UNIVERSITY OF AGDER

PERFORMANCE OF GRID-CONNECTED PV SYSTEM IN SOUTHERN NORWAY

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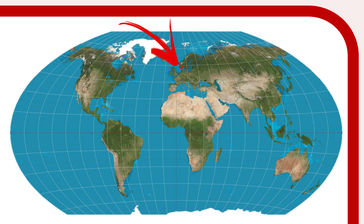
Introduction

Performance results from one of the first grid-connected photovoltaic (PV) systems in Norway are presented. A 45 kW_p system is rack-mounted on a flat roof (tilt angle 20°, azimuth 20° S-W) at the headquarters of Agder Energi in the coastal town of Kristiansand (58°N, 8°E).

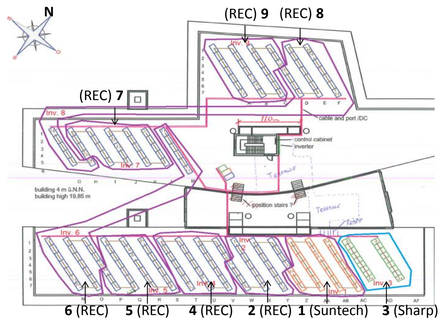
The system consists of eight multi-crystalline Si arrays (5.4 kW_p connected to 4.6 kW_p inverters), and one micromorphous Si array (2.35 kW_p connected to 2.9 kW_p inverter). The system has been in operation since 2011. Global horizontal, diffuse horizontal and global tilted irradiation is recorded to document the solar resource.



Measurement set-up

The PV monitoring system includes:

- Pyranometers (Kipp&Zonen CMP11, CVF3)
- PV temperature sensors (Campbell 110PV)
- Wind sensor and ambient temp. (R.M.Young)
- DC and AC current/voltage transducers
- Datalogging system (Campbell Scientific)
- Database, FTP and Web interface



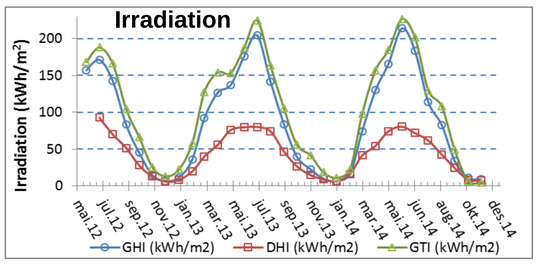
Lay-out of PV arrays and inverters (1-9).

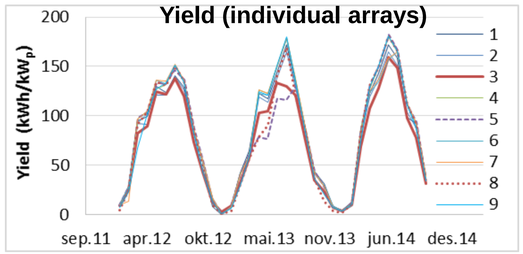
Performance is evaluated according to IEA PVPS Task 13 guidelines and results are reported to the international Task 13 Performance Database [1],[2].

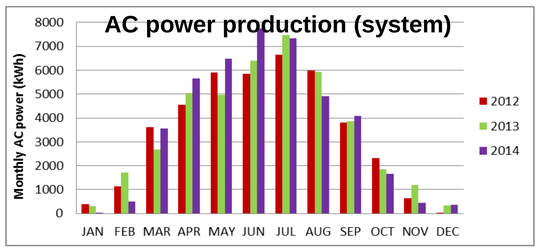
Results

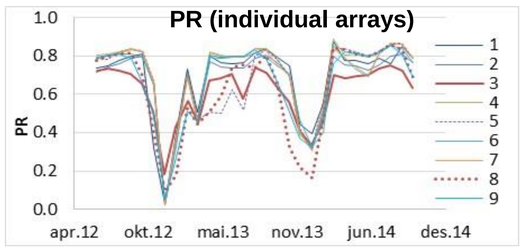
GHI = global horizontal irradiation
DHI = diffuse horizontal irradiation
GTI = global tilted irradiation

Year	Prod. (kWh)	GTI (kWh/m^2)	Eff (%)	PR (P_m)	Specific yield (kWh/kW$_p$)
2012	41 400	-	-	-	916
2013	41 800	1310	9.4	0.70	925
2014	43 000	1200	10.5	0.79	951



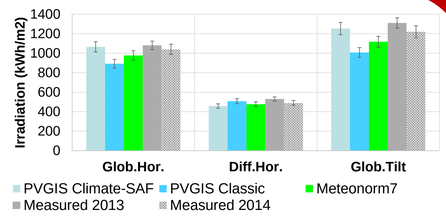




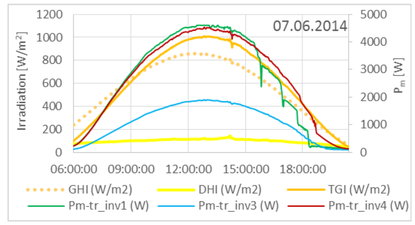


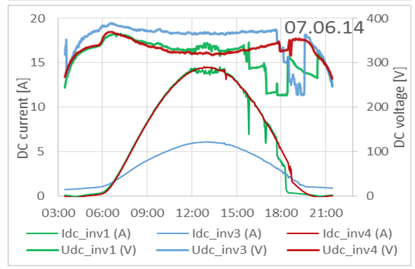
Discussion

Comparing irradiation measurements with common databases [3],[4] (right figure), good agreement is found with the new PVGIS Climate-SAF database.



The yield and PR for each array show some problems with two inverters (5 and 8) resulting in lower performance during summer 2013. The thin film array (3) also shows lower performance, which may be partly related to an oversized inverter for this particular array or degradation with regards to the original power rating.





The performance is affected by partial shading, which is a typical challenge for building implemented systems in urban areas. As an example, the figures to the left show (top) irradiation and AC power and (bottom) DC current and voltage curves for three arrays (inv1, inv3, inv4) during a clear summer day.

For inv1, peak power capping is seen in the middle of the day when the inverter goes into power-derating. Step-wise irregularities related to MPP tracking is seen during the afternoon when shadow from a nearby building feature gradually covers a larger area of the PV array.

Conclusion

The irradiation results so far indicate good conditions for solar utilization in this location, with global horizontal irradiation around 1065 W/(m^2·yr) and a diffuse fraction of around 50 %. The system produces as expected from a design perspective, with annual yield reaching 950 kWh/kW$_p$.

The PR is approaching 0.8 and improvement is seen as the operational experience increase and system downtime is reduced. PR loss can be attributed to part-shading of PV arrays from the surrounding building structures, snow coverage in winter and inverter outages. As similar performance data has not previously been published for Norwegian systems, results form a first basis for further PV development in Norway.

Acknowledgements

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References

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