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Evaluating Floating Photovoltaics potential in providing clean energy and supporting agricultural growth in Vietnam

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Key Messages

- Vietnam's electricity demand annual growth has been more than 12% in recent years, leading to rising coal imports.
- Vietnam has been transformed from a food-insecure nation to a world-leading food exporter.
- Vietnam has thousands of water bodies, used for agriculture/aquaculture offering excellent surfaces for deploying Floating Photovoltaic (FPVs) farms.
- FPVs could significantly contribute to the energy sector in Vietnam by supplying clean electricity that could also be used for modernizing/mechanizing agriculture/aquaculture practices.
- FPV faces some socio-technical barriers including regulatory ambiguity that could hamper expansion of this technology.

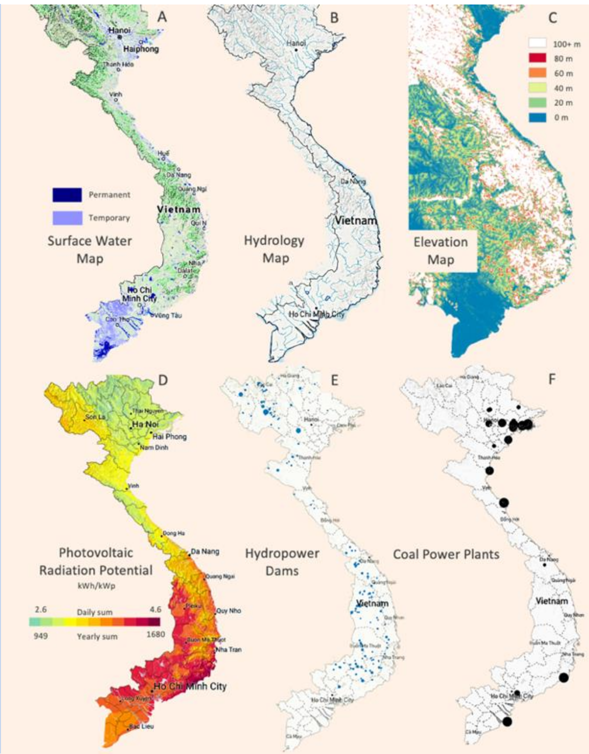

Figure 1. Vietnam's surface water and elevation maps [1], hydrology map, hydropower dams and coal power plants [2] and solar radiation potential [3].

Introduction

Vietnam's GDP has increased 40 times in the past 30 years, reaching US $262 billion in 2019. This growth has been accompanied by an electricity demand annual growth rate of about 12% in recent years and is projected to be 8–9% annually till 2030. In parallel, coal has become one of the most crucial energy sources in the country, and its use grew 75% between 2012–2017 accompanied with increasing investments in new coal-fired plants [4], which could result in a technological lock-in due to the long operational life of these plants.

International Energy Agency (IEA) data suggests that the share of coal in electricity generation in Vietnam has increased from 34,600 GWh in 2014 to 114,180 GWh in 2018, which shows a more than 230% increase. Between 2014 to 2018 the total electricity generation in Vietnam has increased by about 75% approaching 241 TWh, of which 47% belongs to coal. Hydro and natural gas, with 35% and 17%, are in the second and third places respectively, while other resources have played a minor role, for example 0.01% for solar PV in 2018 [5].

Some studies suggest that the generous feed-in tariff (FIT) that the government announced in 2017 for solar projects has had an instrumental role in expanding solar PV in Vietnam. Accordingly, the solar PV plants grid-connected before July 2019 were able to sell their electricity to the state-owned Vietnam Electricity (EVN) at a FIT of US $93.5/MWh for 20 years. It had a significant impact on increasing the installed capacity of solar PV, which changed from 86 MW at the end of 2018 to 4,450 MW by end of June 2019 [6]. The new purchase price for ground-mounted PV electricity was announced in 2020 as US $70.9/MWh for 20 years [7].

To maintain economic growth and follow the Paris Agreement, Vietnam needs access to secure energy supply and sustainably shift its energy resources from fossil fuels to renewables: a process which has been initiated recently with supporting Solar PV policies. However, high population density (310 people per km^2), land morphology, and geography make allocating land for renewable energies, particularly solar farms, quite challenging.

As **Figure 1** suggests, the densely forested highlands in the central part and mountains in the northwest have caused the highest population to cluster in two deltas in the north and south. The significant presence of inland waters (lakes, wetlands, and ponds) also adds to the land scarcity and makes land-use conflict a common and major issue in Vietnam. Moreover, the crucial sector of agriculture exacerbates land shortage for solar farms and makes such installations against the interests of farmers and villagers. Vietnam has been transformed from a food-insecure nation to a world leading exporter of food commodities [8] with 40% of the land dedicated to agriculture and employing nearly 40% of people.

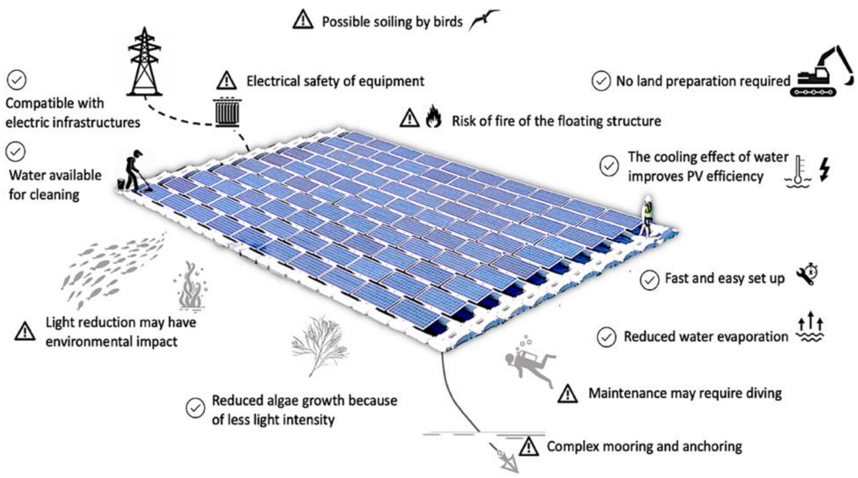

Figure 2. Schematic representation of some of the main advantages of FPVs.

This research aims to show the significant role that floating photovoltaics (FPVs) technology could play in addressing Vietnam's energy needs.

What is floating solar technology?

Floating Photovoltaic (FPVs) systems provide a unique opportunity for Vietnam to address its growing energy demands and transition to a low carbon economy by utilizing a small portion of the water surfaces available for this purpose. FPV is an innovative application of PV technology deployed on water surfaces from very small to large scales that can provide clean, cost-effective, reliable, and secure energy [9].

What makes FPVs different from common PV solar

FPV is more efficient than ground-mounted solar PV due to the cooling effect of water on the temperature of PV panels. FPVs can help mitigating land-use conflicts and generate clean and reliable energy. When deployed in small scales on water surfaces used in farming, the electricity can be used for increasing efficiencies of agriculture.

FPV helps reduce algae growth because of less light intensity, reduces water evaporation, and requires no land use or preparation requirements [10], as depicted in **Figure 2**. FPV is an innovative technology with scarce research available about its different socio-technical aspects, policy implications, and how governments can catalyze its expansion.

How can FPVs address Vietnam's energy needs

Vietnam has truly extensive water surfaces, which include large lakes, wetlands, ponds, more than 2,360 rivers, and 16 major river basins with an average catchment area over 2,500 km^2 each [11]. To demonstrate the potential of FPV technology in Vietnam we have selected 7 reservoirs (**Figure 3**). The one in the North is a hydropower plant reservoir. The other reservoirs are in the South, where the highest irradiance is received in the country (**Figure 1**), and are used for irrigation.

To calculate FPVs potential capacity we used System Advisor Model (SAM) software to simulate the electricity generated if we cover only 1% of the water surface of these 7 reservoirs.

For our calculations we used the FPV systems based on the Sungrow company designs that require about 4,660 m² of surface water per 1 MWp (Megawatt-peak: the rate of power output in ideal conditions) installed.

The results show that a potential capacity close to 1 GWp and an annual potential generation of 1.4 TWh will be realized if only 1% of the surface of these reservoirs are covered by FPVs. Electricity consumption in Vietnam was 227.21 TWh in 2018. The total surface area of the reservoirs selected in this study was close to 443 km^2, which suggests that covering only 4.4 km^2 or 1% of them by FPVs could provide about 0.62% of the total annual electricity needs of Vietnam. Expanding this technology to other water bodies or even to a larger scale in the selected reservoirs could significantly improve this number.

In such large-scale projects the floats can be manufactured locally. Also, the low depths of the water bodies, lowers the anchoring costs. Considering these facts and relying on local labour force, achieving close to 1 USD/Wp for FPV costs is realistic. This estimate is based on a compatible technology that has been used for the 70 MW Anhui project in China [9].

In May 2019 EVN announced the grid-connection of 20.5 MW solar power capacity as phase one of an envisaged 47.5 MW FPV plan [12]. Limited information is available about the challenges faced by this first FPV project in Vietnam; however, a report published by the Asian Development Bank (ADB), which has invested in this project, considers understanding the power purchase agreement (PPA) and its differences with other markets as one of the investment challenges while there have been no major technological issues in terms of deploying FPVs [13].

In 2020, to encourage private sector investment, the Vietnamese government introduced a US $76.9/MWh FPV FIT, which is 8.5% higher than ground-mounted PV solar [7], which seems to have had positive impacts on FPV development as two large-scale floating PV systems were grid-connected at the end of 2020 on two irrigation lakes in the south of Vietnam [14].

How FPVs can help agricultural growth in Vietnam

About 90% of all farms in Vietnam are small family farmers, of which more than 65% are in rural areas. Small scale FPVs on water surfaces used in agriculture/aquaculture would enable smallholders as prosumers, and the electricity generated can be used by the owner/operator or sold to the grid [2]. It will put the farmers in control of irrigating their farmlands and shift reliance on rain-fed agriculture to managed and efficient agricultural practices. Deploying FPVs decentralizes the energy system and makes it more resilient; moreover, it helps sustainable management of Vietnam's vast water resources, particularly through diversifying investments in infrastructure for the water sector and deepening public participation.

Figure 3. Selected reservoirs in this study. A hydropower reservoir in the north and six irrigation reservoirs in the south.

Recommendations

Population density, geography, resources, nature of the economy, and land use make the energy challenges faced by Vietnam unique, complex, and requiring innovative technologies. Floating photovoltaics (FPVs) is such a technology that can transform the renewable energy sector in Vietnam.

- The government needs to investigate and also support investigations for better understanding of the economic, regulatory, technical, and environmental barriers that could hamper FPVs deployment.
- Different policy setting sectors at government level – including energy, agriculture and water managements – need to collaboratively address investors' and users' concerns about potential uncertainties. These concerns include water rights, ownership, and operation when FPVs are deployed on irrigation or hydropower plant reservoirs.
- Incentivizing the electricity generated by FPVs for modernizing the farming process and equipment is needed to encourage smallholders to invest in small scale FPVs.

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Notes

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