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on dam reservoirs and solar-hydro hybridization

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Floating solar powerplants in Vietnam

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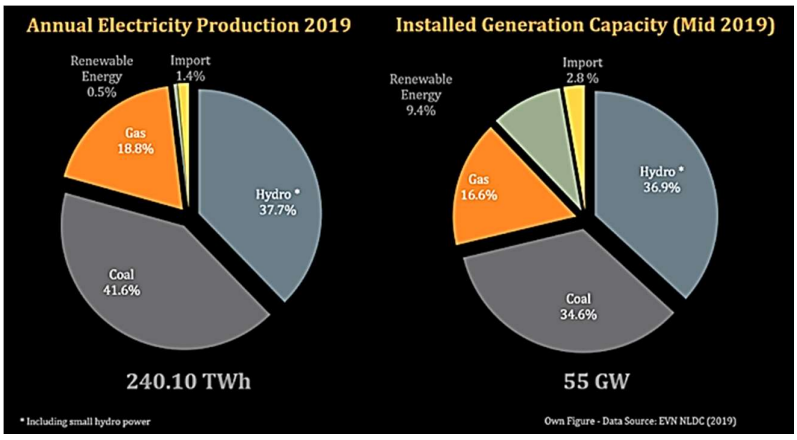
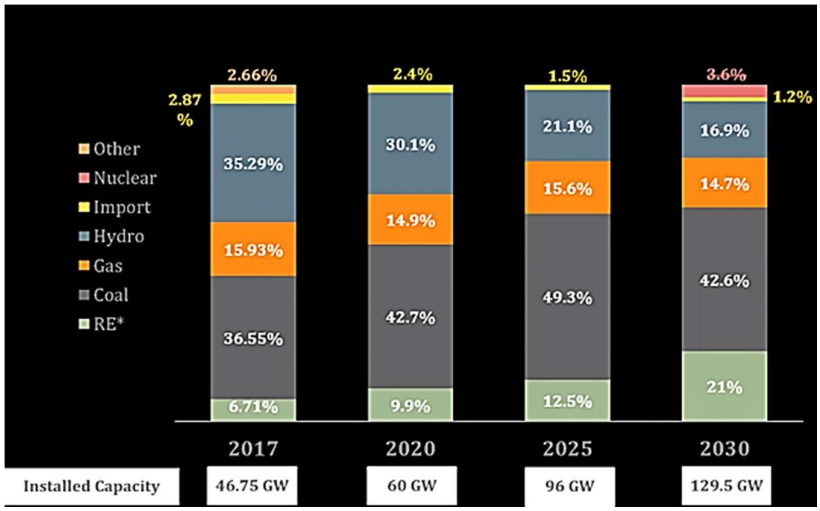
1. General information concerning electricity in Vietnam

- Total country area : 331 230 km^2
- Population (2019) : about 97.5 million inhabitants,
- GDP (PPP) per capita in 2021 about 11 620 USD.
- Electric demand rises about 10% per year. In 2019, the electricity output was 240 TWh. It was projected to be 348 TWh by 2025 and 663 TWh by 2035.



Electricity Production and Installed Capacity

(The percentage of RE production in 2019 was 5% and not 0.5%)



*Installed Capacity Targets**

** It is now decided a reducing of the percentage of coal to about 30%.*

2. The rapid development of solar power

By 2030, Vietnam's electricity sources could reach 132.2 GW with 27% from coal-fired plants, 21% from gas thermal power, 18% from hydroelectricity, 29% from wind, solar, and renewable energy, and 4% from other imported sources.

Vietnam has a great potential to develop solar power, especially in the Central and Southern regions. The 2 regions have average sunshine hours from 2000-2600 hours/year. The average daily solar radiation intensity in the South is 5.9 kWh/m^2.

The National Power Development Master Plan
Solar energy for electricity production

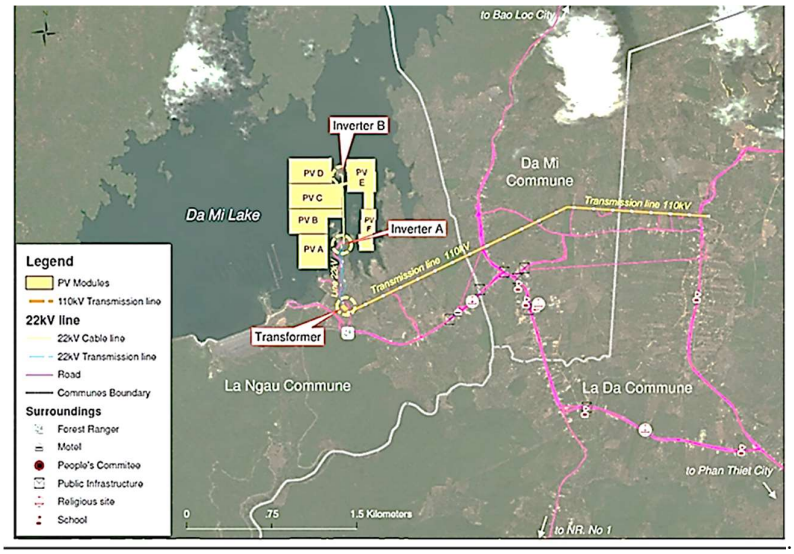
Year	2020	2025	2030
Total capacity (MW)	850	4000	12 000

Installed solar PV in 2020: 16 500 MWp (around ¼ of the country's installed power capacity) and about 10.6 TWh (about 4% of all generation).

More than 101 000 rooftop solar power systems (about 10 000 MWp in 2020) create a 25-fold increase in the solar generating capacity in just one year. However, this rapid expansion has raised challenges due to grid curtailment issues.

3.The first floating photovoltaic (FPV) on the Dami reservoir

The cascade Dami HPP (175 MW) is downstream the Ham Thuan HPP (300 MW) on the La Nga river in the most sunny province of Binh Thuan. It is the first FPV in Vietnam.



The Dami FPV with a capacity of 47.5 MWp and an average power generation of 70 GWh/y. The construction took place in less than one year.

3.1 Dami FPV- Main features

The Dami FPV was chosen at an ideal location:

- High DNR (Direct Normal Radiation),
- Same Owner for the Dami HPP and the Dami FPV (no land acquisition and compensation),
- Site protected by mountains against powerful winds and typhoons with no wave higher than 1.5 m,
- The water level fluctuation of the reservoir, with a free overflow spillway, is less than 3m,
- Better cooling effect, less dust on the surface of PVs easy to clean, in comparison to PV installed on arid or semi-arid land.
- The FPV saves water from evaporation that can also be utilized for hydropower generation, and potentially increases the capacity factor of the hydro powerplant.

The Dami FPV includes 143 940 modules installed on an area of 50 ha on the Dami HPP reservoir. The PV's arrays are fixed by onshore, submerged and basement anchors ($5m^3$ concrete blocks transported by boat and dropped at the bottom of the reservoir) via steel cables. The advantage of this solution is to avoid drillings in the lake with a water pollution (fish farm).

In order to ensure safety for the system, a wave protection includes PVC pipes 300mm diameter surrounding the PV's arrays.

A floating central inverter, a land-based substation, and a new 3.5-kilometer, 110 kV transmission line are the additional facilities at Dami Reservoir to support the FPV plant. The project includes a 22-kV spur transmission line, a 22/110 kV boosting voltage transformer near the shoreline, and a 110-kV spur line connected to the project.

The FPV saves water from evaporation that can also be utilized for hydropower generation, and potentially increases the capacity factor of the hydro powerplant.

3.2 Dami FPV – Risk analysis

For the PV modules and the floating system, some risks can be latent as follows:

- Output of the PV modules can be reduced 0.7% to 1% per year.

- Risk of PV modules damage due to external impact such as hailstone, storm, falling of objects.

- Burning of PV modules due to high voltage at the output of PV string (around 1,5 kV DC) which can cause flame in case connection of DC cables are not adapted to technical requirement.

- Controlling and monitoring system should be designed to detect DC earth fault to isolate fault point in the shortest time to ensure safety condition while inverter working continuously.

The risk analysis for electrical equipment and control equipment of the FPV is carried out following present standard. All electric and metallic element are above water reducing the risk of short-circuit and corrosion.

No particular risk was foreseen for the Dami embankment dam, far from the FPV and with a thick upstream rockfill protection layer.

3.3 Dami FPV – Environmental aspects

A meteorology gauging station was installed on the site before the FPV powerplant design in order to estimate its technical and economical features and to evaluate the possible local meteorological changes after its operation.

For impact of solar power on biological aspects, it was considered the following topics :

- Behavior of creatures in areas covered by the PVs arrays.

- Behavior of migrating birds due to deflection of sun light on PVs.

- Biological aspects linked to the covered densities of PVs array on the reservoir surface, with the advantages and drawbacks.

At the Dami reservoir, there are fishing activities at small scale by some households living near the reservoir and there is no significant impact in general. On the surface of the Dami reservoir, a sturgeon farm is in operation with a total area at around 50 ha. There is so far any information from this company about impact of the project to its fishing activities.

It needs really a long time to evaluate long-term impact of a project which was implemented only since two years, so it doesn't exist presently enough data for conclusion. However, the data collected at the site during this last period do not show any significant negative change.

3.4 Dami FPV- Financial aspects

DHD (Joint Stock Company of EVN) has invested around 64.5 MUSD for the Dami FPV and EVN has the potential to install a future FPV extension with a total capacity of about 300 MWp.

The design and floating equipment (pure-float design with HDPE) were provided by Chinese Companies, the electrical equipment by Chinese and Japanese manufacturers and the transmission lines by Vietnamese companies.

The selling price fixed by the Government for Dami FPV is 9.35 US cents/kWh, but for future FPV this price will be reduced to 7.69 US cents/kWh. The return period for Dami FPV's investment is 14.5 years.

The financing package for Dami FPV includes a 17.6 MUSD loan from ADB, supplemented by 15 MUSD by the Canadian Climate Fund for the Private Sector in Asia. The package also includes a 4.4MUSD parallel loan from the Leading Asia's Private Infrastructure Fund (LEAP), supported by Japan International Cooperation Agency through a 1500 MUSD equity commitment.

4. Gia Hoet 1, the second FPV in Vietnam

The second FPV in Vietnam (12/2020) is installed on the lake of Gia Hoet in the Province of Ba Ria on an area of 33.6 ha with a capacity of 35 MWp and an investment of 34 MUSD.

5. Some FPVs under design in Vietnam

5.1 A list of FPV under study or at the feasibility stage

- Tri An reservoir FPV's output parameters with a 5% water surface coverage: 1465 MWp and 2150 GWh.

- A FPV of 20 MWp on the paddy fields and lakes in the Dong Thap province.

- Several FPV with a total surface of 13 000 ha on the reservoir of the Son La HPP.

- Hoa Binh reservoir FPV's output parameters with a 5% water surface coverage 481 MWp and 541 GWh.

5.2 A Governmental list, for local and foreign investors concerning some FPV projects in Southern Vietnam

- 35 MWp Floating Solar Farm in Vung Tau province.

- 1250 MWp Floating Solar Farm in Tay Ninh provinc.e

- 1300 MWp Floating Solar Farm in Tay Ninh province.

- 48 MWp Floating Solar Farm in Lam Dong.

This program is very ambitious but it can be partly postponed or cancelled depending on the future technical and economical constraints of FPV and the electrical energy prices in Vietnam.

6. Present issues concerning the FPVs in Vietnam

6.1 Technical issues

- The main present issue relates to overloading of grids in Southern provinces where most new solar power facilities are coming up. The very recent rapid expansion of the solar energy (powerplants and rooftops) has raised challenges due to grid curtailment issues, overall the country total installed production surpasses the grid capacity by already 18%. In some provinces as Ninh Thuan and Binh Thuan the situation is even worse as the production is twice the grid capacity.

- The insufficient storage capacity of electricity opposed to the important increase of the Renewable Energy capacity.

- The hybridization between the FPV powerplants and the hydro powerplants is not yet enough developed to alleviate the issue listed above.

- The construction of new transmission lines and maybe the utilization of smart grids in the future could partly alleviate this issue, as it will enable better utilization of the existing transmission network at the hydro powerplant.

6.2 Administrative and financial issues

In spite of the liberalization of the policies in the last few years, investors can face some obstacles such as:

- Lack of capital/funding, although Vietnam is currently the number one investment destination for renewable energy in the region, due to the favorable policies deployed by the government to attract capital.

- Un-bankable power purchasing agreements (PPA) terms;

- Delays in larger projects due to the complex regulatory framework; and

- Some lacks of clarity in future energy prices.

The Author

M. Ho Ta Khanh is graduated of Ecole Nationale des Ponts et Chaussées (Paris). He has worked for 35 years in Electricity of France (EDF) as Dam Engineering specialist. He participed in the design, construction and operation of more than 150 dams in France and abroad. Since his retirement in 2003, he cooperated with the Vietnamese organizations in charge of hydropower and dams in Vietnam, Cambodia and Laos.