Planning for resource adequacy in six not-so-easy steps

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Moment Energy Insights
NARUC RA Training
May 18, 2023
Planning for resource adequacy (RA)

We’ll discuss one of the simpler environments for ensuring resource adequacy:

• A vertically integrated utility with a planning process (e.g. Integrated Resource Planning) and a centralized procurement process

Why is this “simple”?

• Resource decisions are centralized, so resources can be compared to one another in the context of the portfolio and an individual utility’s customer needs

When does it get more complicated?

• Decentralized resource decision-making (e.g. capacity markets, capacity payments, or RA programs that span multiple utilities) require attribution of needs and accreditation of resource contributions
  • Note that these issues can also apply to vertically integrated utilities with tariffs for non-centrally procured resources (e.g. DERs, PURPA projects, voluntary renewables, etc.)
• Everything that I’ll talk about applies in those systems as well... plus more.
## Six not-so-easy steps

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
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<tbody>
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<td>1</td>
<td>Set the planning standard and other policies</td>
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<td>2</td>
<td>Choose (and modify) a model</td>
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<td>3</td>
<td>Find (or develop) the data</td>
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<td>4</td>
<td>Evaluate the system without further action</td>
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<td>5</td>
<td>Design portfolios of actions to (approximately) meet the standard</td>
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<td>6</td>
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Considerations in choosing an RA standard

What are you trying to avoid?
- Any and all supply shortages? Good luck!
- Frequent supply shortages?
- Very large supply shortages?
- Shortages during critical periods, like dangerous weather?

What amount of failure is tolerable?

Do you need multiple criteria to avoid intolerable outcomes?

Some examples:

**Loss of load expectation (LOLE):**
Plan to experience a shortage on less than 1 day every 10 years

**Loss of load probability (LOLP):**
Plan to experience a shortage in less than 5% of all years

**Loss of load hours (LOLH):**
Plan to experience shortages in less than 2.4 hours per year

**Expected Unserved Energy (EUE):**
Plan to meet 99.99% of all demand

**Adequacy during critical events:**
Plan to meet demand during specific stress conditions

**Damage criteria:**
Plan for damages due to shortages to fall below a set value
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Other planning policies

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<th>What can be done other than building or buying new resources to reduce supply risk?</th>
<th>How much of these options should be assumed in planning?</th>
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<td>Scheduling practices, including unit commitment decisions and maintenance scheduling</td>
<td>Should you assume that maintenance is scheduled around the risky periods?</td>
</tr>
<tr>
<td>Improved load and resource forecasting</td>
<td>Should you assume that units are going to be committed during the riskiest periods?</td>
</tr>
<tr>
<td>Imports from neighboring utilities</td>
<td>How much of your import capability during the riskiest periods are you comfortable relying on in planning? And what about the rest of the time?</td>
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• These are policy calls – there is no right answer and some them matter a lot!
• The goal is not necessarily to reflect real operations in planning, but to develop planning policies that align with your risk appetite
Set the planning standard and other policies

Import policies for planning

Example policy: allow imports only to the extent that neighboring systems have excess available generation without additional buildout and subject to transmission limits

Choose (and modify) a model

Example: RA Modeling with GridPath (Monte Carlo weather mode)

RA models typically have several different modules that help to capture different risks, correlations, and system capabilities.

Source: “Advancing RA analysis with the GridPath RA Toolkit,” Oct 2022
https://gridlab.org/gridpathratoolkit/
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## Choose (and modify) a model

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<td>• Simple and fast</td>
<td>• RA metrics limited to LOLH and EUE</td>
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<td>• Cannot capture energy-related constraints (e.g. hydro and storage)</td>
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<tr>
<td>Time-sequential simulation</td>
<td>• Can account for energy-related constraints</td>
<td>• Model is more complex and slower to run</td>
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<td>• Can characterize events in terms of duration, magnitude, and frequency</td>
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<td>• Can improve treatment of correlations</td>
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### 2. Choose (and modify) a model

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The rest of this presentation focuses on time-sequential analysis
Choose (and modify) a model

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### Weather conditions

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<tr>
<td>Historically observed</td>
<td>• Ensures weather correlations are captured</td>
<td>• Limited overlapping historical data availability</td>
</tr>
<tr>
<td>conditions</td>
<td>• Transparent</td>
<td>• May not have enough conditions for high precision in RA metrics</td>
</tr>
<tr>
<td></td>
<td>• Can benchmark to historical operations</td>
<td>• Historical conditions may not be indicative of the future</td>
</tr>
<tr>
<td>Synthesized conditions</td>
<td>• Relatively simple to implement</td>
<td>• Can be difficult to capture correlations</td>
</tr>
<tr>
<td>(e.g. Monte Carlo)</td>
<td>• Can synthesize very large numbers of conditions to achieve high precision in RA metrics</td>
<td>• Can be opaque</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Conditions synthesized based on historical weather may not be indicative of the future</td>
</tr>
<tr>
<td>Future simulated conditions</td>
<td>• Can account for weather correlations</td>
<td>• Requires significant and highly specialized weather modeling effort</td>
</tr>
<tr>
<td></td>
<td>• Can account for climate change</td>
<td>• Requires very large numbers of simulations to achieve precision in RA metrics</td>
</tr>
<tr>
<td></td>
<td>• Can be transparent</td>
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## Choose (and modify) a model

### Outages

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<th>Method</th>
<th>What is it?</th>
<th>When might it be appropriate?</th>
</tr>
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<tbody>
<tr>
<td>Fixed derates</td>
<td>Reduce the max output of every unit by its forced outage rate</td>
<td>• For resources that can be highly modular (e.g. battery storage)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• When unit sizes are very small relative to the size of the system</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• When you need to screen a lot of potential portfolios and you don’t need high precision (i.e. as an intermediate step before more rigorous simulation)</td>
</tr>
<tr>
<td>Monte Carlo time-independent outage simulation</td>
<td>In every time step, randomly draw the outage state based on the forced outage rate regardless of the unit’s state in the prior timestep</td>
<td>• If you are estimating EUE or LOLH and don’t care about event duration or frequency</td>
</tr>
<tr>
<td>Monte Carlo failure/repair outage simulation</td>
<td>In every time step, randomly draw the transition from operating to outage using a failure model and from outage to operating using a repair model</td>
<td>• If you are interested in understanding event duration and frequency and you don’t know how weather impacts failure rates</td>
</tr>
<tr>
<td>Monte Carlo weather-driven failure/repair outage simulation</td>
<td>Use a failure/repair model with weather-driven failure rates</td>
<td>• If you are interested in understanding event duration and frequency and you do know how weather impacts failure rates</td>
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### Operations

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<tr>
<td>Fixed shapes</td>
<td>Assume all resources generate at their maximum capability in all hours&lt;br&gt;Use outboard modeling to estimate fixed shapes for energy-limited resources</td>
<td>Systems with little-to-no energy limited resources (e.g. hydropower, energy storage, or natural gas fuel constraints)</td>
</tr>
<tr>
<td>Heuristic dispatch</td>
<td>Use a set of rules to estimate dispatch in timestep</td>
<td>Single-zone systems (i.e. no transmission constraints)</td>
</tr>
<tr>
<td>Optimization-based dispatch</td>
<td>Use an optimization algorithm to estimate dispatch in order to minimize an objective (e.g. cost or unserved energy)</td>
<td>Multi-zone systems (i.e. systems with transmission constraints), systems with a lot of energy storage, and systems with other system-wide constraints (e.g. GHG emissions)</td>
</tr>
<tr>
<td>Economic unit commitment and</td>
<td>Detailed simulation of system scheduling and operational practices&lt;br&gt;Can require a lot more data and computational power than the other methods</td>
<td>RA analyses that seek to address the implications of forecast error in systems with a high reliance on units that are subject to economic commitment decisions</td>
</tr>
<tr>
<td>dispatch</td>
<td></td>
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Dispatch representation in an RA model may not reflect typical operations, but instead may explore what the system *could* do under highly constrained, typically rare, circumstances.
What other risks might be important for ensuring reliable supply to your customers?

- Off-the-shelf models may not address all of the risks that are important for ensuring RA on a given system
- Customization of RA tools for specific system is common
- These models are always evolving as systems change and new risks emerge

### Additional Risks
- Hydro conditions
- Temperature-based derates
- Icing
- Wildfires
- Transmission outages
- Fuel supply risks
RA analysis requires you to estimate demand and resource capabilities under many, many years of potential conditions (weather, outages, hydro availability, etc.)

- **Key question:** how indicative of future RA-related risks are your datasets?

**Publicly available data for RA analysis in the West**

**Estimated LOLE (days per 10 years) over historical weather record, with 2026 infrastructure**

Source: “Advancing RA analysis with the GridPath RA Toolkit,” Oct 2022
https://gridlab.org/gridpathratoolkit/
A base run, excluding incremental actions, gives you an indication of:

- The timing and nature of the RA challenges that you’re trying to solve
- A baseline from which to measure incremental capacity contributions
- The types of resources that might be well suited to solving the RA challenges

### Loss of Load Metrics

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<th>Value</th>
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<tr>
<td>$LOLP_{\text{year}}$</td>
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<tr>
<td>Average Event Duration (hrs)</td>
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<tr>
<td>Estimated* Perfect Capacity Need (GW)</td>
<td>9.3</td>
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Source: “Advancing RA analysis with the GridPath RA Toolkit,” Oct 2022
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Evaluate the system without further action

A base run, excluding incremental actions, gives you an indication of:
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### Event durations

Short duration solutions that are available on summer evenings (e.g. batteries or demand response) may be well suited to meet needs

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A base run, excluding incremental actions, gives you an indication of:
• The timing and nature of the RA challenges that you’re trying to solve
• A baseline from which to measure incremental capacity contributions
• The types of resources that might be well suited to solving the RA challenges

The base run does not tell you:
• How much capacity of a given type of resource you’d need to solve the RA challenges
  • “Perfect capacity” needs may be reported, but few options in today’s planning environment resemble this hypothetical resource:
    • Available in all hours to provide both capacity to the system without energy limitations
• The best combination of resources to meet your capacity needs

Answering these questions usually requires some guessing and checking
5 Design portfolios of actions to (approximately) meet the standard

- Fully endogenous RA modeling within portfolio optimization is not currently computationally feasible
- Instead, we employ approximations (guesses) in portfolio optimization and capacity expansion models and confirm adequate through roundtrip modeling (checks)

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<td>Effective Load Carrying Capabilities (ELCCs)</td>
<td>Add each candidate resource to the portfolio and calculate the change in perfect capacity needs as a % of installed capacity. Allow this % of the capacity to contribute to meeting the PRM in portfolio optimization.</td>
<td>Evaluating specific resources in an RFP</td>
</tr>
<tr>
<td>ELCC Curves (1-dimensional)</td>
<td>Calculate the avoided perfect capacity needs as more of each resource is added to the portfolio and provide the portfolio optimization with this curve.</td>
<td>IRP portfolio optimization when portfolios effects may be relatively small (e.g. when the portfolio does not include a lot of energy storage or hydropower).</td>
</tr>
<tr>
<td>Portfolio ELCC Surfaces (multi-dimensional)</td>
<td>Calculate the avoided perfect capacity needs as combinations of resources are added to the portfolio and provide the portfolio optimization with this multi-dimensional surface.</td>
<td>IRP or RFP portfolio optimization when portfolio effects are large and the number of resource options is relatively limited.</td>
</tr>
<tr>
<td>Critical condition testing within portfolio optimization</td>
<td>Explicitly model system performance during critical periods within portfolio optimization.</td>
<td>IRP portfolio optimization when critical periods are well understood for the system.</td>
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All values are illustrative – do not cite
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*Even though we refer to these as “ELCC curves”, they are often input into portfolio optimization and capacity expansion models in terms of capacity contribution (i.e. MW)
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*Even though we refer to these as “ELCC curves” and “ELCC surfaces”, they are often input into portfolio optimization and capacity expansion models in terms of capacity contribution (i.e. MW)
Because our approximations are not perfect, round-trip modeling ensures that final portfolios are adequate.

Confirm that the portfolios meet the standard

- Base portfolio
- Determine loss of load risk
- Loss of load metrics
- Portfolio meets standard?
  - Yes: Determine loss of load risk
  - No: Calculate resource contributions

New resources

- Optimized portfolios
  - ELCCs
  - ELCC curves
  - ELCC surfaces
  - Critical conditions

Portfolio meets standard?
- No: Calculate resource contributions
- Yes: Done!

Determine loss of load risk

Note: Sometimes you may need to test if the portfolio is materially overbuilt, by for example, backing out resources
Six Not-So-Easy Steps

1. Set the planning standard and other policies
2. Choose (and modify) a model
3. Find (or develop) the data
4. Evaluate the system without further action
5. Design portfolios of actions to (approximately) meet the standard
6. Confirm that portfolios meet the standard

Contact: Elaine Hart, Moment Energy Insights
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