SCENARIO PLANNING
DEVELOPING AND IMPLEMENTING SCENARIOS FOR YOUR INTEGRATED RESOURCE PLAN

Horizons Energy
Indiana Contemporary Issues Conference
April 25, 2017
AGENDA

• Why Scenario Analysis is Important
• Developing Scenarios (Qualitative)
  – Scenario Building Blocks
  – Themes
  – Story Lines
  – Timelines
• Implementing Scenarios (Quantitative)
  – National Level IRP
  – Utility Level IRP
Why Scenario Analysis Is Important

Challenge the status quo

“If past history was all there was to the game, the richest people would be librarians.”

Warren Buffett

Anticipate the unexpected!

“A failure of imagination. We failed to imagine that the era we now find ourselves in could ever happen.”

Thomas Kean, Chair, 9/11 Commission, July 23, 2004

Consistently assess business decisions

“We are continually faced by great opportunities brilliantly disguised as insoluble problems.”

Lee Iacocca
“As we know, there are known knowns; there are things we know we know.

We also know there are known unknowns; that is to say we know there are some things we do not know.

But there are also unknown unknowns—the ones we don’t know we don’t know.”

Donald Rumsfeld
United States Secretary of Defense, February 12, 2002

Rumsfeld was referring to the Department of Defense use of a Johari Window
**Johari Window**

<table>
<thead>
<tr>
<th>KNOWN</th>
<th>UNKNOWN</th>
</tr>
</thead>
<tbody>
<tr>
<td>“As we know, there are known knowns; there are things we know we know.”</td>
<td>An unknown known is something we know, but do not realize is relevant.</td>
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Black Swan Event (Unknown, Unknown)

Unexpected events of large magnitude and consequence. Such events, considered extreme outliers, collectively play vastly larger roles than regular occurrences.

While Black Swans are unpredictable by definition (unknown, unknown), we still can perhaps study their impacts. In other words, we may not know the cause, but we can guess possible impacts to the utility industry input drivers.
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Scenario Building Blocks

• **Time Horizon** – Generally 20 or more years

• **Predetermined Elements** – Legal, Market, or Societal Forces
  (microgrids, market competition, reliability)

• **Key Uncertainties** – Forces driving fundamental changes
  (renewables, batteries, natural gas, environmental concerns)

• **Prime Movers** – Intuitions and actors that can directly affect Key
  Uncertainties (President, Congress, EPA, FERC, IURC, State
  Governments, RTOs)

• **Wildcards** – High-impact very low probability events (i.e. Black
  Swan Events)

• **Signposts** – Specific future events that may signal or verify the
  existence of a scenario
The scenario building blocks are organized into themes. The idea is to create unique plausible futures based on a theme.

The themes could be around Technology, Reliability, Globalism, Isolationism, Terrorism, Green World, etc.

The goal is to create diverse themes which “bookend” a wide variety of plausible futures. It’s important to avoid the tunnel vision and herd mentality of the day when creating the themes.
A Storyline is developed for each Scenario Theme. In this exercise, the stakeholders identify events which are expected to occur in this scenario including their impact and timing.

The idea is to create a narrative around each plausible future by identifying signposts which may indicate the pace and direction of that particular scenario.
Developing Timelines

A Timeline is developed for each Storyline. The timeline provides the necessary information to model the scenario.

- **EIA load forecast**
  - CAGR ≈ 1%

- **54 GW of coal-fired generation retired (2016-2020)**

- **Forward Curve for fuel blended to EIA Long-Term Forecast**
  - Existing Environmental Regulations

- **5.5 GW of new nuclear on-line**

- **No CO2 Tax**

- **New supply-side resource mix is largely combined cycles, wind, and solar**

- **Renewable generation serves 14% of load**

- **CO₂ emissions reduced to 10% below 2005 levels**

- **73 GW of coal retired (2021-2036)**

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2018 2020 2022 2024 2026 2028 2030 2032 2034 2036
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## Scenario Drivers

<table>
<thead>
<tr>
<th></th>
<th>Status Quo</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
<th>Scenario 4</th>
<th>Scenario 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand</td>
<td>Reference</td>
<td>Low</td>
<td>Medium-Low</td>
<td>Medium-High</td>
<td>High</td>
</tr>
<tr>
<td>Fuel</td>
<td>Reference</td>
<td>Low</td>
<td>Medium-High</td>
<td>Medium-Low</td>
<td>High</td>
</tr>
<tr>
<td>Technology Improvements</td>
<td>Current</td>
<td>Current</td>
<td>Battery, smart grid, EE, EV</td>
<td>Battery, smart grid, EE, EV</td>
<td>Advanced battery, smart grid with fed incentives</td>
</tr>
<tr>
<td>Environmental Regulations</td>
<td>Existing Laws</td>
<td>Existing Laws</td>
<td>CO2 Cap and Trade</td>
<td>CO2 Tax</td>
<td>CO2 Rate Cap</td>
</tr>
<tr>
<td>Reserve Margin</td>
<td>Pool Requirements + 1%</td>
<td>Pool Requirements + 2%</td>
<td>Pool Requirements</td>
<td>Pool Requirements + 2%</td>
<td>Pool Requirements + 3%</td>
</tr>
</tbody>
</table>
Market Simulation (National IRP)

Data

Fundamental Data Sources
- EIA 860
- EIA 923
- FERC 714
- EPA NEEDS
- EIA NEMS
- NYMEX
- NREL
- Horizons Energy Research

EIA NEMS Model

Integrated Market Model
- Energy Prices
- Capacity Prices
- Ancillary Services Prices
- Emissions Prices
- Fuel Prices
- REC Prices
- Capacity Additions
- Capacity Retirements
Balancing Authorities (21)
Balancing Authorities (BA) are defined as the NERC Assessment Areas. The minimum reserve margin is set for each BA.

Areas (76)
Areas are the zonal pricing points (energy, capacity, AS) within ISOs, RTOs, and the traditional market structures. The transmission limits (energy and capacity) are defined between the Areas.

Resources
- Grid-connected generating resources

Fuels
- Fuel and Fuel Delivery

Emissions
- SO₂, NOₓ, CO₂ Emission Rates; Units identified by CPP

Expansion
- Resources are added economically to maintain reliability
From Scenarios to Strategy

External Market Data:
- Emissions Caps
- Transmission Topology
- Demand Requirements
- Existing Generators
- Fuel Supply & Transportation
- Renewable Requirements
- Construction / Retrofits

Local Market Data:
- Demand Requirements
- Existing Generators
- Fuel Delivery Costs
- Renewable Requirements
- Construction / Retrofit Alternatives

Portfolio Data:
- Generator Ownership
- Purchase & Sale Contracts
- Fuel Contracts
- Emission Allowances
- Project Financing

Market Simulation

Market Price Forecasts:
- Power
- Fuel: Coal, Gas, Oil
- Emission Allowances
- Renewable Energy Credits

Portfolio Optimization
National IRP – Scenario 5
The Portfolio Hand-Off

Proceed with caution.

The input driver assumptions (fuel prices, load, policy, etc.) and the output results (energy prices, capacity prices, emission prices, allowance prices, A/S prices, etc.) are then passed to the Utility's portfolio model for detailed optimization.

Be sure all of the inputs and outputs are consistent between the market model and portfolio model including time-of-day data.
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