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Harvest the Sun on Water: A Review on Floating Photovoltaic Solution For Vietnam

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A B S T R A C T

Vietnam has been one of the fastest growing economies in the world and has put great effort to improve the living condition of the people. Energy is particularly important for Vietnam's development and its energy demand keeps increasing in parallel with the country's socio-economic growth. In order to meet its energy demand and to generate sustainable energy, the Vietnamese government has shifted its attention towards renewable energy, especially towards Solar energy generation. Vietnam is a nation with average solar radiation of 4-5 kwh/ m2 /day, which is well-suitable for solar energy generation. The energy from the sun can be harvested using PV panels installed on land, water and rooftops. Land usage becomes a major concern for Vietnam as most of the land areas has been effectively used for agricultural, urban and industrial sectors. There are several solar farms commissioned and actively producing solar energy, but floating solar solution is quite new for Vietnam.

Keywords: Floating Solar Solution, Floating PV in Vietnam, Solar energy efficiency in water, renewable energy

1. Introduction

Solar energy in Vietnam is available throughout the year and it is the free source of energy. Apart from socio-economic benefit, Vietnam can diversify its energy dependency and fulfill its energy requirement by harvesting energy from the sun.

The most common way to harvest this freely available energy is using photovoltaic (PV) system. The PV systems can be mounted on land, rooftops and deployed on water to generate power. Floating solar solution is a new concept for Vietnam in renewable energy generation. A report states that though the world is aware of this floating solar solution, Asia is leading in adapting and generation of solar energy through this solution (SolarPlaza, 2019).

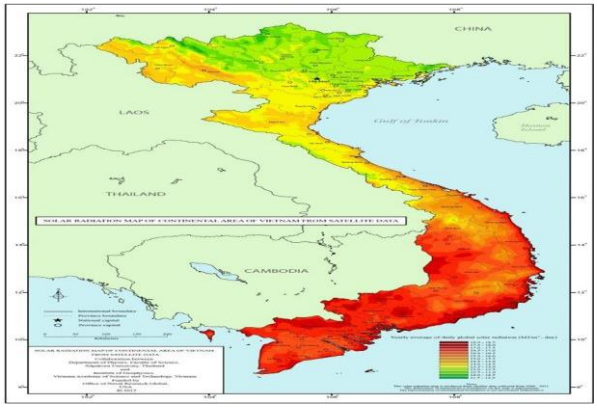

Figure 1: Solar Irradiation Maps Of Vietnam (National Hydro- Meteorological Service Of Vietnam, Mtsat, Skiron, Macc-Ii, Ncep, 2015)

Several studies have pointed out that the power generation efficiency of floating PV systems is higher than that of the land mounted PV panels. (Young-Kwan Choi, 2013). Higher power efficiency and elimination of land usage will be a huge benefit for Vietnam if it considers harvesting energy from the sun on the water. However, a thorough understanding on the consequence of implementing this solution is also important. This study will facilitate to reap more benefit and provide a better understanding the best place to deploy this solution to avoid financial losses.

2. Methods

The float PV solution is a new concept that has not been there for a long time and it is very new to Vietnam. A review about this will facilitate the readers with state-of-art understanding about this technology and act as a starting point. In order to accomplish this review paper, a combination of search method and technique was utilized for literature review on relevant documents.

A. Literature Review:

Snowball search method was used to find literature related to floating solar PV solution. This method used articles on Float PV solution published by World Bank and International Journal of Scientific & Engineering as starting points. Based on the information like key documents and keywords that were available on these documents relevant literature was found. This method was effective as it led to find articles and documents related to the subject.

B. Search Tools and Techniques:

Google Chrome, the most common web browser and Google Search Engine was used to find relevant information. Google is a trustworthy application with efficient searching algorithm that facilitated to provide most relevant result. To save time and fetch only precise information Boolean Searching Technique was used. Initially, Narrow Searching was performed by using AND operator and various terms. This method helped to identify information with all the search term and narrowed down the result with few relevant information. Few Boolean Narrow searching strings is given below.

1) Floating Solar and Energy efficiency in water
2) Floating Solar Panel and Technology
3) Floating Solar Solution and Project
4) Floating Solar solution in Vietnam and Asia

It was also necessary to get more information related to this topic in various countries and various technology, so Broadening Search was used to widen the search. This search was performed by using distinct terms related to the topic and different words. Few Boolean Broadening searching strings is given below.

1) Floating Solar or Offshore solar
2) Floating System or Mooring system
3) Floating solution Japan or china or India or Korea or Iran

3. Results

The snowball search method and Boolean search technique was simple and easy to use. This method saved lot of time and facilitated to gather literature that are vital to produce this review paper on floating PV solution.

Technology Overview:

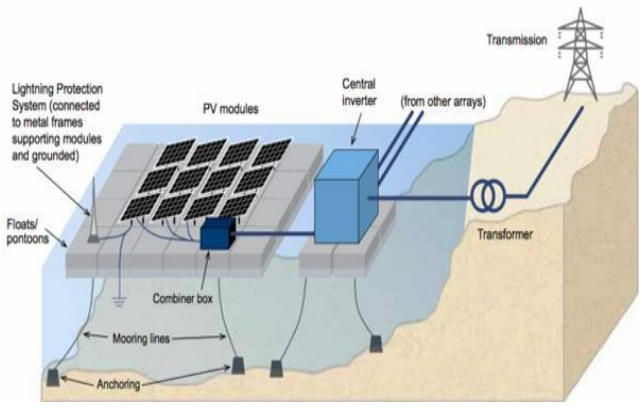

Figure 2 - Floating Pv System Key Components (Nus & Seris)

The combination of PV solar solution and floating solution has resulted in the Floating PV solar solution (FPVS). There are four key components in a FPVS solution:

A. Floating Module: The floating module supports heavy load and provides a platform to install the PV panels.

B. Mooring System: The mooring system is a permanent structure that help the floating modules to adjust itself to the water fluctuation level and maintain its position in a southward direction.
C. PV Modules: The Photovoltaic (PV) is used to generate electricity by capturing the energy from the sun. Sometimes the PV module may contain multiple array of PV panels to increase the efficiency along with invertor, tracking units and battery.
D. Cables: High durable cables are used to transfer the generated power and generally they can withstand harsh condition.

4. Insight on implemented Floating PV Projects

Floating PV solar solution has been adopted in several countries including Japan, India, New Zealand, Portugal, South Korea, etc., Floating PV Solar Solution is suitable for Asian countries where land is scare but with existence of several reservoirs and rivers (Broom, 2019). The floating PV solution facilitates to better utilize the water bodies and eliminate the use of expensive land. The efficiency of the floating solar panel is also high compared to the ground mounted solar panels due to cooling effect of the water (World Bank , ESMAP and SERIS, 2018).

Japan:

The Aichi project in Japan was the first floating PV project installed in the world. It was a pilot project that was deployed in the year 2007 to introduce the floating PV solution to the world (Amanda Nelson, IHS Markit, 2019). This project was executed by National Institute of Advanced Science and Technology in Japan and was funded by the Ministry of Environment, Japan (Patil (Desai) Sujay S., 2017) . An article points out that nearly 43% of the top 100 floating PV projects are based in Hyogo and this was possible because of the existence of approximately 37,759 reservoirs that was mainly used for agriculture (SolarPlaza, 2019). Kagawa region has second largest capacity of floating PV solution installed and one of the most notable projects is the Yamakura floating solar plant with a capacity of 13.5 MW, which became operation in March 2018. As of now Japan has installed nearly 73 floating PV projects with a production capacity of 130.5 MW. Most of these are installed on reservoirs, lakes and ponds. According to world bank report most of the projects are funded in local currencies and by local banks in Japan. The attractive feed-in tariff also played a major role for the high number of floating PV projects installed in Japan (World Bank , ESMAP and SERIS, 2018).

China:

As on January 2019, China has installed nearly 6 floating PV Solar projects that generates 78.36 MW of power. Two big projects in the world is in Anhui-china, which produces nearly 60 MW of power (SolarPlaza, 2019). The Chinese government has taken initiatives to convert the flooded and collapsed mine to floating PV solar farms that can generate enough power to be supplied to nearby homes and this measure has also increased the air quality level. Most of the workers who worked in harmful conditions inside the mines are trained to install and operate the floating PV solution and are earning better and their working condition has improved. This shows how the Chinese government has addressed the environmental and social disaster into an opportunity (World Bank , ESMAP and SERIS, 2018). China has also installed and integrated a land based solar farm in Longyangxia hydropower plant in Qinghai. This is considered as a pilot project to study the possibilities of integrating floating PV project with hydropower plants in near future. Longyangxia hydropower plant has become efficient by combining the power generated from both hydropower and solar farm. China being a leading manufacturer of solar panels and having a mandate to reduce greenhouse gases, will surpass Japan in the capacity of generating energy from floating PV solar projects.

India:

Floating PV projects has been in operation in India for the past few years. Most of the projects are medium size projects located in Kolkata, Kerala and Chandigarh, with a production capacity of approximately 10 kWp. By beginning of 2018, India installed it largest floating PV along with floating sub-station with a capacity of 500 kWp at Wayanad, Kerala (Economic Times, 2017). India is also progressing toward the generation of renewable energy though floating PV solution and it also has installed land based solar power generation projects in the past. Since, India has expertise in the solar energy sector, it would be easy to increase the number of floating PV projects in order to save water from evaporation and meet its energy demand.

Iran:

Water evaporation due to solar irradiation is a major concern in Iran reservoirs. This also degrades the water quality. The Iran government realized this threat and decided to make use of the favorable radiation from the sun to harvest energy. It has tested the floating PV solution in a small scale on 15-Khordad dam in Delijan, Iran. The initial capacity of the project was to generate 1.45 MW of power. The result was astonishing. Even by covering small portion of the reservoir with floating PV system had a significant effect on the water saved annually and the efficiency of the PV panels was high due to the cooling effect of the water (Azami, 2017).

Other Notable Projects:

The K- Water (Korean water resource corporation) installed 100 kWp floating PV project using moisture resistant resistance structure on the South Korean dam called Hapcheon. Another remarkable project was installed in Cheogju, South Korea with special structure that can withstand extreme cold (Patil (Desai) Sujay S., 2017).

The first grid-connected floating PV project was installed by Far Niente Wineries, Napa Valley, California. The special feature of this project is, the system was constructed using modular crystalline PV panels and with built-in walk ways for easy maintenance of the panel (Patil (Desai) Sujay S., 2017).

5. Overview on Vietnam's First Floating PV project:

The EVN (Electricity Vietnam) has announced on 13th May 2019, that it has successfully commissioned and connected the Da Mi floating PV plant to the power grid. This is the first and only project installed in Vietnam until now with a capacity of 47.5 kWp. The investment for this project was 1.5Billion

VND (EVN, 2019). The solar project in Vietnam is currently limited to land-based projects. Due to the land usage issue and for better utilization of land for agriculture purpose, the Vietnam government is considering adapting floating PV projects to maximize the benefits that it get from Solar energy (Vietnam Business, 2019).

Figure 3-Solar Panels Installed on Da Mi Hydroelectric Reservoir (Source - (Evn, 2019)

Benefits:

The efficiency of the PV system is improved between 10-15% when installed on water. This helps to generate more energy with same amount of PV panels installed over the land. Land is a scares resource in Vietnam. The land can be used for agriculture purpose or building houses and the water bodies like reservoirs, ponds, lakes can be used to generate power with the help of floating PV solution with improved efficiency.It is very easy to deploy the floating PV solution and safe to install in water, which does not contain any hazardous materials. It is also easy to dismantle and 100 % recyclable.

Marine installation of floating PV solution can be a viable solution to electrify small and remote islands in Vietnam. Though off-shore and near-shore installations possess challenges, this will be the only best option to provide clean energy to remote island where land is a scare resource.There is no need for leveling the panels are mounted on floating platform and anchored to mooring unit. This make the deployment faster and easier (GEUSS, 2018).

The floating PV solution built in a reservoir with existing hydropower generation can be integrated for better management of water and power. Even a small installation can make significant contribution to the loss of water due to evaporation. Floating PV solution can be installed in abandoned or flooded coal mines and contribute to the recovery of polluted land. It can improve the living condition of people and contribute to the development of social economic condition of the people and can provide more job openings.

Drawbacks:

Constructing the mooring unit becomes difficult if the surface is too deep inside the water. The cable length will also be longer if the surface is deep. The construction may require special equipment's and incur more time and will increase the overall cost of the Floating solar panel solution. Separate skill set is required for installing and maintenance of this floating PV systems. The maintenance team must have skills to swim and operate a boat if required in emergency. It becomes too expensive if installed offshore where the water is not stable. New technology must be used to protect the solar panels from getting damaged from high tides. Most of the reservoirs has limited accessibility due to security issues. This can also delay the deployment of the floating solar panel projects. Lack of proper government policy and regulation can create financial difficulties and may be difficult to attract investment. Corrosion and water temperature can degrade the life of the materials. The fog that is created on the top of water surface can also affect the performance of the entire system. Aquatic eco-system like flora and fauna can be affected due to the lack of proper sunlight. Though this location can be a best place for fish to breed, it also becomes difficult for fishing and other transportation activities.

6. Conclusion

Vietnam is a country with huge potential to tap energy from the sun to meet its energy demand but the scares available of the land makes it impossible to harvest energy from sun using land-based PV projects. Floating PV solution addresses this issue by generating energy with the help of floating PV system installed on reservoirs, ponds, lakes and lagoons. The floating PV panels can save water from evaporation and improve the quality of water by avoiding algae development in the water. Vietnam has nearly 63 reservoirs with hydropower plant and this would be the best location to install floating PV solution to generate more power and get it easily connected to the existing powerplant. This will increase the productivity of energy and help in better water management. There are also nearly 7135 ponds, lakes and reservoirs which can be effectively used to install small and medium size

floating PV systems that can meet the energy requirement of factories and houses near these water bodies (thuyloivietnam, 2019). The floating PV solution is easy to install in in such water bodies with low cost and help to reap huge benefits from generating power and saving water from getting evaporated. Since floating PV solution is quite new for Vietnam, they must gear-up to learn skills to install and to maintain the floating PV panels. In order to effectively implement the floating PV solution like Japan and China, the government should come up with attractive feed-in tariff and very clear

long-term regulation that can catch the interest of investor and other stakeholder involved in the projects. Floating PV solution can help generate more jobs and can help to electrify rural and remote islands. Thus, it can contribute to the social-economic development of the people. Finally, every country has a mandate to reduce the emission of greenhouse gases. This floating PV solution will help the nation to generate and provide to its people green energy by leaving low carbon footprint

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