVsyst and Pvwatt to simulate the generating capacity of solar power plants. The above analysis shows the superiority of solar power over fossil energy sources. To invest in an efficient solar power plant, this study uses specialized software to analyze and evaluate the feasibility of a floating solar power plant. In addition, the study also analyzes the impact of heat island on the environment.

2. FLOATING SOLAR FARM

Hau Giang is one of 13 provinces in the Mekong Delta region of Vietnam. Hau Giang province has an area of 160,244 hectares located in coordinates from $9^0$30'35 to $10^0$19'17 North latitude and from $105^0$14'03 to $106^0$17'57 East longitude. The province's population is 776,663 people, the average density is 452 people/km^2, including the urban population of 201,183 people, accounting for 25.9%; rural population is 575,480 people, accounting for 74.1%. A pilot model of a floating solar farm is installed in Vinh Tuong commune, Vi Thuy district, Hau Giang province.

Table 1: Basic information of floating solar farms

Parameter	Content
Name of project	Floating solar farm
Location	Nuoc Ngot Lake, Vi Thuy, Hau Giang Province
Rate power	50 MW
Connection plan	Direct connection of 110 kV
Solar PV	Photovoltaic – SPV
Inverter	Inverter Zeversolar
Number of panels	147059

3. FEASIBILITY ANALYSIS OF FLOATING SOLAR FARM

3.1 Introduction PVsyst software

PVsyst software was used in 1994, co-founded by two authors, Mr. André Mermoud and Mr. Michel Villoz. PVsyst is a popular tool used to simulate, evaluate and analyze the performance of solar power systems based on parameters: geographical location of installation, installed capacity of the system, selection connection configuration. The software also integrates a database of different types of solar cells, battery systems, power converters, a database of solar radiation, and especially a 3D interface design tool, allows analysis of different architectural situations of buildings. This software allowing the design stand-alone and grid-connected solar power systems and some other functions.

3.2 Analyze economic potential with PVsyst software

This is a grid-connected system, so select the Grid-connected tab and select the location as shown in Figure 1.
Meteo file: select a data file about radiation amount, ambient temperature, wind speed, solar path, at the geographic coordinates of the location we choose, in this case the location of the lake project. soft drink. Data sources can be selected from the following sources: Meteonorm, NASA-SSE, PVGIS-TMY. The data selected in the simulation comes from the Meteonorm source.
Orientation: Adjust the basic configuration parameters of the system such as PV tilt origin, azimuth origin, distance between module rows, width of a row, number of PV modules per row width, size PV panel.
With the above input data, the simulation results are shown as follows: The average total radiant energy ranges from 0.7 kWh/m^2/day to 7.8 kWh/m^2/day, but the thickest point of distribution is between 2 kWh/m^2/day and 7 kWh/m^2/ day. The electricity generated by that system in a day is distributed from 50,000 kWh/day to 300000 kWh/day; Calculation results of horizontal radiation intensity, horizontal diffuse irradiation, average ambient temperature, incident, coverage, effective energy output of array, energy input to grid and part percent performance of the months of the year and of the average total of the year.

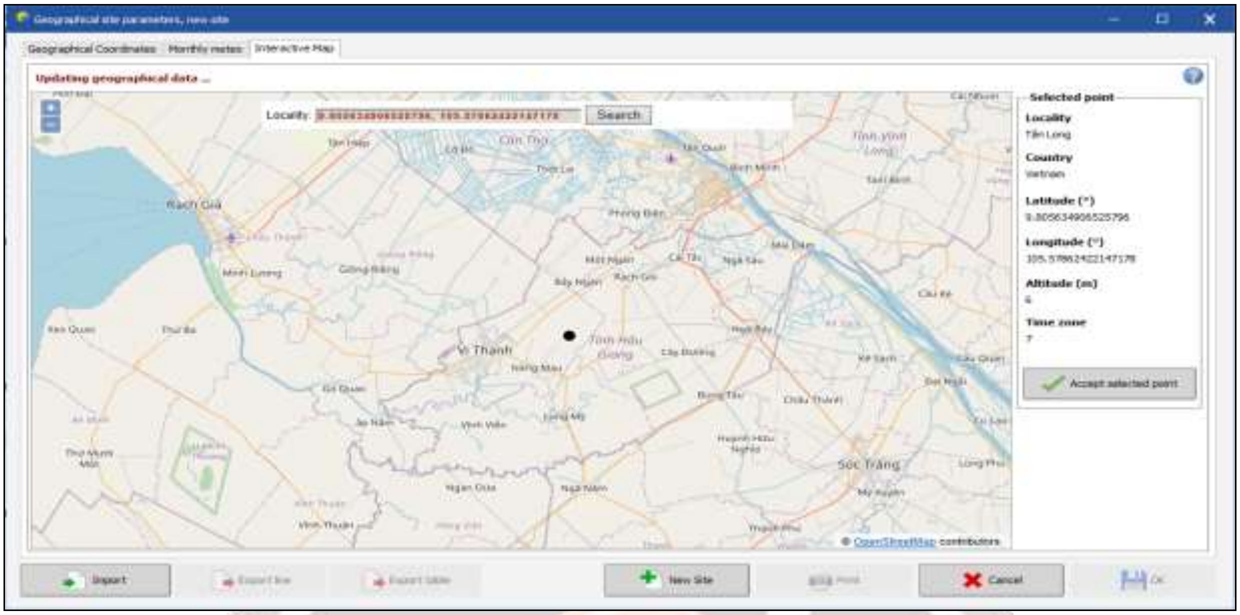


Figure 1: Location to get weather data

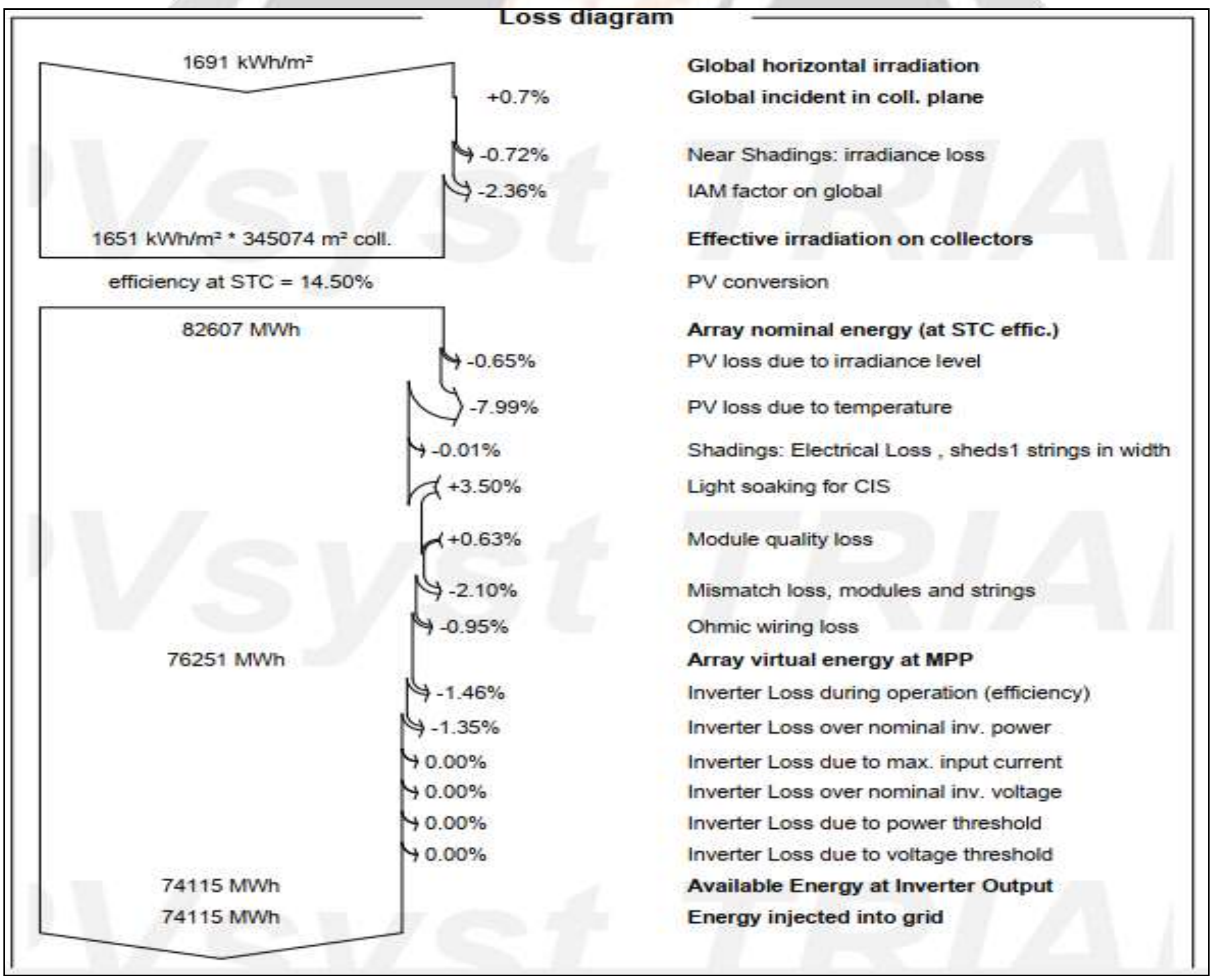
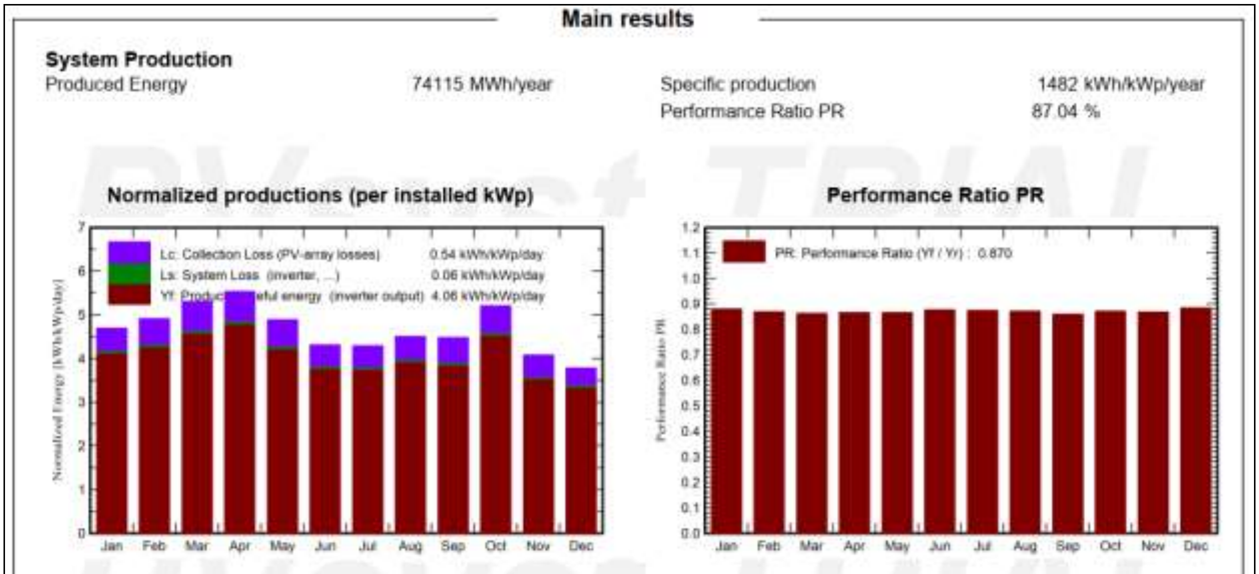


Figure 2: Loss diagram

As a result, there is a reduction between the energy generated from the array and the energy put into the system for use in months. The basic cause is caused by various types of losses such as: loss in inverter operation, loss due to panel temperature, loss of conductor resistance; Energy generated at standard conditions: 806,657.84 kWh loss due to inverter operation: 2.2%; Loss due to panel temperature: 7.9%; Loss due to panel irradiation: 0.7%; Loss due to array and string distribution: 2.10%; And other losses as show in Figure 2.

Run system simulation: The results show important information such as generating capacity, power output, generation efficiency. We can also customize the different types of charts we need to display.



Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR ratio
January	133.8	72.07	26.41	145.5	141.6	6500	6402	0.880
February	130.1	69.48	26.88	137.6	133.8	6069	5979	0.869
March	161.4	85.23	28.20	164.6	160.1	7210	7103	0.863
April	169.4	85.25	28.98	166.0	160.9	7296	7190	0.866
May	159.9	79.59	29.04	151.5	146.4	6656	6559	0.866
June	138.2	78.42	27.95	129.3	124.5	5753	5668	0.877
July	141.0	77.32	27.92	133.1	128.5	5907	5818	0.874
August	144.5	79.23	27.84	139.7	135.0	6180	6088	0.872
September	133.9	67.54	27.14	134.5	130.6	5871	5781	0.860
October	154.7	81.87	27.46	161.5	157.0	7137	7033	0.871
November	115.1	67.05	27.09	122.3	118.6	5386	5307	0.868
December	109.3	70.09	26.82	117.4	113.8	5268	5188	0.884
Year	1691.4	913.14	27.65	1703.0	1650.9	75235	74115	0.870

Figure 3: Simulation results

Hau Giang in the Mekong Delta region is an area with high radiation, with an annual average of 4.73 kWh/m^2/day, the average sunny hours of the whole year is about 2,600 hours. It can be seen that these are favorable conditions for the production of solar power. The annual average radiation intensity of GlobHor is 1,691.4 kWh/m^2. Power generation efficiency of the plant PR=87%, Power output reached 74,115 MWh in the first year. The month with the largest electricity production is April with 7,190 MWh, the month with the lowest electricity output is December with 5,188 MWh Figure 3. The graph in Figure 4 shows the absorption coefficient of solar panels according to the change of the panel inclination angle.

Also calculate the GCR value corresponding to the tilt angle based on the given shader limit angle value. It can be seen that PV panels work at their highest efficiency at tilt angles from 5^o to 15^o. At 0^o and 5^o inclination, GCR coefficients of 100% and 81%, respectively, give the highest ideal yield, but too small an angle can lead to a decrease in the leaching effect of rainwater, cause accumulation of dirt on the panel surface, the actual capacity may be greatly reduced or require more costs and effort to clean and maintain during operation. At an inclination angle of 20° or more, a strong decreasing trend of absorption coefficient and GCR can be seen. An inclination angle of 10° has an absorption coefficient of approximately 1.005 and a GCR = 68.9%. The absorption coefficient on deviation is very small and almost equal.

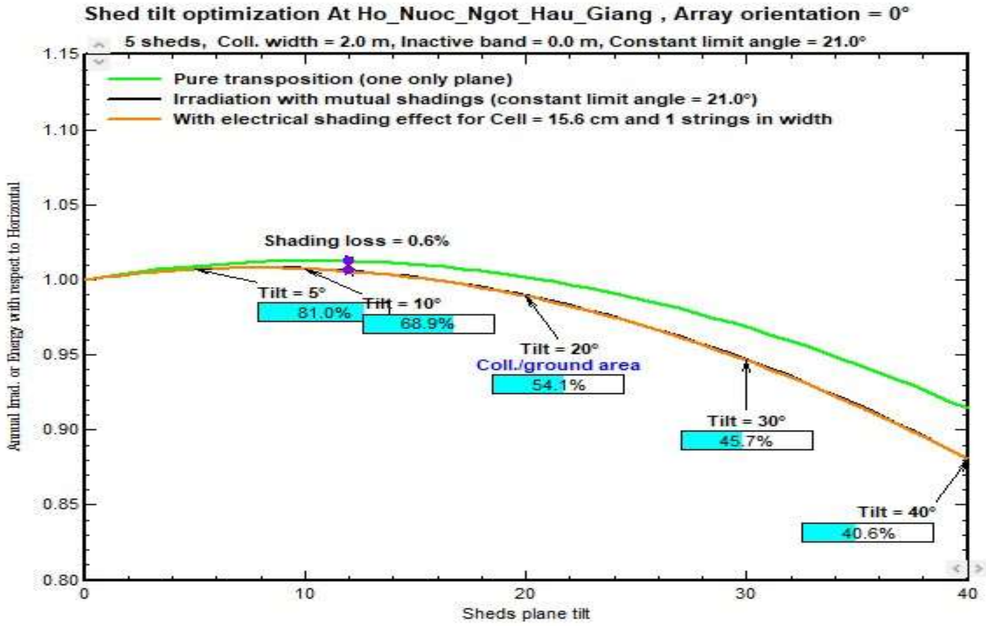


Figure 4: Simulation of optimal tilt angle calculation using Pvsyst

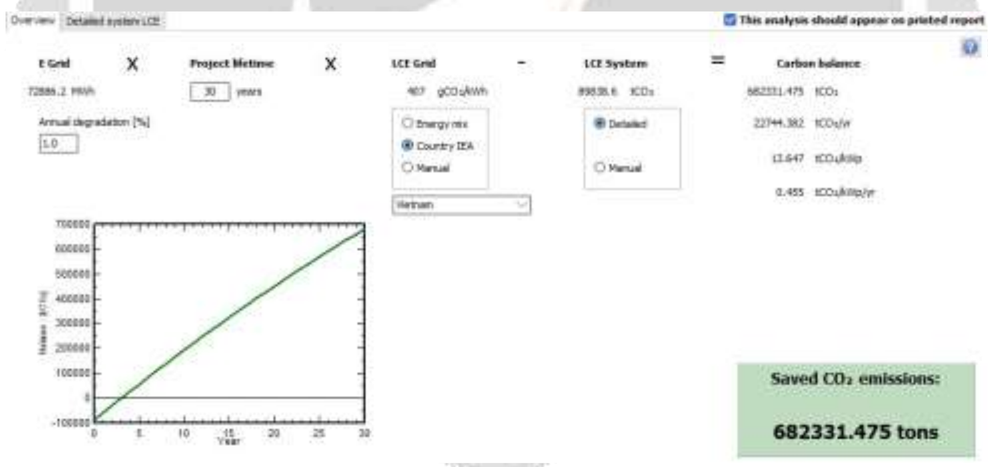


Figure 5: Reduced CO_2 emissions

Financial summary

Installation costs	40'900'000.00	USD
Total yearly cost	1'780'509.10	USD/year
LCOE	0.031	USD/kWh
Payback period	6.5	years

Figure 6: Payback period

With a CO_2 emission factor of the grid of 407 gCO_2/kWh, it is estimated that in the 30 years of project life cycle, 682,332 tons of CO_2 will be reduced, contributing to environmental protection Figure 5. With a total project cost of $40,900,000, O&M costs $150,000, payback period is 6.5 years Figure 6.

4. HEAT ISLAND EFFECT

Corresponding with the increase in PV installations is an increase in PV impact assessments at scale, including those for PV's efficiency to meet energy demand. An issue of growing concern is whether PV installations cause a "heat island" effect (PVHI) in surrounding areas, which in turn potentially affects wildlife habitat, ecosystem function, human health and even quality of life in residential areas near the project.

Like the Urban Heat Island (UHI) effect, large PV power plants create landscape changes that affect reflectivity (Albedo), thereby reducing thermal radiation. Reducing terrestrial albedo from ~20% in natural desert [8] to ~5% on PV panels changes the energy balance of radiation absorption, storage, and release. However, some differences between the UHI effect and the PVHI effect cause comparisons and hypotheses as to whether large-scale PV installations produce heat island effects [9]. Public concerns about the PVHI effect have, in some cases, prevented large-scale solar energy development. However, there is still a lack of basis for whether the PVHI effect is real or simply a matter of perception of environmental change.

Several models have shown that PV systems can cool the local environment, depending on the efficiency and location of the PV panels. But these studies have limited applicability when evaluating large-scale PV installations because they consider changes in albedo and energy exchange in urban environments. At each site, the study monitored the air temperature continuously for more than a year using specialized thermometers. The results show: The average annual temperature is 22.7 + 0.5 °C in the PV installation, while the nearby desert ecosystem is only 20.3 + 0.5 °C, indicating an effecive PVHI application. The temperature difference between regions varies considerably depending on the time of day and month of the year, but PV installations are always greater than or equal to the temperatures in other regions. As is the case with the UHI effect in arid regions, the PVHI effect slows down the cooling of ambient temperatures in the evening, creating a significant difference in nighttime temperatures in all seasons. The average annual temperature at midnight was 19.3 + 0.6 °C in the PV panel, while the nearby desert ecosystem was only 15.8+ 0.6 °C. This PVHI effect is more significant in terms of actual warming (+3.5 °C) during the warm months (spring and summer) [8]. Vasilis Fthenakis and Yuanhao Yu study the heat island phenomenon of large-scale solar power projects. The study shows that the temperature decrease as a function of the distance to the solar farm is shown as Figure 7. At the same time, the study also compared the temperature of the environment and the temperature of the PV panels, the PV temperature was up to 20 ^{o}C higher than the ambient temperature at peak hours (12h) [11].

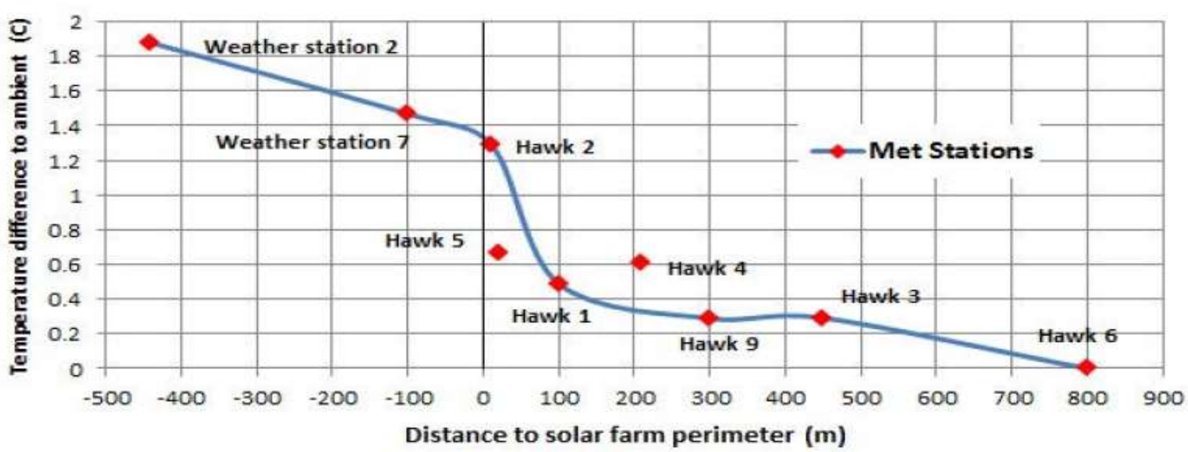


Figure 7: Temperature function by distance to solar farm [11]

The study determined that the temperature at an altitude of 2.5 m above the ground in the center of the solar power plant, the temperature is 1.9 ^{o}C higher than the surrounding environment and the heat is reduced to equal the ambient temperature at an altitude of 5m to 18m. The study also shows that the road in the project can reduce the temperature and therefore increasing the plant construction area may not affect the ambient temperature.

This study investigates the temperature at the existing project in the area. The ambient temperature is measured by the temperature measuring device at the project, taking the date of January 2021 as a representative to compare with the solar panel temperature and the temperature from the meteorological center as shown in Figure 8 and Figure 9. From the results, the temperature difference between the PV panels and the environment in the average months of the maximum temperature is 20 ^{o}C, this result is consistent with the study [11].

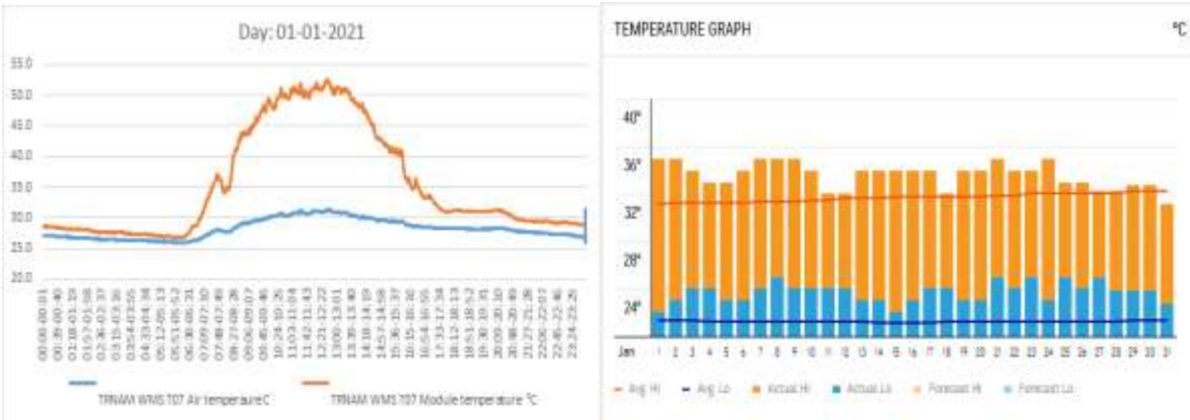


Figure 8: PV panel and environment temperature in January 2021 [12]

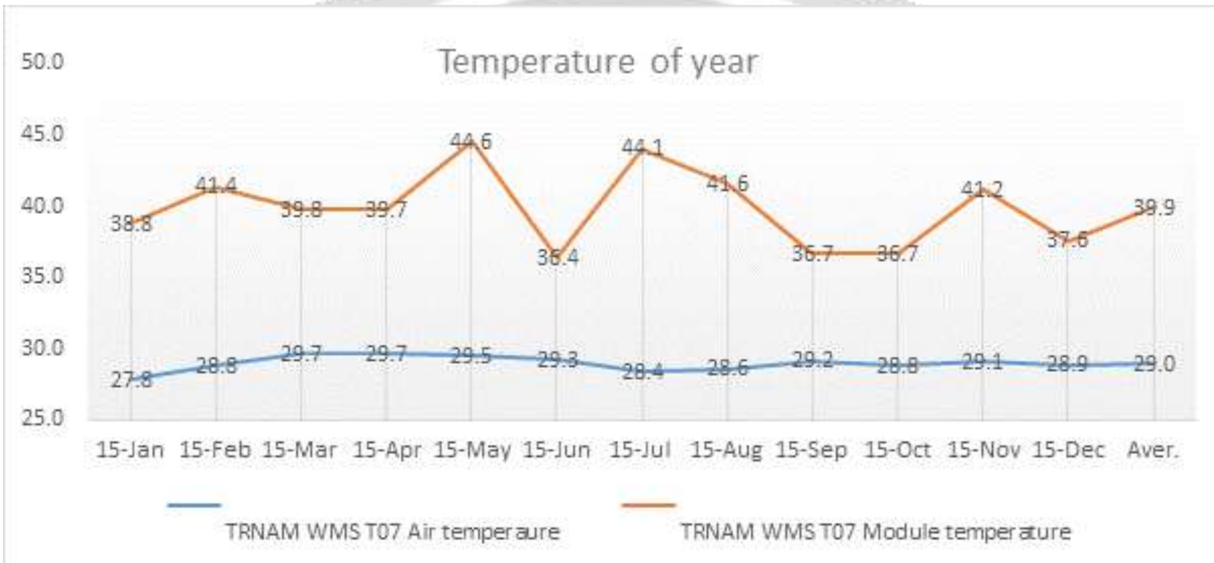


Figure 9: PV panel and environment temperature in 2020

5. CONCLUSIONS

The pre-feasibility study of the floating solar farm at Nuoc Ngot lake, Hau Giang province with a capacity of 50 MW with a total project investment capital of $40,900,000, has the following results:

• Solar power potential in the project: has a high radiation volume, the annual average is 4.73 kWh/m^2/day, the average number of sunny hours of the whole year is about 2,600 hours.

• Power output reached 74,115 MWh in the first year. The month with the largest electricity production is April with 7,190 MWh, the month with the lowest electricity output is December with 5,188 MWh.

• Annual operation and maintenance cost is 150,000 USD/yr, the project will payback in 6.5 years. GHG emission reduction is 22,744 tonCO_2/yr.

• From the research results in the world and the data at the existing project, we can conclude that the PV panel temperature is about 20 ^oC higher than the ambient temperature and this temperature decreases as a function of the distance from the factory. .

• In addition, when there is a road (road) in the project, it will reduce the local temperature of the project, from which it is possible to build a large-scale solar farm without heat island phenomenon if arrange the roads in the project accordingly.

• PV panel temperature is about 20 ^oC higher than ambient temperature, however this temperature has negligible impact on neighboring areas due to very low thermal conductivity of the air environment. From the research results, it is shown that the phenomenon of "Heat Island" is insignificant and has little impact on the environment around the project and the quality of life of people and the surrounding ecosystem.

6. REFERENCES

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