Risk 101 and decision Making in the face of uncertainty

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Any decision on power sector capacity planning involves trading one risk for another.
Planning for small probability catastrophic events is hard

• How low is the probability?
• How bad can be the losses?
• Actions can be directed towards
  – Reducing the probability of the events
  – Reducing the losses when the events occur
• But these actions…
  – Are not unique
  – Require large & irreversible investments
    • Divert economic and institutional resources from other needs
      – Reduce the ability to hedge against other risks
  – Lead to uncertain outcomes
    • May create path dependencies
      – Decisions today determine the availability of future choices

Example: National Academies Consensus 2017: nobody has a primary responsibility for building resilience to LLD-outages
Discussing about these risks and any related decisions may be more productive if we make an effort to share our understanding of uncertainty, risk and the tools to manage it.
What is risk?

An individual is jumping from an airplane without a parachute? Does he face a risk?

We take one ball from a black urn and look at its color. Do we face a risk?

A risk implies both:

• **Exposure** to an undesirable outcome

• **Uncertainty** about the chances of its occurrence

To understand risks it is necessary to characterize both!!
Characterizing Uncertainty

1. Define **random variable**
2. Enumerate all possible outcomes
3. Determine probabilities of outcomes

**Take one ball with your eyes closed**

1. $X =$ color of ball picked up at random
2. $X$ may be **blue** or **red**
3. Probability that $X$ is **blue** is 50%
   Probability that $X$ is **red** is 50%

Repeat experiment several times and try to **infer** the probability

1. $X =$ color of ball picked up at random
2. $X$ may be **blue**, **red**, **yellow**, **green**, ..
3. Probability that $X$ is **blue** is ?%
   Probability that $X$ is **red** is ?%
   Probability that $X$ is **yellow** is ?%

**Uncertainty**

**Deep uncertainty**
Repeat experiment several times and try to **infer** the probability

1. $X =$ color of ball picked up at random
2. $X$ may be **blue**, **red**, ..
3. Probability that $X$ is **blue** is ?%
   Probability that $X$ is **red** is ?%
   Probability that $X$ is **yellow** is ?%

**Frequentist view:**

“**Probability** of an event is the **frequency** with which it occurs in a long sequence of similar trials”
Example random variable

$Z = \text{Price of natural gas in the U.S. in January 2030}$

1. What kind of random variable is this?
2. What is the probability that it will be <$20/MMBtu?
3. What is the probability that it will be <$5/MMBtu?
4. Can we use the frequentist approach to find a probability?

Bayesian view:

“Probability of an event is the degree of a belief a person has that it will occur”

There is no experiment we can conduct to infer the probability

We can develop a model that explains NG prices as a function of other thousand variables but...
EIA Natural Gas Projections, 1979-2012

Henry Hub Natural Gas Price
dollars per million Btu

Historical spot price
STE0 forecast price
NYMEX futures price
95% NYMEX futures upper confidence interval
95% NYMEX futures lower confidence interval

Note: Confidence interval derived from options market information for the 5 trading days ending Apr. 3, 2014. Intervals not calculated for months with sparse trading in near-the-money options contracts.

Source: Short-Term Energy Outlook, April 2014.

Severe EIA Underestimations (1995-2005)
Worst-Possible Type of Error for Kentucky

Kentucky Energy Database, EEC-DEDI, 2012
How to deal with risk?

• Assess risk
  – What is the risk of an large area outage of long duration next year?
    • Define possible causes of LLD outages
    • Assess probabilities of those causes
    • Estimate area affected
    • Estimate duration
  *Unless completely deterministic, refrain from point estimates
  *Estimate as ranges or probability distributions

• Assess opportunities for risk reduction
  – What are possible “insurance” alternatives
    • To reduce the probability of occurrence
    • To reduce the area affected
    • To reduce the duration of the outage

• Assess costs of risk reduction
  – What is the cost of the different alternatives
  – What are associated alternatives

• Assess your own attitudes towards risk
  – Are you comfortable paying a premium to reduce risk?
What is your preference when trading **risk** and **expected return**?
<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>You get $28 if tails, $28 if heads</td>
</tr>
<tr>
<td>2.</td>
<td>You get $24 if tails, $36 if heads</td>
</tr>
<tr>
<td>3.</td>
<td>You get $20 if tails, $44 if heads</td>
</tr>
<tr>
<td>4.</td>
<td>You get $16 if tails, $52 if heads</td>
</tr>
<tr>
<td>5.</td>
<td>You get $12 if tails, $60 if heads</td>
</tr>
<tr>
<td>6.</td>
<td>You get $2 if tails, $70 if heads</td>
</tr>
</tbody>
</table>
What is your preference when trading risk and expected return?

Expected value

- $0
- $6
- $12
- $18
- $24
- $34

Standard deviation

Risk averse
Risk neutral
Risk seeking

What is your preference when trading risk and expected return?
What criteria defines “the best decision alternative” depends on decision maker’s risk preferences!!
We have different preferences

We choose different tradeoffs between risk and expected value of return

How should these choices be made on behalf of the public?

Hard question because the option of “not playing the lottery” (i.e., not making a decision) is not available!

Need to use tools of risk analysis
• to think better about the choices
• to inform a deliberative-participatory process
Tools of risk analysis teach us we should:

1. Determine uncertainties and formulate probabilities

2. Use this uncertainty characterization and find the strategy that:
   - Minimizes risk without exceeding allocated budget
   - Minimizes cost for a desired level of risk-reduction

3. Iterate over 1 and 2

4. Identify strategies that although may not be optimal under any one scenario, are acceptable under all of them

Re substituting uncertainty with the average or most likely value leads to suboptimal choices.

Not easy to agree on the risk measure, or the approach but we must try.

Because probabilities are “subjective beliefs”

ROBUST strategies!!
Thank you!

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