A Challenge Problem: Grid Operation with Emerging Dynamics and Uncertainties

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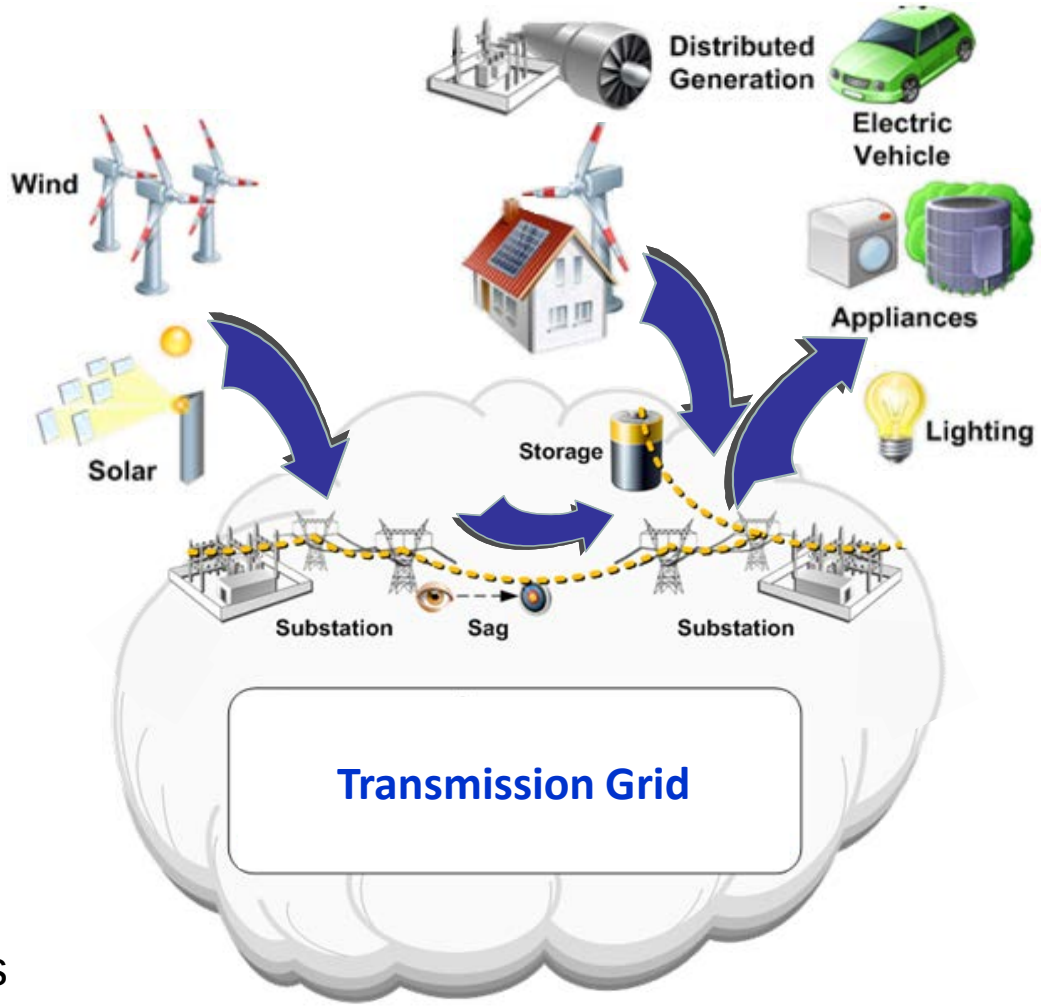
Challenges in future power grid operations

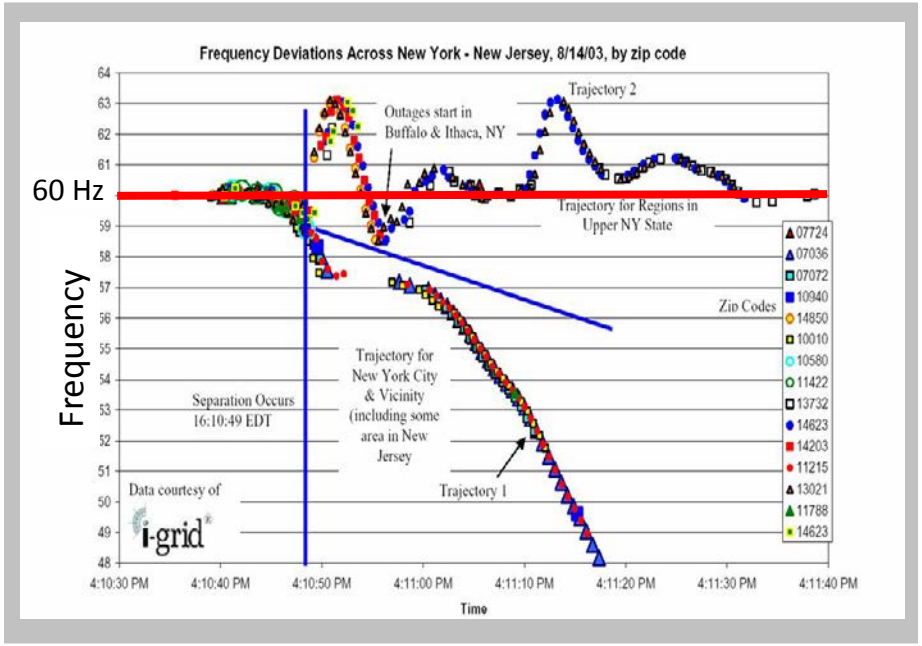
“Grid evolution meets information revolution”

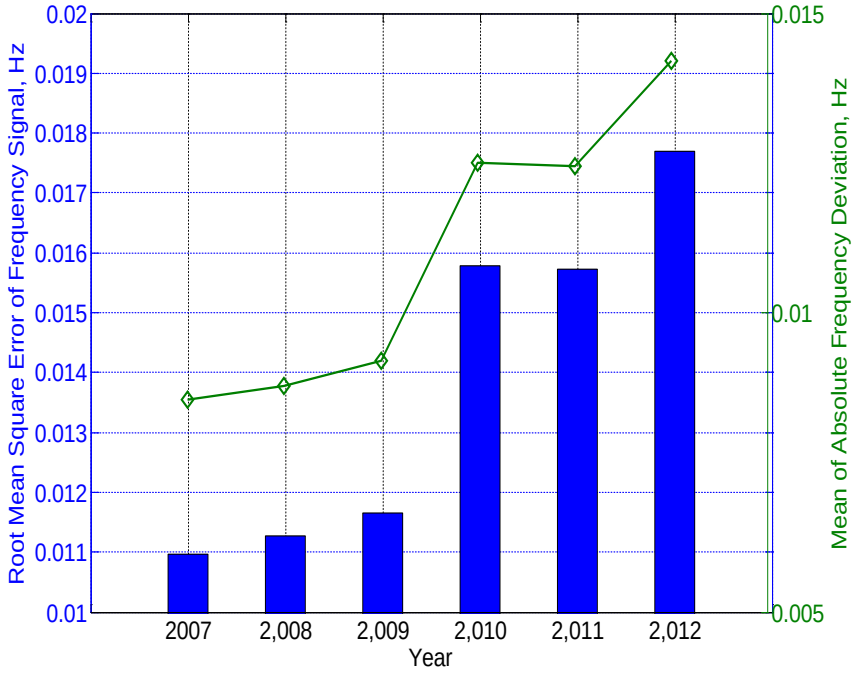
- **Grid Evolution** – stochastic & dynamic
  - Generation: intermittent renewable energy, distributed generation
  - Demand: smart loads, plug-in hybrids
  - Other: storage, new market design/incentives
- **Information Revolution** – data rich but information scarce
  - Large number of phasor measurement units, smart meters, and intelligent devices
  - Requirements of cyber security



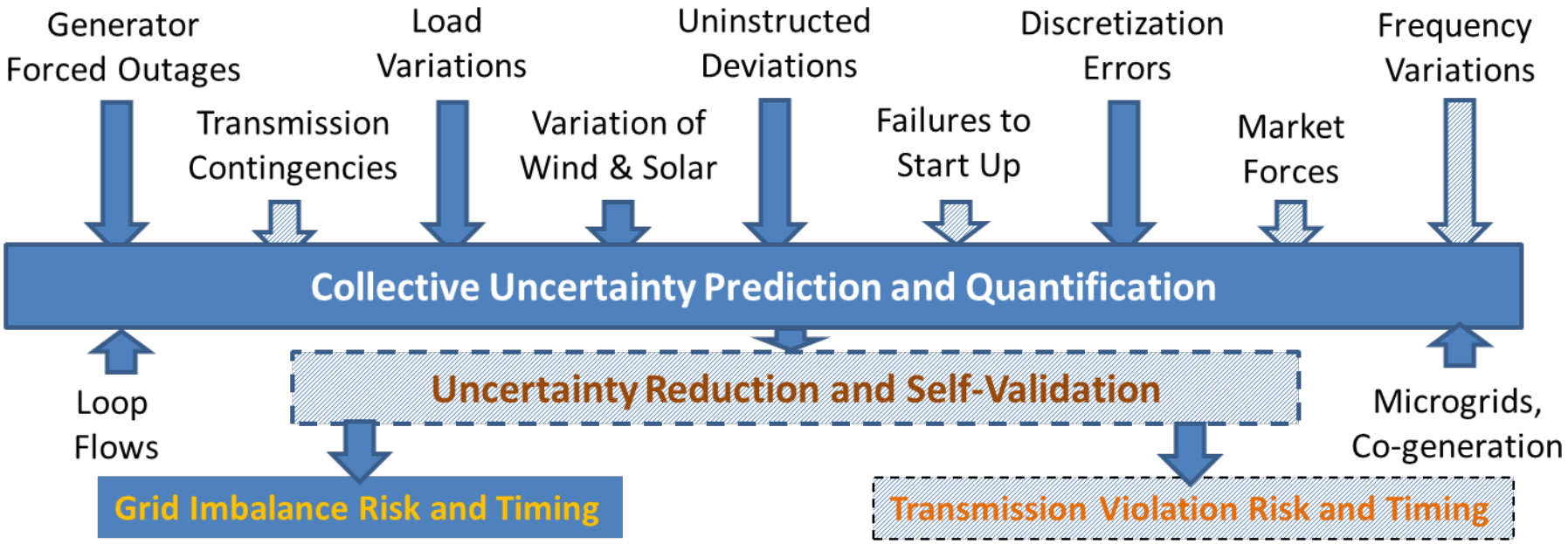
Trend of frequency variance

- Traditional state estimation does not accurately capture the system's dynamic status
  - During emergency situations, frequency is significantly off nominal 60Hz
  - During normal operation, frequency tends to deviate more often from 60Hz





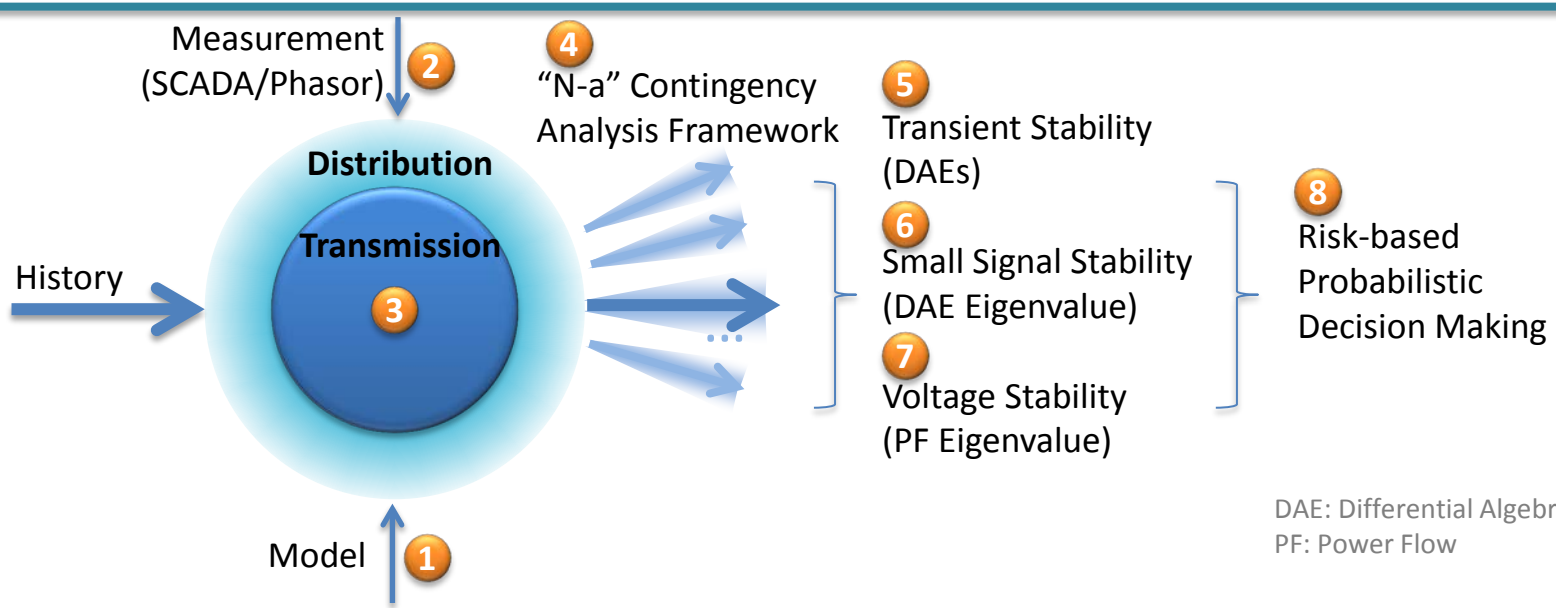
Larger impact of new and traditional uncertainties



- New uncertainties need to be understood and characterized
- Reduced operation margins tolerate less uncertainties

Credit: Yuri Makarov, PNNL

Challenge: predictive grid operation with dynamics and uncertainties



DAE: Differential Algebraic Equations
PF: Power Flow

1. Model building considering Transmission + Distribution, >10x larger equations
2. Data technologies to enable >100x faster ingestion and retrieval speed
3. Dynamic state estimation (model + data assimilation) from seconds (SCADA) to subseconds (phasor)
4. Efficient "N-a" contingency analysis considering mixed discrete (topology changes) and continuous (wind deviations) events with probability distribution
5. Look-ahead dynamic simulation >10x faster than today's tools
6. Small signal stability >10x faster
7. Voltage stability analysis >100x faster
8. Risk-based probabilistic decision making to handle >100x more information within the same or shorter operation cycle

Suggested breakout discussions

- (30 minutes) Refine the challenge problem

- (75 minutes) Envision a solution
  - Candidate workflow of an operational solution
  - Key sub-problems associated with the workflow or key integration problems in delivering the workflow
    - Data requirements
    - Computation requirements
    - Visualization requirements
    - Interoperability of software modules
  - Technology assessment: what is in use, what is in research, what is a gap, where are the risks
- (30 minutes) Measure successes
  - Metrics for workflow and sub-problems: how do we measure success

Questions?