Challenges and experiences of floating PV and BOS components

Floating solar | Floating solar applications continue to grow both in terms of project size and geographical reach, however there remains some uncertainty around the demands placed on balance of system components away from the module, such as floats, clamps, cabling and other electrical equipment. TÜV Rheinland's Jörg Althaus details the factors that may influence purchasing decisions when it comes to FPV projects.

Credit: Sembcorp Industries

Careful consideration is required on the selection of BOS components based on the conditions the system is likely to experience.

Floating Photovoltaics (FPV), sometimes also called floatovoltaics, are solar panels on a floating body on water, mostly reservoirs or lakes, but sometimes also offshore on salt water. The technology opens new opportunities in particularly in densely populated countries with high cost of land.

The market for this technology has grown rapidly in the last 5+ years. Most experience has been collected in Asia, but in recent years many systems are starting to get deployed across Europe as well. Some countries have also started to provide special funding for FPV projects or product development, one example being Germany's Federal Network Agency's support programme announced in October 2021.

As with any new technology there is some uncertainty regarding reliability and code compliance which may impact the bankability for some projects. As holistic standards for FPV have not been developed yet and "field" experience is limited, compared to ground mounted PV, it is essential to look at the potential additional technical risks and take measures to mitigate those.

The various environmental factors influencing FPV reliability are partly additional stresses compared to ground mounted systems. Stresses caused by wind and waves are of main concern here, but the reflection of sunlight from the water surface needs to be considered as well. On the one hand it increases the energy yield of a FPV system, but on the other hand it also increases the potential for UV-related degradation mechanisms.

Further snow and ice loads may need to be taken into account when dimensioning the floats. Cases have been reported where the load bearing was under dimensioned and the systems were loaded such that the modules actually touched the water line, a scenario for which the modules or other system components are not designed.

Finally, vegetation and fauna cannot be neglected. Sea birds see a good place to rest and may leave plenty of dirt behind on their departure, while barnacles and ferns can find a new home on FPV systems.

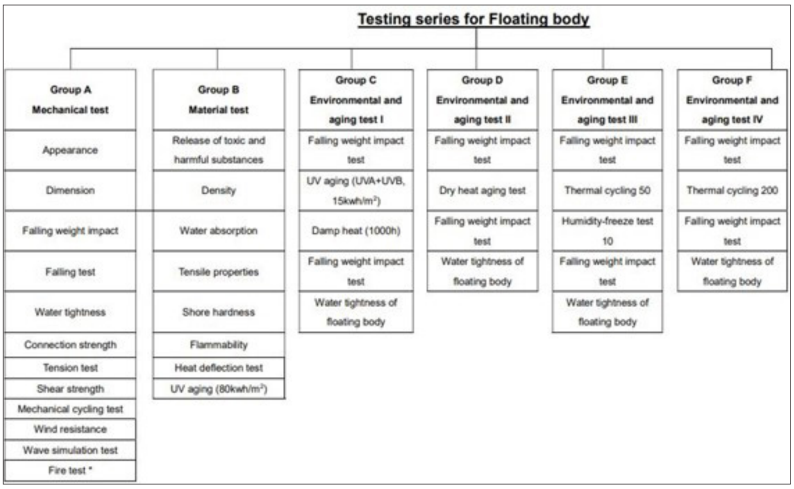
Component selection

The system components of FPV are different or include additional parts than conventional PV systems. Two main design concepts have come to dominate to date: floats made from high-density polyethylene (HDPE) or of reinforced hydro-elastic membranes. Both variants can offer advantages depending on the specific project conditions and design. However, given the challenge of both coping with and protecting the surrounding environments, correct dimensioning and design is crucial. In the absence of an international standard for floating bodies, TÜV Rheinland has put together a test specification to address the various stresses the bodies need to withstand.

TÜV Rheinland's in-house standard - 2 PfG 2731/02.20 Requirements for materials used in and construction of floating bodies - provides a list of test methods to allow the assessment of various designs. Included are a number of mechanical tests looking at the load baring capacity, tensile strength and elongation under heat.

Further environmental tests like UV resistivity, temperature resistivity, water tightness and buoyancy tests also form part of the assessment. Finally, demo systems are taken to a wave laboratory to assess reaction to wind and wave exposure. The first tranche of floating bodies have undergone the extended testing procedure, while more are currently being tested.

On top of the floating bodies, the main system components are fixed - the main being the PV module itself. Here, several points need to be considered when choosing the right module for a system.



Credit: TÜV Rheinland

The test programme for floating bodies from TÜV Rheinland 2PfG 2731

Since some bodies are smaller than the modules that get installed on them, the mounting situation needs to be carefully checked. The typical spread of mounting clamps at a 2/3 position of the module length may not be applicable to all designs. Should the mounting instruction of the module maker not be applicable, it is important to test the mechanical strength of the modules under real installation situations. As dynamic loads through wave and wind are to be expected, it is recommended to request for a Dynamic Mechanical Load Test in accordance with IEC 62782.

The permanent exposure of the modules to moisture may limit the product choice to modules with increased resistivity to moisture ingress. Glass/glass module designs may be a good choice, however some designs with polymeric backsheets also include added moisture barriers, e.g. by aluminum sheets within the multilayer backsheet.

If the system is designed for sea water environments, a Salt Mist Corrosion Test following IEC 61701 is applicable to all critical components.

Due to some reported issues with insulation resistance in FPV systems and the general risk of long-term exposure of electrical components to water TÜV Rheinland has further taken a step ahead in introducing its 2 PfG 2750/09.20: Requirements for cables with improved water resistance for installation in PV Systems. While standard DC cables for PV installations are typically qualified against IEC 62930, respectively EN 50618, such cables are not designed for longer-term submersion in water and may hence have issues in permanently moist environments.

The new standard allows PV cables to be qualified for improved water resistance. A main added requirement here is that the conductor within the cable has to be of Class 5 in accordance with IEC 60228: Fine stranded copper conductors for single and multi-core cables and wires. A requirement for capacitance change after water submersion is also included in this standard, and similar standards are currently under development for other floating system components, such as connectors and wiring compartments.

Combiner boxes and inverters, if installed on the floating bodies as well, certainly also need to be built such that they withstand the higher humidity and dynamic load associated with floating PV proejcts. While these components are typically designed as fixed/non-moving parts, the permanent movement on a floating system may require reinforced containment of the sensitive electronic parts.

The issue of safe and cost-effective anchoring and mooring concepts are also garnering increased attention. Strong wind events or high wave activity as well as long-term fatigue and corrosion are real threats to the anchoring and mooring systems and hence the right choice of components and dimensioning is essential.

System requirements for water reservoirs, where water levels may vary by more than 10 meters, are very different than for an inland lake with only small wave action and rather stable water levels, and a completely different challenge presents itself in the mooring and anchorage for an offshore system.

In all cases the station keeping system shall allow a certain offset, but keep the system in proximity to an anchor point. Mooring systems are no new thing and have been used in the oil and gas industry for years, but statistics do show that on average a mooring system (assessment in period 1980-2001) fails every nine years, with fatigue failure being the biggest worry (Noble Denton Phase 1 Mooring Integrity JIP - Brown, et al., 2005; Noble Denton Europe, 2006). For a 25-year project plan, this suggests close monitoring and potentially integration of failure detection instruments is in place.

Besides the criteria for choosing the right components, O&M practices need to be adjusted to the onsite conditions. Preventive actions against flora and fauna influencing FPV systems performances as well as inspection cycles and content of such inspections deviate from standard on-shore practices. Beside the components above the water line also those below require maintenance.

A point that is still under investigation is the bio compatibility of some of the materials used in FPV systems. It is important for the industry to work together and share the learnings from real installations to make full use of this additional potential for solar energy use. ■

PV Modules	Dynamic Mechanical Load Test (IEC 62782); Salt Mist Corrosion Test (IEC 61701)
Junction Boxes	Development of an amendment to IEC 62790
Connectors	Development of an amendment to IEC 62852 containing an annex with supplement requirements for connectors intended to be installed in a FPV system
Wiring Harness	Project team for creation of a NWIP was founded. A complete new standard is under development
Cables	TÜV Rheinland 2 PfG 2750/09.20: Requirements for cables with improved water resistance for installation in PV Systems
Floating Bodies	TÜV Rheinland 2 PfG 2731/02.20: Specification for technical requirements of floating bodies used in PV Power Plants

Table 1: Status of standardisation for various FPV system components

Authors

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