NYISO Capacity Accreditation: Conceptual Framework and Design Principles

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Background

- In our 2020 State of the Market report, we recommend that NYISO revise its capacity accreditation rules.[1]
- Current rules are inadequate for compensating new resource types and several old types in accordance with their actual reliability value.
  - ✓ We discussed shortcomings of NYISO's current capacity accreditation framework at our June 17, 2021 presentation to ICAPWG.
  - ✓ As the resource mix evolves, capacity market signals will become increasingly disconnected from resources' value.
- This presentation discusses key concepts of a framework that can be applied to all resource types in a changing grid.

[1] See Section VII.C and Appendix Section VI.I of 2020 Report.

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Overview

- This presentation discusses our conceptual framework for designing efficient capacity accreditation rules
- This presentation addresses the following topics:
  - ✓ Key principles and product definition
  - ✓ Approaches to estimating capacity value
  - ✓ Illustration of marginal accreditation approaches (appendix)
- Future presentations will provide further information on the advantages of marginal accreditation methods and details on our proposed methodology

Conceptual Framework:
Key Principles of Capacity Accreditation

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Introduction

- **<u>Design Objective</u>: to efficiently compensate all resources for their contributions to resource adequacy.**
  - ✓ Various resource types can all contribute to reliability but may have diverse characteristics.
    - Must objectively quantify the contributions of very different resources.
  - ✓ Accurate accreditation will be critical to facilitate investment in a diverse resource mix that satisfies reliability and policy criteria at the lowest cost.
- **<u>An efficient framework does NOT:</u>**
  - ✓ Excessively discount the capacity contributions of non-conventional resources.
  - ✓ Establish a firm requirement for some quantity of dispatchable, non-energy limited resources.
  - ✓ Increase total consumer payments by reducing capacity market supply.
  - ✓ Arbitrarily favor any class of resources for reasons unrelated to reliability.

Capacity Accreditation Design Principles

An efficient capacity accreditation framework should:

1. Align capacity payments with each resource's fundamental contribution to satisfying resource adequacy criteria.
2. Provide the same level of compensation to all resources that provide the same value.
   - ✓ Do not arbitrarily discriminate based on technology or between new and old resources.
3. Account for differences between resources' characteristics that affect their relative contributions to resource adequacy.
4. Send market signals that provide efficient incentives to invest in, maintain or retire capacity resources.

Product Definition

- Wholesale markets are designed to encourage competition between any new and existing resources that can provide a comparable service.
- In the capacity market, the relevant service is the resource's ***impact on the planning reliability metric*** (e.g., LOLE or expected unserved energy).
  - ✓ The capacity market is the primary means by which resources are obtained to satisfy planning reliability requirements.
  - ✓ Resources provide capacity value based on their expected effectiveness at reducing load shedding.
  - ✓ Resources with greater expected availability in critical periods when capacity is needed provide greater capacity value.
- The relevant question for accreditation:

  How would reliability be affected if a given resource were to enter the market or retire?

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Product Definition – Illustration

- Suppose the system is at its target level of LOLE = 1 day in 10 years (LOLE = 0.1 days per year).
  - ✓ Adding 10 MW of Resource X reduces LOLE by 0.001 days/year.
  - ✓ Adding 10 MW of Resource Y reduces LOLE by 0.0005 days/year.
  - ✓ Both resources have capacity value, but Resource X has more value per MW of installed capacity than Resource Y.
- Resource X might affect LOLE more because it has:
  - ✓ A lower forced outage rate,
  - ✓ Greater expected output at times when the system is short,
  - ✓ More flexibility to respond to shortage events,
  - ✓ Location downstream of transmission bottlenecks, or
  - ✓ Any other characteristic that affects its ability to reduce load shedding.

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Product Definition
Role of Capacity Requirements

- The ICAP and UCAP requirements are *proxies* for the actual resource adequacy criteria, which is the target LOLE.
- Each year, the IRM/LCRs are set to whatever level is expected to satisfy the LOLE target *given the existing resource mix*.
  - ✓ They are <u>not</u> derived from a fundamental need for some quantity of ICAP MWs.
- The UCAP requirement is a purely market concept derived from the IRM/LCRs and resources' derating factors.
  - ✓ Its purpose is to compensate resources in proportion to their relative capacity value when clearing the market, <u>not</u> to satisfy a fundamental need for a particular quantity of UCAP MWs.
- <u>Takeaway</u>: capacity credit should reflect each resource's impact on resource adequacy criteria, not a fundamental need to satisfy a specific MW target.

Characteristics that Affect Capacity Value

- **Location of resource**
- **Independent (uncorrelated) unavailability**
  - ✓ e.g. forced outages, intermittent output relative to peer group, etc.
- **Correlated unavailability during critical hours**
  - ✓ Resources whose availability in critical hours is correlated (positively or negatively) have diminishing returns or synergies
    - – Fuel source / technology (gas-only generators, wind, solar)
    - – Duration limitations
    - – Size of individual resource – a large unit is like a chunk of correlated capacity
    - – Inflexibility of resource **–** resources with long startup lead times and slow ramp rates may be available in a smaller subset of critical hours than more flexible resources

Conceptual Framework:
Methods to Assess Capacity Credit

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Calculating Capacity Value

- Random forced outage rates (EFORd) capture *independent* availability but not *correlated* availability.
- A resource's impact on LOLE can be calculated in a resource adequacy model (e.g. GE-MARS).
  - ✓ Hourly probabilistic model that simulates uncertainty in resource availability and load.
  - ✓ Inputs resource characteristics (ICAP, hourly profile, EFORd, energy limits, etc) and outputs system reliability metric.
  - ✓ The effects of correlations and synergies are automatically captured when resources are modeled accurately.
- The following slides discuss alternative approaches to estimating capacity value in a resource adequacy model.

Calculating Capacity Value: Average vs. Marginal Approaches

- Recognizing correlated unavailability of resources is key for accurately determining the reliability value of a resource.
- Such correlation causes the next resource of a certain type to be much less valuable when the system has large amounts of that type of resource. In this case:
  - ✓ The average value of all of one type of resource may be high; but
  - ✓ The marginal value of the next resource may be very low.
- Simplified example:
  - ✓ Assume a system with a very large quantity of solar resources whose output are highly correlated.
  - ✓ In this case, tight conditions and shortages are increasingly likely to occur at times when solar output is low.
  - ✓ This can cause the marginal solar unit to have very little value.
  - ✓ However, if other non-solar generators or storage then enter, the marginal solar unit's value is likely to increase.

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Note on Reliability Metrics

- There are multiple alternative reliability metrics. For example:
  - ✓ LOLE – number of days in which load shed occurs (days/year)
  - ✓ Expected Unserved Energy (EUE) – total energy not served during all load shed events (MWh/year)
- LOLE is used in setting NYISO's IRM, in accordance with NPCC and NYSRC rules.
- In principle, any reliability metric could be used for establishing capacity accreditation values.
  - ✓ EUE is likely to produce smoother and more monotonic results.
  - ✓ EUE puts more emphasis on severe/life threatening events (ex. February 2021 ERCOT shortages).
- In this presentation we refer to LOLE, but recommend considering if expected unserved energy can be used.

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Marginal Reliability Improvement (MRI)

- MRI measures a resource's effectiveness at reducing LOLE, relative to 'perfect capacity' that is always available.
  - ✓ MRI methods are used in ISO-NE's capacity market demand curve.

Example MRI calculation for Resource X:

1. Begin with base case reflecting actual resource mix, increase load so that LOLE = 0.1 days/year.
2. Add 50 MW of Resource X to Case 1. Calculate LOLE
3. Add 50 MW of 'perfect capacity' to Case 1. Calculate LOLE

$$MRI_X = [(\Delta LOLE \text{ in Case 2}) / (\Delta LOLE \text{ in Case 3})]$$

- Provides a value for each resource type between 0% and 100%, because no resource is more than perfectly available.

Marginal ELCC

- Marginal ELCC ("M-ELCC") measures how much perfect capacity would produce the same LOLE as an incremental quantity of a given resource.
- **Example Marginal ELCC calculation for Resource X:**
  1. Begin with base case reflecting actual resource mix, increase load so that LOLE = 0.1 days/year
  2. Subtract 50 MW of Resource X from Case 1. Calculate LOLE
  3. Starting from Case 2, add perfect capacity until LOLE = 0.1
- **$M\text{-}ELCC_X$ = [(MW of perfect capacity added in Case 3) / (50 MW of Resource X removed in Case 2)]**
- Provides a value for each resource type between 0% and 100%, because no resource is more than perfectly available.

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MRI vs. Marginal ELCC

- MRI and Marginal ELCC are likely to yield very similar results.
  - ✓ Both approaches compare the impact of an incremental amount of Resource X on LOLE to that of perfect capacity.
- MRI is less computationally intensive than LOLE.
  - ✓ For a given category of resources, MRI always requires a base case and two change cases in MARS.
  - ✓ Marginal ELCC requires iterating until a target LOLE is reached, so the number of change cases is unknown.
  - ✓ MRI requires N+2 runs to test N categories, while M-ELCC requires 3N+1 runs (assumes two iterations for each category).
- When calculating capacity credit for numerous resource categories and locations, MRI is likely a preferable approach.

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Average / "Portfolio" ELCC

- Average ELCC measures how much perfect capacity could replace all capacity of a given category (or group of categories) while holding LOLE constant.
- **Example Average ELCC calculation for Category X:**
  1. Begin with base case reflecting actual resource mix, increase load so that LOLE = 0.1 days/year.
  2. Subtract <u>all</u> MWs of Category X from (1). Calculate LOLE.
  3. Starting from (2), add perfect capacity until LOLE = 0.1
- **Average_ELCC$_X$ is the ratio of perfect capacity added in (3) to quantity of Category X removed in (2).**
- ***Average ELCC has major deficiencies as an accreditation approach.***

Advantages of Marginal Accreditation

- Compensates each resource based on effectiveness at reducing load shedding, regardless of technology or new/existing.
- Recognizes diminishing returns to correlated resources and synergies between resources that have zero/negative correlation.
- Provides efficient incentives to:
  - ✓ Avoid saturation by a particular technology
  - ✓ Invest in a diverse mix of complementary resources
  - ✓ Pair storage with intermittent resources or invest in standalone storage as intermittent penetration rises
  - ✓ Efficiently choose between storage project durations and augment duration of storage over time
  - ✓ Maintain flexible conventional resources if they are needed

Relationship to Resource Adequacy Model

- MRI and ELCC estimates are as accurate as the underlying resource adequacy model.
- NYISO's current GE-MARS model does not account for:
  - ✓ Correlation between load and intermittent resource output
  - ✓ Limitations of gas supply to multiple units simultaneously
  - ✓ Extreme events that affect load, generator availability and renewable output simultaneously
  - ✓ Uncertainty in day-ahead net load forecast
  - ✓ Generator startup lead times
- As resource adequacy modeling is improved over time, capacity credit estimates will also tend to improve.

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Areas for MARS Improvement Affecting Capacity Value

Modeling Issue	Current Status	Description
Correlation of gas-only units	Not modeled	MARS does not consider limits on total pipeline gas supply that constrain operation of multiple gas-only generators.
Correlation of intermittent profiles & load	Partially modeled	Intermittent resources are modeled using variable hourly profiles. However, the profile shape is modeled independently from the load shape.
BTM solar and other load modifiers	Partially modeled	MARS uses historical load shapes from before significant PV. NYISO plans to use more recent load shapes. Most accurate representation would adjust for BTM-PV annually.
Extreme weather / common mode events	Partially modeled	Structural load shape not modeled separate from weather. Simultaneous outcomes (e.g. high load, low wind, gen outages) can occur in MARS, but they are underrepresented because events resulting from single common driver are not modeled.
Energy storage dispatch	Partially modeled	Currently modeled using static output shapes. NYSRC and NYISO are investigating more dynamic approaches.
Forecast error / Start Up Time	No modeled	MARS does not consider these factors.

Appendix:
Illustration of Marginal Approach

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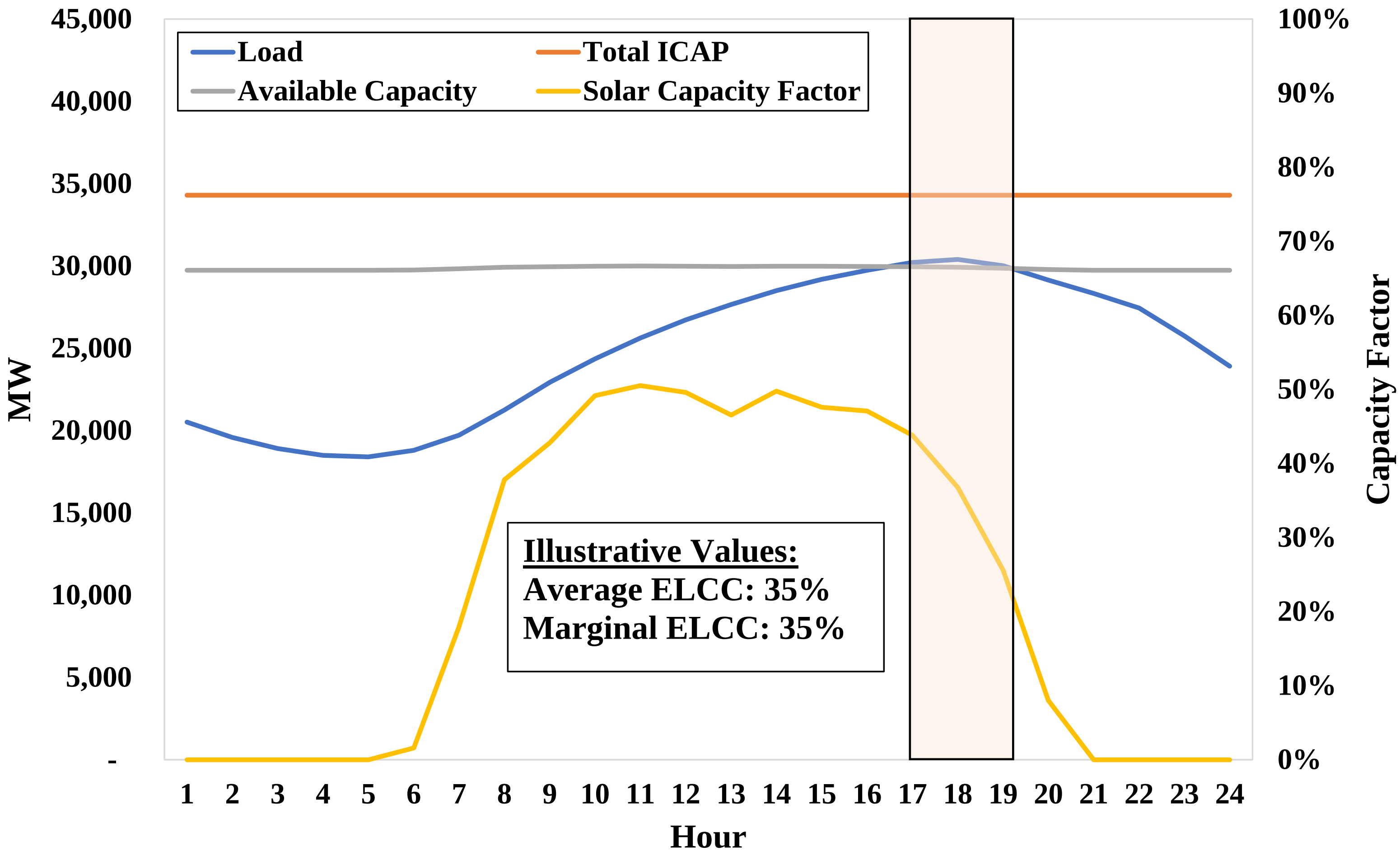
Marginal Accreditation – Conceptual Example

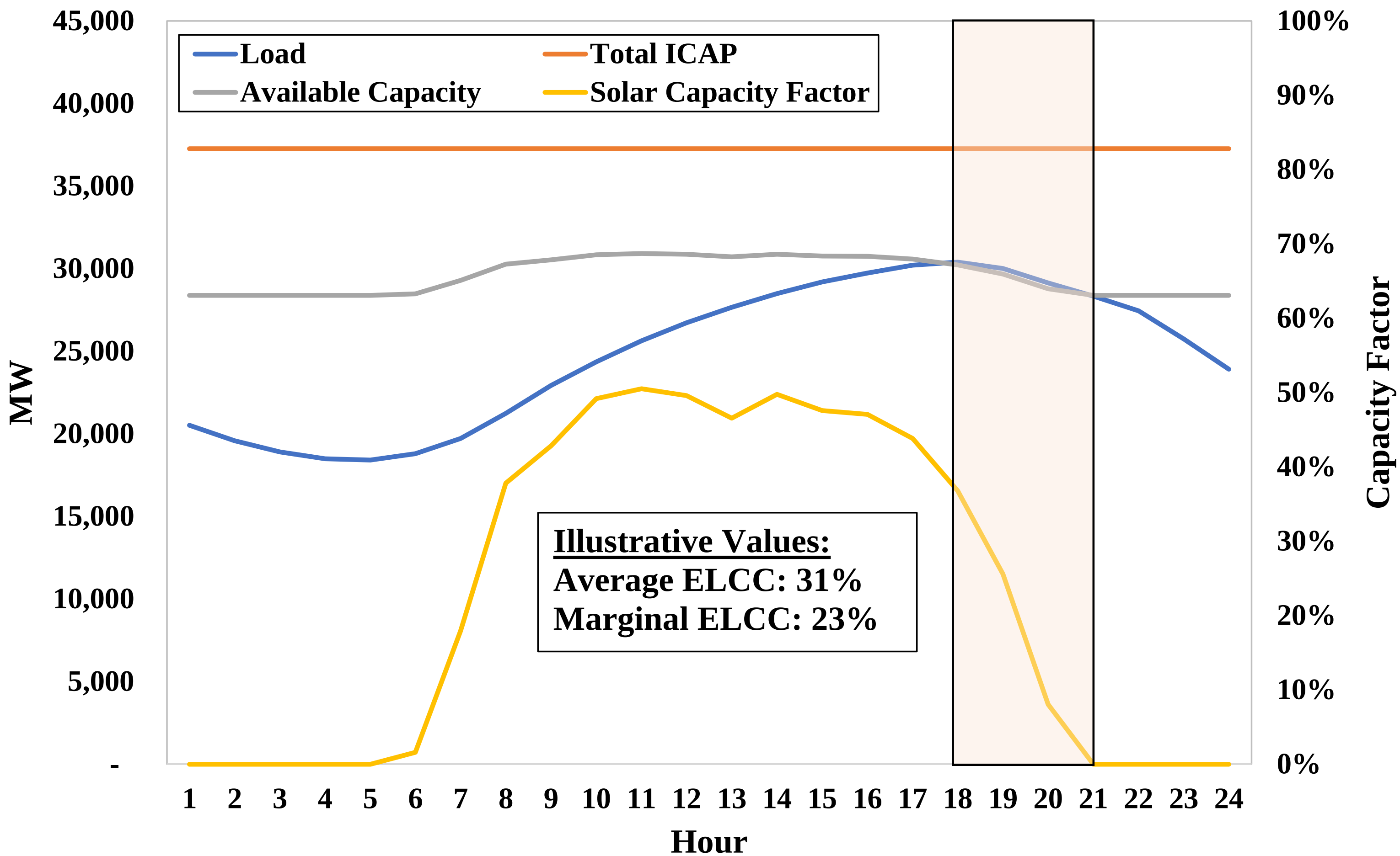
- The following slides show a stylized example of capacity value under marginal (MRI or M-ELCC) methods – ***this is a simplified illustration – NOT an estimate of actual capacity value.***
- Each case represents <u>one day</u> (MARS simulates many years).
- System consists of conventional resources (12% assumed on outage on this day) and solar resources.
- Quantity of conventional resources is calibrated so there is a constant level of load shedding MWhs in every case.
  - ✓ Capacity value is calculated <u>at criteria</u>, so adding solar capacity changes the shape but not quantity of load shedding.
- M-ELCC estimated as capacity factor in hours of load shedding.
- Average ELCC estimated as perfect capacity that could replace all solar in the scenario, holding load shedding MWhs constant.

Illustration of Marginal Approach
500 MW Solar



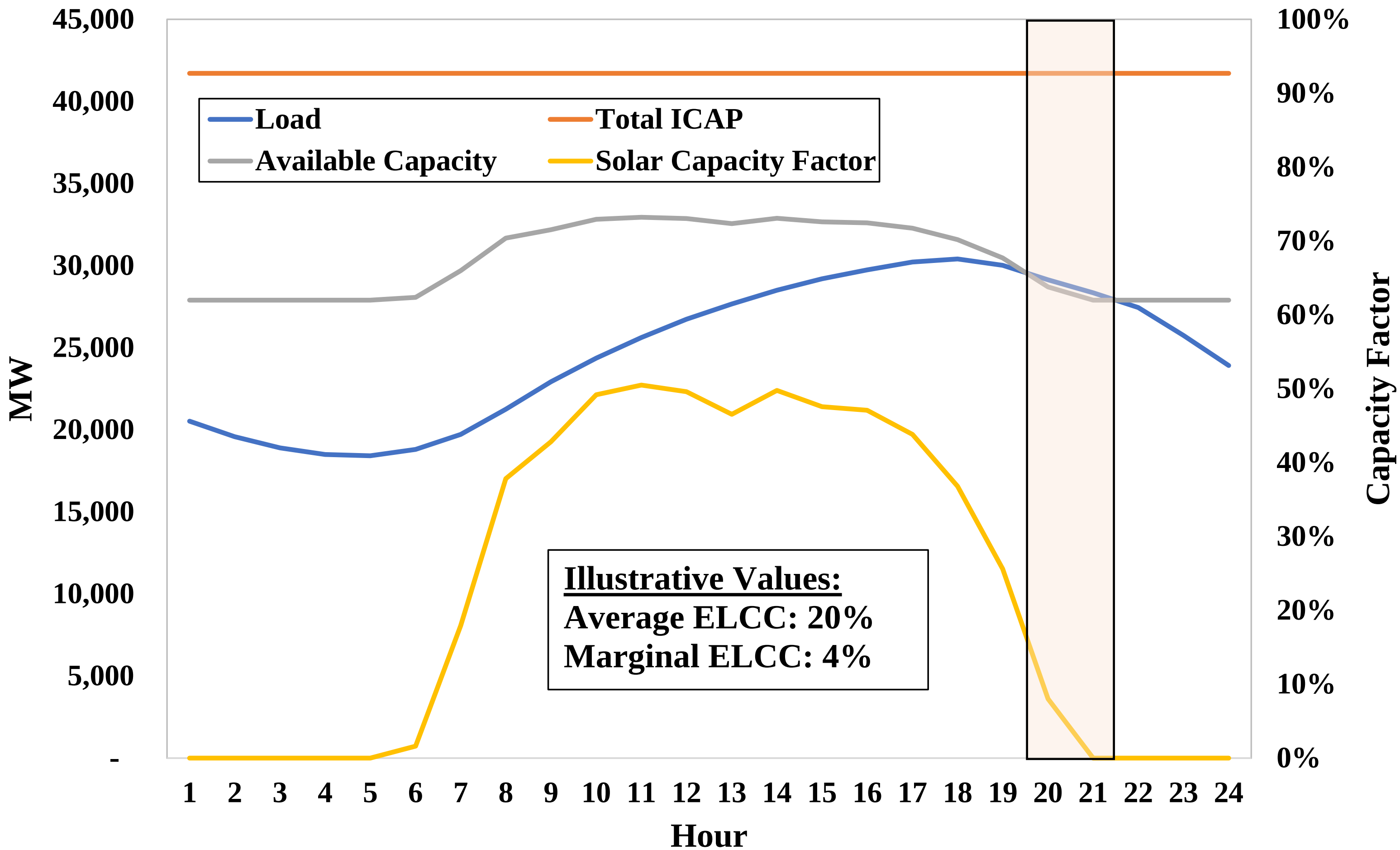
Note: conceptual illustration, NOT an estimate of actual capacity value.

Illustration of Marginal Approach
5,000 MW Solar



Note: conceptual illustration, NOT an estimate of actual capacity value.

Illustration of Marginal Approach
10,000 MW Solar



Note: conceptual illustration, NOT an estimate of actual capacity value.

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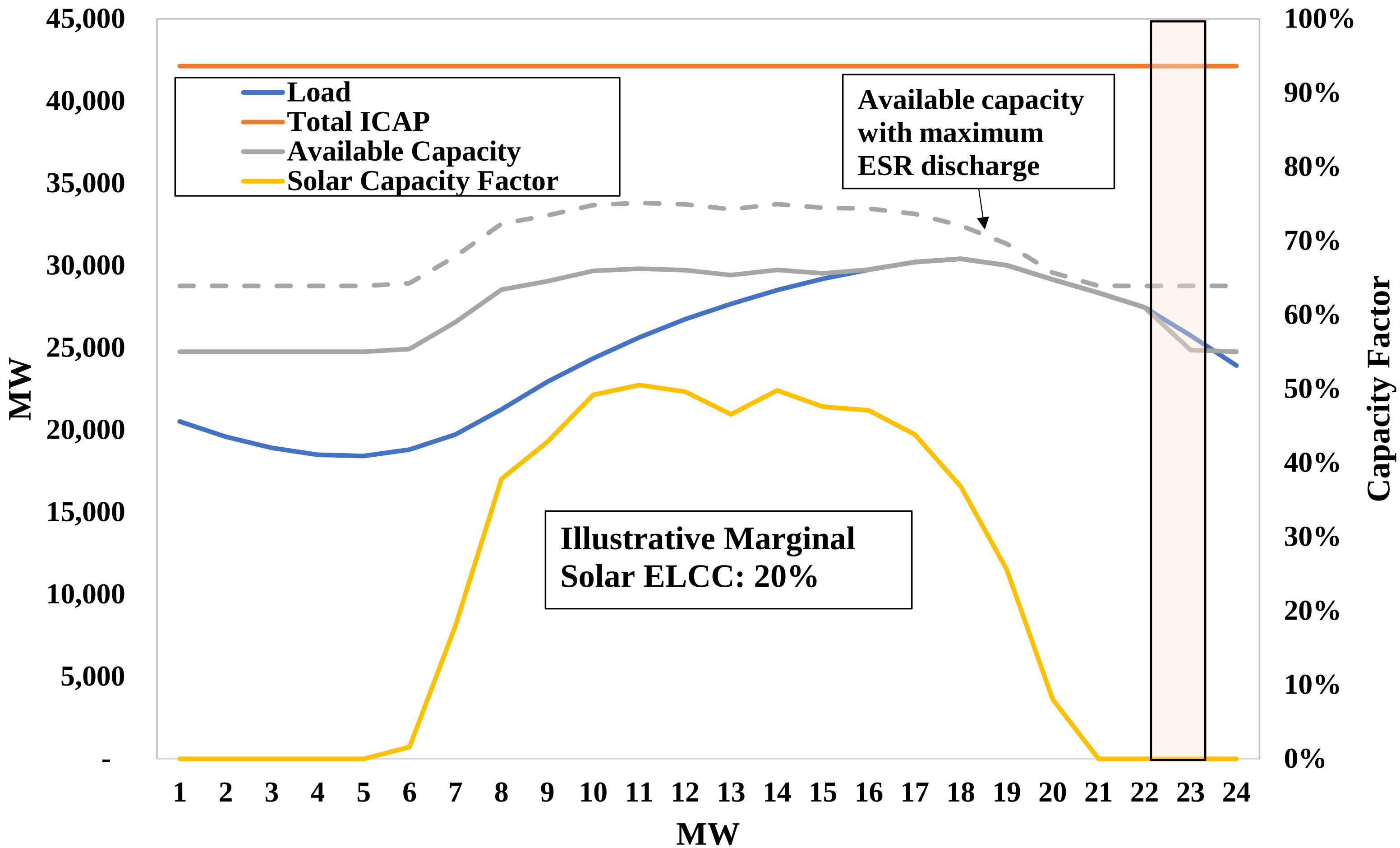
Illustration of Marginal Approach
10,000 MW Solar + 4,000 MW Storage (4-hour)



Note: conceptual illustration, NOT an estimate of actual capacity value.

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Illustration of Marginal Approach Takeaways

- Capacity value is a function of the system's resource mix *as a whole*.
  - ✓ With high solar, hours when load shedding occurs shift to evening.
  - ✓ Adding storage can increase the marginal capacity value of solar.
- Marginal ELCC (or MRI) indicates the resource's contribution at times when load shedding is most likely.
  - ✓ At high penetrations, average ELCC significantly overstates this.
- Capacity value of a resource is distinct from capacity surplus.
  - ✓ Each case had the same level of reliability – no change in surplus.
  - ✓ Capacity value is affected by the timing of critical hours as the resource mix evolves, even if the overall reliability level is constant.
  - ✓ Appropriate compensation is the *value of improving reliability* times the resource's *effectiveness at improving reliability*.