DOE/OE Transmission Reliability Program

Management of Risk and Uncertainty through Optimized Co-operation of Transmission Systems and Microgrids with Responsive Loads

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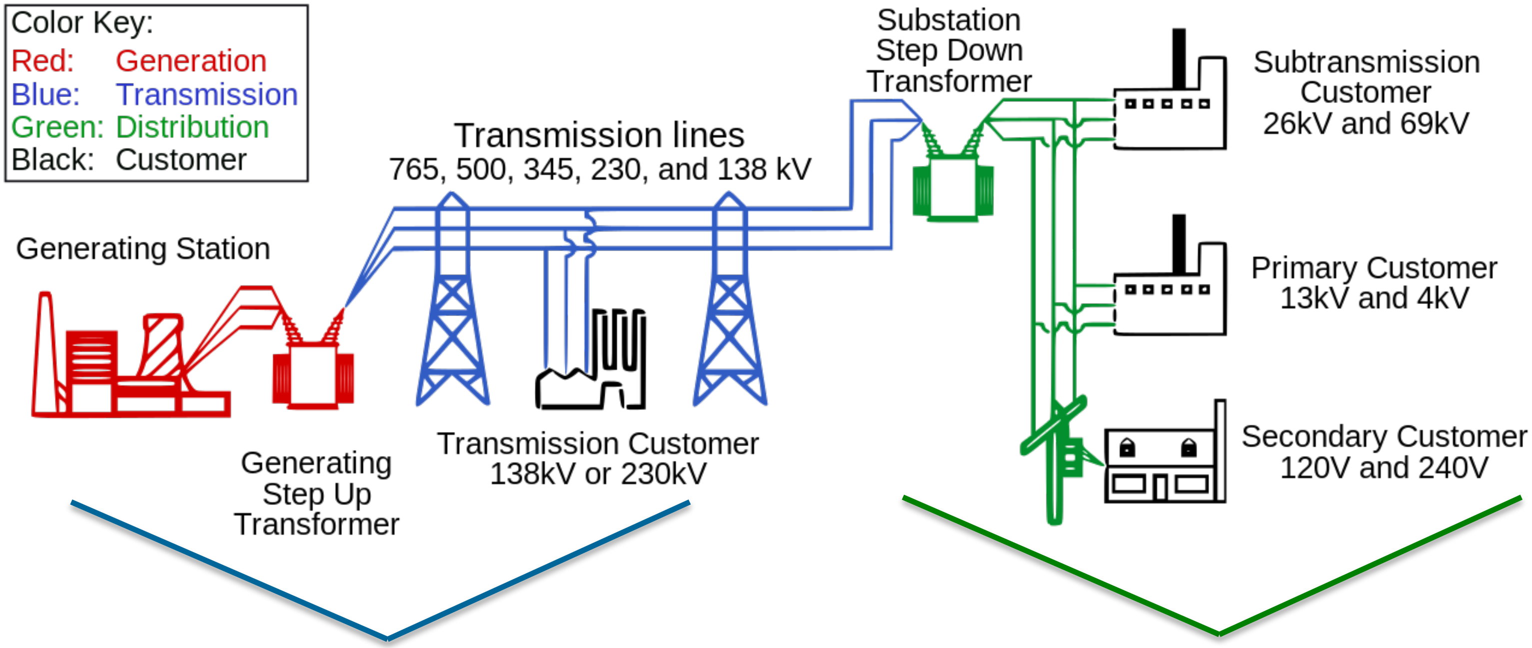
Presentation Overview

- Project Objective
- Progress Update: Phases I and II
- Summary of deliverables
- Looking Forward: Phases III and IV

Project Overview



Utility scale renewables create uncertainty

Responsive loads, and distributed resources

Project Objective

Development of a comprehensive co-optimization framework that incorporates the generation and transmission system with the distribution system and micrograds to include responsive loads, distributed generation, and storage.

The overarching objective of this work will be achieved through the pursuit of four key phases

Project Phases

Phase I: Characterizing uncertainty in renewables

Phase II:

Modeling demand side resources,

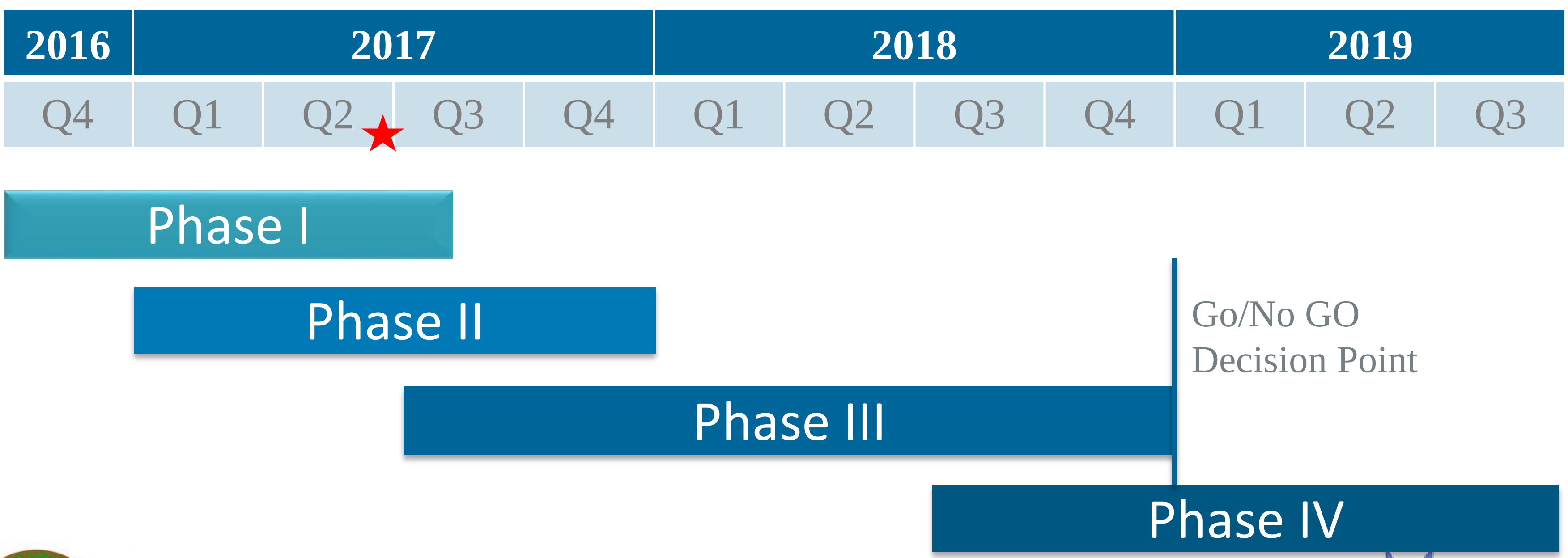
interactive effects

Phase III: Modeling system interactions

Phase IV: Co-optimization framework

Timeline

Timeline for the project was delineated in the updated PMP (Deliverable 1), summarized as follows:



Phase I: Characterizing Uncertainty

Seek to identify best methods for representing *multiple correlated wind farms*

Main contribution: review of multi-area wind modeling methods with the comprehensive comparison

Comparison:

- ✓ Ability of generated scenarios to replicate statistical properties of the historical data;
- ✓ Quality (stability) of the solutions obtained for an economic dispatch problem.

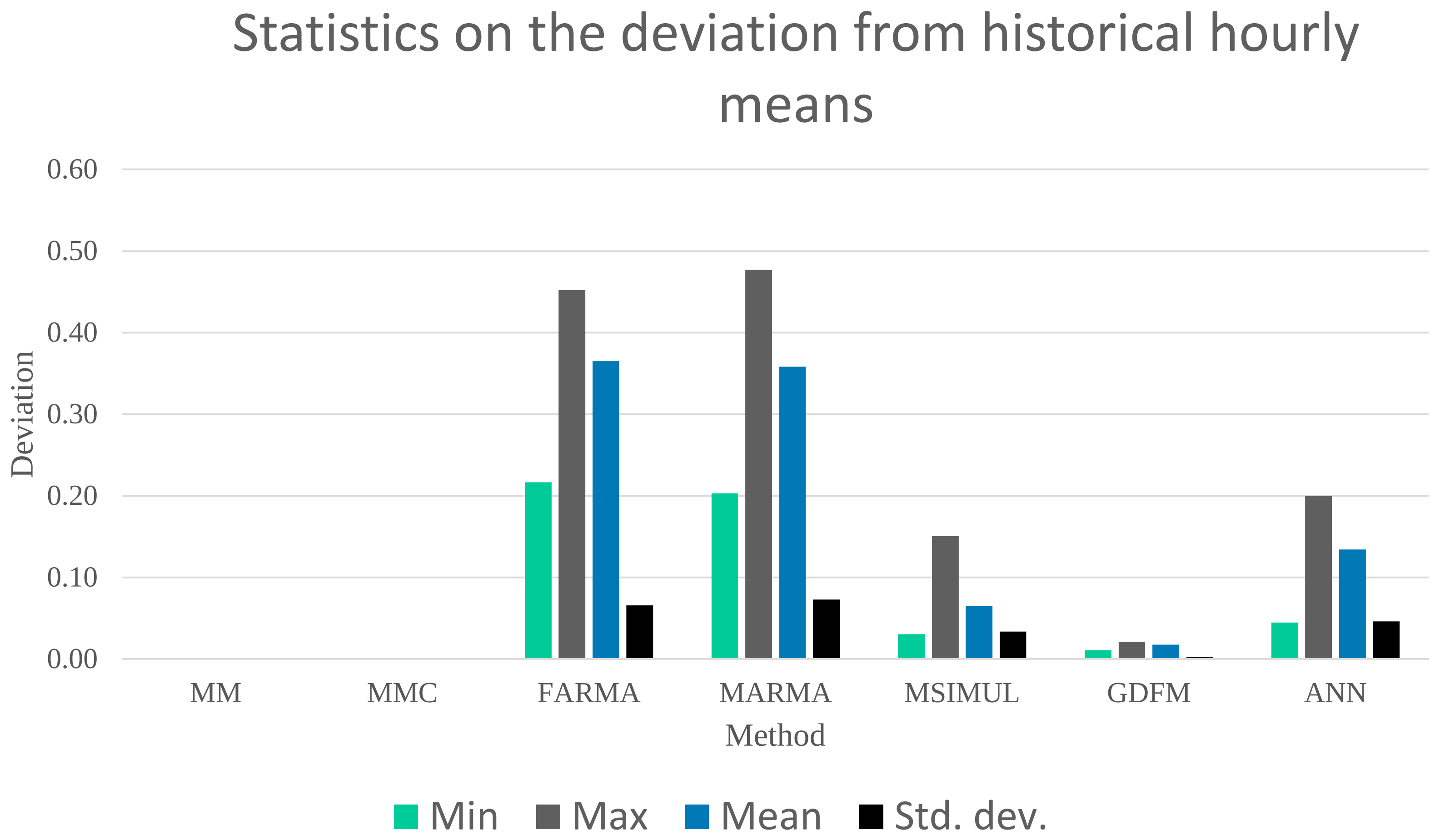
Lead: Cornell, with Anderson & Zéphyr

Classification of assessed methods

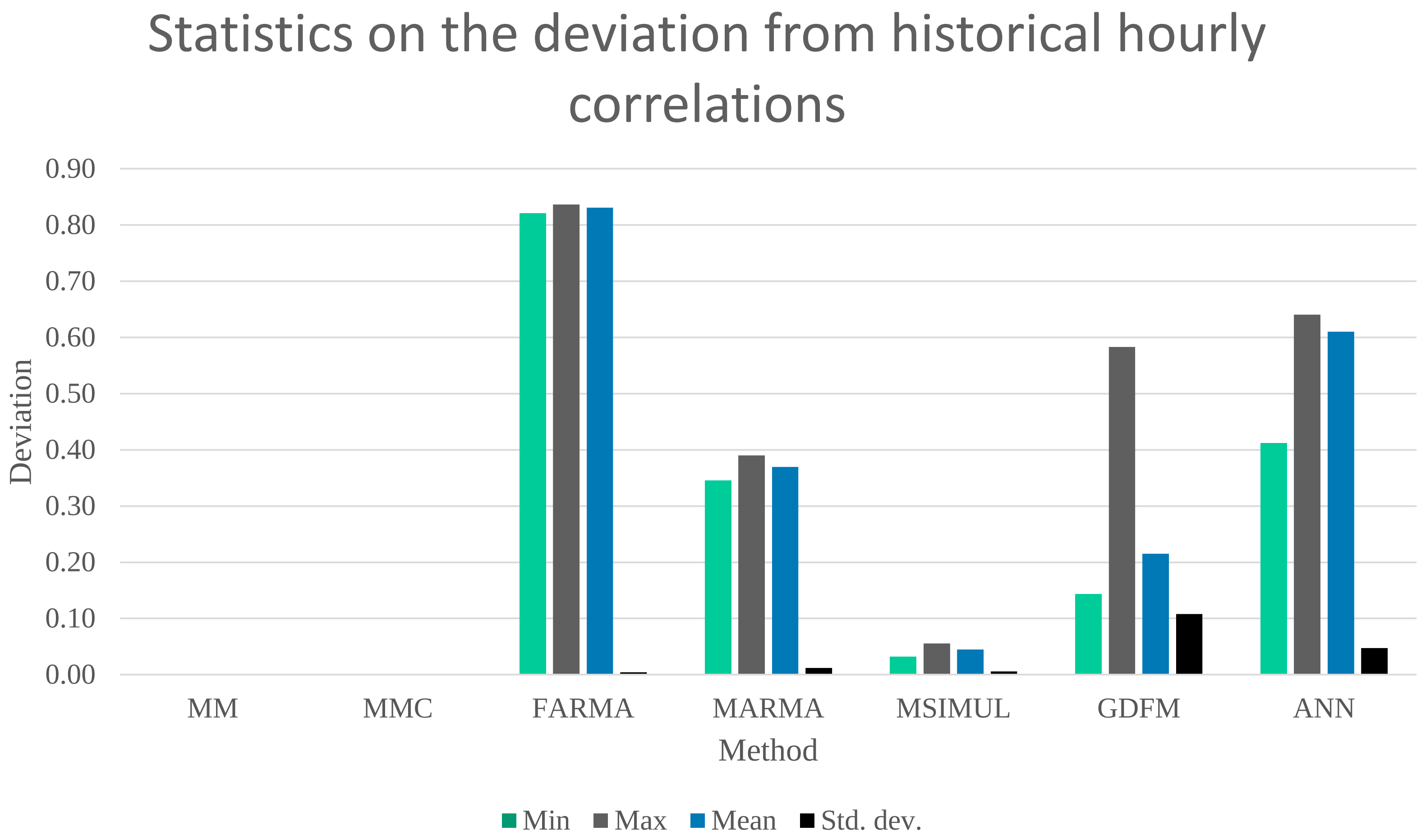
- Statistical moment matching (MM)
- Improved statistical moment matching (MMCC)
- Hybrid optimization and simulation (FARMA, MARMA)
- Monte Carlo simulation (MSIMUL)
- Artificial neural network (ANN)
- Time series methods (GDFM)

For details of each method, see Zéphyr & Anderson (under review -email cla28@cornell.edu for draft)

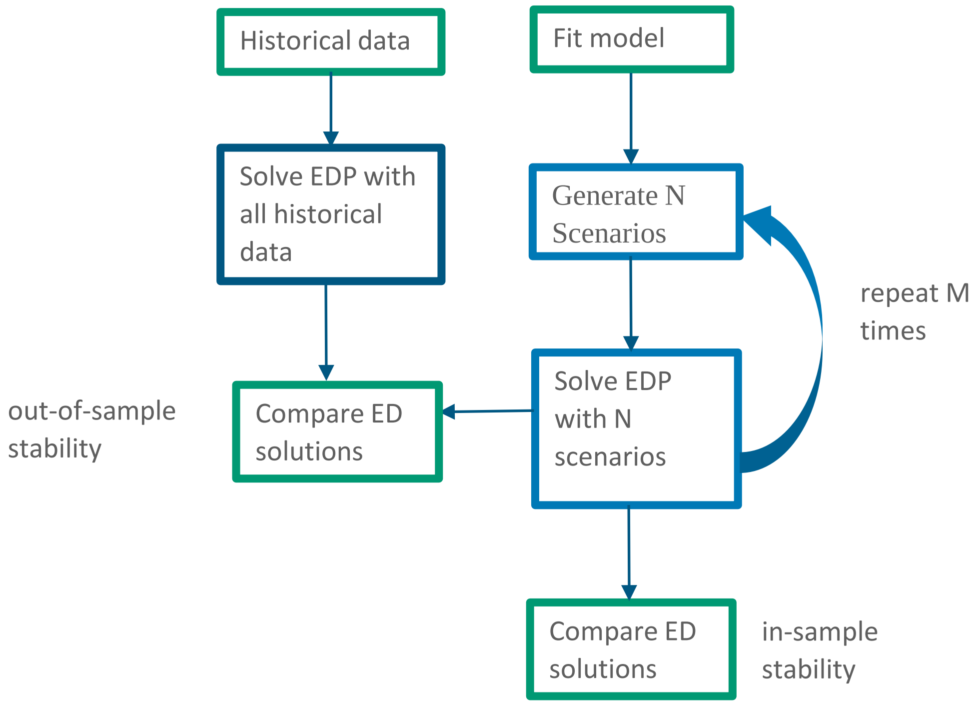
Sample Results: Statistical



Sample Results: Statistical

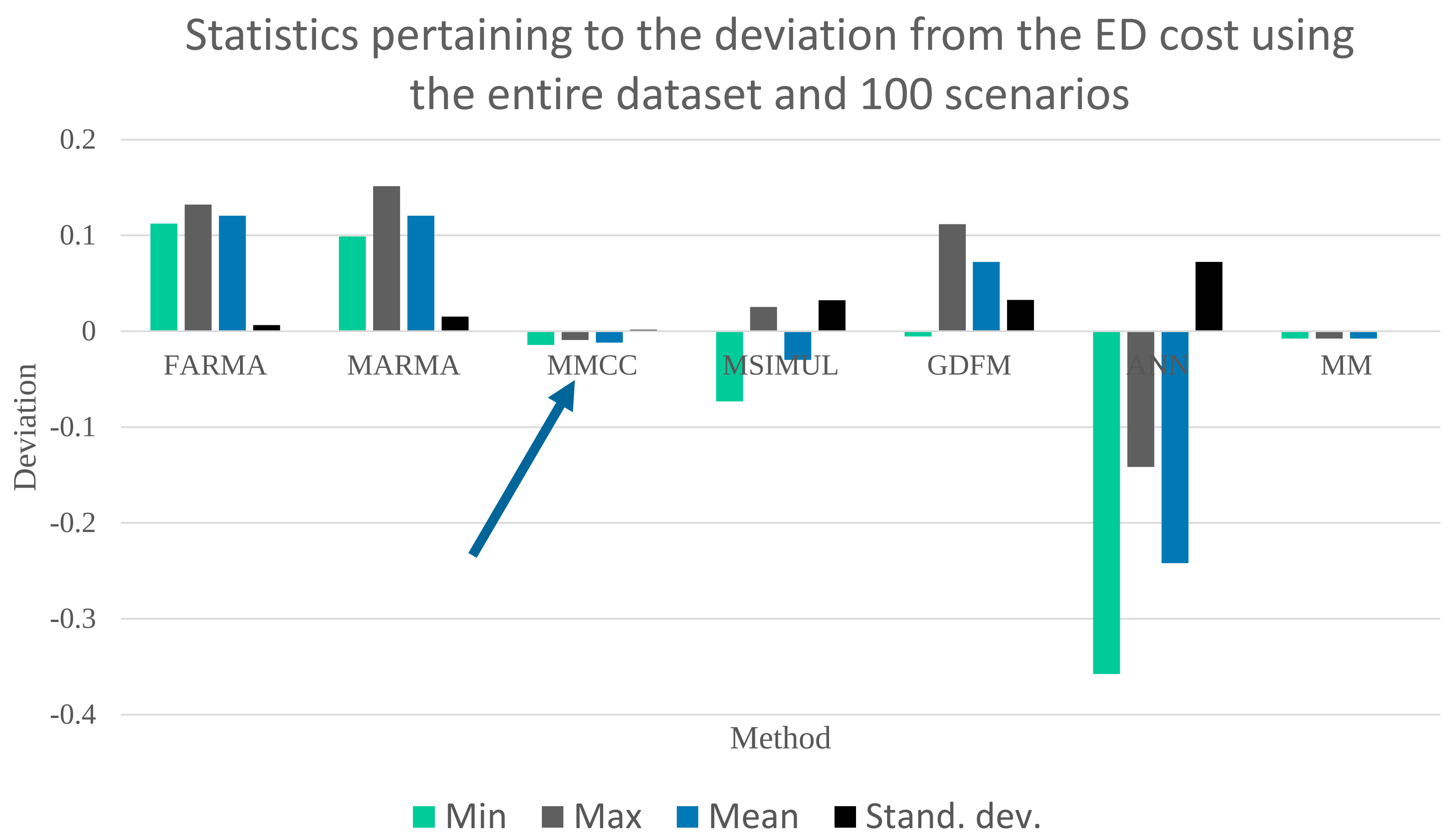


Sample Results: Economic dispatch



The “best” method should provide the dispatch solution closest to the one provided by the full dataset

Sample Results: Economic Dispatch



Summary

Methods that seek that reproduce statistical properties of the historical data will

- ✓ generate more reliable scenarios, and
- ✓ better dispatch decisions

Next steps will

- compare performance on different types of problems,
- assess importance of correlation to specific solutions, and
- test scalability with increasing number of wind farms

Phase II: Demand Side Resources

Phase II focuses on the development of various categories of demand-side resources, addressing

- modeling existing DR programs,
- integration in energy management system, and
- validation and testing to assess performance from various perspectives.

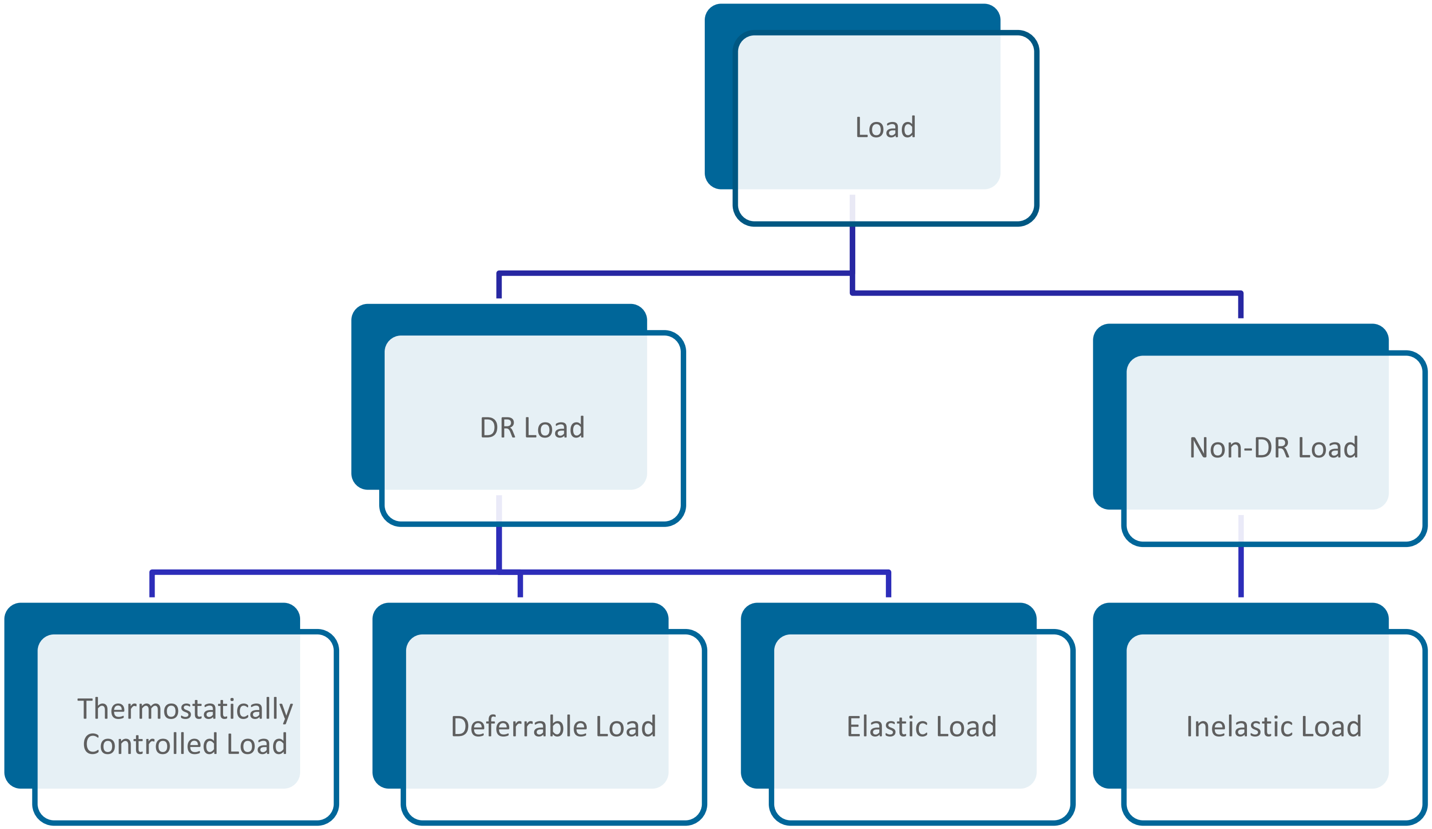
Lead: Smith College, Cardell

with support from Cornell

Progress to date:

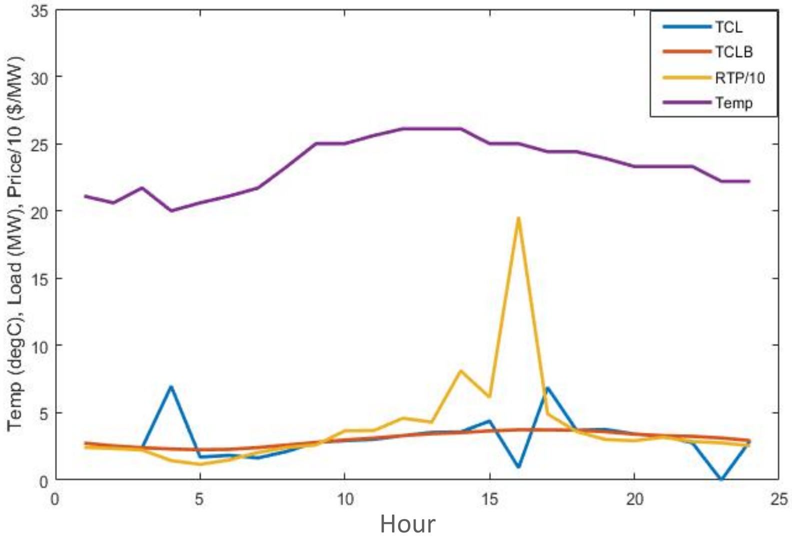
- Representing specific load types and response characteristics
- Developed stochastic rolling horizon model for microgrid with DR, storage and renewables
- Empirical analysis of DR capabilities by class

Demand Response (DR)

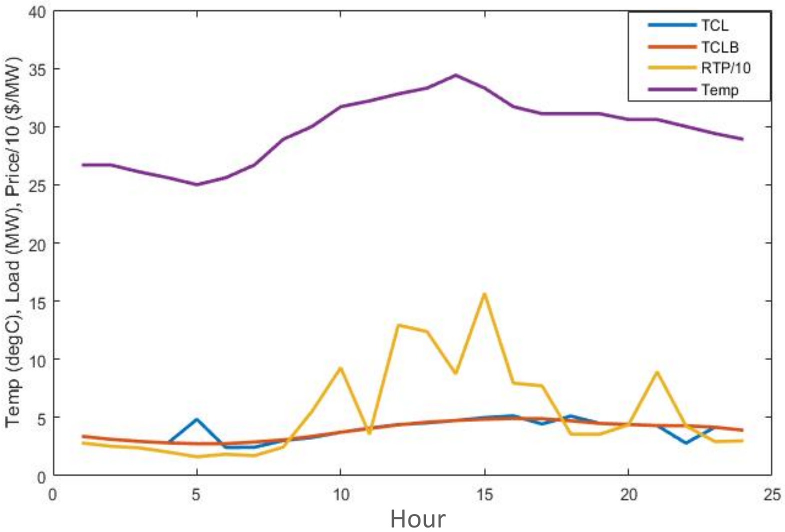


Incorporating these various resources requires a "look-ahead", flexible decision structure

Sample results:
Thermostatically controlled loads (TCL)

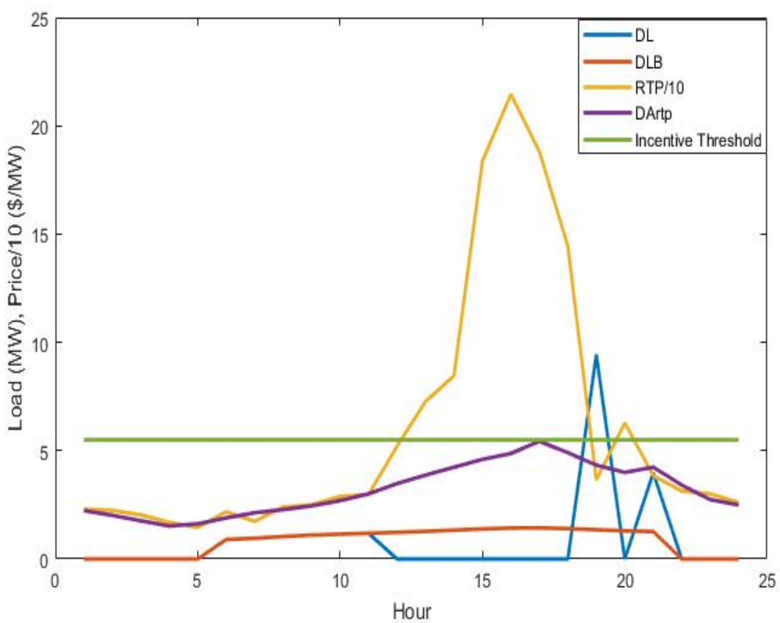


Moderate temperature sample day

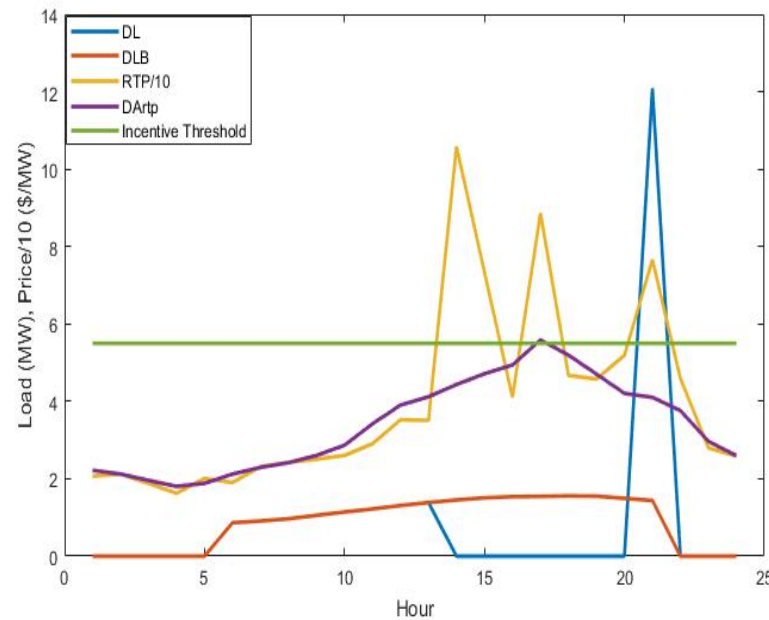


High temperature sample day

Sample results: Deferrable loads (DL)



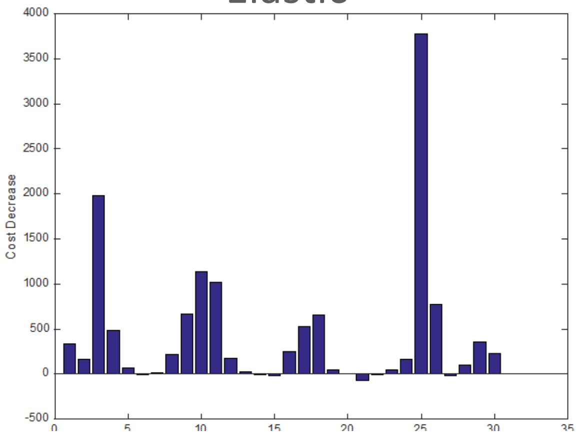
Effective Cost Reduction Case



Mis-forecast (cost increase) Case

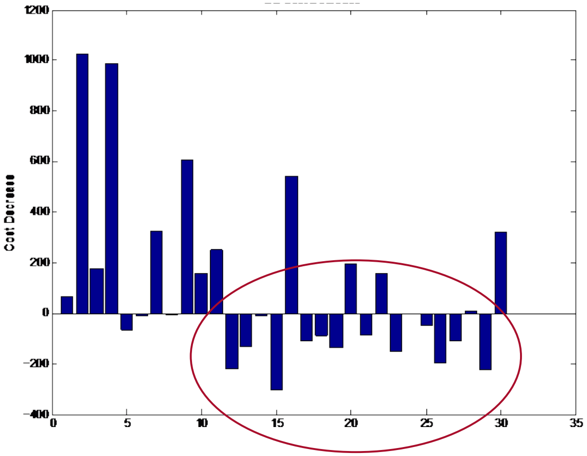
Cost reduction by load type

Elastic



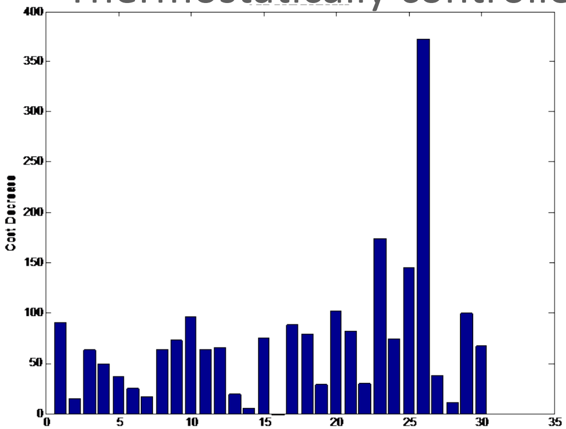
Day

Deferrable



Day

Thermostatically controlled



Day

Different load classes provide load reductions under different conditions

Conclusions

System model incorporates:

- microgrid with renewables, storage and DR
- combined DR programs for specific load classes
- stochastic rolling horizon with forecasts
- analysis of performance of various DR classes

This framework illustrates that various classes of demand response add value to the energy management strategy

Deliverables for 2016/17

Project Start: October 2016

1. Development and release of project website (scheduled for 12/31/16, complete)
2. Data is available to develop and validate models (ongoing for renewables and DR programs)
3. Submission of peer-reviewed journal publication: two papers
   (scheduled for 09/31/17, in progress)
   - ✓ Multi-area wind scenarios paper
     (for Renewable and Sustainable Energy Reviews - submitted)
   - ✓ Microgrid and DR paper
     (for IEEE Transactions on Smart Grid – in final review before submission)

Accepted publications/presentations

1. Cardell, J.B., Zephyr, L., & Anderson, C.L. (2017) A Vision for Co-optimized T&D: System Interaction with Renewables and Demand Response. Proceedings of the 50th Hawaii International Conference on System Sciences.
2. Liu, J., Martínez, M.G., & Anderson, C.L. (2016) Quantifying The Impact Of Microgrid Location And Behavior On Transmission Network Congestion. Proceedings of the 2016 Winter Simulation Conference.

Looking Forward
Phase III: System Co-optimization

Key focus of 2017/18: Impact of interaction schemes on transmission and distribution/micro-grid systems:

Development of candidate co-optimization models to

- study the interactive effect of micro-grid and transmission system behaviors
- assess the importance of microgrid location in conjunction with co-operation strategies

Co-Lead by PI Team, Cornell & Smith College

Looking Forward: Phase IV Validation and Scaling

1. Selection of most promising candidate from Phase III for the stochastic unit commitment (SUC) problem
2. Integration of approximate dynamic programming (ADP) to efficiently and accurately solve economic dispatch
3. Integration of SUC and ED components into co-optimization framework
4. Numerical case studies and scalability testing

Lead: Cornell, with Anderson & Zéphyr
with support from Smith College

Questions?