Pradhan Mantri Surya Sarovar Yojana Promotes Floating Solar to Address Land Constraints and Strengthen India's Renewable Energy Transition

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Recent Developments:

- The **Union Cabinet** approved the **Pradhan Mantri Surya Sarovar Yojana (PM-SSY)** on **31 July 2026** with a total financial outlay of **?5,070 crore** to accelerate the deployment of **Floating Solar Photovoltaic (FSPV)** projects integrated with **Energy Storage Systems (ESS)**.
- The scheme targets **5,000 MW** of floating solar capacity along with co-located energy storage of **10,000 MWh**, with a minimum storage duration of **2 hours**.
- Projects will be sanctioned during **FY 2026–27 to FY 2030–31**, while financial assistance will continue to be disbursed up to **FY 2032–33**.
- The government's decision follows the first comprehensive national assessment by the **National Institute of Solar Energy**, which estimated India's floating-solar potential at approximately **102.18 GWp**.
- The initiative seeks to expand renewable-energy generation without placing additional pressure on scarce land resources and to improve **grid reliability** through integrated energy storage.

Why Floating Solar is Important for India:

Land Constraints in Renewable Energy Expansion:

- India's rapid expansion of solar power has relied substantially on **ground-mounted utility-scale projects**, which require large areas of land.
- Land for renewable-energy projects increasingly competes with **agriculture, urbanisation, infrastructure, biodiversity conservation and other economic uses**.
- Floating solar provides an alternative by using suitable **reservoirs, lakes, industrial ponds and other inland water bodies** without requiring comparable additional land acquisition.
- The approach therefore supports the principle of **land-neutral renewable-energy expansion**, particularly in densely populated regions.

India's Expanding Floating-Solar Potential:

- The **NISE assessment** estimates India's floating-solar potential at **102.18 GWp**, based on the use of only up to **20% of eligible water-body surface areas**.
- The assessment mapped **10,725.99 square kilometres** of water-body area and identified **4,546.01 square kilometres** as suitable under specified technical criteria.
- After applying the utilization constraints, the effective deployment area was estimated at **1,946.24 square kilometres**, corresponding to the national potential of **102.18 GWp**.
- **Maharashtra** has the highest assessed potential at **16.28 GWp**, followed by **Madhya Pradesh at 14.89 GWp, Karnataka at 13.69 GWp, Odisha at 12.81 GWp and Telangana at 10.72 GWp**.

Floating Solar Photovoltaic Systems: Working Principle:

Basic Mechanism:

- **Floating Solar Photovoltaic systems** place solar modules on specially designed floating platforms installed over suitable water bodies.
- The floating structures are secured using **mooring and anchoring systems** connected to the reservoir bed or shoreline, allowing the modules to remain in position despite changes in wind and water conditions.
- Solar electricity generated on the water surface is transmitted to land through **electrical cables**, where it can be integrated with the power grid.
- Depending on project design, **inverters, transformers and other electrical equipment** may be installed either on floating platforms or onshore.

Site Selection:

- The suitability of a water body depends on factors such as **water availability, depth, solar irradiation, proximity to roads and electrical substations, competing water uses and environmental sensitivity**.
- The NISE assessment considered water bodies with a minimum area of **10 hectares**, water depth of approximately **3–30 metres**, year-round water availability and adequate solar irradiation.
- The assessment also considered proximity to road networks and electrical substations to reduce infrastructure and transmission constraints.

Major Benefits of Floating Solar:

Land Conservation:

- Floating solar reduces competition for **agricultural and other productive land** because electricity generation takes place over existing water surfaces.
- It can be particularly useful for regions where suitable land is scarce, expensive or environmentally sensitive.
- The technology can therefore complement ground-mounted solar rather than completely replacing it.

Water Conservation:

- Solar modules can reduce the amount of **direct solar radiation and wind exposure** reaching the water surface, potentially lowering evaporation.
- The magnitude of water savings depends on **surface coverage, climatic conditions, reservoir characteristics and local wind patterns**.
- Water conservation can provide an additional benefit in water-stressed regions, although excessive surface coverage must be avoided.

Improved Solar Performance:

- Water surrounding the floating platforms can provide a **cooling effect**, potentially improving photovoltaic module performance under high-temperature conditions.
- This advantage is particularly relevant for India because high ambient temperatures can reduce the efficiency of conventional photovoltaic modules.

Renewable Energy and Grid Benefits:

- Floating solar can increase renewable-energy generation while making productive use of **existing reservoirs and industrial water bodies**.
- PM-SSY's integration of **energy storage systems** can help address the intermittency of solar power and improve electricity availability beyond daylight hours.
- The government estimates that the scheme could help reduce approximately **10 million tonnes of CO? emissions annually** after implementation.

India's Floating-Solar Progress:

Major Projects:

- **NTPC Limited** commissioned the **100 MW Ramagundam Floating Solar Project in Telangana** and the **92 MW Kayamkulam Floating Solar Project in Kerala** in 2022.
- The **600 MW Omkareshwar Floating Solar Park in Madhya Pradesh** represents another major development in India's floating-solar sector.
- The first phase of the Omkareshwar project has **278 MW** of capacity commissioned, with the remaining capacity under development.
- Despite these projects, India's installed floating-solar capacity remains only around **700 MW**, indicating a substantial gap between assessed potential and actual deployment.

Pradhan Mantri Surya Sarovar Yojana: Key Features:

Financial and Capacity Provisions:

- **PM-SSY** has a total outlay of **?5,070 crore** and aims to establish **5,000 MW of FSPV capacity** with **10,000 MWh of co-located energy storage**.
- The Central Government will provide **Central Financial Assistance of ?1 crore per MW** to eligible floating-solar projects after successful commissioning.
- Up to **?50 lakh per project** will also be available for feasibility studies covering activities such as **bathymetry, hydrography, environmental assessment and other preparatory work**.
- The scheme will cover **all States and Union Territories**, enabling floating-solar development across different regional water-resource settings.

Wider Policy Objectives:

- The scheme aims to promote **renewable-energy capacity addition, energy security, land conservation, grid reliability and domestic manufacturing**.
- It is also expected to support manufacturing across the floating-solar value chain, including **floating systems, photovoltaic cells and modules and energy-storage systems**.
- The initiative therefore links renewable-energy expansion with **Aatmanirbhar Bharat**, industrial development and the broader **Viksit Bharat** objective.

Major Challenges:

Environmental and Ecological Concerns:

- Floating solar is not automatically environmentally neutral because extensive coverage of water surfaces can influence **light penetration, water temperature, dissolved oxygen, aquatic ecosystems and biodiversity**.
- Large projects may affect **fisheries, aquatic vegetation, bird habitats and local livelihoods**, particularly where reservoirs support multiple economic activities.
- Ecologically sensitive water bodies and important biodiversity areas should therefore be subjected to **site-specific environmental assessment** before project approval.

Climate and Weather Vulnerability:

- Floating structures are exposed to **strong winds, waves, storms and rapidly changing water levels**, creating engineering challenges that differ from conventional ground-mounted solar.
- Anchoring and mooring systems must be designed for local hydrological and meteorological conditions.
- Climate-resilient design is particularly important as extreme-weather events can increase structural and operational risks.

Higher Capital and Operational Costs:

- Floating solar generally involves additional costs for **floating platforms, anchoring systems, specialized electrical infrastructure, installation and maintenance** compared with conventional ground-mounted systems.
- Integrating **battery energy storage systems** further increases upfront capital requirements.
- Long-term project economics therefore depend on technology costs, financing conditions, electricity tariffs and capacity-utilization levels.

Institutional Coordination:

- Floating-solar projects require coordination among **State Governments, electricity utilities, water-resource departments, irrigation authorities, municipal bodies, environmental regulators and industries**.
- Unclear ownership or competing uses of water bodies can delay project development.
- A transparent framework for **site identification, leasing, water-use rights, environmental clearance and institutional responsibility** is therefore essential.

Policy Priorities and Way Forward:

Sustainable Site Selection:

- The government should prioritize **degraded, industrial and suitable reservoir surfaces** rather than ecologically sensitive wetlands and biodiversity-rich water bodies.
- A scientifically developed national and State-level database should classify water bodies according to **technical suitability, ecological sensitivity, competing uses and grid connectivity**.
- The NISE assessment can provide the foundation for such evidence-based planning.

Environmental Safeguards:

- Projects should undergo appropriate **environmental impact assessment** and cumulative-impact assessment where multiple projects are proposed within the same water system.
- Surface coverage should remain within scientifically determined limits to protect **aquatic ecosystems, fisheries and water quality**.
- Local communities, fisher groups and other water-dependent stakeholders should be incorporated into project planning.

Technology and Domestic Manufacturing:

- India should promote indigenous manufacturing of **floating platforms, mooring systems, photovoltaic modules, power electronics and energy-storage technologies**.
- Research should focus on materials capable of withstanding **UV exposure, corrosion, high winds, waves and fluctuating reservoir levels**.
- Domestic innovation can reduce project costs and strengthen the resilience of India's floating-solar supply chain.

Storage and Grid Integration:

- Since solar generation is intermittent, combining FSPV with **battery energy storage and other flexible resources** can improve grid reliability.
- Storage should be planned according to **generation profiles, electricity demand, grid constraints and local renewable-energy penetration** rather than treated merely as an additional project component.
- Better forecasting, transmission planning and smart-grid technologies can further improve integration.

Value Addition for UPSC:

Key Facts:

- **PM-SSY outlay: ?5,070 crore**.
- **Floating-solar target: 5,000 MW**.
- **Co-located storage target: 10,000 MWh**, with a minimum duration of **2 hours**.
- **Central Financial Assistance: ?1 crore per MW** after successful commissioning, plus up to **?50 lakh per project** for eligible feasibility studies.
- **India's assessed floating-solar potential: 102.18 GWp**, based on the NISE national assessment.
- **Current installed floating-solar capacity:** approximately **700 MW**.
- **Highest assessed State potential: Maharashtra – 16.28 GWp**, followed by Madhya Pradesh, Karnataka, Odisha and Telangana.
- **Annual emission reduction expected from PM-SSY:** approximately **10 million tonnes of CO?**