Technology Collaboration Programme
by iea

International Energy Agency
Photovoltaic Power Systems Programme

FACT SHEET

Task 13 Reliability and Performance of Photovoltaic Systems

PVPS

Floating Photovoltaic Power Plants

A Review of Energy Yield, Reliability and Maintenance

January

2026

What is Floating PV?

Photovoltaic systems are essential for the transition to sustainable energy, reducing fossil fuel dependence and mitigating climate change. Although PV requires minimal land area – PV can meet the European Union's energy needs using only 0.26% of its land – space for deployment is often scarce in densely populated regions.

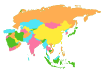
Installation of FPV on a hydropower dam in Europe.

Floating photovoltaics (FPV) offer an effective solution to land-use challenges by installing PV systems on floating structures in water bodies. FPV shows strong potential to support climate targets, but still faces challenges like regulatory barriers, cost competitiveness compared to ground-based PV (GPV), and uncertainties about environmental impacts and system reliability.

Cumulative installed capacity reached

7.7 GW

globally by 2023
(50% in China).



Almost

90%

of the installed FPV capacity is in Asia.
The Netherlands and France are the largest markets outside Asia.

Categorization of Floating PV

Inland FPV

- **Static freshwater bodies**
  - No waves
  - Limited wind
- **Inner waters**
  - Small to medium (1 m) waves
  - Water areas of 1-3 km²
- **Larger inner waters**
  - Medium waves (> 1 m)
  - Area > 3 km²

Marine FPV

- **Nearshore FPV**
  - Reasonably sheltered area
  - Significant wave height < 2-3 m
- **Offshore FPV**
  - Unsheltered water
  - Significant wave height > 2-3 m

Development of Floating PV

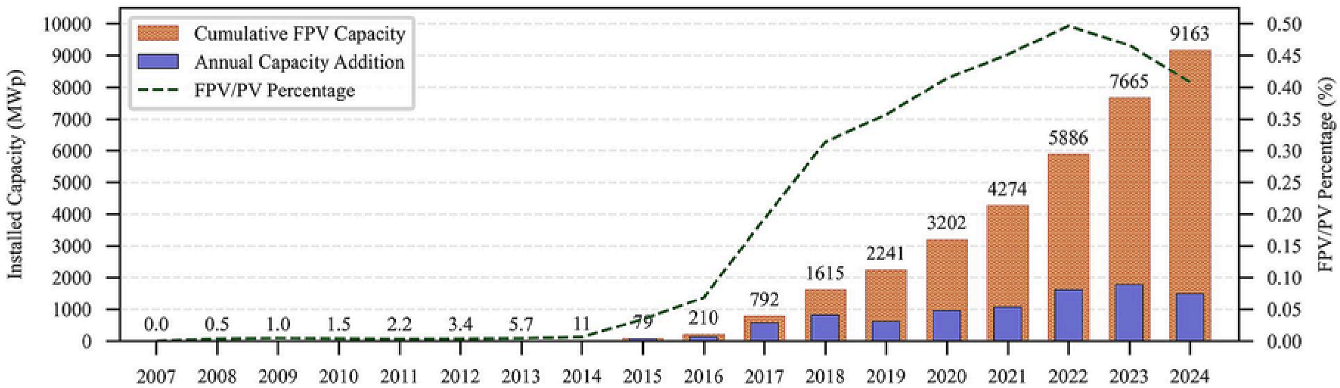


Figure: Walpita (2024). Source Data: SERIES database and Rodríguez-Gallegos (2025).

Examples of Floating PV Systems

1

1. Pure pontoon-based floats (examples: Sungrow, Northman, CTI)

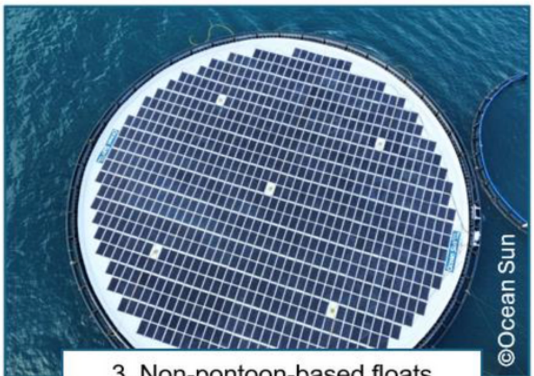
- Fully composed of high-density polyethylene (HDPE) floats supporting modules directly
- Market leaders: Sungrow (27%), Ciel & Terre (12.7%), Northman (14.9%)
- Float properties and design have great development potential, particularly regarding tilt angle and electrical configuration.
- Most widely deployed FPV technology globally

2

2. Pontoon floats + metal/FRP (examples: Scotra, Zimmermann)

- Metal or fiber-reinforced plastic (FRP) structures mounted on floats or pipes
- Floats support the structural frame, not individual modules
- Example: ZIM Float (>250 MW installed, dominant in Europe), Scotra (3.4% market share)

3



3. Non-pontoon-based floats (example: Ocean Sun, Solar Duck)

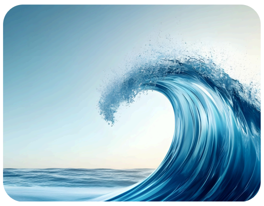
- Different technologies based on other floating structures.
- Example: Ocean Sun (patented membrane technology with HDPE buoyancy ring)
- Horizontal mounting with modules in thermal contact with water
- Different environmental impacts: unique irradiance, wave effects, and cooling behavior

Image Credits: Ciel & Terre, Zimmermann PV-Steel Group, and Ocean Sun.

Energy Yield: Critical Parameters

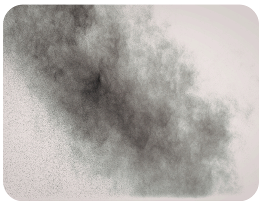
Thermal Losses

- Operating temperature affects both efficiency and long-term degradation. FPV thermal behavior varies significantly by design.
- Improved thermal performance is not an inherent advantage of all FPV installations; it depends critically on system design and local climate conditions.
- **Design factors affecting cooling**
  - **Footprint Size**
  - **Wind Accessibility**
  - **Water Contact**
  - **Tilt Angle**



Wave-Induced Losses

- Module movement from waves creates irradiance variations and electrical mismatch
- **Impact Factors**
  - **Technology**
    - Modules per float (single-module systems most affected)
    - Structural rigidity (membranes > pure-floats > metal/FRP)
    - String length (saturates after 20+ modules)
  - **Environment**
    - Wave features (steep waves=higher losses)
    - Latitude (higher losses at low incident angles)
    - Seasonality (worst in winter for high latitudes)



Soiling Losses

- These losses occur when particles or objects accumulate on top of the solar panel, blocking the irradiance reaching the solar cells, and reducing power output.
- **FPV Specific**
  - **Bird droppings:** Major issue; attracts fauna; causes hotspots
  - **Low tilt (<20°):** Reduces natural cleaning
  - More **biological soiling** than ground PV, but less dust
- Too little open information is currently available to establish a span of expected soiling rates for various FPV technologies in different climates.

Optimisation for Different Conditions

- The economic viability of PV power plants is fundamentally linked to their lifetime energy yield.
- Degradation rates and the overall lifespan of the power plant directly impact electricity production and the levelized cost of energy.
- Climatic and environmental factors play a major role in degradation and are by nature location specific.
- In FPV systems, components are exposed to stress factors that differ significantly from those in ground-mounted PV. Mechanical, thermal, chemical, and electrical stresses vary depending on float design, anchoring systems, and electrical layouts.
- Stress profiles in FPV installations are not yet fully characterised or quantified.

As a result, optimisation strategies for FPV systems must account for local environmental conditions and specific FPV technologies to ensure reliable long-term performance.

FPV Specific Stressors

- Temperature
- Extreme Temperature Fluctuations
- Wave Loads
- Wind Loads
- Humidity
- Shading
- Biofouling & Soiling
- Flora & Fauna
- Tidal Variations
- High Voltages
- Corrosive Compounds
- UV Radiation

Early Failures or Reliability Concerns in FPV Systems

a) Rubbing damage on an HDPE part

b) Rubbing and stress damage on an HDPE part

c) Torsion damage on an aluminium part

d) Loss of mechanical integrity due to wave forces

e) Damage on PV modules due to wave slamming

f) Biofouling of underwater component

g) Corroded junction box

h) Partly delaminated edge seal

Image Credits:
a, b, c, d, e, and g: TNO
f: Oscar Bos/Wageningen Marine Research
h: Institute of Electrical and Electronic Engineers (IEEE)

Operation and Maintenance (O&M)

Preventive

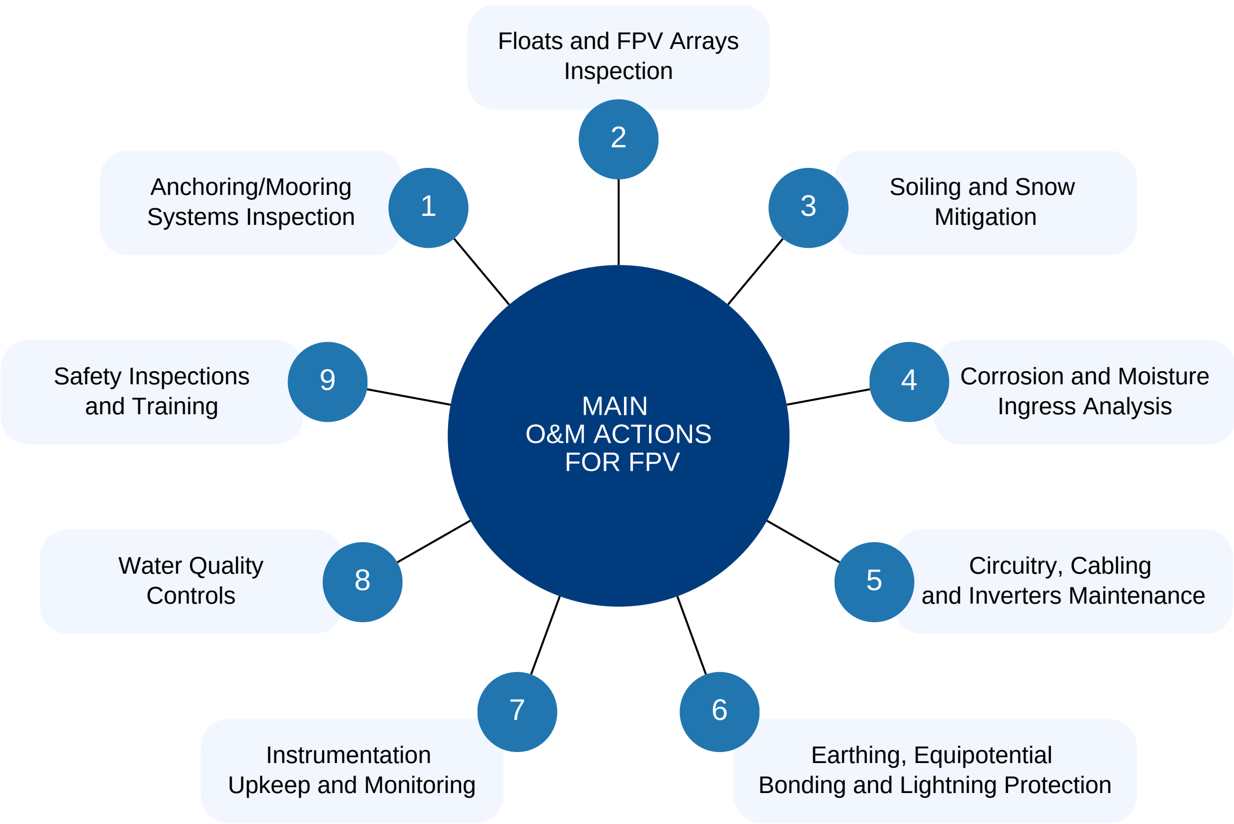
- Regular inspection (monthly/ quarterly/ yearly)
- Periodic recommissioning checks

Corrective

- Unscheduled maintenance (on an as-needed basis)
- Response time should be faster to avoid downtime cost

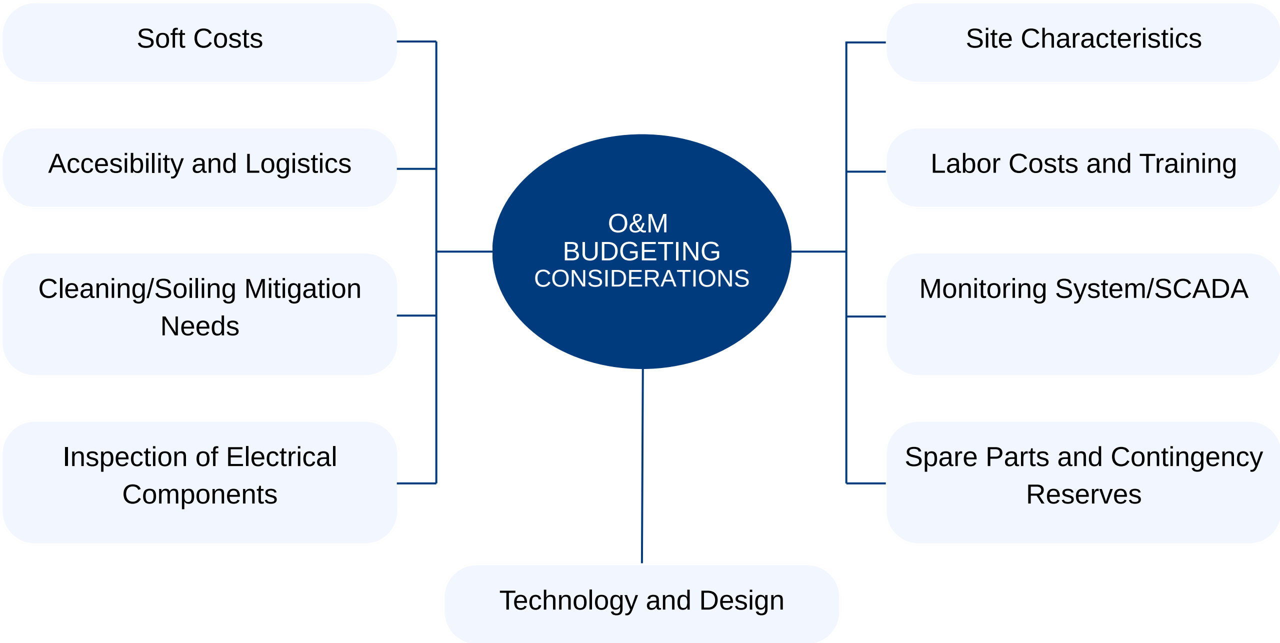
Predictive

- Real-time monitoring to predict possible failure modes
- Early warning system for individual failure events



Challenges:

- Addressing additional risks associated with the water-based working environment;
- Ensuring accessibility and reachability for all maintenance activities across all components;
- Providing safe and cost-effective access to the floating platform;
- Clear cleaning and maintenance requirements are essential, as poor accessibility increases O&M effort and downtime.

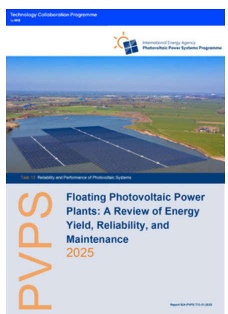


FPV Research Priorities

- Understanding and quantifying the **unique operational conditions and stressors** FPV systems face, including wave action, wind loads, temperature, and biological fouling.
- Developing and verifying **models and methodologies to accurately predict** how these stressors impact FPV system performance over their lifetime and under different operating conditions.
- Develop methodologies and equipment to **automate monitoring and maintenance operations** for FPV power plants.
- Understanding and quantifying **environmental impacts** of FPV systems: evaluating the potential effects of FPV on water quality, aquatic ecosystems, and surrounding habitats.

Want to know more?

If you are interested in more insights and detailed data, explore the full "Floating Photovoltaic Power Plants: A Review of Energy Yield, Reliability, and Maintenance" report.



About IEA PVPS Task 13

Task 13 aims to enhance the quality, performance, and reliability of PV modules and systems by summarizing technical aspects, gathering global data, and disseminating results through reports, workshops, webinars, and web content. Task 13's expertise ensures relevant analysis for stakeholders, contributing to technology advancement, risk mitigation, and standardization in PV research and industry.

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Photo Front Page: PV Floating System in Zwolle, Netherlands. Copyright BayWa r.e

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