# Capacity Based Resource Adequacy Mechanisms: Evolution or Extinction

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# TOPICS

- Resource Adequacy
- Modeling Resources and Loss of Load Probability with the Evolving Resource Mix
- Capacity Based Resource Adequacy Mechanisms with the Evolving Resource Mix
- Flexible Capacity Requirements
- Capacity or Energy Markets
- MOPR Rules, Capacity Mechanisms, and Energy Markets

# RESOURCE ADEQUACY

Maintaining resource adequacy with an evolving resource mix is not just a restructured market issue.

- All balancing areas will need to assess their ability to meet load as their resource mix changes.
- All power pools need mechanisms to avoid undue leaning on the pool:
  - Reserve requirement predate restructured markets;
  - PJM, New York Power Pool and New England Power Pool all had reserve requirements to prevent undue leaning on the pool.
- "Leaning" will have more potential dimensions as the resource mix evolves:
  - Capacity
  - Ramping/balancing capacity
  - Energy balance

# MODELING LOSS OF LOAD

Changes in resource mix are making it more difficult to use traditional planning models to accurately project resource adequacy needs or to assess the adequacy of the resource mix. This will likely get much more difficult with continued evolution of the resource mix. Areas of increased difficulty in accurate loss of load modeling include:

- The need to model variable wind output, variable solar output, and in some regions variable hydro generation output, which will become much more important as the level of intermittent resource capacity reaches even more substantial levels;
- Evolving sources of load forecast uncertainty;
- Increased importance of planned outage modeling;
- Increased complexity in modeling the “world;”
- Accounting for the energy limits of short-term storage resources over the day or periods of a few days;
- Changes in the way resource output must be modeled.

# Modeling Loss of Load

In addition to modeling load uncertainty and forced outage uncertainty, loss of load models have begun to evolve to model uncertain wind output, uncertain solar output, and in some regions uncertain hydro output.

- Historic loss of load models treated forced generation outages as independent uncorrelated events, which was reasonably accurate for coal, oil and hydro units.
- We have seen in the last decade that absent market rules, the outages of gas fired units will not be independent events but will be correlated across gas units on cold winter days.
- We obviously have the same issue of correlated output, or correlated low output, across wind and solar resources.
- Accurately estimating these correlations and applying them in Monte Carlo simulations would be very complex and likely fraught with error.

# MODELING LOSS OF LOAD

Another way to account for the correlations across variations in wind, solar and hydro output would be to draw daily observations for  wind, solar and hydro output .

- This approach requires a lot of data to accurately estimate the potential range of variability of wind, solar and hydro output.
- Since we will not have enough data to accurately estimate these relationships, there is a potential for surprises as the importance of wind and solar capacity reaches more substantial levels, even if we carry out the analysis perfectly.

# MODELING LOSS OF LOAD

Evolving Sources of Load Forecast Uncertainty

- Load variability is typically modeled using temperature models, adjusting for changes over time in load levels associated with temperature levels.
  - The more historic data is used, i.e. the longer one looks back in time, the less accurate the load projections will be.
  - The less data is used, the less accurate the probabilities.
  - Load projections will get even more difficult, and less accurate, as rooftop solar and perhaps other BTM generation becomes substantial because it will become even more difficult to associate historic weather data with current load levels.

# MODELING LOSS OF LOAD

Evolving Sources of Load Forecast Uncertainty (continued)

- With climate change, using long look back periods to assess net load variability may  result in estimates that are too inaccurate to be relied upon
- If shorter look back periods are used so the data is more reflective of changes in BTM generation and climate change, not only will it be more difficult to reliability estimate load variability, it will become even more difficult to estimate the correlation of load with solar and wind output.

# MODELING LOSS OF LOAD

Accurate modeling of planned outages may become more important.

- In the past, utilities could predict the range of load in the shoulder months and schedule maintenance outages to avoid periods with low capacity margins.
- As the level of intermittent resource output rises, it may become more difficult for some balancing areas to schedule maintenance outages to fall in periods of low net load, which may only be forecastable a few days in advance at most.
  - MISO has seen an increase in maximum generation emergencies in the shoulder months, in part because too much capacity is on planned outage at the same time and too much capacity is summer only.
  - Accurately modeling the reliability impact of planned outages in loss of load models will become more important if net load variability rises and the supply balance tightens in the shoulder months.

# MODELING LOSS OF LOAD

Increased complexity in modeling the "world"

- Good planning models take account of the "world" within which the balancing area is located and the balancing area's ability to meet load in part with economic imports.
- Accurately modeling the world will get much more complex when the rest of the world also has a large amount of behind the meter solar, utility solar, wind, and perhaps batteries.

# Modeling Loss of Load

The need to account for the energy limits of short-term storage resources over the day or periods of a few days will make planning time frame loss of load analysis very difficult.

- If substantial amounts of batteries are relied upon to meet load, planning models will need to analyze energy limits over daily and multi-day periods.
  - Will there be enough energy from wind and solar to charge the batteries?
  - How much gas generation will be needed as a back up to charge batteries when wind and solar output is low over a period of days?
  - How much import supply can be relied upon to charge batteries during periods of load solar and wind output within the balancing area?

# MODELING LOSS OF LOAD

- Accurately evaluating reliability with high levels of short-term storage resources will require analyzing energy output and consumption over sequences of days.
  - This will be a burden on the computational effort required for these simulations;
  - More limited data will available to estimate the variability of multiday patterns.

- There will likely be more surprises, at least for some years, even if all of the analysis is reasonably accurate given the available data.

# MODELING LOSS OF LOAD

Changes in the resource mix will likely require changes in the way resource output is modeled in loss of load planning studies.

- Planning models typically use draws of predicted or historical *average hourly output* for intermittent resources;
- This modeling framework based on average hourly output will not work if a balancing area has a substantial amount of solar output. On 8-14 CAISO solar output was:

  7566MW at 5pm,

  5221MW at 6PM,

  1458MW at 7pm,

  38MW at 8PM

Analysis based on average solar output can greatly misstate solar output at the beginning or end of an hour.

# MODELING LOSS OF LOADS

All if these modeling issues are being studied and improved modeling methods tested, or at least considered, but some of these issues are going to be very difficult to accurately address. It will also be very difficult for system operators and regulators to have confidence they have been adequately addressed.

- The more rapidly the resource mix evolves, the more difficult the evolution of accurate planning models will be.
- The industry has started on this evolution of planning models in many regions, and all regions in which policy makers have a goal of large changes in the resource need to be focused on this evolution.

# Modeling loss of loads

It will take time to work through these issues.

- There will be an ability to learn from the modeling choices and mis-steps of other balancing areas.
- However, there will also be important differences in resource mix, and resource performance, across balancing areas that each balancing area will need to learn how to account for in its planning time frame resource adequacy evaluations.

# Capacity markets/Requirements

Both in the U.S. and around the world, some have called for a shift to greater reliance on capacity markets as the solution to increased reliance on intermittent resources.

- It is easy to suggest reliance on capacity markets or capacity requirements to define the resource adequacy needs of a rapidly evolving resource mix.

- It is much more difficult to design a capacity market or requirement for the evolving resource mix that would discourage undue leaning on the pool and assure procurement of a resource mix that could reasonably be expected to maintain the target level of reliability in the real world.

# Capacity markets/Requirements

Another view is that the ongoing changes in resource mix will make it much more difficult, if not completely impossible, to rely on reserve requirements/capacity markets as the primary resource adequacy mechanism to provide a set of resource that will maintain reliability and avoid undue leaning on the pool.

- Load shedding risk will exist at both the gross and net load peak.
- Capacity procured based on average ELCCs will only achieve the target level of reliability if the procured resource mix is reasonably close to the modeled resource mix.
- Traditional capacity market interconnection and RA qualification models evaluate deliverability at the gross load peak, not at net load peaks.

# CAPACITY MARKETS/REQUIREMENTS

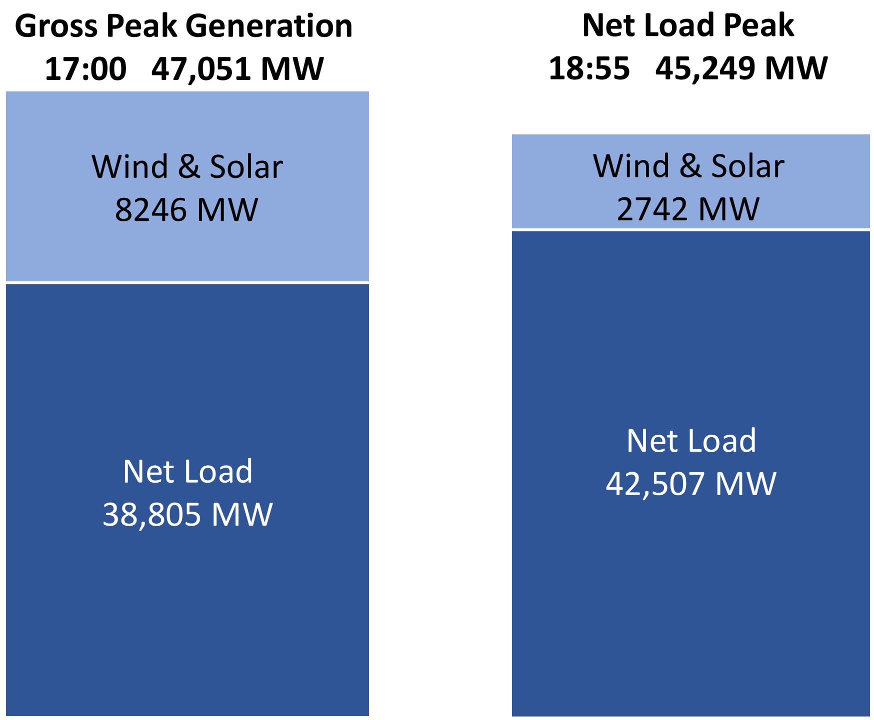
- The value of storage resources not only on depends their injection, withdrawal and storage capacity but also on the amount, mix and operating strategy of the resources (and imports) available to fill the storage;
- Balancing variations in intermittent resource will require both capacity and ramping capability.  The ability of resource to supply ramping capability is not only a function many resource characteristics but is a function of offer prices, and of the overall balancing area resource mix.

# CAPACITY MARKETS/REQUIREMENTS

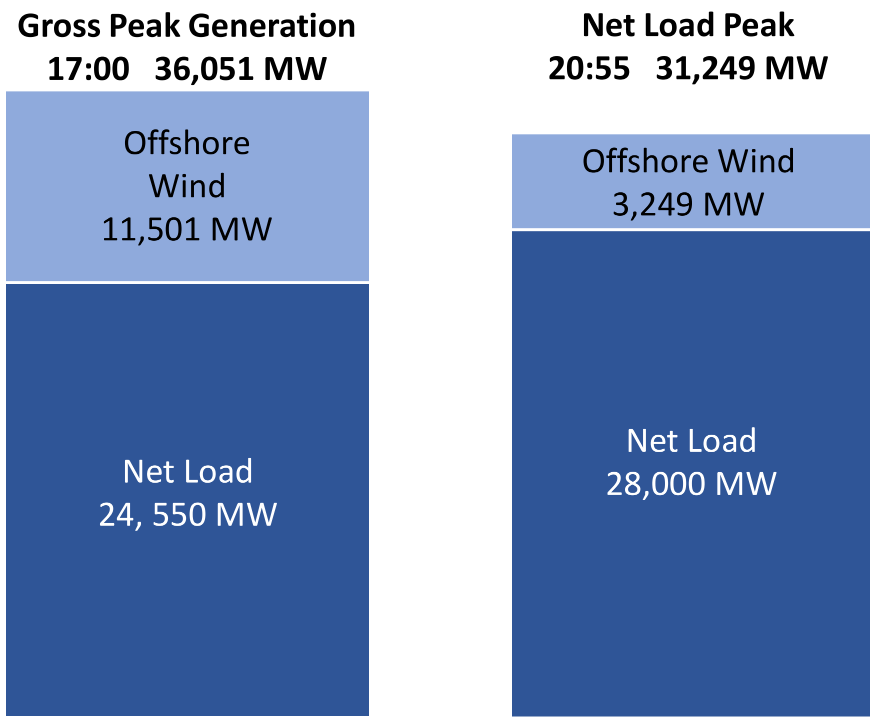
Load shedding risk will exist at the both gross and net load peak.

- Traditional capacity requirements are based on procuring enough capacity to meet load at the gross load peak.
- CAISO load shedding in August occurred well after the gross load peak, around the  net load peak.
- Using traditional capacity requirements to procure capacity needed to meet load at both the gross load peak and net load peaks will require significant changes in capacity market/requirement designs.

August 14, 2020



NYISO August 18, 2027?



# Capacity markets and Requirements

Capacity procurement based on average ELCCs (effective load carrying capacity) will achieve the target level of reliability if the procured resource mix is reasonably similar to the modeled resource mix.

- This will not be the case if some load serving entities replace gas generation in the modeled mix with solar generation with a significant average ELCC but very low marginal ELCC.
- With the introduction of storage, the sum of the storage, solar and wind average ELCC may be larger the average ELCC of the combined resources
  - This is because the wind and solar generation may be needed to provide the energy to fill the storage.  Hence, reductions in wind or storage capacity will also reduce the capacity value of storage.
  - The CPUC has already seen this pattern in its planning models in the summer months.

# CAPACITY MARKETS AND REQUIREMENTS

Traditional interconnection models evaluate deliverability at the gross load peak.

- With high levels of solar generation, capacity that is not deliverable at the gross load peak may be deliverable at the net load peak and needed to meet load at the net load peak.
- We saw this in CAISO in August. As load shedding approached, a significant amount of the actual intermittent resource output was from resources that did not count as RA capacity because they were not deliverable at the gross load peak.
- How will the value of resources deliverable at the net load peak be accounted for?
- As the level of intermittent resource output rises, there may be many different generation patterns at distinct types of net load peaks.

# CPUC/CAISO Flexible Capacity Requirement

Balancing variations in intermittent resource will require both capacity and ramping capability.

- It is natural to propose that this need be met with a requirement for flexible capacity.
- This is easy to suggest and very difficult to effectively implement.
- The CAISO has been working on developing an effective flexible capacity requirement since 2012.
- CAISO implemented an "interim flexible capacity requirement" in 2014 and is still trying to develop a workable long-term design.

# CPUC/CAISO Flexible Capacity Requirement

## Phase 1(Flexible Capacity Must Offer Obligation)

- December 2012 — Design Development Begins
- November 2014 — Interim Design Implemented

## Phase 2

- June 26, 2015 — Issue Paper
- Summer 2016 — Original CAISO Board Approval Target
- Summer 2018 — Process put on hold

## Resource Adequacy Enhancements

- October 23, 2018 — Issue Paper
- December 20, 2019 — 3rd Rev Straw Proposal-covers flexible capacity
- March 17, 2020 — 4th Rev Straw Proposal –no flexible capacity
- July 7, 2020 — 5th Rev Straw Proposal

"The CAISO seeks to close certain gaps in the existing flexible RA construct through a new flexible RA framework that more deliberately captures the CAISO's operational needs and the predictability (or unpredictability) or ramping needs….However, at this time, the Day-Ahead Market Enhancements Proposal requires additional development before the CAISO is able to further advance its flexible RA capacity proposal. Therefore, the CAISO is deferring significant modifications to its flexible RA capacity proposal for this straw proposal." p. 89

# CPUC/CAISO Flexible Capacity Requirement

What are the design elements that make development of effective flexible capacity requirements so difficult?

- How much flexible capacity is needed and how should this be determined?
- What does it mean to require flexible capacity to offer "economically" in real-time?
- Can slow starting resources provide flexible capacity?
  - Should this depend on whether they are economic to keep on-line?
- How many starts per day, month, and year must flexible capacity be capable of?

# CPUC/CAISO Flexible Capacity Requirement

Flexible Capacity Design Elements (continued)

- What kind of energy and emission limits can flexible capacity be subject to?
- Should flexible capacity have a minimum ramp rate?
  - Suppose it is a small unit that is not fast ramping but can ramp to its upper limit in 30 minutes?
- Should the flexible capacity provided by a unit include its minimum load block if it is a fast-starting resource?
  - Suppose it has a long minimum run time?
- Should flexible capacity have a minimum ratio of dispatchable range to minimum load output?

# CPUC/CAISO Flexible Capacity Requirement

Flexible Capacity Design Elements (continued)

- In what time frame must flexible capacity be dispatchable within?
- Can solar generation provide flexible capacity if it can be dispatched down when solar output is high, and if so, how should its flexible capacity be measured?
- How many megawatt hours of storage is required to provide a megawatt of capacity?
- In which hours of the day must a flexible capacity resource offer its output?

# CPUC/CAISO Flexible Capacity Requirement

An accurate answer to most of these questions is that the value of flexible capacity having these properties, depends on the overall amount of capacity having these properties, the operating characteristics of all other resources providing flexible capacity, and the offer prices of the resources.

- The CAISO has observed regarding its current qualification requirements for flexible capacity:

“Under the existing flexible capacity eligibility rule, section 40.10.3.2 of CAISO tariff, resources are required to meet various criteria to be eligible to provide flexible capacity. Many of these criteria are proving to be extremely difficult to validate.”

See California ISO, Resource Adequacy Enhancements, Third Revised Straw Proposal, December 20, 2019 p. 73

# CPUC/CAISO Flexible Capacity Requirement

Flexible Capacity Issues in the CAISO:

- "The following issues are of growing concern to the CAISO:
  - Current RA counting rules do not adequacy reflect resource availability and instead rely on complicated substitution and availability incentive mechanism rules;
  - Flexible capacity counting rules do not sufficiently align with operational needs;
  - Provisions for import resources need clarification to ensure physical capacity and firm delivery from RA imports;
  - Current system and flexible RA showings assessments do not consider the overall effectiveness of the RA portfolio to meet the CAISO's operational needs; and

# CPUC/CAISO Flexible Capacity Requirement

– Growing reliance on availability-limited resources when these resources may not have sufficient run hours or dispatches to maintain and serve the system reliably and meet energy needs in local capacity areas and sub areas.”

California ISO, “Resource Adequacy Enhancements, Fourth Revised Straw Proposal,” March 17, 2020 pp. 4-5. (also in prior straw proposals)

# CPUC/CAISO Flexible Capacity Requirement

Lessons So Far:

- It is not workable for an ISO to specify detailed requirements for what constitutes flexible capacity as the characteristics that are needed depend on the characteristics of the entire set of resources providing flexible capacity, and their offer prices.
- If the ISO specifies requirements broadly, it risks getting too much of particular types of capacity that are low cost, but only useful in limited quantities.
- If the ISO specifies requirements very tightly, allowing only the ideal resources to count, it will have a gold plated resource mix that is likely to be much more expensive than necessary.

# CPUC/CAISO Flexible Capacity Requirement

Lessons So Far:

- In setting flexible capacity requirements or targets the ISO can play an important role in informing utilities and state regulators of the kind of resource characteristics that will be needed to balance load and generation in coming years.

- This is a recurrent annual process in the CAISO, looking out over the next three years to assess needs for flexible capacity.

http://www.caiso.com/informed/Pages/StakeholderProcesses/FlexibleCapacityNeedsAssessmentProcess.aspx

# Capacity or Energy Markets

Are capacity markets as the solution to increased reliance on intermittent resources in meeting load?

- Capacity markets or requirements will incent investment in something, but will it incent investment in the kind of capacity that will maintain reliability and avoid cost shifts or adverse reliability impacts from undue leaning on the pool?
- An alternative approach would be to use planning models to assess reliability levels, enabling the system operator to inform the decisions of load serving entities, generators and regulators with indicative capacity targets.

# Capacity or Energy Markets

- This alternative approach would rely on energy only market, or perhaps back stop capacity markets with strong energy and ancillary service market incentives, to avoid undue leaning on the pool and to incent the construction and retention of the kind resource mix needed to balance net load in unbundled retail access markets.

# MOPR

MOPR and subsidized resources in unbundled retail access markets.

- The potential future entry of subsidized resources is an issue for states that want to rely on unregulated investments.
  - Unregulated investments will not occur if there is a risk of large uneconomic and unexpected subsidized investments being made after the unregulated investment is sunk.
  - When this risk reaches a critical level, unregulated investments will only be made at such high prices that all investments must be made on a regulated basis.

# MOPR

Unpredictable levels of future subsidized investment is not just a capacity market issue. This can be an issue impacting unregulated investment in energy only markets as well.

- The impact of subsidized resources is not an issue in SPP or MISO, states and utilities are already making investment decisions.
- The impact of the potential for high future levels of subsidized investments on investment in unregulated resources is a particular issue for multi-state ISOs as the decisions of a few large states to subsidize large amounts of uneconomic entry may create investment risks that force other states to abandon reliance on market based investment.