A 12 MW Solar Power Plant in Hebbronville, Texas

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Abstract

This study presents the preliminary design and performance assessment of a 12-MW utility-scale photovoltaic (PV) solar power plant proposed for Hebbronville, Texas. The site was selected due to its high solar irradiance, land availability, and proximity to existing electrical infrastructure. Solar resource data obtained primarily from the NREL database, using two years of solar data, is used to evaluate system performance. The study analyzes plant layout, PV module, and inverter selection, and the use of fixed-tilt and tracking panel configurations. Using photovoltaic performance factors (POFs) and standard generation calculations, the plant's expected power generation and annual energy production are estimated to evaluate the anticipated performance of the system.

Methodology

Solar resource data from 2018–2019, including direct normal irradiance (DNI), diffuse horizontal irradiance (DHI), and global horizontal irradiance (GHI), was used to evaluate the performance of the proposed photovoltaic system. These parameters were used to determine the total incident irradiance on a tilted PV surface by accounting for direct, diffuse, and ground-reflected radiation components. The irradiance model also incorporates the effect of panel tilt angle and solar position to more accurately represent real operating conditions.

$$S = DHI \cdot \frac{180-\alpha}{180} + (\text{Albedo}) \cdot GHI \cdot \frac{\alpha}{180} + DNI \cdot \cos(\theta_z - \alpha)$$

The electrical power output of the PV array was then calculated based on the incident irradiance, panel area, and module efficiency. Since PV performance is affected by environmental conditions, a temperature-dependent efficiency model was included to account for reduced performance at higher operating temperatures.

$$P = \eta_{pv} \cdot S \cdot A$$

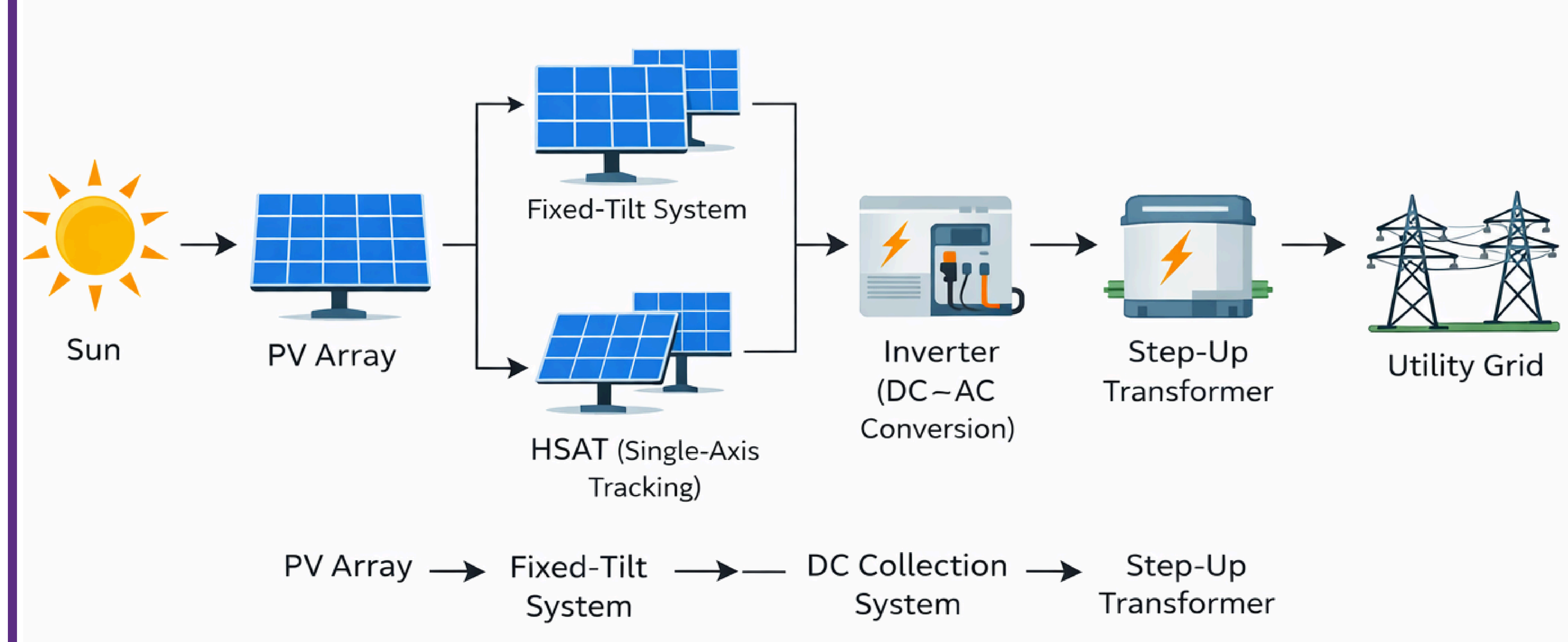
$$\eta_{pv} = \eta_{25} - k(T - 25)$$

To represent real system behavior, inverter efficiency and additional system losses such as wiring, conversion, and standby consumption were incorporated into the model to determine the usable output power delivered to the grid.

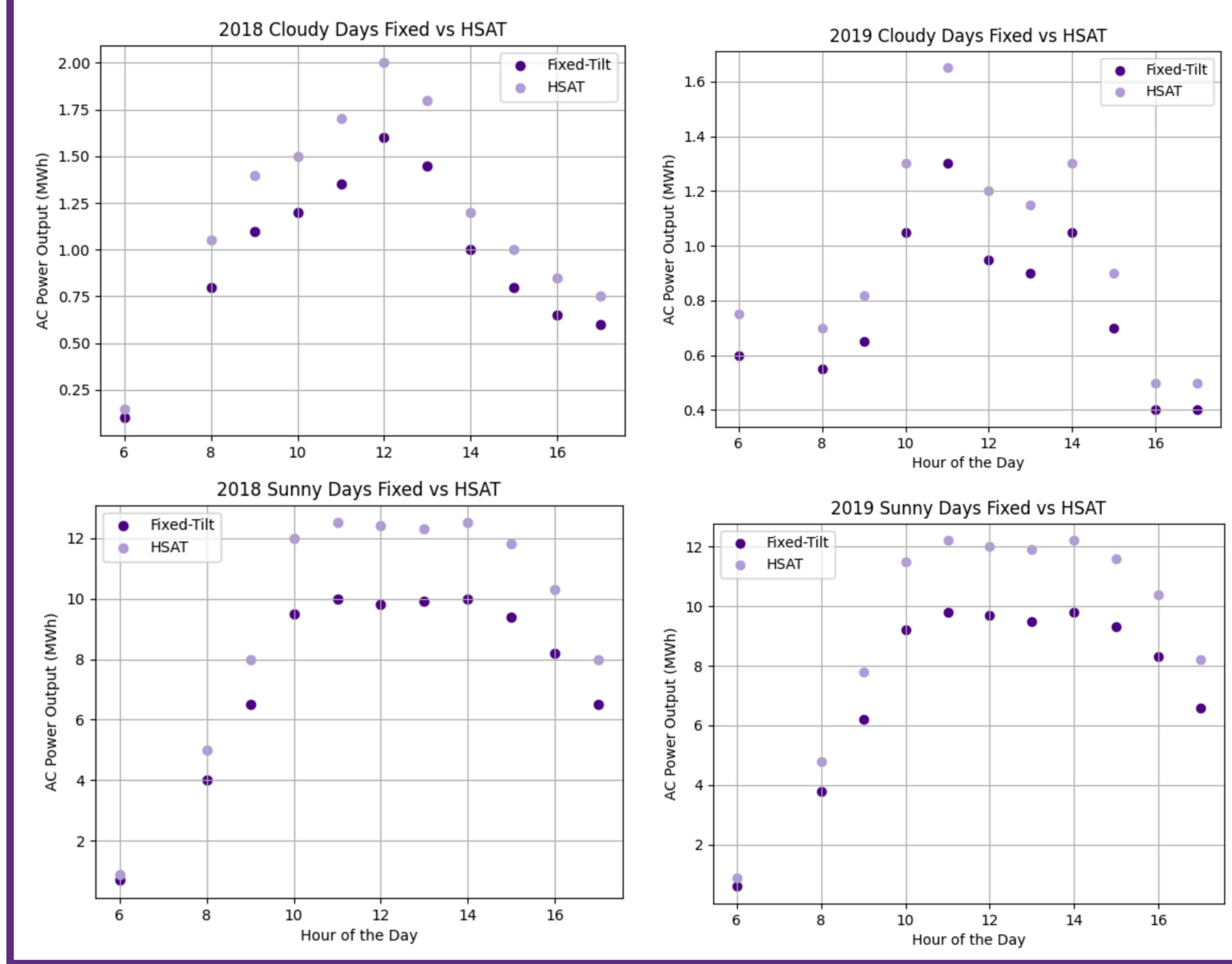
$$P_{out} = P \cdot \eta_{inv} \cdot \eta_{system}$$

Finally, the total energy generation was calculated by summing the power output over time using hourly solar data. System performance was evaluated using the Performance Ratio (PR), which compares actual energy production to the ideal expected output.

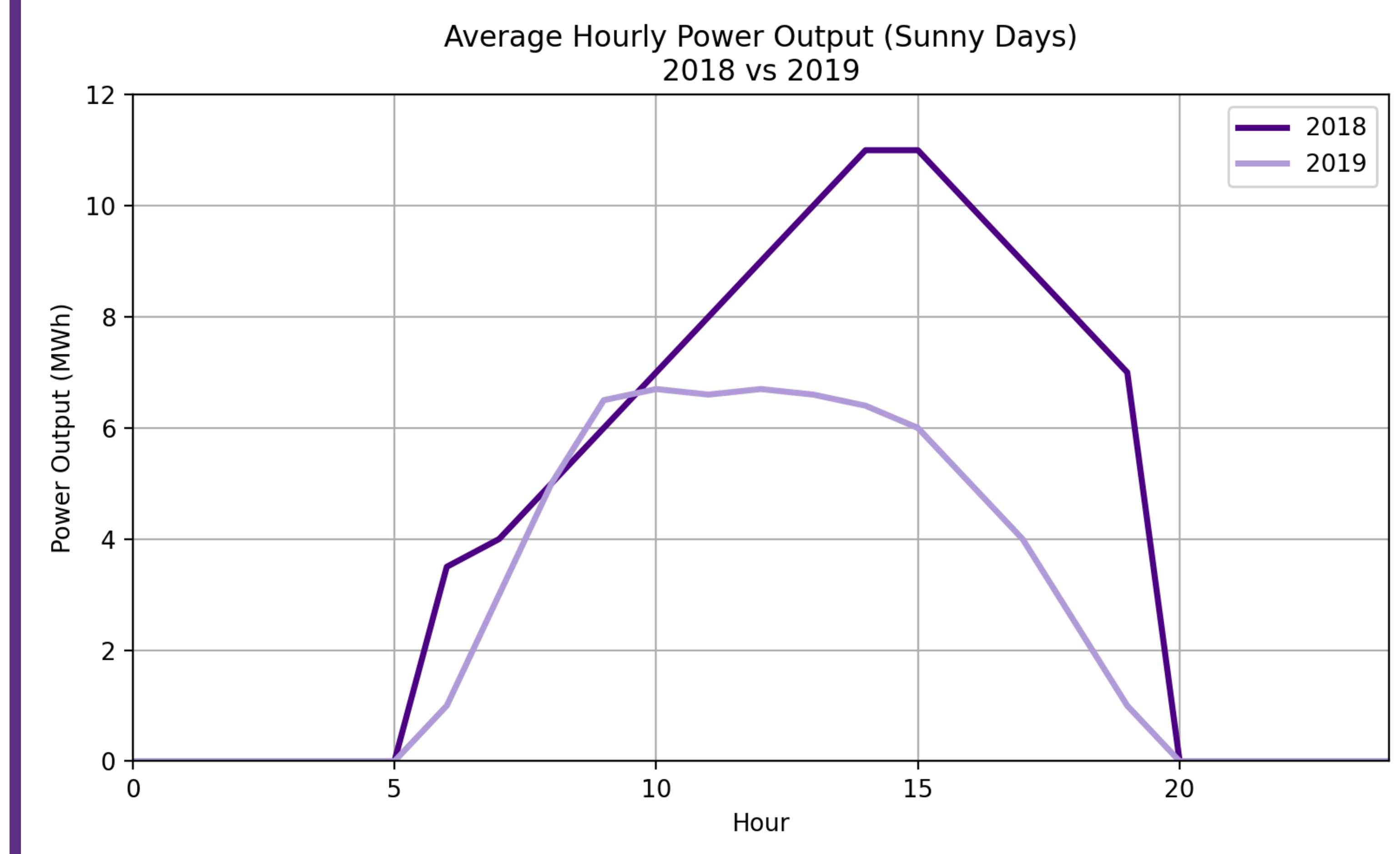
System



Results(1)



Results (2)



Conclusion

The performance assessment of the proposed 12-MW photovoltaic system, based on two years of solar data, demonstrates that energy generation is highly dependent on irradiance conditions. The analysis confirms that system configuration plays a key role in overall performance, with the HSAT design consistently producing higher output than the fixed-tilt system. These findings support the feasibility of the proposed site in Hebbronville, Texas, and highlight the importance of both environmental conditions and system design in optimizing annual energy production.

The proposed PV plant is well-suited for the selected location, with tracking systems offering significant gains in energy yield and overall efficiency.

References

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