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Advanced PV Monitoring for Improved Grid Integration

Intelligent System Analysis, Production Forecasts, and Building Load Control Signal Inputs

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Introduction

Integration of solar photovoltaic (PV) system requires:

- Reliable performance
- Accurate electrical production predictions
- Integrated building load control

Methodology

PV monitoring systems have the potential to offer advanced diagnostics, produce power production forecasts, and provide building load control signals. The advanced monitoring approach can be applied to many different types and sizes of PV plants.

PV Reliability

Intelligent analysis methods, such as machine learning [1] and artificial neural networks [2], can provide advanced, real-time evaluations of PV system performance.

PV Predictions

Monitoring systems can access satellite images to forecast electrical production 5 to 30 minutes in advance. In the present work, satellite images were processed by a Support Vector Machine algorithm to predict the solar irradiance and PV power generations 30 minutes in advance.

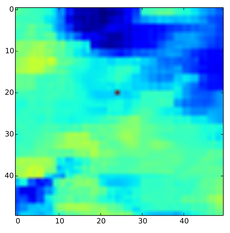


Figure: Cloud cover at 10:30 (269.8w/m^2)

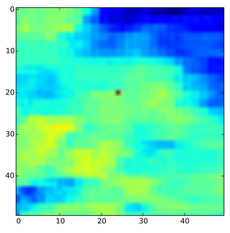
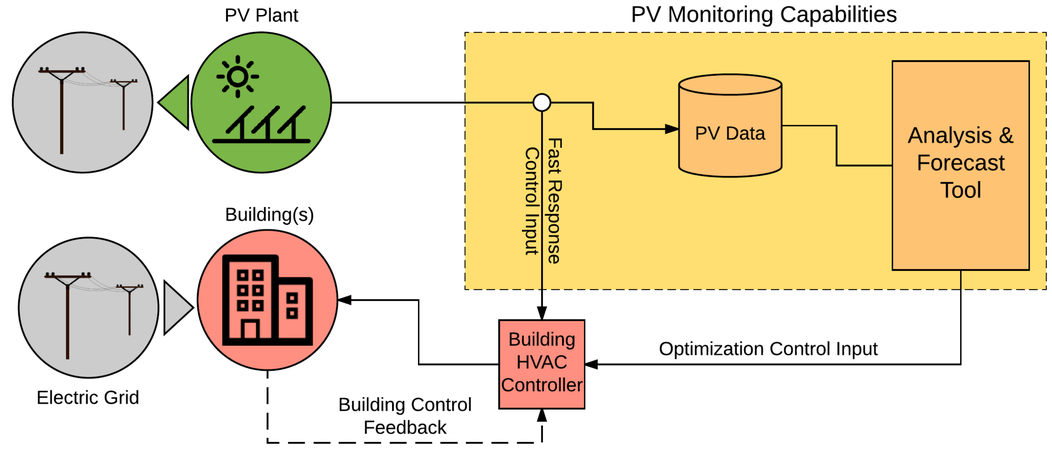


Figure: Cloud cover at 11:00 (193.16w/m^2)

Building Loads

The electrical profile for buildings often does not match with PV production. Therefore, advanced controls can be used to help match the generation and load profiles.

PV Monitoring for Grid Integration



Performance Evaluation

PV System Analysis

PV systems were analyzed succesfully using Laterally Primed Adaptive Resonance Theory (LAPART) neural network, Gaussian Process, and Support Vector Machine algorithms.

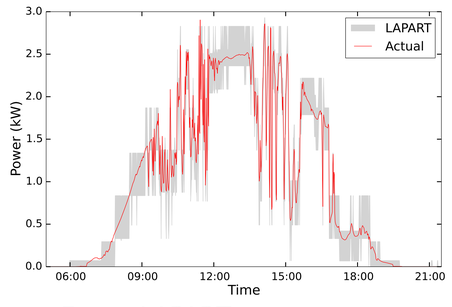


Figure: LAPART system estimates

System Predictions

The Support Vector Machine algorithm was used to forecast solar irradiance and PV plant production based on satellite images and the sun's azimuth angle.

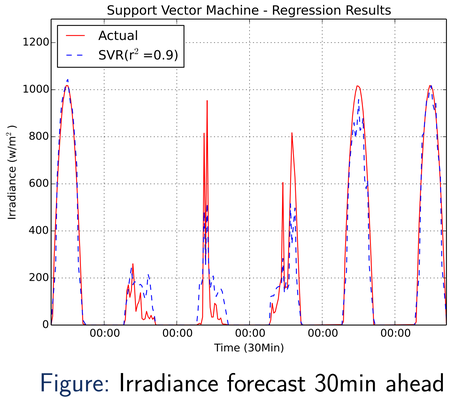


Figure: Irradiance forecast 30min ahead

Building Load Control

Collected PV data was sent in real-time to a building controller. The controller then modulated a HVAC fan motor based on the PV output.

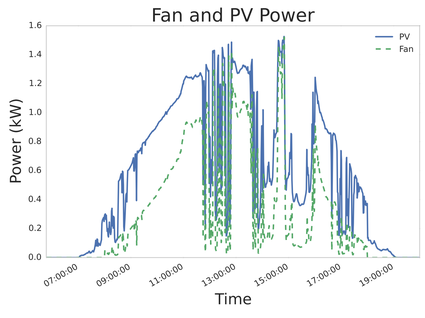


Figure: Fan motor control based on PV output.

The simulation was conducted within a hardware-in-the-loop experiment. An actual motor was modulated and the resulting mass flow rate was measured. The measured flow rate was used by a calibrated zone model to simulate zone temperatures. The zone temperatures were maintained between a comfortable range.

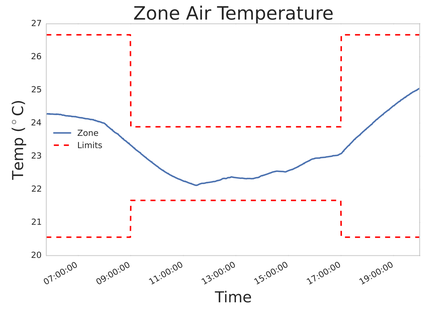


Figure: Zone temperatures maintained

Conclusion

Distributed and utility scale PV plants can be monitored with an advanced system that can analyze performance, predict future production, and provide building control inputs. The present work analyzed the PV plant outputs using learning algorithms. The short term forecasts were also computed by a learning algorithm based on real-time processing satellite images.

References

[1] C. B. Jones, M. Martinez-Ramon, B. King, C. Carmignani, and J. S. Stein, "Wondering what to blame? Turn PV performance assessments into maintenance action items through the deployment of learning algorithms embedded in a Raspberry Pi device," Portland, OR, 2016.

[2] C. B. Jones, J. S. Stein, S. Gonzalez, and B. H. King, "Photovoltaic system fault detection and diagnostics using laterally primed adaptive resonance theory neural network," New Orleans, LA, USA, Jun. 2015.

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