International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2024, 14(2), 218-225.

Techno-economic Comparative Analysis of Floating/On-Ground Solar PV System for Electrification of Gilgel Gibe I Auxiliary Load in Ethiopia

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Received: 10 July 2023 **Accepted:** 29 December 2023 **DOI:** https://doi.org/10.32479/ijeep.14830

ABSTRACT

Ethiopia is well endowed with solar energy resources with daily average radiation ranging from 4.5 to 7.5 kWh/m^2/day. The significant electricity consumption of the country is reliant on hydropower. This dependence on hydropower makes the country susceptible to weather and climate changes, such as droughts, which can lead to reduced water levels in hydropower reservoir and reduced electricity generation. The application of solar floating photovoltaic (FPV) in the existing hydro reservoir would provide solar electric power to support hydropower generation especially during dry periods, and decrease evaporation losses. This implementation also has the cascading effect of increasing the solar power generation from the PV system by reducing the panel temperature through efficiency gain while saving the land requirement for installing the same PV system. Especially for countries like Ethiopia where agriculture is the key source of economy, optimal usage of land is very important. Thus, in this research, a techno-economic comparative analysis of 4MW Grid-tied FPV and ground-mounted PV system on Gilgel gibe I reservoir in Ethiopia for supplying the auxiliary load of the generation plant is done. The results showed that the proposed FPV system has 6.9% more electricity generating capacity than land-mounted PV system and saves 74,400 m^3 of water from evaporation annually. The FPV plant will also save the land cost burden, and results the levelized cost of energy (COE) 0.043$/kWh, which is 15.7% less than land-mounted PV systems. In another way, the proposed FPV system indicated a positive impact on the environment by reducing 993 tons of greenhouse gas emission annually. Thus this research results will offer a clear direction for the concerned stockholders to implement FPV technology on the Ethiopian hydro reservoirs.

Keywords: Solar Radiation, Floating Photovoltaic, Reservoir, Ethiopia

JEL Classifications: Q25, Q42, Q51

1. INTRODUCTION

Global economies are highly dependent on energy. Ethiopia is a developing country with a population of about 112 million at the end of 2021 (CIA The world fact book, 2021; Food and Agriculture Organization of the United States.Country profile - Ethiopia, 2016). Presently, the country has approximately 4650 megawatt of installed generation capacity. From the installed capacity, 88% of electricity is generated from hydropower (Dawit and Erik, 2021; Tiruye et al., 2021).

Because most of the hydropower plants are situated far from the end users, the electric power is transported from the generation to the loads through transmission lines. In this transportation process, significant electric power is lost before the power reaches the end users due to the presence of line parameters and other electromechanical effects. Particularly in various developing countries like Ethiopia, the technical and economic losses of distribution networks are very high due to inefficient system management and poor revenue collections. According to some investigations (e.g. Dawit and Erik, 2021; Tariku and Bekle, 2021; World Bank. Ethiopia renewable energy guarantees program report, 2019), the transmission and distribution power losses in Ethiopia reaches 20%. This value is high compared to the world average ranges of 10% to 13% (Khan and Singh, 2017; Tariku and Bekle, 2021). Moreover, the continuous depletion of fossil fuel resources, the increased long line costs and the climatic influences on the hydropower sector are the other basic concern to meet the ever increasing load demand.

In order to ease these technical difficulties and to reduce emission, the traditional concept of generating electrical power from one centralized station is currently shifted to decentralized generations through renewable distributed generation (DG) systems. Because of the continuing commercial maturation, among the common renewable DG sources, the solar PV is mostly expanding in different areas of the country.

Because of high temperatures and dust, ground-mounted solar PVs were inefficient and took up a lot of area coverage on the land (Pakyala, 2021). As a result, for large solar farms, the area needed for PV implementation increased. As the globe swings towards clean energy, FPV systems are becoming a hot issue of research in enhancing PV power output efficiency. Land is no longer required while using FPV technology. In FPV, the solar panels have been designed to float on the surface of water body. Water bodies like irrigation dam, canal, water reservoir, lake, and ocean are used for floating (Aryani et al., 2019). Due to the water surface cooling effect, the FPV system on the water surface has a lower temperature that reduces the cell temperature of the solar PV panel. Thus, floating solar panel is more efficient than the ground-based solar arrays (Zhang et al., 2016).

The scarcity of land, less efficiency at high operating PV cell temperature, and lack of researches on the area are dominant factors that limit the growth of PV penetration in the globe and particularly in Ethiopia. Besides FPV will try to reduce evaporation loss from reservoirs thus in the process tends to conserve water enabling greater water use efficiency (Kumar et al., 2018).

In the past, various researches have been investigated on the techno-economic viability of land based solar PV system and some researchers have also studied the technical feasibility of FPV system in different parts of the globe.

Zandi et al. (2017) examined the environmental and economic impact of solar PV power for the household energy consumption in Iran using RETScreen software. The output revealed that the development of solar PV system for household use is economical. Akpola et al. (2019) presented performance assessment of 84 kW grid-integrated rooftop solar PV systems in Istanbul, Turkey, using PVSOL software. The simulation results indicated that 13.2% of the buildings' annual energy consumption is supplied from the suggested systems. Ayadi et al. (2018) investigated the economic effectiveness of a grid-connected solar PV system by considering fixed, single and double axis tracking modes for the University of Jordan in Jordan. TRNSYS software is used for the simulation of the proposed system. The results showed that grid-tied single and double axis tracking PV system are less cost-effective than the grid-integrated fixed axis PV system for the location.

Mukisa et al. (2019) investigated the viability analysis of grid-connected rooftop solar PV system for 36 industrial applications in Uganda. Azimuth tools and Google Earth are used to determine the rooftop area. The results portrayed that the suggested PV system was economically feasible. Kazem et al. (2017) analyzed the techno-economic feasibility of 1 MW solar PV grid-tied system in Oman with the help of numerical simulation utilizing MATLAB developed code. From the simulation output they concluded that the proposed grid-connected PV system is economically viable. Bastholm and Fiedler (2018) evaluated the techno-economic examination of grid-integrated PV/diesel/battery power system under grid blackout consideration in Tanzania using HOMER software. The results showed that under power outages above 0.75 h per day, grid-connected PV/diesel/battery system are economically viable for the considered load in the sites. Goswami (2019) presented the economic analysis of FPV and conventional land mounted solar PV power. The technical viability of FPV is performed for the installation of 10 MW system at Neel-Nirjan Dam, west Bengal India. The results showed that FPV power system has 10.2% more generating capacity than land based solar PV system. (Hany amd Ahmed, 2023) investigated the use of the FPV system to reduce the water evaporation loss from Lake Nasser in Egypt and to produce clean energy. Different scenarios of covering the lake's surface with FPV are studied. Further, the effect of covering shallow depths is studied. The results showed that covering 25% and 50%, of the lake can save about 2.1 and 4.2×10^9 m^3/year and produce energy of 2.85×10^9 and 5.67×10^9, MWh/year, consecutively. Nagananthini and Nagavinothini (2021) studied the electric power generation and water-saving capacity model of FPV system with different tilt angles and tracking mechanisms by covering 30% of the total area of Vaigai reservoir in India. The results indicated that the proposed FPV power system with size of 1.14 MW produces 1.9 GWh of energy at its optimum tilt angle with saving of 42,731.56 m^3 water yearly. Sulaeman et al. (2021) evaluated the technical benefits of adding FPV system on the existing amazon dams. System adequacy is assessed with the existing production of dams and with the required capacities of FPV system to compensate for the present underproduction of dams. The results revealed that the investment toward developing FPV system on the reservoirs leads to a significant enhancement to the overall system reliability, and potentially add more flexibility to the operator to dispatch power produced by hydro plants during peak loads.

In the above mentioned literatures, the technical viability and economic advantages of land- mounted and FPV system have been investigated in different locations. However, the techno-economic comparative analysis of ground-mounted and FPV system in the Ethiopian hydropower reservoir is not explored thoroughly enough. Therefore, this study aimed to decrease this gap by providing a techno-economic comparative analysis of grid-connected FPV and ground-mounted PV system on Gilgel gibe I hydro reservoir for supplying the existing auxiliary load of the generation site (Gilgel gibe I load), Ethiopia. A country like Ethiopia where agriculture leads the economy, scarcity of land and food insecurity is critical concerns. FPV technology on the surface water bodies which has not been properly considered is a good option for this challenge.

The technical and economic parameters like, annual PV power generation, yield factor, capacity factor, levelized cost of energy and emission are analyzed. HOMER Pro and PVGIS are used as a simulation tools to examine feasibility of the proposed system.

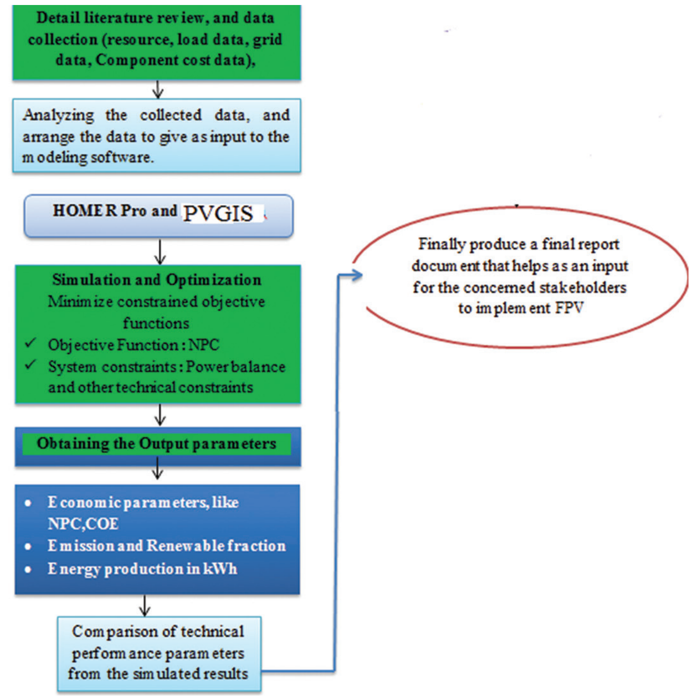
The next sections of the paper are structured as follows: Methodology of the investigation is presented in section 2. Simulation results and discussions are highlighted in Section 3. Lastly, the conclusions of this study are provided in Section 4.

2. METHODOLOGY

Primarily, Gilgel Gibe I reservoir is selected as a case study site. Then, the meteorological data like ambient temperature, solar radiation, wind speed and humidity of the designated location is collected from National meteorology, NASA, PVGIS, HOMER pro software. Then design and mathematical modeling of the FPV/Ground-mounted system is continued. The performance parameters of FPV/ground-mounted, such as performance ratio, capacity utilization factor, greenhouse gas emission, water evaporation, and energy production potential, was analyzed.

The details of the above-mentioned methodology are clearly highlighted by a flowchart revealed in Figure 1.

Figure 1: Methodology of the study



2.1. Details of the Study Area

The Gilgel Gibe I hydropower plant reservoir is one of the earliest reservoir in Ethiopia with a total generation capacity of 200 MW and an energy production of 720 GWh/y. The site dam is located at 7.79°N and 37.28°E. As portrayed in Figure 2 below, the reservoir covers 51 km^2 areas. The average yearly global horizontal irradiation (GHI) of the site is 5.88 $kWh/m^2/day$, with an average wind speed of 2.06 m/s, average annual humidity (%) 73.06, and an average annual ambient temperature of 20.58°C.

Figure 2: Geographical map location of Gilgel Gibe I reservoir from satellite image

2.2. Energy Demand Assessment

The size and cost of the power supply system components are highly influenced by the size of electric loads. Thus, estimating the load is one of the most important steps in the design of the hybrid system. Different types of auxiliary loads like lighting, heating, pumping, exciting and etc. are available in the generation plants, and an average of 1,080,400 kWh/year consumption has been considered in the analysis.

2.3. Rate of Evaporation in the Reservoir

The rate of evaporation varies with the relative humidity, temperature, surface area, vapor pressure variance, wind effect, irradiance and quality of water. To assess the amount of water lost through evaporation, the meteorological data for the Year 2011-2021 is obtained from NASA world power energy prediction homes and national meteorology agency office (NASA Prediction of worldwide energy resource, 2021). The data is depicted in Table 1.

Various empirical techniques are available in the literature to calculate the evaporation rate. In this investigation, a simplified Penman model equation with the same accuracy (Valiantzas, 2006), has been employed as highlighted below.

$$EPEN \approx 0.0478* RS*((T+9.5)\ \hat{}0.5)\ 2.4 *((RS/RA)\ \hat{}2) +0.09 *(T+20)*(1-RH/100) \quad (1)$$

To calculate the daily evaporation in mm from the routine weather data without recourse to wind velocity, here Rs is the global solar irradiation and RA ($MJ/m^2/d$) is the extraterrestrial radiation, T is the ambient temperature and RH is the relative humidity. The computations made are indicated in Table 2, which indicates the annual average evaporation as 5.0977 mm/day amounting to 1860.6 mm/year. The monthly variation in this regard is portrayed in Figure 3.

2.4. Modeling of FPV Plant

The main components required in the design of FPV system for any water storage system are, floating platform to support the PV panels, anchoring and mooring system to fix the platform. Figure 4 illustrates the different parts of a typical FPV.

The PV panel is modeled as a component that produces DC electric power in direct proportion to the solar irradiation. The power output of the PV panel is given by the following equation (Ghenai et al., 2018).

$$P_{pv} = W_{pv} f_{pv} \left(\frac{G_T}{G_{T.STC}} \right) \left[1 + \alpha_p \left(T_C - T_{c.STC} \right) \right] \quad (2)$$

Where W_{pv} is the peak power output [kW], f_{pv} is the PV derating factor (%), G_T is the solar radiation incident on the PV array in the current time step [kW/m^2], $G_{T.STC}$ is the incident radiation at standard test conditions [1 kW/m^2], α_p is the temperature coefficient of power [%/°C], T_C is the PV cell temperature in the current time step [°C], and $T_{c.STC}$ is the PV cell temperature under standard test conditions [25°C].

For FPV system, the key factors that determine cell temperature are wind speed and temperature at sea. The mathematical relationship of sea temperature (T_w) and land temperature (T_a) is given by the following equation (Suh et al., 2020; Umoette et al., 2016).

$$T_w = 5.0 + 0.75T_a \quad (3)$$

Where T_w, sea temperature (°C) and T_a, air temperature (°C). The maximum annual temperature of the location is 23.95°C. Thus,

Figure 3: Monthly average evaporation rate estimated for the area

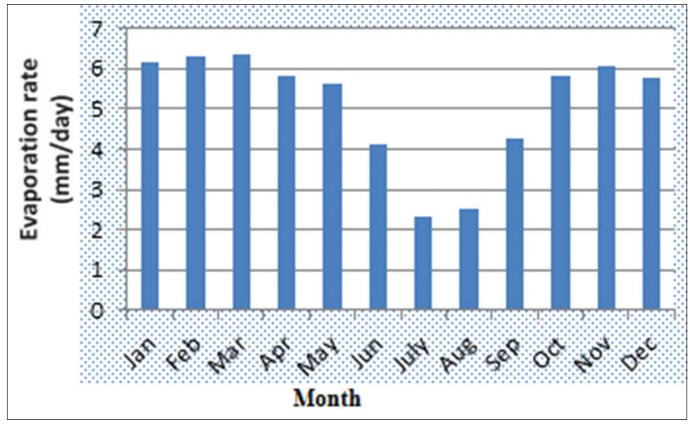


Table 1: Meteorological data of the study area

Months	Global horizontal irradiation (KWh/m²/day)	Wind speed (m/s)	Average ambient temperature (°C)	Relative humidity (%)
Jan	5.78	2.41	22.30	63.69
Feb	6.09	2.18	21.50	59.12
Mar	6.19	2.26	22.31	61.81
Apr	5.95	2.03	23.95	68.94
May	6.68	1.77	20.8	77.38
Jun	5.57	1.85	20.90	85.25
July	4.95	2.08	18.80	88.12
Aug	5.54	2.16	19.57	88.56
Sep	5.86	1.80	18.07	84.44
Oct	6.39	1.62	19.18	72.12
Nov	6.20	1.93	19.90	66.31
Dec	5.37	1.97	19.75	60.12
Annual average	5.88	2.06	20.58	73.06

Table 2: Calculations made from weather data of Gilgel Gibe reservoir

Months	Irradiation (MJ/m²/day)	day	Extraterrestrial radiation kW/m²	Sun shine hours	Extraterrestrial Irradiation (MJ/m²/day)	Evaporation, mm/day E_{PEN}
Jan	20.808	15	1.333557	7.75	37.20624	6.146619
Feb	21.924	45	1.402345	6.94	35.0362	6.324289
Mar	22.284	75	1.367497	7.01	34.51016	6.360618
Apr	21.42	105	1.316363	6.3	29.85511	5.815743
May	24.048	135	1.377116	6.28	31.13383	5.620278
Jun	20.052	165	1.397473	4.88	24.5508	4.138211
July	17.82	195	1.326407	3.62	17.28574	2.319724
Aug	19.944	225	1.342052	3.73	18.02107	2.521875
Sep	21.096	255	1.405192	5.32	26.91224	4.26455
Oct	23.004	285	1.357561	7.5	36.65414	5.827963
Nov	22.32	315	1.31855	8.07	38.30653	6.083082
Dec	19.332	345	1.385944	7.81	38.96721	5.750035
Annual average	21.168		1.405913	6.2675	31.72162	5.0977

$T_w = 5.0 + 0.75Ta = 5.0 + 0.75 \times 23.95 = 22.96°C$.

The velocity of wind in the sea is always higher than that of the land. The wind on sea (V_{ws}) in

terms of land wind speed (V_{wl}) is given by (Lupu et al., 2018):

$$V_{ws} = 1.62 + 1.17 * V_{wl} \quad (4)$$

Where: V_{ws}, Sea wind speed, V_{wl} Land wind speed. Thus,

$V_{ws} = 1.62 + 1.17 * 2.06 = 4.03$ m/s

The cell temperature on land is given by (Triyana et al., 2004):

$$Tc = 0.943 * Ta + 0.0195 * G - 1.528 * V_{wland} + 0.3529 \quad (5)$$

Where; Tc, Land cell temperature, G, STC irradiation (1000 W/m²). Then,

$Tc = 0.943 * 23.95 + 0.0195 * 1000 - 1.528 * 2.06 + 0.3529 = 39.28°C$

The cell temperature on the sea is given by (Lupu et al., 2018)

$$T_{cw} = 0.943 * T_w + 0.0195 * G - 1.528 * V_{wsea} + 0.3529 \quad (6)$$

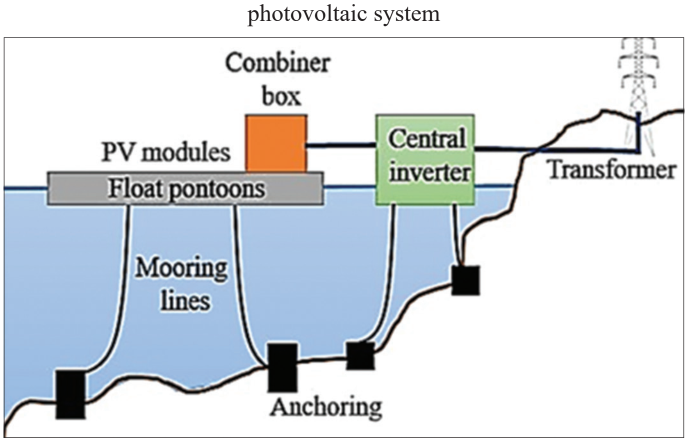
Where: T_{cw}, Sea cell temperature. Then,

$Tcw = 0.943 * 22.96 + 0.0195 * 1000 - 1.528 * 4.03 + 0.3529 = 35.34°C$

2.4.1. Tilt angle

The situation at which the possible amount of direct, diffused and reflected solar irradiation distributed on the surface of the PV panel to extract maximum power all through the year is based on the tilt angle (β) i.e. the angle among the directions of sun to the vector normal to the module. The tilt angle for this proposed PV system is considered as 18^0, which is obtained from the optimized value of the simulation study carried out in PVGIS software.

Figure 4: Key design elements for power generation through floating photovoltaic system



2.4.2. Yield factor (YF)

The yield factor is the ratio of the annual or monthly net AC energy output of the systems to the peak power of the installed PV module at standard test conditions (STC), and it is analyzed by equation (7) (Imam et al., 2019). This factor helps the PV module productivity in some weather conditions.

$$YF = \frac{E_{PV}(kWh/year)}{PV_{rated}(kW)} \quad (7)$$

Where E_{PV} is the annual energy output in kWh and PV_{rated} is the rated PV power in kW.

2.4.3. Capacity factor (CF)

The capacity factor is the ratio of the actual energy yield of solar PV system (E_{kWh}) to the maximum possible output from the PV plant if it is performing at full rated power for 24 h/day for 365 days, and given by the following equation (Sharma and Goel, 2017):

$$CF = \frac{E_{PV}(kWh/year)}{PV_{rated} * 24 * 365} = \frac{YF}{8760} \quad (8)$$

The yield and capacity factor attained from the software for the suggested systems are presented in the result section. The overall specifications for the selected PV panel in this research are given in Table 3. Because of the requirement of special frames and supporting systems to make it floating, the capital expenses including installation price is 1.2 times more than that of On-ground systems (Makhija et al., 2021).

2.4.4. Converter

Converter is needed to most grid-tied and off grid PV systems to regulate the flow of power between the AC and DC elements. During AC demand consumption, inverter mode of converter operation is applied, and to transfer DC power it converts AC into DC in rectification mode. The efficiency of converter is considered as 95% (Kohsri et al., 2018). The technical parameters of the selected converter are depicted in Table 4.

Table 3: Cost and technical data of FPV

Constants	Description
Type of PV	Crystalline silicon
Nominal operational temperature	47°C
Temperature coefficient of power	−0.40°C
Efficiency at standard test conditions	16.02%
Derating factor	80%
Capital price	895$/kW
Operation and maintenance price	12$/kW/yr.
Lifespan (years)	25

FPV: Floating photovoltaic

Table 4: Technical and economic data of the converter

Parameter	Specification
Capital cost	600 $/kW
Replacement price	500 $/kW
Operation and maintenance price	5 $/year
Efficiency	95%
lifespan (years)	15

2.5. On-Ground PV System Modeling

The values of technical and cost parameters considered for PV panels and converter is same as those in the FPV system. The difference is, On-ground PV system needs land purchase charges along with its preparation and transportation charges. Required land area and its cost details are as follows:

Required land area for the proposed solar PV farm = 40,000 meter square

Estimated total land cost = $ 2.5/m^2

Total land cost (including purchase and transportation charges) = $172,320.

3. RESULTS AND DISCUSSION

The economic and technical feasibility of a grid-integrated FPV and ground-mounted power system in Gilgel Gibe I reservoir, Ethiopia is simulated and discussed in this section. To simulate the technical viable system that can meet the specified demands for the investigated region, (PVGIS, and HOMER Pro) software are utilized. The model of optimal systems configuration for the specified location is analyzed and presented below.

The power generation of the FPV plant in the location at various percentages of the usable area of the reservoir, i.e., 1%, 5%, 10%, 30%, and 50% of the entire area of 51,000,000 m^2, is shown in Table 5. The analysis was conducted using 10 m^2 for 1 kw FPV installation (Tarigan, 2021).

After determining the electric power production ability of FPV system, the techno-economic comparative analysis of 4MW grid-connected FPV and ground-mounted PV was chosen as a case study to support the grid and cover the auxiliary load of Gilgel gibe I generation station. The detail analysis of this 4MW grid-connected FPV and land-mounted PV system is explained in the following sub section.

3.1. Viability Analysis of FPV and On-Ground PV System

3.1.1. Grid/FPV system

In this system configuration, the solar FPV is tied to the grid for the sake of assessing the technical and economic sustainability of grid-connected FPV system. During the analysis the existing grid tariff (0.04$/kWh) is taken into account. Table 6 displays the outputs attained for the optimal grid/FPV system. 5000 kW, 4000 kW and 1800 kW size of grid, PV and converter is sequentially designated in the systems design. The NPC and COE of the system are realized as $3,620,000 and 0.043 $/kWh, respectively. For the analysis purpose the auxiliary load in the location which is 1,080,400 kWh/year is considered. The proposed size of grid-tied FPV system is initially supplies the auxiliary loads and the excess generated power is injected to the grid.

The summary of annual electricity production and utilization of grid/FPV system in the place is revealed in Table 7. 6,988,831 kWh/year energy were produced by the solar FPV, and the produced energy were injected to the grid to supply the demand.

From this system analysis, we realized that the grid-connected FPV technology is technically and economically competitive and is found in the matured stage in the location and in the country when we compared to grid alone tariff of the country.

3.1.2. Grid-tied on-ground PV system

The same size of the aforementioned component and load that was considered in the FPV is considered in the land-mounted PV system also. The project lifetime was assumed to be 25 years. Table 8 portrays the outputs obtained for the optimal grid/PV system. The COE of the system are realized as 0.051 $/kWh, which is slightly higher than the FPV system COE. As it is observed in the analysis, the high solar PV cell temperature of land-based installation decreases the total energy production from the PV cell, and the proposed land based PV system resulted 6.9% less electricity generating capacity than FPV system.

3.2. Water Saving from FPV Covering System

In addition to its power production, the other key advantages of the hybrid FPV with grid system configuration are the minimization of water loss due to evaporation, the accessible grid connectivity and high efficiency in comparison with land-based PV system. Furthermore, the amount of water saved by the FPV covering system through preventing evaporation is also directed to generate hydroelectricity.

Table 5: FPV power generation capacity of Gilgel Gibe I at different area of coverage

Reservoir	Total surface area (m^2)	FPV power generation capacity for five cases of area coverage (MW)				
		1%	5%	10%	30%	50%
Gilgel Gibe	51,000,000	51	255	510	1530	2550

FPV: Floating photovoltaic

Table 6: Economic features of optimized grid/FPV system

Grid (kW)	PV (kW)	Converter (kW)	NPC ($)	COE ($/kWh)	RF
5000	4000	1800	3,620,000	0.043	95.5

FPV: Floating photovoltaic

Table 7: Annual electricity generation of grid/FPV systems in the location

Grid purchase (kWh/year)	PV production (kWh/year)	Yield factor	Capacity factor (%)
211,300	6,988, 831	1,742	19.7

FPV: Floating photovoltaic

Table 8: Economic features of optimized grid/land -mounted PV system

Grid (kW)	PV (kW)	Converter (kW)	PV production (kWh/year)	COE ($/kWh)	RF
5000	4000	1800	6,519,120	0.051	94.5

As indicated earlier, significant evaporation rate (1860.6 mm/year) was perceived in the location. This in turn affects the hydroelectric power production considerably. Thus, the FPV system in a reservoir saves water by reducing the evaporation rates.

Using 10 m^2 for 1 kW FPV installation, the proposed 4MW FPV covers a total areas of 40,000 m^2. Then the estimated indirect water-saving effect is analyzed by multiplying 1860.6 mm/year/m^2 with the considered area coverage of FPV in the specified site. This can saves 74,400 m^3 of water annually in addition to the power production.

3.3. Carbon Footprint Analysis

One of the main advantages of power generation from solar PV is the reduction of emission compared to conventional energy sources. Thus, it is essential to estimate the equivalent quantity of carbon emission while deploying FPV system. Different literatures indicated that the maximum possible CO_2 emissions that could be reduced with the solar power plant are given by Eq. (9) (Bayod-Rújula et al., 2011; Kumar et al., 2017):

$$CO_2 \text{ mitigation by PV plant} = \text{Annual energy production} * \text{emission factor} \quad (9)$$

Where, CO_2 mitigation by PV plant is represented in tCO_2/MWh, annual energy generation is the amount energy produced by the PV plant in MWh or kWh, and emission factor is the amount of the emissions that is released per kWh or MWh.

The recommended 4MW FPV system in this study can generate up to 6.98 GWh of annual energy that can be fed to the grid. The greenhouse gas (GHG) emission factor of the baseline electricity mix (fuel type) in Ethiopia is 0.142 tCO_2/MWh. The net annual GHG emission reduction of the proposed system would be 993 tCO_2. Therefore, a large-scale FPV system utilizing a different floating platform will further decrease the carbon emission, making this technology more environmentally acceptable.

4. CONCLUSION

Even though Ethiopia are focusing to increase the total installed and power generation capacity of the PV sector, yet FPV is not implemented across the country in any reservoir. The share of land-mounted PV system is also not significant in the present country energy market. This study involves a detailed techno-economic comparative analysis of the FPV/ground-mounted PV system in the Ethiopian hydro power reservoir named Gilgel gibe I. The reservoir covers an area of 51 square kilometer. By considering 4MWof grid-tied FPV system on the specified reservoir, 6.988GWh energy is generated annually, and with the same area for ground-mounted PV system, 6.5 GWh energy is generated yearly. From the analysis we deduced also, the COE of land-mounted PV system is 15.7% higher than FPV system.

Following the assessment of electrical performance and economic, the carbon footprint and analysis of the PV system are also carried out. The results depicted that the modeled FPV system in the Gilgel gibe reservoir will help in reducing 993 tons of CO_2 emission annually. From all aspects, FPV system was found best viable solution compared to ground-mounted grid-tied PV system.

Due to the convincible potential of water saving, economical/ technical advantages and carbon saving through FPV systems; it is good if this system analysis is conducted to other arid and semi-arid areas of Ethiopia.

5. ACKNOWLEDGMENT

The researcher would like to extend the thanks to Ethiopian National Meteorological Agency and Ethiopian Electric power for their cooperation to provide the meteorological, load and data. The Exist Project in, Jimma Institute of Technology through German Development Bank (KfW) under Ethio-German Cooperation also supported the investigation.

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