Appendices

Appendix 1. Floating Solar System Costs

The capital costs (CAPEX) of floating PV are slightly higher or comparable to those of ground-mounted PV, owing to the need for floats, moorings, and more resilient electrical components.

Total capital expenditures for turnkey FSPV installations in 2018 generally ranged between US$0.8 and US$1.2 per Wp, depending on the location of the project, the depth of the water body, variations in the depth, and the size of the system.[2]

A rough estimation of the renewable electricity cost for Ulu Tutong Dam is as follows.

Electricity capacity	330 MWp
CAPEX	330 MWp x (0.8–1.2) US$/Wp = US$264 million–US$396 million
Electricity generated	550,000 MWh/y
Years of depreciation	10 years
Electricity cost	(US$264 million–US$396 million) x 0.1/550,000 MWh = <u>0.05~0.07</u> US$/kWh

[2] World Bank Group (2019), *Floating Solar Market Report*.

Appendix 2. Policy and Regulatory Considerations

(1) Regulations and Guidelines for FSPV Installation in Asian Countries

Japan

At the end of 2021, design and construction guidelines for floating solar power generation systems were enacted by the New Energy and Industrial Technology Development Organization (NEDO).[3]

However, the scope of application is limited to systems installed on freshwater bodies, such as lakes, man-made lakes, and reservoirs, etc., where there is no flow.

As a general rule, these guidelines do not apply to equipment installed on the rivers and seas where unique natural conditions such as storm surges and tsunamis are expected to occur.

The guidelines include the following items:

- Preliminary survey
- Structural design and construction planning
- Electrical design and construction planning
- Maintenance plan

In addition, Japan's Ministry of Agriculture, Forestry and Fisheries has issued guidance on the installation of floating PV systems in agricultural reservoirs.[4]

Republic of Korea

Regarding FSPV, there was a restriction in the past that the ratio of the installation area should be within 10% for reservoirs and within 20% for freshwater lakes, but this has now been abolished.

In addition, construction standards for installation on water bodies have been created in the solar construction standards under the jurisdiction of the New and Renewable Energy Center.

Taiwan

Regarding installation on water bodies, the installation area of FSPV is limited to 50% or less of the irrigation reservoir area according to the management principle of the installation of solar power generation equipment.

It is regulated that the water quality should be tested regularly, the water quality standards for irrigation should be met, and the use of detergents that pollute the water should be restricted.

[3] NEDO (2021), *Design and Construction Guidelines for Floating Solar Power Generation Systems* (in Japanese).
[4] Ministry of Agriculture, Forestry and Fisheries (2021), *Guidance on Installation of Floating Solar Power Generation Equipment in Agricultural*, Ponds Rural Development Bureau (in Japanese).

(2) Environmental and Social Aspects of FSPV Systems

Environmental and social aspects specific to the construction and operation of FSPV projects are as follows.

Water quality

FSPV projects may affect water quality to varying degrees, depending on their type and design characteristics. The use or accidental release of oil and/or lubricants from boats used during maintenance activities or detergents used to clean panels can affect water quality and aquatic flora and fauna. Some have argued that FSPVs should not be installed in reservoirs that serve as drinking water sources, and a full safety assessment is required when installing FSPVs in such bodies of water.

In Japan, the installation of FSPV in ponds used for agricultural water is progressing, and it is required to confirm whether the installation of FSPV will deteriorate the quality of stored water. In addition, there are cases where power generation companies are required to conduct water quality inspections of ponds once a year and take necessary measures at their own expense if problems arise in terms of water quality.

FSPV installation permits

In some countries, drinking water reservoirs or hydropower reservoirs are considered national-security sites, making permitting more complex and potentially protracted.

Appendix 3. FSPV Damage Countermeasures

1. Damage by Typhoons

- Kawashima Sun and Nature's Megumi Solar Park, 7.55 MW, Saitama, Japan

  (1) The mega solar plant started operating on 26 October 2015, and 27,456 solar panels are fixed on floating mounts.

  (2) Kawashima Sun and Nature's Megumi Solar Park was damaged by Typhoon No. 9 on 22 August 2016.

  (3) 152 panels (41.8 kW) and floating racks were damaged by strong winds and high waves.

  (4) Since empty floats without panels on the periphery were not connected, the panels protruded from the float and were easily blown by the wind.

- Chiba Yamakura Floating Mega Solar Power Plant, 13.7 MW, Japan

  (1) On the afternoon of 9 September 2019, when Typhoon No. 15 passed through Chiba Prefecture, a fire broke out at the Chiba Yamakura Floating Mega Solar Power Plant on the surface of Yamakura Dam in Chiba Prefecture.

  (2) Due to the strong winds from the typhoon, the float mounts were damaged so that they were stacked on top of each other.

<u>Countermeasures:</u>

- The floating island (a PV power generation system installed on the water) was simplified and downsized and divided into six parts to prevent a local concentration of power.
- Increased the number of float anchors from 420 to 904 to improve wind safety.
- In order to prevent electric fires, measures such as dividing the electric cables into positive and negative and putting them in protective tubes were taken.

2. Salt Damage for Offshore Installations

It is important to take countermeasures against salt damage when installing FSPV offshore, and countermeasures are summarised in Table A1.

Table A1. Measures Against Salt Damage

Manufacturer	Measure
Sharp	Dedicated modules and mounts are available for each region where salt damage countermeasures are required. Products other than tile type (NT-58K1D, NT-41K1D) are also resistant to heavy salt damage. However, places where seawater directly splashes during strong winds are excluded.
Mitsubishi Electric	Module: In preparation for installation in salt-damage areas, a 3-layer structure back film with excellent weather resistance, moisture residence, and sealing performance is used. Corrosion-resistant plating is used for the frame and screws. Frame: Aluminium that forms an oxide film and clear coat prevent corrosion and salt damage.
Kyocera	Solar cell modules and rack systems can be installed as standard products, even in coastal areas. They cannot be installed in places where seawater, etc. directly splashes. Photovoltaic module: Light receiving surface is made of tempered glass (white plate heat-treated glass); the back surface is a multi-layered film (back sheet) with excellent weather resistance; and the frame is also made of aluminium alloy with various surface treatments (anodised, electrodeposition) applied. The internal solar cells are completely sealed with a thin layer of transparent resin, etc. to protect them from moisture and dust. The connector is also dustproof and waterproof. Rack system: Hot-dip galvanised steel, hot-dip zinc-aluminium-magnesium-coated steel, stainless steel, and aluminium alloy with a similar surface treatment to the frame of solar modules. Power conditioner: Cannot be installed in areas where salt damage is expected within 500 m from the coast.
Canadian Solar	In salt-damage areas (areas not directly exposed to droplets and within 500 m of the coast), a salt-damage stand is required and installation is possible. The solar modules are PID free, salt corrosion resistant, and ammonia resistant. Passed the most rigorous tests for salt corrosion resistance, certified to IEC61701 Ed2 (salt spray test) and IEC60068-2-52 Ed.2 (environmental test severity 1), standards adopted in 2011.
Solar Frontier	Solar Frontier's CIS thin-film solar cells are certified by TUV Rheinland Japan (IEC Standard), under writers Laboratories, and BRE Global (Microgeneration Certification Scheme). They are also certified for resistance to salt and ammonia and can be installed in coastal and agriculture areas.

CIS = copper, indium, and selenium; PID = potential-induced degradation.
Source: Authors.