Update on Reliability Risk Modeling

CIFP - Resource Adequacy
July 17, 2023
Purpose of this Presentation

• Provide an update on RTO reliability risk modeling

• Review and discuss the results of the updated analysis, including sensitivities on the extended weather history and climate change adjustments

• Share indicative results of accreditation by resource class reflecting contribution to reliability in the latest analysis
Review: Reliability Risk Modeling Framework

**Weather Scenarios**
Historical weather patterns observed from expanded history
• Adjusted to capture impact of climate change on temperatures

**Load Scenarios**
Hourly load profiles derived from PJM’s Load Forecast model for each weather scenario
• Weather patterns shifted forward and backward to account for day of the week / holiday variables

**Resource Performance Scenarios**
Unit, class, & fleet historical performance (forced outages, ambient de-rates, etc.) as a function of weather for thermal and variable generation
• Correlated outages for any reason captured in patterns and distribution of class & fleet outage rates

**Resource Adequacy Analysis**
Model system resource adequacy under thousands of alternative histories
• One alternative weather history, reflecting distribution of uncertainty given 50+ years of history
• One alternative load history, reflecting distribution of load forecasts given weather, time/date, etc.
• One alternative realization of capacity resource performance, reflecting distribution of potential performance of individual resources and historically observed correlations across resources

**Risk Metrics & Patterns of Reliability Risk**
## Summary of Model Updates

<table>
<thead>
<tr>
<th>Model Update</th>
<th>Relative Shift in Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Adjusted modeling of resource performance in extreme hot temperatures (now slightly worse than before)</td>
<td>+ Summer risk</td>
</tr>
<tr>
<td>2. Applied weather rotation across days of week (impacting load forecast, not generation)</td>
<td>+ Summer risk</td>
</tr>
<tr>
<td>3. Updated thermal fleet to derive performance shapes</td>
<td>Negligible</td>
</tr>
<tr>
<td>4. Capped resource output at CIRs</td>
<td>Negligible</td>
</tr>
<tr>
<td>5. Expanded weather history to 50 years*</td>
<td>+ Winter risk</td>
</tr>
<tr>
<td>6. Applied adjustment to account for climate change*</td>
<td>+ Summer risk</td>
</tr>
</tbody>
</table>

* Simulations run with and without extended weather history and climate change adjustments
Climate Change Adjustments: Alternatives

Method A “Trends in Extremes”

For each season…
For each hour of the day…
- Estimate trend in seasonal minimum
- Estimate trend in seasonal mean
- Estimate trend in seasonal maximum
- Apply adjustment to historical temperatures:
  • Adjust min temp by trend in minimum
  • Adjust mean temp adjusted by in means
  • Adjust max temp by trend in maximums
  • Adjust in between by interpolation

Method B “Trends in Means”

For each season…
For each hour of the day…
- Estimate trend in seasonal mean
- Apply adjustment to historical temperatures:
  • All temps adjusted by trend in means

Additional detail provided in appendix
Summary of Latest Simulations and Results

<table>
<thead>
<tr>
<th>Simulation</th>
<th>EUE</th>
<th>LOLH</th>
<th>LOLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Updated risk modeling with:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Weather history back to 1993</td>
<td>64% 36%</td>
<td>49% 51%</td>
<td>31% 69%</td>
</tr>
<tr>
<td>- No climate change adjustment</td>
<td>EUE = 1,400 MWh</td>
<td>LOLH = 0.33 hours</td>
<td>LOLE = 0.10 days</td>
</tr>
<tr>
<td>2 Simulations that use extended weather history back to 1973</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 With no climate change adjustment</td>
<td>W:71% S:29%</td>
<td>W:57% S:43%</td>
<td>W:42% S:58%</td>
</tr>
<tr>
<td></td>
<td>1,700 MWh</td>
<td>0.38 hours</td>
<td>0.10 days</td>
</tr>
<tr>
<td>2A With climate change adjustment using Method A</td>
<td>W:35% S:65%</td>
<td>W:25% S:75%</td>
<td>W:17% S:83%</td>
</tr>
<tr>
<td></td>
<td>1,200 MWh</td>
<td>0.31 hours</td>
<td>0.10 days</td>
</tr>
<tr>
<td>2B With climate change adjustment using Method B (mean trend only)</td>
<td>W:46% S:54%</td>
<td>W:30% S:70%</td>
<td>W:21% S:79%</td>
</tr>
<tr>
<td></td>
<td>1,400 MWh</td>
<td>0.33 hours</td>
<td>0.10 days</td>
</tr>
</tbody>
</table>

Summer: 51% \(\text{LOLH} = 0.33\) hours \(\text{EUE} = 1,400\) MWh

Winter: 49% \(\text{LOLH} = 0.33\) hours \(\text{EUE} = 1,400\) MWh

LOLH = 0.33 hours

LOLE = 0.10 days
Expanding weather history to 1970s introduced more uncertainty than expected:

- Additional data reduces variance but introduces bias that must be accounted for
- Alternative reasonable assessments of climate trends materially impact patterns of risk
- In-house assessment of trends found different trends than expected from climate literature, and we have not identified a scientific consensus regarding how to conduct the necessary adjustments

In other words, it is unclear what we learn from the additional data on climate extremes in the 1970s & ‘80s if, given the changing climate:

- There is uncertainty regarding how different those weather events would look today, and
- There is uncertainty regarding the probability with which they would re-occur today

**Working Proposal:** Maintain ~30 year weather window to 1993; may re-evaluate post CIFP

Seeking stakeholder feedback on this initial course of action
## Estimated 26/27 Class Average Accreditation Values
*(based on “Model 1” to 1993)*

<table>
<thead>
<tr>
<th>Resource Type</th>
<th>Summer</th>
<th>Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermals (Overall) *</td>
<td>95%</td>
<td>78%</td>
</tr>
<tr>
<td>Nuclear *</td>
<td>98%</td>
<td>96%</td>
</tr>
<tr>
<td>Coal *</td>
<td>89%</td>
<td>86%</td>
</tr>
<tr>
<td>Gas CC *</td>
<td>97%</td>
<td>76%</td>
</tr>
<tr>
<td>Gas CT *</td>
<td>98%</td>
<td>63%</td>
</tr>
</tbody>
</table>

### Existing ELCC Resources

<table>
<thead>
<tr>
<th>Resource Type</th>
<th>Summer</th>
<th>Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onshore Wind</td>
<td>9%</td>
<td>36%</td>
</tr>
<tr>
<td>Offshore Wind</td>
<td>17%</td>
<td>68%</td>
</tr>
<tr>
<td>Solar Fixed Panel</td>
<td>19%</td>
<td>2%</td>
</tr>
<tr>
<td>Solar Tracking Panel</td>
<td>32%</td>
<td>2%</td>
</tr>
</tbody>
</table>

### Class Rating

<table>
<thead>
<tr>
<th>Resource Type</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onshore Wind</td>
<td>10%</td>
</tr>
<tr>
<td>Offshore Wind</td>
<td>21%</td>
</tr>
<tr>
<td>Solar Fixed Panel</td>
<td>30%</td>
</tr>
<tr>
<td>Solar Tracking Panel</td>
<td>50%</td>
</tr>
</tbody>
</table>

For reference: Current 25/26 BRA ELCC for certain classes

Accreditation for remaining classes forthcoming.

* Does not yet reflect impact of planned & maintenance outages.
Next Steps

1. Complete accreditation calculation for all classes
   - Demand response, storage, hydro, etc.

2. Calculate summer & winter reliability requirements

3. Based on stakeholder feedback, assess sensitivity of risk modeling and accreditation results to:
   - Changes in assumed resource mix

4. Implement final changes to risk model:
   - Winter planned outages
Appendix
All Stations Mean Temp Trend since 1973 (Summer)

All Station Mean Temps Hour Ending 18 1973-2021

Mean temperature trending up by 0.07 degrees/yr
All Stations Mean Temp Trend since 1973 (Winter)

Mean temperature trending up by 0.08 degrees/yr
Slope of Estimated Linear Trend by Hour (Summer)

Slope of Temperature Trend by Hour of Day

-0.2
-0.15
-0.1
-0.05
0
0.05
0.1
0.15

Degrees/yr (°F)

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Current Hour Ending

Min Model Slope
Mean Model Slope
Max Model Slope