

Machine Learning-based Predictive State Estimation

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Project: Grid Optimization with Solar (GO-Solar)

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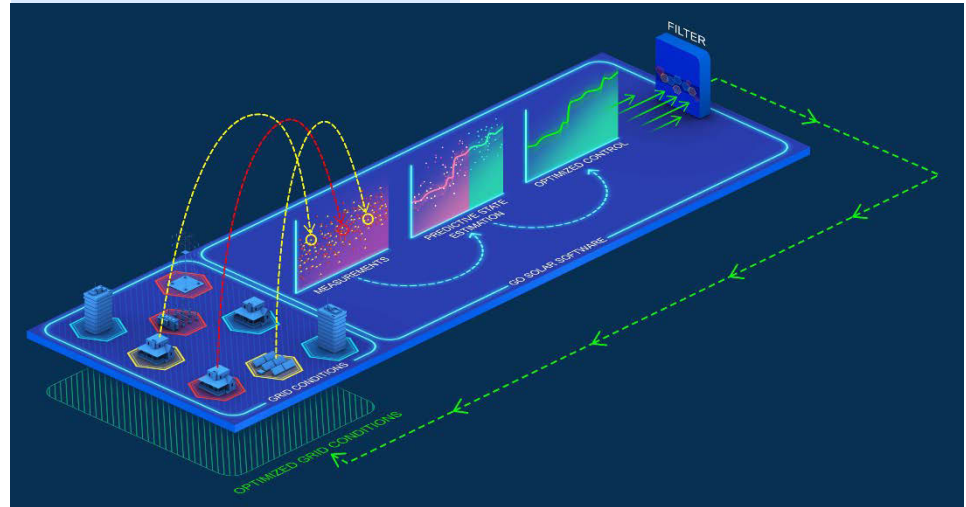
Workshop on Distribution and Transmission System Monitoring
October 30, 2020

GO-Solar Objectives

Challenge #1:
Operations with extreme
penetrations of
distributed PV

Challenge #2:
Communicate and
control with
millions of DERs

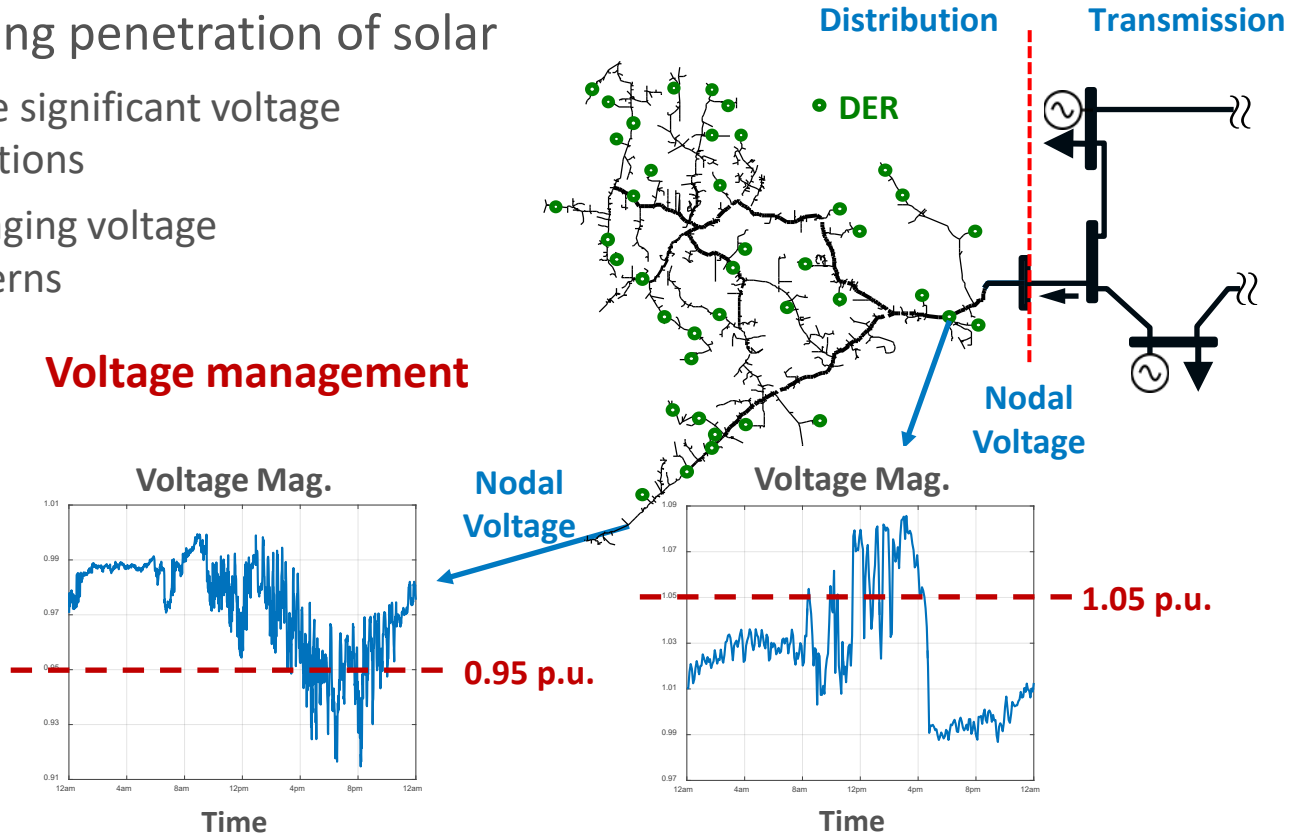
GO-Solar Solution



Manage **extreme penetrations of solar** and other DERs using **only a few measurement points** through matrix completion and multi-kernel learning-based **predictive state estimation (PSE)** and **only a few control nodes** dispatched through dual timescale **online multi-objective optimization (OMOO)** using voltage-load sensitivities to guide fast feedback response

Why PSE?

- Increasing penetration of solar
 - More significant voltage violations
 - Changing voltage patterns

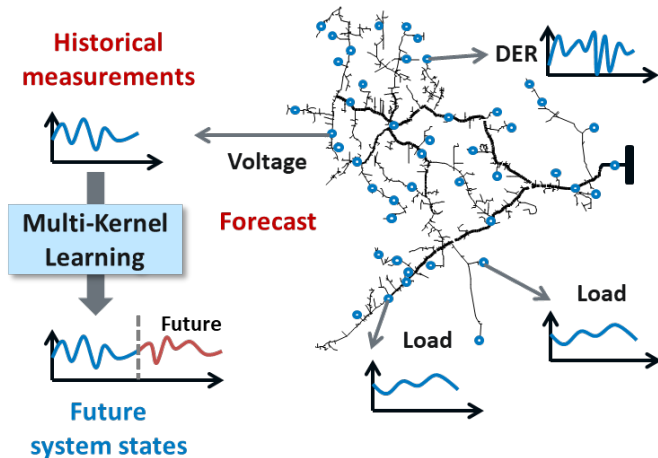


Innovation: Multi-Kernel Learning for State Forecasting

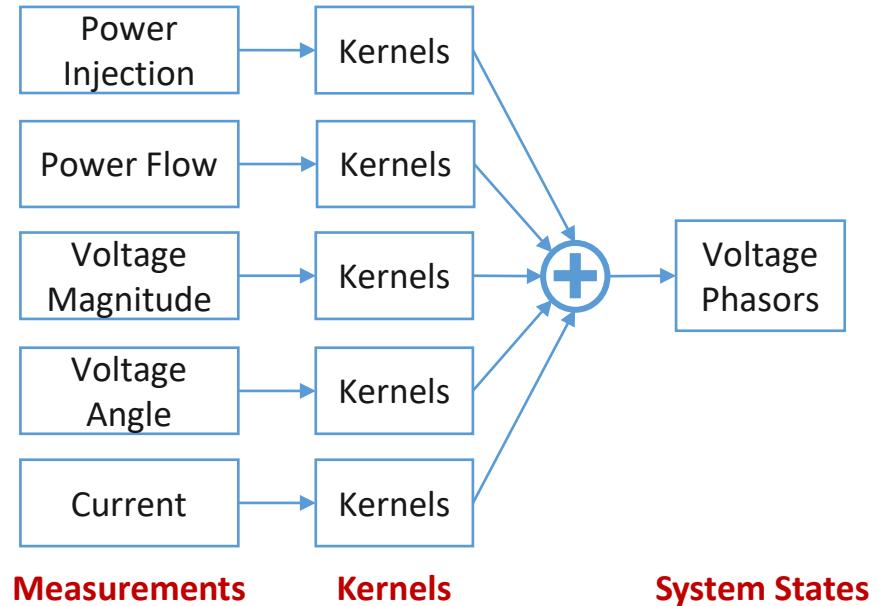
Goal: Learn the spatiotemporal correlation between measurements and system states

Kernel Learning Concept

- Use kernel functions to map the input space to a higher-dimension feature space
- Learn the relationship in the feature space

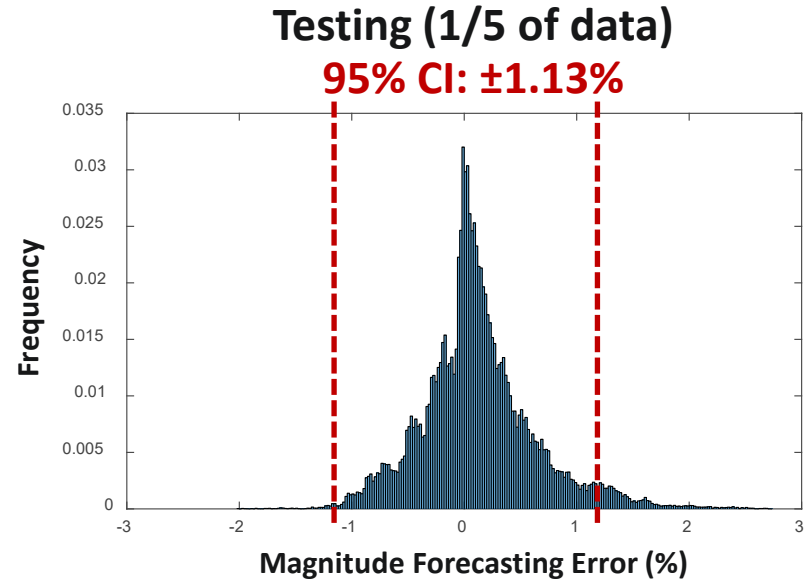
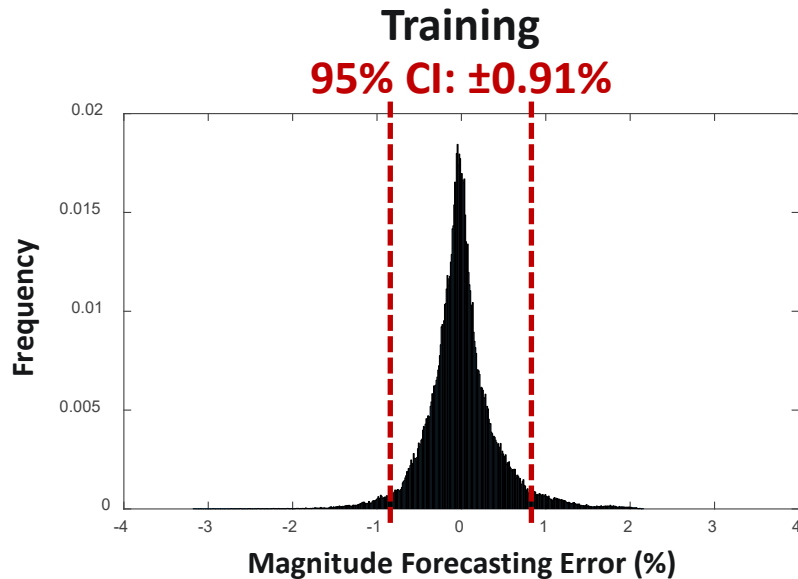


Expanding to Multi-Kernel Learning



Representative Results

- 15-minute-ahead @ 1-minute resolution
- Input: P and Q at load nodes for the past 1 hour
- Training: 1-minute state estimation results for 3 days (sliding window)

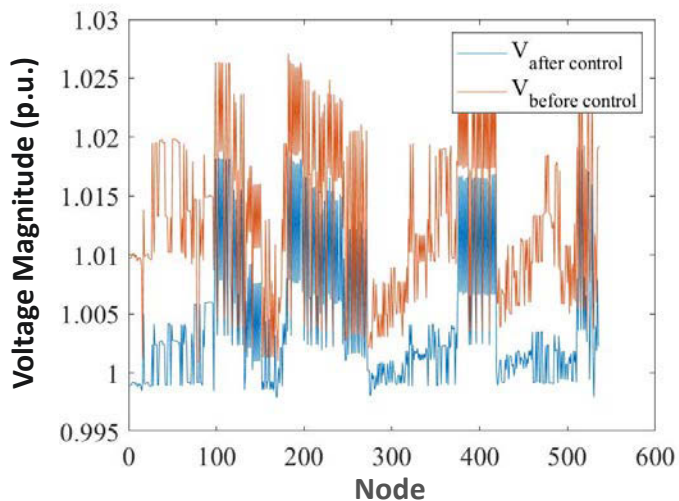


Superior voltage forecasting accuracy with high PV penetrations

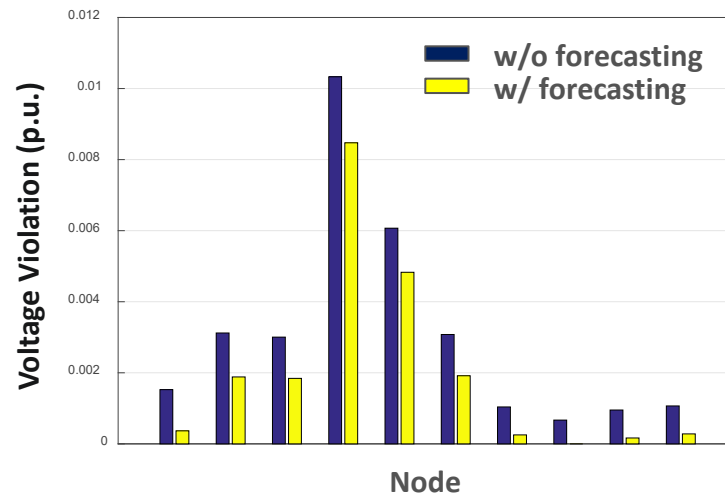
Impacts

- Proactively dispatch controllable resources
- Better coordinate control efforts
- Prioritize the control needs

Voltage Control



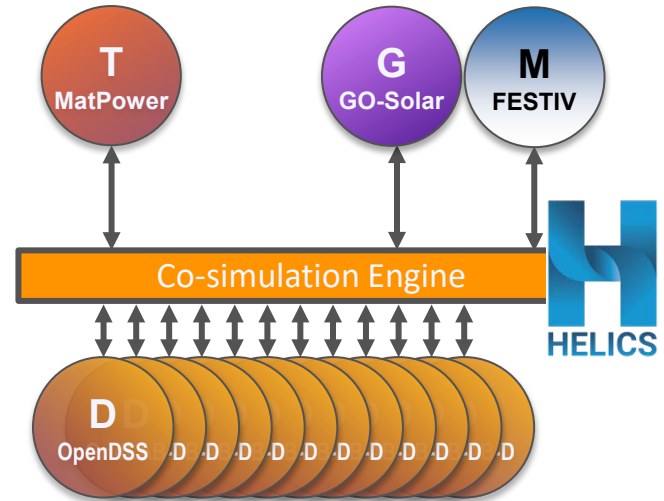
Voltage Violation



Summary and Next Steps

- PSE is **crucial** for predictive situational awareness
- Ongoing work
 - Scalability
 - System changes
- Pathway to future integration into utility operations

Full-scale Simulation-based Validation





Thank you!

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NREL/PR-5D00-78875

This work was authored by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Solar Energy Technologies Office. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.



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