The Cost of Policy Uncertainty in Electric Sector Capacity Planning

*Implications for Instrument Choice*

Dr. Benjamin D. Leibowicz
Assistant Professor
Graduate Program in Operations Research and Industrial Engineering
Graduate Program in Energy and Earth Resources
Department of Mechanical Engineering
The University of Texas at Austin
Dealing with Uncertainty

- Generation assets have long service lives, over which a number of relevant factors are highly uncertain.
  - Energy commodity prices, policies, electricity demand, etc.

- There are several methodologies for making power sector investment decisions under uncertainty.
  - For example: sensitivity analysis, scenario analysis, Monte Carlo simulation, decision analysis, stochastic programming.
Stochastic Programming

• Determine the optimal near-term hedging strategy $x$ and state-dependent recourse decisions $y$ that maximize (or minimize) the expectation of objective value $z$ over all states of the world $s$.

• Hedging incorporates generality and flexibility.
• If we know from the start which state of the world will occur, we can perfectly tailor all decisions to that state.

• Suppose the objective is cost minimization.

• Expected value of perfect information (EVPI) tells us how much less costly our perfect information solution is, on average, than our stochastic solution.
Capacity Planning in ERCOT

**2016 Energy Use**
351 billion kilowatt-hours of energy used in 2016, 1.1 percent more than 2015.
*Includes solar, hydro, petroleum coke, biomass, landfill gas and DC Ties.

**2016 Generation Capacity**
*Includes solar, hydro and biomass.

- **Natural Gas**: 153,492,278 MWh (43.7%)
- **Coal**: 101,107,061 MWh (28.8%)
- **Wind**: 53,134,173 MWh (15.1%)
- **Nuclear**: 42,090,729 MWh (12%)
- **Other**: 1,699,114 MWh (0.5%)

71,110 MW Record peak demand (Aug. 11, 2016)

- **Wind Generation record**: 16,022 MW (Dec. 25, 2016)
- **Wind Penetration record**: 48.28 percent (March 23, 2016)

556 MW of utility-scale installed solar capacity as of January 2017
- Solar capacity in queue:
  - 2017: 1,211 MW
  - 2018: 1,511 MW
OSeMOSYS Model for ERCOT

- Minimize total generation system costs over 2016–2040.
- Dispatch computed for 20 representative timeslices parameterized using hourly load, wind, and solar data.
Climate Policy Uncertainty

• Reformulate OSeMOSYS as a two-stage stochastic program to determine the optimal near-term hedging strategy under climate policy uncertainty.

• Consider three alternative instruments.
  – Carbon tax, carbon cap, renewable portfolio standard.

• Five possible policy levels for each instrument.
  – No policy, Weak, Moderate, Strong, Very strong.

• Calibrate the instruments so that, in a deterministic setting, they all lead to the same minimized cost objective value at each policy level.
Most Relevant Literature

• **Energy modeling based on stochastic programming:**

• **Instrument choice:**
Calibrated Policy Instruments

<table>
<thead>
<tr>
<th>Policy Level</th>
<th>Probability</th>
<th>Tax ($/tCO₂)</th>
<th>Cap (MMtCO₂)</th>
<th>RPS (%)</th>
<th>Cost ($Billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Policy</td>
<td>0.2</td>
<td>0</td>
<td>159.3</td>
<td>12.5</td>
<td>216.6</td>
</tr>
<tr>
<td>Weak</td>
<td>0.4</td>
<td>20</td>
<td>72.1</td>
<td>56.3</td>
<td>235.7</td>
</tr>
<tr>
<td>Moderate</td>
<td>0.2</td>
<td>40</td>
<td>33.9</td>
<td>77.2</td>
<td>251.4</td>
</tr>
<tr>
<td>Strong</td>
<td>0.1</td>
<td>60</td>
<td>16.9</td>
<td>86.2</td>
<td>260.5</td>
</tr>
<tr>
<td>Very Strong</td>
<td>0.1</td>
<td>80</td>
<td>12.9</td>
<td>89.8</td>
<td>265.0</td>
</tr>
</tbody>
</table>

- This carbon tax distribution is based on a survey of 14 utilities in the Western U.S. (Bistline, 2015).
- The other instruments are calibrated to result in the same minimized cost objective values.
Summary of Findings

• Facing an uncertain carbon tax, the optimal hedging strategy is a wait-and-see approach.
  – Delay action as much as possible, then accelerate decarbonization if the tax turns out to be high.

• Facing an uncertain carbon cap or RPS, the optimal hedging strategy is a prepare-for-the-strictest approach.
  – Decarbonize aggressively in the near term, and accept the unnecessary cost this entails if the policy turns out to be weak.

• The cost of policy uncertainty is higher under a cap than a tax, and highest under an RPS.
Hedging Under a Carbon Tax
Hedging Under a Carbon Cap
Hedging Under an RPS
Carbon Emissions

**Carbon Tax**
- Years: 2015 to 2040
- Emissions (MMtCO₂): 0 to 200

**Carbon Cap**
- Years: 2015 to 2040
- Emissions (MMtCO₂): 0 to 200

**RPS**
- Years: 2015 to 2040
- Emissions (MMtCO₂): 0 to 200

Legends:
- No Policy
- Weak
- Moderate
- Strong
- Very Strong
- Stochastic - No Policy
- Stochastic - Weak
- Stochastic - Moderate
- Stochastic - Strong
- Stochastic - Very Strong
Cost of Policy Uncertainty

![Bar chart showing cost of policy uncertainty for Carbon Tax, Carbon Cap, and RPS. The costs are measured in billions. Carbon Cap has a moderate cost, while RPS has a much higher cost.]
Takeaways

• Policy uncertainty is costly in the electric sector, so commitments to long-term policies are valuable.

• Some degree of policy uncertainty is inevitable, and from the perspective of electricity decision making, this favors price-based over quantity-based instruments.

• Price-based instruments offer greater flexibility because they affect parameters of the objective function, rather than constraints that restrict the feasible region.
The End


