Uncertainty, Risk and Electricity Sector Planning

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We Simply Don’t Know...

EIA Natural Gas Price Forecasts, 1979-2012

Energy Information Administration - Annual Energy Outlook - Reference Case or Equivalent - Average Delivered Price - All Sectors

Real Natural Gas Price (2010 US$ per MMBTU)

Kentucky Energy Database, EEC-DEDI, 2012

Source: Aron Patrick KY Energy and Environment Cabinet
Energy markets, Energy technology, & Regulation in the energy sector Are hard to forecast

→ Electricity sector planning is difficult
Actually it’s really difficult

Because electric utility capital investments:

• Are large & irreversible
• Have multiple alternatives
• Lead to uncertain outcomes
  – long lifetime, lead times
  – uncertain inputs – e.g. fuel prices
  – alternative investment costs are uncertain
  – path dependencies
Perfect Foresight Scenario Analysis

Use model to project optimal investment and operations decisions for a known future
• Optimal timing
• Optimal for single future

*Know future is uncertain so do for multiple scenarios*

• Series of optimal decisions for known futures
• Does not pick hedging investment
• Does not produce risk metrics

This is how utility planning decisions are typically presented to public utility commissions
Picking Scenarios

Scenarios should capture full range of uncertainty for all relevant scenarios

• May require multiple scenarios for key variables

• Combinations of sources of uncertainty

• How many scenarios?
  – As many as you can process and effectively communicate
Risk

There are different definitions depending on the discipline: Finance, economics, psychology, political science,…

A risk implies both:
• Exposure to an undesirable outcome
• Uncertainty about the chances of its occurrence

Once you have calculated or assessed risk you need to weigh it against other objectives like cost
• What does it cost to reduce risk?
**Example Risk Metric: Regret Scores**

<table>
<thead>
<tr>
<th>Total Cost of Generation Plans (30-year NPV)</th>
<th>Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Possible Investments:</td>
<td></td>
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</tbody>
</table>

**Retire 1000MW of coal, replace with 1000MW NGCC**

**Retrofit 1000 MW of coal with emissions controls**

**Note that scenario selection is key and can change the results**

- Determine maximum regret score for each option
- Investment # 2
  - Optimal under only 1 scenario
  - Robust – lowest maximum regret score

Possible Investments:
Real Options Basics

Real Options analysis means considering all managerial flexibility in an investment decision

• ability to defer/delay, build in stages, mothball, abandon

When an investment is made, you lose the option to wait

• Assumes investment is irreversible

Pindyck & Dixit’s Real Options

• Traditional Net Present Value (NPV) analysis:
  – “Invest if $\text{PV(Benefits)} - \text{PV(Costs)} > 0$”

• Options (or “modified NPV rule”) analysis
  – “Invest if $\text{PV(Benefits)} - \text{PV(Costs)} - \text{PV(Forgone option)} > 0$”
Real Options Basics Cont.

Perfect foresight scenario analysis does not capture this value

Practical implication: decisions or investments that delay major capital investments have value that may not be captured

• PPAs, incremental generation, etc.
• Wait for information to avoid regrets
• Can model this value
• *Does not mean capital investments should be deferred, rather options to defer and the potential gains from deferral should be examined*
  – *Lead times may mean you cannot defer a decision*
Sensitivity Analysis

Sensitivity of results to changes in uncertain variables
• what variables matter (based on plausible range)

How much can variable X change before changing optimization outcome
• Generally change 1 variable at a time
• Can change more than 1 variable
Thank you

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Additional Resources

• *Making Hard Decisions*, Clemen and Riley

Assessing the Risk of Utility Investments in a Least-Cost Planning Framework

Least Risk Planning for Electric Utilities