INCREMENTAL DEMAND OF FLOATING SOLAR PV POWER PROJECT IN INDIA

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I. INTRODUCTION

Floating solar technology is fastest growing technology for countries were limited area of land available and difficulties to acquired/procured land for solar installation viz. India. Considering the present renewable target of Indian Government to achieved 100GW of solar installation by 2022, it is becoming more and more popular technology in India. According to World Bank and the Solar Energy Research Institute of Singapore (SERIS) report the estimated potential is around 400GW [11]. Floating solar as name indicated the installation shall be on surface of backwater of dams, lakes, reservoirs, manmade ponds, hydropower reservoirs and near coastal areas where water are stationary. These are the most favorable place for installation of floating solar power project.

As floating solar technology maturing day by day therefore capacity of installation comes from Kilowatts to Megawatts to Gigawatts scale. Today, this is one of the fastest growing technology in word for solar power generation. Also technological advantage, unused water area and difficulty for land acquisition/ procurement over traditional solar power are the favorable conditions for floating solar.

Why Floating Solar??

Floating solar PV technology has certain advantages over ground mounted solar PV technology installation considering use of unused water area, difficulties for land acquisition/procurement especially country like India and densely populated country where land availability is concern. Floating solar technology has some technical advantage compare to ground mounting; it includes higher efficiencies due to cooling media, may use existing power evacuation arrangement, can meets power requirement to nearby area in case of small supply reservoirs and minimum dust accumulation. Furthermore, it will restrict water evaporation of reservoir, pond, dam and minimize unnecessary growth of water bodies.

Hydropower reservoir can be the better option for floating solar to increase generation during peak hours. Therefore, it may be favorable where grid is weak in nature.

A. Global:

Floating solar is emerging technology and leading for lager installation as new market opportunities globally. Floating solar PV technology is now mature enough for larger installation; the first system built in 2007 at Aichi, Japan and continue further by France, Italy, Korea, Spain and US. These are very small installation as a pilot project for research work. However, first commercial installation was carried out of 175kWp capacity in California,

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2008[11].

Further, plant capacity has increased from kilowatts to megawatts in China and other part of world. The first large installation has been built in 2016 and more than 100MW capacity addition in 2018. The research agencies in China, Europe and US has come up for trial installation before goes for larger installation. Last couple of years the floating solar has grown up from few MW to 250 MW and increasing very fast.

Recently, largest solar floating plant was built in China having installed capacity of 40 MW and project commissioned in 2017. Also 6.3MW installed in London's Elizabeth Reservoir in UK.

B. India:

The country has ambitious target for renewable energy of 175GW by 2022 and solar alone is 100GW hence floating solar. It has become popular as alternate source to ground mounting solar PV plant. Now Government has focusing on policies for floating solar and putted up requisition through State to come up for larger installation. This can be seen through several state has come up with tender for larger capacity to be develop viz. Kerala and Maharashtra tender for 100 MW and 1000MW respectively. Also, Damodar Valley Plans 1.7 GW of Floating Solar Projects in West Bengal and Jharkhand.

India's first floating solar plant has developed in 2014 at Kolkata having capacity of 10kW. This

Plant capacity is finance through Ministry of New and Renewable Energy (MNRE) as pilot project. This project became pioneer and boost for other installation in the Country. Several other small, medium size plant come up in due course of time and leads for lager installation.

As reported by The Energy and Resources Institute (TERI) about 18,000 km2 water surface area suitable for installation spread across for FSPV plants and having about 280GW of potential.

Countries favorable policy and higher tariff are attracting developers for large scale installation. In line with policies several state has floated tender enquiry for large scale installation across government reservoirs and dams in Maharashtra, Uttar Pradesh, West Bengal, Kerala, etc. Presently, about 1,700 MW of FSPV projects are under development and many more lined up for future.

II FLOATING SOLAR POLICY

The Government of India has announced an ambitious plan to develop 10 GW Gigawatt (GW) of floating solar capacity in the country over the next three years till 2020-21. Soon after, the Solar Energy Corporation of India (SECI), India's central public sector undertaking responsible for implementing renewable energy schemes in the country floated an expression of interest (EoI) from project developers to develop 10 GW of floating solar capacity. The objective of this EOI was to understand the feasibility of developing large scale floating solar PV capacities across the country. While the industry has praised the intent of the government and been forthcoming with its suggestions, the common view is that a target is highly ambitious and multiple challenges need to be addressed considering current technology and costs.

The drinking water reservoirs, hydropower

reservoirs and dams catchment area are considered for national security sites; obtaining permission is more difficult and time consuming. The present policies supporting floating solar installation by providing financial incentives, higher feed in tariffs, better regulatory guidelines and tax benefits etc. The dedicated tendering process to expedite and faster installation for identified locations. Many states has come up with favorable policies to attract developer installation to support aggressive target of renewable power for India. Whereas, most floating solar developer trying to get experience in early stage with slightly higher price comparing with ground mounting installation.

III FLOATING SOLAR SYSTEM / COMPONENT

The general layout of floating PV Solar System is more or less is similar to ground mounted solar plant, PV mounting and inverter are placed on floating platform are the only major different. The small floating plant placed closed to shore and inverter on land. The mounting platform along with its anchoring and mooring system is an important part of any floating PV installation.

The following are major system component for floating solar plant.

A. PV modules:

PV modules selection is depend on power requirement and power generating capacity is major concern while selecting the panels. The care should be taken for exposure to water, corrosive atmosphere and short circuit possibility. The PV modules are classified as poly, mono, thin film or hybrid. It follow more stringent requirements compared to land-based PV modules due to exposure to water, corrosion environment, possible short circuiting, etc. The panel efficiency provides numbers of modules installed and power output.

B. Floating platform:

The floating platform is held in place by an anchoring and mooring system, the design of which depends on factors such as wind load, float type, water depth, and variability in the water level. The floating platform can generally be anchored to a bank, to the bottom, to piles or to a combination of the three.

The floating material should float on water bodies, nontoxic, resistant to salt/ alkaline water nature, recyclable, UV resistant, withstand wide range of temperature, longer life more than 30 years. The solution to these problem is HDPE (High Density Poly Ethylene) material. These HDPE structures are preferred due to their low cost and high reliability.

The floats are typically made of HDPE (high density poly-ethylene), known for its tensile strength, UV and corrosion resistance. Currently most large-scale floating PV plants are deployed using pontoon-type floats, with PV panels mounted at a fixed tilt angle. Typically, the floating structure can be made of so-called pure floats or floats that are combined with metal trusses. A pure float configuration uses specially designed self-buoyant bodies to which PV panels can be directly affixed. This configuration is the most common. Another type of design uses metal structures to support PV panels in a manner similar to land-based systems.

C. Anchoring and mooring system:

The anchoring and mooring system used to hooked up at the banks or at the bottom. Anchoring at bank is most cost effective anchoring system and anchoring at bottom are most widely installed all over the world. In some cases both system may use depend upon the requirement. This system can adjust to water level fluctuations while maintaining its position in a southward direction [8].

The developer selects a design suitable to the platform's location, bathymetry (water profile and depth), soil conditions and variation in water level. Bank anchoring is particularly suitable for small and shallow ponds, but most floating installations are anchored to the bottom. Irrespective of these requirement the anchoring system should remain in place for entire plant life i.e. 20 years or more. Mooring lines need to be properly selected to accommodate stresses and variations in water level.

D. Floating solar PV System:

The floating solar PV system comprises of PV plant and floating system, a floating body viz. structure, anchoring, mooring system. The Floater that allows the installation of the PV module on water bodies. PV panels are mounted on floating structure with fixed tilt. PV generation system to electrical junction boxes that are installed on top of the floating system and underwater Cables transfers the generated power from PV modules/ arrays to inverters and subsequent to transmission line to grid.

The construction of a floating system contains the major parts as floating structures, PV panels, Inverter Mechanism, Transmission of power to grid, Control Mechanism and Monitoring Mechanism. The energy generated by floating power plant can be transmitted to load or grid by cable submerged in water. Proper planning is required to produce the electric power by using floating solar power plants without interrupting the works of ponds and reservoirs. By using proper software's and remote control mechanism monitoring of plant elements like metrological parameters and floating

E. Inverters:

Based on the geometry of the water body, power requirement, commercial and considering these requirement detailed system design of floating solar PV based on centralized as well as string inverters are used and can be placed either on land or on floating platform.

F. DC & AC cables:

AC/DC cables should have excellent weather proofing characteristics and safety features is selection criteria and can be evaluate during detailed engineering design. It may be place in water proof conduit for additional safety and longer life of cables.

IV DESIGN FACTOR TO BE CONSIDERED FOR INSTALLATION

The following are the design factors to be considered for floating Solar Plant;

A. Site selection and validation:

Historical data of water bodies, flood, rainfall and associated environment of identified area to be collected. The GIS based study for water coverage area and availability of water throughout year to be captured for design calculation. Site visit to check location accessibility, type of water body, distance from

substations for grid connectivity, nearby buildings infrastructures if any for shadow free area are major factors to be considered for site selections.

B. Bathymetry/ Hydrography:

Bathymetry is measurement of the depth of water in oceans, rivers, or lakes etc and look like topographic maps, which shows the shape and elevation of land features. Bathymetric surveys allow us to measure the depth of a water body as well as map the underwater features of a water body. Bathymetric surveys are used for research including flood inundation, contour of streams and reservoirs, leakage, scour and stabilization, water-quality studies, dam removal, storage, fill in reservoirs and ponds.

The different survey methods area as under;

a. Single-beam surveying: Rather than sending out a wide set of beams, single-beam bathymetry measures the water depth directly under the boat. Single-beam surveys are generally used for smaller water bodies.

b. Multi-beam surveying: A multi-beam echo sounder attached to a boat sends out a wide array of beams across a "swath" of the waterbody floor. As the beams are bounced back from the water body floor, the data is collected and processed. Multi-beam surveying is generally done in larger water bodies.

c. Acoustic Doppler Current Profiler (ADCP): ADCP are used to measure stream flow by measuring velocity by transmitting sound waves which are reflected off sediment and other materials in the water. Data collected from ADCPs can then be used for bathymetric mapping.

d. Sub-bottom profilers: Sub-bottom profilers are mostly used to view the layers of sediment and rocks under the water body.

e. Ecomapper Autonomous Underwater Vehicle: The Ecomapper can collect detailed bathymetric data, down to one-foot contours. The Ecomapper uses side-scan sonar and a Doppler velocity log.

C. Siltation study and soil testing:

a. Siltation is process of accumulation of sediments viz. dust, soil, sand, gravels and other particles in the river or dam. Rivers brings large quantity of soil particles called silt through erosion and it gets deposits on banks of rivers or dam or water body. Silt is deposited all along river banks in normal floods. Formation of big reservoirs disturbs silting pattern all along the banks.

b. Large accumulation of silt in the nearby area of reservoir reduces the live storage. Hence reservoir capacity gets reduced. The siltation study hence required to get exact silt available in or nearby water bodies accordingly design parameter can be decide for anchoring or mooring system.

D. Environmental Impact Assessment (EIA):

It is process of evaluating likely environmental impacts of a proposed project or development. The purpose of an EIA is to determine the potential environmental, social and health effects of a proposed development. It is intended to facilitate decision-making while seeking to avoid, reduce or mitigate potential adverse impacts through alternative options. It all covered in EIA Study hence it is important for any project or idea being emerge.

E. Design Parameters:

a. Meteorological data for adequate period, solar irradiance, wind direction, wind velocity ,wave height, water level variations, humidity, ambient temperature, rainfall, flood level, back water effect etc. these data to be captured for accurate design of floating solar systems.

b. Seasonal variation of level in the water bodies and type of water bodies.

c. Equipment placement viz. inverter, cable etc. at water bodies or land.

F. Anchoring and Mooring System

a. An appropriate anchoring and mooring system is a critical part of an FSPV plant. The bank anchoring, bottom anchoring or piles ways to hold a floating platform in place. Developers choose the design that best suits the platform location, bathymetry, soil conditions and variation in water level.

b. Bottom anchoring is used in vast majority of existing FSPV plants. One self-seating anchor commonly used for FSPV consists of a dead weight, usually a large concrete block. This cheap and simple option is effective in many cases.

c. Self-seating anchor include mushroom anchors and pyramid anchors. Where the terrain and soil conditions are more complex or where loads are large, installed anchors may be needed to provide a stronger hold to the bottom.

d. Bank anchoring Bank anchoring is particularly suitable for small, shallow ponds, where the FSPV plant is close to shore. It allows easy access to anchoring points, both for deployment and for periodical inspection during O&M.

e. Piles for some (typically shallow) water bodies, it may be possible to drill or ram piles into the basin floor. Pile drilling usually involves specialized equipment and civil work hence it is much more costly than anchoring.

V CHALLENGES AND RISKS INVOLVED IN FSPV INSTALLATION

Floating solar has many benefits but most challenging factor involved cost. Installation cost for floating solar technology is just doubled as compared with ground mounting solar. The biggest challenge is long term reliability for over period of 25 years or plant life to recovered cost. The drive has been initiated to make floating solar project is commercially viable for implementing and this is being seen with reference to Government bidding's for several state in India and Globe. The challenges for floating solar technology are;

A. Higher capital Cost:

Capital cost involved in floating solar is higher than the ground mounting solar PV project. This higher cost due to complex design/technology, anchoring, mooring arrangement, safety of electrical component used and lastly the installation methodology. But higher initial cost shall be normalized with higher generation. This cost will be come down as the mature in technology, competition and increase skill manpower to take up installation.

B. Installation challenges:

This technology is not enough established thus availability of skilled personal and expensive hiring may require for faster completion of project. The anchoring or mooring is biggest challenge for system stability and smooth operation of any floating solar project

during high wind, tides, heavy rains, longer plant life etc. The anchoring points should be properly hooked at nearby surface of installation. Safety of personnel is equally important aspect as complete assembly on surface of water, special attention for cable routings are required while doing installation. The space available for infrastructure set up and nearby store area is very minimal as installation is in water bodies hence enough space may not be available for material stacking. The requirement of float material are very high in large project and space nearby installation may not be available. This will lead to rehandling of material from stacked place to nearby installation.

All most all reservoirs, dams are Government custody hence security, restricted entry and permissions/formalities required to access the location. It will take more time for permissions or more formalities to access locations. Also power evacuation arrangement through the locations and Right of Way (RoW) for outside premises is more difficult as land nearby reservoir or dam is more fertile hence cost or expectation shall be more as compare to ground mounting PV project.

C. Operation and maintenance cost:

Operation and maintenance costs for floating solar shall be more as compare to ground mounting PV. Also availability of skilled or experience manpower availability shall be one of the challenges as technology not mature enough in India.

Easy access to installation not possible due to water level up and down throughout a year; it may lead operational difficulties for manpower to adapt frequently change. Operation becomes more difficult during rainy seasons or high wind.

D. Easy availability of component in local market:

This technology is maturing in world and new in India hence component availability is less in local market. The almost material dependency is on outside or OEM of India. This leads more time to procure material extended delivery timeline and may be higher opportunity cost for OEM. However, this can be minimize by encouraging local manufacturer to setup industry to meet requirement.

E. Environmental:

The complete installation is in water area, there is very much uncertainty about the environment impact for large installation regarding high wind, high tides, floods and heavy rains. As floating solar is new technology there is no enough easily available dada to access impact on system components like Modules, floating material and cables etc. The continuous water contact with system components which may leads rusting or deteriorating of material resulting may damage to aquatic environment.

VI ADVANTAGES

The biggest advantage of floating solar is no need of land requirement to set up project as land acquisition is most difficult factor in India and for other countries facing land availability issues. It can be installed in natural and man-made water bodies like lakes, dam reservoirs, water treatment plants, water storage ponds of local authority. These are foremost advantages of floating solar over traditional project as mentioned below;

A. Installation Space or no land

requirement:

Floating solar project does not required valuable land to be purchase as compare to traditional Solar PV project. The installation can be carried out in unused space like lakes, ponds, reservoirs, dams, water treatment plant etc. Land preparedness does not required as installations are on the water bodies.

B. No land Cost:

As floating solar installation on water bodies thus initial costly land purchase not required. Hence saving on land part and difficulties involved thereafter. The revenue can be generated easy from unused place with no cost of land.

C. Higher Performance of PV Panel:

Solar PV performance adversely affecting the atmospheric and panel temperature. Water cools panel and helps to reduce thermal losses resulting increase in power output and efficiency. This cooling effect of water resultant for longer life and lesser degradation of solar panel. Floating solar on water bodies performs better result because of the cooling effect of water in the surroundings, thus more power output with same installation, higher efficiency and longer life.

D. Environmental and water conservation benefits:

Floating solar panels play great role by proving better environment. The bodies help to reduce formation of algae in freshwater or drinking water. The floating solar panel installation shrinks evaporation of water and effect is more in hot summer. It is also conserve water by reducing evaporation and minimizing global warming in eco-friendly way.

E. Easy Installation and maintenance:

The floating solar installation is easy with low anchoring, mooring requirements it leading to faster installations. This reduces need for major site preparation such as area grading/levelling and preparation of foundations for structure mountings. The regular cleaning of solar modules is easier as water is readily available.

In addition to above, solar energy can be picked up first when water availability is low for hydropower plant. It can be reliable source for pumping and irrigation. As a clean source of energy it help to reduce emission of greenhouse gas and other pollutant for better human health.

VII DISADVANTAGES

Even though floating solar has various advantage as stated above but it has some disadvantages here are listed below;

A. Capital Costs:

The floating solar technology involved additional cost for its design to cater need of installation on surface of water, specialized equipment for longer life and environmental factors. The special base material to float in water, longer plant life and working in corrosion free environment which attract additional cost.

B. Applications:

Floating solar is meant for specific for installation in water surface of small/limited area, large developers are may not be interested for smaller installation. As indicated above, it has higher efficiency as compared to ground mounting PV but cost involvement is much higher. The tracking not possible in floating solar as installation and other difficulties may

resulting reduced generation with respect to radiation of inclination. Floating solar could not be installed in sea as higher tidal waves and wind speed cause less generation and operational difficulties.

C. Installation difficulties:

Floating solar installation required more skilled personnel which will attract higher charges. Special care should be taken while doing installation for electrical system as component lies at water thus robust safety majors to be implemented throughout plant life. The ups and down of water level causing problem for installation of floats, modules and cables. Enough space may not be available for anchoring and mooring for more stability of floaters and safety of equipment. This arrangement should withstand heavy winds during severe storms, hurricanes, typhoons and cyclones etc. Hence, these arrangements build in such a way to surpass this extreme situations. As per data floating structures and floats available are designed to withstand corrosion, waves up to a height of 2 meters and winds up to 190km/h. Evacuation arrangement and cable termination at equipment end required special safety majors. Developers prefer to install solar inverters nearby available land for easy accessibility which leads to higher cable costs and transmission losses. As indicated above, power evacuation charges for RoW shall be much higher as line passing through nearby fertile land.

D. Higher Operation and maintenance cost:

It required higher operation and maintenance cost because all assembly floated on water reaching to desire location required boats or divers thus required higher cost per fault. The skilled manpower comes with higher packages. Equipment and human safety is to be addressed on top most priority which comes with additional cost.

E. Environmental disturbance:

The floating solar installation is in water, this may be leads to corrosion problem in long term and disturb the life in the water. The anchoring or mooring arrangement touching the bed of water this may disturb the aquatic life. The heavy wind and rains cause problem of low generation or no generation against predicted values.

VIII CONCLUSION

Nowadays, floating solar is emerging technology and widely accepted system globally. The advantages over distress of floating solar making more and more suitable for government and developer for installation. Considering the techno-commercial advantages becoming floating solar viable alternative for ground mounting PV and definitely boost up to achieve ambitious renewable target. No doubt, the challenges, not enough track record, higher product cost, environmental uncertainty, technical complexity and in water operational difficulties like electrical safety, anchoring, mooring issues and maintenance are the factor to be consider while going with floating solar. Also it has minimum skillset to develop tender specification, mature supplier and construction.

It has been found that there is reduction in costs due to decline cost of floaters as improvement in

manufacturing process, cost of material, reduction in thickness floaters, and aggressive biddings to get early experience by FSPV bidder are favorable factors.

However, floating solar is emerge as one of the most accelerated technology to achieve ambitious target and opened up new opportunity for developer to make sustainable business. As indicated, global potential is more than 400GW becomes most of the countries/Government to think for floating solar installation by widening favorable horizon to become viable solution for developers/owners.

To summarize the above, floating solar has higher generation, minimize the rate of evaporation, very minimal initial development charges, utilization of unused water area these are the favorable factors for any country to go for floating solar as one of the option for future solar power project. As indicated earlier, floating solar may be useful for additional hydropower generation for day time and further evaluate for commercial viability. Furthermore, initial cost of installation will be reduced after maturing technology and competition base. Government support, favorable policy and easy funding options will be driving factors to speed up floating solar installation thus to support to achieve renewable ambitious target of India.

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