Fundamentals and History of Capacity Accreditation

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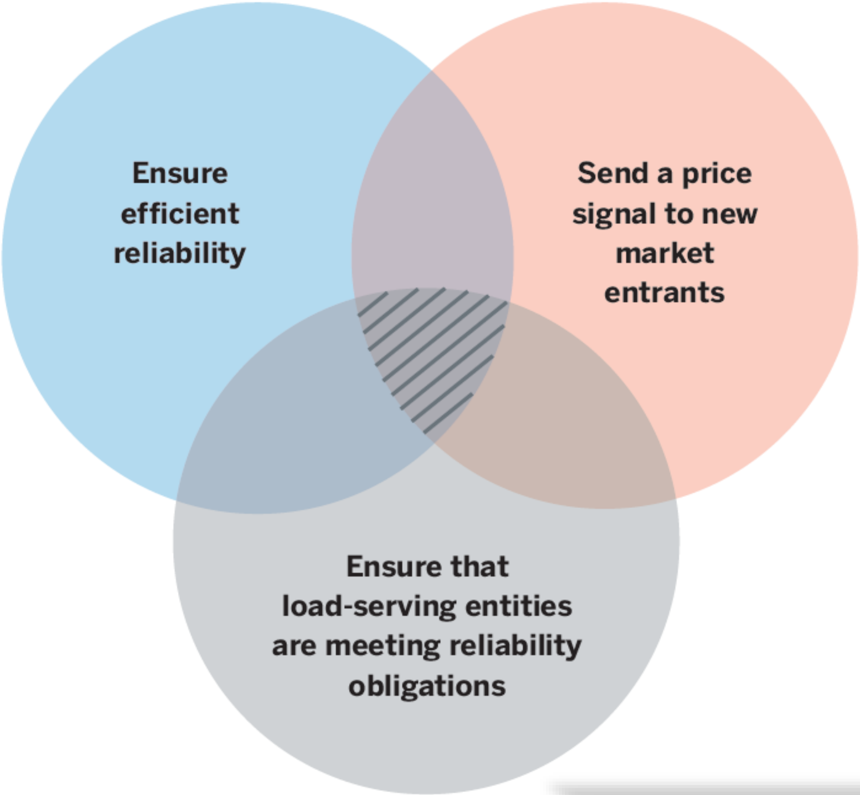
Motivation for Capacity Accreditation



Source: Energy Systems Integration Group.

Applications for Resource Accreditation

The most straightforward application for accreditation values is for **resource adequacy assessments**. Planners run a series of studies that help determine whether the region is going to meet its target or compliance using system level metrics. The same tools to evaluate these system-level metrics are used to determine accreditation values for resources. The values can be used for sensitivities as the planners add resources to achieve an adequate system. The values are then also passed to other applications for further actions.

The second application is for **long-range supply resource expansion planning**. When utilities are developing their resource plans, often called **integrated resource plans** (IRPs), which are used internally and approved by their regulators, they must think about whether their future portfolio is sufficient to meet resource adequacy standards. Utilities may use capacity expansion tools and processes to determine any new builds and any potential retirements due to policies, economics, and RA needs. Having values that are assigned to the RA contribution of different resources or resource types can help the accuracy of the capacity expansion process that is used to determine utility resource plans.

The third application is within **electricity markets**. There are different ways markets are designed to incentivize individual actors or market participants to contribute to meeting adequacy. This can include incentives within the spot energy market that can sufficiently incentivize investment, scarcity pricing, bilateral exchanges between load-serving entities and suppliers, self-supply showings, or centralized capacity auctions. Capacity auctions are particularly linked to resource accreditation; in these auctions, resources are often assigned an accreditation value, which is then used within auction algorithms to determine the capacity payment levels as a function of each resource's contribution to meet adequacy targets.

History of Capacity Accreditation

Phase 1

- To determine whether a given system would meet its RA target, the sum of **installed capacity** (ICAP) of all existing and planned resources was compared to the target **planning reserve margi**n (PRM).

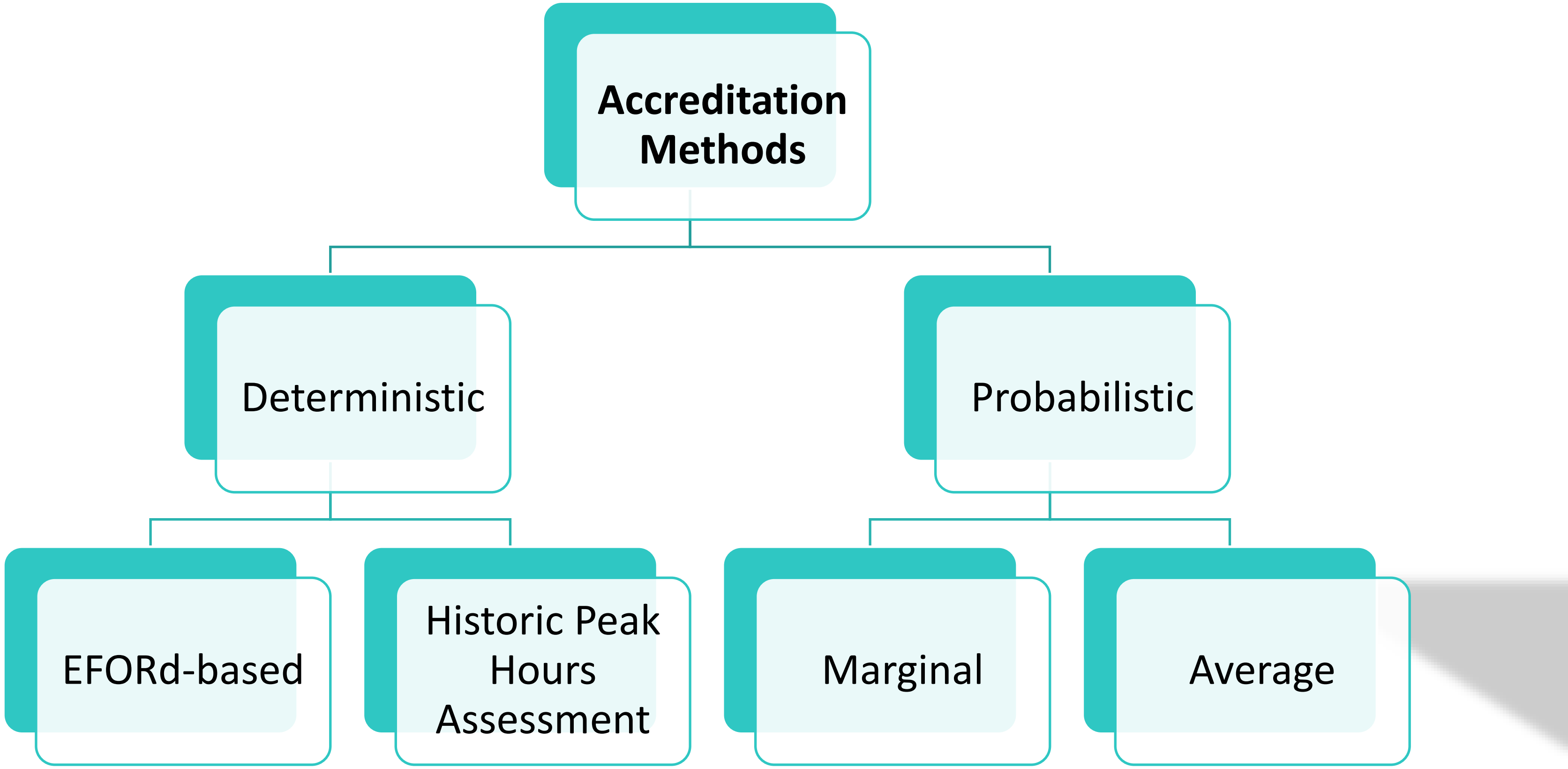
Phase 2

- Entities transitioned from using ICAP to **UCAP** to capture some individual characteristics of a resource availability. The UCAP is a separate deterministic accreditation value that derates the ICAP value by an amount equal to the resource's equivalent forced outage rate on demand (EFORd).
- For wind and solar, a deterministic accreditation value was used based on a time-based assessment where historical output during time windows of highest load were averaged.

Phase 3

- Emergence of probabilistic methods:
  - Early research as early as the **1930s** with the publication of work by Calabrese and others.
  - L. Garver in **1966** developed a linear approximation technique for accreditation for thermal resources in 1966.
  - Interest in ELCC was revived in the **mid-1990s** when researchers began to apply it to systems with wind generation.

Probabilistic vs. Deterministic and Methods vs. Metrics



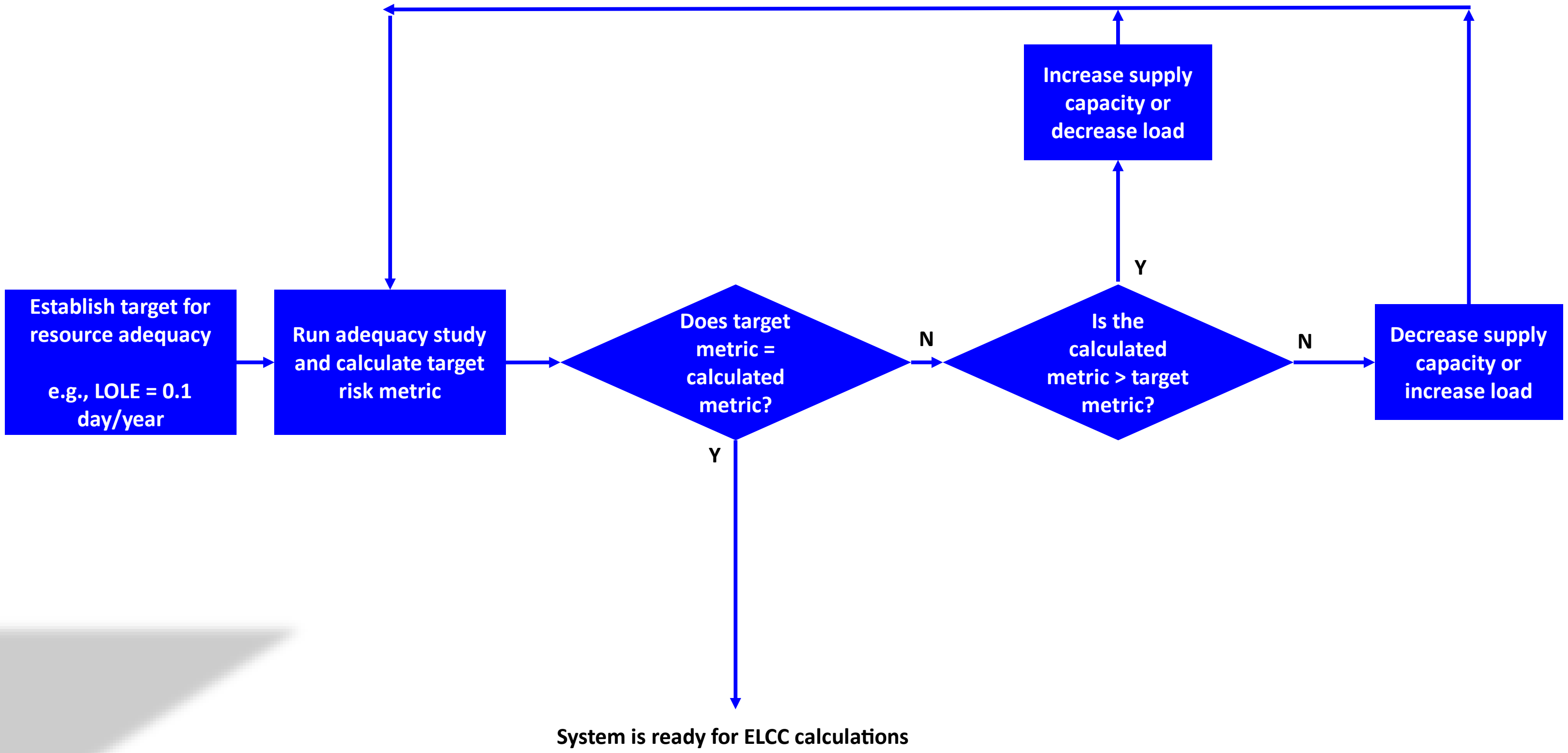
ELCC: method or metric?

In the historical use of the term, ELCC has been used to refer to both a method and a metric. It is still sometimes (erroneously) used as a global term to refer to all methods to calculate a range of probabilistic capacity accreditation metrics. **The use of the term *ELCC* is recommended to refer specifically to the ELCC metric, while using "ELCC method" for calculating the ELCC metric in the common way it is calculated.**

Bringing a System to Criteria and Target Risk Metrics

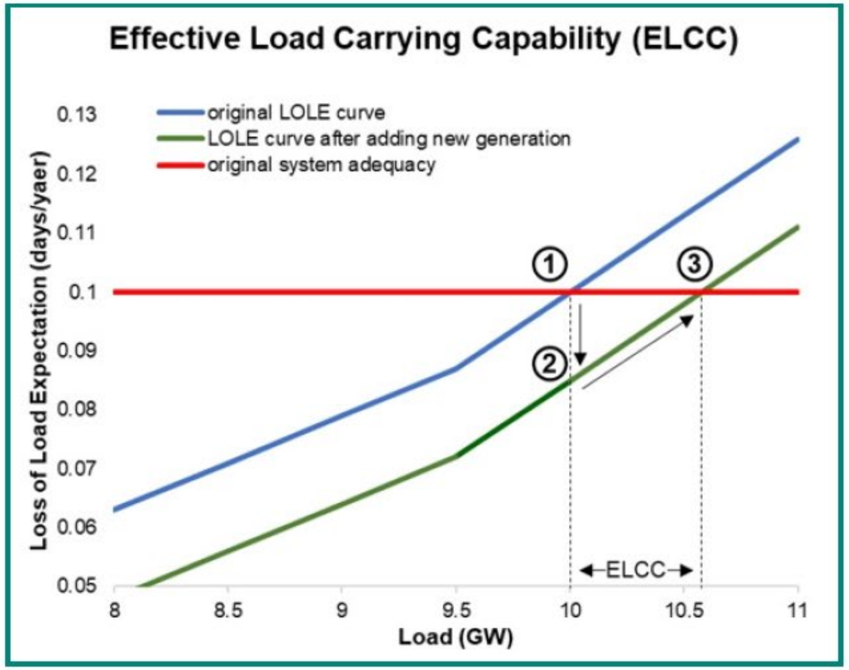
Should the base system be brought to criteria, or should accreditation be calculated using actual system LOLE values?

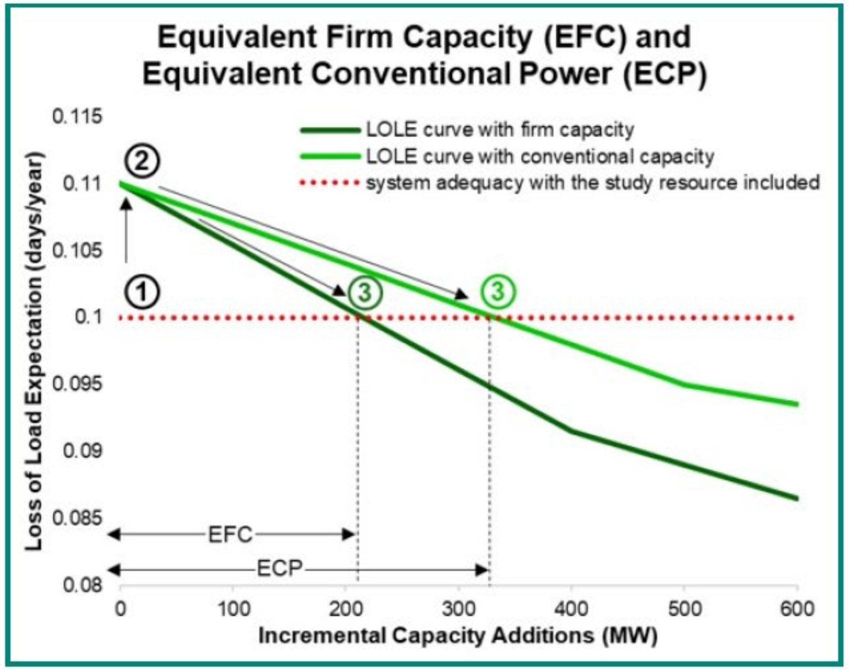
This is a relevant policy question to consider: should a system be examined as-is, or relative to a commonly used benchmark? Any change in load or installed capacity conducted while bringing a system to criteria can influence ELCC calculations, and therefore resource accreditation, resource buildouts, and capacity market payments. The implications of this choice are therefore non-trivial.



ELCC vs. EFC Methods

- **Effective load-carrying capability (ELCC)** and **Equivalent Firm Capacity (EFC)** are often used interchangeably in industry, although they are defined slightly differently, as shown below.
  - ELCC calculations involve (1) calculating the LOLE for a system without adding in the new resource, (2) calculating the LOLE of the system when a new resource is added in, and (3) calculating by how much additional load is needed to bring the system LOLE back up to its value in step (1). This amount of load in MW is the resource's ELCC.
  - EFC calculations involve (1) calculating the LOLE for a system without adding in the new resource, (2) calculating the LOLE of the system when a new resource is removed, and (3) calculating by how much additional capacity is needed to bring the system LOLE back up to its value in step (1). This amount of load in MW is the resource's EFC.
- While their exact calculation steps differ, each quantifies the probabilistic reduction in loss-of-load expectation when adding a resource to the system.





Marginal Reliability Improvement

ELCC and EFC cannot be calculated directly and generally involve multiple RA model iterations to get to their final values. The MRI calculation is generally faster, as it can be calculated in two iterations once the system is at the criterion. MRI capacity values are calculated as follows:

$$Capacity\ Value = \frac{LOLE_i - LOLE_m}{LOLE_i - LOLE_p} = \frac{\Delta LOLE_{resource}}{\Delta LOLE_{perfect\ capacity}}$$

Where **$LOLE_i$** is the starting system LOLE (often defined as 0.1 days/year),
$LOLE_m$ is the LOLE of the system once an incremental MW of the representative unit has been added, and
$LOLE_p$ is the LOLE of the system once a unit with perfect capacity of the same size and in the same location as the representative unit has been added

LOLP Capacity Factor

The LOLP capacity factor method* calculates the average availability of a resource during a sliding risk window, identified by loss-of-load hours or low margin periods.

Key advantage:
Does not require iterative modeling for each resource type.

* The LOLP capacity factor method was developed in part by the ESIG Redefining Resource Adequacy Task Force but builds on work done previously (Milligan, 2002; PacifiCorp, 2021).

LOLP Capacity Factor illustration of a hypothetical system and solar resource.

System Unserved Energy

	Weather Year 1			Weather Year 2		
Hour of Year	Sample 1	Sample 2	Sample N	Sample 1	Sample 2	Sample N
1	0	0	0	10	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	20	0	0	0	0	0
5	40	0	0	0	30	0
6	10	0	0	0	10	0
7	0	0	0	0	5	0
8	0	0	0	0	2	0
9	0	0	0	0	1	0
10	0	0	0	0	0	0
...	0	0	6	0	0	0
8758	0	0	10	0	0	0
8759	0	0	2	0	0	0
8760	0	0	0	0	0	0

Two weather years, six outage samples
LOLE = 0.67 days/year
LOLH = 2 hours/year
EUE = 24.3 MWh/year

Generator Availability (installed capacity = 10 MW)

	Weather Year 1			Weather Year 2		
Hour of Year	Sample 1	Sample 2	Sample N	Sample 1	Sample 2	Sample N
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	1	1	1	0	0	0
4	4	4	4	2	2	2
5	8	8	8	3	3	3
6	3	3	3	1	1	1
7	1	1	1	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	1	1	1	2	2	2
...	5	5	5	6	6	6
8758	10	10	10	0	0	0
8759	6	6	6	6	6	6
8760	3	3	3	1	1	1

Average output during events = 3.33 MW
Nameplate capacity = 10 MW
Capacity accreditation = 33%

Source: Energy Systems Integration Group

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Different Flavors of Capacity Accreditation Methods

Many different options to consider when selecting a capacity accreditation method:

- Deterministic vs. Probabilistic
- Marginal vs. Average
- Prospective vs. Retrospective

Many different variations are available even within a same method:

- Choice of risk metric (LOLE, EUE, etc)
- Perturbation method
- Choice of resource adequacy target
- Method to bring the system up to target
- …

ACCREDITATION METRIC	SYSTEM RISK METRIC	PERTURBATION	VALUE
ELCC (marginal)	LOLE	Increase resource capacity; then increase load	Δload @ constant LOLE
ELCC (average)	LOLE	Increase resource class capacity; then increase load	Δload @ constant LOLE *(resource capacity/resource class capacity)
EFC	LOLE	Increase resource capacity; then decrease perfect supply	Δsupply @ constant LOLE
MRI	EUE	Increase resource capacity	ΔEUE/ΔEUE(perfect resource) *ICAP

Insights Into Probabilistic Accreditation Methods

1. There are (typically) not very many risk hours, therefore resource accreditation is obtained during a relatively small number of hours in the year

2. Accreditation depends upon individual unit characteristics and LOLE shape

3. Risk is not necessarily correlated with peak loads; resources with high accreditation value may not be highly correlated with annual peak

   This insight is increasingly true for systems incorporating growing shares of variable energy resources (VER) and energy storage.

4. The accreditation characteristics of thermal resources differ from those of variable energy resources

   Additionally, there are complex interactions that arise between VERs when employing marginal accreditation methods where the capacity value of any individual VER can be extremely sensitive to the order in which it is introduced into accreditation simulations.

5. Storage and other energy-limited resources' accreditation depend upon whether they are operated for economics, reliability, or a blend of optimization targets

6. Transmission and import capacity have an impact on resource adequacy and on the accreditation of many, and possibly all, resources

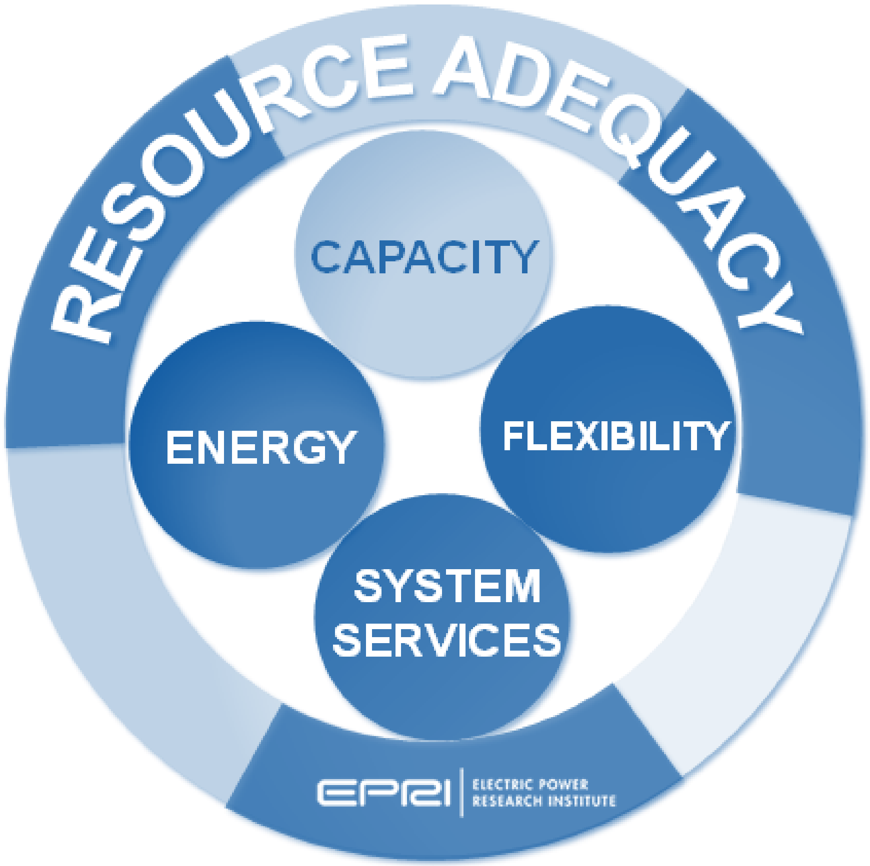
Impact of Resource Adequacy Tool and Data on Adequacy and Accreditation

Unit commitment	Objective function	Temporal Granularity
Locational granularity (system, zonal, nodal)	Short-term forecast error and multi-stage operation	Ramp rates and start-up times
Interchange	Energy storage state-of-charge	Combined cycle modes

The impact and choice of tools and data used can possibly have a larger impact on accreditation value differences than would using different accreditation methods entirely.

Operational Features in RA and Impacts on Accreditation

- How much operational detailed should be included in RA?
- Should flexibility needs be part of RA assessments?
- Should system services be represented in detail in RA assessments?
- **All the above will have a material impact on resource accreditation**
- EPRI has conducted work on the above and will continue to explore the above questions in 2024



Resource Adequacy Initiative

Scope and Deliverables

RA Process

- Recommended Metrics and Criteria
- Future Scenario Database and Tool

Models and Data

- Emerging Resource & Demand Side Models
- Model Data Development Tools

Analysis Tools

- Existing RA Tool Capabilities
- New Algorithms and open-source code

Case Studies	Evaluation of existing and development of new capabilities based on 4-6 regional RA case studies covering differing RA issues and tools.
Tech Transfer	Reports and workshops to be conducted to disseminate results and to promote broad adoption in commercial tools.

25+ Participants

Southern California Edison – Energy for What's Ahead, CPS Energy, Duke Energy, aeci Associated Electric Cooperative Inc., Hawaiian Electric, American Electric Power, LCRA, conEdison, Ameren, TVA, Austin Energy, New York State of Opportunity NY Power Authority, LA DWP Los Angeles Department of Water & Power, Arkansas Electric Cooperative Corporation, Southern Company, SRP, NERC North American Electric Reliability Corporation, MISO, SPP Southwest Power Pool, aps, ISO new england, pjm, Entergy, evergy, New York ISO Independent System Operator, Manitoba Hydro, NPCC, Inc.

Partners

TELOS ENERGY, ASTRAPÉ CONSULTING innovation in electric system planning, GE, MOMENT ENERGY INSIGHTS, Blue Marble Analytics, ENELYTIX® powered by PSO

External Advisory

NARUC, NREL, ESIG, GridPath, RROs, DOE, ISOs/RTOs, G-PST, Consultants, Universities, etc.)

www.epri.com/resource-adequacy

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Upcoming EPRI Resource Adequacy Efforts: Assessing Capacity Accreditation Choice on Resource Mix Outcomes

Candidate portfolios from capacity model are analyzed in more detail

Capacity Expansion Model

- Planning horizon decades into the future
- Only representative days are evaluated
- New resources built to meet peak demand plus planning reserve margin

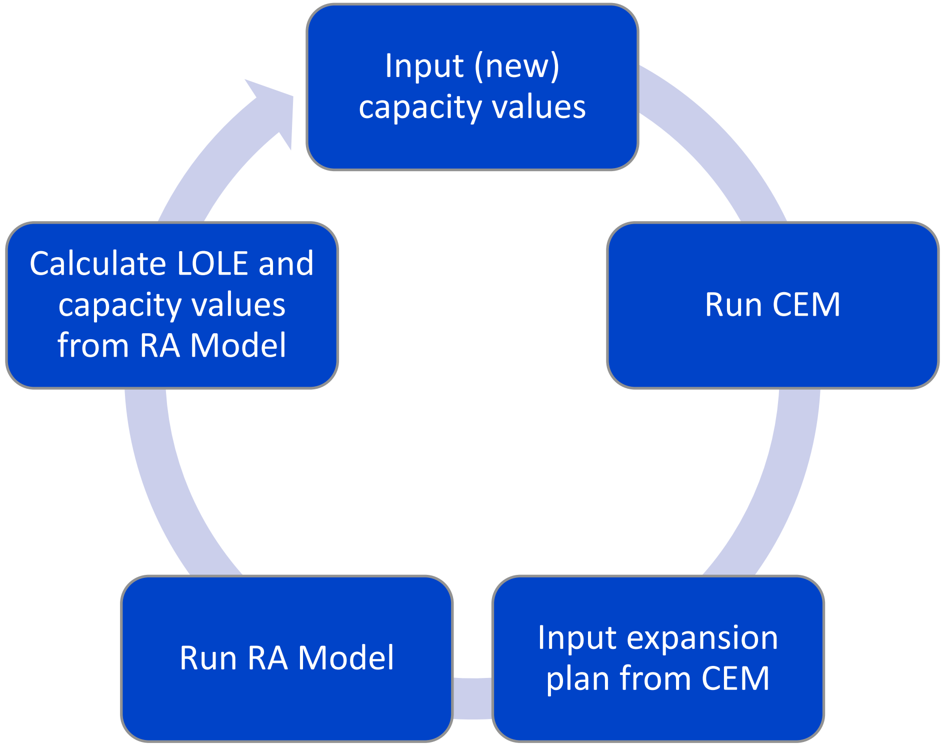
Resource Adequacy Model

- Hourly analysis for a set capacity buildout scenario
- Probabilistic analysis (outages and weather uncertainty)
- Solution identifies periods of shortfall risk over the full year

Planning reserve margin and resource capacity accreditation are updated based on RA results

Goal: Provide guidance on ways to bridge the gap and improve coordination between RA and capacity expansion models.

Upcoming EPRI Resource Adequacy Efforts : Assessing Capacity Accreditation Choice on Resource Mix Outcomes



Capacity accreditation methodologies evaluated so far:

- LOLP Capacity Factor
- Equivalent Firm Capacity
- Marginal Reliability Improvement

Possible subsequent sensitivities to be run include incorporation of build-out varying capacity values, analysis of the capacity accreditation metrics for storage and thermal resources, evaluation of seasonal capacity values, etc.

Analysis leverages a Plexos model of a regional North American system.

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