Resource Capacity Accreditation in the Forward Capacity Market

FCA 18/19 Accreditation Sensitivity Analysis, Part 2

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Resource Capacity Accreditation in the Forward Capacity Market

WMPP ID: 157

Proposed Effective Date: Forward Capacity Auction 19 (FCA 19) with a one-year delay

- The Resource Capacity Accreditation (RCA) project proposes improvements to ISO-NE's accreditation processes in the Forward Capacity Market (FCM) to further support a reliable, clean-energy transition by implementing methodologies that will more appropriately accredit resource contributions to resource adequacy as the resource mix transforms
- At the March 2024 Markets Committee (MC) meeting, the ISO reviewed the seasonal risk splits for sensitivity scenarios 1-3
- This presentation provides responses to questions from the March MC and discusses seasonal performance factors and gas performance details for sensitivity scenarios 1-3

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- The sensitivity scenario results will be discussed over several meetings, allowing for further and deeper discussion with stakeholders
  - March 2024: Seasonal risk splits for scenarios 1-3 (**Complete**)
  - April 2024: Seasonal performance factors and gas performance details for scenarios 1-3
  - May 2024: Class-average rMRIs, participant rMRI requests, energy storage details, and Net Installed Capacity Requirements for scenarios 1-3
  - June 2024: Results for updated scenario 4

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Outline of today's discussion:

Disclaimer

- These results represent the ISO’s best efforts to reflect the proposed design; however, they do not reflect a full production-level implementation
- The results should be understood as indicative under the prescribed sensitivity scenario assumptions; no claim is made as to their validity under other assumptions

INTRODUCTION AND RESPONSES TO QUESTIONS

Impact Analysis Phases

- The impact analysis has three phases
  - Phase 1: Base Case Resource Accreditation (February 2024)
  - Phase 2: Resource Accreditation Sensitivities (March 2024 – June 2024)
  - Phase 3: Base Case Capacity Market Impact (May 2024 – June 2024)
- This presentation summarizes accreditation sensitivities for the FCA 18/19 framework (Phase 2)

Responses to March 2024 MC Questions

- Do seasonal QC calculation rules affect accreditation?
  - For IPRs, no.

    IPRs are modeled using profiles in the RAA process, and seasonal QCs do not affect these profiles.
  - For non-IPRs, yes.

    Non-IPRs are generally modeled at their seasonal QCs.

Responses to March 2024 MC Questions

- Can accreditation details be provided for gas-only fast start and gas-only non-fast start resources?
  - No, gas-only fast start resources have concentrated ownership and providing gas-only non-fast start results would reveal those values

OVERVIEW OF SENSITIVITY SCENARIOS

Overview of Sensitivity Scenarios

Introduced
February 2024
MC Meeting

- Accreditation results for three sensitivity scenarios are provided in this presentation
  1. Retire coal, add renewables/storage
  2. Retire oil-only, add renewables/storage
  3. Add renewables/storage
- The Future Grid Reliability Study Scenario 1 “replacement rate” and renewable/storage distribution was used
  - Replacement rate = 8.61 MW renewables/storage per 1 MW conventional
  - Note: A multiplication error in the earlier scenario spreadsheet was corrected for these results
- All scenarios assume Daily Operating Hours Requirement (DOHR) = 12 hours

Scenario 1 Details

Introduced January 2024 MC Meeting

- *Purpose*: Study how accreditation changes when thermal resources are replaced by IPRs and storage
- Retirements
  - Coal: 438 MW (summer QC)
- Additions
  - Behind the Meter PV: 1,022 MW (nameplate)
  - Land-based Wind: 343 MW (nameplate)
  - Offshore Wind: 1,066 MW (nameplate)
  - IPR PV: 1,076 MW (nameplate)
  - Energy Storage, 4-hour duration: 265 MW (summer QC)

Scenario 2 Details

Introduced January 2024 MC Meeting

- *Purpose*: Study how accreditation changes when oil-only resources are replaced by IPRs and storage
- Retirements based on resource age
  - RFO-only: 662 MW (summer QC)
  - DFO/KER-only: 716 MW (summer QC)
- Additions
  - Behind the Meter PV: 3,214 MW (nameplate)
  - Land-based Wind: 1,078 MW (nameplate)
  - Offshore Wind: 3,351 MW (nameplate)
  - IPR PV: 3,382 MW (nameplate)
  - Energy Storage, 4-hour duration: 835 MW (summer QC)

Scenario 3 Details

Introduced
January 2024
MC Meeting

- *Purpose*: Study how accreditation changes when IPRs and storage are added without retirements

- Retirements
  - None

- Additions

  Same as Scenario 1
  - Behind the Meter PV: 1,022 MW (nameplate)
  - Land-based Wind: 343 MW (nameplate)
  - Offshore Wind: 1,066 MW (nameplate)
  - IPR PV: 1,076 MW (nameplate)
  - Energy Storage, 4-hour duration: 265 MW (summer QC)

SENSITIVITY RESULTS – APRIL 2024

Seasonal Performance Factors and Gas Performance Details

RELEVANT BASE CASE RESULTS

Reviewed
February 2024
MC Meeting

Base Case Seasonal Performance Factors

$$Seasonal\ QMRIC = Seasonal\ Capacity \times \frac{Seasonal\ MRI}{Seasonal\ MRI_{perfect}} \times \frac{Seasonal\ MRI_{perfect}}{Annual\ MRI_{perfect}}$$

- Seasonal performance factors express how well a resource performs seasonally relative to seasonal perfect capacity

Class	Summer Performance Factor	Winter Performance Factor
Dual Fuel†	89.99%	87.07%
Gas-only†	95.22%	97.09%
Other Non-IPR	92.08%	89.75%
Passive DR	94.80%	85.98%
Oil-only†	72.66%	62.63%
Energy Storage	61.60%	36.81%
Import	96.58%	96.32%
Other IPR	92.05%	89.20%
ADCR	54.15%	47.71%
IPR Wind	113.60%	76.03%
IPR PV*	48.61%	16.30%
Hybrid	44.58%	31.00%
Fuel Cell	87.50%	87.91%
Non-IPR Hydro	91.68%	94.98%
IPR Hydro	116.87%	87.46%
	Summer Perfect Capacity MRI Split	**Winter Perfect Capacity MRI Split**
	71.73%	28.27%

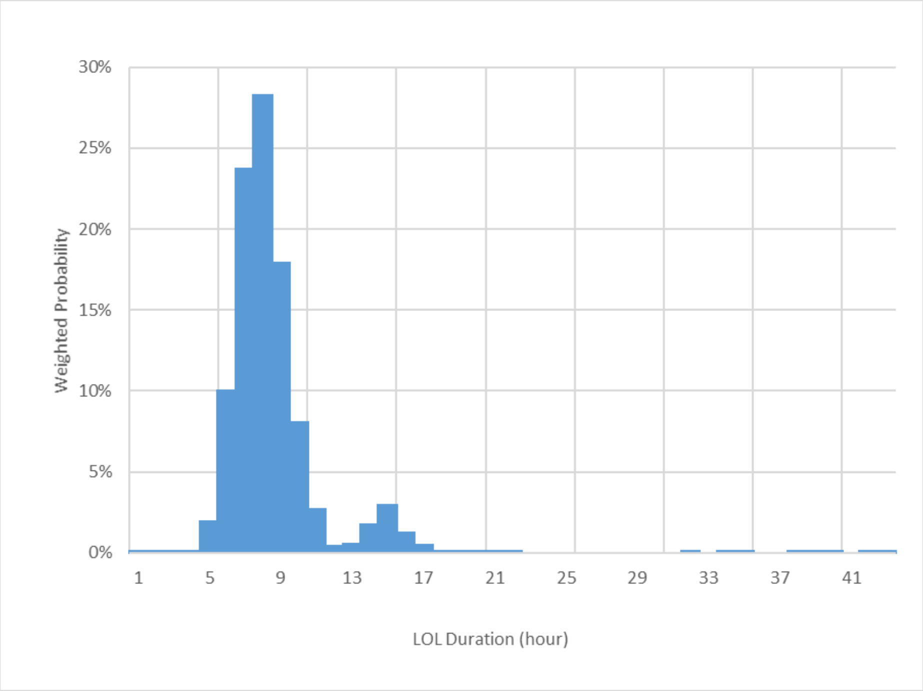
* $Winter\ QMRIC = Summer\ Capacity \times \frac{Winter\ MRI}{Annual\ MRI_{perfect}}$

† Winter Performance Factor expressed relative to winter DQC

Base Case Estimated Annual RAA MRI Event Durations

Reviewed February 2024 MC Meeting

- A substantial percentage (36.1%) of RAA MRI events lasted more than 8 hours
  - Max duration = 43 hours
- The first peak, centered on 8 hours, is a consequence of both summer and winter events
- The second peak, centered on 15 hours, is a consequence of winter events



Reviewed February 2024 MC Meeting

Base Case Gas Performance and Derating

- Winter gas performance can be expressed as QMRIC (*i.e.,* equivalent annual perfect capacity) or expected output during Winter RAA MRI hours (i.e., equivalent winter perfect capacity)

$$Expected\ output\ during\ Winter\ RAA\ MRI\ hours = Winter\ QMRIC \times \frac{Annual\ MRI_{perfect}}{Winter\ MRI_{perfect}}$$

Annual $MRI_{perfect}$ ← 0.75

Winter $MRI_{perfect}$ ← 0.214

	Expected output during Winter RAA MRI hours	Winter QMRIC
Gas fleet total	4,014.018	1,145.333
Assignment to gas Energy Capability QC	909.803	259.597
Gas fleet remainder	3,104.215	885.736
Calculated maximum for gas capacity other than gas Energy Capability QC	8,241.883	2,351.684
Gas fleet remainder / Calculated maximum	37.66%	37.66%
Derate factor	62.34%	62.34%

SEASONAL PERFORMANCE FACTORS

Seasonal Performance Factors

- Seasonal performance factors express how well a resource performs seasonally relative to seasonal perfect capacity
  - Expected output (per seasonal QC MW) in seasonal RAA MRI hours
- The following slides provide summer and winter performance factors by class with observations

$$Seasonal\ Performance\ Factor = \frac{Seasonal\ MRI}{Seasonal\ MRI_{perfect}}$$

Summer Performance Factors

Class	Base Case Summer Performance Factor	Scenario 1 Summer Performance Factor	Scenario 2 Summer Performance Factor	Scenario 3 Summer Performance Factor
Dual Fuel	89.99%	90.19%	90.24%	90.71%
Gas-only	95.22%	95.41%	95.32%	95.92%
Other Non-IPR	92.08%	95.45%	92.50%	92.99%
Passive DR	94.80%	93.60%	91.08%	93.94%
Oil-only	72.66%	72.84%	68.82%	73.29%
Energy Storage	61.60%	65.28%	72.20%	65.78%
Import	96.58%	96.79%	96.83%	97.27%
Other IPR	92.05%	92.79%	93.24%	93.20%
ADCR	54.15%	53.79%	52.75%	54.04%
IPR Wind	113.60%	94.85%	66.90%	95.36%
IPR PV	48.61%	40.57%	26.97%	40.71%
Hybrid	44.58%	43.91%	43.35%	44.06%
Fuel Cell	87.50%	87.77%	87.82%	88.48%
Non-IPR Hydro	91.68%	91.86%	91.89%	92.34%
IPR Hydro	116.87%	117.18%	115.96%	118.26%

- Many categories have similar performance across scenarios
- Certain categories have notable changes
  - Other Non-IPR, Energy Storage, IPR Wind, IPR PV

Note: Hybrid = Configuration 3 and 4 co-located resources

Summer Performance Factors: Other Non-IPR

Class	Base Case Summer Performance Factor	Scenario 1 Summer Performance Factor	Scenario 2 Summer Performance Factor	Scenario 3 Summer Performance Factor
Other Non-IPR	92.08%	95.45%	92.50%	92.99%

Throughout presentation, yellow results will be discussed in more detail

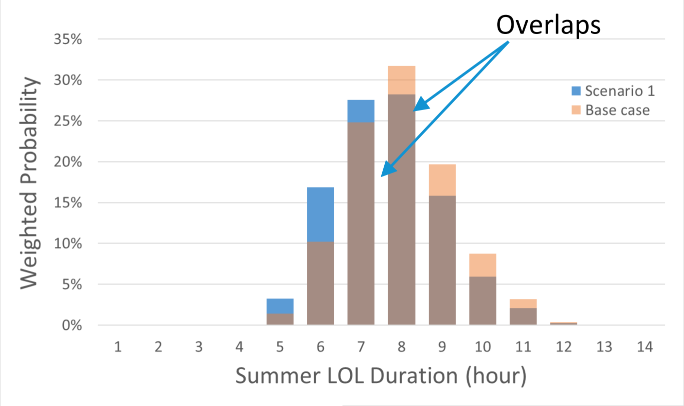
- Existing coal resources are relatively large and have relatively high xEFORds
- As such, the presence of coal resources has a measurable impact on the class-average performance factor
- In scenario 1, coal resources are retired so the Other Non-IPR performance factor increases

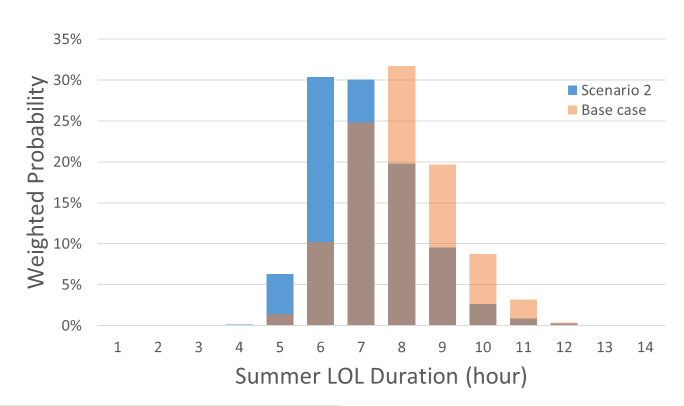
Summer Performance Factors: Energy Storage

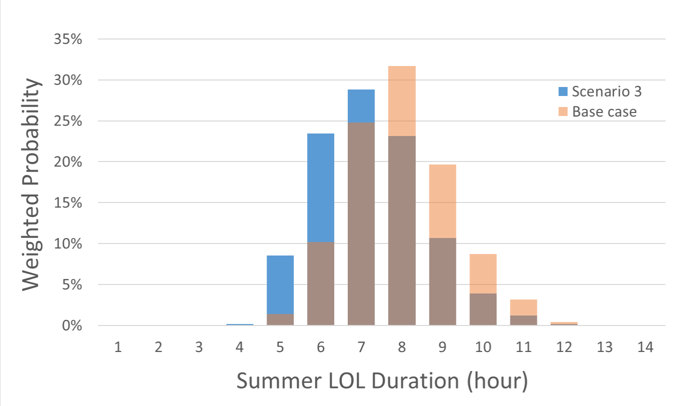
Class	Base Case Summer Performance Factor	Scenario 1 Summer Performance Factor	Scenario 2 Summer Performance Factor	Scenario 3 Summer Performance Factor
Energy Storage	61.60%	65.28%	72.20%	65.78%

- The performance of energy storage resources is closely related to the duration of RAA MRI hours
- In scenarios 1-3, the presence of additional IPRs (especially IPR PV) delays the start of RAA MRI events and therefore shortens them
  - Scenarios 1 and 3 have the same IPR penetration level
  - Scenario 2 has the highest IPR penetration level

Estimated Summer RAA MRI Event Duration







The summer RAA MRI event durations shift left in all scenarios

Summer Performance Factors: IPR Wind

Class	Base Case Summer Performance Factor	Scenario 1 Summer Performance Factor	Scenario 2 Summer Performance Factor	Scenario 3 Summer Performance Factor
IPR Wind	113.60%	94.85%	66.90%	95.36%

- The IPR Wind penetration level affects its performance factor
  - Higher penetration → Higher output during similar hours → Lower likelihood that those hours are RAA MRI hours → Lower performance factor
- Scenarios 1 and 3 have the same IPR Wind penetration level
  - 3,350 MW (nameplate)
- Scenario 2 has the highest IPR Wind penetration level
  - 6,369 MW (nameplate)

Summer Performance Factors: IPR PV

Class	Base Case Summer Performance Factor	Scenario 1 Summer Performance Factor	Scenario 2 Summer Performance Factor	Scenario 3 Summer Performance Factor
IPR PV	48.61%	40.57%	26.97%	40.71%

- Similar to IPR Wind, penetration level affects IPR PV's performance factor
- Scenarios 1 and 3 have the same IPR PV penetration level
  - 2,255 MW (nameplate)
- Scenario 2 has the highest IPR PV penetration level
  - 4,560 MW (nameplate)

Winter Performance Factors

Class	Base Case Winter Performance Factor	Scenario 1 Winter Performance Factor	Scenario 2 Winter Performance Factor	Scenario 3 Winter Performance Factor
Dual Fuel†	87.07%	87.26%	86.43%	87.32%
Gas-only†	97.09%	97.09%	97.10%	97.10%
Other Non-IPR	89.75%	93.30%	88.70%	89.78%
Passive DR	85.98%	83.45%	86.49%	84.11%
Oil-only†	62.63%	62.81%	60.99%	63.12%
Energy Storage	36.81%	28.27%	32.63%	29.69%
Import	96.32%	96.04%	95.19%	96.39%
Other IPR	89.20%	89.09%	89.30%	89.15%
ADCR	47.71%	46.99%	47.75%	47.32%
IPR Wind	76.03%	60.99%	24.71%	59.67%
IPR PV*	16.30%	12.93%	14.31%	13.30%
Hybrid	31.00%	23.11%	25.77%	24.02%
Fuel Cell	87.91%	88.13%	87.04%	87.80%
Non-IPR Hydro	94.98%	94.99%	94.26%	95.38%
IPR Hydro	87.46%	87.47%	90.47%	87.58%

- Many categories have similar performance across scenarios
- Certain categories have notable changes
  - Other Non-IPR, Energy Storage, IPR Wind, IPR PV, Hybrid

Note: Hybrid = Configuration 3 and 4 co-located resources

$* \; Winter\ QMRIC = Summer\ Capacity \times \frac{Winter\ MRI}{Annual\ MRI_{perfect}}$

† Winter Performance Factor expressed relative to winter DQC

Winter Performance Factors: Fuel-limited Classes

Class	Base Case Winter Performance Factor	Scenario 1 Winter Performance Factor	Scenario 2 Winter Performance Factor	Scenario 3 Winter Performance Factor
Dual Fuel†	87.07%	87.26%	86.43%	87.32%
Gas-only†	97.09%	97.09%	97.10%	97.10%
Oil-only†	62.63%	62.81%	60.99%	63.12%

- At first glance, it may seem odd that dual fuel, gas-only, and oil-only classes have small winter performance changes across scenarios
- An explanation of this behavior is provided later in the presentation

† Winter Performance Factor expressed relative to winter DQC

Winter Performance Factors: Other Non-IPR

Class	Base Case Winter Performance Factor	Scenario 1 Winter Performance Factor	Scenario 2 Winter Performance Factor	Scenario 3 Winter Performance Factor
Other Non-IPR	89.75%	93.30%	88.70%	89.78%

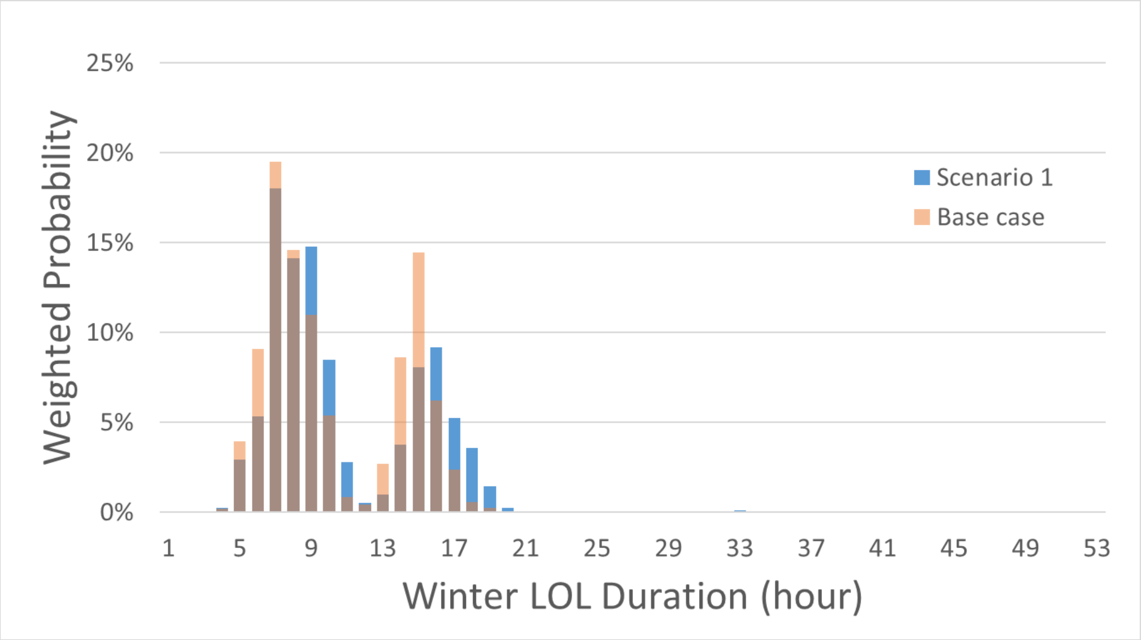
- The scenario 1 winter performance factor of Other Non-IPR increases for the same reason as the Scenario 1 summer performance factor (see Slide 23)
  - Coal resources, which are relatively large with relatively high xEFORd, are retired

Winter Performance Factors: Energy Storage

Class	Base Case Winter Performance Factor	Scenario 1 Winter Performance Factor	Scenario 2 Winter Performance Factor	Scenario 3 Winter Performance Factor
Energy Storage	36.81%	28.27%	32.63%	29.69%

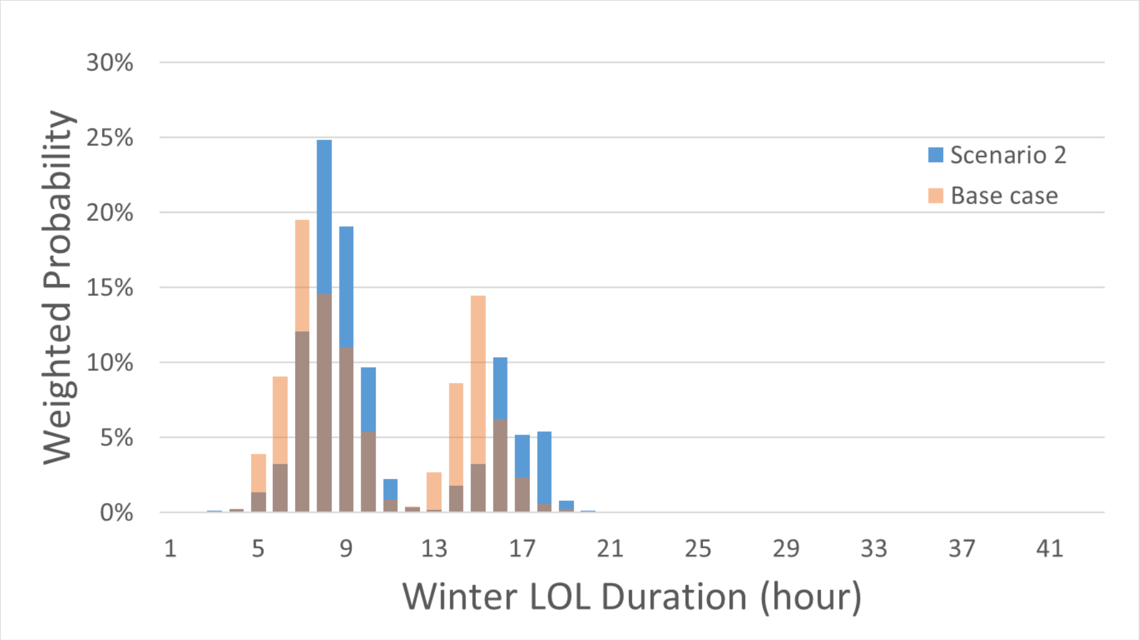
- In scenarios 1 and 2, the presence of additional IPRs does not offset the winter reliability contributions from coal and oil-only retirements
  - RAA MRI events become longer
- In scenario 3, RAA MRI events include more storage charging so net energy storage output during RAA MRI hours decreases

Estimated Winter RAA MRI Event Duration, Scenario 1



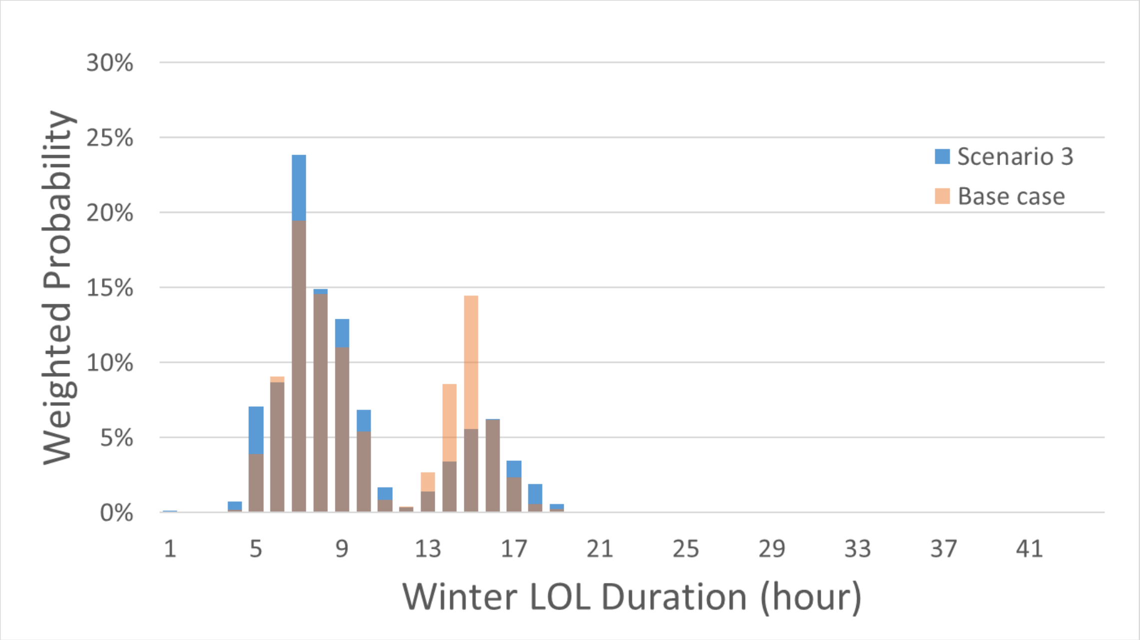
The winter RAA MRI event durations become longer

Estimated Winter RAA MRI Event Duration, Scenario 2



The winter RAA MRI event durations become longer

Estimated Winter RAA MRI Event Duration, Scenario 3



Some winter RAA MRI event durations become longer while others become shorter

Winter Performance Factors: IPR Wind

Class	Base Case Winter Performance Factor	Scenario 1 Winter Performance Factor	Scenario 2 Winter Performance Factor	Scenario 3 Winter Performance Factor
IPR Wind	76.03%	60.99%	24.71%	59.67%

- The IPR Wind penetration level affects its performance factor
- Scenarios 1 and 3 have the same IPR Wind penetration level
- Scenario 2 has the highest IPR Wind penetration level

Winter Performance Factors: IPR PV

Class	Base Case Winter Performance Factor	Scenario 1 Winter Performance Factor	Scenario 2 Winter Performance Factor	Scenario 3 Winter Performance Factor
IPR PV*	16.30%	12.93%	14.31%	13.30%

- Each scenario involves, to different degrees, the shifting of winter RAA MRI hours in the day
  - Scenarios 1-3 have a larger percentage of RAA MRI hours occurring in the late evening/overnight when IPR PV output is low/0
    - See LOLH heat maps on Slides 86/88/90

$* \; Winter\ QMRIC = Summer\ Capacity \times \frac{Winter\ MRI}{Annual\ MRI_{perfect}}$

Winter Performance Factors: Hybrid

Class	Base Case Winter Performance Factor	Scenario 1 Winter Performance Factor	Scenario 2 Winter Performance Factor	Scenario 3 Winter Performance Factor
Hybrid	31.00%	23.11%	25.77%	24.02%

- Hybrid resources are accredited as a combination of energy storage and IPR PV
  - The winter performance factor of the Energy Storage component decreased in all scenarios relative to the base case
  - The winter performance factor of the IPR PV component either decreased or slightly increased
- *Note*: These results were derived using a previous iteration of hybrid accreditation rules
  - See April 2023 Reliability Committee presentation

Note: Hybrid = Configuration 3 and 4 co-located resources

GAS PERFORMANCE DETAILS

Gas Performance in Sensitivity Scenarios

Scenario 1	Expected output Winter RAA MRI hours	Winter QMRIC
Gas fleet total	3,999.999	1,468.354
Assignment to gas Energy Capability QC	909.802	333.978
Gas fleet remainder	3,090.197	1,134.376
Calculated maximum for gas capacity other than gas Energy Capability QC	8,241.882	3,025.501
Gas fleet remainder / Calculated maximum	37.49%	37.49%
Derate factor	62.51%	62.51%

Scenario 2	Expected output Winter RAA MRI hours	Winter QMRIC
Gas fleet total	3,918.922	476.974
Assignment to gas Energy Capability QC	909.798	110.732
Gas fleet remainder	3,009.123	366.242
Calculated maximum for gas capacity other than gas Energy Capability QC	8,241.884	1,003.124
Gas fleet remainder / Calculated maximum	36.51%	36.51%
Derate factor	63.49%	63.49%

Scenario 3	Expected output Winter RAA MRI hours	Winter QMRIC
Gas fleet total	3,985.980	1,146.505
Assignment to gas Energy Capability QC	909.801	261.690
Gas fleet remainder	3,076.179	884.815
Calculated maximum for gas capacity other than gas Energy Capability QC	8,241.883	2,370.649
Gas fleet remainder / Calculated maximum	37.32%	37.32%
Derate factor	62.68%	62.68%

Discussion of Gas Fleet Expected Output

- All sensitivity scenarios imply ~4 GW of expected gas fleet output during winter RAA MRI hours, same as the base case
- Why?
  - Daily available gas is allocated to each hour based on the historical gas generation pattern, which largely follows the load profile
  - The winter load profile is relatively flat, especially during the day
    - See January 2024 Reliability Committee presentation
  - As a consequence, the gas fleet's expected output during winter RAA MRI hours should not change much even if RAA MRI hours change

Discussion of Derating Factor

- All sensitivity scenarios have a derating factor of ~62%, same as the base case
- Why?
  - Consider the generic gas resource accreditation equation

$$Gas\ QMRIC = QC \times (1 - xEFORd) \times \frac{Winter\ MRI_{perfect}}{Annual\ MRI_{perfect}}$$

  - For expected output, multiply QMRIC by $\frac{Annual\ MRI_{perfect}}{Winter\ MRI_{perfect}}$

$$Gas\ expected\ output\ during\ Winter\ RAA\ MRI\ Hours = QC \times (1 - xEFORd)$$

Not changed in sensitivity scenarios

Discussion of Derating Factor, Continued

$$Derating\ Factor = 1 - \frac{Expected\ output\ of\ gas\ fleet - \sum Expected\ output\ of\ gas\ Energy\ Capability\ QC}{\sum Max\ output\ of\ remaining\ gas\ Winter\ QC}$$

- Expected output of gas Energy Capability QC is unchanged in the sensitivity scenarios
- Max output of gas capacity other than Energy Capability QC is also unchanged in the sensitivity scenarios
- The expected output of the gas fleet is ~4GW in all sensitivity scenarios
- The derating factor, which is a function of the above values, only changes slightly in the sensitivity scenarios

Key Takeaways

- Energy Storage, IPR Wind, and IPR PV seasonal performance factors depend on the RAA MRI hour pattern in the sensitivity scenario (duration, distribution during the day)
- The seasonal performance factors of other classes do not vary much between sensitivity scenarios
- Expected gas output in winter RAA MRI hours is similar across scenarios, reflecting the fact that gas availability is not being changed and the load profile is relatively flat

SENSITIVITY RESULTS – MAY 2024

Class-average rMRIs, participant rMRI requests, energy storage details, and Net Installed Capacity Requirements

RELEVANT BASE CASE RESULTS

Base Case rMRI Results

Reviewed February 2024 MC Meeting

$$QMRIC = FCA\ QC \times rMRI$$

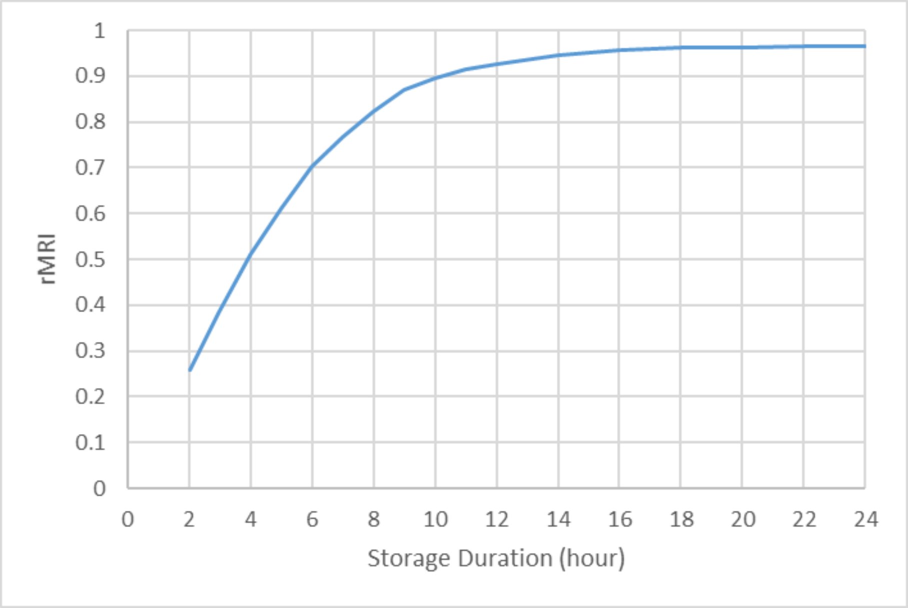
Class	rMRI	Existing FCA QC	Existing QMRIC	Δ Accreditation
Dual Fuel	0.879	9,044.110	7,948.912	-12.11%
Gas-only	0.808	7,868.280	6,356.522	-19.21%
Other Non-IPR	0.918	4,263.950	3,913.591	-8.22%
Passive DR	1.025	1,986.419	2,036.339	2.51%
Oil-only	0.705	2,783.860	1,961.735	-29.53%
Energy Storage	0.547	3,004.261	1,643.061	-45.31%
Import	0.968	1,187.690	1,149.244	-3.24%
Other IPR	0.931	225.150	209.577	-6.92%
ADCR	0.538	731.800	393.624	-46.21%
IPR Wind	1.260	367.140	462.768	26.05%
IPR PV	0.395	457.800	180.930	-60.48%
Hybrid	0.418	216.436	90.387	-58.24%
Fuel Cell	0.891	21.640	19.274	-10.94%
Non-IPR Hydro	0.958	1,215.180	1,163.720	-4.23%
IPR Hydro	1.509	126.780	191.374	50.95%
Resource mix	0.827	33,500.496	27,721.058	-17.25%
Perfect capacity reference	1 (MRI = 0.75)			

Note: “Existing” means modeled in RAA process.

Note: “Hybrid” reflects co-located facilities that elected single-resource participation in the FCM; QMRIC calculation described at the April 2023 RC Meeting.

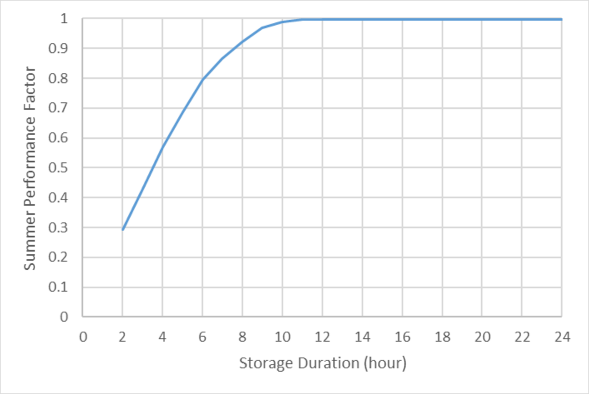
Reviewed
February 2024
MC Meeting

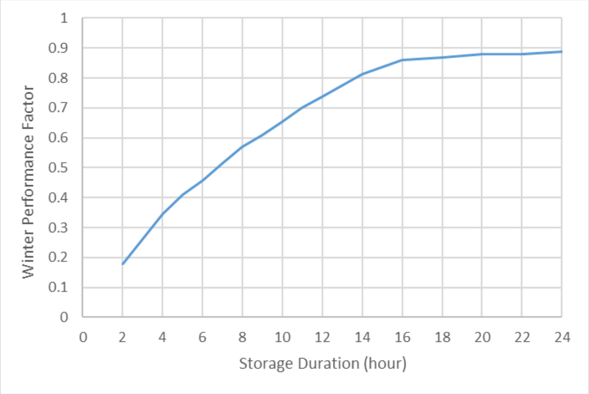
Base Case Indicative Storage rMRIs



- This curve shows the rMRIs of hypothetical storage resources with different durations
- rMRI increases with duration but is always less than 1
  - Reason 1: Storage does not recharge storage
  - Reason 2: Storage charging between LOL events may be limited by time and/or available energy

Base Case Seasonal Storage Analysis





- The summer performance factor is over 95% by 9-hour duration
- The winter performance factor is ~60% for 9-hour storage
  - There were a significant number of long duration winter RAA MRI events

Base Case Net Installed Capacity Requirement

Reviewed
February 2024
MC Meeting

Total MW Breakdown	FCA18/19 Base Case (Summer QC MW)
Generating Capacity Resources	29,690
Demand Resources	3,025
Import Capacity Resources	1,188
Tie Benefits	2,115
OP-4 Actions 6 & 8 (Voltage Reduction)	262
Minimum System Reserve	(700)
Total MW	35,580
Other Details	
Annual Peak (50/50)	27,748
ALCC	2,044
Net ICR	31,576

← Corrected value (Demand Resources)

← Updated based on correction (Net ICR)

CLASS-AVERAGE RELATIVE MRI VALUES

Class-average rMRI

$$rMRI = \frac{QMRIC_{Summer\ component} + QMRIC_{Winter\ component}}{FCA\ QC}$$

	rMRI			
Class	**Base case**	**Scenario 1**	**Scenario 2**	**Scenario 3**
Dual Fuel	0.879	0.871	0.898	0.879
Gas-only	0.808	0.764	0.896	0.806
Other Non-IPR	0.918	0.948	0.927	0.919
Passive DR	1.025	0.986	1.029	1.006
Oil-only	0.705	0.696	0.699	0.706
Energy Storage	0.547	0.517	0.679	0.552
Import	0.968	0.965	0.973	0.968
Other IPR	0.931	0.935	0.941	0.934
ADCR	0.538	0.527	0.537	0.533
IPR Wind	1.260	1.057	0.653	1.027
IPR PV	0.395	0.304	0.256	0.327
Hybrid	0.418	0.370	0.437	0.394
Fuel Cell	0.891	0.894	0.891	0.893
Non-IPR Hydro	0.958	0.959	0.957	0.959
IPR Hydro	1.509	1.605	1.322	1.517
Resource mix	0.827	0.802	0.831	0.817

rMRI Calculation Observations

- rMRI is a function of seasonal QMRIC components and FCA QC
- A resource's FCA QC does not change between sensitivity scenarios, so rMRI changes are a result of seasonal QMRIC component changes

$$QMRIC_{Seasonal\ component} = Seasonal\ QC \times \frac{Seasonal\ MRI}{Seasonal\ MRI_{perfect}} \times \frac{Seasonal\ MRI_{perfect}}{Annual\ MRI_{perfect}}$$

- Seasonal QC: No change between scenarios, except for gas resources (small derating differences)
- $Seasonal\ MRI_{perfect}$ (denominator of first fraction): **May change between scenarios** (Seasonal performance factor)
- $Annual\ MRI_{perfect}$: **Changes between scenarios** (Perfect capacity MRI split)

Class-average rMRI: Dual Fuel and Gas-only

	rMRI			
Class	**Base case**	**Scenario 1**	**Scenario 2**	**Scenario 3**
Dual Fuel	0.879	0.871	0.898	0.879
Gas-only	0.808	0.764	0.896	0.806

- rMRI is driven by perfect capacity MRI split and seasonal QC difference
  - Scenario 1 has the highest winter risk → lower rMRI due to larger impact of derated winter QC
    - Gas-only is subject to more derating than Dual Fuel
  - Scenario 2 has the lowest winter risk → higher rMRI due to smaller impact of derated winter QC
    - Gas-only is subject to more derating than Dual Fuel

Class-average rMRI: Other Non-IPR

	rMRI			
Class	**Base case**	**Scenario 1**	**Scenario 2**	**Scenario 3**
Other Non-IPR	0.918	0.948	0.927	0.919

- rMRI is driven by seasonal performance factors
  - In scenario 1, the retirement of coal resources increases Other Non-IPR summer and winter performance factors
  - Higher seasonal performance factors → higher rMRI

Class-average rMRI: Energy Storage

	rMRI			
Class	Base case	Scenario 1	Scenario 2	Scenario 3
Energy Storage	0.547	0.517	0.679	0.552

- rMRI is driven by seasonal performance factors and perfect capacity MRI split
  - Energy storage has significantly higher summer performance factors
  - Scenario 1 has the lowest summer risk → lower rMRI due to smaller impact of summer performance factor
  - Scenario 2 has the highest summer risk → higher rMRI due to larger impact of summer performance factor

Class-average rMRI: IPR Wind

	rMRI			
Class	**Base case**	**Scenario 1**	**Scenario 2**	**Scenario 3**
IPR Wind	1.260	1.057	0.653	1.027

- rMRI is driven by seasonal performance factors
  - Ordering from highest seasonal performance factors to lowest, Base case > Scenario 1/Scenario 3 > Scenario 2
  - Scenario 2 has the lowest seasonal performance factors → lowest rMRI
  - Scenarios 1 and 3 have similar seasonal performance factors → similar rMRIs

Class-average rMRI: IPR PV

	rMRI			
Class	**Base case**	**Scenario 1**	**Scenario 2**	**Scenario 3**
IPR PV	0.395	0.304	0.256	0.327

- rMRI is driven by seasonal performance factors and perfect capacity MRI split
  - Ordering from highest summer performance factor to lowest, Base case > Scenario 1/Scenario 3 > Scenario 2
  - Summer performance factor is higher than winter performance factor
  - Scenario 2 has the highest summer risk → lowest rMRI due to larger impact of summer performance factor
  - Scenario 3 has a summer risk almost the same as the base case but a lower summer performance factor → lower rMRI than base case
  - Scenario 1 has the lowest summer risk → lower rMRI than scenario 3 due to lower impact of summer performance

Class-average rMRI: IPR Hydro

	rMRI			
Class	Base case	Scenario 1	Scenario 2	Scenario 3
IPR Hydro	1.509	1.605	1.322	1.517

- rMRI is driven by seasonal QC and perfect capacity MRI split
  - IPR Hydro has significantly higher winter QC than summer QC
  - Scenario 2 has lowest winter risk → lowest rMRI due to smaller impact of winter performance factor
  - Scenario 1 has highest winter risk → highest rMRI due to larger impact of winter performance factor

PARTICIPANT RELATIVE MRI REQUESTS

Participant rMRI Requests

Distinction	Base case	Scenario 1	Scenario 2	Scenario 3
Dual Fuel, Fast Start	0.886	0.877	0.903	0.888
Dual Fuel, Non-Fast Start	0.877	0.870	0.897	0.877
Oil-only, Fast Start	0.843	0.828	0.922	0.843
Oil-only, Non-Fast Start	0.644	0.639	0.672	0.647
RFO-only	0.638	0.633	*	0.641
DFO-only	0.842	0.828	*	0.842
Combined Cycle	0.851	0.821	0.911	0.849
Gas Turbine	0.861	0.848	0.896	0.862
Land-based Wind	*	1.473	1.408	1.486
Offshore Wind	*	0.950	0.510	0.909

* Not enough resources in class to provide separate values

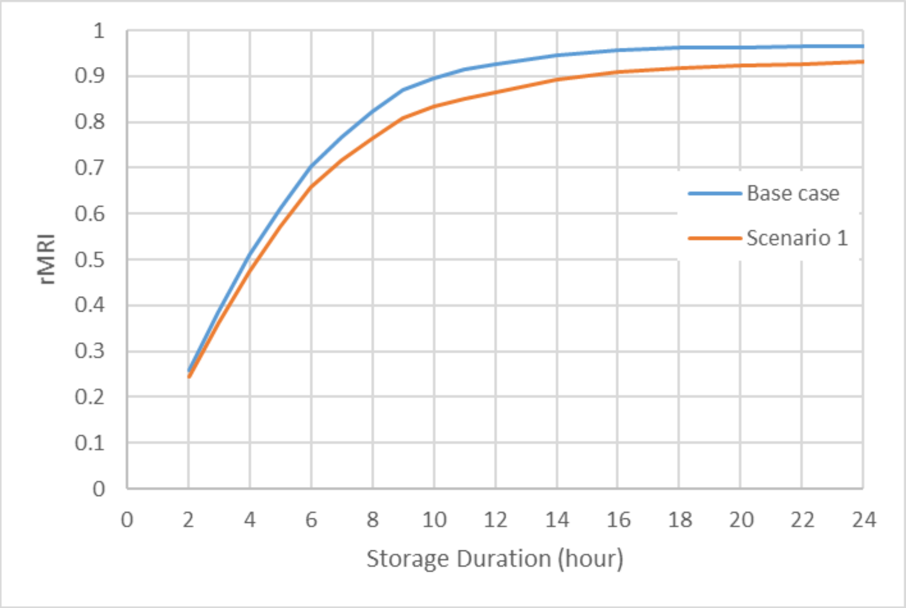
- Land-based wind receives a higher rMRI than offshore wind
- Scenario 2 results in the highest rMRIs for non-wind categories on this slide
  - Non-wind categories include resources subject to fuel constraints, but scenario 2 has the highest percentage of RAA MRI hours in the summer when there are no fuel constraints

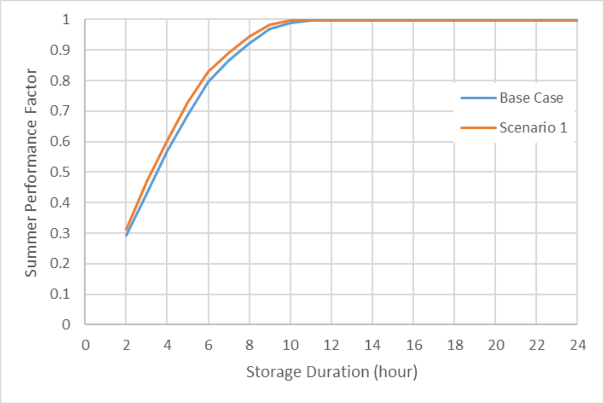
ENERGY STORAGE DETAILS

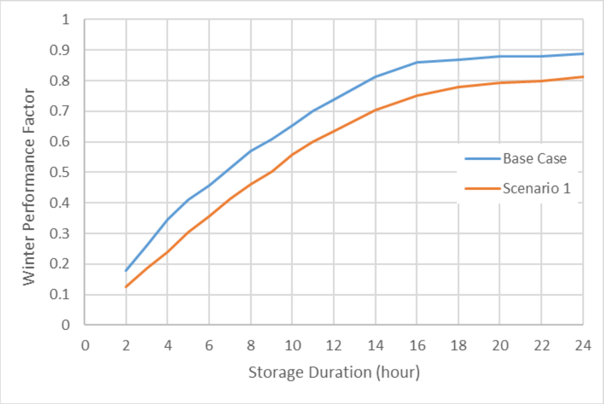
Indicative Storage MRIs

- Energy storage MRIs are affected by
  - Duration of RAA MRI hours
    - Summer and winter duration curves were presented on Slide 25 (summer) and Slide 32-34 (winter)
  - Inability of storage to recharge storage in GE MARS
  - Energy availability between LOL events
- Explanations for energy storage MRIs follow the seasonal performance factor explanations for energy storage
  - Slide 24 (summer) and Slide 31 (winter)
- Because energy storage has summer QC = winter QC = FCA QC, rMRI can be expressed as a simple weighting of seasonal MRIs

Indicative Storage MRIs: Scenario 1



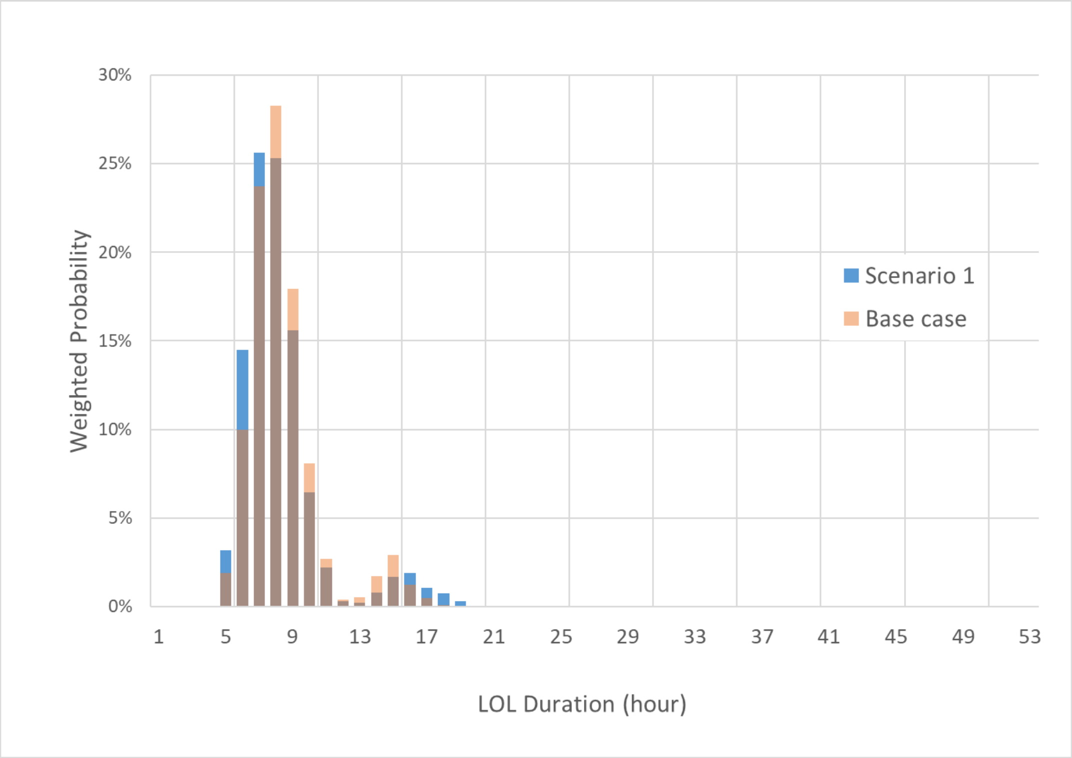




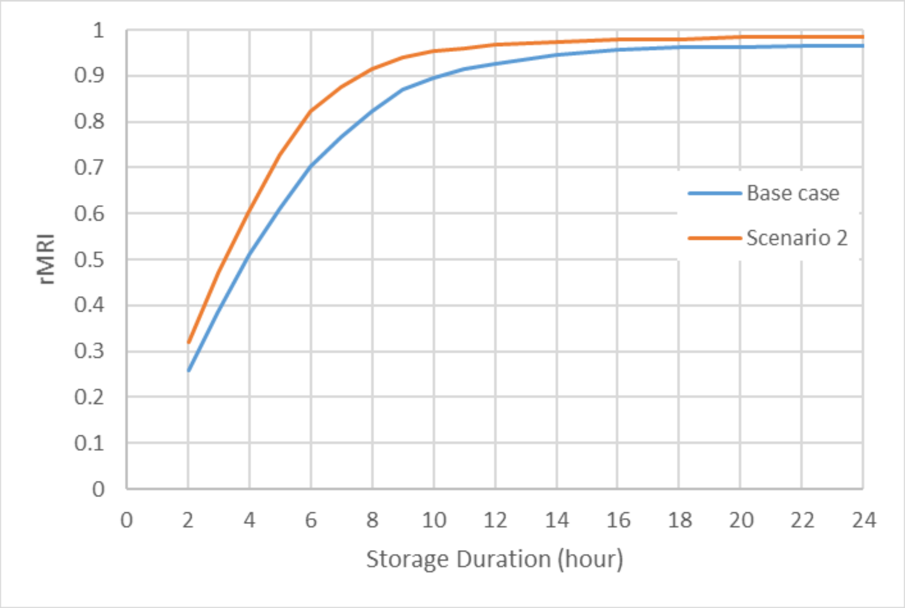
$$rMRI = Summer\ performance\ factor \times 0.633 + Winter\ performance\ factor \times 0.367$$

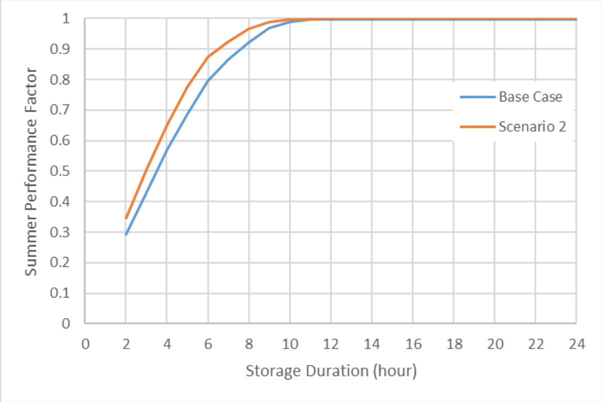
Perfect capacity MRI split

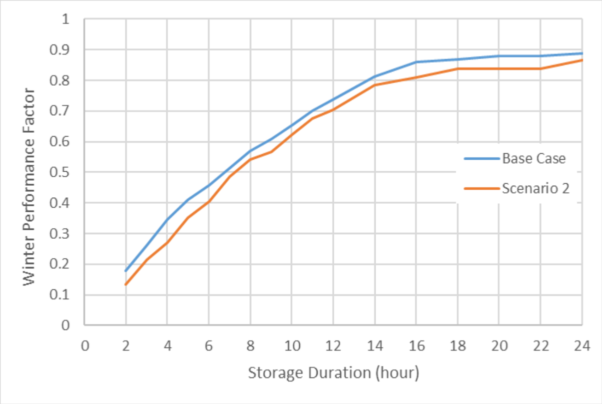
Estimated Annual RAA MRI Event Durations: Scenario 1



Indicative Storage MRIs: Scenario 2



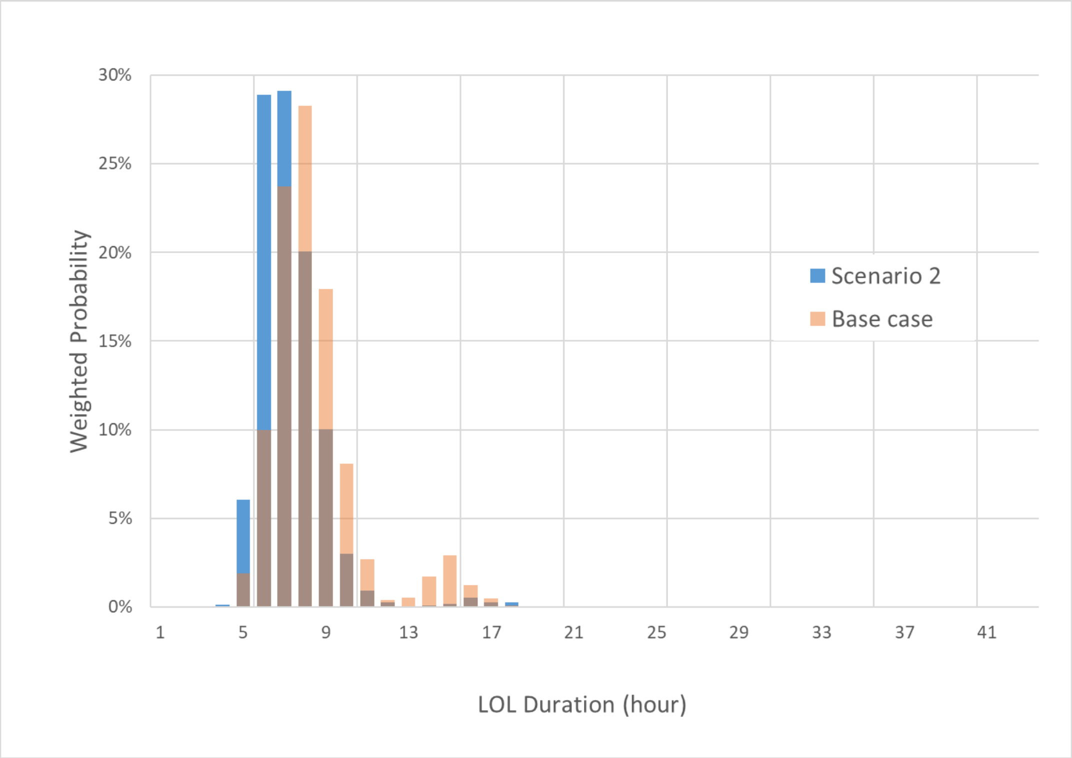




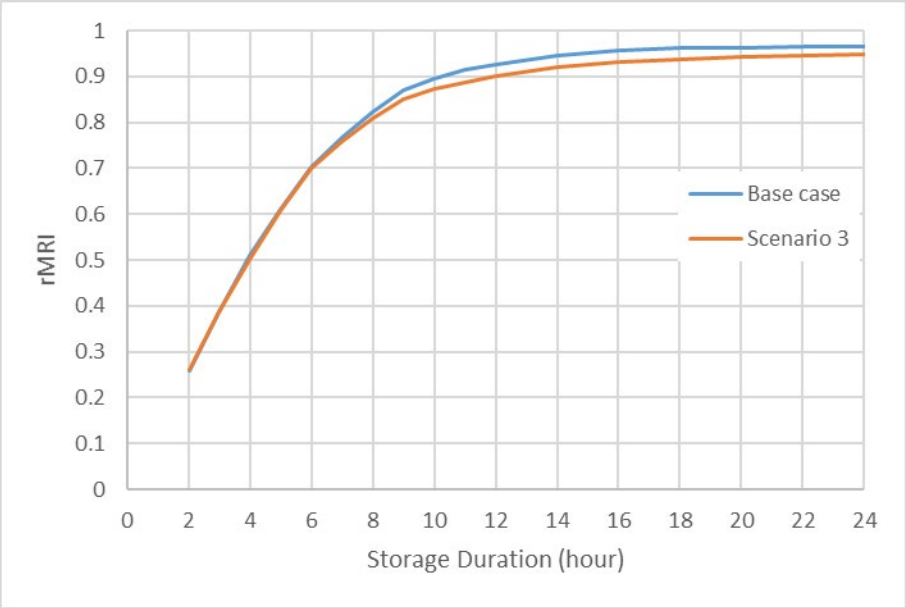
$$rMRI = Summer\ performance\ factor \times 0.885 + Winter\ performance\ factor \times 0.115$$

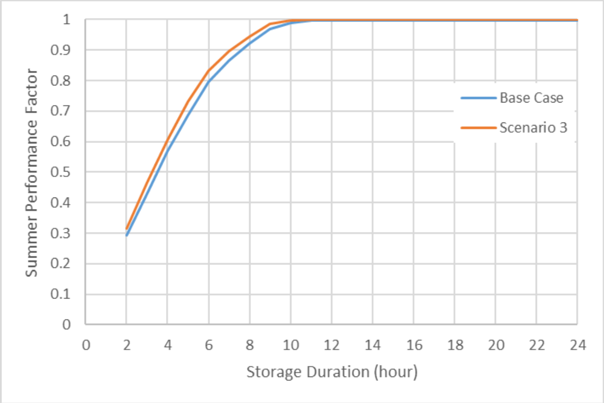
Perfect capacity MRI split

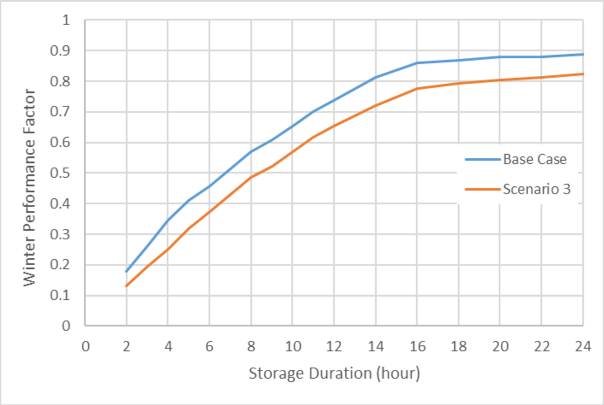
Estimated Annual RAA MRI Event Durations: Scenario 2



Indicative Storage MRIs: Scenario 3



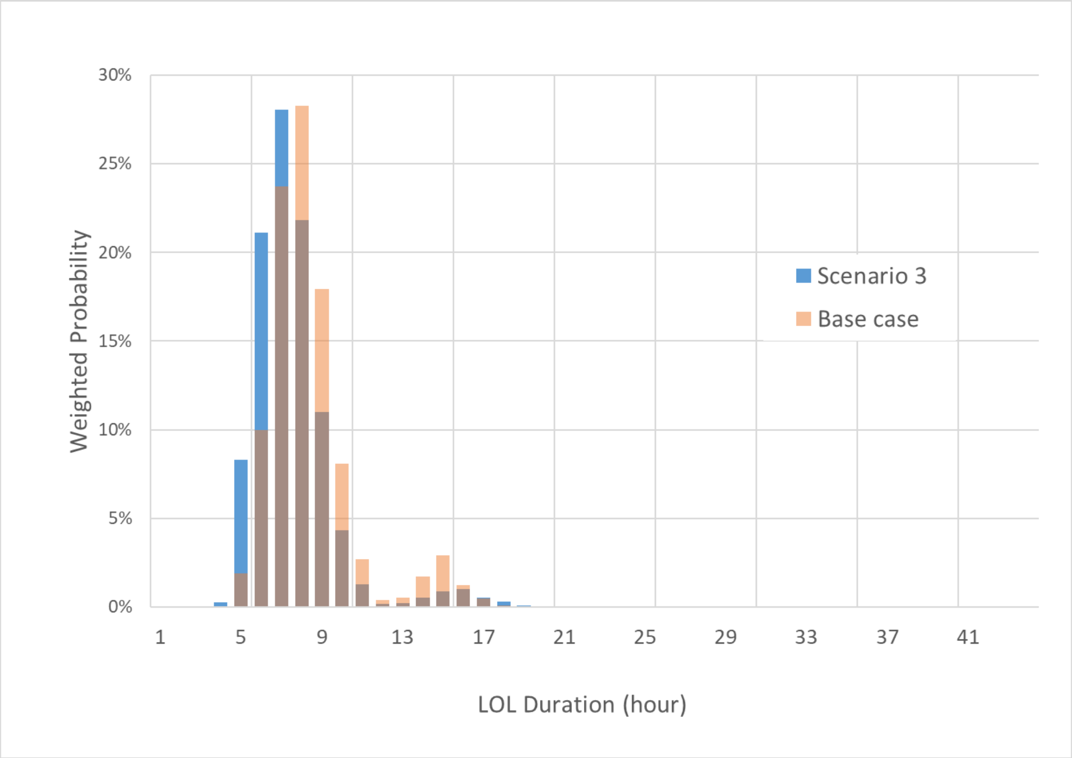




$$rMRI = Summer\ performance\ factor \times 0.710$$
$$+Winter\ performance\ factor \times 0.290$$

Perfect capacity MRI split

Estimated Annual RAA MRI Event Durations: Scenario 3



NET INSTALLED CAPACITY REQUIREMENTS

Net Installed Capacity Requirements

	Summer LOLE	ALCC	Net ICR
Base case	80.3%	7.368%	31,576
Scenario 1	80.4%	9.300%	31,560
Scenario 2	95.0%	12.377%	31,827
Scenario 3	85.1%	10.655%	31,569

- The base case and scenario 1-3 have similar summer LOLEs and similar Net ICRs
  - Small increase in scenario 2 Net ICR is due to added IPRs/storage being slightly less effective at reducing summer LOLE than oil-only resources

Key Takeaways

- Class-average rMRIs depend on differences in seasonal QCs, seasonal performance factors, and perfect capacity MRI split
  - Certain classes are affected by some factors more than others
- Land-based wind has a higher rMRI than offshore wind
- Energy storage rMRI is affected by RAA MRI event durations, which differ by season, and the perfect capacity MRI split
- Net Installed Capacity Requirements are similar for the base case and sensitivity scenarios 1-3

CONCLUSION

Conclusion

- For sensitivity scenarios 1-3, this presentation provided
  - Explanations of seasonal risk split changes
  - Seasonal resource performance details
  - Gas performance and derating intuition
  - Class-average rMRIs
  - Additional participant-requested class rMRIs
  - Indicative storage MRI curves
  - Net Installed Capacity Requirements

STAKEHOLDER SCHEDULE

Stakeholder Process - Overview

- As previously discussed, the RCA forward, annual project schedule has three phases:
  - Conceptual & Detailed Design: November 2023 – May 2024
  - Finalize Design, Review Tariff Language, and Stakeholder Amendments: June 2024 – August 2024
  - Voting: September 2024 (Technical Committees) and October 2024 (Participants Committee)

- In addition, the impact analysis is planned to be reviewed as follows:
  - January 2024: Review revised input assumptions and scenarios
  - February 2024 – July 2024: Review available results
  - August 2024: Final report

2023			2024											
Q4			Q1			Q2			Q3			Q4		
O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Refresher	Conceptual and Detail Design							Final Design, Review Tariff, and Amendments			MC/RC Vote	PC Vote; File		Eff. Date

Review Revised IA Input Assumptions and Scenarios

Review Available IA Results

Final IA Report

Parallel Stakeholder Processes

- The ISO has recommended taking additional time to prepare for CCP 19 to develop a prompt and seasonal capacity market and is filing a further delay to FCA 19 with the Commission
- While the FCA 19 further delay filing is pending before the Commission, ISO is continuing to develop and prepare to implement RCA in a forward, annual construct in 2026
  - For additional details on the timeline of possible paths associated with the further delay, please see the ISO's March [MC material on the Alternative FCM Commitment Horizons]
- Below are the parallel stakeholder processes associated with these CCP 19-related efforts

<table>
<tr><th></th><th colspan="3">2023</th><th colspan="12">2024</th></tr>
<tr><th></th><th colspan="3">Q4</th><th colspan="3">Q1</th><th colspan="3">Q2</th><th colspan="3">Q3</th><th colspan="3">Q4</th></tr>
<tr><th></th><th>O</th><th>N</th><th>D</th><th>J</th><th>F</th><th>M</th><th>A</th><th>M</th><th>J</th><th>J</th><th>A</th><th>S</th><th>O</th><th>N</th><th>D</th></tr>
<tr><td>RCA
Forward, Annual Design</td><td>Refresher</td><td colspan="7">Conceptual and
Detail Design</td><td colspan="3">Final Design, Review Tariff, and Amendments</td><td>MC/RC Vote</td><td>PC Vote; File</td><td></td><td>Eff. Date</td></tr>
<tr><td rowspan="2">RCA
Forward, Annual IA</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2">Review revised input assumptions and scenarios</td><td rowspan="2">Review
Base Case
Resource Accreditation</td><td colspan="5">Review
Resource Accreditation Sensitivities</td><td rowspan="2">Final Report</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td colspan="2"></td><td colspan="3">Review Base Case
Capacity Market Impact</td></tr>
<tr><td>Alternative
FCM Commitment Horizons</td><td colspan="2">Analysis -
Scope & Methodology</td><td colspan="2">Analysis
Findings &
Stakeholder Feedback</td><td>ISO recommendation on whether to develop prompt proposal
____
If recommending to develop prompt proposal, introduce additional delay to FCA 19</td><td>MC Vote on additional FCA 19 delay</td><td>PC Vote on additional FCA 19 delay; File</td><td></td><td>Eff. Date</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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Questions

APPENDIX

SENSITIVITY RESULTS – MARCH 2024

Seasonal Risk Splits

RELEVANT BASE CASE RESULTS

Base Case Seasonal Risk Split

Reviewed
February 2024
MC Meeting

- Loss of Load Equivalent (LOLE) split: 80% summer, 20% winter
- Perfect capacity MRI split: 72% summer, 28% winter
  - This seasonal split affects accreditation for resources with different seasonal capabilities

$$Seasonal\ QMRIC = \underbrace{Seasonal\ QC \times \frac{Seasonal\ MRI}{Seasonal\ MRI_{perfect}}}_{\text{Expected output in seasonal RAA MRI hours}} \times \underbrace{\frac{Seasonal\ MRI_{perfect}}{Annual\ MRI_{perfect}}}_{\text{Perfect capacity MRI split (\% of annual RAA MRI hours in season)}}$$

Expected output in seasonal RAA MRI hours

Perfect capacity MRI split
(% of annual RAA MRI hours in season)

Base Case LOLH Heat Map

- Loss of Load Hours (LOLHs) occurred in
  - June through September
    - Low July LOLH frequency due to mild 2021 July weather
  - December through February
- January had at least one Loss of Load (LOL) observation in each hourly bin
  - Implies rare LOL events crossing daily boundaries
- Substantial number of peak winter period LOLHs in evening/night

LOLH Distribution

Hour of Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	0.01%	<0.005%	-	-	-	-	-	-	-	-	-	-	0.01%
2	<0.005%	-	-	-	-	-	-	-	-	-	-	-	<0.005%
3	<0.005%	-	-	-	-	-	-	-	-	-	-	-	<0.005%
4	<0.005%	-	-	-	-	-	-	-	-	-	-	-	<0.005%
5	<0.005%	-	-	-	-	-	-	-	-	-	-	-	<0.005%
6	<0.005%	-	-	-	-	-	-	-	-	-	-	-	<0.005%
7	0.01%	<0.005%	-	-	-	-	-	-	-	-	-	-	0.01%
8	0.09%	<0.005%	-	-	-	-	-	-	-	-	-	<0.005%	0.09%
9	0.16%	<0.005%	-	-	-	-	-	-	-	-	-	<0.005%	0.16%
10	0.21%	<0.005%	-	-	-	-	-	-	-	-	-	0.01%	0.21%
11	0.18%	<0.005%	-	-	-	-	-	-	-	-	-	0.01%	0.20%
12	0.16%	-	-	-	-	0.01%	-	<0.005%	-	-	-	0.02%	0.19%
13	0.11%	-	-	-	-	0.16%	<0.005%	<0.005%	-	-	-	0.03%	0.30%
14	0.12%	-	-	-	-	0.91%	<0.005%	0.07%	-	-	-	0.05%	1.16%
15	0.14%	-	-	-	-	2.09%	<0.005%	0.67%	-	-	-	0.10%	3.00%
16	0.17%	-	-	-	-	3.25%	0.02%	2.08%	-	-	-	0.24%	5.76%
17	0.26%	-	-	-	-	4.72%	0.06%	4.44%	<0.005%	-	-	0.75%	10.24%
18	1.14%	<0.005%	-	-	-	7.19%	0.17%	8.65%	<0.005%	-	-	2.39%	19.54%
19	1.07%	<0.005%	-	-	-	7.67%	0.17%	8.48%	<0.005%	-	-	2.42%	19.81%
20	1.51%	<0.005%	-	-	-	7.18%	0.08%	8.27%	<0.005%	-	-	2.77%	19.82%
21	1.13%	<0.005%	-	-	-	5.14%	0.02%	4.78%	<0.005%	-	-	2.03%	13.09%
22	0.65%	<0.005%	-	-	-	2.46%	<0.005%	1.16%	-	-	-	1.43%	5.70%
23	0.27%	<0.005%	-	-	-	0.01%	-	<0.005%	-	-	-	0.31%	0.59%
24	0.11%	<0.005%	-	-	-	-	-	-	-	-	-	0.01%	0.11%
Monthly	7.49%	<0.005%	-	-	-	40.79%	0.53%	38.60%	0.01%	-	-	12.58%	100.00%

SEASONAL RISK SPLITS

Seasonal Risk Splits

	Base case		Scenario 1		Scenario 2		Scenario 3	
	Summer	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**
LOLE	80.3%	19.7%	80.4%	19.6%	95.0%	5.0%	85.1%	14.9%
LOLH	79.9%	20.1%	74.6%	25.4%	93.1%	6.9%	81.2%	18.8%
EUE	83.0%	17.0%	76.2%	23.8%	93.6%	6.4%	83.1%	16.9%
Perfect capacity MRI	71.7%	28.3%	63.3%	36.7%	88.5%	11.5%	71.0%	29.0%

- Risk in scenarios 1, 2, and 3 is weighted toward the summer
  - Implication: Summer performance has a larger impact on accreditation than winter performance
- The following slides provide explanations for each scenario’s results

Seasonal Risk Splits – Comparisons

- While each scenario's results could be compared directly to the base case, that approach would make it difficult to verify that changes between sensitivity scenarios are logical
- As an alternative, scenario 3 is compared directly to the base case, scenario 1 is compared to scenario 3, and scenario 2 is compared to scenario 1

Scenario 3 – Renewables/Storage Addition LOLE Split Observations

- Summer LOL events don't span days
  - Increasing renewables/storage won't necessarily decrease the number of summer LOL days
- Some winter LOL events do span days
  - Increasing renewables/storage can decrease the number of winter LOL days
- Conclusion: Relative to the base case, LOLE shifts toward the summer

	Base case		Scenario 3	
	Summer	Winter	Summer	Winter
LOLE	80.3%	19.7%	85.1%	14.9%
LOLH	79.9%	20.1%	81.2%	18.8%
EUE	83.0%	17.0%	83.1%	16.9%
Perfect capacity MRI	71.7%	28.3%	71.0%	29.0%

LOLH Heat Map – Scenario 3

Hour of Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	0.04%	<0.005%	-	-	-	-	-	-	-	-	-	<0.005%	0.04%
2	0.02%	-	-	-	-	-	-	-	-	-	-	-	0.02%
3	0.01%	-	-	-	-	-	-	-	-	-	-	-	0.01%
4	<0.005%	-	-	-	-	-	-	-	-	-	-	-	<0.005%
5	0.01%	-	-	-	-	-	-	-	-	-	-	-	0.01%
6	0.02%	-	-	-	-	-	-	-	-	-	-	-	0.02%
7	0.05%	<0.005%	-	-	-	-	-	-	-	-	-	<0.005%	0.05%
8	0.20%	<0.005%	-	-	-	-	-	-	-	-	-	<0.005%	0.20%
9	0.30%	<0.005%	-	-	-	-	-	-	-	-	-	0.01%	0.31%
10	0.35%	<0.005%	-	-	-	-	-	-	-	-	-	0.01%	0.36%
11	0.32%	<0.005%	-	-	-	-	-	-	-	-	-	0.01%	0.33%
12	0.25%	<0.005%	-	-	-	<0.005%	-	-	-	-	-	0.02%	0.27%
13	0.16%	-	-	-	-	0.07%	-	<0.005%	-	-	-	0.03%	0.26%
14	0.18%	-	-	-	-	0.51%	<0.005%	0.02%	-	-	-	0.04%	0.76%
15	0.21%	-	-	-	-	1.30%	<0.005%	0.28%	-	-	-	0.08%	1.88%
16	0.26%	-	-	-	-	2.22%	0.01%	1.36%	-	-	-	0.18%	4.03%
17	0.41%	-	-	-	-	3.73%	0.05%	3.87%	<0.005%	-	-	0.49%	8.55%
18	1.09%	-	-	-	-	6.64%	0.21%	9.22%	<0.005%	-	-	1.36%	18.52%
19	1.16%	<0.005%	-	-	-	7.69%	0.20%	9.48%	<0.005%	-	-	1.41%	19.96%
20	1.51%	<0.005%	-	-	-	7.60%	0.14%	9.73%	0.01%	-	-	1.63%	20.62%
21	1.40%	<0.005%	-	-	-	5.59%	0.05%	6.65%	<0.005%	-	-	1.62%	15.31%
22	1.21%	<0.005%	-	-	-	2.85%	<0.005%	1.66%	-	-	-	1.18%	6.91%
23	0.63%	<0.005%	-	-	-	0.03%	-	<0.005%	-	-	-	0.54%	1.20%
24	0.34%	<0.005%	-	-	-	-	-	-	-	-	-	0.06%	0.39%
Monthly	10.14%	<0.005%	-	-	-	38.23%	0.66%	42.28%	0.01%	-	-	8.67%	100.00%

Scenario 3 – Renewables/Storage Addition Perfect Capacity MRI Split Observations

- In scenario 3, additional IPRs shorten summer LOL events more than they shorten winter LOL events
  - IPR PV additions help shorten events more in the summer than in the winter
- Conclusion: RAA MRI hour split remains close to the base case

	Base case		Scenario 3	
	Summer	**Winter**	**Summer**	**Winter**
LOLE	80.3%	19.7%	85.1%	14.9%
LOLH	79.9%	20.1%	81.2%	18.8%
EUE	83.0%	17.0%	83.1%	16.9%
Perfect capacity MRI	71.7%	28.3%	71.0%	29.0%

LOLH Heat Map – Scenario 3

Hour of Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	0.04%	<0.005%	-	-	-	-	-	-	-	-	-	<0.005%	0.04%
2	0.02%	-	-	-	-	-	-	-	-	-	-	-	0.02%
3	0.01%	-	-	-	-	-	-	-	-	-	-	-	0.01%
4	<0.005%	-	-	-	-	-	-	-	-	-	-	-	<0.005%
5	0.01%	-	-	-	-	-	-	-	-	-	-	-	0.01%
6	0.02%	-	-	-	-	-	-	-	-	-	-	-	0.02%
7	0.05%	<0.005%	-	-	-	-	-	-	-	-	-	<0.005%	0.05%
8	0.20%	<0.005%	-	-	-	-	-	-	-	-	-	<0.005%	0.20%
9	0.30%	<0.005%	-	-	-	-	-	-	-	-	-	0.01%	0.31%
10	0.35%	<0.005%	-	-	-	-	-	-	-	-	-	0.01%	0.36%
11	0.32%	<0.005%	-	-	-	-	-	-	-	-	-	0.01%	0.33%
12	0.25%	<0.005%	-	-	-	<0.005%	-	-	-	-	-	0.02%	0.27%
13	0.16%	-	-	-	-	0.07%	-	<0.005%	-	-	-	0.03%	0.26%
14	0.18%	-	-	-	-	0.51%	<0.005%	0.02%	-	-	-	0.04%	0.76%
15	0.21%	-	-	-	-	1.30%	<0.005%	0.28%	-	-	-	0.08%	1.88%
16	0.26%	-	-	-	-	2.22%	0.01%	1.36%	-	-	-	0.18%	4.03%
17	0.41%	-	-	-	-	3.73%	0.05%	3.87%	<0.005%	-	-	0.49%	8.55%
18	1.09%	-	-	-	-	6.64%	0.21%	9.22%	<0.005%	-	-	1.36%	18.52%
19	1.16%	<0.005%	-	-	-	7.69%	0.20%	9.48%	<0.005%	-	-	1.41%	19.96%
20	1.51%	<0.005%	-	-	-	7.60%	0.14%	9.73%	0.01%	-	-	1.63%	20.62%
21	1.40%	<0.005%	-	-	-	5.59%	0.05%	6.65%	<0.005%	-	-	1.62%	15.31%
22	1.21%	<0.005%	-	-	-	2.85%	<0.005%	1.66%	-	-	-	1.18%	6.91%
23	0.63%	<0.005%	-	-	-	0.03%	-	<0.005%	-	-	-	0.54%	1.20%
24	0.34%	<0.005%	-	-	-	-	-	-	-	-	-	0.06%	0.39%
Monthly	10.14%	<0.005%	-	-	-	38.23%	0.66%	42.28%	0.01%	-	-	8.67%	100.00%

Scenario 1 – Renewables/Storage Addition, Coal Retirement LOLE Split Observations

- Coal resources are modeled as fuel-unconstrained thermal resources, which can help prevent LOL events from crossing days in the winter
- Scenario 1 retires coal resources on top of the scenario 3 additions, so there is a higher likelihood of LOL events spanning days in the winter
- Conclusion: Relative to scenario 3, LOLE shifts toward the winter

	Scenario 3		Scenario 1	
	Summer	Winter	Summer	Winter
LOLE	85.1%	14.9%	80.4%	19.6%
LOLH	81.2%	18.8%	74.6%	25.4%
EUE	83.1%	16.9%	76.2%	23.8%
Perfect capacity MRI	71.0%	29.0%	63.3%	36.7%

LOLH Heat Map – Scenario 1

Hour of Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	0.08%	<0.005%	-	-	-	-	-	-	-	-	-	<0.005%	0.09%
2	0.05%	-	-	-	-	-	-	-	-	-	-	<0.005%	0.05%
3	0.02%	-	-	-	-	-	-	-	-	-	-	-	0.02%
4	0.01%	-	-	-	-	-	-	-	-	-	-	<0.005%	0.01%
5	0.03%	-	-	-	-	-	-	-	-	-	-	<0.005%	0.03%
6	0.04%	-	-	-	-	-	-	-	-	-	-	<0.005%	0.04%
7	0.08%	<0.005%	-	-	-	-	-	-	-	-	-	<0.005%	0.08%
8	0.30%	<0.005%	-	-	-	-	-	-	-	-	-	<0.005%	0.31%
9	0.45%	<0.005%	-	-	-	-	-	-	-	-	-	0.01%	0.46%
10	0.51%	<0.005%	-	-	-	-	-	-	-	-	-	0.01%	0.52%
11	0.45%	<0.005%	-	-	-	-	-	-	-	-	-	0.02%	0.48%
12	0.36%	<0.005%	-	-	-	<0.005%	-	-	-	-	-	0.03%	0.39%
13	0.24%	-	-	-	-	0.06%	-	<0.005%	-	-	-	0.04%	0.34%
14	0.26%	-	-	-	-	0.44%	<0.005%	0.02%	-	-	-	0.06%	0.78%
15	0.31%	-	-	-	-	1.19%	<0.005%	0.23%	-	-	-	0.12%	1.85%
16	0.39%	-	-	-	-	2.02%	0.01%	1.20%	-	-	-	0.24%	3.84%
17	0.61%	-	-	-	-	3.40%	0.04%	3.50%	<0.005%	-	-	0.66%	8.21%
18	1.46%	-	-	-	-	6.07%	0.17%	8.48%	<0.005%	-	-	1.67%	17.86%
19	1.55%	<0.005%	-	-	-	7.13%	0.17%	8.77%	<0.005%	-	-	1.79%	19.41%
20	1.99%	<0.005%	-	-	-	7.00%	0.11%	9.04%	<0.005%	-	-	2.04%	20.18%
21	1.86%	<0.005%	-	-	-	5.19%	0.05%	6.16%	<0.005%	-	-	2.04%	15.30%
22	1.70%	<0.005%	-	-	-	2.65%	<0.005%	1.50%	-	-	-	1.52%	7.37%
23	0.96%	<0.005%	-	-	-	0.02%	-	0.01%	-	-	-	0.76%	1.75%
24	0.53%	<0.005%	-	-	-	-	-	-	-	-	-	0.10%	0.63%
Monthly	14.25%	<0.005%	-	-	-	35.17%	0.55%	38.89%	<0.005%	-	-	11.13%	100.00%

Scenario 1 – Renewables/Storage Addition, Coal Retirement Perfect Capacity MRI Split Observations

- After retiring coal resources, LOL events last longer in the winter
- Longer LOL events imply more LOLHs and more RAA MRI hours
- Conclusion: Relative to scenario 3, RAA MRI hours shift toward the winter

	Scenario 3		Scenario 1	
	Summer	Winter	Summer	Winter
LOLE	85.1%	14.9%	80.4%	19.6%
LOLH	81.2%	18.8%	74.6%	25.4%
EUE	83.1%	16.9%	76.2%	23.8%
Perfect capacity MRI	71.0%	29.0%	63.3%	36.7%

LOLH Heat Map – Scenario 1

Hour of Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	0.08%	<0.005%	-	-	-	-	-	-	-	-	-	<0.005%	0.09%
2	0.05%	-	-	-	-	-	-	-	-	-	-	<0.005%	0.05%
3	0.02%	-	-	-	-	-	-	-	-	-	-	-	0.02%
4	0.01%	-	-	-	-	-	-	-	-	-	-	<0.005%	0.01%
5	0.03%	-	-	-	-	-	-	-	-	-	-	<0.005%	0.03%
6	0.04%	-	-	-	-	-	-	-	-	-	-	<0.005%	0.04%
7	0.08%	<0.005%	-	-	-	-	-	-	-	-	-	<0.005%	0.08%
8	0.30%	<0.005%	-	-	-	-	-	-	-	-	-	<0.005%	0.31%
9	0.45%	<0.005%	-	-	-	-	-	-	-	-	-	0.01%	0.46%
10	0.51%	<0.005%	-	-	-	-	-	-	-	-	-	0.01%	0.52%
11	0.45%	<0.005%	-	-	-	-	-	-	-	-	-	0.02%	0.48%
12	0.36%	<0.005%	-	-	-	<0.005%	-	-	-	-	-	0.03%	0.39%
13	0.24%	-	-	-	-	0.06%	-	<0.005%	-	-	-	0.04%	0.34%
14	0.26%	-	-	-	-	0.44%	<0.005%	0.02%	-	-	-	0.06%	0.78%
15	0.31%	-	-	-	-	1.19%	<0.005%	0.23%	-	-	-	0.12%	1.85%
16	0.39%	-	-	-	-	2.02%	0.01%	1.20%	-	-	-	0.24%	3.84%
17	0.61%	-	-	-	-	3.40%	0.04%	3.50%	<0.005%	-	-	0.66%	8.21%
18	1.46%	-	-	-	-	6.07%	0.17%	8.48%	<0.005%	-	-	1.67%	17.86%
19	1.55%	<0.005%	-	-	-	7.13%	0.17%	8.77%	<0.005%	-	-	1.79%	19.41%
20	1.99%	<0.005%	-	-	-	7.00%	0.11%	9.04%	<0.005%	-	-	2.04%	20.18%
21	1.86%	<0.005%	-	-	-	5.19%	0.05%	6.16%	<0.005%	-	-	2.04%	15.30%
22	1.70%	<0.005%	-	-	-	2.65%	<0.005%	1.50%	-	-	-	1.52%	7.37%
23	0.96%	<0.005%	-	-	-	0.02%	-	0.01%	-	-	-	0.76%	1.75%
24	0.53%	<0.005%	-	-	-	-	-	-	-	-	-	0.10%	0.63%
Monthly	14.25%	<0.005%	-	-	-	35.17%	0.55%	38.89%	<0.005%	-	-	11.13%	100.00%

Scenario 2 – Renewables/Storage Addition, Oil-only Retirement LOLE Split Observations

- Oil-only resources are modeled as fuel-constrained in the winter
- Compared to scenario 1, scenario 2 can be thought of as retiring proportionally more summer capacity than winter capacity
- Conclusion: Relative to scenario 1, LOLE shifts toward the summer

	Scenario 1		Scenario 2	
	Summer	Winter	Summer	Winter
LOLE	80.4%	19.6%	95.0%	5.0%
LOLH	74.6%	25.4%	93.1%	6.9%
EUE	76.2%	23.8%	93.6%	6.4%
Perfect capacity MRI	63.3%	36.7%	88.5%	11.5%

LOLH Heat Map – Scenario 2

Hour of Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	0.01%	-	-	-	-	-	-	-	-	-	-	<0.005%	0.01%
2	<0.005%	-	-	-	-	-	-	-	-	-	-	-	<0.005%
3	<0.005%	-	-	-	-	-	-	-	-	-	-	-	<0.005%
4	<0.005%	-	-	-	-	-	-	-	-	-	-	-	<0.005%
5	<0.005%	-	-	-	-	-	-	-	-	-	-	<0.005%	<0.005%
6	<0.005%	-	-	-	-	-	-	-	-	-	-	<0.005%	<0.005%
7	<0.005%	-	-	-	-	-	-	-	-	-	-	<0.005%	<0.005%
8	0.06%	-	-	-	-	-	-	-	-	-	-	<0.005%	0.06%
9	0.09%	-	-	-	-	-	-	-	-	-	-	<0.005%	0.09%
10	0.08%	-	-	-	-	-	-	-	-	-	-	<0.005%	0.08%
11	0.07%	-	-	-	-	-	-	-	-	-	-	<0.005%	0.07%
12	0.06%	-	-	-	-	<0.005%	-	-	-	-	-	0.01%	0.06%
13	0.03%	-	-	-	-	0.01%	-	-	-	-	-	0.01%	0.05%
14	0.04%	-	-	-	-	0.17%	<0.005%	<0.005%	-	-	-	0.02%	0.22%
15	0.04%	-	-	-	-	0.55%	<0.005%	0.04%	-	-	-	0.03%	0.67%
16	0.05%	-	-	-	-	1.14%	<0.005%	0.45%	-	-	-	0.07%	1.72%
17	0.09%	-	-	-	-	2.36%	0.04%	2.56%	<0.005%	-	-	0.21%	5.26%
18	0.27%	-	-	-	-	5.81%	0.27%	9.93%	0.01%	-	-	0.52%	16.80%
19	0.31%	-	-	-	-	7.97%	0.36%	13.10%	0.01%	-	-	0.57%	22.31%
20	0.38%	-	-	-	-	8.36%	0.28%	13.32%	0.01%	-	-	0.63%	22.98%
21	0.40%	-	-	-	-	7.16%	0.17%	9.91%	<0.005%	-	-	0.73%	18.38%
22	0.43%	-	-	-	-	4.93%	0.06%	3.76%	<0.005%	-	-	0.67%	9.84%
23	0.29%	-	-	-	-	0.25%	-	0.09%	-	-	-	0.47%	1.09%
24	0.17%	-	-	-	-	-	-	-	-	-	-	0.12%	0.29%
Monthly	2.87%	-	-	-	-	38.71%	1.17%	53.16%	0.03%	-	-	4.06%	100.00%

Scenario 2 – Renewables/Storage Addition, Oil-only Retirement Perfect Capacity MRI Split Observations

- A smaller percentage of LOLE in the winter implies a smaller percentage of RAA MRI hours in the winter, all else being equal
- Conclusion: Relative to scenario 1, RAA MRI hours shift toward the summer

	Scenario 1		Scenario 2	
	Summer	Winter	Summer	Winter
LOLE	80.4%	19.6%	95.0%	5.0%
LOLH	74.6%	25.4%	93.1%	6.9%
EUE	76.2%	23.8%	93.6%	6.4%
Perfect capacity MRI	63.3%	36.7%	88.5%	11.5%

LOLH Heat Map – Scenario 2

Hour of Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	0.01%	-	-	-	-	-	-	-	-	-	-	<0.005%	0.01%
2	<0.005%	-	-	-	-	-	-	-	-	-	-	-	<0.005%
3	<0.005%	-	-	-	-	-	-	-	-	-	-	-	<0.005%
4	<0.005%	-	-	-	-	-	-	-	-	-	-	-	<0.005%
5	<0.005%	-	-	-	-	-	-	-	-	-	-	<0.005%	<0.005%
6	<0.005%	-	-	-	-	-	-	-	-	-	-	<0.005%	<0.005%
7	<0.005%	-	-	-	-	-	-	-	-	-	-	<0.005%	<0.005%
8	0.06%	-	-	-	-	-	-	-	-	-	-	<0.005%	0.06%
9	0.09%	-	-	-	-	-	-	-	-	-	-	<0.005%	0.09%
10	0.08%	-	-	-	-	-	-	-	-	-	-	<0.005%	0.08%
11	0.07%	-	-	-	-	-	-	-	-	-	-	<0.005%	0.07%
12	0.06%	-	-	-	-	<0.005%	-	-	-	-	-	0.01%	0.06%
13	0.03%	-	-	-	-	0.01%	-	-	-	-	-	0.01%	0.05%
14	0.04%	-	-	-	-	0.17%	<0.005%	<0.005%	-	-	-	0.02%	0.22%
15	0.04%	-	-	-	-	0.55%	<0.005%	0.04%	-	-	-	0.03%	0.67%
16	0.05%	-	-	-	-	1.14%	<0.005%	0.45%	-	-	-	0.07%	1.72%
17	0.09%	-	-	-	-	2.36%	0.04%	2.56%	<0.005%	-	-	0.21%	5.26%
18	0.27%	-	-	-	-	5.81%	0.27%	9.93%	0.01%	-	-	0.52%	16.80%
19	0.31%	-	-	-	-	7.97%	0.36%	13.10%	0.01%	-	-	0.57%	22.31%
20	0.38%	-	-	-	-	8.36%	0.28%	13.32%	0.01%	-	-	0.63%	22.98%
21	0.40%	-	-	-	-	7.16%	0.17%	9.91%	<0.005%	-	-	0.73%	18.38%
22	0.43%	-	-	-	-	4.93%	0.06%	3.76%	<0.005%	-	-	0.67%	9.84%
23	0.29%	-	-	-	-	0.25%	-	0.09%	-	-	-	0.47%	1.09%
24	0.17%	-	-	-	-	-	-	-	-	-	-	0.12%	0.29%
Monthly	2.87%	-	-	-	-	38.71%	1.17%	53.16%	0.03%	-	-	4.06%	100.00%

Key Takeaways

- Seasonal risk splits are consistent with expectations
  - Adding renewables/storage changes RAA MRI hours in the summer and RAA MRI hours and LOL days in the winter
  - The seasonal output characteristics of retiring and new resources are important to the seasonal risk split