The present invention is directed towards a floating solar power plant. A floating Y-shaped module is a basic building block for the floating solar power plant. The Y-shaped structure has three arms which are radiating outwardly from a central point, wherein the free ends of the arms have one or more coupling means. The Y-shaped module is interconnected to produce a hexagonal space grid structure to support the solar panels. The solar panels are mounted with the help of mounting structures on the hexagonal space grid structure. The hexagonal space grid structure is enclosed in a floating enclosure to minimize the effect of the water waves on the solar power plant. The floating enclosure is also anchored to restrict the movement of the floating solar power plant. The floating solar power plant is further configured with a positioning system, altitude tracking controllers, propellers and pneumatic structures.
FLOATING SOLAR POWER PLANT

FILED OF INVENTION

The present invention generally relates to the generation of electricity through renewable energy, and is more particularly directed towards generating electricity through a floating solar power plant.

BACKGROUND OF THE INVENTION

The sun is an inexhaustible source of energy. The earth intercepts a tiny fraction of the energy emitted from the sun, approximately 170 million GW. This tiny fraction also is many thousand times greater than the present consumption rate of energy on earth. Due to the geometry of the earth-sun movement, however, there are large variations in the amount of solar radiation received at any location. Regions of our planet at higher latitudes receive far less concentrated solar energy than the regions at lower latitudes. India, located in the equatorial sun belt of the earth, receives an annual global radiation, within the range of 1600 to 2200 kWh/sq.-m. The equivalent energy potential is about 6,000 million GW-h of energy per year.

Even though there is huge potential in this domain of solar energy harvesting, the capability of solar industry to handle peak demand is limited because of its intermittency in production. This is primarily due to practical limitations of large-scale implementation of energy producing systems that rely on the sun. Apart from these requirements, some other factors that are hurdles for ground mounted solar power generation are elaborated herein below.

A major drawback of ground-based solar power plants, is that they are susceptible to the fact that land surface absorb a lot of solar radiation. This, as a result, has a causal effect on surface and ambient temperatures. The efficiency of solar cells, like all semiconductor devices, on the other hand is sensitive to temperature. Prolonged exposure or usage of the solar cell above a specified temperature due to extreme hot weather degrades the efficiency of solar panels.

Hence, an optimum temperature range is required to get more out of solar panels with respect to the output efficiency, which is usually difficult to achieve in case of ground mounted solar power plants.

A second drawback of ground based solar power plants emanates from the fact that large tracts of 'shadow-free' land are required, as shading of solar panels has a disproportionate effect on the envisaged power output. The probability of finding a broad expanse of flat land devoid of vegetation is often low, especially in densely populated countries such as India.
A third major drawback, in case of ground based power plants, is the cost (both social and financial) associated with land acquisition. This materializes from the fact that large real estate is required for megawatt level of power generation. Such large contiguous parcels of land are often unavailable or if available, then it happens to be expensive, as land has several competing uses, thereby making the ground-based solar power stations often impractical or appreciably expensive. Hence, the optimum conditions for obtaining a high utilization factor, namely - large open space that is inexpensive, relatively flat and devoid of vegetation; and has high levels of irradiation with low ambient temperatures - is relatively difficult to meet for ground based solar power plants.

Another factor, apart from the ones mentioned above, and probably the most difficult to achieve for a ground based solar power plant, is to provide for a dust-free atmosphere. Solar panel operative efficiency and output largely depends on how clean, read dust-free, the environment is. Ground based solar power panels are prone to dust and scratches due to movement of dust particles through the wind or by any other means. Thus, large costs associated with regular cleaning of solar panels are often required to maintain a clean environment in case of ground based solar power plants.

There are several other limitations of the grounded solar plants such as non-availability of effective energy storage system, availability of terrains and clearance issues.

Therefore, it is a long felt need to provide a water based floating solar power plants on small or big water reservoir or any water body to overcome above mentioned drawbacks of the ground based solar power plants.

The area of floating solar power plant is not much explored and remains nascent for research and development. An efficient water floating solar system is a need of the hour as it would provide an economical source of alternative energy. A water based solar power plant, however, requires robust construction, requisite buoyancy, optimum weight distribution and possibility of synchronized longitudinal and azimuthal movement of panels for appropriate tracking of the sun, through the day and round the year, which remains a challenge till date.

This section is intended to provide only a background or context to the invention. The description herein may include concepts that could be pursued, but are not necessarily ones that have been previously conceived or pursued. Therefore, unless otherwise indicated herein,
what is described in this section is not prior art to the description and explains in this application and is not admitted to be prior art by inclusion in this section.

SUMMARY OF THE INVENTION

One of the key objects of the present invention is to provide a floating solar power plant for generation of electricity in economic and cost effective manner. Accordingly, the present invention is directed towards a modular floating solar power plant which is implemented on a water surface of a water body.

The present invention provides a vast, levelled, hindrance free surface for proper functioning of solar power panels and thereby providing a high utilization factor for the solar power plant.

The present invention encompasses a floating module, comprising a Y shaped structure having three arms outwardly radiating from a central point, wherein the free ends of the arms have one or more coupling means.

The present invention further encompasses a hierarchal hexagonal grid structure made up of plurality of Y shaped structures integrated together via one or more coupling means provided at the free ends of their arms.

The present invention further encompasses a floating solar power plant, comprising Y shaped structures integrated to form a hierarchal hexagonal grid structure; one or more solar panels mounted on the hierarchal hexagonal grid structure; a propulsion system is coupled on the hierarchal hexagonal grid structure to facilitate azimuthal movement of said one or more solar panels with respect to the sun; a floating enclosure for enclosing the hierarchal hexagonal grid structure; and an altitude controller configured to facilitate vertical movement of said one or more panels with respect to the sun.

The present invention also provides an inexpensive means of power generation by using underutilized/untapped water reservoirs surfaces.

The present invention also provides an effective natural evaporative cooling mechanism for optimizing operational efficiency of floating solar power plant.

The present invention also provides an easy and cost effective way of azimuthal tracking of the sun by the solar panels.

The present invention also provides a sustainable and economical floating solar power plant.

BRIEF DESCRIPTION OF DRAWINGS
Figure 1 depicts a cross sectional view of the floating solar power plant in an embodiment.

Figure 2 depicts a single Y-shaped floating module.

Figure 3 depicts three Y-shaped floating modules integrated to form a base hexagonal floating module.

Figure 4 depicts mounting of the solar panel over at least one base hexagonal floating module.

Figure 5 depicts joining of a plurality of Y-shaped modules to form a hierarchical hexagonal grid structure supporting plurality of solar panels.

Figure 6 depicts floating hierarchical hexagonal grid structure made from a plurality of Y-shaped modules enclosed within a circular enclosure.

**BRIEF DESCRIPTION OF THE INVENTION**

In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be apparent, however, that the present invention may be practiced without these specific details.

Several features are described hereafter that can each be used independently of one another or with any combination of other features. However, an individual feature might only address one of the problems discussed above. Some of the problems discussed above might not be fully addressed by any of the features described herein.

In one aspect of the invention, a floating solar power plant may be implemented on the water surface of any water body in a below described way. A Y-shaped module is a floating module, comprising three arms radiating outwardly from a central point, wherein the free ends of the arms have one or more coupling means. The Y-shaped module is integrated as a base hexagonal structure by interlocking the arms of three Y-shaped modules via a nut-bolt mechanism in the coupling means and when this hexagonal structure is repeated in a specific direction in to a space a hierarchical hexagonal honeycomb grid structure is constructed. The hierarchical hexagonal honeycomb grid structure is used for supporting plurality of rows of mounting structure which houses the solar photovoltaic modules. This hierarchical hexagonal honeycomb grid structure is rotatable around the central perpendicular axis of the grid. The rotation is configured using the water submerged propellers. The rotational motion helps in optimizing the angular azimuthal orientation thereof relative to the position of the sun of the solar panel. The hierarchical hexagonal honeycomb grid structure is also enclosed in a circular
floatable concrete or poly-ethylene enclosure. The circular floatable enclosure is also adapted with the anchor mechanism to anchor the floating solar power plant to a specific point on the water body. The solar panels are configured with plurality of altitude tracking controllers for regulating the vertical position of the solar panels such that the tilt of the panels are equivalent to the altitude angle of the sun such that rays of the sun fall perpendicular to the solar panels. The floating power plant is also configured with the energy storage modules to collect the power produced using the solar photovoltaic modules. The floating solar power plant is also configured with a positioning system such as GPS to control the movement along the surface of the water bodies as well as to track the movement of the floating solar power plant.

The solar power plant of the present invention may be implemented on any water reservoir or body for example, dams, lakes, ponds, lagoons or rivers. In another embodiment, the floating solar power plant may be implemented on any offshore water bodies for example, ocean or sea.

The floating solar power plant would be explained below by referring to the accompanied drawings.

As an exemplary embodiment, Fig. 1 illustrates the cross section view of a floating solar power plant 10. The floating solar power plant 10 comprising a hierarchal hexagonal grid structure 400 to support one or more solar panels 202; wherein hierarchal hexagonal grid structure 400 is integrated from a Y-shaped module, the hierarchal hexagonal grid structure 400 is enclosed in a floating enclosure 208, one or more solar panels 202 mounted on the hierarchal hexagonal grid structure 400, a propulsion system 210 is coupled on the hierarchal hexagonal grid structure 400 to facilitate azimuthal movement of said one or more solar panels 202 with respect to the sun, a floating enclosure 208 for enclosing the hierarchal hexagonal grid structure 400, a positioning system 212 for determining the position of the floating solar power plant 10, an inflatable pneumatic structure 214 for providing stability to the floating power plant from the external forces such as wind, and an altitude controller 216 configured to facilitate vertical movement of said one or more solar panels 202 with respect to the sun.

The propulsion system 210, referred herein, is an electrical system which uses motor as a power source to generate the thrust or force to move the hierarchal hexagonal grid structure 400. The propulsion system 210 is configured to rotate the hierarchal hexagonal grid structure 400 such that the solar panels 202 mounted on it follow the Sun horizontally throughout the day from the sunrise in the east to sunset in the west. Thus, the propulsion system 210 helps in
tracking the azimuthal angle of the sun with respect to the solar panels 202. The propulsion system 210 may be submerged under the water to facilitate the movement of the hierarchal hexagonal grid structure 400. Besides facilitating the azimuthal movement of said one or more solar panels 202 with respect to the sun, the propulsion system 210 may also move hierarchal hexagonal grid structure 400, if required, to a desired location - such as closer to the shore in case of any weather event. The propulsion system 210 may draw the power from the external power source to generate the required thrust for the movement of the hierarchical hexagonal grid structure 400.

The positioning system 212, referred herein, is a Global Positioning System (GPS) with an appropriate computing equipment including the algorithms and associated software, to maintain the position of the solar power plant 10 during the day when it essentially turns through about 180 degrees to follow the sun from rise in the east to sunset in the west. The positioning system 212 may be coupled with the propulsion system 210 to achieve the desired positioning objectives.

The floating solar power plant 10 further encompasses the use of inflatable pneumatic structures 214 using tensairity, particularly via appropriate sensors and dynamic control of an inbuilt compressor system. The pneumatic structure 214 may be also be used for compressed air energy storage. The pneumatic structure 214 is used or providing stability to the floating power plant 100 from the external forces such as wind.

The altitude-tracking controller 216, referred herein, is a software or hardware or both to track the vertical movement of the sun w.r.t the solar panels 202. In an embodiment, the altitude-tracking controller 216 may be configured with the solar panels 202. The altitude-tracking controller 216 ensures that sun rays fall perpendicular to the solar panels 202 surface as the sun changes the altitude with respect to the solar panels 202 during the course of the year. An altitude-tracking controller 216 may be configured with the predefined set of solar panels 202, for example on the specified array of solar panels 202 arranged in a row or column on the hierarchal hexagonal grid structure 400. In an embodiment, the altitude-tracking controller 216 may be a single controller that may control the entire solar panels of the floating solar power plant. In still another embodiment, the altitude-tracking controller 216 may be more than one controller to implement the vertical tracking of the sun.

The power generated using said floating solar power plant 10 may be stored in power storage units (not depicted in the drawings) for example in batteries, primary cell batteries, secondary
batteries etc. In another embodiment, the power storage unit may also be any type of storage
capacitors for example, super capacitors, and ultra-capacitors. In another embodiment, the
power generated through the solar power plant 10 may be directly feed to power transmission
or storage grid system. In still another embodiment, the power storage unit may also be a
compressed air energy storage. The power storage units may be provided at site of the floating
solar power plant 10 or it may also be provided at the appropriate remote site.

The floating solar power plant 10 further encompasses the solar panels 202, wherein said solar
panels 202 is an energy-generating device which converts the solar energy into the electric
energy. The solar panels 202 include multiple arrays of solar cells to convert solar energy into
the electric energy. In an embodiment, solar panels 202 are mounted on the hierarchal
hexagonal grid structure 400 such that the mounting structure 210 provide support to the solar
panels 202 and it may be mounted at the junctions or at the hexagonal grid structure 400
vertices of adjoining Y-shaped shaped modules 100. The solar panels 202 may be arranged
parallel to each other.

FIG. 2 illustrates, in an exemplary embodiment, the Y-shaped module 100 used to integrate the
hierarchal hexagonal grid structure 400. The Y-shaped module 100 is a floating module having
three arms 102a, 102b, 102c radiating out of a central point 104. In an embodiment, the each
arms 102a, 102b, 102c may enclose an angle of 120 degrees. The free ends of the arms 102a,
102b, and 102c have atleast one coupling mean 106. The coupling means 106 may be an
interlocking mechanism 204 for holding another Y-shaped module 100. In an embodiment, the
interlocking mechanism 204 may also be a latch. In another embodiment, interlocking
mechanism 204 may also be a strap or sleeve mechanism. In an embodiment, the coupling
means 106 may facilities an interlocking connection 204 with the other Y-shaped module 100.
In another embodiment, the interlocking connection 204 may be a slide and lock arrangement.

In still another embodiment, the slide and lock arrangement may be nuts and bolts locking
arrangement. The Y-shaped modules 100 may be made up of any material capable of floating,
however; in a preferred embodiment it is made up of poly-ethylene. In alternate embodiments,
the Y-shaped module 100 may also be made of polycarbonate, Poly Vinyl Chloride (PVC) or
Fibre Reinforced Plastic (FRP), etc. The distance between the free ends of the arms 102a, 102b,
and 102c of Y-shaped module 100 may be dependent upon the solar panel size to be used for
the solar power plant.
FIG. 3 in an exemplary embodiment illustrates a base hexagonal space frame 200. The three Y-shaped modules 100 are integrated to form a base hexagonal space frame 200. In an alternate embodiment, more than three Y-shaped modules 100 may also be used to form a base hexagonal space frame 200. The integration of the Y-shaped module 100 to formulate the base hexagonal space frame 200 is done through the interlocking mechanism 204. FIG. 4 shows a base hexagonal space frame 200 supporting a solar panel 202. In an embodiment, the base hexagonal space frame 200 provides support for at least one solar panel 202. The solar panels 202 may be mounted using a mounting structure 210. In an embodiment, the mounting structure 210 may be a metallic pipe with a polygonal base at one end to connect from the base hexagonal space frame 200 and a rectangular portion at another end to engage with the solar panel 202. In one embodiment, the Y-shaped modules 100 may be modified to integrate the mounting structure 210 for the solar panel 202. In another embodiment, a requisite panel mount can be clamped onto the Y-modules 100 for holding the solar panels 202 through one or multiple holes provided in the Y-modules 100. In an embodiment, the Y-shaped module 100 to integrate into the base hexagonal space frame 200 may be facilitated at the site of the solar power plant, thereby making the solar power plant a modular in nature.

FIG. 5 illustrates a hierarchical hexagonal honeycomb grid structure 400 that is formulated or integrated by the Y-shaped modules 100. The incremental size of the hierarchical hexagonal honeycomb grid structure 400 is dependent on the length of arms 102a, 102b, and 102c of the Y-shaped modules 100. Thus, these Y-shaped modules 100 are repeated via interlocking mechanism 204 to form a hierarchical hexagonal honeycomb grid structure 400 based on the site conditions and load considerations, however, the structure of the grid 400 may be modified. The use of polyethylene or a similar material along with the structural strength provides a high level of buoyancy and essential to support the weight of solar panels 202, and also allows for its easy movement in water. The hierarchical hexagonal grid structure 400 also absorbs any lateral forcing by evenly distributing the forces over the grid.

The hierarchical hexagonal grid structure 400, further provides the supporting structure for the solar panels 202, where an appropriate casing for the solar panel 202 is supported with the help of a mounting structure 210. In an embodiment, the metallic pipe may be placed at the vertices of the base hexagonal space frame 200 to support the solar panels 202.

The present invention further encompasses the hierarchical hexagonal grid structure 400 to support plurality of solar panels 202 which are arranged end to end in the parallel rows. Any
given row of panels includes a plurality of metallic pipe-supported in upright direction at the vertices of the base hexagonal structure 200, as described above, which in turn hold the solar panels 202.

Further, the hierarchical hexagonal grid structure 400 helps in reducing the overall weight of the floating solar power plant 10 as well as it also flexible enough to tolerance any lateral wind force acting on the solar modules 202.

FIG. 6 illustrates a floating enclosure 208 enclosing the hierarchical hexagonal grid structure 400. The floating enclosure 208 may be made up any material capable of floating or may be devised to make it float on water such as concrete, polyethylene, or their combination thereof. This floating enclosure 208 serves as a protective structure for the hierarchical hexagonal grid structure 400. The floating enclosure 208 reduces turbulence due to waves and also acts as an inspection deck. Further, it also allows the hierarchical hexagonal grid structure 400 to pivot around a fixed path. The fixed path may be obtained by providing at least one requisite anchors 206 at pre-defined position. In an embodiment, the anchor 206 may be a dead weight to restrict the movement of the hierarchical hexagonal grid structure 400. The anchors 206 may be coupled to the hierarchical hexagonal grid structure 400 or to the floating enclosure 208 by the pulley arrangement. The floating enclosure 208, in one particular embodiment, is shaped like a hollow cylinder with an inner diameter and an outer diameter, the ratio of which ensures the desired buoyancy factor. In another embodiment, the floating enclosure 208 may be elliptically shaped with a pre-defined polygonal cross-sections. In still another embodiment, the floating enclosure 208 may be filled with a foam to improve the safety factor of the floating solar power plant 10.

Thus, in accordance with the above, the present invention relates to the water based floating structure that is equipped with the solar energy collection facilities. More particularly, the present invention relates to a floating solar power plant, which is capable of producing electrical energy in a cost-effective manner.

The present invention encompasses improvement over the contemporary ground mounted solar PV power plants, where the improvements relate to the operating conditions of the solar PV panels. The improvements along with optimization of available solar resource, results in an improvement in the capacity utilization factor (CUF) of the resultant floating solar PV power plant 10. There are several secondary benefits also in addition to the aforementioned objects, which the present invention provides such as reduce algae growth in the water bodies, ability
to merge as hatcheries for fish inhabiting the area, reduction in trans-evaporation levels (especially for areas where water is a scarce commodity), and a provision for CDM mechanism for GHG emission.

The present invention further encompasses provisions for expedited and simplified installation, and commissioning of the solar power plant 10, wherein prefabricated components could be used for easily assembling on-site. The grid junction points interlocks Y modules 100 and solar panels 202 together for fast assembly and a unified structure. For example, the honeycomb shaped hierarchal hexagonal grid structure 400 is constructed by assembling several Y shaped modules 100. All the Y shaped modules 100 may be exact replicas of each other, and therefore, the assembly is a repetitive process of interlocking adjacent modules to formulate a hexagonal structure 200.

Having generally described some of the features of the present invention, in the above description, reference is made to the accompanying drawings, which form a part hereof and that show by way of illustration specific embodiments in which the invention may be practiced. It is to be understood that person skilled in the art may utilize other embodiments that are part of the present invention and that may be made without departing from the scope of the present invention.
We Claim:

1. A floating module, comprising a Y shaped structure having three arms outwardly radiating from a central point, wherein the free ends of the arms have one or more coupling means.

2. The floating module as claimed in claim 1, wherein the Y-shaped module may be made-up of polyethylene, polycarbonate, poly vinyl chloride (PVC), or fibre-reinforced plastic (FRP) or their combination thereof.

3. The floating module as claimed in claim 1, wherein the one or more coupling means are adapted to support one or more solar panels.

4. The floating module as claimed in claim 1, wherein the one or more coupling means are adapted to interlock with other Y shaped modules.

5. The floating module as claimed in claim 1, wherein the interlocking is done using a slide and lock system.

6. The floating module as claimed in claim 1, wherein the slide and lock system further utilizes a nut and bolt mechanism.

7. The floating module as claimed in claim 1, further adapted to anchor with the waterbody.

8. The anchor system as claimed in claim 7, is adjustable to the water level in the water body.

9. A hierarchal hexagonal grid structure made up of plurality of Y shaped structures integrated together via one or more coupling means provided at the free ends of their arms.
10. The floating module as claimed in claim 9, wherein the one or more coupling means are adapted to support one or more solar panels.

11. The hierarchal hexagonal grid structure as claimed in claim 9, being enclosed in a floating enclosure.

12. The floating enclosure as claimed in claim 11, is a circular floating enclosure.

13. The floating enclosure as claimed in claim 11, further adapted to anchor with the waterbody.

14. The hierarchal hexagonal grid structure as claimed in claim 9, may be made up of polyethylene, polycarbonate, poly vinyl chloride (PVC), or fibre-reinforced plastic (FRP) or their combination thereof.

15. The hierarchal hexagonal grid structure as claimed in claim 9, may be made up of concrete, poly-ethylene or their combination thereof.

16. The hierarchal hexagonal grid structure as claimed in claim 9, provided with a propulsion system for facilitating azimuthal movement of the one or more solar panels with respect to the Sun.

17. A floating solar power plant, comprising:
   - Y-shaped structures integrated to form a hierarchal hexagonal grid structure;
   - one or more solar panels mounted on the hierarchal hexagonal grid structure;
   - a propulsion system is coupled on the hierarchal hexagonal grid structure to facilitate azimuthal movement of said one or more solar panels with respect to the sun;
   - a floating enclosure for enclosing the hierarchal hexagonal grid structure; and
   - an altitude controller configured to facilitate vertical movement of said one or more panels with respect to the sun.
18. The floating solar power plant of claim 17, may further comprise of an inflatable pneumatic structure.

19. The floating solar power plant of claim 17, may further comprise of a global positioning system (GPS).

20. The floating solar power plant of claim 17, wherein the solar panels are arranged parallel to each other facing the sun on the hierarchal hexagonal grid structure.
**INTERNATIONAL SEARCH REPORT**

**International application No.**
PCT/IB2016/000664

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**A. CLASSIFICATION OF SUBJECT MATTER**
F24J/06 Version=2016.01

According to International Patent Classification (IPC) or to both national classification and IPC

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**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

F24 J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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<td>US 20120305051 A1 (Yuri Kokotov et al.) 06/12/2012 See Abstract, Paragraph 02-04, Paragraph 0038</td>
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<td>US 5772791 A (Johannes Nikolaus Laing) 30/06/1998 See figure 01, Abstract</td>
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Further documents are listed in the continuation of Box C. See patent family annex.

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