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

Elaine Hart
Moment Energy Insights
NARUC RA Training
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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

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

1

Set the planning standard and other policies

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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1 Set the planning standard and other policies

Other planning policies

What can be done other than building or buying new resources to reduce supply risk?
Scheduling practices, including unit commitment decisions and maintenance scheduling
Improved load and resource forecasting
Imports from neighboring utilities

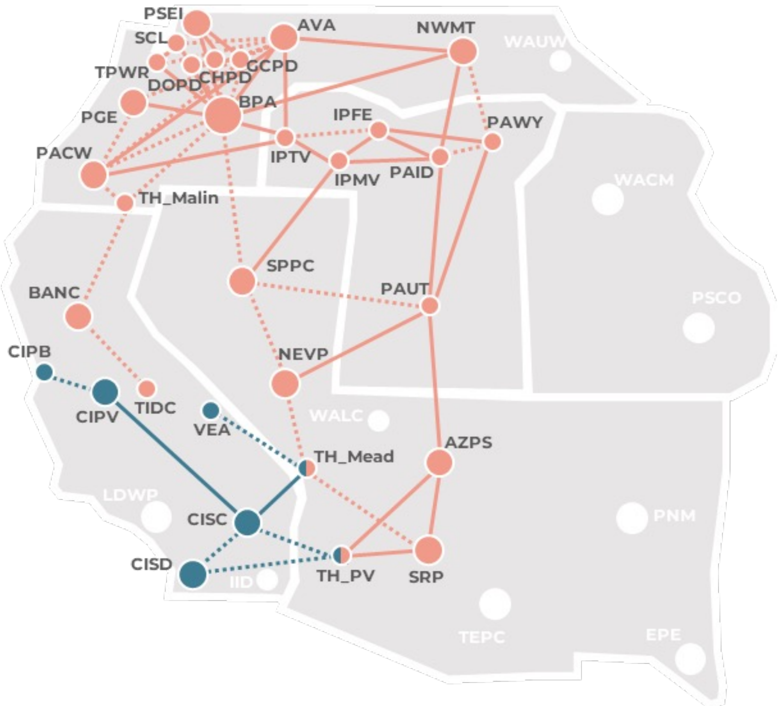
How much of these options should be assumed in planning?
Should you assume that maintenance is scheduled around the risky periods?
Should you assume that units are going to be committed during the riskiest periods?
How much of your import capability during the riskiest periods are you comfortable relying on in planning? And what about the rest of the time?

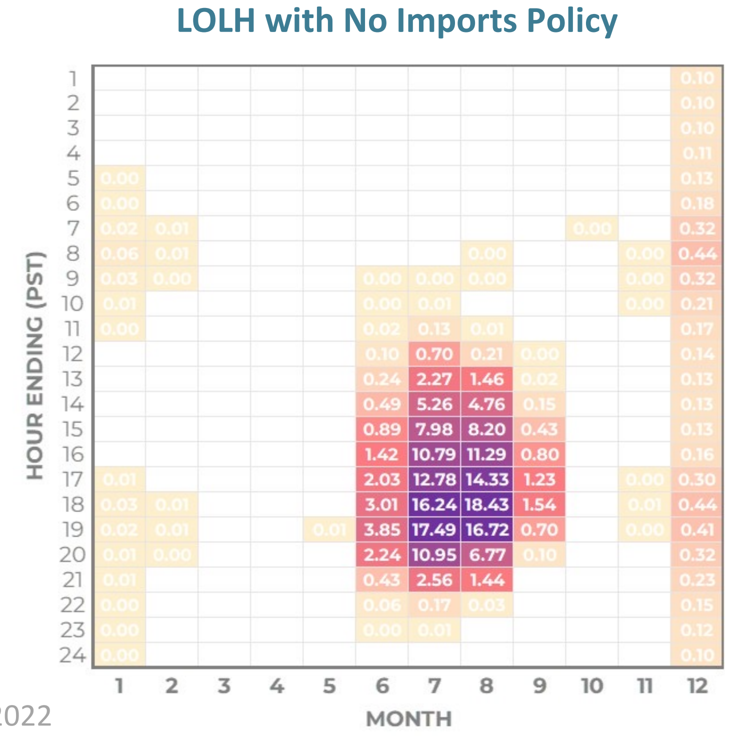
- These are policy calls – there is no right answer and some them matter a lot!
- The goal is not necessarily to reflect real operations in planning, but to develop planning policies that align with your risk appetite

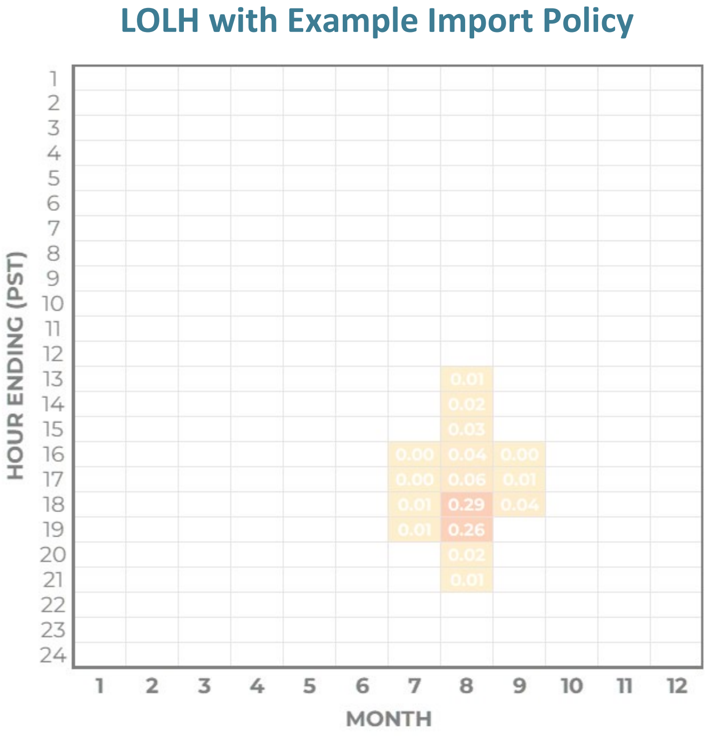
1 Set the planning standard and other policies

Import policies for planning

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



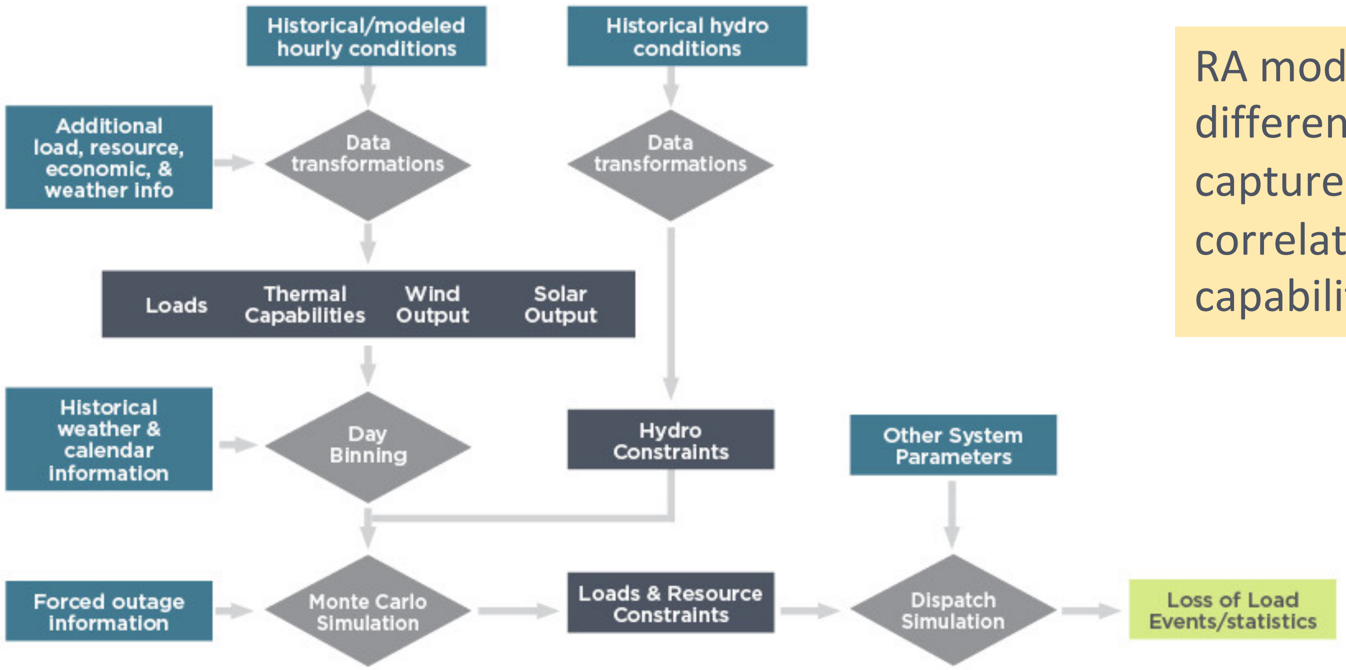




Source: "Advancing RA analysis with the GridPath RA Toolkit," Oct 2022
https://gridlab.org/gridpathratoolkit/

2 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.

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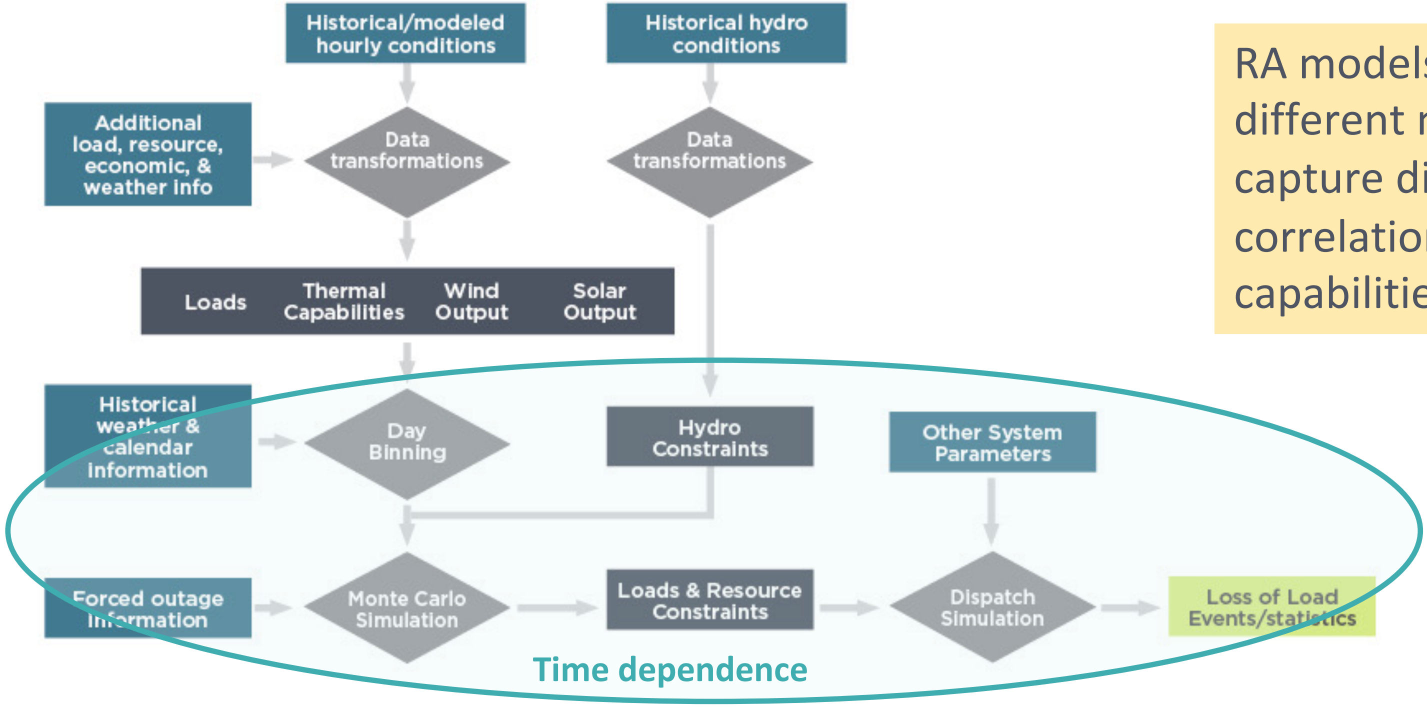

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Time-dependence

Method	Benefits	Drawbacks
Time-independent convolution-based methods	• Simple and fast	• RA metrics limited to LOLH and EUE • Cannot capture energy-related constraints (e.g. hydro and storage)
Time-sequential simulation	• Can account for energy-related constraints • Can characterize events in terms of duration, magnitude, and frequency • Can improve treatment of correlations • Can be more transparent	• Model is more complex and slower to run

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The rest of this presentation focuses on time-sequential analysis

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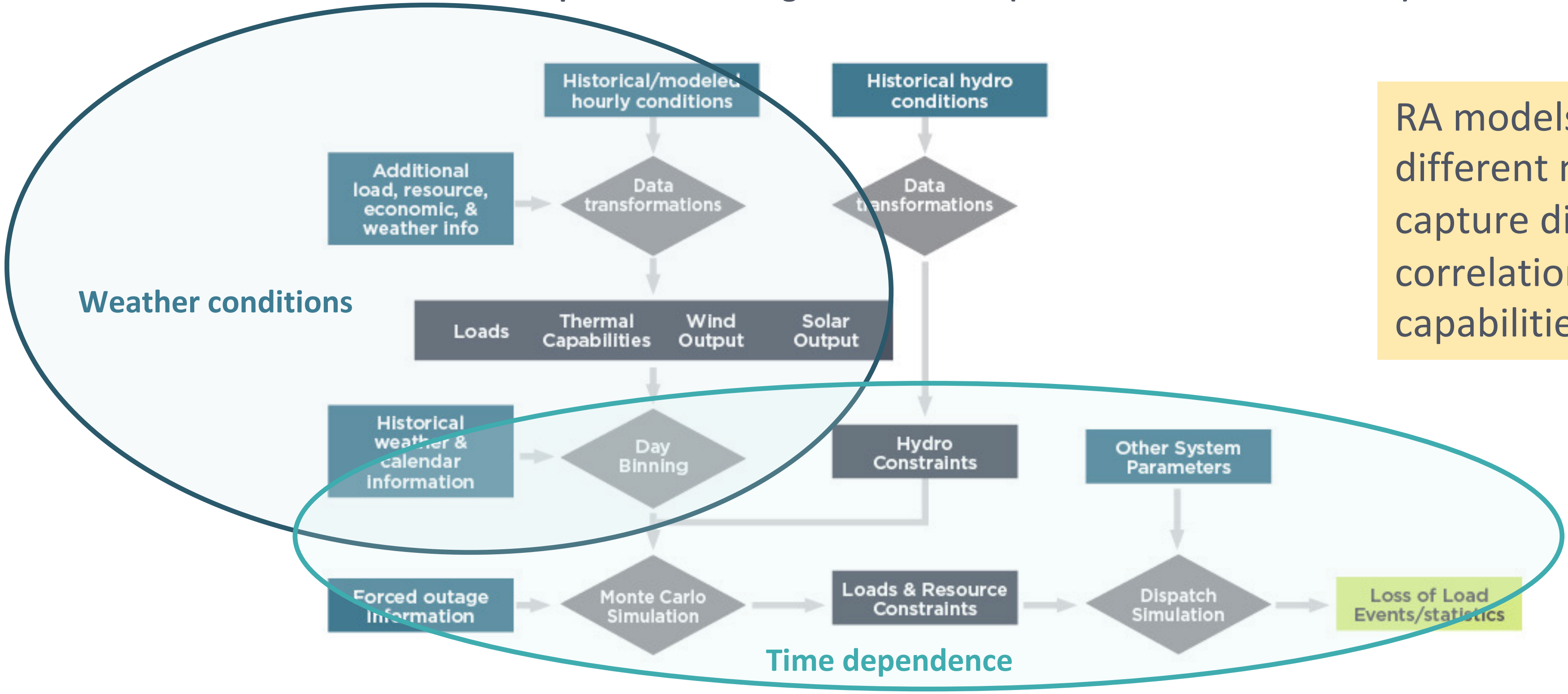

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Choose (and modify) a model

Weather conditions

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

2 Choose (and modify) a model

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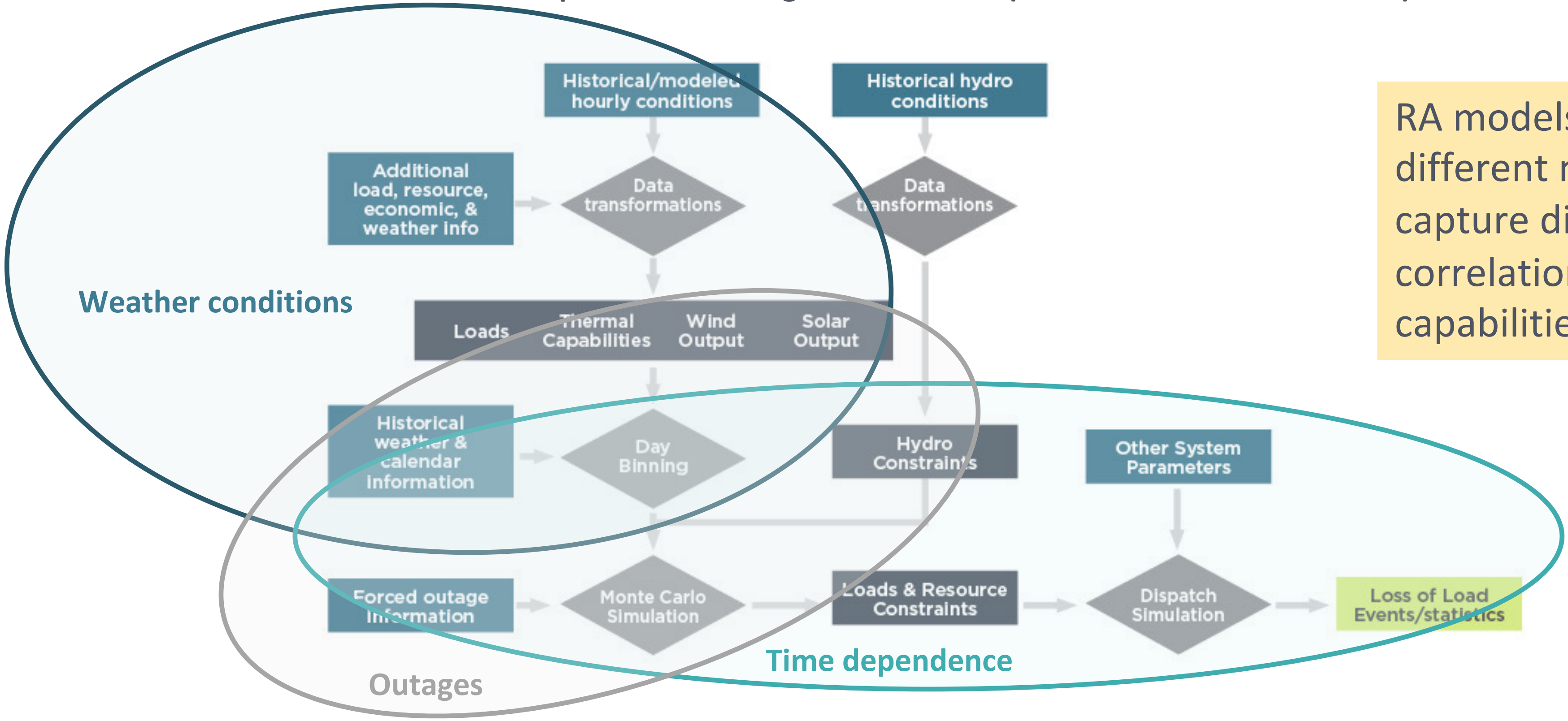

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Outages

Method	What is it?	When might it be appropriate?
Fixed derates	Reduce the max output of every unit by its forced outage rate	• For resources that can be highly modular (e.g. battery storage) • When unit sizes are very small relative to the size of the system • 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)
Monte Carlo time-independent outage simulation	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	• If you are estimating EUE or LOLH and don't care about event duration or frequency
Monte Carlo failure/repair outage simulation	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	• If you are interested in understanding event duration and frequency and you don't know how weather impacts failure rates
Monte Carlo weather-driven failure/repair outage simulation	Use a failure/repair model with weather-driven failure rates	• If you are interested in understanding event duration and frequency and you do know how weather impacts failure rates

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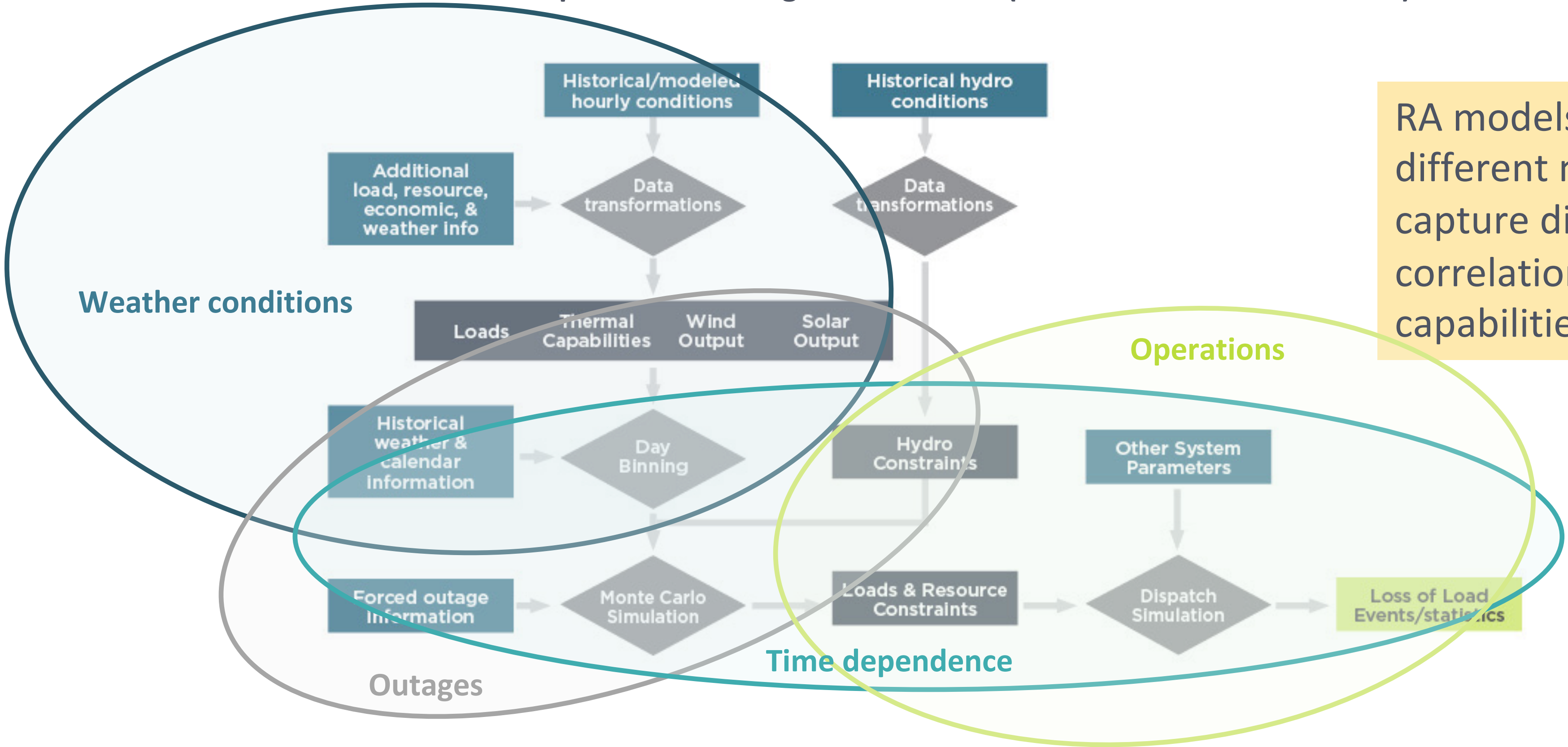

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Operations

Method	What is it?	When might it be appropriate?
Fixed shapes	Assume all resources generate at their maximum capability in all hours Use outboard modeling to estimate fixed shapes for energy-limited resources	Systems with little-to-no energy limited resources (e.g. hydropower, energy storage, or natural gas fuel constraints)
Heuristic dispatch	Use a set of rules to estimate dispatch in timestep	Single-zone systems (i.e. no transmission constraints)
Optimization-based dispatch	Use an optimization algorithm to estimate dispatch in order to minimize an objective (e.g. cost or unserved energy)	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)
Economic unit commitment and dispatch	Detailed simulation of system scheduling and operational practices Can require a lot more data and computational power than the other methods	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

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

2 Choose (and modify) a model

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

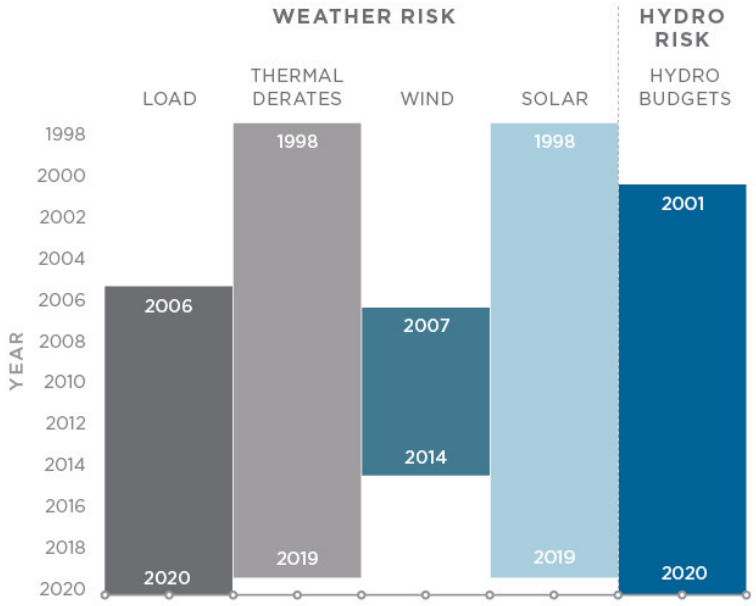
Additional Risks
Hydro conditions
Temperature-based derates
Icing
Wildfires
Transmission outages
Fuel supply risks

3 Find (or develop) the data

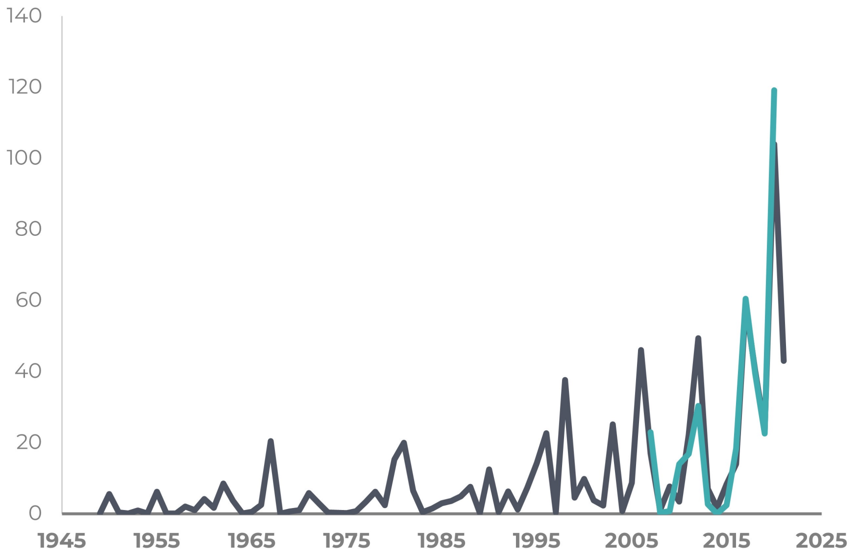
RA analysis requires you to estimate demand and resource capabilities under many, <u>many</u> years of potential conditions (weather, outages, hydro availability, etc.)

- **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



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4 Evaluate the system without further action

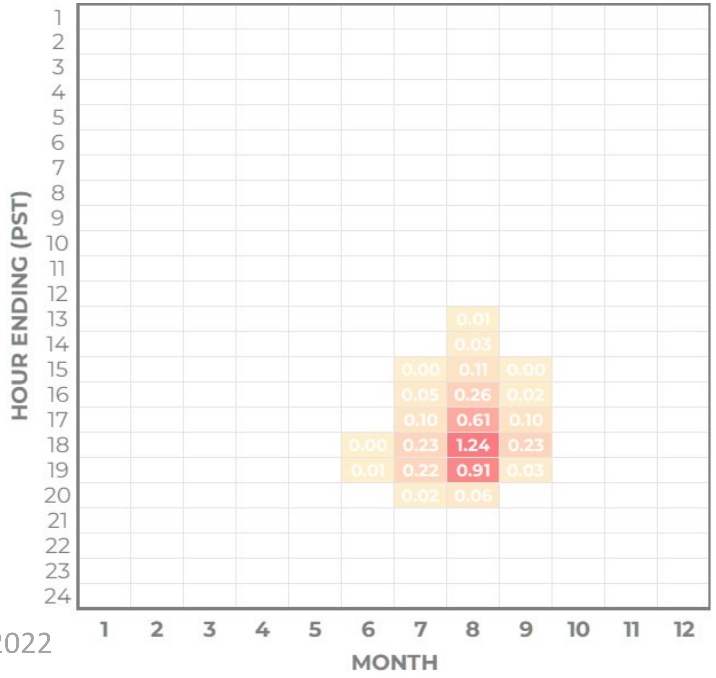
A base run, excluding incremental actions, gives you an indication of:

- 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

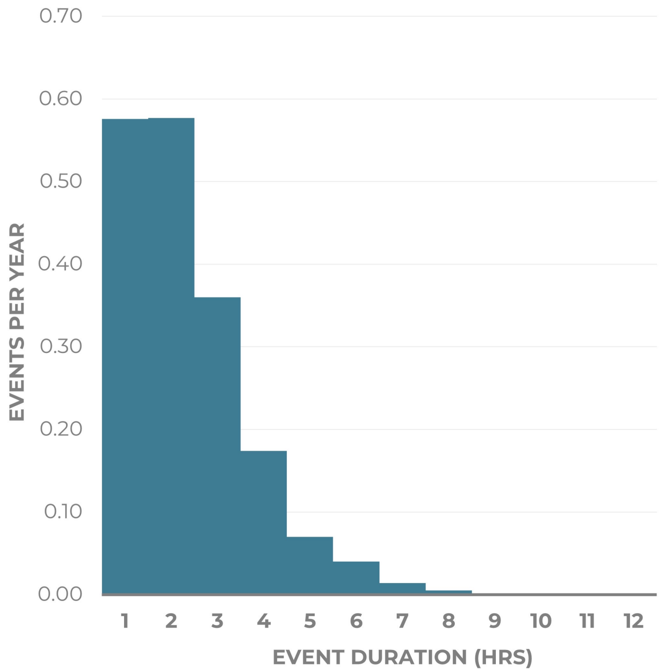
Loss of load metrics

Metric	Value
$LOLP_{year}$	69%
LOLE (days/10yrs)	18.2
LOLH (hrs/yr)	4.23
EUE (MWh/yr)	13,797
EUE_{norm} (ppm)	19.4
Average Event Duration (hrs)	2.33
Estimated* Perfect Capacity Need (GW)	9.3

LOLH (hrs/yr)



Event durations



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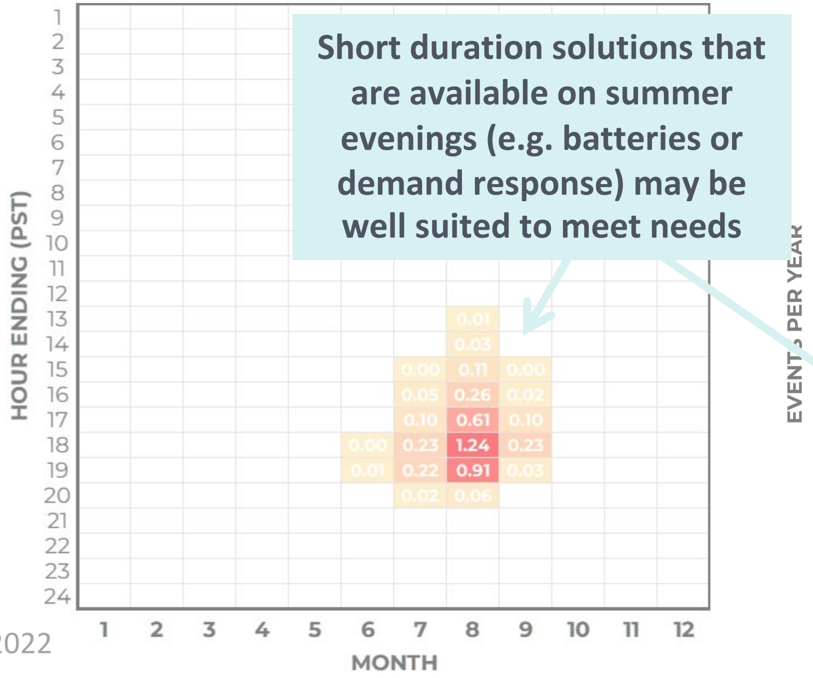

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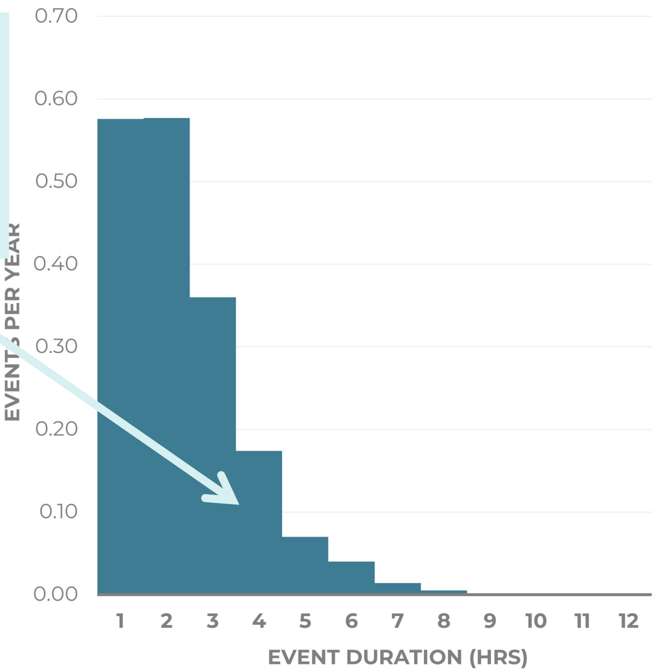

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The base run does <u>not</u> tell you:

- 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)

Method	What is it?	When might you take this approach?
Effective Load Carrying Capabilities (ELCCs)	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.	Evaluating specific resources in an RFP
ELCC Curves (1-dimensional)	Calculate the avoided perfect capacity needs as more of each resource is added to the portfolio and provide the portfolio optimization with this curve.	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).
Portfolio ELCC Surfaces (multi-dimensional)	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.	IRP or RFP portfolio optimization when portfolio effects are large and the number of resource options is relatively limited.
Critical condition testing within portfolio optimization	Explicitly model system performance during critical periods within portfolio optimization.	IRP portfolio optimization when critical periods are well understood for the system.

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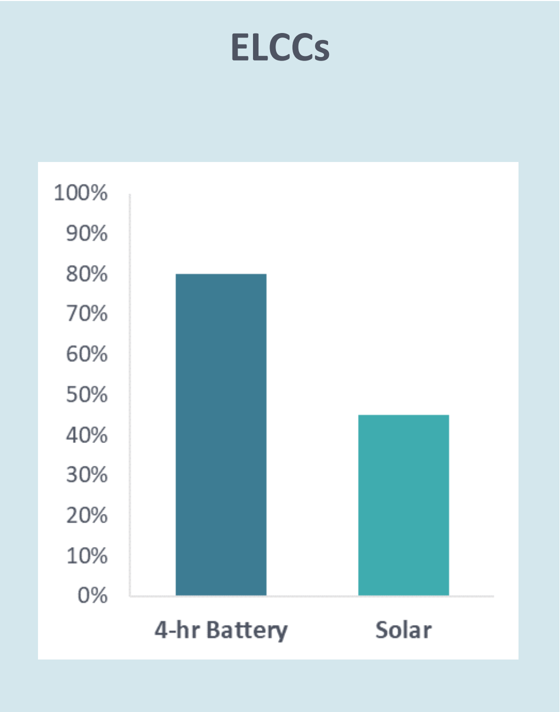

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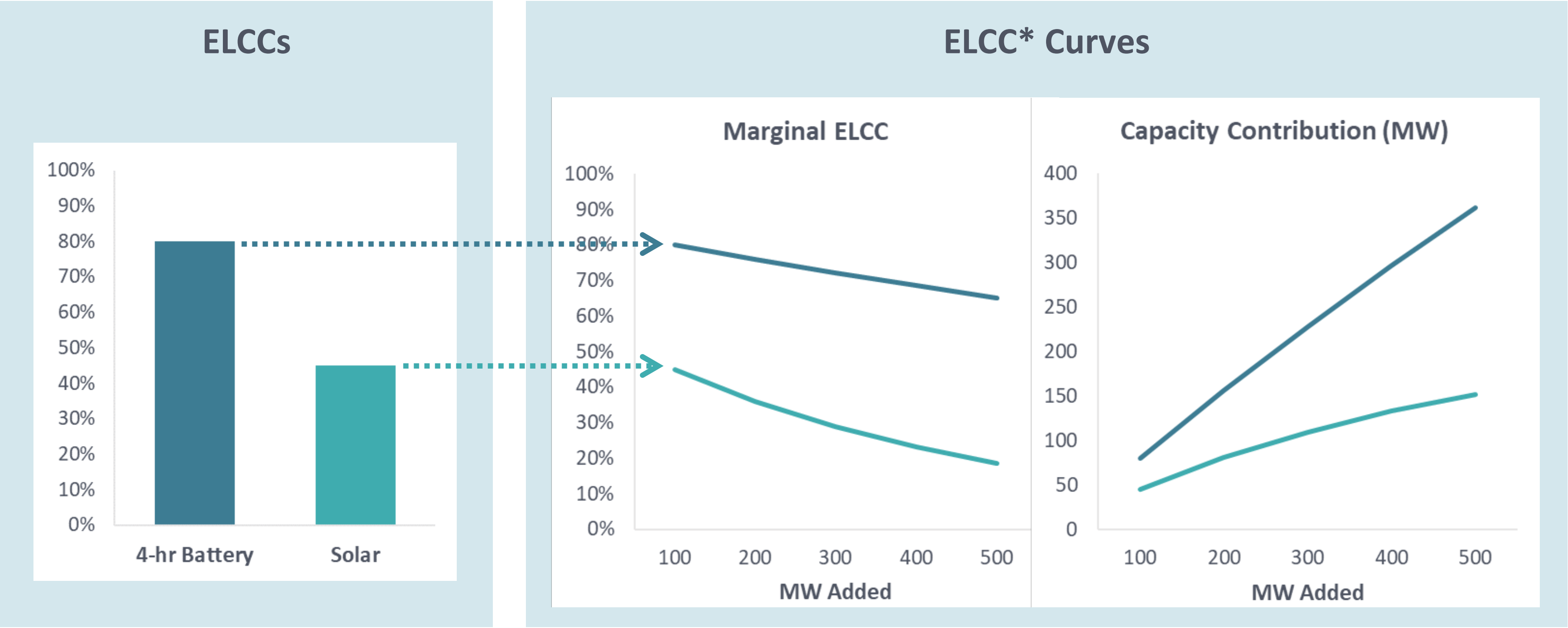

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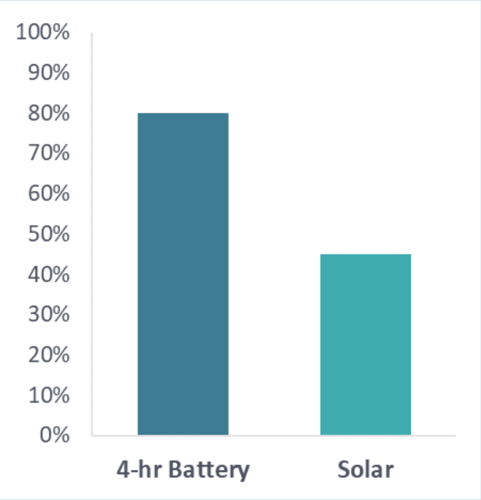
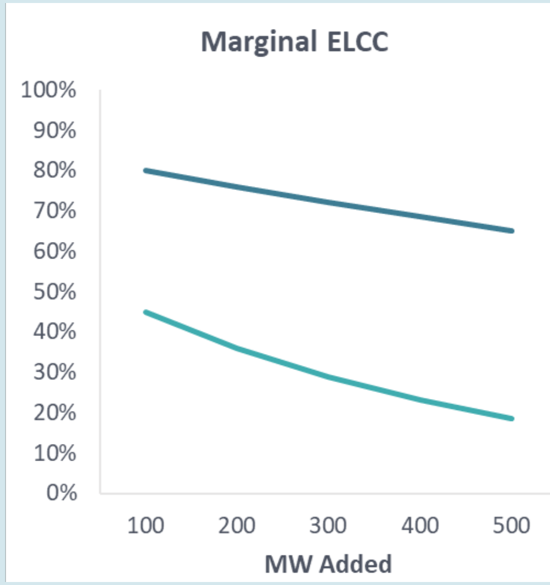
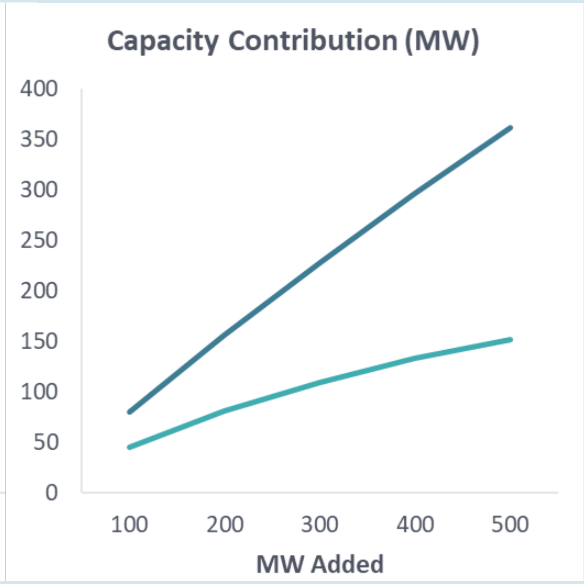


ELCC* Curves





ELCC* Surfaces

MW of Solar Added \ MW of 4-hr Batteries Added	0	100	200	300	400	500
0	0	80	156	228	297	362
100	45	150	237	317	390	456
200	81	190	275	352	423	487
300	110	220	303	379	447	509
400	133	243	324	397	464	524
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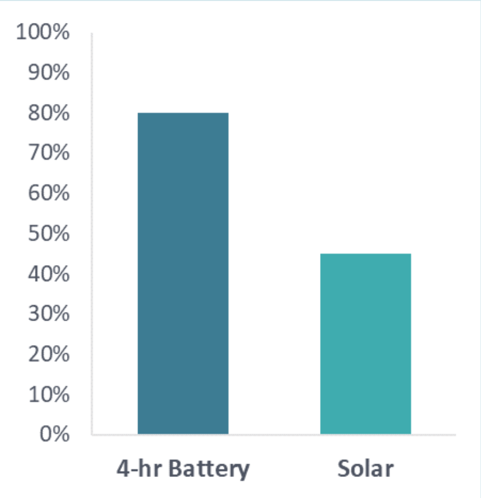

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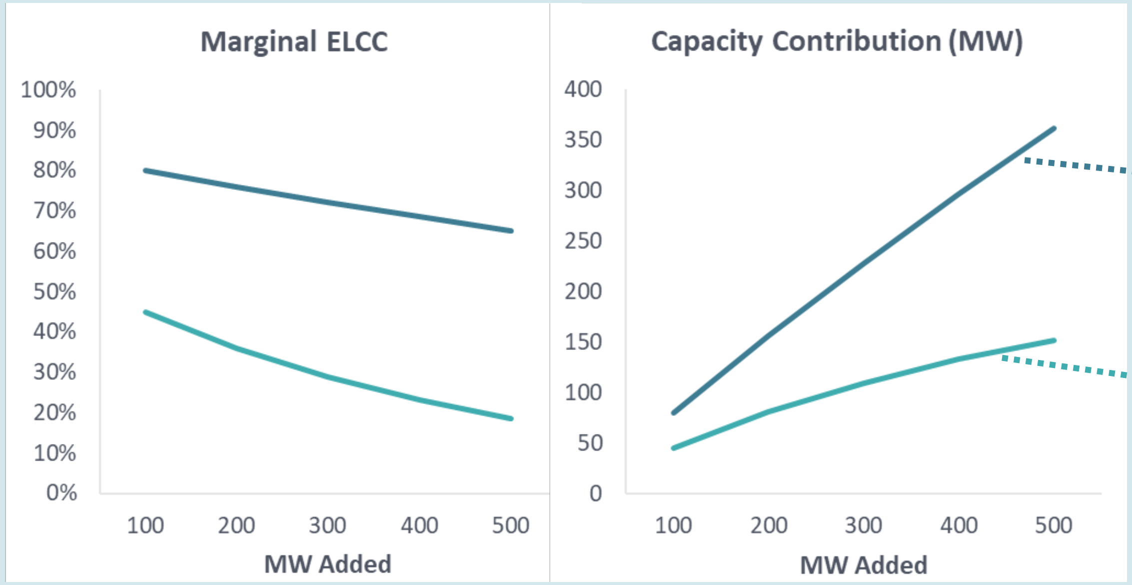

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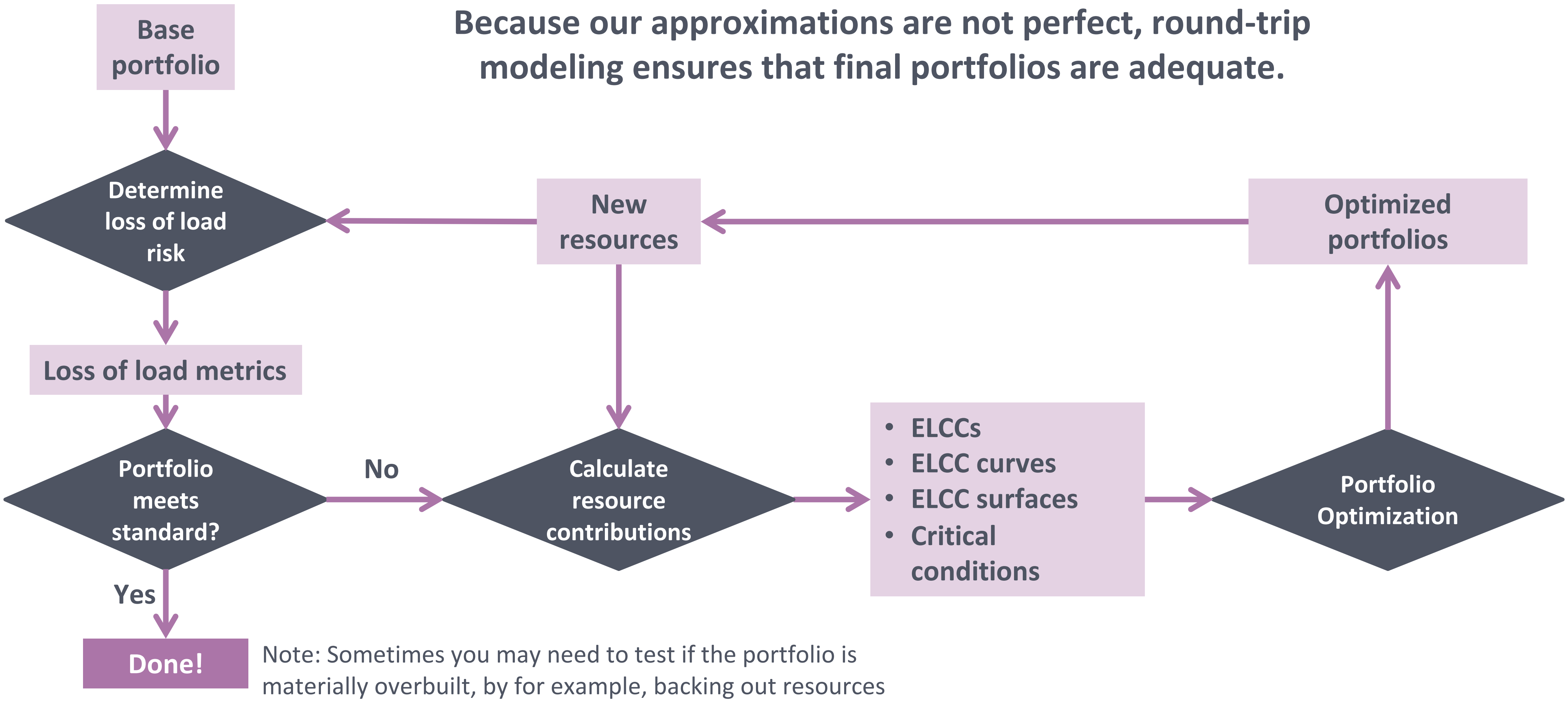
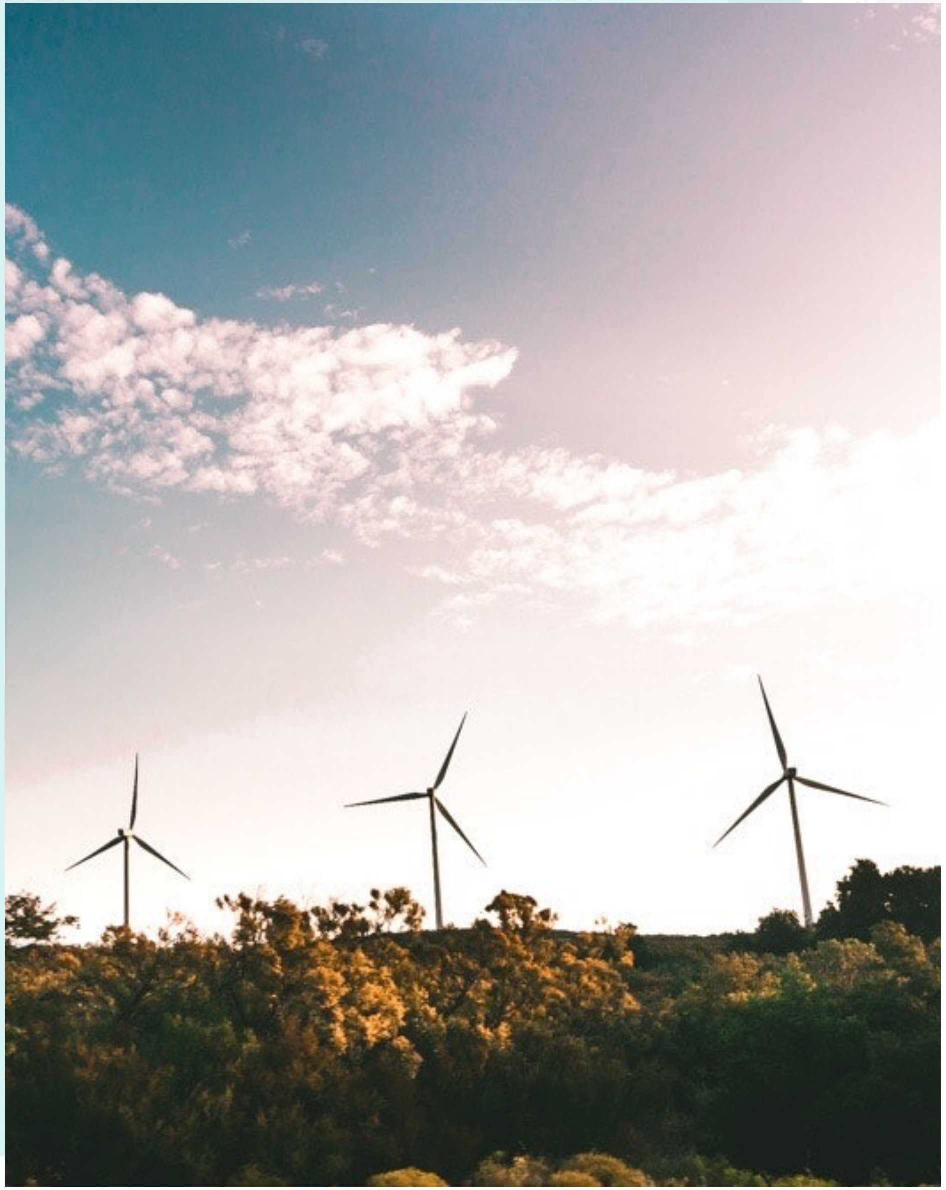
Because our approximations are not perfect, round-trip modeling ensures that final portfolios are adequate.



Note: Sometimes you may need to test if the portfolio is materially overbuilt, by for example, backing out resources



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