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Clean Energy to Combat Climate Change: A Case Study from Visakhapatnam, Andhra Pradesh

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Abstract: ***A huge chunk of the GHGs (Green House Gases) such as coal, oil and gas are the large contributors to climate change, and it is accounting over 75% of global GHGs and nearly 90% of co2 emissions. To overcome this negative impact and to reduce the GHG emissions, accessible of alternative sources of energy which are clean, sustainable and affordable, reliable are the good option to reduce the GHGs and also helps to reach the goal of SDG (13) climate action 2030. The renewable energy sources which are available in all around us from Water, Waste, Wind, Sun, Heat from the earth is replenished by nature and produce little to no pollutants or Green House Gases.***

This paper presenting about India's one of the floating solar point installed on the surface of Meghadrigedda reservoir to generate 3 MW power which is located at Visakhapatnam city executed under UCCRTF (Urban Climate Change Resilient Trust Fund) support of Asian Development Bank (ADB). These floating solar power plants is 100% eco-friendly compared to roof top and ground mounted such as better efficiency due to cooling of panel by air above the water bodies, it reduces water evaporation because of shading of water and reduces algae growth.

Keywords: Climate change, clean energy, renewable resources, floating solar power plant.

I. INTRODUCTION

Andhra Pradesh is poised for rapid industrial growth driven by infrastructure investments and has also been selected by Ministry of Power as one of the pilot states for implementation of the 24X7 – Power for All (PFA) scheme. Solar energy can become an important source in meeting the growing power requirements of the State. AP has large agriculture consumption constituting around 24% of the total energy consumption of the State. Solar power can also help shift the agriculture load and meet the power demand during the daytime.

With the support of Urban Climate Change Resilient Trust Fund (UCCRTF) support, Andhra Pradesh government installed a 3MW floating solar power plant on the surface of Meghadrigedda reservoir to generate renewable energy parallelly to reduce the need of valuable land area, save drinking water that would otherwise be lost through evaporation. The energy obtained from Solar Floating Photovoltaic (FPV) system is renewable, eco-friendly, and sustainable with long life of system. The produced solar power is planned to use for power supply to water pumping stations and E-Vehicles charging & swapping stations which are also executed under ADB-UCCRTF grant.

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This installed floating solar power plant converts solar energy into electrical energy by the PhotoVoltaic effect. When the sunlight is incident upon a surface of material, the presented electrons in valence band absorbs energy and being excited, jump to the conduction band and becomes free. These non-thermal electros which are highly excited are some diffuse and some reach a junction where these are accelerated into a different material by build in potential (Galvani Potential) which generates an electromotive force and thus the light energy is converted into electric energy. With this floating solar, could prevent around 70% of the evaporation which would in turn help in the retaining sufficient amount of waters in the reservoir and also the less algae forms in water due to reduction in the photosynthesis process to produce algae.

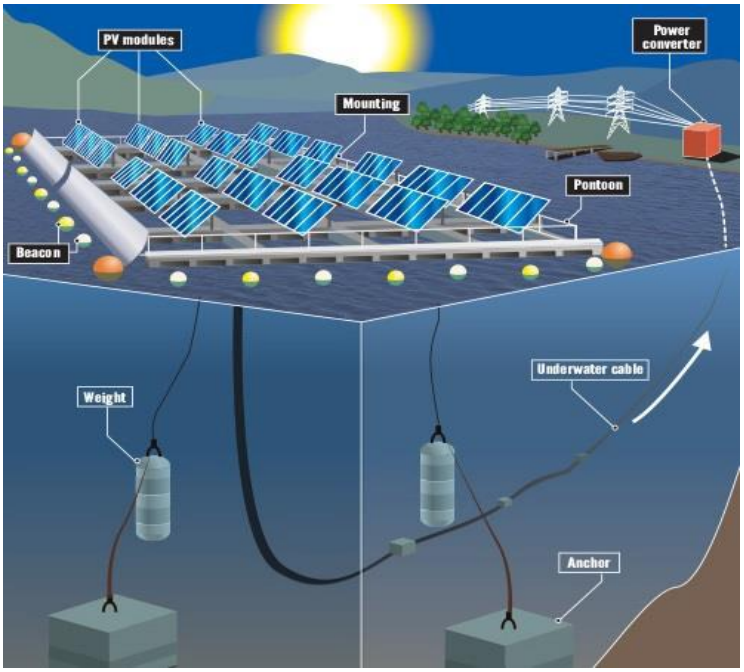

Fig.1 Technical details for FPV (Source: Google)

II. Literature Review

2.1 Solar panels reduce both global warming and urban heat island – a research work carried by Valery Masson at al, French center for Aerospatial research, Toulouse, France.

The production of solar power in urban areas is clearly a way to reduce the dependency on fossil fuels and it is s best way to mitigate global warming by reducing the emission of GHGs. In this research works, author presented the way to implement solar plants in town energy balance schemes considering the account of energy production for thermal & photovoltaic panels and found that the solar panels reduces the energy needed for air-conditioning by 12% , Urban Heat Island to 0.2k by up to 0.3.k at night and author concluded that solar panel is good both locally and globally to produce renewable energy especially in summer.

2.2 Technologies to slow climate change by Ajit Niranjan, Nature and Environment articles dated 31st December 2019.

Wind and Solar energy sectors being cheap, reliable and performing well opens up a lot of possibilities. Industrial materials like, iron, concrete, petrochemicals, steel etc., are responsible for about 10% of global and CO2 emissions as per the report from the center on Global Energy policy. The Cement Industry alone is responsible for about 8% of CO2 emission in cement production which is more than three times of the aviation industry.

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Plantation and Trees that extract CO2 from the atmosphere and it turns it into oxygen through Photosynthesis, but it turns to oxygen through photosynthesis are on way to do this, but it takes large tracts of land which needed for other purpose like growing food- and which is not secure way of storing carbon because it felled for firewood or burned in forest fires.

2.3 Renewable Energy is Key to fighting Climate Change by Kevin Steinberger July 26, 2016

Renewable energy is one of the good effective tools we have to fight against climate change. Solar and wind energy have experiencing remarkable growth and huge cost improvements over the past decade without any slowing down and it is becoming increasingly competitive with fossil fuels all around the nation. The non-market benefits of renewable energy also are a considerable point because that supports nearly 200,000 jobs and 5.2. billion dollars worth of health benefits through improved quality of air parallelly. The top leading renewable states experienced very Low electricity price increases that the bottom 10 states between 2002 and 2013.

2.4 The need for Renewable Energy sources by Umair Shahzad, Department of Electrical Engineering, Riphah International University, Faisalabad, Pakisthan

In this paper author has explained that the ever-growing population means and ever-growing requirement of energy. Recently economy of energy cannot be denied. it is most essential in every walk of life. Energy sources can broadly classify as non-renewable and renewable. Knowing the dreadful fact that nonrenewable sources will eventually deplete the importance of renewable sources which cannot be underestimated. The most important aspect while utilizing them is their impact on the environment. This author elaborated the importance of various renewable resources of energy owing to the backdrop of fossil fuels. Major emphasis is places on the use of the alternative energy technologies. Some applications of renewable sources and future of energy is also discussed.

2.5 Renewable energy for sustainable development in India- present status, future prospectus, challenges, employment and investment opportunities by charles Rajesh Kumar & Majid

The Key objective of this work is to develop renewable energy in India to improve energy security, economic development, improve access to the energy, mitigate climate change impacts, sustainable development, if possible, by use of sustainable energy by ensuring access to affordable, reliable, sustainable and modern energy for citizens. Very strong support and the increasingly opportunity economic situation have pushed India to be one of the top leaders in the world most attractive renewable market. Indian governments made policies, programs to attract foreign investments to ramp up the country in the renewable energy market at rapid rate. This paper main objective to present significant achievements, projections and prospects for generation of electricity as well as challenges and investment and employment opportunities to develop the renewable energy in India. Author identified various obstacles facing by renewable sector and these outcomes will provide useful information for policymakers, project developers, investors, industries and associated stakeholders, researchers and scientists.

2.6 Renewable energy efficiency by Pavel Bexrukikh, Sergey M.Karabanov & Pavel P. Bezrukigh

In this research paper author worked out the results of ecology, energy, operational and social efficiency of renewable energy (Photovoltaic and wind power) and comparison results of renewable and traditional energy efficiency. It is establishing that wind and photovoltaic power stations are more effective than the thermal stations and their ecological efficiency is considerably very high than that of thermal stations and research found that the use of photo voltaic and wind power stations increases social stability

2.7 Solar energy – the key to tackle climate change and meeting increasing energy demands published in Pinion editorial by HE Saeed Mohammed AI Tayer, MD & CEO of Dubai Electricity and water Authority

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The issues of climate change have become a threat to all living and non-living, the biodiversity & Environment on earth and this has become a major challenge is that the entire world must unite to overcome. The challenge faced by the modern-day world is but a fraction of what we can expect to face in the future, if we do not react quickly and work to mitigate the effects of raising climate change. Main cause of GHGs are generating fossil fuels and it is most important step towards addressing climate change, by using alternative solutions like renewable energy, solar power, hydropower, wind power, geothermal energy, tidal power, while rationalizing consumption and enhancing energy efficiency. Author also suggested to establish relevant policies, laws and legislations to preserve renewable energy, while making larger investment in the field of renewable energy.

2.8 Super -Size Solar Farms are taking over the world –by will Mathis and Brian Eckhouse

As many of the world's major corporations and governments move to transition the global power supply away from fossil fuels and developers are transforming the deserts, agricultural land, and rural lakefront into vast solar energy farms. The mega sized projects represent a new class of renewable power capacity that's finally approaching the scale of coal, oil and natural gas fired plants. Large scale solar projects are getting very common every year. In 2019, developers set a record by commissioning at least 35 projects of at lease 200 MW worldwide, about 17% from the year prior, according to an analysis of data compiled, about 3,000 solar panels needed for each MW capacity, a 200 MW project would be at least as big as 550 American football fields.

2.9 Renewable Energy in Indonesia: current status, potential, and future development by Nugroho Agung Pambudi, Ridho Alfan Firdaus, Reza Rizkiana at all.

The demand for renewable energy in Indonesia has increased along with the rise in consumption. Following this, energy consumption increased by 0.99%, which was approximately 939.100 million BOE in 2021 for biogas, oil, electricity, natural gas, coal, LPG, biodiesel, and biomass. Energy consumption in several sectors including transportation has the largest energy consumption with approximately 45.76% of oil. In industries and households sector, the consumption rates are 31.11% for boiler steam generation purposes and 16.89% for electricity as well as LPG. Furthermore, the commercial sector consumes 4.97% of energy for lighting and air conditioning, while the remaining 1.27% is used for other sectors. The main focus of this paper is to provide a detailed analysis of the status, prospects, and information on Indonesia's sustainable energy sources. Furthermore, the novelty of this research entails updating the latest data related to renewable energy and its availability in Indonesia. The essence is to portray a picture of its potential development in the future.

III. The Key Objectives of this Research Work are to:

3.1 Identify the climate conditions, assess the reservoir surface area, wind speed, anchoring ability, movement patterns of the water, aquatic environment, water depth condition to plan panels and install anchors

3.2 Carry out the insulation and cable management test as the cables are in touch with water

3.3 Design the floating panels subject to mechanical stress and continual friction to not get by catastrophic failures in future

3.4 Adopt internationally approved components of solar system

3.5 Plan the quality of combiner box to meet the technical requirements of the project, which is most important part of solar systems as it connected to the output of the solar modules

3.6 Plan central inverter component as per specific needs of the system like size, power levels and flexibility to ensure the long-term success of a solar energy system.

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IV. PROJECT BACKGROUND

Project Site at Meghadrigedda Reservoir, Vishakhapatnam India is located at Latitude/Longitude 17° 45' 59" North, 83° 11' 0" East. The Meghadrigedda Reservoir project was constructed across the river Naravagedda and Meghadrigedda at Kamarapalem village in Visakhapatnam District in the year 1977. The catchment area is about 368 sq.kms, which includes the reservoir. The reservoir was commissioned in the year 1979 with a storage capacity of 29.31 M.cum and later, during the year 1989, the water withdrawal capacity of the reservoir was increased to 10.00 million gallons per day (source: zilla prajaparishad), with the reservoir capacity increased to 33.1024 M.cum @ F.R.L + 18.60 m. The maximum length of the reservoir is 2950 m and the maximum breadth is around 1700 m. with a total area of approx.s.5015 sq km. Meghadrigedda is a typical shallow reservoir covering a large area.

Fig 2: location map of project area.

4.1 Data Collection:

To fulfill the first / 3.1 objective of this work, data has been collected through comprehensive literature survey, discussion with stakeholder agencies, and field visits to the proposed subproject sites.

4.1.1 Climate and Rainfall:

According to Thornthwaite's scheme of climatic classification (Ref:4, pg.13) the city area falls under semi-arid type of climate.

- Absolute maximum -44.4 degrees & minimum-12.8 degrees, Sea surface temperature Minimum-20.2 degrees C & Maximum-32.3 degrees C, Monthly mean relative humidity is Absolute maximum-100% & Absolute minimum-4%
- Monthly Wind Speed Mean value-10-16 kmph Prevailing Direction Southwest Frequency Distribution-44.5%
- Highest monthly mean wind speed for 24 hours-21.4 kmph. Extreme wind velocity-131 kmph.
- Monthly sea level pressure : Mean value-1009 mb, Maximum observed-1014 mb
- Monthly Visibility: Less than ½ N mile, less than 1 mile, less than 2 N miles, less than 10 N miles.
- Fog is infrequent at sea in all seasons. Reduction in visibility is mostly due to heavy rains, which during the southwest monsoon can reduce visibility below fog levels.
- Rainfall Average Annual: 973.6 mm

  Annual Min: 654.0 mm & Annual Max: 1308.6 mm

  Maximum recorded in a day: 375.2

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Highest annual: 1,314

Highest monthly: 606 mm & Highest daily: 293.3 mm

Fog: Months: December to February

4.1.2 Coastal and Oceanographic Data: The cyclonic activity, coastal and offshore data was collected from Indian Meteorological Department sites / meeting experts, Visakhapatnam (Ref:5 of pg.13) to analyze the various factors that affect the proposed components of the project.

4.1.3 Monsoons and Cyclones: In the Bay of Bengal, depressions are likely to be encountered in all seasons of the year with a gradual fall in pressure. On an average 4 to 5 cyclones per year occur. However, at particular locations the average frequencies may be lower. Hind casting studies (Ref:6) indicated that the Coast is mainly affected by waves generated by Cyclones from the Southeast to Southwest direction. The highest waves are experienced in the period April to September when the winds are more intense and consistent. The deep-sea waves with the highest and lowest period frequent from the Southwest quadrant. Waves of over 1.5 mtrs in the height may be expected approximately 14% of the time. Therecord of tidal level data sheets from INCOIS- Indian National Center for Ocean Information Services (Ref:7)shows two highs and two lows and indicates that strong tides as much as 60 cms in excess of the predicted tides may occur during the cyclones.

4.2 Environmental Impacts & adopted Mitigation Measures

Location impacts are associated with planning particularly on the site selection, and include impacts due to encroaching on sensitive areas, and impacts on the people who might lose their homes or livelihoods. The site has some trees and bushes around and were avoided during the transportation and storage of the power plant components.

4.2.1 Utilities: Transmission line from the reservoir to the substation, Various utilities (telephone lines, sewers and pipelines) were shifted. To mitigate the adverse impacts due to relocation of the utilities, conducted detailed site surveys with the construction drawings and discussed with the respective agencies before site clearance and start of excavation work; and also prepared a contingency plan to include actions to be done in case of unintentional interruption of services.

4.2.2 Construction impacts: No welding operations were carried out for installation of PV modules as those are prefabricated. The required earth works done by using sight rails and barricades, excavated materials are stocked within the areas. Measures taken while transportation of materials and installation of works to not impact on environment and sensitive receptors such as residents, business and the community in general.

4.2.3 Air Quality: as the installation works not used welding, the impact on air quality was minimal and temporary. Emissions from construction vehicles, equipment, and machinery used for excavation and installation induced short term and temporary impacts.

4.2.4 Surface Water Quality. All the installation works carried out during dry season to prevent temporary impacts for installation PV panels and conducted surface quality analysis for every fortnight to assess the impact.

V. PUBLIC CONSULTATION

On 7th September 2018, project officials from GVMC(Greater Visakhapatnam Municipal Corporation) organized stakeholder consultation with 22 residents, mostly belonging to fisherman community(fig.3). Project officials explained about the project proposal that, 1% of the reservoir area in the southwest is proposed to use for this project and the remaining area can be used for fishing. The settlements in the west and the southeast (closer to the sluice gates) which are using the reservoir for

fishing can continue to access the reservoir without any hindrance as no work is proposed in these areas. They were assured that the proposed works will not affect their fishing activity and were informed that they could contact the GVMC in charge engineer of this project if they have any issues during its implementation and even afterwards.

5.1.1 Consultation, disclosure, and Grievance Redress Mechanism. The stakeholders were involved in developing this project and their expressed view on safety & environmental measures were incorporated in the planning and development of the project. The project documents made available at all public disclosed to a wider audience via the Asian Development Bank(ADB) and GVMC websites. A dedicated GRM (Grievance Redressal Mechanism) was developed at hierarchy level and addressed grievances quickly.

Fig.3: Consultation with fisherman community

VI. Technical Specifications, Components & Benefits of Floating Solar PV System

6.1 Technical Specifications

- Number of solar panels : 8970
- Mass of flotation device : 08 Kg,
- Buoyancy of flotation : 80Kgs,
- Dimensions : 2500MM×260MM×270MM
- Temperature compatibility : 40°C to 80°C
- Water-tightness Impermeable seamless outer shell with EPS foam filling that has moisture retention : < 5% Density of EPS 18 – 25 kg/m3
- Design resistance of tenon and mortise joint : 5568 N
- Maximum bend angle of flotation device : 10° of Modules:8970nos.,
- Module-rating : 335p&330p,
- Capacity of each Inverter : 90kW

6.2 Components of Floating Solar PV System: to achieve the objectives from 3.2 to 3.6 of this work, standardized materials/ equipments are procured as per the standards of Ministry of New and Renewable energy, Govt, of India and installed panel float, moorings, anchoring, cabling, etc as discussed below from paragraph 6.2.1 to 6.2.6

6.2.1 Solar Module: ZXP6-D72 series Zn-shine solar 5BB- Double glazed poly PV module having the qualities of the risk free of micro crack, higher efficiency, PID free, better weak illumination response, higher reliability. These modules are tested and approved by the Solar Energy Corporation of India (SECI)

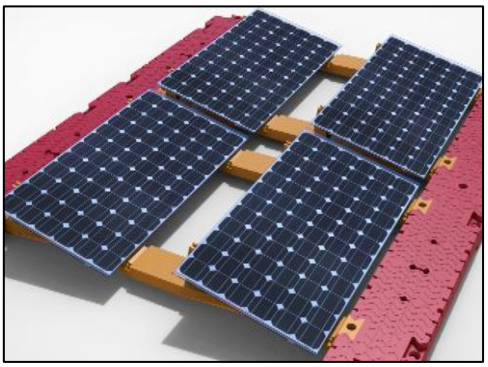
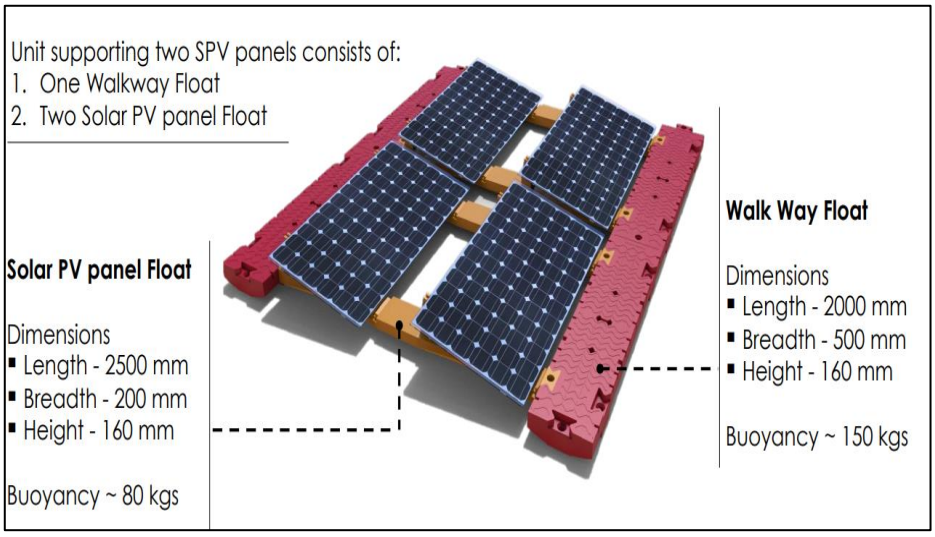


Fig. 4: Image of used solar module

6.2.2 Floating Structure: Seahorse technology (One single unit of this consists of one walkway float and two solar PV panel float for supporting two solar PV panels.) optimized for cost and space efficiencies, standardized, prefabricated and modular, aerodynamic design, guaranteed unsinkability, easy handing and fast installation and high packing density. This is standardized, prefabricated modular and ability to handle large volumes with a capacity of 60MWp/annum. Enhanced air circulation structure of this panel facilitates natural evaporative colling with high stability during severe wind loads up to 55 m/s



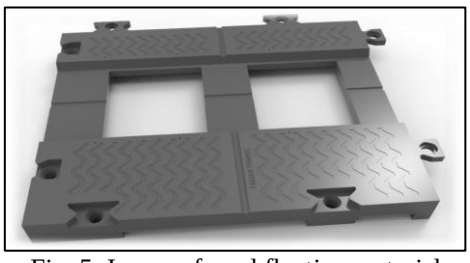


Fig. 5: Image of used floating material

6.2.3 **Panel float**: The panel float is utilized for installation of one or more solar modules at a predetermined tilt of 5°. The solar PV modules are fixed onto the panel float by utilizing clamps. The solar modules are placed on floaters are manufactured with High-Density Polyethylene (HDPE) materials and this entire system is anchored via special High Modules Polyethylene Ropes which are most popular good material being used in a majority of the floating Solar power plants across the globe

6.2.4 **Walk-ways:** The walkway float is utilized for movement of personnel and equipment to be used by service personnel for day to-day operations and to fulfill maintenance requirements. **Maintenance of FPV modules**: Maintenance is the greatest concern because of bird droppings which is cause significant spoiling for FPV systems. Floating structures generally attract avian wildlife & they use them as landing and resting points. Because of this dropping, it reduces power output and performance through partial shading and hot spots, which can cause substantial loss of production (Deign 2017). In the long term, these may cause permanent degradation of solar cells and modules. To overcome this, planning to install non barrier methods like ultrasonic devices, Repeller/ visual scare devises are proposed to use at site.

Fig. 6 : Floating photovoltaic plant on surface of Meghadrigedda reservoir

Fig.7 : walkways to FPV Meghadrigedda reservoir

6.2.5 **Cabling:** 800V 400 sq mm cables are specifically designed and are resistant against UV radiation and extremely high temperature fluctuations and unaffected by the weather conditions like +80 degree C & (standard of: BS/ EN 50618 / TUV 2pfg 1169/08.2007)

6.2.6 **Inverters:** DC power generates from FPV is taken to the inverter through a series of combiner boxes and then converted into AC power located on land near to the FPV.

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Fig.9: Aerial view of 3MW transformer installed

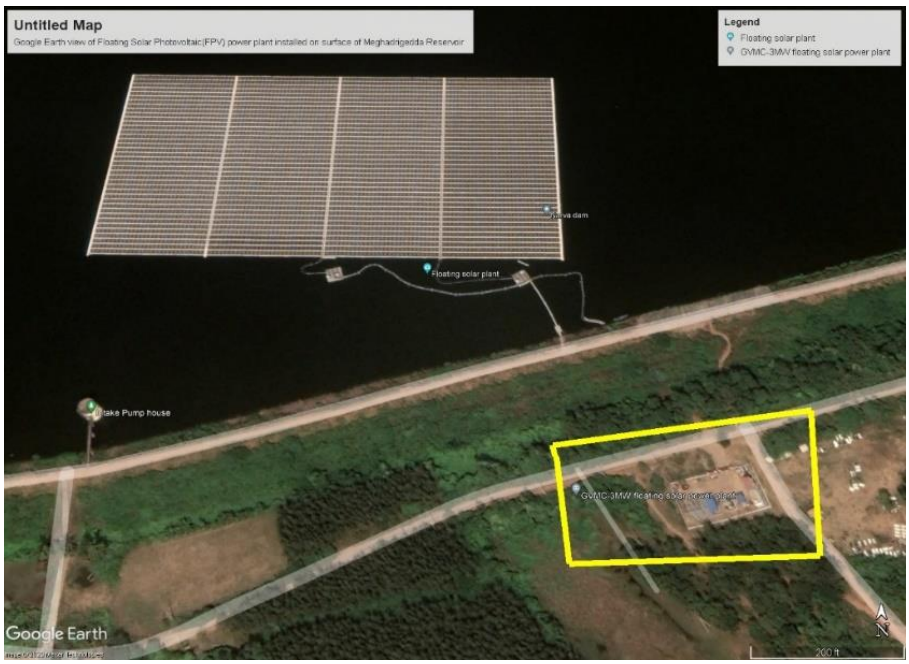

Fig.10: Google earth map view of installed Floating Photovoltaic Solar plant

VII. Benefits, Advantages and Challenges of this FPV Project

7.1 Benefits:

- ✓ **CO2 Emission control**: Real time data monitoring using SCADA (Supervisory Control And Data Acquisition) system. This online monitoring control system established near to the project location to monitor online data of solar power generation, The figure@11 below showing the screenshot of SCADA monitoring system performance captured on 31.01.2023

- ✓ This project operation started on 30th June 2022 with a capacity to generate 08-10 MWh per day. (Considering all seasons temperatures)
- ✓ As on 31st January 2023(~7 months), as showed at below screenshot image, total solar power generated is 1.82 GWh(Gigawatt hours)/1820 MWh(megawatt hour) and parallelly reduced 1.82 kt(Kiloton) of CO2 . (An average 1MW of solar power reduced 1 Kt of CO2)
- ✓ This reduced CO2 indicates that saved 50,000 tons of coal
- ✓ Land area covered/land saved: 0.005 Sq Km (0.1% of reservoir area)/ 12acre,
- ✓ Cost savings-3.43 Crores,
- ✓ Return of Investment in 5 years

Fig.11 : SCADA monitoring system performance captured on 31.01.2023

7.2 Pros and Cons of FPV

- ✓ Water exerts a cooling effect, and which improves the performance of panels by 5 to 10% (Ref: 8)
- ✓ CMagnesium alloy coating is prevents from rust or corrosion
- ✓ FPVs above the water bodies reduces water evaporation
- ✓ The shade of solar panels helps to reduce the growth of of algae due to absence of photosynthesis.
- ✓ Minimizing the associated water treatment and labor work to clean the algae
- ✓ reduces the need of tree removal, forest clearance etc. which is a practice that is used in the case of solar plants installed on land Panels on water works efficiently in high temperatures / hot climatic conditions also

Cons

- ✓ Construction, Engineering expenses are greater than the ground based solar farm
- ✓ As water and energy involved in this FPV, insulation testing, cable management must give major attention as part of safety concern

- ✓ Perfect management of FPV is needed in view of any catastrophic failures
- ✓ Cleaning of Floating panels is a major challenge due to more bird droppings.

VIII. Conclusion and Way Forward

A floating solar power plant is one of the best environmentally friendly alternatives for power generations and its helps in preserving land resources for their valuable usage.in addition to this, working efficiency of FPVs increases due to the cooling tendency of water and reduces the co2 emissions to the environment

In India many large water bodies are available in southern, eastern, and southeastern part of country in the states such as Andhra Pradesh, west Bengal, assam, Orissa, Tamilnadu and Kerala and this FPV technology can be adopted in these states to conserve the resources, reduce the emissions and bring down power generation expenses.

Way forward:

The technology used for this FPV efficiency to install on Meghadrigedda reservoir can be utilized a good reference for future with thorough understanding the water environment, appropriate safety measures to transport the power from the water to the land.

As per this present FPV study work, it is to recommend that the “there is necessity to carry out to research to find that the Install FPVs on saltwater surfaces and its impacts and also the technology to clean of panels to generate the power without any harm to the aquatic environment and power supply interruptions.

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