SUNGROW
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SOLARPLAZA
FLOATING SOLAR

GLOBAL UPDATE ON FLOATING SOLAR

VISIONS FROM A KEY FPV PLAYER

Source: Sungrow FPV

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1. Intro

"Where there is water, there is potential for FPV."

Since the development of the first floating photovoltaic (FPV) power generation system in Japan in 2007, the application of these systems has gradually gained popularity in many countries around the world including China, South Korea, Taiwan, France, the Netherlands, Vietnam and the US. The last four years have been particularly important in terms of global FPV capacity gain. From 2017 onwards, the annual capacity additions have become significantly higher due to the increasing number of large-scale projects, primarily located in China.

According to data from the Solar Energy Research Institute of Singapore (SERIS), the global cumulative installed Floating PV capacity surpassed 2.0 GW in September 2020, distributed over more than 500 projects worldwide. As highlighted in Solarplaza's 2021 analysis of the "Top 50 Operational Floating Solar Projects", Asia is home to about 90% of the total capacity of the 50 largest FPV projects on that list.

So, globally, Asia continues to be dominant as the market-leading continent. However, it's becoming clear that, out of all other continents, mainly Europe is starting to pick up speed and gain some market share. Within Europe, the Netherlands has now emerged as the biggest market.

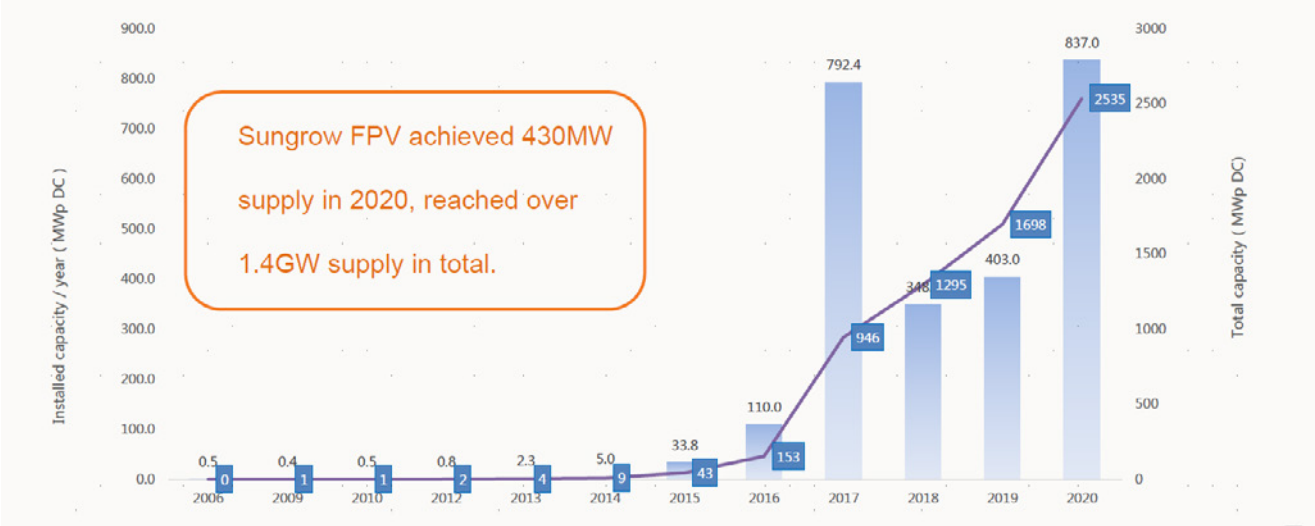
Apart from these geographical developments, there's also been a lot of innovation in this maturing market segment. Innovation with regards to the technology empowering the projects and keeping them afloat - and anchored, but also innovation with regards to how they're being developed and (co-)located.

In order to gain some perspective on the latest developments in important floating solar markets, Solarplaza reached out to Sungrow FPV, one of the world's leading players in the floating solar space. Through interviews with their experts, we've jointly compiled this comprehensive whitepaper that seeks to give an overview of what we can expect for floating solar in the years to come.

Thailand 58.5 MW FPV project (hydropower dam) Source: Sungrow FPV

2. Current State of the Market

2.1 Market Growth



Source: Sungrow FPV

This chart by SERIS clearly shows the development trend of floating PV in the past several years. It distinctively shows two 'booming' periods of growth: one from 2016 to 2017 and a second one from 2019 to 2020. The first spike can largely be attributed to China's 'Top Runner' policy, which led to FPV becoming such a hot topic in China. The main reason for the occurence of the second boom is the dramatic increase in floating solar developments in Southeast Asian countries, such as Singapore, Thailand and Vietnam. Numbers from SERIS showed how, in September 2020, the global floating solar capacity had already crossed the 2 GW mark. In the year 2020, Sungrow FPV boasted the impressive achievement of supplying 430 MW of that. By June 2021, the company's total supply to floating solar projects had already exceeded 1.4 GW.

2.2 Leading Markets

From a global point of view, Asia is clearly expected to remain a key player for floating solar, with its abundant water resources and favorable government policies across the region. However, there are more markets on the verge of scaling up. In the Middle East, for example, Israel is a rising star on the scene of FPV. In Europe, The Netherlands has continued to develop quickly over the last two years. Germany and Portugal also show large potential. Germany still features a lot of coal mining subsidence areas which could host FPV systems, in a similar way as those have been implemented in such areas in China. And on the Iberian peninsula, Portugal has announced plans to develop 500 MWs' worth of floating PV projects in the near future.

2.3 Impact of Covid-19

As in many areas of the solar industry, a big question looms on how large the impact of Covid-19 has been on the growth and development of the segment. In Sungrow FPV's view, Covid-19 has not had a major influence on developments in China. As a floating system supplier, they have not seen an impact on manufacturing in China. However, on a global scale, they have found that some foreign FPV projects have taken longer to be developed due to delays in (building) permitting. Freight and transportation costs have also become significantly higher, which can slow down the process of realizing a floating solar project. Acting on that, Sungrow FPV is actually developing factories abroad and is expanding its global supply chain to relieve pressure from transportation costs and logistics and support its clients with realizing projects as fast as possible.

Singapore 60 MW FPV project (drinking water reservoir) Source: Sungrow FPV

3. Relevant technological trends and developments

3.1 Offshore projects

With favorable policies for green energy around the world, the photovoltaic industry has developed vigorously. However, the surface required for large-scale project development is becoming increasingly scarce - on land. Floating solar projects have provided an obvious alternative, by instrumentalizing water surfaces. With an initial focus on land-locked water basins, floating solar has scaled up. However, especially in developed coastal cities, with high energy demand, the potential for offshore FPV applications looms. However, offshare projects bring forth a unique set of challenges. Currently, a lot of research is being done on offshore solutions, relating to the challenges of high wind speeds, high flow velocities and high wave heights. Sungrow FPV has been making great efforts to combine the research of wave breakers with the wave elimination principles done by top universities, to formulate the most economical and durable technical scheme. Another challenge of offshore applications is the impact of corrosion and enhancement of weather resistance. Sungrow FPV has therefore been developing a better product material formula, which strengthens the environmental resistance of floating projects.

3.2 Anchoring and mooring systems

Furthermore, important design improvements are still being made in the area of anchoring and mooring systems for floating PV plants. Following five years of product improvement and project experience, design improvements have now been made on anchoring cables - from the original anchor chains and steel wire rope to the currently-applied forms of elastic ropes and floating balls, suitable for great water depths and large water variations.

Sungrow FPV has also been involved with formulating the first anchoring design standard for the floating solar industry in China, which should make the design of the anchoring system more standardized and will allow for a better and more uniform development of the FPV industry. Including scientific calculation theories, this anchoring method has been certified by the Chinese Photovoltaic Association (CPIA) and verified by DNV.

3.3 Panel Size

Another element that influences plant design is the development in the physical sizes of panels. As seen in the market, panels are gradually transitioning from 182-cell to 210-cell formats. At present, there are already 600W+ modules available on the market, with panel dimensions reaching 2400x1350mm. This, of course, influences mounting systems and plant design.

Taiwan 93 MW FPV project (offshore) Source: Sungrow FPV

3.4 Overall Plant Design

With the growing number of segments and applications for FPV in mind and with a quickly-growing track record of experiences, Sungrow FPV is now able to provide floating system designs in accordance with many applications. That includes 'traditional' areas like ponds, coal mining areas, and reservoirs, as well as more complex areas such as offshore sections, hydropower stations, dams with great water depths and large water variations, and areas that have to deal with extremely cold conditions or extreme weather conditions (eg. typhons). Sungrow FPV have tailored their solution to adapt to the diversity of project conditions and offer safe and reliable design solutions.

3.5 Hydropower Projects

As alluded to in the last section, applications of floating PV systems in combination with hydropower projects has been a specific niche that's growing in popularity. At present, there are 1200+ GWs' worth of hydropower stations in the world, therefore the potential for this kind of co-location is great. Furthermore, utilizing the existing construction facilities and transmission infrastructure of hydropower stations can greatly reduce the investment cost of FPV. So, simultaneously, the existing, underutilized, water surface resources of the hydropower station can easily be used without need for land acquisition; investment costs can be reduced; and the total installed power generation capacity is increased. Also increasing the stability of the power supply, the combination of FPV and hydropower stations can be dynamically adjusted to maximize power generation efficiency. An example of that is the EGAT 58.5 MW project in Thailand, which is a typical case of combining water-surface PV power generation with a hydropower station. This case, and the larger ambitions surrounding it, are highlighted in detail in the Appendix of this white paper.

4. Outlook

4.1 Main Challenges

When asked about the main challenges for the period ahead, Sungrow FPV highlights the system design of offshore FPV projects. As offshore conditions are much more complicated than inland conditions, and the corrosiveness of seawater has a greater impact on metal parts, more research on the overall system is required to be able to guarantee for at least 25 years of safe operations of the power stations.

Sungrow FPV has already performed research on wave-elimination plans, non-metal anchoring systems, salt spray testing of metal parts, grounding resistance testing of products (in tidal zones), fatigue analysis and more. However, the potential of unlocking offshore applications of FPV is so great, that it more than warrants the efforts invested in overcoming these challenges.

4.2 Growing out of niche status?

"Building up from 0 to 1 always takes longer than scaling up from 1 to 10." It's already been forecasted that floating solar will grow out to be the third pillar of the solar industry, alongside ground-mounted and rooftop-based solar applications. That naturally means that floating solar will become a commonly-accepted application, rather than remaining in niche market status. The benefits of FPV are obvious with, for instance, the higher power generation due to the cooling effect and the beneficial side effect of protecting water basins from water evaporation. Moreover, the growing diversity of application scenarios present more advantages. So far, Sungrow FPV has successfully applied its floating systems in a wide range of spaces, including offshore, acid water basins, drinking water reservoirs, dams and areas dealing with extreme cold or extreme weather conditions. It goes to show that "where there is water, there is potential for FPV." At the same time, the technology for FPV is maturing and becoming more reliable with the increasing amount of years of experience. As a pioneer floating solar system supplier, Sungrow FPV is keen to share the lessons learnt from 1.4 GWs' worth of projects with others to support the industry and guarantee the safety of FPV projects in the future.

4.3 Ecological impact

Another element of recent discussion has been the ecological impact of floating solar systems. In relation to that, Sungrow FPV shared some insights from their projects.

For example, their Huainan Panji project was, at 40 MW, the world's first large-scale FPV station. It was connected to the grid in 2016 and has been in operation since. In 2019, the project passed TÜV Rheinland quality testing on water quality, which shows that - in 3 years' time - the project had no impact on the water quality. The impact of FPV on the ecology of the water body is mainly reflected in the coverage ratio, because the coverage affects the ratios of dissolved oxygen and light transmittance of the water body. Sungrow FPV considers the environmental protection of the product plan to a greater extent when researching new products. Currently, the water surface coverage in plant design does not exceed 20%, so the light transmittance and oxygen content of the water body suffer almost no impact. The traditional plan floating body had at least 45% of water surface coverage.

The 17 MW FPV system at the Gaoan fishery in China has demonstrated the potential of a FPV project's light-complementary nature, and led to a stabilization of fish farming output. And, in 2021, the world's first drinking water FPV project in Singapore's Tengeh Reservoir demonstrated that the product materials of Sungrow FPV can reach food grade and inflict zero harm to the water body.

4.4 Cost developments

Discussing the topic of cost developments, Sungrow FPV has a positive view on the trends and expects a further decrease in overall costs.

With gradual maturation and standardization of the entire system from solution to product, with large-capacity and high-efficiency PV panels, more stable electrical equipment, lower failure rate, and more standardized solutions and anchoring designs for FPV, the cost per Watt of FPV projects is steadily declining. Secondly, with the improvements in automation, the necessity of operations and maintenance work is being reduced, with the system being checked online and data more easily obtained. Once a fault is encountered, it can be located fast, which reduces troubleshooting time and speeds up the process of bringing the plant back to full operation. The usage of drones also contributes to more convenient and (cost-)effective operations and maintenance, aiding in regular inspections and advanced troubleshooting.

Thailand 58.5 MW FPV project (hydropower dam) Source: Sungrow FPV

5. Conclusion

With over 1.4 GW of track record and intimate involvement in both the project development and the research and standardization processes surrounding floating solar PV, Sungrow FPV has in-depth knowledge and insights on the global market. Identifying a strong growth of markets, great potential for more diverse applications, continued trends of cost declines throughout the system components, and enhanced efficiency and safety through improved system design, floating solar PV is on a solid trajectory towards claiming the prophesized position of becoming the third pillar of the global solar industry.

Appendix I - Case Study EGAT

The Electricity Generating Authority of Thailand (EGAT) is Thailand's largest power producer. As a state enterprise, under management of the Thai Ministry of Energy, it is responsible for electric power generation and transmission, along with most of the power sales in the country.

Under the concept of 'Sustainable Firm Green Energy', the company is developing renewable energy projects with reduced intermittency. This program includes a plan to develop a 'Hydro-Floating Solar Hybrid Project' on 16 sites, with a total installed capacity of 2,725 MW.
The first pilot project was launched at Sirindhorn Dam, for which the LOI issuance happened in December 2019. The project, developed in partnership by Sungrow FPV, is currently under commissioning and is expected to be completed by the end of this year. It's a combination of hydropower and floating solar power in a hybrid system.

As such, it's been designed with an Energy Management System (EMS) that can automatically control, monitor and optimize the plant's generation performance, allowing for more power and longer supply both in daytime and nighttime. Moreover, it allows for the prediction of solar energy generation in order to enhance the stability of hybrid generation.

The project uses two core system components from Sungrow FPV; (1) a HDPE floater with UV resistance and long durability, and (2) a high-efficiency central inverter integrated with IV Curve monitoring functionality for online analysis and fast troubleshooting. Once completed, the project will be the largest of its kind in Thailand.

Source: EGAT

When asked about the future of floating solar in Thailand, EGAT outlines a clear vision and strategy. They have identified hydro-floating solar hybrid projects as a key solution in their efforts to create 'Sustainable Firm Green Energy' with low cost, high stability and less impact on the environment and communities.

- Low cost: utilizing existing assets and reservoirs of hydropower plants as well as reaching economies of scale enables cost reductions for the projects, allowing them to achieve a feasible price and be competitive with others in the market.
- High stability: reducing the intermittency of floating solar energy by leveraging smart technologies:
- Phase I: Creating hybrid systems by combining floating solar and hydropower, controlled by Energy Management Systems (EMS) to increase flexibility in power generation.
- Phase II: Combining advanced technologies, such as Energy Storage Systems (ESS), to enhance the stability of hybrid generation.
- Phase III: Building a Renewable Energy Control Center (RECC) with AI integration, to allow for the forecasting and management of all floating solar and renewable energy plants and control overall renewable energy security.
- Less impact on environments and communities:
- Using eco-friendly materials, such as Sungrow FPV's HDPE Food Grade floater, which poses no harm to water quality and aquatic life.
- Conducting real-time environmental monitoring with advanced technology for fast response times and further preventive measures.

Including EGAT's planned projects, only 1-2% of the surface of the country's water reservoirs will be covered. That means there is still huge potential for further expansion of the projects, which may play a key role in supporting the growth of renewable energy in Thailand.

Appendix II - Case Study Chenya Energy

Since the beginning of 2020, the Taiwanese solar project developer Chenya Energy has been cooperating with Sungrow FPV on the 93 MW offshore floating solar project (with a total capacity of 181MW) located at the Changhua Coastal Industrial Park, in the Changbin Lunwei East district of the island. Due to the joint effort between Chenya and Sungrow FPV, the Changbin project was successfully connected to the grid already in 2020, and it is set to become one of the largest floating solar projects in the world.

According to Chenya, the project presents many challenges, which are not uncommon when it comes to offshore floating solar: wave and wind resistance, tide effects and the lifetime and reliability of the system and its components (due to the humid and corrosive conditions). In order to try and minimize the potential negative effects to the plant, Chechnya and Sungrow FPV have worked together on a special plant design, in which the bottom of the floating body can adapt to the grounding situation of the plant. Other innovative features of the project design are the anti-over-turn edge of the floating island and the highly resistant anchorage system, which can improve the anti-wave performance of the overall floating solar plant.

When asked about their views on the future of floating solar, Chenya stressed their strong belief in the growth of the floating solar market. In the company's perspective, the scarcity of land resources (especially in developed coastal cities and densely populated areas) will continue to drive demand for electricity. Large scale offshore floating solar projects will continue to emerge, especially with the continued research and technological development.

Taiwan 93 MW FPV project (offshore) Source: Sungrow FPV

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