Planning Reliable Grid with Variable Generation and Storage

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Bits and Watts
August 9, 2018
Stanford Bits and Watts Initiative

- Around 20 industrial affiliates: Utilities, OEMs, other
- 15 faculty & research staff
  - Arun Majumdar is Faculty Director
- 5 schools & Hoover Institution
- 25+ graduate students
Planning for Reliable Renewable Power
2018-2019 Bits & Watts Project

Problem
Planning future low-carbon grid
Must keep power supply reliable, despite increase in variability

Goals & Objectives
1. Develop data-driven ML tools
   for probabilistic risk analysis
   • Renewables and storage
   • Extreme weather risk
   • Reliability and economics
2. Help utilities, RTOs, and NERC
to solve practical problems
3. Support decision making on
   regional and national levels

Dimitry Gorinevsky, EE
Sanjay Lall, EE / Aero Astro
Stephen Boyd, EE / MS&E / CS
Frank Wolak, Economics
Stephen Chu, Physics
Dian Grueneich, Precourt Institute
Optimize Investment into Evolving Power Grid

New England ISO
- Large power system, 3-year ahead planning

Horizon/Western Australia
- Mini-grid planning for remote community

ISO-NE Example
Horizon Power Esperance Example
1. Estimate probability distributions from data
2. Use the model to analyze the risk
   - Compute probabilistic assessment indexes: LOLP, LOLH
   - Base cases for detailed analysis, Monte Carlo simulations
RAPIER Tool
Risk Analysis and Prediction for Integrated Energy from Renewables

Constraints: Capacity, Transmission, Storage, Ramp Rate

Historical Data For Power Grid

Generator Outage
Solar Generation
Wind Generation
Demand Distribution

Multiple QR Model with Long Tails

Integrate Components

Assess Risk for Scenarios

Historical Data For Power Demand

LOLE = \sum_j \text{LOLP}(Z_j) \cdot P(Z_j)

Historical Data For Power Grid

Constraints: Capacity, Transmission, Storage, Ramp Rate

LOLP(Z_j) \rightarrow LOLH

Multiple QR Model with Long Tails

Conditional PDF for (Aug, Wed, 3pm, Workday)

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July 2018
Collaboration

- Open for partnerships with ISOs and NERC
- Guide research towards maximum impact
- Provide insights into probabilistic risk analysis issues