Session 5

Renewable Energy Integration: Technological and Market Design Challenges

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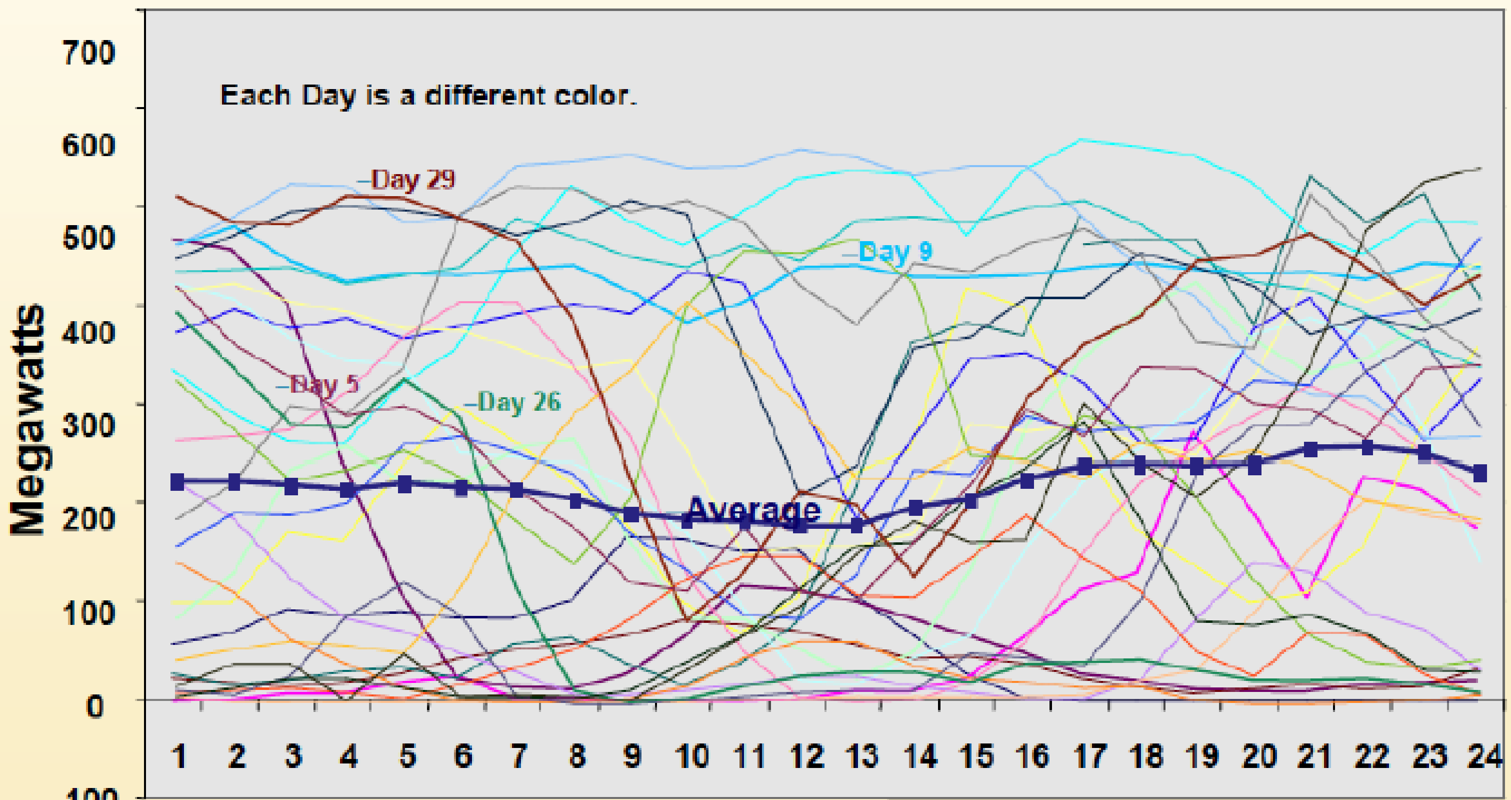
Future Grid Forum
June 27-28, 2012
Washington D.C.

Uncertainty

Tehachapi Wind Generation in April – 2005

Could you predict the energy production for this wind park
either day-ahead or 5 hours in advance?



14

Hour

California ISO
Your Link to Power

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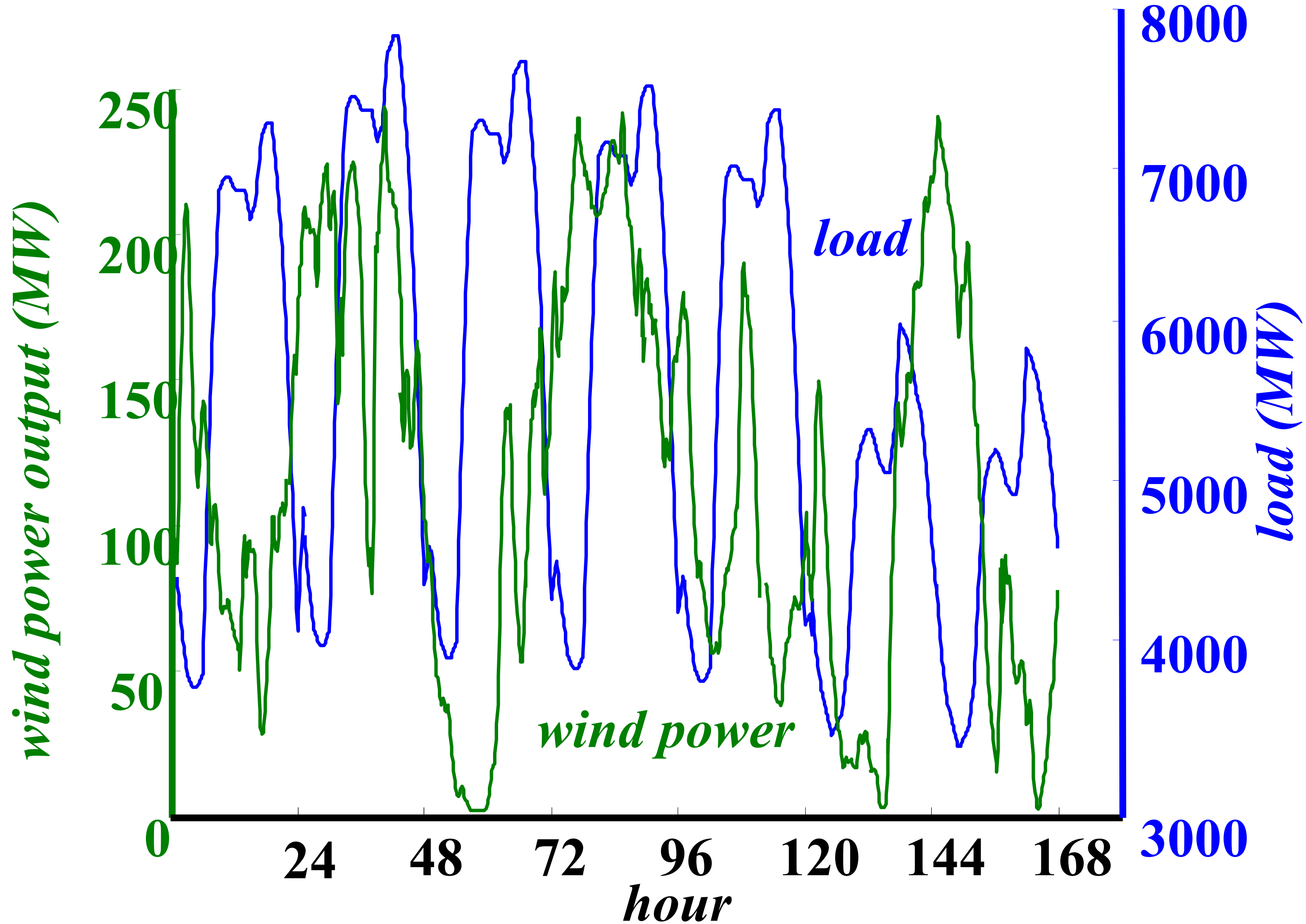
Negative Correlation with Load



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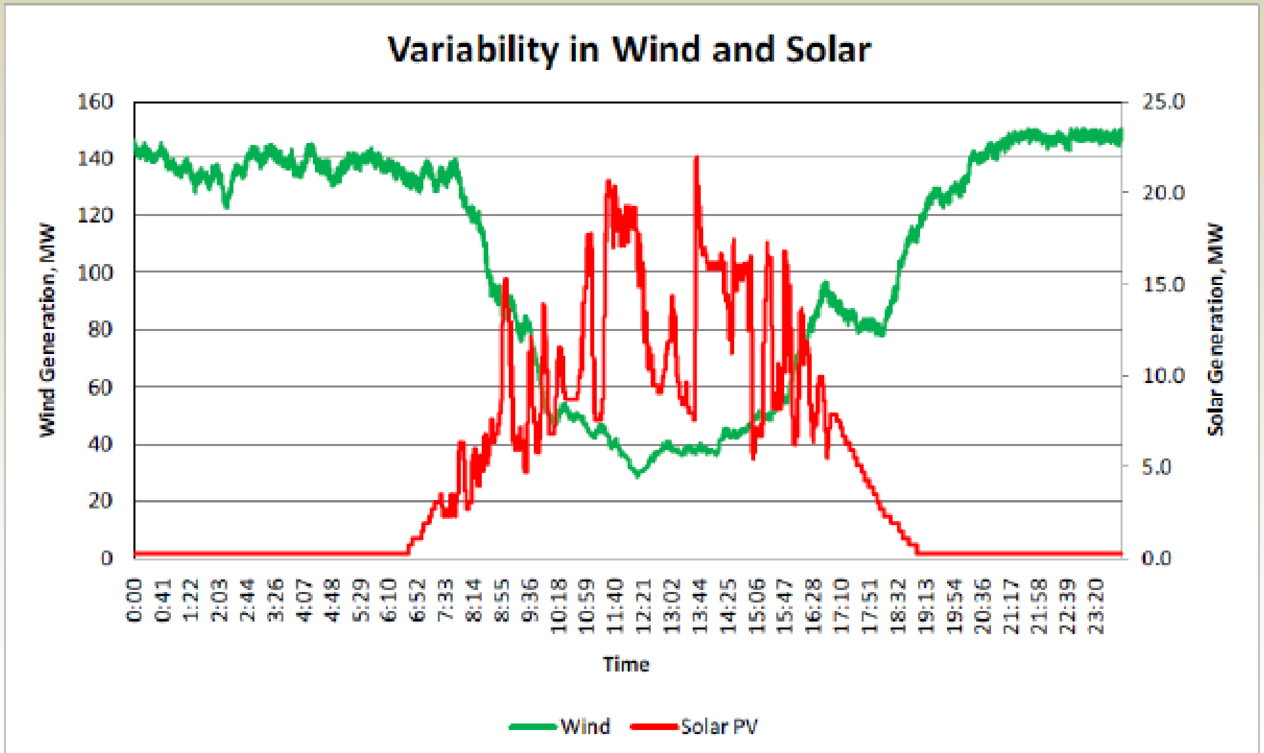
Variability

Variability of wind and solar resources - June 24, 2010



California ISO Your Link to Power

A 150 MW wind plant and a 24 MW solar resource

Slide 5

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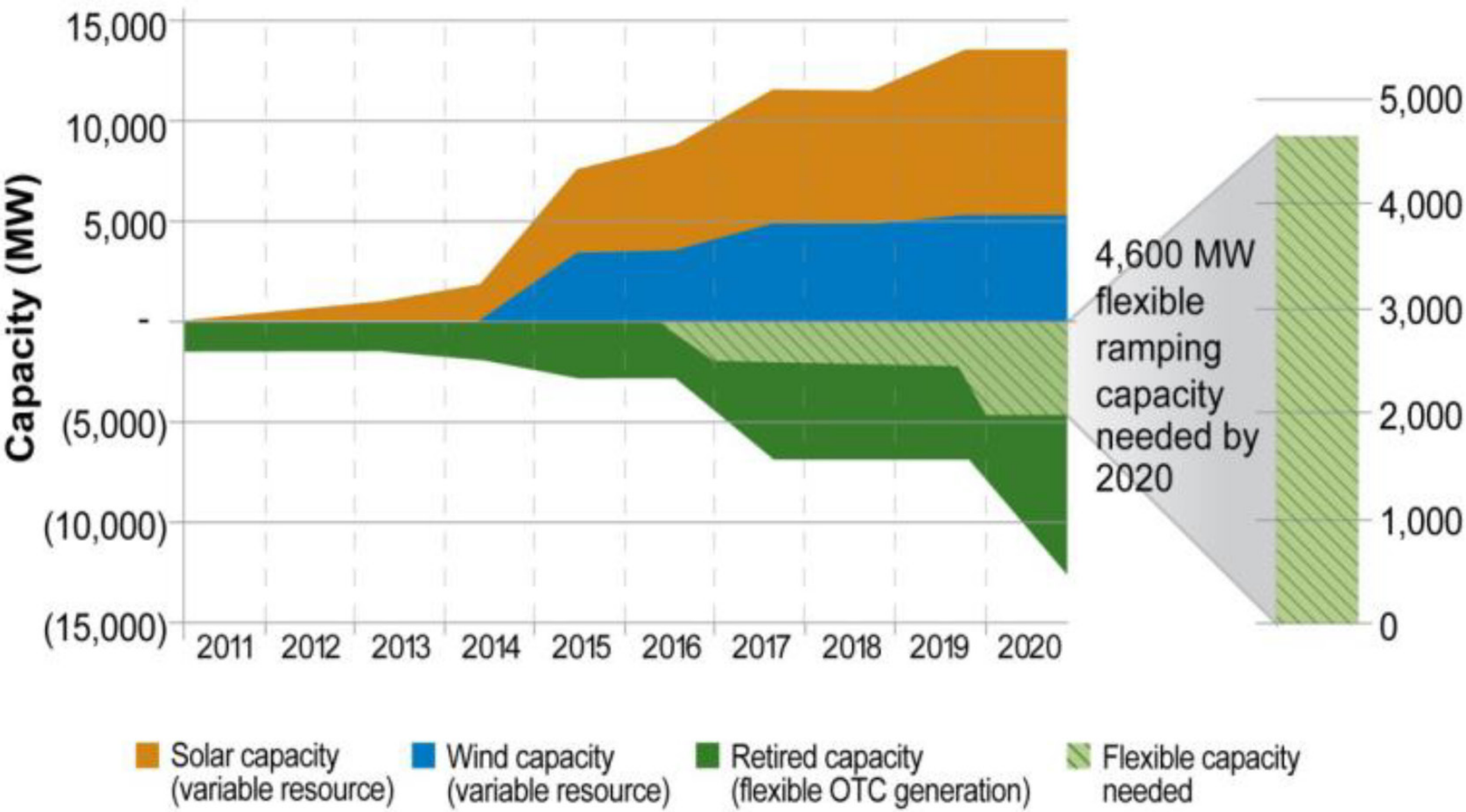
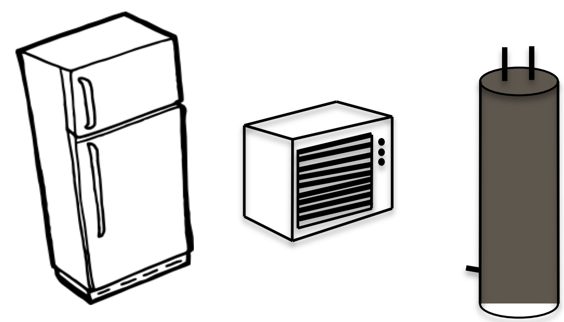
Conventional Solution



Source: CAISO

The DR Alternative to Expanding Flexible Thermal Generation

- Mobilizing demand response (DR) and a paradigm shift to “load following available supply” provides an economically viable and sustainable path to a renewable low carbon future.
    - Price responsive load
    - Energy efficiency
    - Deferrable loads:
        - EV/PHEV
        - HVAC
        - Water heaters
        - Electric space heaters
        - Refrigeration
        - Agricultural pumping



TCLs

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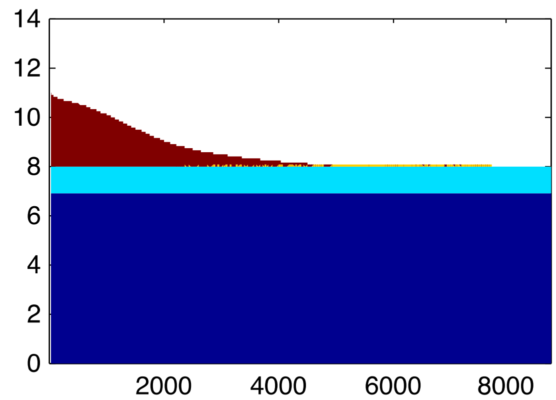
How BIG is the Resource Potential?

Estimates for most of California (5 largest utilities) based on RECs and CEC data.

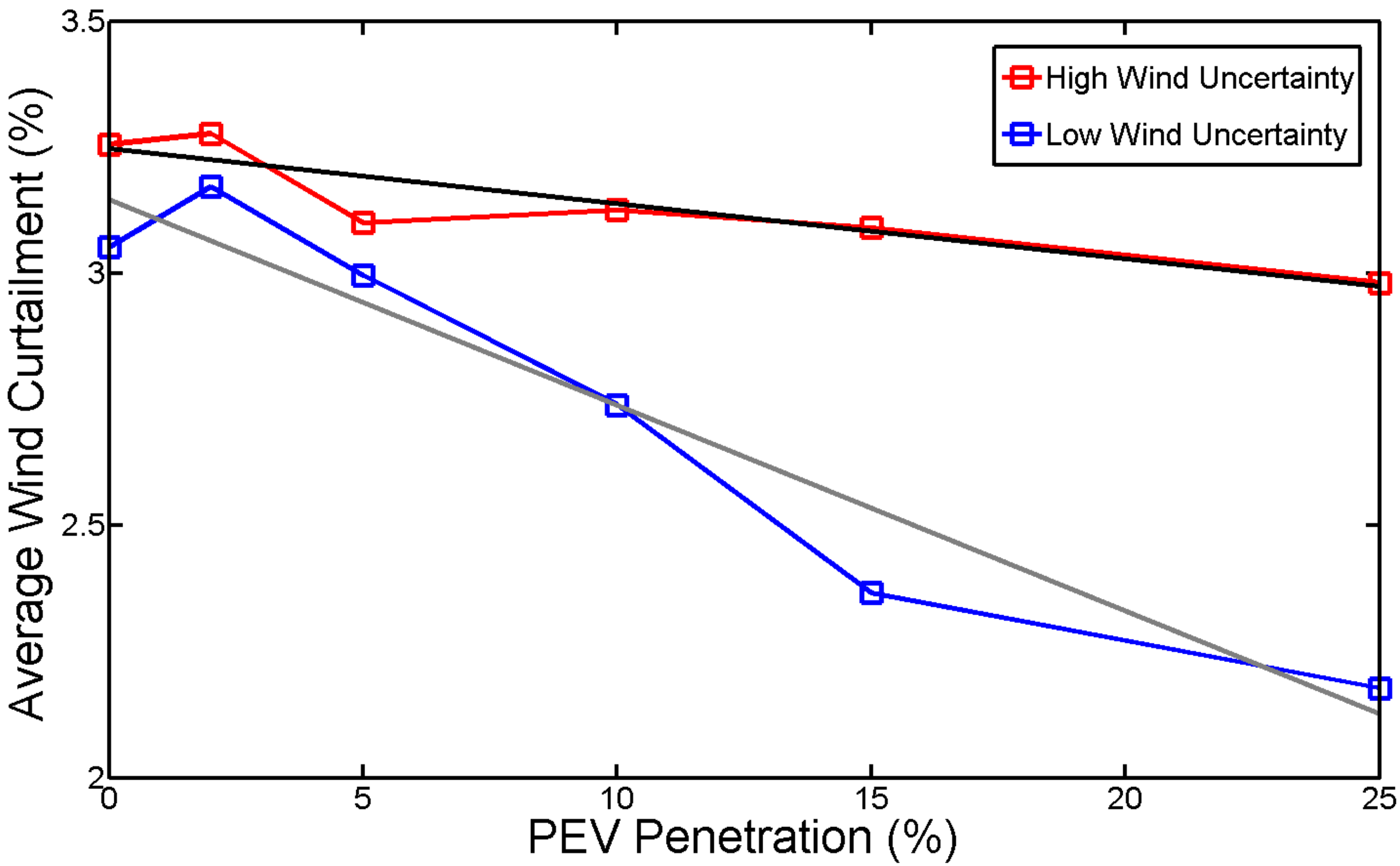
2012 Resource Duration Curve



2020 Resource Duration Curve, assuming increased efficiency and 30% of water/space heaters converted to electric

Potential for Wind + PEV Coupling

(Based on NYISO case study)



Challenges

- Develop distributed control paradigms and business models for mobilizing demand response to mitigate the uncertainty and variability introduced by massive integration of renewable energy resources
- Develop market mechanisms that will incentivize load response and flexibility and correctly price uncertainty (or uncertainty reduction) on the demand and supply side.
- Develop dispatch and planning tools that can explicitly account for uncertainty, variability and flexibility (e.g. storage) in resource optimization and reserves procurement.
- Develop simulation tools that can account for increased uncertainty in verifying system and market performance

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Task 3.1

Direct and Telemetric Coupling of Renewable Energy Resources with Flexible Loads

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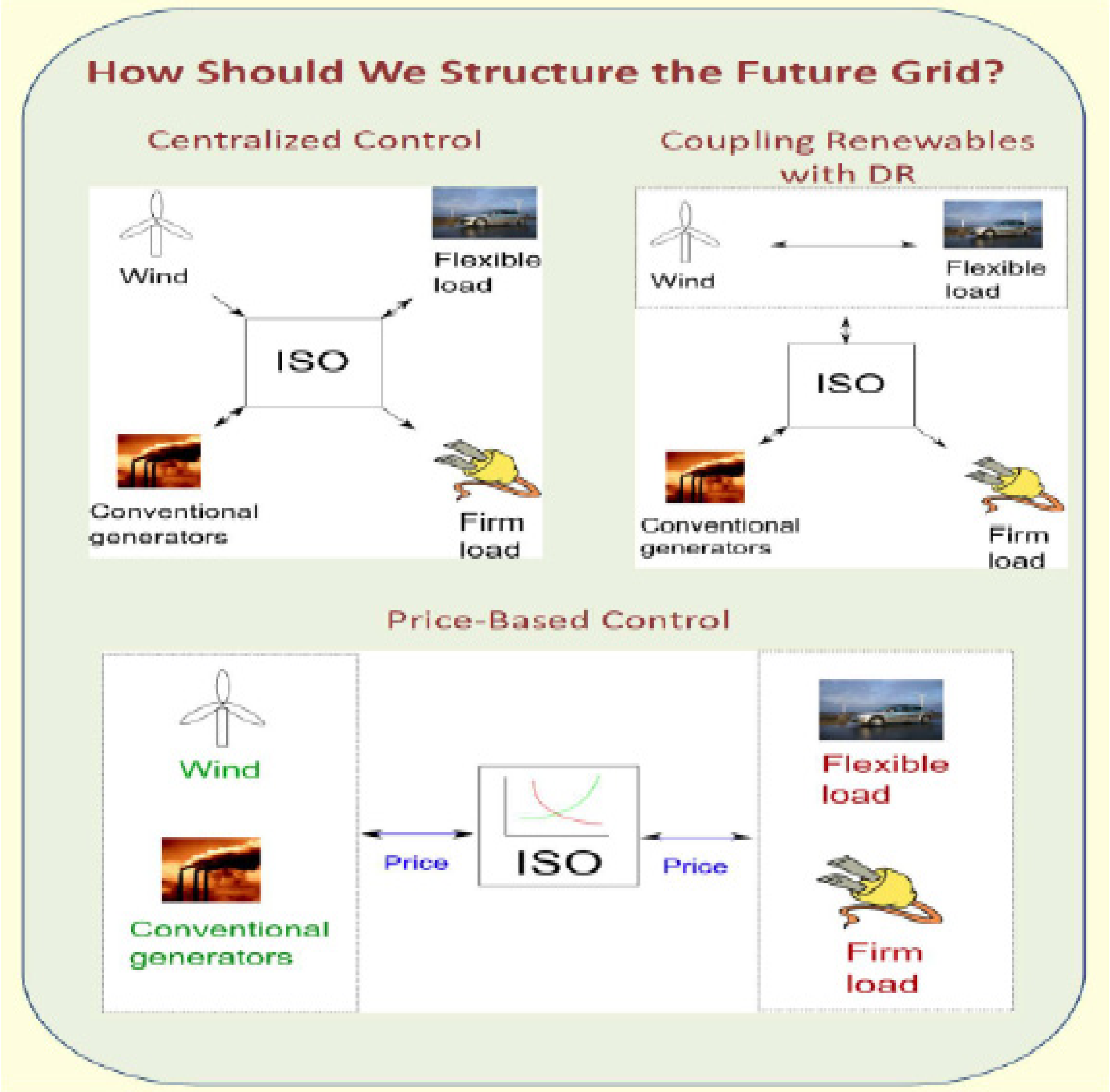
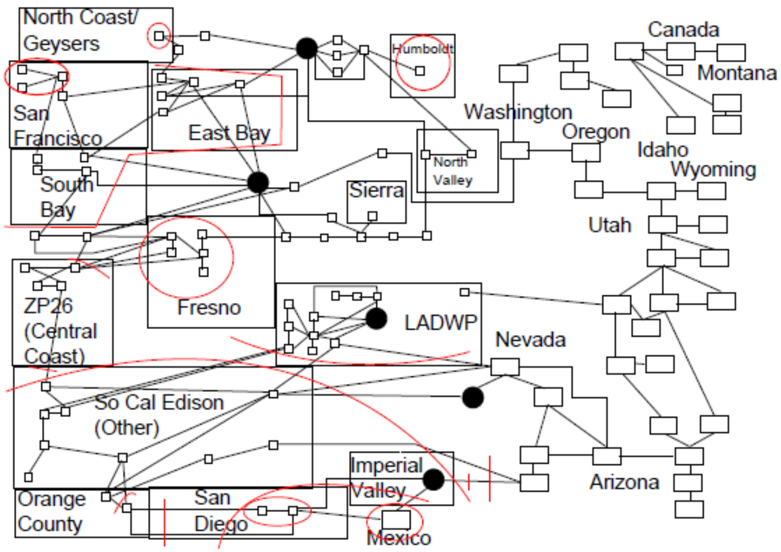
Alternative DR Paradigms



Evaluation Methodology

- Comparison requires explicit accounting for uncertainty for consistent determination of locational reserves.
- Stochastic unit commitment optimization accounts for uncertainty by considering a limited number of probabilistic wind and contingency scenarios, committing slow reserves early with fast reserves and demand response adjusted after uncertainties are revealed.
- Economic and reliability outcomes are calculated using Monte Carlo simulation with large number of probabilistic scenarios and contingencies

California Case Study



- 225 buses
- 375 transmission lines
- 124 units (82 fast, 42 slow)
- 53665 MW power plant capacity
- 42 scenarios
- Four studies
  - With transmission constraints, contingencies:
    - No wind
    - Moderate (7.1% energy integration, 2012)
    - Deep (14% energy integration, 2020)
  - Deep (14% energy integration) without transmission constraints, contingencies

- Stochastic Optimization captures nearly 50% of gains under perfect forecasting of load and wind outcomes
- Direct coupling marginally more expensive than a centralized market but reduces load shedding due to better representation of load flexibility
- Transmission constraints can play a significant role in determining cost and resource adequacy

Task 3.3

Planning and Market Design for Using Dispatchable Loads to Meet Renewable Portfolio Standards and Emissions Reduction Targets

Timothy Mount
Robert Thomas
Max Zhang
Cornell University

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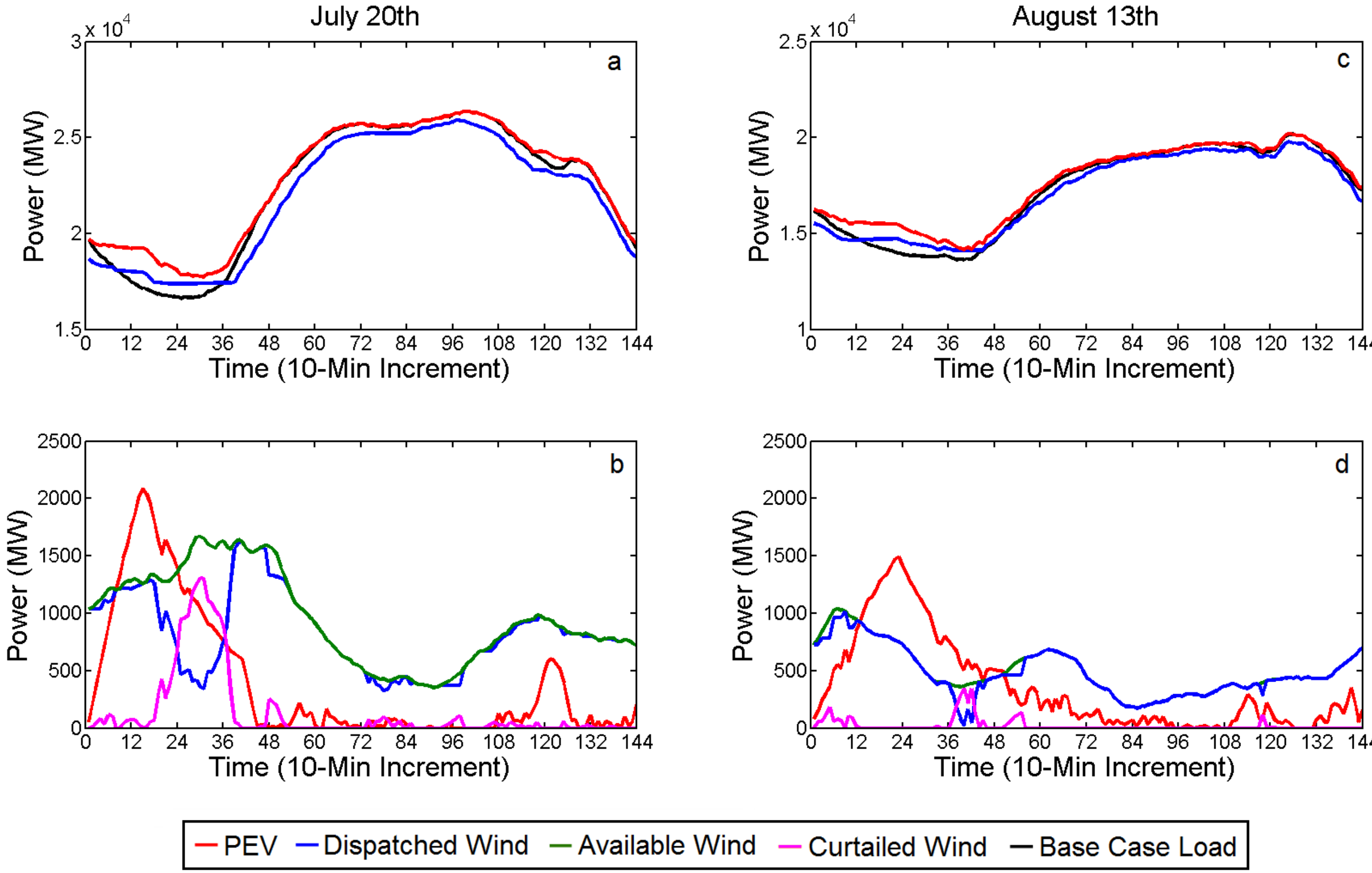
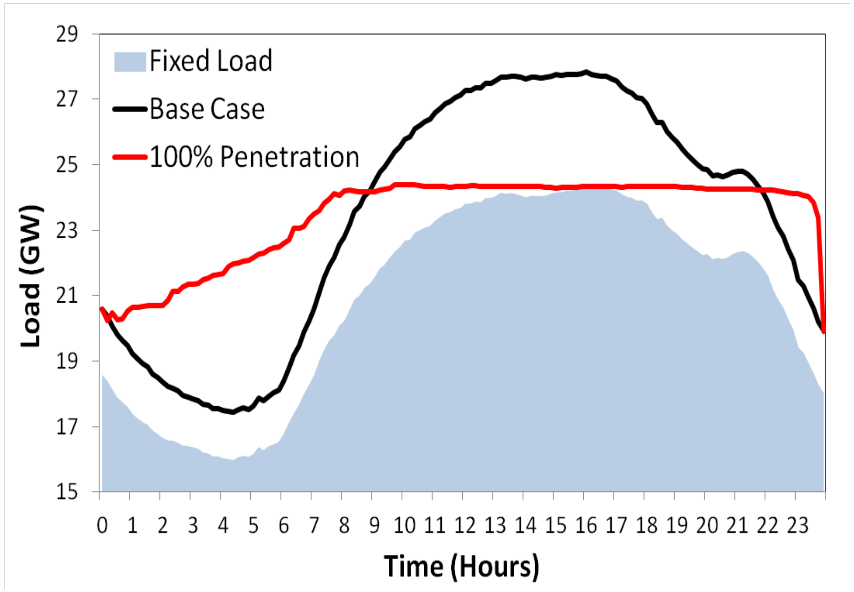
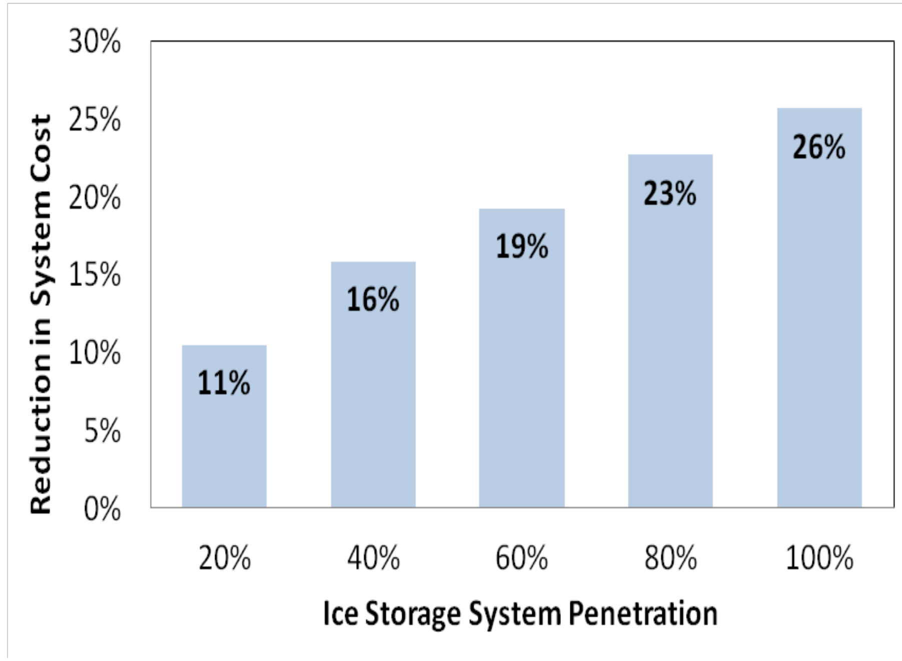
Wind and PEV Dispatch Patterns



In scenarios with significant wind curtailment, curtailment largely occurs in the valley-load hours. Similar pattern is observed for PEV dispatch. Valley-load smoothing is performed to reduce generator start ups and shut downs, and ramping operations which increase production and maintenance cost.

Price Responsive Ice Storage Systems





- Case study aimed to evaluate the benefits of aggregating Ice Storage Systems in large commercial and industrial buildings in New York State to reduce NYSO system costs.
- Heuristic methods were used to reduce system costs for a two-settlement market operation, where both steady-state and ramping costs are taken into consideration.
- Optimal allocation manages to reduce peak load and total system cost, and flatten out the load profile.

Task 3.2

Mitigating Renewables Intermittency through Nondisruptive Distributed Load Control

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Johanna Mathieu

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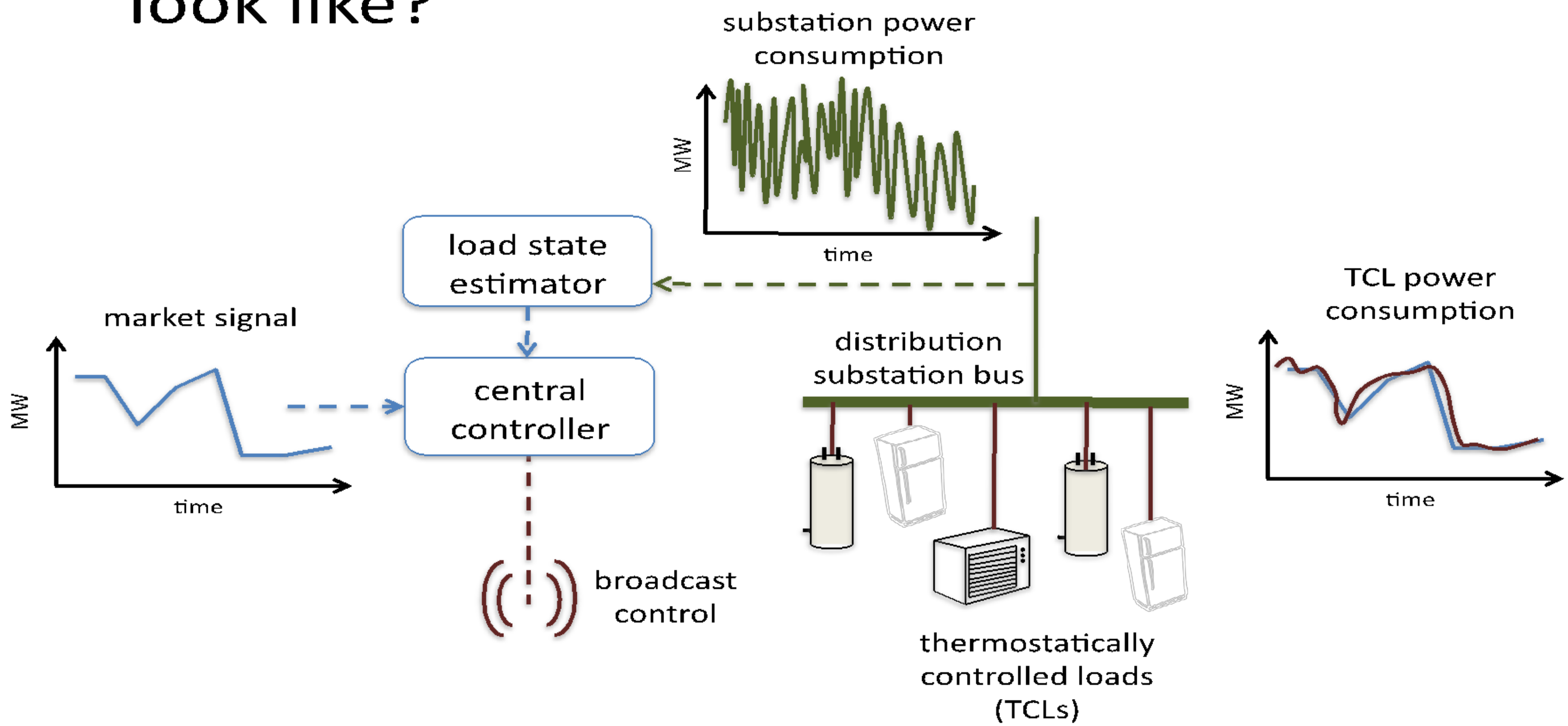
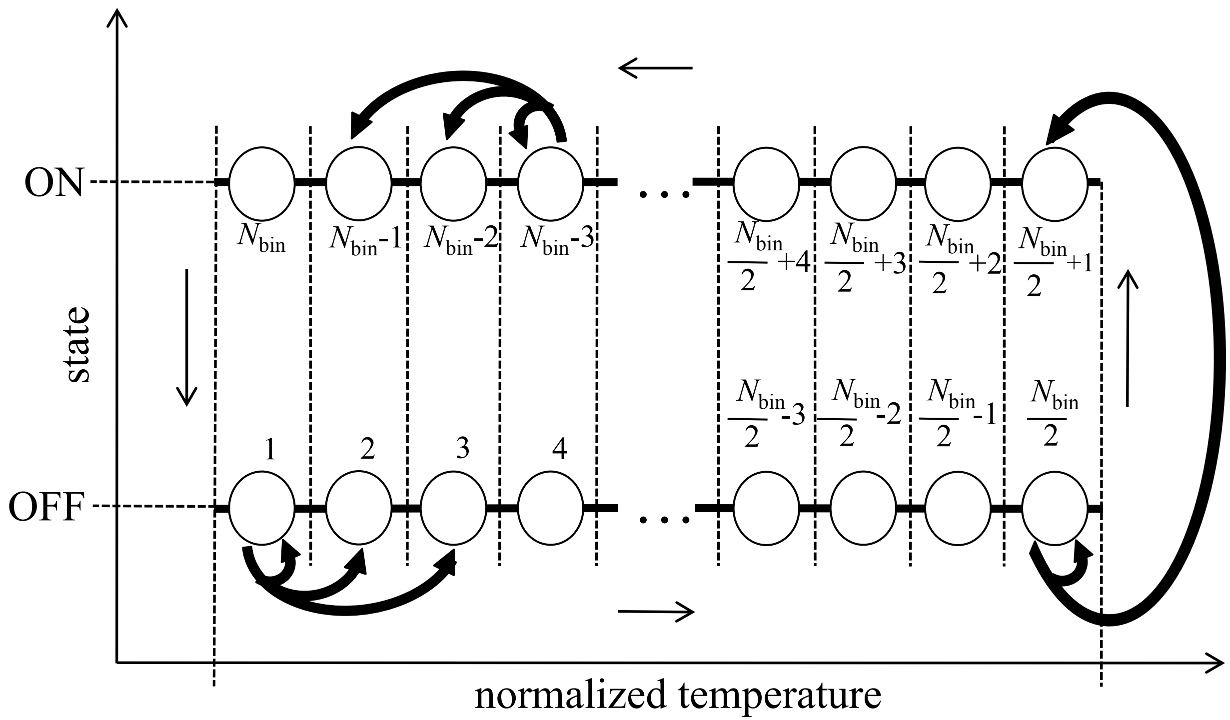
Control Paradigm

What might the low infrastructure case look like?



11/10/11 J. Mathieu, UC Berkeley 10

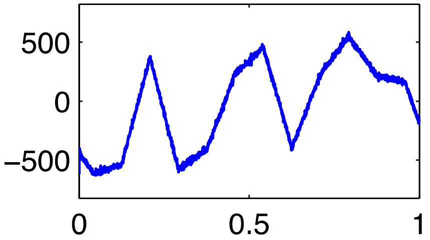
Modeling Aggregated TCLs: 'State Bin Transition Model'



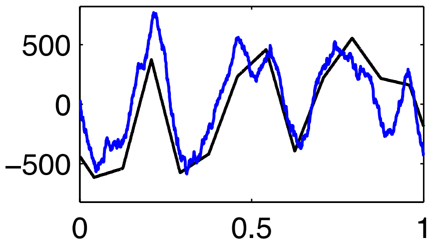
A Markov Transition Matrix describes the movement of TCLs around the dead-band.

Controlling TCLs to Track a 5-Minute Market Signal

1,000 Air Conditioners, Broadcast Control



5% Forecast Error



Task 3.4

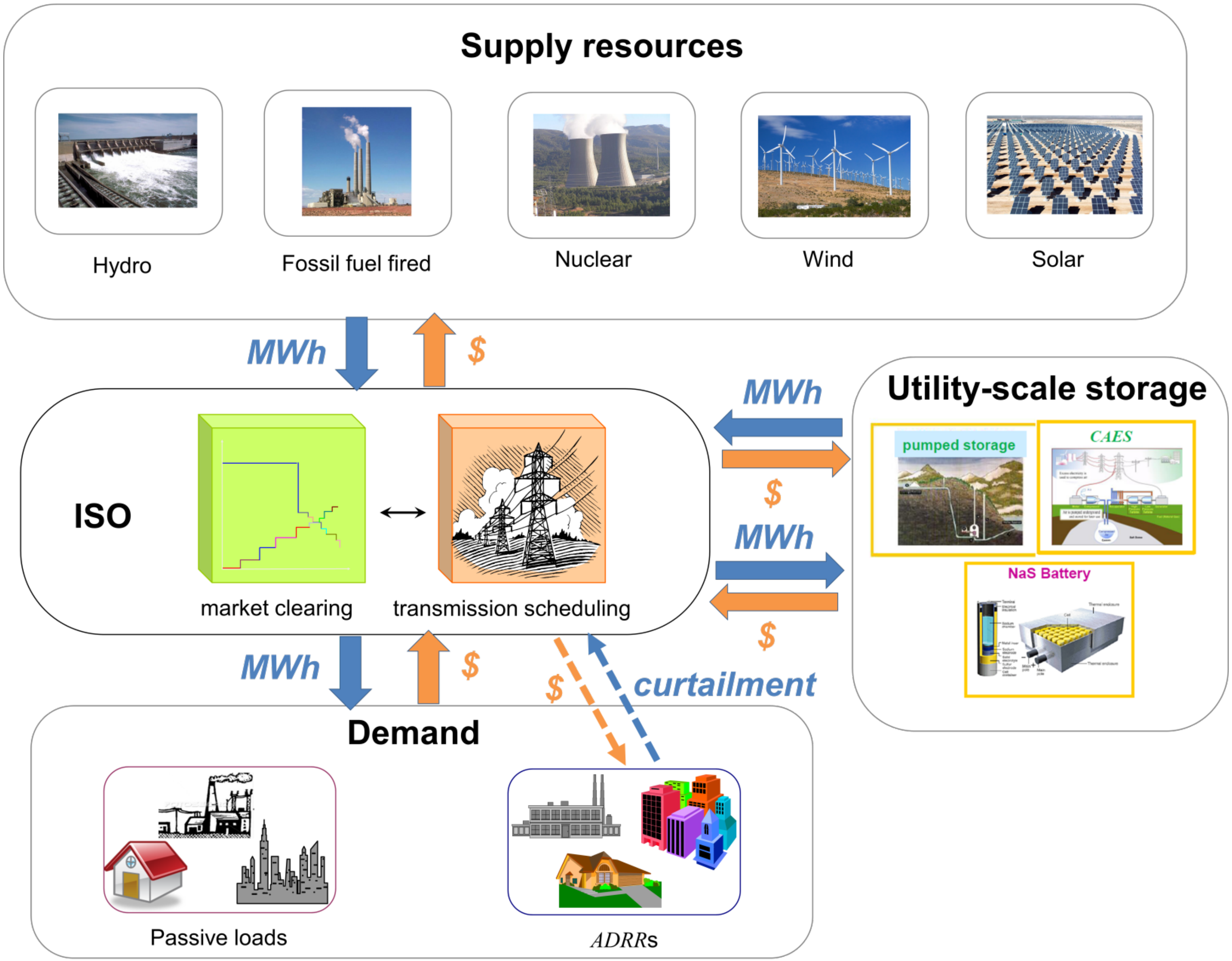
Probabilistic Simulation of Power Systems With Integrated Renewable, Demand Response and Storage Resources

Alejandro Dominguez-Garcia

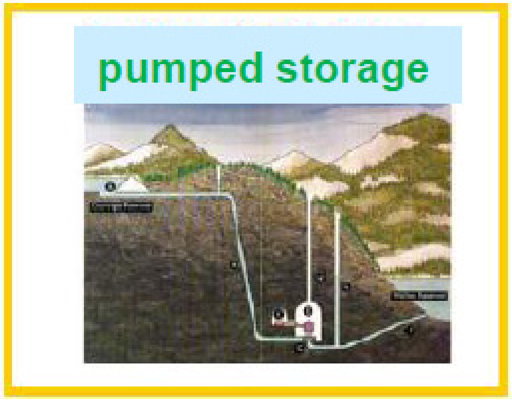
George Gross

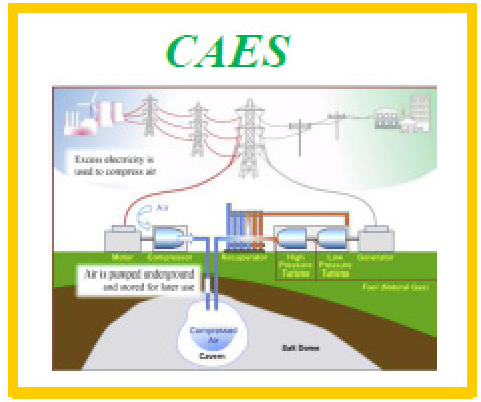
University of Illinois at Urbana/Champaign

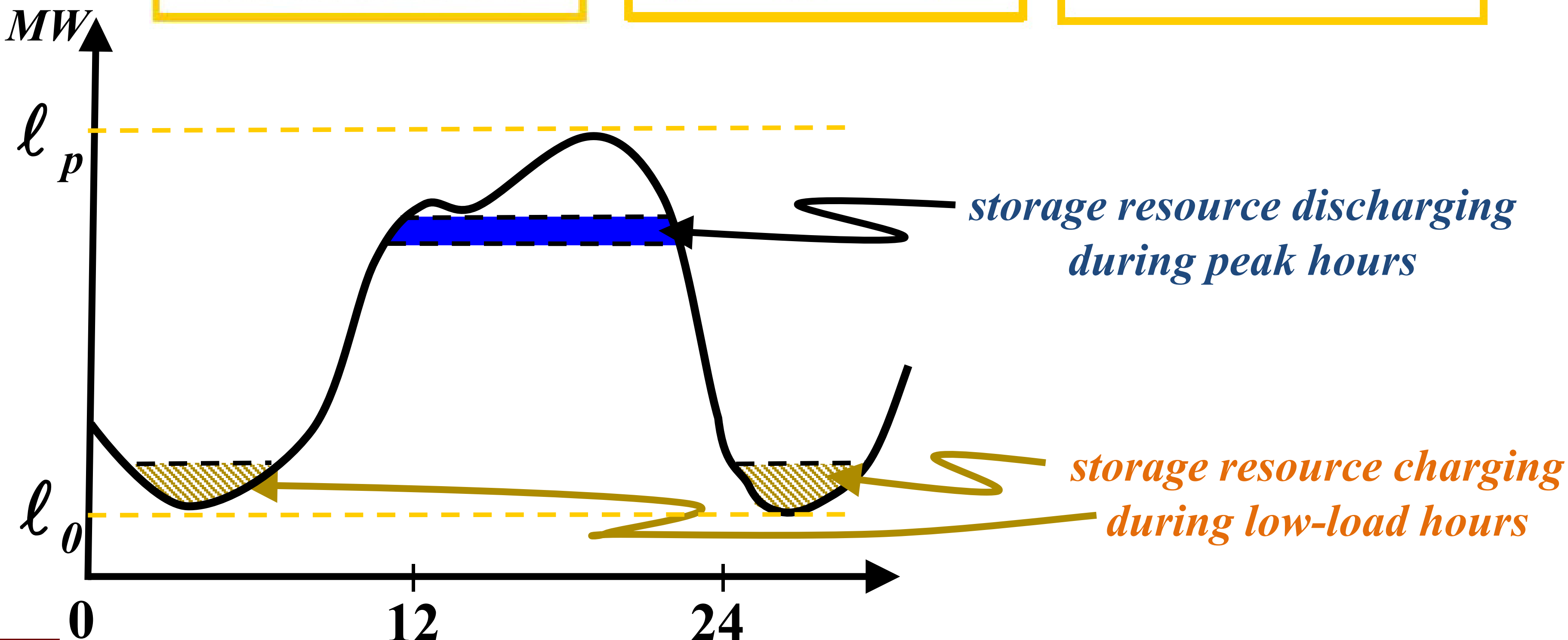
Resource Mix Planning



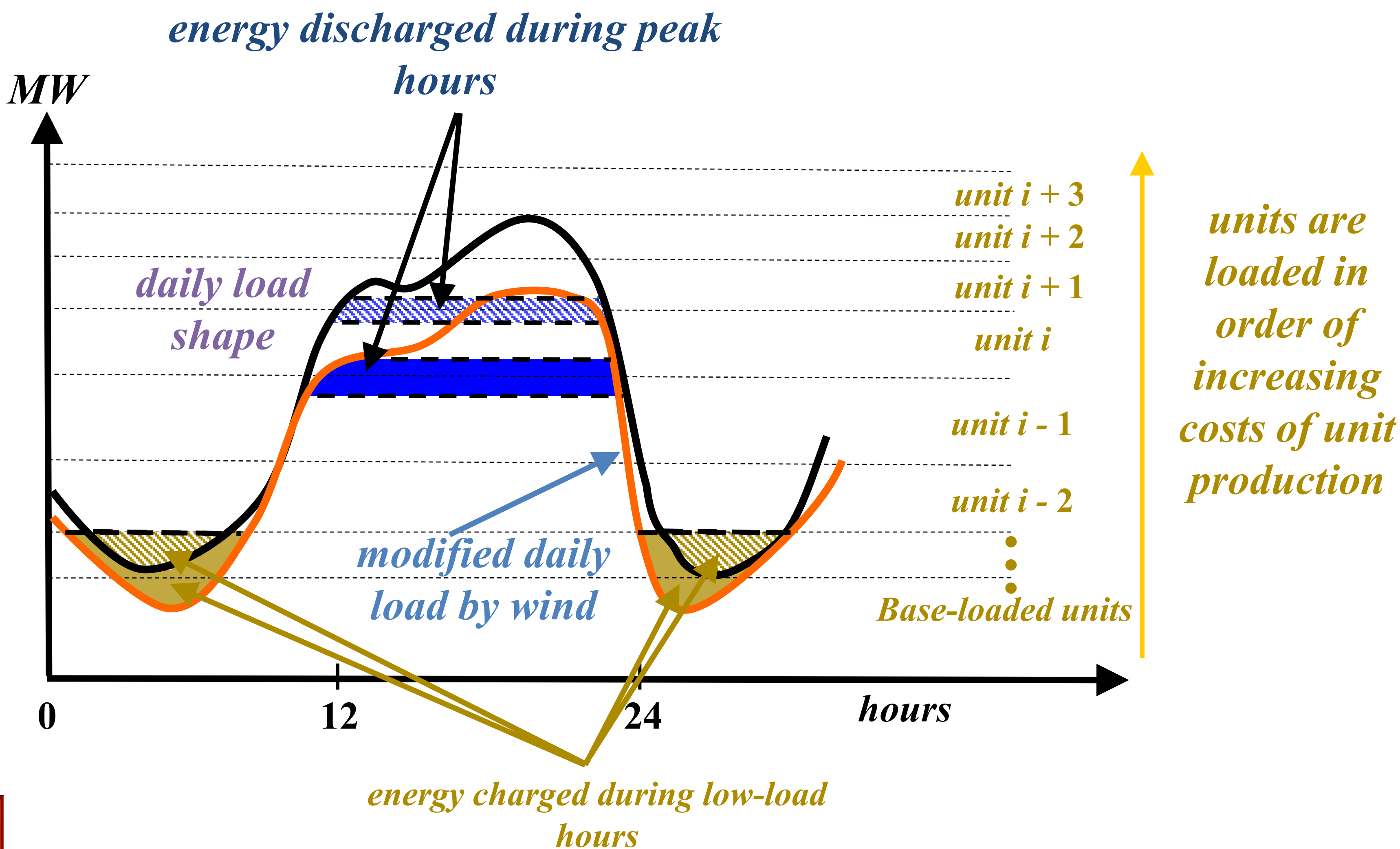
Utility-Scale Storage Application



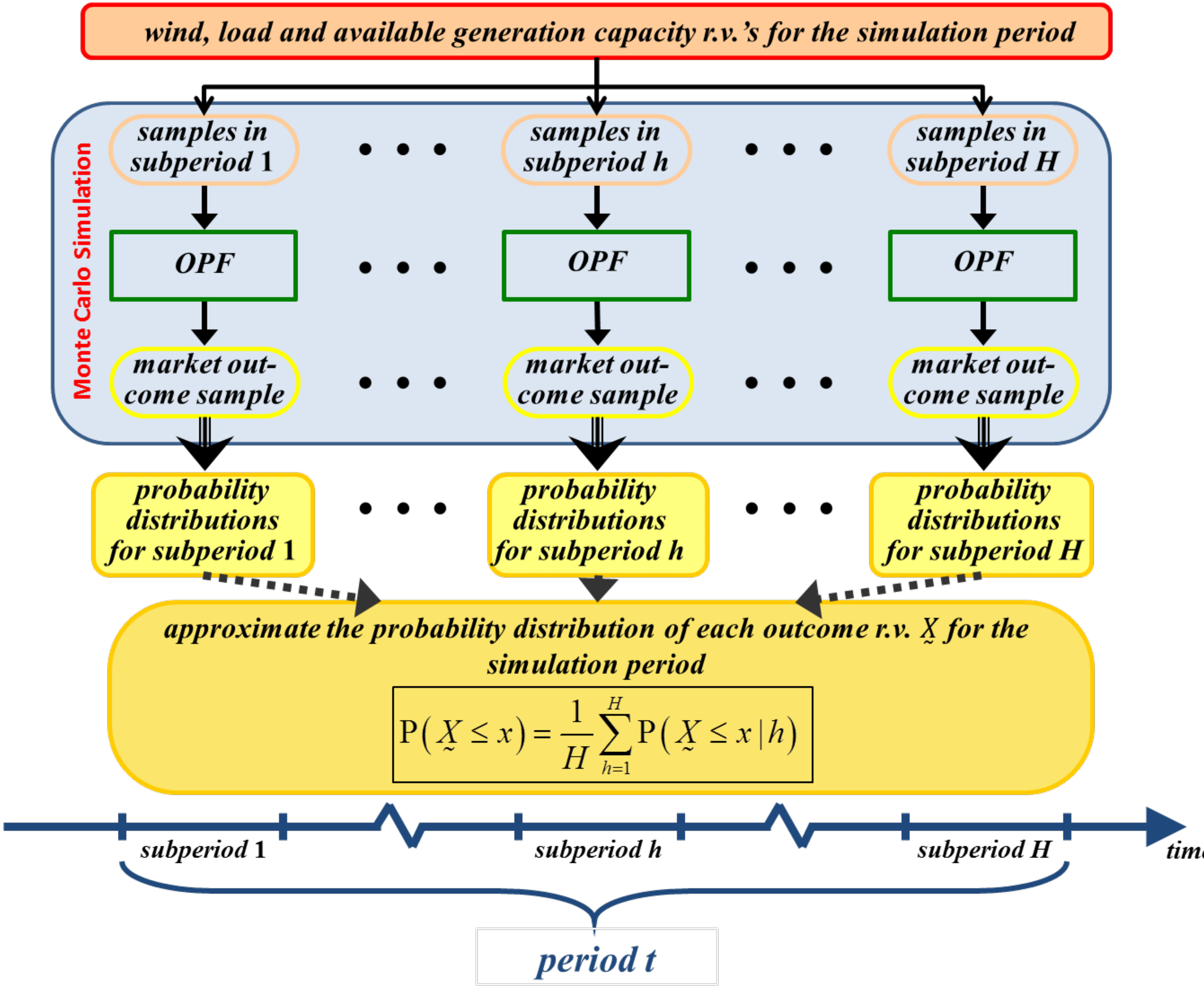




Wind/Storage Interactions



Simulation Approach



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