Will Africa follow suit on Asia's upbeat plans to develop floating solar across the continent?

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Before discussing the potential of floating solar to the African continent, the advantages this technology can bring and its current level of maturity, it is important to first set the stage on a global scale and understand since when we are speaking about "floating solar" as an additional solution to land-based (including rooftop) solar PV systems.

Whilst the exact debut of floating solar worldwide remains debatable[1], the advancement and deployment of the technology emerged in Asia, particularly in Japan and South Korea, from 2013 onwards. Although systems remained at first relatively small, commercial projects in the 1–3 MW_p range started emerging between 2013 and 2015, often built on irrigation reservoirs. Land scarcity, which translated into high land acquisition costs and difficulty in obtaining land rights (or in converting land earmarked for other purposes such as agriculture), pushed these two countries to find alternate solutions to land-based solar PV projects, which benefited at the time from preferential feed-in tariffs (FiTs).

After a few years, China rapidly came into the picture with significantly larger (around 8 MW_p) floating solar PV (FPV) systems, which started operating in 2015. Meanwhile pilots and small-scale projects also emerged in Europe and elsewhere with various entrepreneurial companies launching innovative designs, competing for higher energy output, easier maintenance, and costs reduction while keeping quality, transportability and modularity as high as possible. In 2016, a 20 MW_p floating solar plant was built in China, the first large-scale project of many more to come, built on a coal mining subsidence area, and tendered by the government under the Top Runner programme. Built on flooded coal mines, these projects allowed reviving depleted areas and retraining/upskilling local communities, which were previously largely dependent upon the coal mining industry. Other landmark floating solar projects in 2016 were the 6.3 MW_p Queen Elizabeth II and 2.9 MW_p Godley systems, built on water treatment reservoirs in the United Kingdom. From 2017 onwards, projects became larger, to even reaching the record level of 150 MW_p in China (also built on coal mining subsidence areas in the Anhui and Shandong provinces), the two world's largest floating solar projects completed to date.

As shown in Figure 1 below, the last three years witnessed the global floating solar installed capacity gaining significant momentum, mainly due to the advent of large projects in China. Whilst China still holds the record in terms of project size, other countries are following suit and planning to build sizeable floating solar projects, some even in the multiple hundreds of MW-scale, also making them better candidate for non-recourse project financing[2]. Just to name a few, South Korea is planning more than 2 GW_p of floating solar projects (to be built in various phases) at the Saemangeum Seawall dyke on the coast of the Yellow Sea. EGAT, the power utility in Thailand, has announced a pipeline of floating solar projects totalling 2.7 GW_p, including 16 plants on 9 hydropower dams (the first one

[1] According to SERIS research, the very first 20 kW_p project was built in Japan in 2007, quickly followed in 2008 by a 175 kW_p in the United States, built on an irrigation reservoir in a Californian winery.

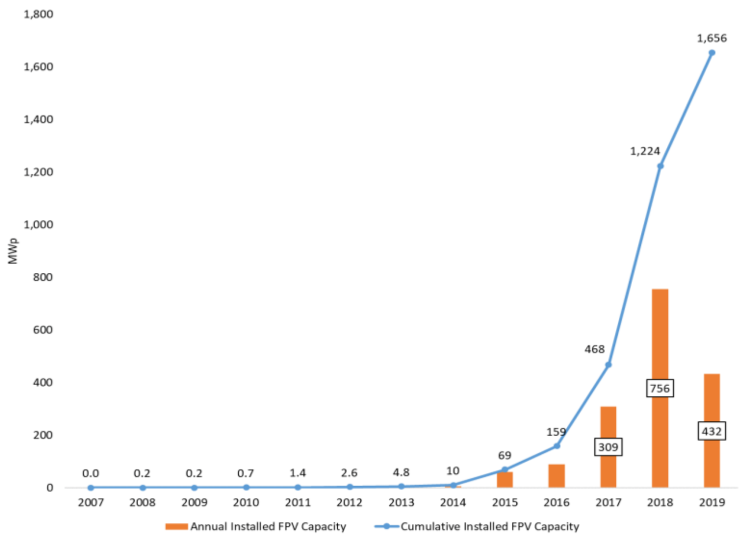
[2] Non-recourse project financing has remained relatively scarce to date for floating solar projects given that the industry is relatively new and many projects remained too small to attract investment banks.

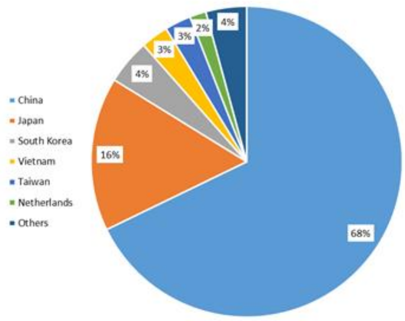
totalling 45 MW_{AC} was tendered and awarded as an EPC contract in 2019). In Taiwan, a project of around 150 MW_p is being built at the Changhua Coastal Industrial Park. NTPC in India, the country's largest power utility, has already tendered more than 270 MW_p of floating solar projects to be built on water reservoirs and dams at some of its coal, CCGT and hydropower plants. In Vietnam, as the country is moving away from FiTs, the first solar PV auctions are expected to be organized in 2020 and 2021 and will consist of floating solar projects built on hydropower dams for a total of 350-400 MW_p. In Indonesia, Abu Dhabi-headquartered Masdar won the first 145 MW_p floating solar project to be jointly built with a subsidiary of PT PLN on Cirata hydropower dam in West Java. There is no doubt that floating solar, the 'new' third pillar of solar PV, is growing fast with Asia leading the world in terms of future installed capacity. Even though the 2019 total installed capacity was 95% based in Asia, Europe is also embracing this new technology – though at a smaller scale – with Netherlands, France and the United Kingdom counting a combined 55 MW_p installed base as of end 2019. Smaller projects are also being developed in the United States, mainly led by water utilities, and the first pilot projects started being implemented in South America, mainly at hydropower dams and on irrigation reservoirs. Many countries in different parts of the world have shown their interests and started conducting feasibility studies to understand the potential this new technology could bring to their own energy mix.

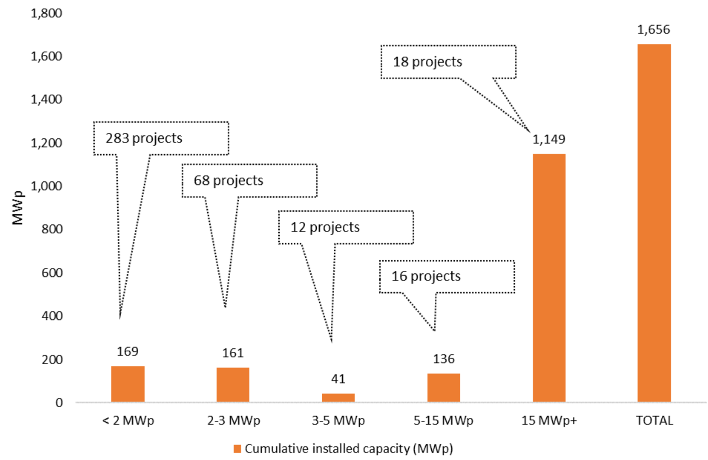
Noteworthy, floating solar has historically been (and will certainly continue to be) developed on freshwater bodies, but some new landmark projects, such as the ones in South Korea and Taiwan, will be built on sea water within special industrial zones along the coast. Other countries looking at seawater near-shore and off-shore floating solar developments include the Seychelles, Maldives, Singapore, Philippines, Netherlands and Belgium, to name a few.

But what has been developed in Africa so far? A small 59 kW_p FPV system was installed in 2019 in the Western Cape, South Africa, on a fruit farm reservoir. A pilot system was also installed in 2017 in Tunisia for research purposes. Various countries are showing interest in the technology. Some countries such as Liberia, Burundi, Malawi, Tunisia and Zimbabwe are starting to conduct feasibility studies. A notable progress was the January 2020 announcement of the winning bidder for the 4 MW_{AC} FPV system to be built on Le Rocher lagoon in Mahé in the Seychelles. With the backing of the African Legal Support Facility and the Clinton Foundation, this IPP project, first in the country and expected to be completed in 2020, will also be one of the first seawater floating solar projects built worldwide. The project will sell all its electricity under a 25-year PPA with PUC at a tariff of USD 9.5 cents per kWh, which provides a significant cost (and environmental!) advantage over electricity produced by diesel gensets. This is a great achievement and one can hope to see many more of these reaching the African continent beyond 2020.

Figure 1: Global floating solar installed capacity (annual and cumulative) and geographic/project size distribution; data as of end 2019







Source: Solar Energy Research Institute of Singapore (SERIS), National University of Singapore (NUS)

Why has floating solar gained such momentum? To answer the question, it is important to look at the benefits this technology can bring, but also be cognisant of the remaining challenges.

Floating solar is not meant to re-invent the wheel. The general layout of a floating solar PV system is relatively similar to that of a land-based PV system, other than the fact that the PV arrays and often the inverters are mounted on floating structures, membranes or platforms, which form modular "islands". For smaller FPV systems located close to the shore, inverters can be placed on land. For larger systems, both central or string inverters are typically placed on a floating structure adjacent to the solar arrays. The platform, together with its anchoring and mooring system, is an integral part of any FPV installation. Solar modules, inverters, transformers, cabling and other equipment can be the same as models used on land as long as they can withstand a certain degree of humidity and moisture. Double-glass modules have also been commonly used in floating solar applications, yet more research and long-term data is needed to confirm this choice. Some manufacturers are also starting to adjust their product range and offer some equipment better geared for floating solar applications.

Different types of floating structures exist, which need to be selected on a project base, suitable for the actual site and the water body's specifications. The choice of the system design will also depend upon the prevalent climatic conditions, which can span from, for example, (very) strong winds (e.g.

typhoons), icing-snow conditions, high tidal fluctuations to still water bodies with (very) low wind and waves.

To date, the vast majority of the global floating solar installed base is using pure-float structures made of high-density polyethylene (HDPE). However, as the technology is still maturing, this should not preclude any other existing and future technologies in reversing this trend. Indeed, numerous equipment suppliers are entering this segment and proposing new floating structure solutions; some of them coming from adjacent lines of businesses (e.g. marinas, fishing, plastic products' manufacturers, etc.) where they can leverage their specialized know-how for this new application. Metal structures, hybrid structures consisting of a combination of metal and HDPE, and hydro-elastic membranes are currently the most common alternatives to pure-floats whilst others exist as well (e.g. ferro-cement structures).

The main advantages of floating solar PV systems are both technical and commercial. The most commonly cited one is more commercial in nature and consists of utilizing spaces that are often not used at all and where there is less competing use compared to land-based PV. This advantage is key in countries where land is scarce (or unsuitable such as in certain mountainous regions), expensive or where complex land titles constitute a major obstacle to the land acquisition process. Also, man-made water bodies are often located close to demand centres. Thereby, if combined with floating solar, transmission costs can in certain instances be significantly reduced.

On the technical side, FPV projects benefit from the evaporative cooling effect of the water body, which tends to lower the operating temperatures of the PV modules, thereby increasing the system's energy output. Shading also tends to be reduced on water as opposed to land. Furthermore, when placed on water, dust on the panels could be significantly reduced, especially in arid and desert locations where solar farms are often constructed. The exact impact on the energy yield will depend upon sites, climates and design of the FPV systems. Data from various testbeds, including SERIS testbed in Singapore, as well as early projects across the world show that an increased energy yield can be expected. This is very much dependent on the location and system design, but can be as high as 10% in hot climates.

Another technical advantage is the hybridization of floating solar with existing hydropower plants. The additional FPV system can use existing grid interconnection transmission infrastructure in case excess evacuation capacity is available. Hydropower plants fitted with fast-responding turbines can help reduce the variability of electricity generated by the FPV system. In any case, there is complementarity during the diurnal cycle (using solar power during the day and hydropower at night), and possibly even across seasons, whereby the floating solar system could help save water in precious months of the year where the sun is more prevalent (e.g. dry season). Typically, a hydro-connected floating solar project would reduce seasonal variations in power production and could also reduce power curtailment. Hybrid hydro-FPV projects are gaining attention worldwide and several research projects are on-going to quantify their techno-economic benefits.

Another benefit, which could prove useful in certain African countries, is the fact that certain FPV designs can help reduce water evaporation. Typically, these systems would require a larger footprint on the water surface to reduce water evaporation; hence, their environmental impact should be properly assessed if built on an ecology-sensitive water body. However, this advantage might come at the expense of the cooling effect on the PV panels, which might be then reduced.

In general, floating solar can be an attractive option in countries where access to land is a major obstacle or where other conservation objectives are sought such as reduction of water evaporation. However, a few challenges remain in place.

First of all, costs of floating solar projects still remain higher than their ground-based solar PV counterparts. However, this argument is very much dependent on the prevalent site conditions, both for the floating and ground-mounted PV projects as certain sites might present more favourable conditions for floating structures as opposed to land-based systems. Moreover, FPV systems could even become cheaper than ground-mounted ones as floating structure costs are expected to reduce over time.

Another key aspect is how easy the maintenance of the FPV system can be implemented. Indeed, access to the site (including the anchoring and mooring system) is often more complex (e.g. might require boats) and will likely be a bit more costly. Nevertheless, the expected higher O&M costs can be (partly) compensated in certain countries by the reduced frequency of PV module cleaning required on a water body as opposed to PV systems located on a dusty piece of land, which might require frequent cleaning routines. Nevertheless, not just the PV modules, but regular checks of smaller parts of the FPV system such as cables, ties, connection points, bolts between floats will also be important to ensure the longevity of the entire system. After all, the system is constantly moving (more or less, depending on wind, waves and currents).

Much emphasis should also be placed on proper anchoring and mooring, which is a key element of the islands' structure. Indeed, the anchoring and mooring can, in some instances, especially where water level variation, waves, currents and wind are high, affect the durability and safety of a project, if not designed properly. It is therefore important to rely on experts with relevant track records of projects located in similar climatic conditions than the project being assessed.

Finally, as many operating FPV projects are still relatively young, the amount of long-term data available remains limited. Durability of the systems and their potential impact on the environment (e.g. water quality, flora, fauna, etc.) will need to be tested outside the labs, in real-world conditions and a variety of climates. The positive outcome is that many countries are joining the race, which means that more data will become available with time, which will help build a robust, sustainable and long-standing technology for the future.

Together with the World Bank and ESMAP, SERIS published two reports on floating solar as part of the publication series "Where Sun Meets Water", disseminating the knowledge gained over many years and based upon SERIS industry outreach and on-going research from its 1 MW_p floating solar testbed in Singapore:

- Floating Solar Market Report, published in June 2019
- Floating Solar Handbook for Practitioners, published in October 2019

The full reports are accessible on SERIS and the World Bank, ESMAP websites.

About SERIS

The Solar Energy Research Institute of Singapore (SERIS) at the National University of Singapore (NUS), founded in 2008, is Singapore's national institute for applied solar energy research. SERIS is supported by the National University of Singapore (NUS), the National Research Foundation (NRF) and the

Singapore Economic Development Board (EDB). It has the stature of an NUS University-level Research Institute and is endowed with considerable autonomy and flexibility, including an industry-friendly intellectual property policy.

SERIS' multi-disciplinary research team includes more than 140 scientists, engineers, technicians and PhD students working in R&D clusters including (i) solar cells development and simulation; (ii) PV modules development, testing, characterization and simulation; (iii) PV systems, system technologies, including floating PV, BIPV and PV grid integration.

SERIS has extensive knowledge and experience with floating PV systems, including having designed and operating the world's largest floating PV testbed in Tengeh Reservoir, Singapore, together with PUB, Singapore's National Water Agency, and the Singapore Economic Development Board (EDB). Launched in October 2016, this testbed compares side by side 10 leading floating PV solutions from around the world. Through detailed monitoring and in-depth analysis of performance of all the systems, SERIS accumulated deep insight into floating solar and SERIS' objective is to disseminate the best practices in installation and operation of floating solar systems as well as to help formulating standards for floating PV.

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