Energy Management Strategies for Distributed Energy Resources

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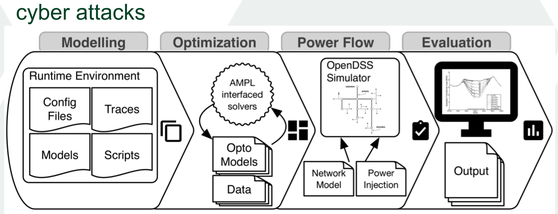
BACKGROUND

The traditional power grid has profoundly changed in recent years due to the growing adoption of Distributed Energy Resources (DERs)—energy storage systems, solar photovoltaic (PV) systems, and wind turbines—introduction of time-of-use pricing and renewable energy subsidies, active participation of customers in emerging electricity markets, and the availability of high-precision measurements from multiple locations in the grid through smart meters and phasor measurement units (PMUs). These changes have led to (a) unprecedented levels of uncertainty and variability over multiple time scales; (b) increased visibility into generation, transmission, distribution, and consumption of electricity.

PROJECT OBJECTIVES

- Investigating various sources of uncertainty in the grid, e.g., renewable generation, household electricity demand, electricity price, electric vehicle mobility
- Developing novel state estimation techniques for wide-area situational awareness
- Designing efficient energy management strategies which incorporate model predictions and real-time measurements from smart meters, inverters, and phasor measurement units
- Evaluating the efficacy of energy management strategies through co-simulation involving hardware and software systems
- Designing mechanisms to protect the entire sensing, networking, and control architecture from cyber attacks

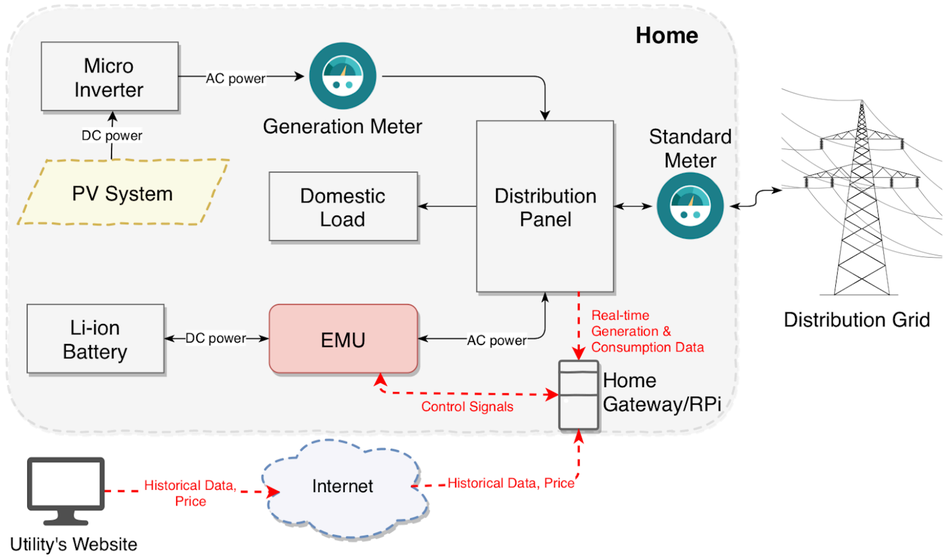


PROJECT OVERVIEW

Our work aims to develop proactive, data-driven energy management strategies that combine *real-time measurements* with *model predictions* to optimally control a large number of DERs with minimum human intervention. These energy management strategies must improve reliability and efficiency of the power system, enabling it to adapt to changes in a timely and efficient manner.

The efficacy of these strategies will be evaluated using (a) a co-simulation framework and (b) an advanced test environment available in the Future Smart Grid Technologies lab. Additionally, a state-of-the-art monitoring and control infrastructure will be developed for the smart grid which enables large-scale integration and seamless operation of geographically dispersed DERs. This infrastructure will support the execution of decentralized, proactive, and data-driven energy management strategies, which will play a pivotal role in enhancing efficiency, reliability, and cybersecurity of the smart grid.

The longer-term goal of this project is to make the power grid smarter, more efficient, and resilient against cyber attacks.



THEME OVERVIEW

T06 Grids and Storage

New technologies enable us to exploit renewable energy resources, but truly harnessing their energy requires the ability to control and adapt to the complex interaction between multiple sources and users. Smart grid technology will enable systems that can adapt to the variation in supply that is common from renewable sources, while new storage technologies will make it possible to retain energy generated at during peak times to be withheld for later use. Developing hybrid grids that can accommodate both AC and DC power, accommodating distributed generation, and effectively interfacing with legacy grid systems will be essential to our energy future.

EXPECTED OUTCOMES

- Prototype energy systems operated by the proposed energy management strategies
- Policies concerning interconnection and operation of DER in distribution grids
- Guidelines for installing new sensors (e.g., distribution-level PMUs) in the distribution network
- Pilot projects showcasing the proposed monitoring, networking, and control architecture, and phasor-based DER control

References

1. Omid Ardakanian, "Advances in Distribution System Monitoring", Encyclopedia of Wireless Networks, September 2018.
2. Ye Yuan, Wei Zhou, Hai-Tao Zhang, Zuowei Ping, Omid Ardakanian, "Sparse Bayesian Harmonic State Estimation", Proc. IEEE Smartgridcomm, October 2018.
3. Omid Ardakanian, S. Keshav, Catherine Rosenberg, “Integration of Renewable Generation and Elastic Loads into Distribution Grids“, Springer Briefs in Electrical and Computer Engineering, 2016

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