memo

**To:** NEPOOL Markets Committee, Reliability Committee, and Transmission Committee

**From:** ISO New England, Inc.

**Date:** September 3, 2025

**Subject:** Marginal Reliability Impact (MRI) Framework for Accrediting Capacity Resources

## Section 1. Executive Summary

This memorandum discusses the conceptual framework for the ISO's proposed accreditation methodology under the Capacity Auction Reforms (CAR). The MRI framework will result in summer and winter accredited capacity that reflects resources' expected performance during simulated hours where resource adequacy is at risk. More specifically, using General Electric Vernova's Resource Adequacy software (formerly GE-MARS), resources will be accredited based on their expected performance during simulated hours where additional available capacity would mitigate or prevent load shed.

All capacity market design decisions are informed by three design objectives:[1]

**Reliability:** to ensure that the capacity market is designed to satisfy the North American Electric Reliability Corporation' (NERC) one-day-in-ten Loss of Load Expectation (LOLE) resource adequacy standard.

**Sustainability:** to incent the investment needed to meet the reliability design objective over time as system and market conditions change.

**Cost-effectiveness:** to procure capacity to meet the reliability and sustainability design objectives while minimizing costs.

This memo considers i) relevant factors for how the existing accreditation framework impacts the manner in which the capacity market achieves its design objectives and ii) how the proposed MRI framework would improve the capacity market's ability to achieve those objectives. The memo reaches the following conclusions:

- Resources' current accredited capacity values and their expected contributions to resource adequacy could be more closely linked. As a result, some resources should be paid more than is the case under current rules, and others less. Improving the linkage between resource adequacy contributions and capacity market compensation will better help the capacity market to achieve its three design objectives. Such improvements will be particularly important in the coming

[1] Note that the Reliability, Sustainability, and Cost-effectiveness design objectives are long-standing. See, for example, the ISO's presentation on the FCM Zonal demand curves here. For a more recent discussion, see the CAR Project Scope Discussion presentation here.

years; as market conditions evolve, the risk that the existing accreditation framework will cause the capacity market to fall short of its design objectives is likely to increase.

- Accrediting resources based on their expected performance during the simulated hours that are important for resource adequacy directly links resources' capacity market compensation with their expected reliability contributions. By compensating resources in a manner commensurate with their expected contributions to resource adequacy, the MRI framework will address many of the shortcomings associated with the existing accreditation rules. Critically, the MRI framework will help the capacity market to achieve its design objectives not only under current conditions, but also as the grid evolves.

The remainder of this memo is split into four sections:

- The first section discusses the region's existing accreditation framework and the circumstances under which, as system conditions and the resource mix evolve, the current design may achieve less than ideal outcomes given the capacity market's design objectives.

- The second section discusses the MRI framework to explore how accrediting resources based on their expected performance during simulated hours when resource adequacy is at risk ameliorates the shortcomings associated with the current framework.

- The third section focuses on two key features of the MRI framework: 1) how resources' performance will be modeled, and 2) how the ISO will identify the simulated hours that are important for resource adequacy ("the MRI Hours"). While this memo touches on how resources will be modeled under CAR, a separate memo and presentation planned for the September Reliability Committee will explore the significant modeling improvements planned for CAR in greater detail.

- The fourth section provides an overview of the changes planned for CAR relative to the Resource Capacity Accreditation (RCA) proposal.

**Section 2. Existing Accreditation Process: Qualified Capacity (QC)**

The capacity, energy, and ancillary services markets provide revenue for resources that are needed to meet the one-day-in-ten standard. While resources earn revenue from the energy and ancillary services markets, some may require capacity market revenue to cover their costs and continue operation. As such, the capacity market plays a critical role in meeting the region's reliability standard.

A resource's capacity market compensation is determined by two factors: the maximum quantity of capacity that they can sell in the market (their "accredited capacity"), and the price they are paid per unit of capacity. As one of the two factors that determine capacity market compensation, capacity accreditation is a critical piece to ensuring the capacity market meets its design objectives.

Under current rules, we call resources' accredited capacity their Qualified Capacity (QC). Specifics vary by resource subtype and operating characteristics, but in general, resources have their QC set as follows:[2]

1. For the Intermittent Power Resources (IPRs), QCs are set by the average of their median output in a fixed set of peak "Reliability Hours" over the last five years.[3,4]

2. QCs for non-IPRs (e.g., gas and nuclear resources) are based on a maximum demonstrated audited capability over one to two hours in each season.

Note that there are important differences between the Reliability Hours upon which IPRs are currently accredited and the MRI Hours that will be the foundation of the MRI approach to accreditation under CAR. The Reliability Hours are a pre-defined set of hours centered on peak summer and winter hours. While the MRI Hours can potentially include the peak hours, they are more comprehensive and will include any simulated hour where additional capacity would reduce unserved energy. The MRI Hours thus provide a more representative set of conditions in which resources can contribute to resource adequacy.

Additional material planned for future months will walk through the shortcomings of the existing accreditation approach in greater detail, but this section focuses on three specific concerns with QC.

**Section 2.1. Concern 1: With current rules, the capacity market may ignore certain factors relevant to determining resource performance during tight system conditions**

Resources contribute to resource adequacy if their capacity is available during tight system conditions where load shed is possible. The current rules assume that accrediting resources based on their maximum capability or their expected median output during a fixed set of peak hours will approximate this expected contribution to resource adequacy. If this assumption is not true because resources are available at only a fraction of their QC during tight system conditions, the capacity market may not procure the set of resources that is needed to meet the region's one-day-in-ten reliability requirement, violating the Reliability design objective. This subsection highlights three examples where the current design's assumptions regarding resource availability can be improved.

**Section 2.1.1. Current accreditation framework does not account for outage rates**

Accrediting non-IPRs according to their maximum capability alone does not account for the possibility that these resources can be on outage during tight system conditions. Figure 1 below provides box and

[2] For demand capacity resources, their QC is administratively set based on project documentation submitted in the New Capacity Qualification Process. For Import Capacity resources, their QC is administratively set based on project data submitted by the Project Sponsor from the native control area. Both demand resources and import resources will be discussed in greater detail in coming months.

[3] Specifically, summer QC for the IPRs is determined by the average of the median output from hour ending 2:00 pm to hour ending 6:00 pm for the last five years, while their winter QC is set by the average of their median output from hour ending 6:00 pm to hour ending 7:00 pm over the last five years. The Reliability Hours also include any Capacity Scarcity Condition (CSC) event hours for each season over the last five years.

[4] On-Peak and Seasonal Peak Resources have their QC established through a similar approach to IPR by evaluating performance across a set of reliability hours.

whisker plots of resource outage rates by resource type. In the following bullets we will walk through Figure 1 in detail:

- Figure 1's x-axis lists the four categories of resources that are modeled with outage rates: combined cycles (CC), combustion turbines (CT), steam turbines (ST), and all other resources that have an outage rate (Other).

- Figure 1's y-axis lists equivalent forced outage rates on demand, excluding outside management control events[5] (EFORd). These EFORd were calculated using data from May 2019 to April 2024. EFORd can range from 0% (reflecting a resource that never goes on forced outage (or derate) except for outside management control events) to 100% (reflecting a resource that is always on outage).

- Each dot within each column represents the EFORd for one resource in that column's class. E.g., a dot in the teal box provides the EFORd for one steam turbine resource. Note that the dots are "jittered" (spaced out horizontally) to make individual resource EFORds easier to see.

- Each column's box and whisker plot provides data on the distribution of EFORds within that class:

    - The bottom of each box provides the 25$^{th}$ percentile EFORd for that class.

    - The solid line running through the middle of each box provides the median EFORd for that class.

    - The top of each box provides the 75$^{th}$ percentile EFORd for that class.

    - The lines (or "whiskers") that extend from the boxes reflect all of the resources that are not between the 25$^{th}$ and 75$^{th}$ percentiles of that class but that are not outliers.

    - The bold dots reflect resource EFORds that are outliers for their class, where outliers are any observation that is outside of the range 1.5*(75$^{th}$ percentile – 25$^{th}$ percentile.) Thus, the high value outliers have EFORds greater than the 75$^{th}$ percentile for that class plus 1.5*(75$^{th}$ percentile – 25$^{th}$ percentile.)

[5] You can find a list of the outside management control events here.

Figure 1: Box and Whisker Plot of EFORds

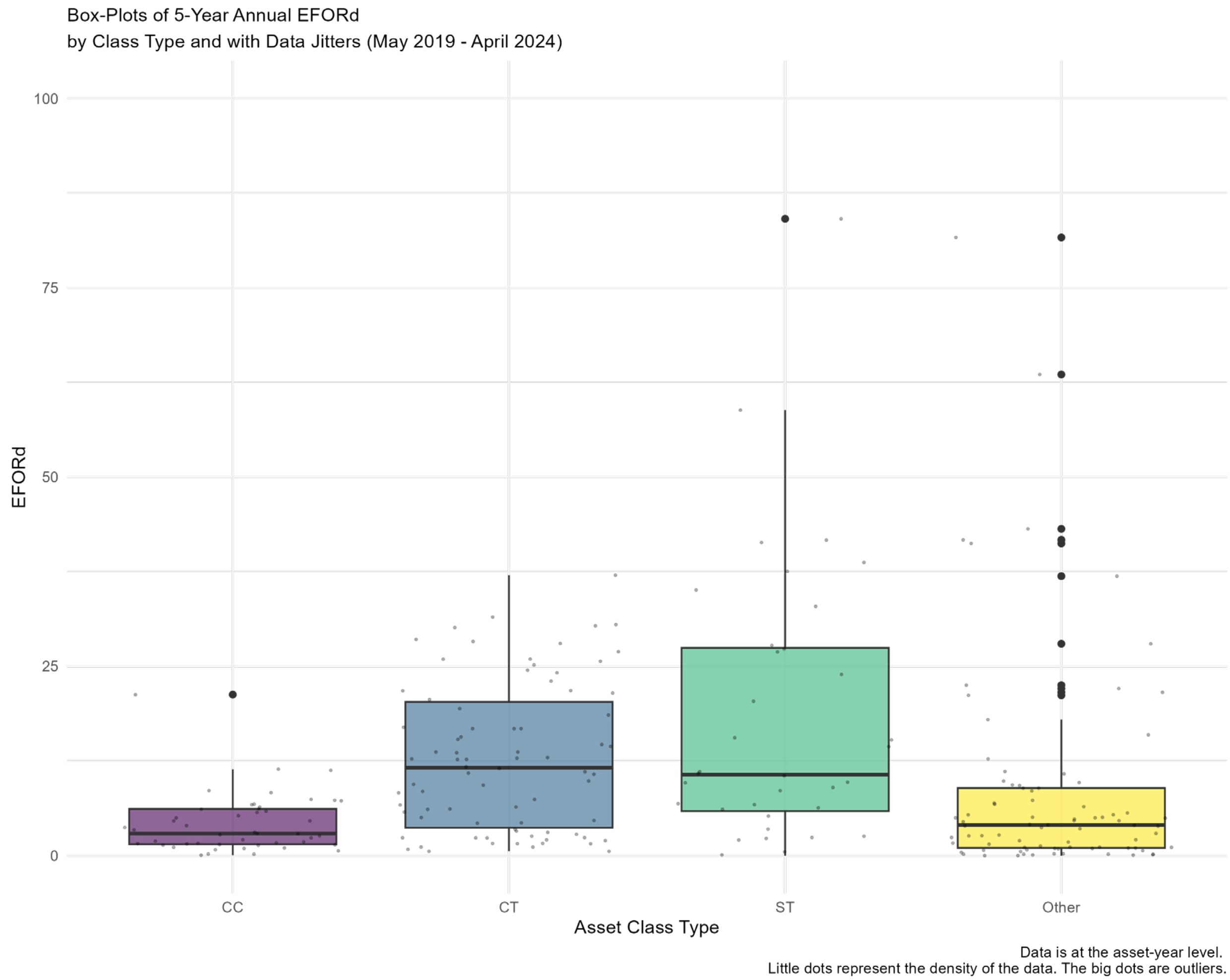


Figure 1 shows that many resources have significant outage rates, some as high as 50% or more. As a result, many of these resources may be unavailable when the system needs them most. Failing to account for outage rates in resources' accredited capacity may cause the capacity market to procure capacity that has a high probability of being unavailable when needed, negatively impacting system reliability.

### Section 2.1.1.1. Example 1

We will next walk through a simple example to demonstrate how ignoring outage rates in capacity accreditation could result in the capacity market procuring resources that are unable to perform during the hours that are important for resource adequacy.[6] Note that versions of this example will be used throughout the memo. Here, we start with the example in its simplest form and will add complexity as we move through the memo.

Example 1 assumes there are three hours that are important for resource adequacy. Conceptually, these hours could be hours with load shed where every additional MW of available capacity would

[6] This and other examples in this memorandum are for illustrative purposes and are not indicative of actual capacity procurement in Forward Capacity Auctions run to date.

reduce unserved energy. Such hours are precisely the type of hours for which the capacity market procures resources to ensure system reliability. Table 1 below considers the hourly performance of two resources:

- Thermal1 is a dispatchable resource that is never on outage (has a 0% EFORd) and has a maximum capability of 100 MW.
- Thermal2 is a dispatchable resource that is on outage in one third of hours (has a 33% EFORd) and has a maximum capability of 120 MW.

The first three rows of Table 1 provide the hourly performance of each resource. Row 4 provides the expected performance of the two resources in these three hours, and Row 5 provides their accredited capacity according to current rules (QC). Consistent with their outage rates, Thermal1 is available in all hours, while Thermal2 is available in only two thirds of the hours (Hours 2 and 3).

Table 1: Thermal Resources' QC may not Align with their Expected Performance during MRI Hours

| Hour | Thermal1 | Thermal2 |
|---|---|---|
| 1 | 100 MW | 0 MW |
| 2 | 100 MW | 120 MW |
| 3 | 100 MW | 120 MW |
| E[Performance] | 100 MW | 80 MW |
| QC | 100 MW | 120 MW |

Note that Thermal1's accredited capacity under the existing framework (QC) reflects its expected contribution to resource adequacy in these hours (Thermal1 is available at 100 MW in all three hours and is accredited at 100 MW.) As a result, if the capacity market procured Thermal1, it would procure capacity that is expected to be available in the hours where resource adequacy is at risk.

For Thermal2, however, their accredited capacity does not reflect their expected contribution to resource adequacy: Thermal2 is accredited at 120 MW but is only available at that level in two of the three hours where system reliability is at risk. Consequently, if the capacity market procured Thermal2, it would procure capacity that may frequently be unavailable in the hours when the system needs it most, violating the Reliability design objective.

**Section 2.1.2. Current accreditation framework only accounts for intermittent resource performance during pre-defined reliability hours**

Accrediting IPRs according to their expected median performance during the pre-defined set of Reliability Hours ignores resources' performance in other hours which also may be important for resource adequacy. The RCA Impact Analysis suggested that there are many hours outside of the Reliability Hours that, as system conditions change, may be important for resource adequacy.[7] For example, because the summer Reliability Hours are all daylight hours, solar resources' summer QC values do not account for the non-performance of solar resources during hours after sunset where resource adequacy may be at risk. As solar resource (or other IPR) procurement increases, failing to account for potential non-performance from the IPRs in some of the MRI Hours may cause the capacity

[7] See, for example, slide 27 of the February 2024 RCA Impact Analysis slides that includes a heat map of loss of load hours.

market to procure resources that cannot perform during the tight system conditions that are important for resource adequacy.

**Section 2.1.2.1. Example 2**

We will now walk through a numerical example that demonstrates how accrediting IPRs based only on their expected median performance during the Reliability Hours could result in the capacity market procuring resources that cannot perform during the full range of hours with resource adequacy risk.

Example 2 uses the same three-hour structure as Example 1 but instead considers two IPRs:

- IPR1 whose output varies over the example's three hours and whose expected median performance during the Reliability Hours is assumed to be 100 MW.
- IPR2 whose output also varies over the example's three hours but whose expected median performance during the Reliability Hours is assumed to be 120 MW.

As with Table 1, the first three rows of Table 2 provide the hourly performance of each resource, while Row 4 provides the expected performance of the two resources in the example's three hours, and Row 5 provides their accredited capacity according to current rules (QC).

Table 2: IPR QCs may not Align with their Expected Performance during MRI Hours

| Hour | IPR1 | IPR2 |
|---|---|---|
| 1 | 70 MW | 70 MW |
| 2 | 130 MW | 90 MW |
| 3 | 100 MW | 80 MW |
| E[Performance] | 100 MW | 80 MW |
| QC | 100 MW | 120 MW |

IPR1's performance in the example's three hours is greater than or equal to IPR2's performance in those hours. IPR2 has more accredited capacity, however, suggesting stronger performance in the pre-defined Reliability Hours. This is consistent with the observation that the hours that are important for resource adequacy and the fixed Reliability Hours are not necessarily the same: some hours that are important for resource adequacy may not be included in the Reliability Hours, and there will be some Reliability Hours where resource adequacy is not at risk.

Note that IPR1's accredited capacity reflects its expected contribution to resource adequacy: IPR1 is accredited at 100 MW and IPR1's average performance in the hours where resource adequacy is threatened is also 100 MW. As a result, if the capacity market procured IPR1, it would procure 100 MW of accredited capacity that is expected to perform at 100 MW, on average, during the hours where resource adequacy is at risk.

The same cannot be said for IPR2, however. If the capacity market procured IPR2, it would be purchasing 120 MW of accredited capacity but IPR2 would only be expected to perform at 80 MW during the hours where resource adequacy is at risk.

Example 2 shows that, with the current accreditation framework, the capacity market may procure resources that cannot perform during the hours when the system needs them most, violating the Reliability design objective.

### Section 2.1.3. Current accreditation framework ignores energy limits for energy storage resources beyond two hours

Energy storage resources (including battery storage and pumped-storage hydro resources) are currently accredited at their maximum capability if they can store enough energy to discharge at that maximum for two hours. Accrediting energy storage resources based only on their ability to perform for two consecutive hours does not account for their performance during longer duration events, which may cause the capacity market to procure resources that cannot perform during the hours that are important for resource adequacy.

#### Section 2.1.3.1. Example 3

Example 3 demonstrates that ignoring energy storage resource's energy limits may cause the capacity market to procure resources that cannot perform during the hours that are important for resource adequacy. As with Examples 1 and 2, Example 3 uses the same three-hour structure, but considers two energy storage resources:

- ES1 is an energy storage resource with a 100 MW maximum capability that can store three hours of energy. That is, when fully charged, ES1 can discharge at 100 MW for three consecutive hours before running out of energy.

- ES2 is an energy storage resource with a 120 MW maximum capability but that can store only two hours of energy. That is, when fully charged, ES2 can discharge at 120 MW for two consecutive hours.

As with Tables 1 and 2, the first three rows of Table 3 provide the hourly performance for ES1 and ES2, Row 4 provides the resources' expected performance across the three hours, and Row 5 provides their accredited capacity according to the existing accreditation framework.

Table 3: Energy Storage QCs do not Reflect Energy Limits Beyond Two Hours

| Hour | ES1 | ES2 |
|---|---|---|
| 1 | 100 MW | 120 MW |
| 2 | 100 MW | 120 MW |
| 3 | 100 MW | 0 MW |
| E[Performance] | 100 MW | 80 MW |
| QC | 100 MW | 120 MW |

Consistent with the assumption that Hours 1-3 are load shed hours, both energy storage resources are available at their maximum capability to minimize unserved energy. Because ES1 can store three hours of energy, it is available at its maximum in all three hours. ES2, however, is only available at its maximum in Hours 1 and 2 because it can only store two hours of energy. That is, by Hour 3, ES2 has exhausted its stored energy.

Note that ES1's qualified capacity reflects its expected resource adequacy contribution. ES1 is accredited at 100 MW and its expected performance during the example's three hours where resource adequacy is at risk is also 100 MW. Consequently, if the capacity market procured ES1, it would procure 100 MW of capacity that is expected to be available at 100 MW during the three hours when resource adequacy is at risk.

ES2's two-hour energy limit does not yield the same result, however. Recall that, under the existing accreditation framework, energy storage resources are accredited at their maximum capability if they can store at least two hours of energy. Because ES2 can store two hours of energy, their QC is therefore 120 MW. However, ES2's energy limit prevents them from providing capacity in Hour 3, reducing their expected performance during the hours when resource adequacy is at risk to 80 MW. As a result, if the capacity market procured ES2, it would procure 120 MW of accredited capacity that is expected to provide only 80 MW, on average, during the hours when resource adequacy is at risk.

Like the first two examples, Example 3 demonstrates that the current accreditation framework may cause the capacity market to procure resources that may be unavailable during the hours when the system needs them most.

**Section 2.2. Concern 2: With current rules, the capacity market may not send resources the most accurate entry/exit signals as system and market conditions change**

The ISO forecasts significant changes to system conditions and the resource mix. For example, the expected winter peak is likely to approach the expected summer peak by 2035.[8] Additionally, while the existing resource mix is dominated by gas, oil, or nuclear resources, over 99% of New England's current interconnection queue is associated with solar, wind, or battery storage capacity.[9]

As system conditions evolve, resources' contributions to resource adequacy are likely to change as well. E.g., greater penetration of behind-the-meter solar capacity may push the summer hours that are important for resource adequacy later in the day, impacting the reliability contributions of grid-scale solar resources, while higher winter loads may result in a higher number of winter hours important to resource adequacy. Because resources' QC values reflect either their maximum capability or their median performance during a fixed set of Reliability Hours, most resources' accreditation values are likely to remain stable even as the system changes.

This disconnect between changing system conditions and resources' accredited capacity values could potentially distort the capacity market's entry/exit signals. Specifically, if changes in system conditions cause a resource to provide greater contributions to resource adequacy, their capacity market compensation should increase in a commensurate manner relative to other resources. If resources are not paid more (less) as their resource adequacy contributions increase (decrease), the capacity market will not send accurate entry/exit signals. In the absence of accurate price signals, the capacity market may not procure the set of resources needed to achieve the one-day-in-ten resource adequacy requirement as system conditions evolve, violating the capacity market's Sustainability design objective.

**Section 2.3. Concern 3: With current rules, capacity market compensation may not provide the most accurate reflection of resources' contributions to resource adequacy**

The current accreditation rules assume that a resource's QC will approximate their contribution to resource adequacy. If this assumption is incorrect, some resources that contribute more to resource adequacy may be paid less than those that contribute less, impacting market signals.

Consider Examples 1, 2, and 3 above. In each case, the existing accreditation framework may over accredit resources relative to other resources in the same class that are expected to provide more capacity during the hours where resource adequacy is at risk. E.g., in Example 1, Thermal2 is accredited at 120 MW under the existing accreditation framework while their expected performance during the

[8] See the 2025 CELT report, located here.
[9] See information on the ISO's interconnection queue, located here.

hours where resource adequacy is at risk is only 80 MW. Additionally, even though Thermal1's expected performance during the three hours where resource adequacy is at risk is 100 MW and Thermal2's expected performance during those hours is only 80 MW, Thermal2 would be paid for 120 MW while Thermal1 would only be paid for 100 MW under the existing framework. That is, even though Thermal1 contributes **more** to resource adequacy, they would be paid **less** than Thermal2 under the existing accreditation framework, distorting the market signals that are key to maintaining reliability and minimizing consumer costs.

To summarize, by failing to account for many of the attributes that are important in determining resource adequacy contributions, the existing accreditation framework may yield inefficient capacity market compensation as system conditions and the resource mix evolve.

**Section 2.4. Key Takeaways**

- IPRs are currently accredited based on their expected median performance in a pre-defined set of Reliability Hours centered around the seasonal peak hours. These Reliability Hours are distinct from the MRI Hours upon which resources will be accredited under the MRI framework. While the MRI Hours can include the peak hours, they can also include other hours that are important for resource adequacy. Additionally, unlike the Reliability Hours which are static, the MRI Hours will change over time, reflecting changing system conditions.

- By failing to incorporate resource attributes that are important for resource adequacy into the existing accreditation process: i) the capacity market may not procure the resources needed to achieve the region's one-day-in-ten loss of load standard, violating the capacity market's Reliability design objective, and ii) the existing accreditation framework may yield inefficient capacity market compensation, burdening consumers with unnecessary costs.

- Resources' QC values are largely static, which may cause disparities between resources' capacity market compensation and their resource adequacy contributions as system conditions evolve. If reliability contributions and capacity market compensation diverge, the capacity market may fail to procure the resources it needs to meet the one-day-in-ten standard in a sustainable manner, violating the capacity market's Sustainability design objective.

**Section 3. MRI Accreditation Framework**

The previous section summarized the existing accreditation framework and highlighted the need to change the design to be responsive to changing system and market conditions. This section describes the MRI framework and explores how it addresses those concerns.

The MRI framework for accreditation will yield accredited capacity values that reflect resources' expected performance during the simulated hours where resource adequacy is at risk. By accrediting resources based on their expected performance in these MRI Hours, the CAR design will closely link resources' capacity market compensation with their expected resource adequacy contributions. Each of the three features discussed in this section explores how the MRI framework supports the capacity market's design objectives and addresses the concerns associated with the existing accreditation process.

**Section 3.1. Feature 1: By accrediting resources based on their expected performance during the MRI Hours, the capacity market will better procure resources that can perform during tight system conditions**

Concern 1 above notes that the existing accreditation framework can be improved upon to ensure the market procures resources that can perform during the hours that are important for resource adequacy. The MRI framework improves upon the existing framework by directly accrediting resources on their expected performance during such conditions. That is, assuming resource modeling accurately reflects resources' expected availability, the MRI framework will help the capacity market to procure a set of resources that are expected to perform during hours where resource adequacy is at risk.

The previous section included three examples that demonstrated how the existing accreditation framework could be improved to better capture resource performance during hours where resource adequacy is at risk. We will revisit these examples below to see how the MRI framework ameliorates this concern.

**Section 3.1.1. MRI Framework will Incorporate Resources' Outage Rates into their Accreditation**

By accrediting thermal resources based on their expected performance during the MRI Hours, the MRI framework will help align the amount of capacity resources can sell with the amount of capacity they are expected to provide on average during hours important for resource adequacy.

Consider Table 1b below. Table 1b is identical to Table 1 from Example 1, except it adds a sixth row that includes the accredited capacity Thermal1 and Thermal2 would receive with the MRI framework. We call accredited capacity under the MRI framework "MRI Capacity." Recall that the MRI framework will accredit resources based on their expected performance during the simulated hours where resource adequacy is at risk, so that the resources' expected performance in Row 4 equals their accredited capacity under the MRI framework in Row 6.

Table 1b: MRI Framework Incorporates Resource Outages into Accreditation

| Hour | Thermal1 | Thermal2 |
|---|---|---|
| 1 | 100 MW | 0 MW |
| 2 | 100 MW | 120 MW |
| 3 | 100 MW | 120 MW |
| E[Performance] | 100 MW | 80 MW |
| QC | 100 MW | 120 MW |
| MRI Capacity | 100 MW | 80 MW |

To see the improvement provided by the MRI framework, consider how Thermal2's accredited capacity changes from the existing accreditation framework to the MRI framework. Under the existing accreditation framework, Thermal2's accredited capacity (their QC) is 120 MW. As a result, if the capacity market procures Thermal2, it would procure 120 MW of capacity that is only expected to be available at 80 MW, on average, during the hours where resource adequacy is at risk. Procuring capacity that is frequently unavailable when needed decreases system reliability, violating the Reliability design objective. The MRI framework improves upon the existing accreditation rules by accrediting Thermal2 based on their expected performance during the MRI Hours directly. That is, under the MRI framework, if the capacity market procures Thermal2, it would procure 80 MW of accredited capacity that is expected to be available at 80 MW, on average, during the hours where resource adequacy is at risk.

**Section 3.1.2. MRI Framework Accounts for IPRs' Expected Performance in Hours Outside of the Fixed Reliability Hours**

The existing framework accredits IPRs based on their average median performance in the fixed Reliability Hours over the last five seasons. As a result, the existing accreditation framework does not directly account for IPRs' performance (or non-performance) during hours that are important for resource adequacy outside of the Reliability Hours. By accrediting the IPRs based on their expected performance during *all* simulated hours that are important for resource adequacy, the MRI framework will improve the manner in which the capacity market procures resources that are expected to be available during tight system conditions.

Consider Table 2b below, which is identical to Table 2 from Example 2 except it adds a sixth row that includes IPR1's and IPR2's accredited capacity under the MRI framework (MRI Capacity).

Table 2b: MRI Framework Incorporates IPR Performance in all Hours where Resource Adequacy is Threatened

| Hour | IPR1 | IPR2 |
|---|---|---|
| 1 | 70 MW | 70 MW |
| 2 | 130 MW | 90 MW |
| 3 | 100 MW | 80 MW |
| E[Performance] | 100 MW | 80 MW |
| QC | 100 MW | 120 MW |
| MRI Capacity | 100 MW | 80 MW |

We can see the improvement provided by the MRI framework by examining IPR2's accreditation under the existing framework and  the MRI approach. Under the existing accreditation approach, IPR2 is accredited at 120 MW based on their assumed average median performance during the fixed Reliability Hours. However, their expected performance during the simulated hours where resource adequacy is at risk (Hours 1-3) is only 80 MW. As a result, if the capacity market procures IPR2, it would purchase 120 MW of capacity that is expected to only provide 80 MW, on average, during conditions when the system needs that capacity most.

The MRI framework improves upon the existing framework by accrediting IPR2 based on their expected performance during such conditions directly. If the capacity market procures IPR2 under the MRI framework, it would purchase 80 MW of accredited capacity that is available at 80 MW, on average, in the hours where resource adequacy is threatened.

We reach a similar conclusion as was provided by Table 1b above: by incorporating IPR performance outside of the Reliability Hours where resource adequacy is at risk, the MRI framework will help the capacity market to procure resources that can perform during the hours when the system needs them most.

**Section 3.1.3. MRI Framework Better Reflects Energy Storage Resources Energy Limitations**

The existing accreditation framework accredits energy storage resources at their maximum capability if they can store at least two hours of energy, which does not account for potential non-performance of energy storage resources during events that last longer than two consecutive hours. The MRI framework improves upon the current framework by accrediting the energy storage resources based on their expected performance during events where resource adequacy is threatened.

Consider Table 3b below, which is an extension of Table 3 from Example 3 above. As with Tables 1b and 2b, Table 3b is identical to Table 3 except for the addition of Row 6, which includes the accredited capacity for ES1 and ES2 using the MRI framework.

Table 3b: MRI Framework Incorpoates Energy Storage Resource Energy Limits into Capacity Accreditation

| Hour | ES1 | ES2 |
|---|---|---|
| 1 | 100 MW | 120 MW |
| 2 | 100 MW | 120 MW |
| 3 | 100 MW | 0 MW |
| E[Performance] | 100 MW | 80 MW |
| QC | 100 MW | 120 MW |
| MRI Capacity | 100 MW | 80 MW |

To see how the MRI framework will better account for the energy limitations of these resources, consider how ES2 is accredited under both the existing framework and the MRI framework. Under the existing framework, ES2 is accredited at its maximum capability, 120 MW, because it can store at least two hours of energy. However, ES2 can only provide 80 MW, on average, across the example's three hours. As a result, if the capacity market procures ES2, it will purchase 120 MW of capacity that can only provide 80 MW, on average, during the hours where resource adequacy is at risk.

The MRI framework improves upon the existing framework by directly accrediting ES2 based on its expected performance during the MRI Hours. Under the MRI framework, by procuring ES2, the capacity market would purchase 80 MW of accredited capacity that is expected to provide 80 MW, on average, during the hours where resource adequacy is threatened. That is, the MRI framework results in the capacity market procuring a quantity of accredited capacity that is commensurate with that capacity's expected resource adequacy contribution.

**Section 3.2. Feature 2: Accrediting resources based on their expected performance during the MRI Hours will yield capacity market compensation that reflects resources' evolving reliability contributions over time**

Concern 2 above notes that the existing accreditation rules yield QC values that do not change to reflect resources' evolving resource adequacy contributions over time, resulting in less accurate entry/exit signals. The MRI accreditation framework addresses by allowing accredited capacity values to change with evolving resource adequacy contributions.

Specifically, under the MRI accreditation framework, resources are accredited based on their expected performance during the MRI Hours. Unlike the fixed Reliability Hours upon which IPRs are currently accredited, the MRI Hours will change over time to reflect changing system conditions. By accrediting resources based on their expected performance during the hours that are modeled as important for system reliability, resources' capacity market compensation will reflect their evolving reliability contributions. As a result, the capacity market will provide resources with more accurate entry/exit signals as system conditions and the resource mix evolve.

**Section 3.3. Feature 3: Accrediting resources based on their expected performance during the MRI Hours will help the capacity market to better compensate resources in a manner commensurate with their resource adequacy contributions**

Concern 3 above notes that, by failing to tie resources' expected resource adequacy contributions to their capacity market compensation, the existing accreditation rules may not cost-effectively procure the capacity needed to meet the region's one-day-in-ten reliability requirement. The MRI framework improves upon the existing accreditation methodology by accrediting resources based on their expected performance during the MRI Hours and, in doing so, directly linking resources' expected resource adequacy contributions to their capacity market compensation.

Consider Tables 1b, 2b, and 3b above. In each case, a capacity market with the MRI framework would pay more to the resource that contributes more to resource adequacy. Because the intuition is the same in each example, we will focus on Table 1b for brevity.

In Table 1b, Thermal1 is expected to perform better than Thermal2 in the hours where resource adequacy is threatened (see Row 4, where Thermal1's expected performance is 100 MW while Thermal2's expected performance is only 80 MW.) A cost-effective design would pay Thermal2 less than Thermal1, reflecting the fact that they are expected to contribute less to resource adequacy. However, if both resources sold their full accredited capacity in a market with the existing design, Thermal2 would be paid more than Thermal1 because Thermal2's accredited capacity under the existing accreditation framework (120 MW) is greater than Thermal1's accredited capacity under the existing framework (100 MW.) The MRI framework corrects this issue by accrediting Thermal1 and Thermal2 based on their expected performance during the hours where resource adequacy is at risk; in Row 6, we can see that, under the MRI framework, Thermal1 will be able to sell 100 MW of accredited capacity in the capacity market, while Thermal2 would only be able to sell 80 MW. As a result, if both resources were to sell their accredited capacity in the market, Thermal1 would be paid more than Thermal2: the resource that contributes more to resource adequacy will be paid more than the resource that contributes less.

To summarize, capacity market compensation that is based on resources' expected performance during tight system conditions will help to ensure that resources that contribute more to resource adequacy are compensated more than those that contribute less. This is a critical requirement to cost-effectively procuring capacity.

**Section 3.4. Key Takeaways**

- Accrediting resources based on their expected performance during tight system conditions will help to ensure the region procures a set of resources that can perform during tight system conditions. This will help the capacity market meet the one-day-in-ten LOLE resource adequacy standard, satisfying the Reliability design objective.

- The MRI framework will help to ensure accurate entry/exit signals over time as system conditions change. These accurate entry/exit signals will incent the level of investment required to meet the region's one-day-in-ten reliability standard as system conditions evolve, satisfying the Sustainability design objective.

- The MRI framework will better link resources' expected resource adequacy contributions to their capacity market compensation. Specifically, resources that contribute more to resource adequacy should be paid more than those that contribute less, and the MRI framework will help the capacity market to achieve this. As a result, the capacity market will more cost effectively procure the resources needed to meet the Reliability and Sustainability design objectives, satisfying the Cost-Effectiveness design objective.

### Section 4. Methodology for Determining Resources' Expected Performance During MRI Hours

Previous sections have noted that the MRI framework will yield accredited capacity that is based on resources' expected performance during the MRI Hours. This interpretation naturally leads to two questions:

1. How will resources' performance be modeled?

2. What are the MRI Hours and how are they identified?

This section provides a high-level overview of both topics, describing broadly how resources will be modeled for the purposes of accreditation and defining more granularly how the model determines when resource adequacy is at risk. A numerical example is included, demonstrating both the modeling frameworks and the different types of MRI Hours. Subsequent material in future months will discuss the modeling of individual resource types in greater detail, and a forthcoming memo will discuss the significant modeling improvements proposed as part of CAR.

#### Section 4.1. Resource Modeling Frameworks

For most resources, the ISO will use GE Vernova's Resource Adequacy software to model their performance in a variety of forecasted conditions to determine their accredited capacity. This sub-section provides an overview of the three broad groups of frameworks for modeling resources in GE Vernova's software: thermal modeling, energy-limited modeling, and profile modeling. After this brief introduction, we will walk through a numerical example that includes each of the three modeling frameworks to demonstrate how the MRI Hours are identified.

##### Section 4.1.1. Thermal Modeling

"Thermal" resources are modeled based on their expected outage rates. Thermal resources that are not on outage are modeled at their maximum capability, while resources that are on outage are modeled at 0 MW. The ISO uses resources' EFORd to determine how likely a resource is to be on outage. E.g., a resource with a 10% EFORd will be on outage in approximately 10% of the hours in a simulated year. In future months, we will discuss which resources will be modeled as thermal, but in general, thermal modeling is appropriate for resources that are dispatchable and do not have significant energy limitations. Note that the modeling of Thermal1 and Thermal2 in Example 1 above is conceptually consistent with how thermal resources are modeled in GE Vernova's software.

##### Section 4.1.2. Energy Limited Modeling

Thermal modeling assumes that resources can always provide available capacity when they are not on outage. GE Vernova's software includes several "energy limited" modeling frameworks that relax this assumption, allowing resources to provide capacity only when they have the necessary stored energy. Different energy-limited modeling frameworks make different assumptions around how and when resources can replenish their stored energy. For example, resources modeled as "energy storage" can replenish their energy only by charging when the system has more available capacity than is needed to meet load. Whenever possible, energy storage resources will replenish their stored energy to ensure that they can be available in future hours.

Unlike resources modeled with the thermal framework, energy limited resources only provide available capacity when needed to avoid load shed. This allows energy limited resources to most efficiently use their limited energy to mitigate unserved energy.

In future months, we will discuss which resources will be modeled as energy limited. In general, energy limited modeling is appropriate for resources that have significant energy limitations that prevent them from providing capacity over prolonged periods. Note that the modeling of ES1 and ES2 in Example 3 above is conceptually consistent with how energy limited resources are modeled in GE Vernova's software.

**Section 4.1.3. Profile Modeling**

Profile modeling allows resources' available capacity to vary hour by hour as a function of the resources' physical characteristics or historical performance. As such, profile modeling is well-suited for resources that are not dispatchable or whose available capacity varies significantly within a day. Resources can have several hourly profiles, where each hourly profile includes an available capacity quantity in each hour of a simulated year. For a given simulation year, GE Vernova's software can randomly select one of a resource's hourly profiles for that year. In this way, the model can incorporate randomness into profiled resources' available capacity. Note that the modeling of IPR1 and IPR2 in Example 2 above is consistent with how profiled resources are modeled in GE Vernova's software.

**Section 4.2. Determination of MRI Hours**

In each hour of a simulation year, GE Vernova's software compares load in that hour with available capacity. If demand exceeds available capacity in an hour, load shed occurs and there is unserved energy. **Hours where additional available capacity would reduce unserved energy in that hour or in a subsequent hour are MRI Hours.** There are three types of MRI Hours:

1. **Hours with load shed.** Simulated hours with load shed are MRI Hours because additional available capacity in such hours would reduce unserved energy.

2. **Hours where energy limited resources are dispatched to prevent load shed.** Hours where energy limited resources are dispatched to prevent unserved energy ahead of a load shed event can be MRI Hours because additional available capacity in those hours could allow the energy limited resources to save some of their energy for a future load shed event.

3. **Hours where energy storage resources are charging constrained.** Hours where there is not enough surplus available capacity for all energy storage resources to charge at their maximum can be MRI Hours if there is a load shed event before the energy storage fleet can fully recharge.

In the following subsections, we will walk through numerical examples that consider each type of MRI Hour. As we will see, these numerical examples build upon Examples 1-3 above.

**Section 4.2.1. Example 4**

This example considers the first category of MRI Hours: hours that include load shed. Table 4 below contains the same three hours from Examples 1-3. Columns 2-4 include the available capacity from Thermal1 from Table 1, IPR1 from Table 2, and ES2 from Table 3. Column 5 provides the sum of the available capacities from our three resources. For example, Total Available Capacity in Hour 1, 290 MW, is the sum of Thermal1's available capacity (100 MW), IPR1's available capacity (70 MW), and ES1's available capacity (120 MW). Column 6 provides the assumed load levels for each hour. Finally, Column 7 provides unserved energy in each hour, which is the difference between Load in Column 6 and Total Available Capacity in Column 5.

Table 4: Load Shed Occurs in Hours 1, 2, and 3

| Hour | Thermal1 | IPR1 | ES2 | Total Avail. Cap. | Load | Unserved Energy |
|---|---|---|---|---|---|---|
| 1 | 100 MW | 70 MW | 120 MW | 290 MW | 300 MW | 10 MWh |
| 2 | 100 MW | 130 MW | 120 MW | 350 MW | 370 MW | 20 MWh |
| 3 | 100 MW | 100 MW | 0 MW | 200 MW | 300 MW | 100 MWh |

As we can see, in each of Hours 1-3, total available capacity is less than load, which results in load shed and unserved energy. Recalling that MRI Hours are, by definition, hours where additional available capacity would reduce unserved energy in that hour or in a subsequent hour, Table 4b below considers how additional available capacity in each of Hours 1-3 would impact unserved energy.

Table 4b: Additional Available Capacity in Hours 1-3 Would Reduce Unserved Energy

| Hour | Thermal1 | IPR1 | ES2 | Added Cap. | Total Avail. Cap. | Load | Unserved Energy |
|---|---|---|---|---|---|---|---|
| 1 | 100 MW | 70 MW | 120 MW | +1 MW | 290 MW + 1 MW | 300 MW | 10 MWh - 1 MWh |
| 2 | 100 MW | 130 MW | 120 MW | +1 MW | 350 MW + 1 MW | 370 MW | 20 MWh - 1 MWh |
| 3 | 100 MW | 100 MW | 0 MW | +1 MW | 200 MW + 1 MW | 300 MW | 100 MWh - 1 MWh |

Note that Table 4b has a new column, Added Cap., which represents the additional capacity we are adding to the system in each hour to check whether the hours are MRI Hours. The impact of the additional capacity in each hour can be observed by the change in Total Available Capacity (now in Column 6) and Unserved Energy (now in Column 8). For example, an additional MW of available capacity in Hour 1 increases total available capacity in Hour 1 by 1 MW, so that total available capacity is now 290 MW + 1 MW. This additional MW of total available capacity in Hour 1 decreases unserved energy in that hour by 1 MWh; see Hour 1 Column 8, where unserved energy is now 10 MWh – 1 MWh. Like Hour 1, Hours 2 and 3 are also MRI Hours because an additional MW of available capacity in those hours reduces unserved energy by 1 MWh.

Example 4 walked through the simplest category of MRI Hours: those that include load shed themselves. Next, Example 5 considers hours where energy limited resources are dispatched to prevent load shed.

**Section 4.2.2. Example 5**

Example 5 demonstrates that hours where energy limited resources are dispatched to avoid unserved energy can be MRI Hours. Table 5 below is like Table 4 above but adds three additional hours, Hours 4-6.

Table 5: ES2 is Dispatched in Hour 5 to Avoid Load Shed

| Hour | Thermal1 | IPR1 | ES2 | Total Avail. Cap. | Load | Unserved Energy |
|---|---|---|---|---|---|---|
| 1 | 100 MW | 70 MW | 120 MW | 290 MW | 300 MW | 10 MWh |
| 2 | 100 MW | 130 MW | 120 MW | 350 MW | 370 MW | 20 MWh |
| 3 | 100 MW | 100 MW | 0 MW | 200 MW | 300 MW | 100 MWh |
| 4 | 100 MW | 50 MW | -50 MW | 100 MW | 100 MW | 0 MWh |
| 5 | 100 MW | 120 MW | 10 MW | 230 MW | 230 MW | 0 MWh |
| 6 | 100 MW | 130 MW | 40 MW | 270 MW | 300 MW | 30 MWh |

We'll walk through the three new hours one-by-one.

- In Hour 4, there is surplus available capacity on the system that allows ES2 to charge to replenish some of its stored energy. (Recall that in Hours 1 and 2, ES2 exhausted its stored energy to mitigate load shed in those hours.) Specifically, Thermal1 and IPR1 together provide 150 MW of available capacity in Hour 4 and load in that hour is only 100 MW. As a result, ES2 can charge at 50 MW in that hour.[10] (See Hour 4 Column 4, where ES2's available capacity is -50 MW, indicating that they are charging 50 MWh in that hour.) Note that ES2 would like to charge more, if possible, but there is only 50 MW of surplus available capacity in Hour 4, so ES2 can only charge 50 MWh.

- In Hour 5, Thermal1 and IPR1 can provide only 220 MW of capacity by themselves, which is 10 MW less than load in that hour (230 MW). ES2 is thus dispatched in Hour 5 at 10 MW to avoid load shed. Note that, while ES2 has 50 MWh of stored energy, it is only dispatched at 10 MW in Hour 5 to preserve its remaining 40 MWh of energy for mitigating load shed in a future hour.

- Like Hours 1-3, Hour 6 is an hour with load shed. The total available capacity in Hour 6 is 270 MW, 30 MW less than load in that hour. Note that ES2 can only provide 40 MW of available capacity in Hour 6 because it was only able to charge 50 MWh in Hour 4 and expended 10 MWh of that energy in Hour 5 to prevent load shed in Hour 5.

Table 5b below considers whether Hour 5 is an MRI Hour by examining how an additional MW of available capacity in that hour impacts unserved energy.

[10] In this simple example, we assume that ES2 has a 100% round trip efficiency.

Table 5b: Additional Available Capacity in Hour 5 Decreases Unserved Energy in Hour 6

| Hour | Thermal1 | IPR1 | ES2 | Added Cap. | Total Avail. Cap. | Load | Unserved Energy |
|---|---|---|---|---|---|---|---|
| 1 | 100 MW | 70 MW | 120 MW | | 290 MW | 300 MW | 10 MWh |
| 2 | 100 MW | 130 MW | 120 MW | | 350 MW | 370 MW | 20 MWh |
| 3 | 100 MW | 100 MW | 0 MW | | 200 MW | 300 MW | 100 MWh |
| 4 | 100 MW | 50 MW | -50 MW | | 100 MW | 100 MW | 0 MWh |
| 5 | 100 MW | 120 MW | 10 MW - 1 MW | +1 MW | 230 MW | 230 MW | 0 MWh |
| 6 | 100 MW | 130 MW | 40 MW + 1 MW | | 270 MW + 1 MW | 300 MW | 30 MWh - 1 MWh |

Note that, in the Added Capacity column, there is an additional MW of available capacity in Hour 5. This additional MW of capacity in Hour 5 reduces the amount of energy that ES2 needs to provide in that hour. This is reflected Hour 5 Column 4, where ES2's dispatch in Hour 5 is decreased by 1 MW. By reducing ES2's dispatch in Hour 5, ES2 has more energy to provide during Hour 6 to mitigate load shed. (See Hour 6 Column 4). ES2's additional MW of available capacity in Hour 6 increases total available capacity in Hour 6 Column 6. As a result, unserved energy decreases by 1 MWh in Hour 6.

To summarize: Example 5 demonstrates that additional available capacity in Hour 5 reduces unserved energy in a subsequent hour. As a result, Hour 5 is an MRI Hour. Next, Example 6 will demonstrate the final category of MRI Hours.

**Section 4.2.3. Example 6**

Example 6 demonstrates the final category of MRI Hours: hours where energy storage resources are recharging ahead of a load shed event but cannot recharge at their maximum. Example 6 considers the same six hours from Table 5. Table 6 below adds additional capacity in the hour when ES2 recharges (Hour 4) to determine if it is an MRI Hour.

Table 6: Additional Capacity in Hour 4 Decreases Unserved Energy in Hour 6

| Hour | Thermal1 | IPR1 | ES2 | Added Cap. | Total Avail. Cap. | Load | Unserved Energy |
|---|---|---|---|---|---|---|---|
| 1 | 100 MW | 70 MW | 120 MW | | 290 MW | 300 MW | 10 MWh |
| 2 | 100 MW | 130 MW | 120 MW | | 350 MW | 370 MW | 20 MWh |
| 3 | 100 MW | 100 MW | 0 MW | | 200 MW | 300 MW | 100 MWh |
| 4 | 100 MW | 50 MW | -50 MW - 1 MW | +1 MW | 100 MW | 100 MW | 0 MWh |
| 5 | 100 MW | 120 MW | 10 MW | | 230 MW | 230 MW | 0 MWh |
| 6 | 100 MW | 130 MW | 40 MW + 1 MW | | 270 MW + 1 MW | 300 MW | 30 MWh - 1 MWh |

Note that Table 6 includes an additional MW of capacity in Hour 4 in the Added Capacity column. Let's consider the consequences of this additional MW of capacity step by step:

- The additional MW of capacity in Hour 4 allows ES2 to charge an additional MWh of energy in Hour 4. More specifically, before the additional MW of capacity in Hour 4, ES2 charged using all the surplus available capacity (50 MW.) With the additional MW of available capacity, there is now 51 MW of surplus available capacity, which allows ES2 to charge 51 MWh instead of 50 MWh in Hour 4.

- In Hour 5, ES2 is still dispatched at 10 MW because only 10 MW of capacity is needed from ES2 to avoid load shed in that hour.

- In Hour 6, ES2 can provide an additional MW of available capacity (41 MW rather than 40 MW) because it was able to charge an additional MWh in Hour 4.

- By providing an additional MW of available capacity in Hour 6, ES2 increases total available capacity from 270 MW to 271 MW.

- The increase of total available capacity to 271 MW reduces unserved energy in Hour 6 from 30 MWh to 30 MWh – 1 MWh, as seen in the last column of Hour 6.

Because additional available capacity in Hour 4 reduces unserved energy in a subsequent hour, Hour 4 is an MRI Hour.

**Key Takeaways**

- In general, capacity resources will be modeled in GE-MARS for the purposes of accreditation. There are three groups of modeling frameworks:

    - Thermal modeling, where resources are modeled as available at their maximum capability unless they are on random outage;

    - Energy limited modeling, where resources are available when needed to mitigate or prevent load shed. Once an energy limited resource has exhausted their stored energy, they are modeled at 0 MW until they can replenish that energy;

    - Profile modeling, where resources' available capacity varies hour-to-hour.

- Under the CAR proposal, resources will be accredited based on their modeled performance in simulated hours where additional available capacity would decrease unserved energy in that hour or a subsequent hour. There are three varieties of these "MRI Hours":

    - Hours with unserved energy;

    - Hours where energy limited resources are dispatched to prevent load shed in advance of a load shed event;

    - Hours where energy limited resources cannot charge at their maximum capability in advance of a load shed event.

**Section 5. Overview of Planned Changes for CAR Relative to RCA**

This section provides a high-level overview of the planned changes for CAR relative to the previously proposed RCA design. With the move from an annual to a seasonal market, all the design pieces will have at least minor conforming changes. The table below identifies for which design elements significant changes are planned relative to the RCA proposal. Note that this table is specifically focused on the modeling and accreditation elements of CAR, though some additional changes associated with the seasonal market are highlighted as well.

| Topic | Significant Change Planned Relative to RCA |
|---|---|
| QC Elimination/Replacement | ✓ |
| Application of CNRC to Resource Modeling | |
| Non-Energy Limited Thermal Resource Modeling and Accreditation (e.g., Pondage Hydro, Municipal Solid Waste, Nuclear, etc.) | |
| Energy Limited Oil-Only and Dual Fuel Resource Modeling and Accreditation | ✓ |
| Passive Demand Response Modeling and Accreditation | ✓ |
| Modeling of Gas Availability for Power Generation | ✓ |
| Active Demand Capacity Resource (ADCR) Modeling and Accreditation | ✓ |
| Development of Gas Market Constraint | ✓ |
| Battery and Pumped Hydro Modeling and Accreditation | ✓ |
| Gas-only resource accreditation | ✓ |
| Tie Benefits Modeling and HQICC Accreditation | ✓ |
| IPR Modeling and Accreditation | ✓ |
| Import Resource Modeling and Accreditation | ✓ |
| Hybrid Resource Modeling and Accreditation | ✓ |