Design of floating solar PV system for typical household on Debre Mariam Island

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Design of floating solar PV system for typical household on Debre Mariam Island

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Abstract: Solar PV is possible alternative renewable energy resources, particularly for rural electrification. Its high demand growth may cause for land scarcity, and this will be a serious problem in countries like Ethiopia where agriculture is main source of economy and population large size. In addition to land scarcity, low efficiency of photovoltaic land installation is another problem. Hence, photovoltaic performance is relying on weather conditions, operation parameters like temperature and wind speed. Water bodies can be alternatives to install photovoltaic to the scarcest land and decrease impact of temperature on photovoltaic. To reduce the affirmation problems floating system is an alternative technology. Floating photovoltaic plants are an emerging form of PV system that floats on water bodies. Land installation of photovoltaic increases risk of PV module efficiency drops land scarcity. Therefore, the objective of this study was to design floating system for Debre Mariam Island to increases efficiency of solar cell and save land. To tackle mentioned problems floating photovoltaic installation is method used. Floating photovoltaic provides efficient energy supply and new strategy to save land. Thus, floating photovoltaic system is modeled so as to satisfy daily energy load demand of Debre Mariam Island community electric loads. The temperature and wind speed are major contributory factors for panel efficiency drops and low power output in land

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PUBLIC INTEREST STATEMENT

Renewable energy sources are the alternative source of electrical power generation. It is easy to use, less pollutant, and abundant in nature. Among these, solar photovoltaic is possible alternative renewable energy resources, particularly for rural electrification. In recent years demand of solar energy is increased in worldwide. Abundant and endless energy resource, easy installation, less cost, energy demand rise, and policies intensives are positive attraction of solar energy. However, growth of solar energy demand causes for land scarcity, hence solar photovoltaic needs a space for installation. Solar photovoltaic installation growth is a serious problem in countries like Ethiopia where agriculture is main source economy and large population size. Thus, solar photovoltaic floating on water surface has a positive attraction in recent years. Therefore, the objective of this study was to design floating system for typical household electrification on Debre Mariam Island to increases efficiency of solar photovoltaic and save land.
Photovoltaic installations. 294.8 kW is the generated power output of solar floating system whereas 289.9 kW is the generated power output of land photovoltaic installation. Thus, floating PV installation increases the generated power output by 4.9 kW.

**Subjects:** Renewable Energy; Energy & Fuels; Power Engineering

**Keywords:** Efficiency; floating PV; cell temperature; wind speed

### 1. Introduction

Renewable energy sources are the alternative source of electrical power generation. It is easy to use, less pollutant, and abundant in nature. Thus, renewable energies are more suitable than conventional sources of energy. Nonconventional form energies are not only renewable but also maintain ecology and environment and do not contribute to global warming. Solar PV is possible alternative renewable energy resources, particularly for rural electrification. In recent years, the demand of solar energy is increased in worldwide. Abundant and endless energy resource, easy installation, less cost, energy demand rise, and policies intensives are positive attraction of solar energy. This significant growth of solar energy demand may cause for land scarcity (Ajitha et al., 2019; Kumar et al., 2018). Solar PV installation growth is a serious problem in countries like Ethiopia where agriculture is main source economy and large population size. Thus, solar PV floating on water surface has a positive attraction in recent years. In this study, the main focus is on solar energy efficiency and how water surface contributes to improved energy efficiencies in floating solar PV.

Solar PV performance is relying on weather conditions, operation parameters like temperature and wind speed (Kumar et al., 2020; Kumar, 2019). Efficiency of solar cells reduces with high temperature, since the solar energy captured by cell is not converted to electrical energy. Ethiopia has lots of lakes and human-made irrigational dams in different parts of the country. These, water bodies can be alternatives to install solar PV to the scarcest land and decrease impact of temperature on solar PV. Therefore, using water bodies for solar power generation increases efficiency of solar cell and save the land. Electric power generation with floating solar PV system is in excess of land installation. This is due, the cooling effect of the water surface. In addition to generation efficiency, the system provides environmental benefits such as reducing water evaporation, improve quality of water and reduces the growth of algae by shading the water from sun (Ramadhan & Naseeb, 2011). Floating solar PV plants are an emerging form of PV system that floats on the surface of water bodies. Land solar PV installation increases the risk of PV module efficiency drops.

In recent years low efficiency of land-based solar PV system leads to floating PV installation on water body (Sahu et al., 2016; Triyana et al., 2004; Zhou et al., 2009). Floating solar PV power plants uses the surface of water bodies such as irrigation, canals or remediation, water reservoirs, lakes and tailing ponds, ocean, water treatment plants (Ferrer-Gisbert et al., 2013; Trapani & Redón Santafe, 2015; Yamashita, 2019). Floating solar PV system on the surface of water bodies provides the energy that Island community need for their domestic uses.

Electrifying Island community is difficult to electrify with national grid. Due to scarce of government investment, extending the grid lacks proper planning and difficult geography keep the national electric grid from extending to Island community. However, it is not a choice to have reliable, secure and affordable energy service to the community to ensure economic and social welfare. All of the population in Debre Mariam Island are living without access to electricity, which entirely dependent on agriculture at a subsistence level. This shows that the community living in the island is facing significant challenges like lack of clean water, inadequate sanitation and no access to ICT. Thus, communities in this Island use kerosene lighting, charcoal and cow dungs for their domestic uses. This causes for community health problems and unpleasant environmental
impact. Therefore, the objective of this study was to design floating system for typical household electrification on Debre Mariam Island to increases efficiency of solar cell and save the land.

2. Methods

2.1. Case study area

A floating system study was conducted on Debre Mariam Island. Debre Mariam is one of the Islands which are found in Lake Tana near by the capital city of Amhara regional state Bahir Dar on the outlet of the Blue Nile. Lake Tana is largest lake in Ethiopia, located at 11.5742°N latitude and 37.3614°E longitude (Dejen et al., 2002; Tamrat & Bekele, 2014). In the Island there is an ancient Monastery called Debre Mariam Monastery which is Saint Mary church and one of the tourist’s destinations in Ethiopia. It was established in the 14th century and rebuilt again by Emperor Tewodros in the 19th century (Geremew & Triest, 2019; Mundt, 2012). The main source of income for the peoples live in the island is fishing and there is no enough land to install the PV panel. To preserve this precious land and electrify the community, the design is proposed on the surface of Lake Tana (Figure 1) (Earth, 2018).

2.2. Resource assessment

The term resource applies to anything coming from outside the system that is used by the system to generate electric power. Renewable resources depend extremely on geographical location. The solar resource depends strongly on latitude and climate. Solar resource data indicate the amount of global solar radiation that strikes Earth’s surface in a typical year. The data can be hourly average global solar radiation on the horizontal surface (kWh/m²). Secondary data collection was used and the data were collected from NASA.

The average solar radiation (Table 1), maximum ambient air temperature (Table 2) and average wind speed (Table 3) for the last 20 years for the Bahir Dar city is taken from NASA surface meteorology and solar energy data base (Islam et al., 2010; Mohammad et al., 2020; Sparks, 2018). Temperature and wind speed are corrected to fit surface temperature of the water.

2.3. Energy demand assessment

The first step in designing power system is determining the total power consumption of the study area. The size and cost of floating solar PV system components are influenced by the size of power consumption. The steps to estimate electricity required in the study area is to list all electrical appliances, estimate its rating power, multiply by number of operating hours and add up the watt hours for all appliances (Table 4).

Figure 1. Location map of Debre Mariam Island.
Table 1. Monthly average daily insolation incident on horizontal surface (kWh/m²/day) of Bahir Dar

| Lat 11.5742° N Lon 37.3614° E | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual average |
|--------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----------------|
| 20 years average              | 6.4 | 6.7 | 7.0 | 6.9 | 6.6 | 5.6 | 4.6 | 4.8 | 6.03| 6.6 | 6.4 | 6.1 | 6.14           |

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| Lat | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual average |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----------------|
| 11.5742° N Lon 37.3614° E | 29  | 31  | 32  | 32  | 32  | 29  | 26  | 25  | 26  | 27  | 28  | 28  | 28.75          |
| 20 years average           |     |     |     |     |     |     |     |     |     |     |     |     |                |
Table 3. Monthly average wind speed (m/s) at Bahir Dar

| Lat 11.5742° N Lon 37.3614° E | Jan  | Feb | Mar  | Apr  | May  | Jun  | Jul  | Aug  | Sep  | Oct  | Nov  | Dec  | Annual average |
|--------------------------------|------|-----|------|------|------|------|------|------|------|------|------|------|----------------|
| 20 years average              | 6.64 | 7.1 | 7.14 | 7.34 | 7.36 | 6.12 | 6.12 | 5.74 | 5.98 | 6.5  | 6.7  | 6.7  | 6.72           |
There are three hundred household on Debre Mariam Island. These island households are assumed to divide in to two classes, as high and low house based on their economic income. Depending on the population and economic growth 300 households of the island will be increased to a certain number. However, the energy demand of the island is estimated based on current numbers of households. All communities on the island may not have the same economic status, some of households are relatively rich and others are comparatively poor. Out of the 300 households of the island 50 of them are categorized under high-income households (Table 5) and the rest are assumed as low houses. Thus, the load demand is estimated based on the level of income and way of living standard. There are also public loads like Mariam Monastery/church (Table 6), Water pump (Table 7), health post (Table 8), and school (Table 9).

| Appliance     | Quantity | Power rating (W) | Hours/day | Peak load (W) | Daily use of electricity (Wh per day) |
|---------------|----------|------------------|-----------|---------------|--------------------------------------|
| Lighting      | 3        | 11               | 5         | 33            | 165                                  |
| Tape/radio    | 1        | 14               | 2         | 14            | 28                                   |
| TV set        | 1        | 60               | 4         | 60            | 240                                  |
| Mobile charger| 1        | 4                | 4         | 4             | 16                                   |
| Stove         | 1        | 1000             | 3         | 1000          | 3000                                 |
| **Sub total** |          |                  |           | **1,111**     | **3,449**                            |
| **Total (250 household)** |          |                  |           | **277,750**   | **862,250**                          |

| Appliance     | Quantity | Power rating (W) | Hours/day | Peak load (W) | Daily use of electricity (Wh per day) |
|---------------|----------|------------------|-----------|---------------|--------------------------------------|
| Lighting      | 3        | 11               | 5         | 33            | 165                                  |
| Tape/radio    | 1        | 14               | 2         | 14            | 28                                   |
| TV set        | 1        | 60               | 4         | 60            | 240                                  |
| Mobile charger| 1        | 4                | 4         | 4             | 16                                   |
| Fan           | 1        | 3                | 4         | 3             | 12                                   |
| Stove         | 1        | 2000             | 4         | 2000          | 8000                                 |
| Refrigerator  | 1        | 132              | 24        | 132           | 3168                                 |
| **Sub total** |          |                  |           | **2,246**     | **11,633**                           |
| **Total (50 household)** |          |                  |           | **112,300**   | **581,650**                          |

There are three hundred household on Debre Mariam Island. These island households are assumed to divide in to two classes, as high and low house based on their economic income. Depending on the population and economic growth 300 households of the island will be increased to a certain number. However, the energy demand of the island is estimated based on current numbers of households. All communities on the island may not have the same economic status, some of households are relatively rich and others are comparatively poor. Out of the 300 households of the island 50 of them are categorized under high-income households (Table 5) and the rest are assumed as low houses. Thus, the load demand is estimated based on the level of income and way of living standard. There are also public loads like Mariam Monastery/church (Table 6), Water pump (Table 7), health post (Table 8), and school (Table 9).

| Appliance     | Quantity | Power rating (W) | Hours/day | Peak load (W) | Daily use of electricity (Wh per day) |
|---------------|----------|------------------|-----------|---------------|--------------------------------------|
| Lighting      | 6        | 11               | 6         | 66            | 396                                  |
| Microphone    | 1        | 55               | 10        | 55            | 550                                  |
| **Total**     |          |                  |           | **121**       | **946**                              |
2.4. Floating system modeling

2.4.1. Mathematical modeling

For floating PV system, the main factors that determine cell temperature are wind speed and temperature at sea (Umoette et al., 2016; Suh et al., 2020).

\[ T_w = 5 + 0.75T_{amb} \]

(1)

Where:

\[ T_w \] – Sea temperature (°C)

\[ T_{amb} \] – Air temperature (°C)

Due to the thermal cooling effect of the water, response of water temperature is reduced, which is depicted in coefficients in a given formula. As shown in the formula above, the water temperature will be increased when the air temperature is below 20°C (Mohammad et al., 2020; Mccafferty et al., 2013).

Table 7. Daily load demand of Water pump for drinking

| Appliance    | Quantity | Power rating (W) | Hours/day | Peak load (W) | Daily use of electricity (Wh per day) |
|--------------|----------|------------------|-----------|---------------|--------------------------------------|
| Water pump   | 3        | 960              | 6         | 2880          | 17,280                               |
| Total        |          |                  |           | 2,880         | 17,280                               |

Table 8. Daily load demand of health post

| Appliance      | Quantity | Power rating (W) | Hours/day | Peak load (W) | Daily use of electricity (Wh per day) |
|----------------|----------|------------------|-----------|---------------|--------------------------------------|
| Lighting       | 6        | 11               | 6         | 66            | 396                                  |
| Refrigerator   | 1        | 200              | 12        | 200           | 2400                                 |
| Total          |          |                  |           | 266           | 2,796                                |

Table 9. Daily load demand of school

| Appliance                  | Quantity | Power rating (W) | Hours/day | Peak load (W) | Daily use of electricity (Wh per day) |
|----------------------------|----------|------------------|-----------|---------------|--------------------------------------|
| Lighting for office and classroom | 15      | 11               | 4         | 165           | 660                                  |
| Mobile charger            | 4        | 4                | 2         | 16            | 32                                   |
| Tape/radio                | 6        | 14               | 4         | 84            | 336                                  |
| Desktop Computer          | 2        | 55               | 8         | 110           | 880                                  |
| Photocopy machine         | 1        | 185              | 5         | 185           | 925                                  |
| Printer                   | 1        | 77               | 3         | 77            | 231                                  |
| Total                     |          |                  |           | 637           | 3,064                                |
The maximum annual temperature (Table 3) is 28.75°C

\[ T_w = 5 + 0.75 \times 28.75 = 26.56°C \]

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 \( (V_{wl}) \) (Lupu et al., 2018) is given by

\[ V_{ws} = 1.62 + 1.17 \times V_{wl} \] (2)

Where:

- \( V_{ws} \) – Sea wind speed
- \( V_{wl} \) – Land wind speed

\[ V_{ws} = 1.62 + 1.17 \times 6.75 = 9.52 m/s \]

Cell temperature on land is given by (Triyana et al., 2004)

\[ T_c = 0.943 \times T_a + 0.0195 \times G - 1.528 \times V_{wl} + 0.3529 \] (3)

Where:

- \( T_c \) – Land cell temperature
- \( G \) – STC irradiation (1000 W/m²)

\[ T_c = 0.943 \times 28.75 + 0.0195 \times 1000 - 1.528 \times 6.72 + 0.3529 = 36.70°C \]

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

\[ T_{cw} = 0.943 \times T_w + 0.0195 \times G - 1.528 \times V_{ws} + 0.3529 \] (4)

Where:

- \( T_{cw} \) – Sea cell temperature

\[ T_{cw} = 0.943 \times 26.56 + 0.0195 \times 1000 - 1.528 \times 9.52 + 0.3529 = 30.35°C \]

2.4.2 Sizing of floating PV array
2.4.2.1 Sizing of PV array. The outpour power for PV array can be determined by Equation 5 (Bandyopadhyay et al., 2019; Kumar et al., 2019; Markvart et al., 2006)

\[ P_{pvarray} = \frac{EL}{(\frac{G}{G_{STC}}) \times (f_{DC/AC}) \times f_{temp}} \] (5)

Where:

- \( EL \) – Estimated energy required per day (Wh/day)
- \( f_{DC/AC} \) – DC to AC de-rating factor [%] = 0.778
Where:

\[ \beta = \text{PV cell temperature in current time step (°C)} = -0.38\% \]

For sea PV installation

\[ f_{\text{temp}} = 1 - \beta(T_{\text{cell}} - T_{\text{STC}}) \]  \hspace{1cm} (6)

\[ f_{\text{temp}} = 1 - [-0.38\% (30.35 - 25)] = 1.02 \]

Therefore,

\[ P_{\text{array}} = \frac{1467986}{(1.02) 	imes (0.778) 	imes 1.02} = 301,282.41 \text{W} \]

Mono crystalline silicon module HCP78X9-400 W made in China with 400 Wp per panel capacity (Table 10) is selected for this research (Bouzidi et al., 2020; Dinis et al., 2012; Harrouni et al., 2003).

72 V system voltage is selected and number of modules in series is given by Equation 7 (Jariso et al., 2017; Jogunuri et al., 2017)

\[ N_{\text{ms}} = \frac{V_{\text{system}}}{V_{\text{module}}} \]  \hspace{1cm} (7)

Where:

\[ N_{\text{ms}} = \text{Number of modules in series} \]
\[ V_{\text{system}} = \text{System voltage} \]
\[ V_{\text{module}} = \text{Module voltage} \]

\[ N_{\text{ms}} = \frac{72}{42} = 1.714 \approx 2 \]

| Table 10. Solar photovoltaic specification |
|------------------------------------------|
| **Module type**                          | **HCP78X9-400 W** |
| Maximum power \( P_{\text{max}} \)       | 400W              |
| Open-circuit voltage \( V_{\text{oc}} \)  | 51.6 V            |
| Maximum power voltage \( V_{\text{mp}} \) | 42.0 V            |
| Short-circuit current \( I_{\text{sc}} \) | 9.95A             |
| Maximum power current \( I_{\text{mp}} \) | 9.53A             |
| Module efficiency (%)                    | 18.38%            |
| Power tolerance                          | 0~+5 W            |
| Temperature coefficient of \( I_{\text{sc}} \) | 0.05%/°C          |
| Temperature coefficient of \( V_{\text{oc}} \) | -0.31%/°C         |
| Temperature coefficient of \( P_{\text{max}} \) | -0.38%/°C         |
| Standard test environment                | Irradiance 1000 W/m², cell temperature 25°C, Spectrum AM 1.5 |
Number of modules connected in parallel is given by Equation 8 (Jariso et al., 2017; Jogunuri et al., 2017)

\[ N_{mp} = \frac{P_{array}}{N_{ms} \times P_{module}} \]  \hspace{1cm} (8)

\[ N_{mp} = \frac{301.28241}{2 \times 400} = 376.603 \approx 377 \]

The total number of modules required to generate 1,467,986 Wh/day power is given by Equation 9 (Jariso et al., 2017; Jogunuri et al., 2017)

\[ N_{mt} = N_{ms} + N_{mp} \]  \hspace{1cm} (9)

\[ N_{mt} = 2 \times 377 = 754 \]

2.4.2.2. Battery bank capacity sizing. The battery bank capacity required (Cx) is given by (Jariso et al., 2017; Jogunuri et al., 2017)

\[ C_x = \frac{N_c \times E_L}{DOD_{max} \times V_{system} \times \eta_{out}} \]  \hspace{1cm} (10)

Where:

\[ C_x \] = Required battery capacity in Ah

\[ N_c \] = Number of days of autonomy = 3

\[ E_L \] = Estimated load energy in Wh = 1467986WH

\[ DOD_{max} \] = Maximum depth of discharge = 0.5

\[ \eta_{out} \] = Output efficiency

\[ \eta_{out} = \eta_{bat} \times \eta_{inv} \]  \hspace{1cm} (11)

\[ \eta_{bat} = 0.85, \eta_{inv} = 0.985 \]

\[ \eta_{out} = 0.85 \times 0.985 = 0.84 \]

\[ C_x = \frac{3 \times 1467986}{0.5 \times 72 \times 0.84} = 145,633.53 \]

Sunway 12 V 200Ah, AGM Deep Cycle Solar Batteries Sealed Lead Acid Battery is selected.

Number of batteries requires is given by Equation 12 (Jariso et al., 2017; Jogunuri et al., 2017)
Number of batteries in series is given by Equation 13

\[ N_{bs} = \frac{V_{system}}{V_{battery}} \tag{13} \]

\[ N_{bs} = \frac{72}{12} = 6 \]

Number of batteries in parallel is given by Equation 14

\[ N_{bp} = \frac{N_{breq}}{N_{bs}} \tag{14} \]

\[ N_{bp} = \frac{730}{6} = 121.67 \approx 122 \]

Correction: the total number of batteries required for the system is 122 * 6 = 732

2.4.2.3. Inverter capacity sizing. In sizing the inverter, the actual power drawn from the appliances that run at the same time must be determined first. 50% of the loads are considered as running simultaneously for this study and multiplied by 1.25 as a safety factor (Mondol et al., 2006; Nurunnabi et al., 2019; Ismael et al., 2019).

\[ P_{inv} = P_{RS} \times 1.25 \tag{15} \]

Where:

- \( P_{inv} \) – Inverter power rating
- \( P_{RS} \) – Power of appliances running simultaneously

\[ P_{inv} = 196977 \times 1.25 = 246,221.25W \]

The selected inverter capacity should be greater than 246,221.25W with 72 V. AP-KSS000 (5 kW), 72 V inverter is selected for this research. Thus, the total number of inverters required is determined by dividing the inverter power rating by selected inverter rating and a total of 50 inverter with 5 kW rating is required.

2.4.2.4. Charge controller sizing. The rated current of the regulator is given by

\[ I_{rated} = N_{mp} \times I_{sc} \times f_{safety} \tag{16} \]
Number of modules in parallel: \( N_{mp} \)

Module short circuit current: \( I_{sc} = 9.95 \text{A} \)

Safety factor: \( f_{safety} = 1.25 \)

\( I_{rated} = 377 \times 9.95 \times 1.25 = 4,688.94 \text{A} \)

Mabelstar MPPT Solar Charge Controller 72 V 100A with LED and LCD Display is selected for this research (Chel \textit{et al.}, 2009; Καλδέλλης, 2015; Nikhil & Subhakar, 2013).

Number of charge controller required is given by Equation 17

\[
N_{ccreq} = \frac{I_{rated}}{I_{selected}}
\]  

(17)

\[
N_{ccreq} = \frac{4,688.94}{100} = 46.89 \approx 47
\]

2.4.2.5. Cable sizing. Selecting an appropriate size and type of cable enhances the performance and reliability of the system. Current flows through cable from solar PV to charge controller \( I_{cab} \) is equal to the rating of the charge controller (Jariso \textit{et al.}, 2017; Mosheer & Gan, 2015).

The cross-sectional area of the cable is determined by (Jogunuri \textit{et al.}, 2017; Ali \textit{et al.}, 2018)

\[
A = \frac{\rho L I_{rated}}{V_d} + 2
\]

(18)

Where: \( \rho \) = resistivity of copper conductor selected for the system is taken as \( 1.724 \times 10^{-8} \)

\( L \) = length of the conductor (12 m)

In both AC and DC wiring for standalone photovoltaic system the voltage drop is taken not to exceed 4% (Jogunuri \textit{et al.}, 2017).

\[
A = \frac{1.724 \times 10^{-8} \times 12 \times 100}{72 \times 0.04} + 2 = 14.37 \times 10^{-6}
\]

Therefore, cable with 16mm\(^2\) cross-sectional area is selected.

2.4.3. Modeling of floating system with mat lab

The daily electrical energy consumption of Debre Mariam Island is 1467.986 kWh with average solar radiation of 6.14 kWh/m\(^2\) (Table 1). The sea temperature (\( T_w \)) and sea cell temperature (\( T_{cw} \)) are 26.56\(^o\) C and 30.5\(^o\)C, respectively. The ambient temperature (\( T_a \)) 28.75\(^o\)C and cell temperature on surface of land is 36.70\(^o\)C. With these details, the floating system model was done by MATLAB/Simulink (Figure 2). The result of the Mat-lab mode is discussed in the result section (Figure 3 & Figure 4).

3. Result and discussion

The simulation result includes power output of floating solar PV and land-based solar PV installations. The variation in power output is observed between 289.9 kW and 294.8 kW.
The estimated daily load demand of Debre Mariam Island is 1467986 Wh to satisfy this demand 754 number of panes is required. Two of panels are connected in series whereas 377 panels connected in parallel. Three days are considered as day autonomy to size battery for daily load and 732 batteries are required.

High solar PV cell temperature of land-based installation decrease the power output in this study area. At land temperature of 36.70°C, generated power output is 289.9 kW (Figure 4) which is 4.9 less to floating solar PV installation.
High wind speed on water body reduces floating solar PV cell temperature from 36.70°C to 30.35°C. As the cell temperature is decreased efficiency of the solar PV installation and the generated power output of the PV is increased. The power output at 30.35°C is 294.8 kW (Figure 4) the output power is increased by 4.9 kW.

4. Conclusion
In this study, floating system design for Debre Mariam Island has been presented. The result obtained from floating system shows that floating system power output is more 4.9 kW of land based solar power output. These indicate that Lake Tana and other water bodies in Ethiopia have potential to generate electric power. The cooling effect of water bodies increases the power outputs of floating solar PV. High temperature and wind speed are the main factors that affect the power outputs of land base solar PV installation. For this study PV panel installation with floating structure is proposed to preserve the scarce land for other use. Hence, floating solar PV system has advantage over land base solar installation, these were enhanced energy efficiencies, decrease temperatures, land saving, water conservation.

Abbreviations
GW: Gigowatt
W: Watt
Wh: Watt hour
PV: Photovoltaic

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