A study on PV floating solar system for Grouper Fish aquaculture in Pulau Panggang, Jakarta

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Abstract.
This paper presents the study of floating photovoltaic (PV) system integrated with Grouper fish in Panggang Island, Indonesia. The Grouper fish in Panggang island is generally cage, therefore, the study included the floating PV system, the type of site location of aquaculture and the supporting structure. The outcome of the study is to make an initial concept of form and the supporting system for the PV floating PV systems that is suitable with the existing cage type.

Keywords: floating PV system, aquaculture site, structure

1. Introduction
Solar energy is a promising renewable energy [1], and one of several alternative energies that can be used for generating electricity in an area that are not reached by local grid. It is also well acknowledged that currently solar energy technology has been widely developed, and PV floating solar system is one of them. This technology is developed not only to reduce the use of land (land-based system) and improving the solar cell performance, but also to provide energy alternative for any type of offshore buildings [2].

In terms of the application of the PV floating systems, there are several requirements that should be considered, particularly when it is integrated to an aquaculture which has specific activities. Aquaculture is essentially a farming in water or sea whereas the activity of breeding, raising and harvesting fish or aquatic plants [3]. The study took Grouper fish culture in Panggang island that located in northern of Jakarta. This aquaculture was selected since that fish culture is being actively conducted by the local fisherman.

Therefore, this paper is aimed to study the form of floating PV systems that suitable for an aquaculture, particularly for Grouper fish aquaculture. The study include : (1) the floting PV systems, (2) type of aquaculture construction, (3) analysis of the case study, and (4) some presedence of integrated PV panel and aquaculture. The outcome of this study is a concept of integrated PV panel and aquacultrr construction.
2. Floating PV systems

In general, floating photovoltaic (PV) systems can be illustrated in Figure 1. The figure shows that the energy, that is harvested from the PV panel, is transported to the substation by an underground cable, and from the substation, then to the distribution line. Substation is a station where the inverters are placed. Inverter is an instrument to convert the Direct Current (DC) to the Alternating Current (AC).

Essentially, the system is the same with the PV systems that is installed on land or roof top. The basic structure is also similar, only the floating PV system structure needs floater to support the PV structure, mooring system to adjust water level fluctuations while maintaining its position in a southward direction and underground cable.

While, a floating PV system for an aquaculture could be an offgrid PV system. The harvested energy is only for the need of the aquaculture since the area for the PV panel is minimal. The main use of the harvested energy is the aerotor to maintain the water condition. Therefore, the diagram can be illustrated in Figure 2. As shown in the figure, the type of aerotor is advised to deploy a direct current (DC) aerotor, so that reduce a space for an inverter.

3. Type of sea aquaculture reconstruction

Generally there are 2 (two) types of construction of off shore aquaculture or direct water-based system, they are: (1) cage farming and (2) pen farming [5]. Cage culture is essentially a total enclosure.
except the top of the cage, while pen culture, the bottom of the enclosure is shaped by the lake or sea bottom. The side by side of both the cage and the pen is mesh or netting.

Acc to [6], the site of the aquaculture can be classified into three location (Table 1), in which the construction of the aquaculture required different material to meet the location condition characteristics. Table 1 shows the type of site characteristics and the material that is usually used at each site. The major criteria for selecting a material for cage or pen are based on the characteristics like mechanical strength, resistance against corrosion and easy repairing and maintenance cost.

### Table 1. The type of site for aquaculture based on location

| Criteria                  | Coastal                             | Off the coast                        | Off shore                          |
|---------------------------|-------------------------------------|--------------------------------------|-------------------------------------|
| **Location hydrography**  | About more than 500 m from the coast, at least 10 depth, low tide and usually sheltered | About 500-3000 m from the coast, the depth between 10-50 m | More than 3 km from the coast, could be an open zone. The depth of the water is more than 50 m |
| Environment               | Hs usually < 1m                      | Hs <= 3 - 4m                          | Hs 5m or more, regularly 2-3m        |
|                           | The degree of exposure is small      | Some tidal streams, localised coastal current | Variable wind periods, oceanic swells, possibly less local current effect. |
|                           | Short period, winds                  |                                      |                                     |
|                           | Possibly strong tidal streams, localised coastal current |                                      |                                     |
| Access                    | 100% can accessed, and possible for landing at all time | Accessible on at least 90%>• once daily basis Landing usually possible• | Usually > 80% accessible• landing may be possible, peri•odically, e.g. every 3 - 10 days |
| Operation                 | Regular, manual involvement, feeding, monitoring, etc | Some automated operations, e.g. feeding, monitoring, etc | Remote operations Automated feeding• Distance monitoring, system function |
| The construction of aquaculture | Generally it is simple and made of High Density Polyethylene (HDPE) | Usually it is a cage mooring. The frame of the cage can be made from galvanized iron (GI), aluminum or steel. | In general the form and the material are similar with the off coastal aquaculture. Only, the specification of the material may different, such as the size and the thick of the material. |

**Hs : Significant Wave Height**

### 4. Analysis on Grouper fish aquaculture in Pulau Panggang

The study took the Grouper fish aquaculture in Panggang island, specifically in Karang Lebar. Panggang Island is one of an area called Seribu (Thousand) island. These islands are located in the northern of Jakarta, Indonesia. The name of Karang Lebar means wide coral since the area is contained with corals (Figure 3). Grouper fish that is also knowed as the coral fish, can be found here.
because of the natural habitats is suitable for the Grouper Fish. The Panggang island is an area where the local fishermen live. Currently, some of the fishermen also do the Grouper fish culture beside fishing to increase their income.

Figure 3. The location of Karang Lebar from Panggang Island

The site characteristics of Karang Lebar based on the definition at Table 1, are shown in Table 2. And by referring to the FAO definition, the site location is the coastal area.

Table 2. The Site criteria of Karang Lebar, Panggang Island

| Criteria            | Karang Lebar, Panggang Island                                                                 |
|---------------------|---------------------------------------------------------------------------------------------|
| **Location / hydrograph** | The depth is 75 meters. Each island of Seribu island is shelf up to 20 times wider than the island concerned with a depth of less than 5 meters. Almost every island also has a fairly wide area of coral flats (reef flats) with depths varying from 50 cm at the lowest tide to 1 meter at a distance of 60 meters to 80 meters from the coastline. |
| Environment         | The base of the coral flats is a variation between sand, dead coral, and live rock. On the seabed, the edges of the reef flats are often followed by steep slopes of up to 70 ° and reach the seabed with depths varying from 10 meters to 75 meters. The wind speed in the West monsoon varies between 7-20 knots per hour, generally blowing from the Southwest to the Northwest. Strong winds of 20 knots per hour usually occur between December and February. In the eastern season the wind speed ranges from 7-15 knots per hour blowing from the East to Southeast. |
| Access              | It is easy to access using motor boat from the near land.                                   |
| Operation           | Manual feeding and monitoring.                                                             |

The construction of the aquaculture in Karang Lebar is presented in Figure 4. This type of construction is suitable for the coastal aquaculture. It is made of High Density Polyethylene (HDPE)
In order to define how the PV panel will be installed, Table 3 presents the analysis from 2 (two) cases of the integrated PV panel and aquaculture.

**Table 3. The analysis of case studies**

| Type of Aquaculture | Form            | Curve | folded |
|---------------------|-----------------|-------|--------|
|                     | Stability on the existing aquaculture structure. | The form looks more stable for water area, the load is distributed to the corner of the aquaculture. This corner is actually tied with the mooring. | Since the distribution of loads is carry out by the column, whereas, the aquaculture structure is a floating structure which has no column or foundation. Only the mooring |

Based on the Table 3, the selected form is curve. Then, an analysis of what the suitable structure for to support the curve form is shown in Table 4. The analysis is based on [8].

**Table 4. The structure analysis for curve form**

| Load distribution | Form active | Vector active | Surface active |
|-------------------|-------------|---------------|----------------|
|                   | It is flexible, non rigid whereas the load is distributed through form design. | It is a structure of solid straight line elements. The distribution of loads is through vector partition, meaning it is a multi-directional splitting of forces. | It is flexible. The load distribution is effected by the surface resistant. |
| Type              | Cable systems, tent systems, pneumatics and arch systems. | Flat trusses, transmitted flat trusses, curved trusses, space trusses | Plate systems, folded plate systems, shell systems. |
| PV panel application | Thin film PV technology | Wafer and thin film PV technology | Thin film PV technology |

From the table, it can be seen that the potential structure systems are as follows:

- Arch system, from the Form active structure system.
- Curved trusses, from the Vector active structure system.
- Shell system, from the Surface active structure system.
5. Concluding remarks

The study of implementing floating PV systems on Grouper fish aquaculture in Karang Lebar, Panggang island has been conducted. The main consideration on this study is how to select the suitable structure system to support the floating PV systems over the existing cage. The results of this study are the most suitable form is curve and the suitable supporting structure can be an arch system, curve trusses or shell system. The material of the PV panel is the thin film which is easy to bend.

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