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Analytics For Renewable Energy Management In Microgrids

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Research PIs

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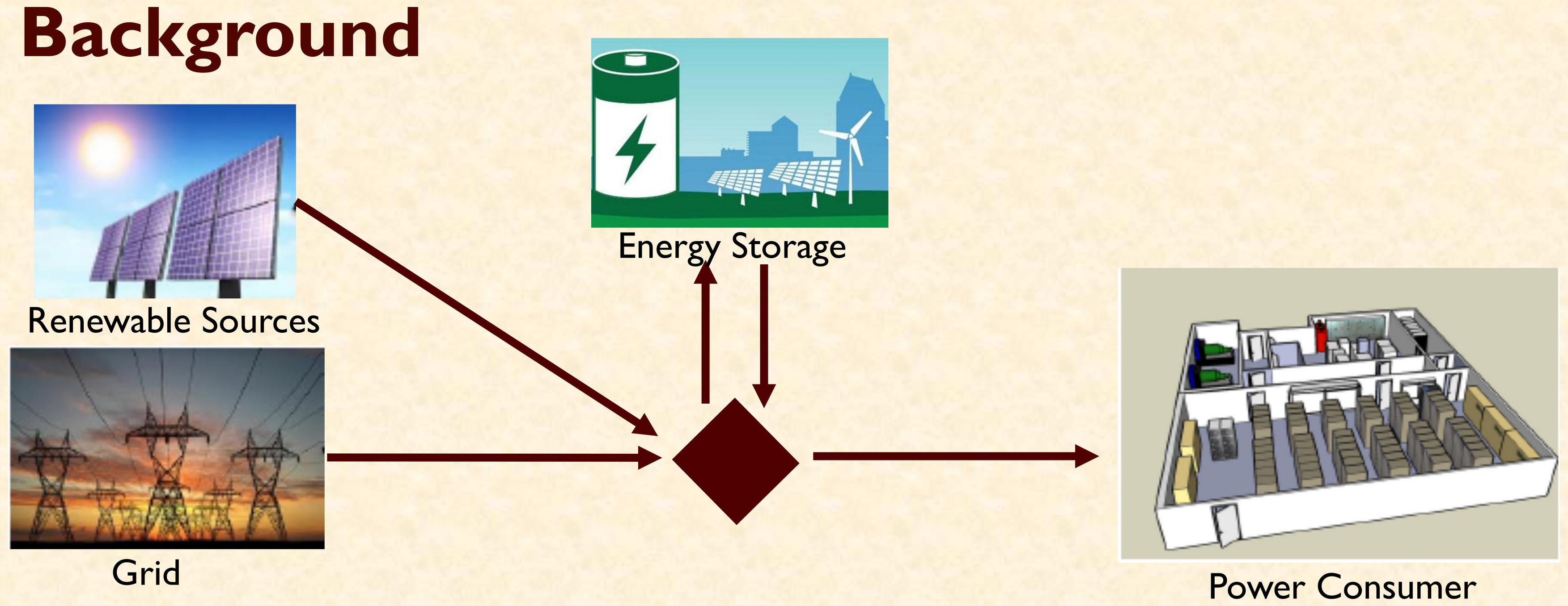
Background

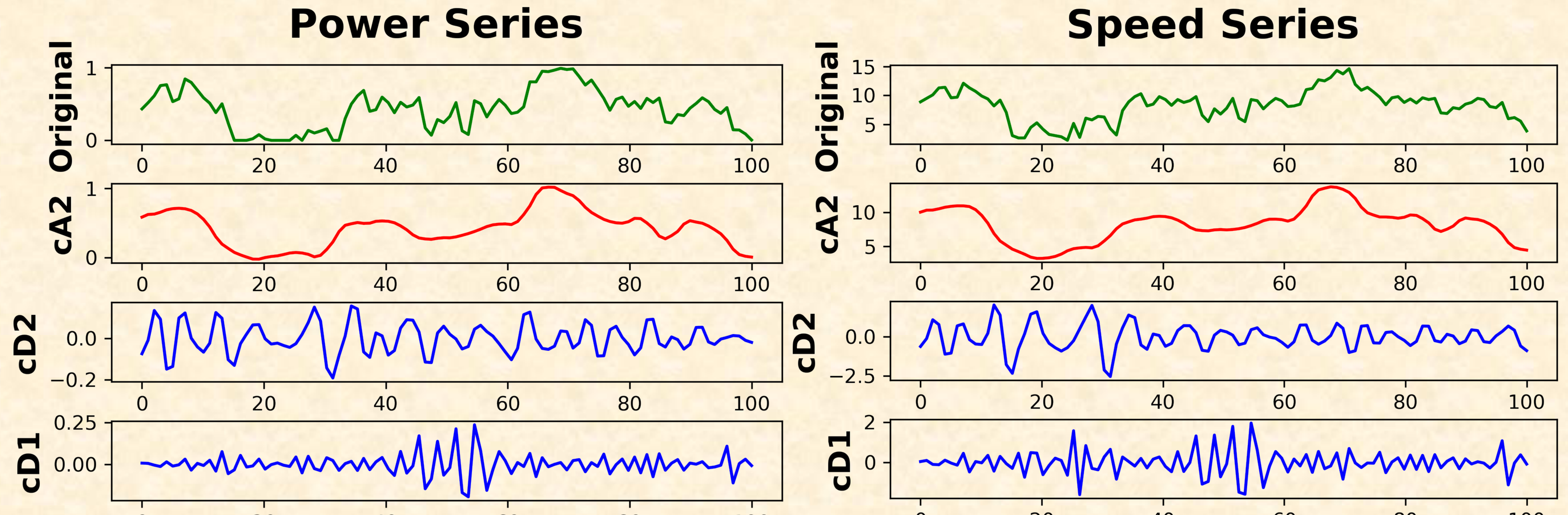


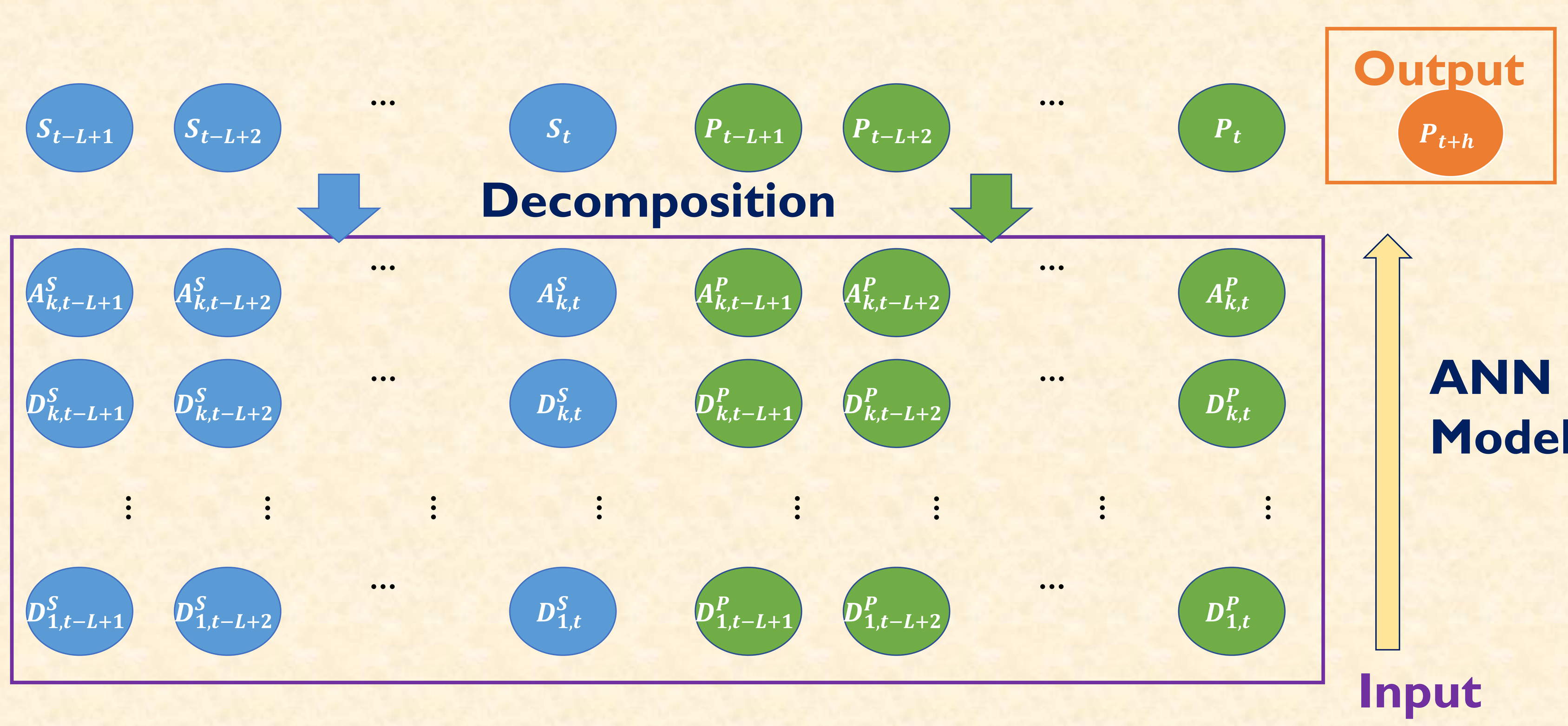
Objective

- Predictive analytics: Forecasts of demand and supply
- Prescriptive analytics:
  - Manage power generation
  - Sell or buy power from energy market
  - Perform demand response

Rolling Horizon Predictive Model

- **ANN Model Based on Wavelet Decomposition**





Rolling Horizon Predictive Model (continued)

- **Data Source**
  - NREL hourly wind speed and power data for a specific site
  - From January 1st 2007 to January 31st 2012
- **Forecasting Results**

Hour-ahead	PER	ANN	HMC	Our Model
1	3.9122	4.6726	4.0756	3.3114
2	9.4628	11.2724	8.8771	7.5258
3	14.9313	16.6970	13.1483	10.5257
4	20.3395	23.2260	16.9544	13.5997
5	25.6180	27.6655	20.3686	15.4361
6	30.6119	34.8077	23.3255	18.0406

MSE Comparison

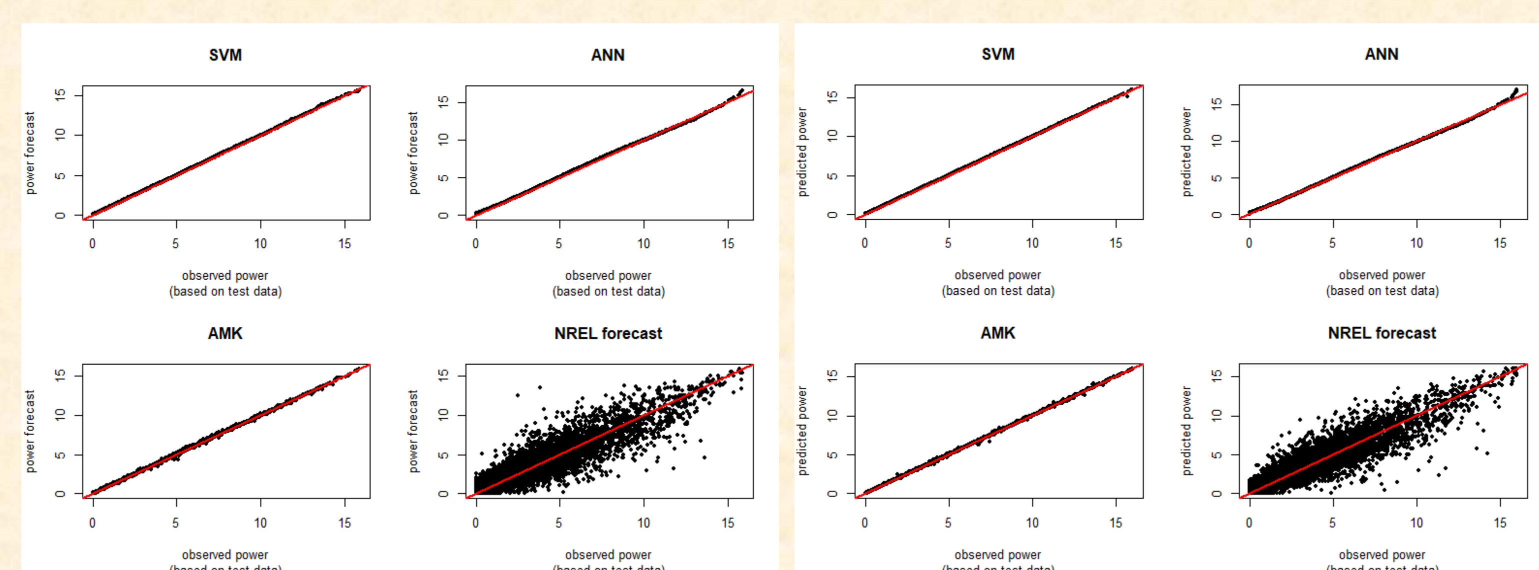
Hour-ahead	PER	ANN	HMC	Our Model
1	1.2307	1.3738	1.3641	1.1909
2	1.9985	2.3131	2.1217	1.9526
3	2.6226	2.9201	2.7115	2.3856
4	3.1676	3.5045	3.1998	2.8282
5	3.6630	3.9317	3.6051	3.0429
6	4.1029	4.4775	3.9392	3.3648

MAE Comparison

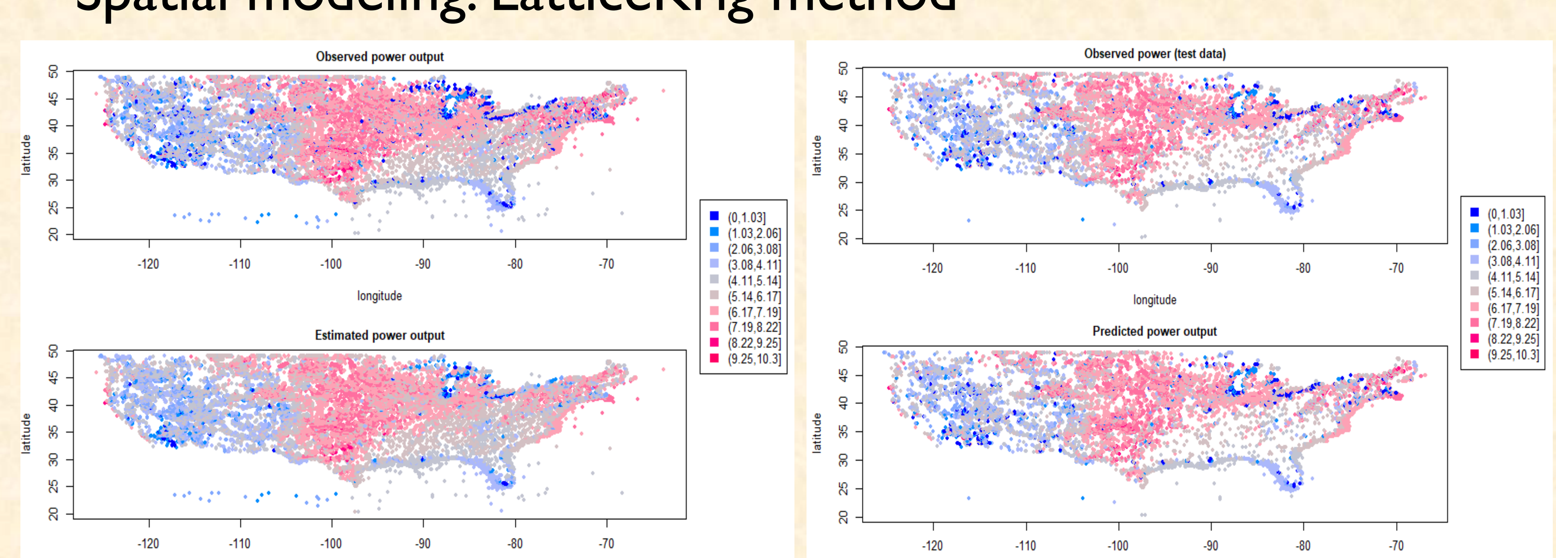
Covariates Based Wind Power Forecasting

- **Part I: Forecast and prediction for a specific site in or near California (latitude: 23.51041, longitude: -117.1473)**
  - Comparative Analysis: Three competing methods

Scenario	Error Measures	SVM	ANN	AMK	NREL forecast
Forecast	RMSPE	0.020	0.063	0.020	1.043
	MAPE	0.016	0.047	0.016	0.670
Prediction	RMSPE	0.019	0.067	0.029	0.992
	MAPE	0.015	0.047	0.011	0.644



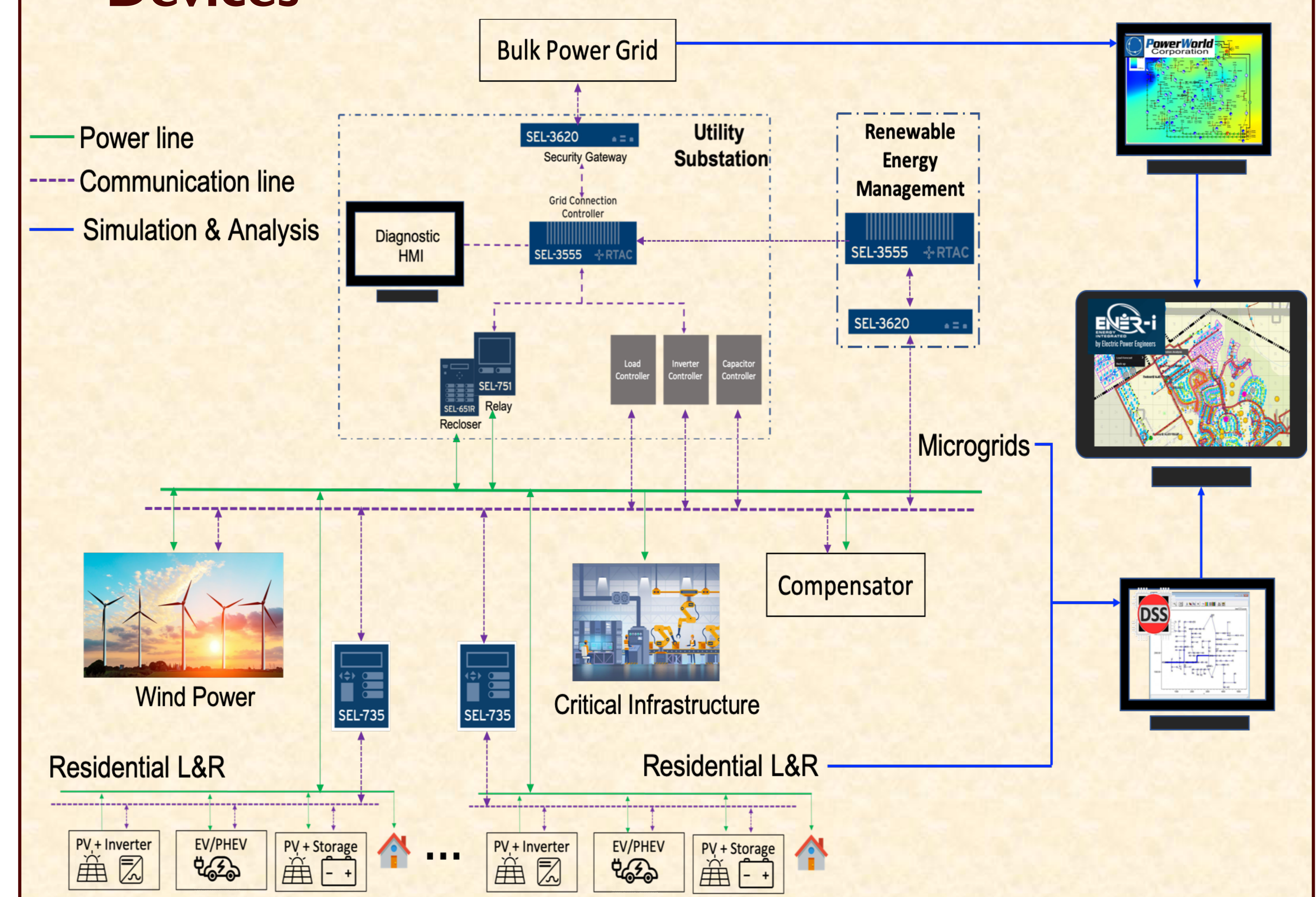
  - Both SVM and AMK were preferred over ANN.
- **Part II: Estimation and prediction of wind power (on an average) over different sites**
  - Spatial modeling: LatticeKrig method



RMSE = 0.86 and MAE = 0.53   **RMSPE = 0.92 and MAPE = 0.57**

Hardware-in-the-Loop Testbed Design

- **Integrating Renewables, Microgrids, Bulk Power Grid and Power System Control and Protective Devices**



- Analyze how renewable energies impact Microgrids and Bulk Power Grid operation and management with uncertainties
- Validate predictive models and demand response algorithms in a realistic environment
- Generate realistic power system cyber and physical data sets based on historical renewable energy data
- Develop data-driven model to manage renewables, microgrids, and bulk grids securely and economically

Conclusion

- **We developed a data-driven model to predict 1-6 hours ahead wind power generation with high accuracy**
- **We presented a site specific comparative analysis of 3 existing methods, and proposed a spatial method that predicts the wind power with high accuracy.**
- **We developed a hardware-in-the-loop testbed architecture that combines models, data sources, and data-driven approaches to study how renewable energies impact power systems**

Reference

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