Qualitative & Quantitative Foundations of Energy Emergency Management

Jeffrey R. Pillon, Director of Energy Assurance
National Association of State Energy Officials
Workshop Topics

- Qualitative and Quantitative Foundations of Energy Emergency Management
- Communicating Energy Data Analysis for Informed Decision-Making
- Energy Assurance and Resilience: A Cross-Functional View
- Federal Resources to Support States’ Energy Data and Risk Analysis
- DOE CESER/HAMMER ESF-12 Training Demonstration
- Transforming Raw Data into Actionable Data
- State-Led Training and Exercise Best Practices
- Protecting Critical Infrastructure Information from public disclosure
Energy Assurance -- Preparedness and Resiliency

- **Mitigate Risks** through policies, programs and investments that provide for a more secure and resilient energy infrastructure that also reduces interdependencies impacts.

- **Plan and Respond** to events that disrupt energy supply and assure a rapid return to normal conditions. This is a coordinated effort involving the private energy sector’s response, augmented by local, state, and federal governments as needed.
**Qualitative vs. Quantitative**

- **Qualitative** -- relating to, or involving peculiar and essential character
  - Example: I am hearing from a lot of energy suppliers that they are having supply problems.

- **Quantitative** -- relating to, or involving the measurement of quantity or amount
  - Example: 75 percent of the 50 energy suppliers in our weekly survey are limiting deliveries

*Note: both perspectives have value, but quantitative is of greater importance to most decision makers.*
Qualitative and Quantitative Data Analysis
Understanding what’s going on

- How do you develop a big picture view from all the various sources of data and information to make informed decisions?

- Consider three perspectives:
  1. What is the data telling you (quantitative)
  2. What are the energy suppliers telling you (qualitative)
  3. Trade publications, mass media, social media (quantitative and qualitative)

- Where do the conclusions concur and diverge? How do you reconcile the divergent information?

- How is the information actionable?
Types of Analysis

- **Comparative and Predictive Statistics** e.g. how do market indicators like inventories, productions, prices, etc. from last year compare to today or an average of recent years, or with conditions in other states and regions. The use of introspection of the data using graphs and short term forecast can be very helpful in the analysis.

- **Time Series Statistical Analysis** looks at trends and relationships with other explanatory variables. How are various times series correlated? For example, how much residential natural gas is used by heating degree day which can be determined by using single or multiple regression analysis to see how two or more variables are related and the strength of the relationship.

- **Econometric Modeling** overlaps with statistical analysis to a considerable degree however the focused is more in economic data. For example adjusting a price times series in to real constant dollars which removes the effects of inflation and allows for prices to be compared over times in a more consistent ways. Models can be more complex and consider the dynamic relationships and how various economic activity measure's change in relationship with one another.
Risk – The potential for an unwanted outcome resulting from an incident, event, or occurrence, as determined by its likelihood and the associated consequences.

- **Consequences:** If something happens, what are the human and economic impacts to society?
  - Must also consider how economic impacts will affect interdependent infrastructures and behavior of impacted populations
- **Threats/Hazards:** What can happen? What is the frequency/probability?
- **Vulnerabilities:** Are there weak links in the energy supply chain and infrastructure? Are components antiquated/old and failure prone? Are there infrastructure co-locations or bottlenecks? Why is it critical?
  - Includes consideration of energy infrastructure attributes and interdependencies

Figure 4 – Critical Infrastructure Risk in the Context of National Preparedness

Source: NIPP 2013 Partnering for Critical Infrastructure Security and Resilience
The April 16, 2013, assault on the Pacific Gas and Electric Company’s Metcalf substation near San Jose, California damaged 17 transformers, caused $15 million in damage, and put the facility out of service for nearly a month.
In the last five years weather and climate disasters have costing a total of $513 billion & 3,910 deaths.

The Enbridge Pipeline – A Case Study

The Michigan Pipeline Safety Advisory Board, oversaw extensive studies on a single critical energy infrastructure the 65 year old Enbridge pipeline (Line 5) which moves 23 million gallons per day of light crude oil and natural gas liquids through Michigan.

- Two studies were done at a total costs of $3.6 million paid for by Enbridge and conducted under the direction of the State of Michigan to provide a cost benefit analysis.
  - An Alternative Analysis was which looked the cost and feasibility of a range of alternatives to replace the dual pipeline line crossing the bottom of the Straits of Mackinaw.
  - An Independent Risk Analysis that looked at the economic, environmental and human consequences of a worst case scenario from a pipeline rupture.
**Alternative Analysis**

A consultant analyzed the alternatives to Line 5. The Final Report includes an analysis of the alternatives that the state identified to transport the same amount of product that moved through the existing Straits pipelines. The cost of shutting down the existing pipeline was also included in the analysis. Lead times for completion were also estimated.

<table>
<thead>
<tr>
<th>Alternatives Assessed</th>
<th>Construction Cost in Millions</th>
<th>Operating Cost Million $ per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing pipeline</td>
<td>N/A</td>
<td>$95</td>
</tr>
<tr>
<td>New Pipeline</td>
<td>$2,025</td>
<td>$586</td>
</tr>
<tr>
<td>Rail Transportation</td>
<td>$908</td>
<td>$1,220</td>
</tr>
<tr>
<td>New Trenched Crossing</td>
<td>$27</td>
<td>$95</td>
</tr>
<tr>
<td>New Tunnel Crossing</td>
<td>$153*</td>
<td>$95</td>
</tr>
</tbody>
</table>

*A subsequent Enbridge report to the State of Michigan titled “Alternatives for replacing Enbridge’s dual Line 5 pipelines crossing the Straits of Mackinac” June 2018 concluded the tunnel crossing would cost between $300 and $500 million and take 5 to 6 years to complete based on additional geological data.*
Based on this, six critical locations, shown above the analysis looked at the impact of each including both pinhole leak and full-bore rupture failure modes.

The “worst-case scenario” was the release of 58,000 barrels (2.4 million gallons) of oil from a double rupture which would cause at least $1.9 billion in costs for environmental cleanup, property loss, lost income from tourism and recreation, and other damages and impact more than 400 miles of shoreline in Michigan, Wisconsin, and Canada.
Cost Benefit Summary

- The cost to construct the pipeline tunnel is currently estimated to be between $350 and $500 million which would reducing the environmental od a risk of a spill into the great lakes to near zero vs. the $1.9 billion plus risk estimate.

- Will improve reliability create jobs, and minizine the risk of a fuel shortage.

- Enbridge will pay for the cost of constructing and operation of the tunnel which will be owned by the state upon completion.

- For more information and copies of the studies go to https://mipetroleumpipelines.com/
Forecasting

- Short-term time series forecast Like the EIA Short-Term Energy Outlook can be useful due to the lag in the reporting of actual data. For example, forecasting residential propane demand under normal weather conditions and a plus and minus 10% range can provide baseline and boundaries for actual observed conditions.

- The Michigan Energy Appraisal used a statistical method called Auto-Regressive Integrated Moving Average (ARIMA) which is an econometric forecasting tool which uses a maximum likelihood estimation and not ordinary least squares used in regression analysis.
Use of Graphs and Other Means to Visually Display Quantitative Data

- Types of Displays
  - Time series graphs
  - Mapping (GIS)
  - Comparative graphs
  - Showing relationships
  - Process flow charts
  - Dashboards
  - Pictures
  - Short videos

- Some Do’s & Don’t
  - Don’t use legends use direct labels
  - List the sources used or the URL reference(s)
  - Include the date (mm/yy)
  - Make sure it tells the story
  - Don’t use decimal places when displaying numbers unless they are significant
Crude Oil Prices react to a variety of geopolitical and economic events

$/b (real 2010 dollars)

Source: Energy Information Administration, What drives crude oil prices? January 9, 2018 | Washington, DC
Figure 6. East Coast and Gulf Coast refineries and key product flows

https://www.eia.gov/analysis/transportationfuels/padd1n3/pdf/transportation_fuels_padd1n3.pdf
Figure 6. Generalized Midwest and Rocky Mountain key refinery hubs and product flows

Source: U.S. Energy Information Administration

Product Supply Overview:
Midwest (PADD 2) and Rocky Mountain (PADD 4)
Generalized Flows of Transportation Fuels

Note: The flows of transportation fuels depicted have been simplified. Actual routes, pipelines, and flows vary.
Figure 1: US oil and gas employment and oil prices


NEW ENGLAND DASHBOARD

11/14/19 Capacity status, megawatts (MW)

20,315 MW
Today's capacity

17,350 MW
Today's forecasted peak demand hour ending 6:00 p.m.

17,409 MW
Yesterday's peak demand hour ending 6:00 PM

7,236 MW
Generation outages / reductions

100 %
Regional nuclear utilization

Normal
Current grid status as of 11/14/19, 10:29 a.m.

15,990 MW
Current demand 11/14/19, hour ending 8:00 a.m.

28,130 MW
Historic winter peak demand 8/2/06

-3,356 MW
Today's peak hour interchange (-) imports / (+) exports 11/14/19, hour ending 6:00 PM

3.68 Bcf/d
Net natural gas inflows

$1.69/MMBtu
Algonquin Citygate Basis to Henry Hub

Spark spread
($/megawatt-hour)

Current 19.00 11/14/19
Previous 14.59 11/13/19
U.S. net imports of crude oil and liquid fuels

million barrels per day

Note: Liquids fuels include: gasoline, distillate fuels, hydrocarbon gas liquids, jet fuel, residual fuel oil, unfinished oils, other hydrocarbons/oxygenates, and other oils.

Source: Short-Term Energy Outlook, November 2019
Figure 3.20  Infrastructure Interdependencies

<table>
<thead>
<tr>
<th>Element</th>
<th>Electrical Power</th>
<th>Natural Gas</th>
<th>Oil Industry</th>
<th>Water Purification</th>
<th>Sewage Treatment</th>
<th>Hospital &amp; Health Care Services</th>
<th>Food Industry</th>
<th>Meteorological Services</th>
<th>Rail Services</th>
<th>Trucking</th>
<th>Municipal Transit Systems</th>
<th>Roads Infrastructure</th>
<th>Hazardous Materials</th>
<th>Public Works</th>
<th>Police Services</th>
<th>Fire Services</th>
<th>Ambulance Services</th>
<th>911 Services</th>
<th>Warning Sirens</th>
<th>Flood Control</th>
<th>Search and Rescue</th>
<th>Office Building Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Services</td>
<td>Hospital &amp; Health Care Services</td>
<td>Food Industry</td>
<td>Postal and Courier Services</td>
<td>Meteorological Services</td>
<td>Financial Services</td>
<td>Rail Services</td>
<td>Trucking</td>
<td>Municipal Transit Systems</td>
<td>Roads Infrastructure</td>
<td>Hazardous Materials</td>
<td>Public Works</td>
<td>Police Services</td>
<td>Fire Services</td>
<td>Ambulance Services</td>
<td>911 Services</td>
<td>Warning Sirens</td>
<td>Flood Control</td>
<td>Search and Rescue</td>
<td>Office Building Systems</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transportation</td>
<td>Rail Services</td>
<td>Trunking</td>
<td>Municipal Transit System</td>
<td>Roads Infrastructure</td>
<td>Traffic Control</td>
<td>Hazardous Materials</td>
<td>Public Works</td>
<td>Police Services</td>
<td>Fire Services</td>
<td>Ambulance Services</td>
<td>911 Services</td>
<td>Warning Sirens</td>
<td>Flood Control</td>
<td>Search and Rescue</td>
<td>Office Building Systems</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

improve reliability
Figure 16. Central Atlantic motor gasoline supply/demand balance, 2014

Note: All domestic movements and inventory changes are reported on a net basis.
Source: ICF Analysis of EIA, FHWA, FERC, and company 10-K data

https://www.eia.gov/analysis/transportationfuels/padd1n3/pdf/transportation_fuels_padd1n3.pdf page 39
Figure 25. Southeast motor gasoline supply/demand balance, 2014

Note: All domestic movements and inventory changes are reported on a net basis.
Source: ICF Analysis of EIA, FHWA, FERC, and company 10-K data

https://www.eia.gov/analysis/transportationfuels/padd1n3/pdf/transportation_fuels_padd1n3.pdf page 59
Figure 13. Eastern Midwest motor gasoline supply/demand balance, 2015

Note: All domestic movements and inventory changes are reported on a net basis. Sources: ICF analysis of EIA, FERC, and company 10-K data.
# Electricity CO2 Emission Intensities

Source: Commissioner J Andrew McAllister, California Energy Commission, NASEO Annual Meeting Septembers 2019
In Conclusion:

Key Points to Remember

1. Know the state’s and local critical energy infrastructure supply chains and its capacity and throughput.
2. Know about energy infrastructure in other regions and states that are important to your energy supply.
4. Maintain up to date spreadsheets or date bases or references on your State’s key energy statistics you’ll never know when you might really need them.
5. Keep a library of other important online statistics of supply and demand indicators like Heating Degree Days, measures of economic activities, state demographic -- population, housing units by heating fuel, vehicles registrations, etc.
6. Find and use graphs you like, don’t use legends or too many decimal points.
Thank you!

Questions, Comments, or Observations?

Jeff Pillon, Director, Energy Assurance, NASEO
Telephone: 517.580.7626
Email: jpillon@naseo.org