Climate-resilient Power Systems Planning

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Climate Resilience in Power Systems

Key considerations:
- Current weather risks vs. long-term climate trends
- Especially significant for systems with centralized and interconnected network of generation, transmission and distribution assets spread over a wide geography
- Vulnerability assessment: Supply-side (RE and thermal) and demand-side
- Resilience building approaches: more work needed to inform investment decision-making
  - System wide planning, and
  - Project level design

Challenges:
- Regional climate variations, geographic spread of the system
- Availability of down-scaled data
- Variation in generation mix
- Availability of climate projections and derivatives in a format for supply side impact assessment

**Climate Projections**
- Obtain relevant raw climate variables projections for the system (based on generation mix and resource base)

**Climate Derivatives**
- Obtain/develop custom derivatives for climate metrics

**Response Functions**
- Develop mathematical functions b/w climate-metrics and performance of generation technologies, siting of new generation, electricity demand, etc.

**Resilience Measures**
- Identify resilience measures including: generation technology alternatives, siting options, regional power market, demand-side response, etc. Each measure will assume certain technical and institutional capabilities

**Modeling approach**
- Incorporate these functions and resilience measures in the planning model
Assessing Climate Impacts for Power System

**Demand-side**
- Raw climate variables
- Climate derivatives (HDD, CDD)
  - Temp-Sensitive Demand and non-TSD
  - Weather-response functions
- Impacts:
  - LDC shifts, increased peak demand, demand-response limitations
- Significant studies available

**Supply-side**
- Raw climate variables
  - temp, precipitation, sea-level rise, incidence of extreme events, etc.
- Climate derivatives
  - HDD, CDD, coastal and river flooding risk, consecutive dry days, heat wave duration index
- Impacts:
  - Generation (RE & thermal), transmission, distribution
  - Less studied: integration of climate projections to assess system-wide impacts
Modeling approach

**Stochastic Programming**
- uncertainties around climate and conventional parameters (fuel prices/availability, economic growth, outages, etc.) captured *directly* in the planning optimization by specifying probability distributions
- planning optimization seeks an expected-least-cost generation/transmission plan that will deliver the best performance on average
- Limitation: relies on quantification of risks by explicitly specifying probability distributions (quantified uncertainties)

**Robust Decision-making**
- when climate models do not converge or other climate data constraints, use a range for future climate variables (e.g. +/-20%) based on current weather
- no probability distributions assigned to indicate deep uncertainty
- solve the model for the entire range of scenarios
- use statistical analyses to identify key conditions under which each strategy satisfies or fails the stated objectives