Rev 1

Resource Modeling under RCA

Review of proposed Resource Adequacy Assessment (RAA) Resource Modeling changed for the Resource Capacity Accreditation (RCA) project

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Resource Capacity Accreditation in the Forward Capacity Market | WMPP ID: 157

Proposed Effective Date: FCA 19 (with one year delay)

- The Resource Capacity Accreditation (RCA) project proposes improvements to accreditation processes used for the Forward Capacity Market (FCM) by implementing methodologies that will more appropriately accredit resource contributions to resource adequacy as the resource mix transforms supporting a reliable transition to clean energy technologies
  - See the Key Project page for links to prior presentations
- Improvements are required to the Resource Adequacy Assessment (RAA) used currently to calculate capacity requirements (demand) and develop resource-specific accreditation values
- Focus of today is on changes being proposed to Resource Modeling

Resource Capacity Accreditation in the Forward Capacity Market	WMPP ID: 157

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Outline of today's discussion:

- RCA RAA Background (Slides 4-8)
- Overall RAA Resource Modeling (Slides 9-21)
- Intermittent Power Resources Modeling (Slides 22-49)
- Energy Storage Resources Modeling (Slides 50-55)
- Import Resources Modeling (Slide 56-59)
- Tie Benefits Modeling (Slides 60-61)
- Future Topics (Slides 62-63)
- Wrap up (Slides 64-65)
- Appendix (Slides 66-69)

RCA RAA BACKGROUND

Review of motivation for changes to the RAA under the RCA project

RAA is used to establish capacity requirements and demand curves and, under RCA, resource accreditation

- RAA is currently used as the basis for determining the system and local capacity requirements and demand curves
  - Determines the system's ability to meet the one-in-ten ("1-in-10") loss-of-load expectation (LOLE) reliability criterion
- Under RCA, the RAA is also being used as the basis for the development of resource-specific accreditation
  - Much more focus on individual resource's seasonal performance rather than the aggregate impacts to reliability of load and resource performance

Improvements to RAA modeling are required for more accurate MRI-based accreditation

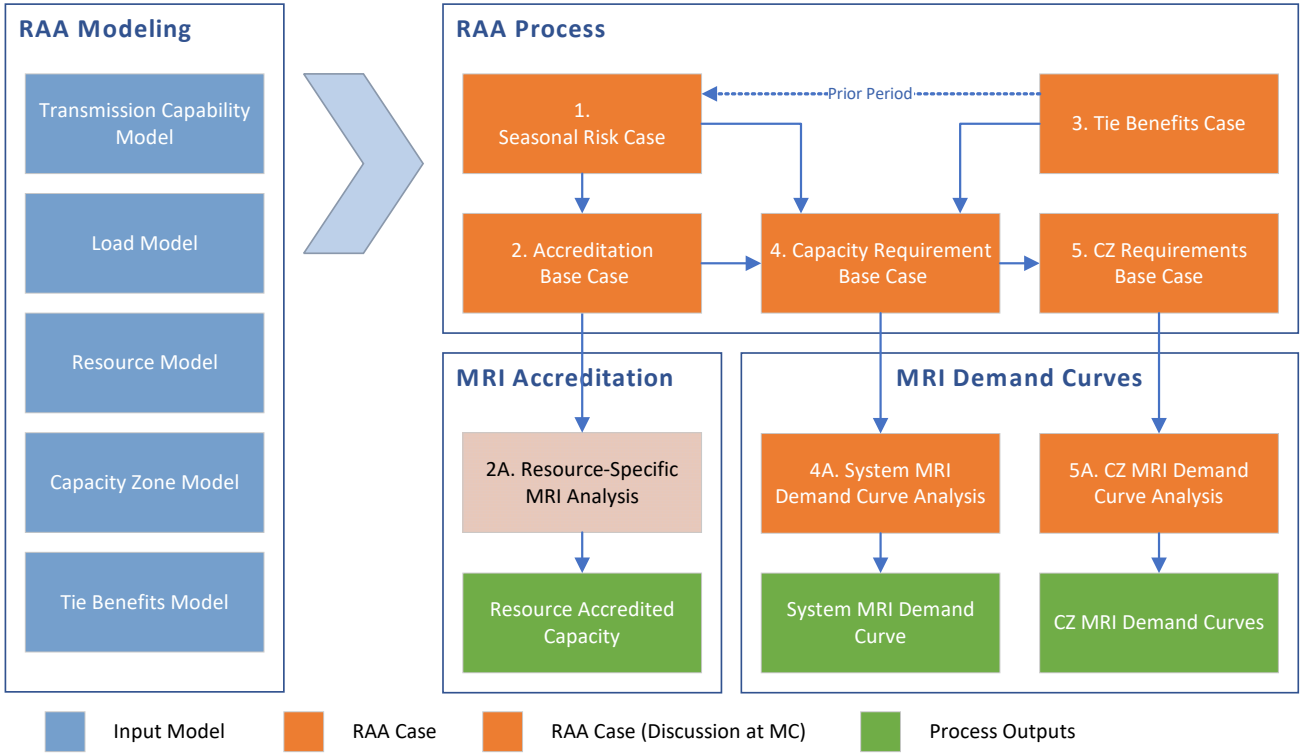
- A marginal approach to accreditation is conceptually a measure of the expected performance of resources during hours of reliability risk (e.g., system is experiencing loss of load)
- Improvements to the RAA will better identify when loss-of-load events occur and their duration and will improve how individual resource performance is reflected during these events
- There are four broad drivers of changes being considered in the RAA:
  - Model system conditions with greater accuracy and granularity
  - Better capture resources' performance and interactions among different resources
  - Better reflect the correlation between resources' performance and system loading conditions and weather
  - Improve modeling consistency among different types of resources

All aspects of the RAA are impacted by the proposed RCA improvements

- **RAA Process.** Defines the modeling approach and input assumptions for each RAA case:
  - Seasonal Risk Case
  - Accreditation Base Case
  - FCA System Capacity Requirement Base Case
  - FCA Zonal Capacity Requirement Base Cases*
  - ARA-related cases*
- **Load Model.** Defines how the expected load is represented in the RAA cases:
  - Seasonal Load Shape and Peak Uncertainty Factors
  - Energy Uncertainty Factors
  - Passive Demand Resource Treatment
  - Behind-the-Meter Solar and other Load Modifiers
- **Resource Model.** Defines the modeling approach and input assumptions associated with each resource type:
  - Generation Capacity Resource
  - Demand Capacity Resource
  - Import Capacity Resource
  - Distributed Energy Capacity Resource
- **Tie Benefits Model.** Defines how the seasonal tie benefits are established
- **Transmission Interface Model.** Defines expected capacity transfer capability (CTC) for the external and internal interfaces

* Items that will be discussed in RCA Phase II for FCA19

Conceptual RAA Process Flow



RESOURCE MODELING IN THE RAA

Review proposed changes to Resource Modeling in the RAA under RCA

Changes to the RAA Resource Model are focused on improving how expected performance is reflected

- Conceptually, the accredited capacity (i.e., qualified marginal reliability impact capacity [QMRIC]) reflects a resource's expected output in the hours experiencing loss of load simulated in the RAA or where additional available capacity would reduce load shed in another hour (i.e., RAA MRI Hours)
- RCA related changes are focused on improving how the expected output of all resources is determined by simulating the system condition dynamically on an hourly basis:
  - Random unplanned outages
  - Planned outages
  - Output variations due to weather and fuel constraint
  - Correlation of resources' performance to weather/load
  - Interaction among different resources

Different types of resources will be reflected in the RAA using different models

- RAA Resources are modeled in the RAA as either an:
  - Aggregated RAA Resource, which is a grouping of like Capacity Resources or other supply capacity
    - Shared fuel supply (e.g., gas or oil resources in the Peak Winter Period of Dec-Feb)
    - Small, similar performing technologies (e.g., IPR)
  - Individual RAA Resource, which is associated with an individual Capacity Resource or other supply capacity
  - Certain Capacity Resources may be modeled as different RAA Resources by time period
- There are four modeling options for how RAA Resources are treated:
  - Thermal Model: Modeled at its Seasonal Qualified Capacity (QC) with an outage rate
  - Profile Model: Modeled based upon an hourly expected performance profile
  - Storage Model: Modeled based upon its energy limitations
  - Perfect Capacity (PC) Model: Modeled at its Seasonal QC with no outage rate
- RAA Resources are modeled using one of these models to capture their reliability contribution by reflecting their physical characteristics

Discussion Today Focuses on Resource Modeling

Topics for Discussion Today

- Generation Capacity Resources
  - Intermittent Power Resources (IPR)
  - Energy Storage Resources (ESR)
  - Non-ESR/Non-IPR Generation Resources
- Import Capacity Resources
- Tie Benefits (functions as a supply)

Topics for Discussion in January

- Demand Capacity Resources
  - Active Demand Capacity Resources (ACDR)
  - (Passive) Seasonal Peak and On-Peak Demand Resources
- Distributed Energy Capacity Resources (DECR)
- Generation Capacity Resources
  - Gas and Oil Resources (for Peak Winter Period)
  - Co-Located (Generation) Technologies

RAA RESOURCE MODEL

Review of modeling options to reflect Capacity Resource and other supply capability in the RAA

Thermal Model

- Major input parameters
  - Maximum Output (MW): Generally, reflected through Seasonal QC
  - Outage Rate (p.u.): Generally, reflected through an annual equivalent forced outage rate on demand excluding activities outside of management control (xEFORd)
  - Annual maintenance requirement (weeks)
- Simulation process
  - Planned maintenance is first scheduled for all resources to levelize system reserves for the entire study period
    - Planned maintenances are typically scheduled in the shoulder months when the loads are low, thus has little impact of system risks
  - Sequential Monte Carlo simulation is then used to determine each resource's hourly capacity state based on its outage rate
    - A resource's capacity state in a hour is dependent on its state in previous hours and influences its state in future hours
  - Hourly capacity is finally derived from the Seasonal QC and capacity state, and will be used in assessing system reliability
    - Thousands of hourly capacity combinations for a whole year are simulated

Storage Model

- Major input parameters
  - Maximum Output (MW): Generally, reflected through Seasonal QC
  - Maximum Charging/Pumping (MW): Reflected based upon seasonal physical capability (may be demonstrated in future)
  - Storage Capability (MWh): Usable energy when full (generally a constant value)
  - Round-trip efficiency (p.u.): Average annual round-trip efficiency of the resource
- Simulation process
  - Planned maintenance is scheduled for all resources to levelize system reserves prior to the beginning of simulation
  - Discharge is scheduled for the hours when available capacity from all other resources is not enough to meet the demand in a sequential dispatch
  - Charge is determined during the hours when there is surplus capacity available and storage resources are not at their Storage Capability
    - Losses are considered using round-trip efficiency when resource is charging
  - Discharge and charge order is from greatest to least duration
    - Resources in the same duration are dispatched/charged proportionally
  - There are no limits applied on the total cycles per day, month, season, or year

Profile Model

- Major input parameters
  - Hourly shape (MW): Hourly representation of a resource's expected performance
    - Option 1: Shape explicitly reflects expected MW output (e.g., Gas Resources)
    - Option 2: Shape calculated using nameplate capacity (MW) and hourly normalized profile (%) (e.g., IPR)
  - Multiple shapes can be used for a resource, and each shape can be associated with a certain probability
  - Hourly shape can be correlated to a specific load level
- Simulation process
  - Resource output is based on the deterministic hourly output from the shape
    - Have the option to randomly select a day-shape from a time window to use in modeling a given day (e.g., allows randomness to be reflected in Solar Resource performance in the Summer Solar Period)
  - When multiple shapes are used, one of these shapes is selected based on the associated probability of occurrence (e.g., equal probability that annual hourly profile for an IPR could be selected from any one of the last five years)

Perfect Capacity Model

- Major input parameters
  - Maximum Output (MW): Reflected through Seasonal QC
- Simulation process
  - Resource is modeled at constant output in each season based upon its Maximum Output
- This model is an extension of the Thermal Model with an assumed 0% outage rate and without annual maintenance requirement

SUMMARY OF PROPOSED RAA RESOURCE MODELS FOR DIFFERENT TYPES OF CAPACITY

Review of proposed RAA Resource Model that is used to reflect Capacity Resource and other supply capability in the RAA

Most generation technologies use the Thermal Model in the RAA

Capacity Resource/ Supply Capability	Proposed RAA Resource Model
Nuclear/Coal/Fuel Cell/Non-IPR Hydro Resources	Thermal Model • Seasonal QC will be used
Gas-only/Gas Dual-Fuel/Oil Resources (for months of Mar to Nov)	Thermal Model • Seasonal QC will be used
Import Resources	Thermal Model • Seasonal cleared MW from a prior FCA will be used
Tie Benefits	Thermal Model • Seasonal tie benefits will be used

IPR and ESR use the Profile and Storage Models respectively

Capacity Resource	Proposed RAA Resource Model
IPR Solar (fixed and tracking)/Hydro/ Biomass/Waste/Landfill Gas/Wind/ others	Profile Model (a change from current Thermal Model) • IPR with a Nameplate Capacity < 10 MW are included in an Aggregated RAA Resource • IPR with a Nameplate Capacity >= 10 MW are included in an Individual RAA Resource
ESR Battery Storage/PSH	Storage Model (a change for PSH from current Thermal Model)

Proposed RCA Modeling to be discussed in January

Capacity Resource
Gas-only/Gas Dual-Fuel/Oil For Peak Winter Period (Dec-Feb)
Active Demand Capacity Resources (ACDR)
(Passive) Seasonal Peak and On-Peak Demand Resources
Distributed Energy Capacity Resources (DECR)
Co-Located (Generation) Technologies

INTERMITTENT POWER RESOURCE MODELING

Review of proposed modeling improvements for RAA Resources associated with Intermittent Power Resources (IPR)

Current IPR modeling does not provide a good reflection of these resource's expected performance

- In the current RAA, IPR are generally treated as Aggregated Perfect Capacity RAA Resources at their Summer QC in the Summer Period (Jun-Sep) and at their Winter QC in Winter Period (Oct-May)
- Seasonal QC, which are calculated based on median historical output during pre-defined reliability hours (HE14-18 during Summer Period and HE18-19 during Winter Period), may not be representative of expected hourly performance
  - Reliability contribution will not be properly captured when the loss of load hours observed in the RAA are not aligned with the pre-defined reliability hours

Under RCA, all standalone IPR are treated as Profiled RAA Resources

- Using the Profiled RAA Resource model allows for IPR expected hourly performance throughout the year reflecting the variability based upon past performance
  - Approach dynamically changes the accreditation of these resources as the hours and seasons in which risk is observed changes
- These changes improve the ability for the RAA to identify the hours with loss-of-load risk and the associated event duration and better reflect expected performance of IPR during these events unlike the “static” Seasonal QC approach

IPR RAA modeling changes better reflect their expected hourly performance

- Only existing IPRs (i.e., cleared in the FCA and not terminated/retired) are included in the RAA
  - Either as an individual profiled resource or part of an aggregated resource
- Hourly normalized profiles, developed differently for years in which the IPR was commercial (historic) and non-commercial (simulated or proxy), would reflect the expected energy it is capable of producing under different conditions
  - Profiles are adjusted to reflect when an IPR is not fully interconnected or partially cleared
- All IPRs are treated in the same manner; except for Solar Resources in the Solar Summer Period (Apr-Sep)
  - Different treatment in profiles reflects the correlation of performance to the load (based on 2021 weather)

Size determines if a Capacity Resource is part of an Aggregated RAA Resource or is an Individual RAA Resource

- **Individual RAA Resource:** IPRs with a Nameplate Capacity (as reflected as the maximum MW output at the point of interconnection*) that is greater than or equal to 10 MW are reflected as Individual RAA Resource and have profiles developed specifically for them
- **Aggregated RAA Resource:** IPRs with a NC that is less than 10 MW are grouped into an Aggregated RAA Resource by Load Zone and have profiles developed reflecting the aggregation of IPRs

* This value will be set based upon the winter network resource capability (NRC)

IPR MODELING (EXCLUDING SUMMER SOLAR)

Review of proposed modeling improvements for RAA Resources associated with IPR, excluding Solar Resources in the Solar Summer Period

IPR PROFILE DEVELOPMENT

Review of how commercial and non-commercial IPR (excluding Solar Resources in the Solar Summer Period) are developed

Hourly normalized profiles are developed for all RAA Resources associated with IPR

- Hourly normalized profiles are developed for past five years reflecting a combination of historical performance (when commercial) and simulated/proxy performance (when non-commercial)*
  - Commercial: Developed the same way independent of IPR technology or whether the IPR is part of an Aggregated RAA Resource or an Individual RAA Resource
  - Non-commercial: Developed as a function of IPR technology
- For each year, performance is transformed into a normalized hourly profile (percentage) based upon the NC of the RAA Resource
- One normalized yearly profile for all IPR is randomly selected with equal probability for each replication from the five yearly normalized profiles
  - Selected normalized profile and the effective nameplate capacity (ENC) of the RAA Resource are used to determine the hourly performance

*Solar Resources only have profiles for the past five years in the Winter Solar Period (Oct-Mar)

Normalized profiles for commercial resources are developed based upon historical performance

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- Normalized hourly profiles (%) are calculated for each hour in a year in which the IPRs associated with the RAA Resource is fully commercial for the entire calendar year*

$$\frac{\left(Hourly\ Output_{RAA\ Resource,IPR} + Hourly\ Curtailment_{RAA\ Resource,IPR}\right)}{Nameplate\ Capacity_{RAA\ Resource,IPR}}$$

- The normalized profile reflects the unrestricted energy (with no curtailments) the modeled resource is capable of producing for each hour, based on weather conditions and the resources' characteristics.
  - Consistent modeling for commercial and non-commercial resources that have no historical curtailment data available
  - Deliverability within the Load Zone is considered in the CNRC and between Load Zones is considered in the Capacity Zone construct
  - Output reduction due to economics is not considered for any resource types

* For Aggregated RAA Resources there is no adjustment applied for Hourly Curtailments.

Commercial normalized profiles for Aggregated and Individual RAA Resources use the same approach

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- Individual RAA Resource A is comprised of a single commercial IPR (1)
  - Adjusted output reflects curtailments
- Aggregated RAA Resource B is comprised of two commercial IPRs (2 and 3)
  - No curtailment adjustment is applied per design

Individual RAA Resource A / IPR 1							
HE	NC (MW)	Output (MWh)			Curtailment (MWh)	Adj. Output (MWh)	Normalized Profile (%)
13	20.0	10.0			-	10.0	50.0%
14	20.0	13.0			-	13.0	65.0%
15	20.0	7.0			5.0	12.0	60.0%
16	20.0	3.0			5.0	8.0	40.0%
17	20.0	15.0			-	15.0	75.0%

Aggregated RAA Resource B							
HE	IPR 2		IPR 3		RAA Resource B		
	NC (MW)	Output (MWh)	NC (MW)	Output (MWh)	NC (MW)	Adj. Output (MWh)	Normalized Profile (%)
13	7.0	2.0	5.0	4.0	12.0	6.0	50.0%
14	7.0	1.0	5.0	3.0	12.0	4.0	33.3%
15	7.0	7.0	5.0	4.0	12.0	11.0	91.7%
16	7.0	6.0	5.0	3.0	12.0	9.0	75.0%
17	7.0	5.0	5.0	6.0	12.0	11.0	91.7%

Non-commercial profiles for Individual RAA Resources are different by IPR technology

- For all technologies modeled as Individual RAA Resources (except Solar and Wind Resources), proxy profiles are developed based upon:
  - NC-weighted average of the normalized hourly profiles from other Individual RAA Resources of the same technology within the Load Zone
    - If there are less than four Individual RAA Resources of the same technology, then Individual RAA Resources of the same technology from adjacent Load Zones are included as well
- For Wind and Solar Resources modeled as Individual RAA Resources, profiles are developed based upon simulations of weather and technology adjusted to reflect the output at the point of interconnection (POI)

Non-commercial profiles for Aggregated RAA Resources are a function of the commercial resources in the aggregation

- For a year in which the IPR modeled in an Aggregated RAA Resource is not commercial where there are commercial IPR for that year in the Aggregated RAA Resource, the normalized hourly profile use a proxy profile from the commercial Aggregated RAA Resource
- For a year in which the IPR modeled in an Aggregated RAA Resource is not commercial and there are no commercial IPR for that year in the Aggregated RAA Resource, the normalized hourly profile uses proxy profile developed based upon:
  - NC-weighted average of the normalized hourly profiles from the commercial Aggregated RAA Resource(s) of the same technology from adjacent Load Zones

ADJUSTMENTS TO NAMEPLATE CAPACITY AND RAA HOURLY OUTPUT FOR IPR

Review how the Nameplate Capacity (NC) is adjusted for IPR (excluding Solar Resources in the Solar Summer Period) and used to calculate the hourly output profiles in the RAA

Nameplate Capacity adjustments are applied to reflect when an IPR is not fully interconnected

- Normalized profiles represent an output level that is reflected as capacity based upon the average of seasonal claimed capability (SCC) (i.e., Average SCC or uncapped QC)
- If the Average SCC exceeds the CNRC, this indicates that the IPR either:
  - Not fully cleared in the FCM; or,
  - Not fully interconnect the resource consistent with its Average SCC (i.e., CNRC is less than the uncapped QC)
- An adjustment is calculated to the NC when Average SCC exceeds the CNRC that shifts the hourly output down

ENC is calculated for RAA Resources based upon its CNRC and Historical SCC

- Effective Nameplate Capacity (ENC) is a single value calculated based upon the Summer CNRC for the target period and the average of the Summer SCC for the most recent five capacity commitment periods (CCP) (for the periods where the IPR was not commercial Summer SCC is derived from the modeled profiles) *

$$NC_{RAA\ Resource,IPR} \cdot MIN\left(\frac{Summer\ CNRC_{RAA\ Resource,IPR}}{Average\ Summer\ SCC_{RAA\ Resource,IPR}}, 100\%\right)$$

- ENC is used with the normalized profile to calculate the hourly MW output for the RAA Resource

$$ENC_{RAA\ Resource,CCP} \cdot Normalized\ Profile_{RAA\ Resource,Hour}$$

* This adjustment is not included for Solar Resources in the Winter Solar Period.

Impact of ENC on an Individual RAA Resource can be demonstrated using Resource A from prior example

- Individual RAA Resource A's expected hourly output is demonstrated under two conditions:
  - S1: CNRC < Average SCC
  - S2: CNRC >= Average SCC
- As long as the Average SCC <= CNRC, there is no adjustment to the ENC
- When Average SCC > CNRC this indicates that the resource is partially cleared or did not fully interconnect relative its capability (as measured through the SCC)
  - The hourly output is reduced reflecting the expected hourly capacity from the resource

Individual RAA Resource A				
Scenario	NC (MW)	Summer CNRC (MW)	Average Summer SCC (MW)	ENC (MW)
1	20.0	10.0	15.0	13.3
2	20.0	10.0	10.0	20.0

Individual RAA Resource A: S1			
HE	ENC (MW)	Normalized Profile (%)	RAA Output (MWh)
13	13.3	50.0%	6.7
14	13.3	65.0%	8.7
15	13.3	60.0%	8.0
16	13.3	40.0%	5.3
17	13.3	75.0%	10.0

Individual RAA Resource A: S2			
HE	ENC (MW)	Normalized Profile (%)	RAA Output (MWh)
13	20.0	50.0%	10.0
14	20.0	65.0%	13.0
15	20.0	60.0%	12.0
16	20.0	40.0%	8.0
17	20.0	75.0%	15.0

Impact of ENC on an Aggregated RAA Resource can be demonstrated using Resource B from prior example

- Aggregated RAA Resource B's ENC is demonstrated under two conditions:
  - S1: CNRC >= Average SCC
  - S2: CNRC < Average SCC
- ENC adjustment is established at the Aggregated RAA Resource level, not for each individual IPR

Commercial Aggregated RAA Resource B				
Scenario	**NC (MW)**	**Summer CNRC (MW)**	**Average Summer SCC (MW)**	**ENC (MW)**
1	12.0	5.0	4.0	12.0
2	12.0	5.0	7.0	8.6
IPR 2				
Scenario	**NC (MW)**	**Summer CNRC (MW)**	**Average Summer SCC (MW)**	**ENC (MW)**
1	7.0	3.0	3.0	
2	7.0	3.0	5.0	
IPR 3				
Scenario	**NC (MW)**	**Summer CNRC (MW)**	**Average Summer SCC (MW)**	**ENC (MW)**
1	5.0	2.0	1.0	
2	5.0	2.0	2.0	

Aggregated RAA Resource B: S2			
HE	**ENC (MW)**	**Normalized Profile (%)**	**RAA Output (MWh)**
13	8.6	50.0%	4.3
14	8.6	33.3%	2.9
15	8.6	91.7%	7.9
16	8.6	75.0%	6.4
17	8.6	91.7%	7.9

Impact of a non-commercial IPR on an Aggregated RAA Resource can be demonstrated from prior example

- The addition of IPR 4 to Aggregated RAA Resource B increases the total NC, ENC and CNRC associated with Resource B
- Since IPR 4 is not commercial, it has no impact on the normalized profile used in the prior example
  - The normalized hourly profile uses a proxy profile from the commercial Aggregated RAA Resource B

Aggregated RAA Resource B (Total)			
NC (MW)	Summer CNRC (MW)	Average Summer SCC (MW)	ENC (MW)
18.0	8.0	9.0	16.0
IPR 4 (Non-Commercial)			
NC (MW)	Summer CNRC (MW)	Average Summer SCC (MW)	ENC (MW)
6.0	3.0	2.0	
Aggregated RAA Resource B (Commercial)			
NC (MW)	Summer CNRC (MW)	Average Summer SCC (MW)	ENC (MW)
12.0	5.0	7.0	12.0

Aggregated RAA Resource B			
HE	ENC (MW)	Normalized Profile (%)	RAA Output (MWh)
13	16.0	50.0%	8.0
14	16.0	33.3%	5.3
15	16.0	91.7%	14.7
16	16.0	75.0%	12.0
17	16.0	91.7%	14.7

SOLAR MODELING IN SUMMER SOLAR PERIOD

Review of proposed modeling improvements for RAA Resources associated with Solar Resources in the Solar Summer Period

Solar performance is correlated to weather in the summer resulting in different treatment than other IPR

- Primary differences between Solar Resources and other IPR in the Summer Solar Period (Apr-Sep) is in how the hourly normalized profiles are created and used
  - Solar profiles are specifically developed based upon the 2021 year
  - Solar profiles are selected based upon a random daily draw from the seven days around the calendar day
- Since only a single year of information is used to formulate the normalized hourly profile, the NC adjustment is also slightly different to allow more recent changes in performance to adjust the profile higher

Hourly normalized profiles are developed for all RAA Resources associated with Solar Resources

- Hourly normalized profiles are developed for 2021 Solar Summer Period based upon either historical performance (when commercial) or simulated/proxy performance (when non-commercial)
- Performance is transformed into a normalized hourly profile (percentage) based upon the NC of the RAA Resource for each year
- An hourly profile for a day within a seven-day window (+/- three days) for the day under study is randomly selected to reflect weather uncertainty
  - Serves as a proxy representation of the possible solar output variation that are not fully correlated with load for certain hour
  - For example, output may be reduced for a short period of time due to cloud coverage while the load does not change instantly
- Normalized profile and the Effective Nameplate Capacity (ENC) of the RAA Resource are used to determine the hourly performance

Normalized hourly profiles for commercial resources are developed based upon historical performance

- Normalized hourly profiles (%) are calculated for each hour in Solar Summer Period for 2021 in which the Solar Resource(s) associated with the RAA Resource is fully commercial for the entire calendar year (CY) of 2021
  - Same approach is used for Individual and Aggregated RAA Resources

$$\frac{\left(Hourly\ Output_{RAA\ Resource,Solar} + Hourly\ Curtailment_{RAA\ Resource,Solar}\right)}{Nameplate\ Capacity_{RAA\ Resource,Solar}}$$

- The normalized hourly profile reflects the unrestricted energy (with no curtailments) the modeled resource is capable of producing for each hour, based on weather conditions and the resources' characteristics
  - Consistent modeling for commercial and non-commercial resources that have no historical curtailment data available
  - Deliverability within the Load Zone is considered in the CNRC and between Load Zones is considered in the Capacity Zone construct
  - Output reduction due to economics is not considered for any resource types

Non-commercial profiles for Individual RAA Resources associated with Solar are simulated

- For Solar Resources modeled as Individual RAA Resources, profiles are developed based on simulations of weather and technology adjusted to reflect the output at the POI
- This process mirrors how profiles for Wind Resources modeled as Individual RAA Resources are developed

Non-commercial profiles for Aggregated Solar RAA Resources are a function of the commercial resources in the aggregation

- If a Solar Resource modeled in an Aggregated RAA Resource that is not commercial for CY 2021, where there are commercial Solar Resources for CY 2021 in the Aggregated RAA Resource, its normalized profile uses a proxy profile from the commercial Aggregated RAA Resource
- If a Solar Resource modeled in an Aggregated RAA Resource that is not commercial for CY 2021, where there are not commercial Solar Resources for CY 2021 in the Aggregated RAA Resource, its normalized profile uses a proxy profile based upon:
  - NC-weighted average of the normalized hourly profiles from the commercial Aggregated Solar RAA Resource(s) from adjacent Load Zones

ENC is calculated for Solar RAA Resources based upon its QC and 2021 SCC

- Since the hourly normalized profile is based on 2021 weather and recent performance changes are not represented in performance, the NC can be scaled up or down based upon the most recent Summer QC
  - Use of Summer QC recognizes the interconnection limitations and recent performance since it is the lesser of the Average Summer SCC and CNRC
  - Adjustment is only applied in Solar Summer Period, there is no adjustment to NC for Solar RAA Resources in the Winter Solar Period
- ENC is calculated based upon the Summer QC for the target period and its 2021 Summer SCC or derived Summer SCC from the simulated 2021 profile:

$$NC_{RAA\ Resource,CCP} \cdot \left(\frac{Summer\ QC_{CCP,RAA\ Resource}}{Summer\ SCC_{2021,RAA\ Resource}} \right)$$

- Like all IPR, the ENC is used with the normalized profile to calculate the hourly MW output for the RAA Resource

$$ENC_{RAA\ Resource,CCP} \cdot Normalized\ Profile_{RAA\ Resource,Hour}$$

Impact of ENC on an Individual Solar RAA Resource RAA Output can be demonstrated

- Individual RAA Resource C's expected hourly output is demonstrated under three conditions:
  - S1: QC < 2021 SCC
  - S2: QC = 2021 SCC
  - S3: QC > 2021 SCC
- When 2021 SCC > QC, this indicates that the resource is partially cleared or did not fully interconnect relative to its capability (as measured through the SCC)
  - Hourly output is reduced
- When 2021 SCC < QC, this indicates the resource is performing better than what is reflected in its 2021 profile
  - Hourly output is increased

Individual RAA Resource C				
Scenario	NC (MW)	Summer QC (MW)	2021 SCC (MW)	ENC (MW)
1	20.0	10.0	15.0	13.3
2	20.0	10.0	10.0	20.0
3	20.0	10.0	8.0	25.0

Individual RAA Resource C: S1			
HE	ENC (MW)	Normalized Profile (%)	RAA Output
13	13.3	80.0%	10.7
14	13.3	85.0%	11.3
15	13.3	80.0%	10.7
16	13.3	70.0%	9.3
17	13.3	50.0%	6.7

Individual RAA Resource C: S2			
HE	ENC (MW)	Normalized Profile (%)	RAA Output
13	20.0	80.0%	16.0
14	20.0	85.0%	17.0
15	20.0	80.0%	16.0
16	20.0	70.0%	14.0
17	20.0	50.0%	10.0

Individual RAA Resource C: S3			
HE	ENC (MW)	Normalized Profile (%)	RAA Output (MWh)
13	25.0	80.0%	20.0
14	25.0	85.0%	21.3
15	25.0	80.0%	20.0
16	25.0	70.0%	17.5
17	25.0	50.0%	12.5

KEY TAKEAWAYS

IPR modeling changes better reflect their expected hourly performance

- Only existing IPR (i.e., cleared in the FCA and not terminated/retired) continue to be included in the RAA
  - Either an Individual Profiled RAA Resource or part of an Aggregated Profiled RAA Resource
- Hourly normalized profiles are developed differently for years in which the IPR was commercial (historic) and non-commercial (simulated/proxy) and reflect the expected energy they are capable of producing under different conditions
  - Profiles are adjusted to reflect when an IPR is not fully interconnected or partially cleared
- All IPRs are treated in the same manner; except for Solar Resources in the Solar Summer Period (Apr-Sep)
  - Different treatment in profiles reflects the correlation of performance to the 2021 weather

ENERGY STORAGE RESOURCE MODELING

Review of proposed modeling improvements for RAA Resources associated with Pumped-Storage Hydro (PSH) Resources and treatment of Battery Storage Resources

Battery Storage Resources continue to be modeled as Individual Storage RAA Resources

- No major changes are proposed to how Battery Storage Resources are modeled in the RAA as this current approach reflects their energy limitations
- Modeled based upon their Seasonal QC (for charging and discharging), Usable Storage Capacity, Annual Average Round-Trip Efficiency
  - No xEFORd is applied because:
    - Energy limitation is expected to be the dominate constraint
    - Consistency in modeling other ESR that have shared storage capability

Current PSH modeling may not provide a good reflection of these resource's expected performance

- Currently, Pumped-Storage Hydro (PSH) Resources are modeled as Thermal RAA Resources at their Summer QC and their historical xEFORd
  - Essentially, they are considered available to serve demand for all the hours when they are not on maintenance and outage without energy limitations
- Current approach may overstate resource performance and system reliability in the situations where reliability events may extend longer than what can be supported by their available energy
  - Approach does not factor in limitations associated with pumping demand that may constrain operation on subsequent day(s)
  - Inconsistent with current modeling for Battery Storage Resources

PSH are modeled as Individual Storage RAA Resources to reflect their energy limitations

- Reflecting energy limitations of PSH better captures the ability for PSH to provide energy during reliability events and when there may be limited ability to replenish energy (charge) from the system
- Modeled based upon their Seasonal QC (for supply), Seasonal Maximum Demand (for pumping), Usable Storage Capacity and Annual Average Round-Trip Efficiency
  - Usable Storage Capacity is allocated to each PSH Resource associated with the shared fuel supply based upon Summer QC
  - No xEFORd is applied because of modeling challenges with reflecting a shared fuel supply and an outage rate and the expectation that the energy limit will be the dominant constraint, not the capacity constraint (related to the xEFORd)
    - This is also a consistent treatment with battery storage resources

Application of xEFORd can undercount ability to deliver shared energy during reliability events

- PSH D is comprised of two 100 MW turbines (D.1 and D.2) with 400 MWh where D.1 is on outage in HE15 and 16
  - Conceptually, PSH D should be able to provide 400 MWh; however, may not by able to with the xEFORd used

Not Proposed: Model Assigned Energy and xEFORd					
HE	LOLH	D.1 Output	D.1 Stored Energy	D.2 Output	D.2 Stored Energy
13	N	-	200	-	200
14	Y	100	100	100	100
15	Y		100	100	-
16	Y		100	-	-
17	N	-	100	-	-
Totals		***100***		***200***	***300***

Conceptual: Model Shared Energy and xEFORd				
HE	LOLH	D.1 Output	D.2 Output	Shared Stored Energy
13	N	-	-	400
14	Y	100	100	200
15	Y		100	100
16	Y		100	-
17	N	-	-	-
Totals		***100***	***300***	***400***

Proposed: Model Assigned Energy w/o xEFORd					
HE	LOLH	D.1 Output	D.1 Stored Energy	D.2 Output	D.2 Stored Energy
13	N	-	200	-	200
14	Y	100	100	100	100
15	Y	100	-	100	-
16	Y	-	-	-	-
17	N	-	-	-	-
Totals		***200***		***200***	***400***

ESR modeling changes better reflect the energy limitations associated with the PSH Resources

- Battery Storage Resources continue to be modeled as Individual Storage RAA Resources; however, without an outage rate
- PSH Resources are now modeled as Individual Storage RAA Resources based upon their physical characteristics
  - Outage rate is not included because of challenges with modeling shared storage capability
- Battery Storage Resources and PSH Resources are now modeled in a consistent manner

IMPORT CAPACITY RESOURCE MODELING

Review of proposed modeling improvements for RAA Resources associated with Import Resources

Current modeling of Imports does not reflect seasonal performance or expected resource mix

- Existing Import Resources, like other Non-IPR, are modeled as Thermal RAA Resources based upon their Summer QC in both the Summer and Winter Periods and the applicable outage rate
  - Resource-backed Import Resources have the xEFORd based on the NERC class average of “HYDRO 30 Plus” plus its associate Interface’s outage rate (adjusted for coincident resource and Interface outages) applied
  - Pool-backed Import Resources have its associate Interface’s outage rate applied
- Approach may not reflect the seasonal capability of Import Resources, but also creates the potential for a significant difference in the resource mix before and after the FCA
  - Existing Import Resources are included in the RAA; however, most Import Resources participate as new for each period so are not included in the RAA until they clear and are reflected in the subsequent annual reconfiguration auction (ARA) RAA model

Under RCA, Import Resources that cleared in a prior FCA will be included in the resource mix in the RAA

- RCA uses an ex-ante approach to the resource mix assumptions for accreditation (not forecasting what may or may not clear); however, significant differences in the resource mix assumptions can impact seasonal risk and accreditation
  - Import Resources can reflect a persistent difference in the ex-ante and ex-post resource mix assumptions
- Under RCA, the RAA will include the cleared Import Resources from the FCA whose total cleared amount is the median of the last five FCAs to establish their modeled seasonal capacity
  - Total Import Resource seasonal capacity will be limited at the Seasonal Capacity Transfer Limit (CTL)

Import Resources will continue to be modeled as Individual Thermal RAA Resources at their Seasonal QC

- Development of outage rates and annual maintenance requirements are unchanged
- Treatment of Import Resources associated with an Elective Transmission Upgrades (ETU) is the same as a non-ETU Interface

TIE BENEFITS MODELING

Review of proposed modeling improvements for RAA Resources associated with Tie Benefits

Tie Benefits have different Summer and Winter Period values under RCA

- Under RCA, Tie Benefits are modeled as an Individual Thermal RAA Resource based upon their seasonal values and the applicable Interface's outage rate
  - Modeled identical to pool-backed Import Resources

ITEMS FOR DISCUSSION NEXT MONTH

Review of the Resource Modeling topics for the January Reliability Committee

Discussion at January RC on Resource Modeling will focus on the following resource types

- Passive Demand Capacity Resources
  - Proposed approach is conceptually unchanged, but will be implemented as a load modifier rather than supply
- Active Demand Capacity Resources
  - Conceptually approach is the same as previously proposed, but profiles will be created for each season based upon a temperature threshold
- Gas and Oil Resource in Peak Winter Period
  - Overview of modeling for these resources was presented at December 12 Joint NEPOOL Markets and Reliability Committee meeting
- Co-Located Generation Technologies
  - Technologies that participate as separate Capacity Resources will be modeled as an RAA Resource based upon their characteristics
  - Technologies that participate as a single Capacity Resource will be modeled as a Perfect Capacity RAA Resource
  - Accreditation will not be directly connected to the RAA model for some co-located technologies
- Distributed Energy Capacity Resources (DECR)
  - Review proposed approach for how to include new capacity resource type introduced under Order 2222

CONCLUSION

Improvements to RAA modeling are required for more accurate MRI-based accreditation

- A marginal approach to accreditation is conceptually a measure of the expected performance of resources during hours of reliability risk (e.g., system is experiencing loss of load)
- Improvements to the RAA will better identify when loss-of-load events occur and their duration and will improve how individual resource performance is reflected during these events
- There are four broad drivers of changes being considered in the RAA:
  - Model system conditions with greater accuracy and granularity
  - Better capture resources' performance and interactions among different resources
  - Better reflect the correlation between resources' performance and system loading conditions and weather
  - Improve modeling consistency among different types of resources

APPENDIX

Time Period used in RAA Modeling

Period	Start	End
Capacity Commitment Period (CCP)	June (Year)	May (Year+1)
Calendar Year (CY)	January	December
Summer Season (default)	June	September
Winter Season (default)	October (Year)	May (Year+1)
Demand Resource Summer Period	April	November
Demand Resource Winter Period	December (Year)	March (Year+1)
Solar Summer Period	April	September
Solar Winter Period	October (Year)	March (Year+1)
Gas/Oil Peak Winter Period	December (Year)	February (Year+1)
Gas/Oil Non-Peak Winter Period	October (Year) March (Year+1)	November (Year) May (Year+1)

Acronyms

ADCR	Active Demand Capacity Resource
ARA	Annual Reconfiguration Auction
CY	Calendar Year
CCP	Capacity Commitment Period
CNRC	Capacity Network Resource Capability
CTC	Capacity Transfer Capability
CTL	Capacity Transfer Limit
DR	Demand Resource

DECR	Distributed Energy Capacity Resources
ENC	Effective Nameplate Capacity
ETU	Elective Transmission Upgrade
ESR	Energy Storage Resource
xEFORd	Equivalent forced outage rate on demand excluding events out of management control
FCA	Forward Capacity Auction
FCM	Forward Capacity Market

Acronyms

IPR	Intermittent Power Resource
LOLE	Loss of Load Expectation
MRI	Marginal Reliability Impact
MW	Megawatt
MWh	Megawatt-hour
NC	Nameplate Capacity
NRC	Network Resource Capability
NERC	North American Reliability Council
PC	Perfect Capacity

POI	Point of Interconnection
PSH	Pumped Storage Hydro
QC	Qualified Capacity
QMRIC	Qualified MRI Capacity
RAA	Resource Adequacy Assessment
RCA	Resource Capacity Accreditation
SCC	Seasonal Claimed Capability