WORLD BANK GROUP
Energy & Extractives

Climate-resilient Power Systems Planning

Neha Mukhi (Climate Change Specialist)

March 16, 2016

Climate Resilience in Power Systems

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

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

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