Winter Resource Adequacy

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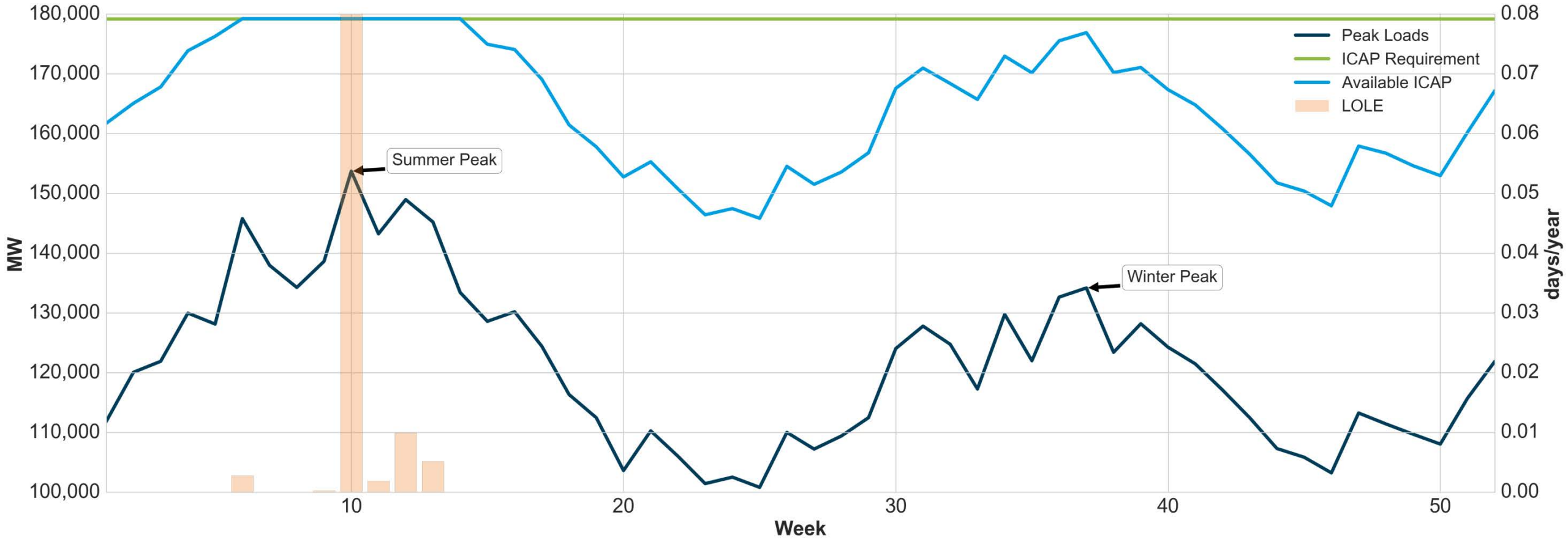
Introduction

- Resource Adequacy at PJM
  - Two main Loss of Load Expectation (LOLE) studies
    - Reserve Requirement Study (RRS) or Installed Reserve Margin (IRM) Study
    - Capacity Emergency Transfer Objective (CETO) Study
  - Both studies calculate annual LOLE to meet a defined criteria using a software called PRISM
    - RRS: 0.1 day/year (or 1 day in 10 years)
    - CETO: 0.04 days/year (or 1 day in 25 years)

LOLE Studies

- Some key assumptions
  - LOLE is calculated weekly. LOLE is then summed across the 52 weeks in a delivery year.
  - Load uncertainty is modeled using 52 normal distributions whose means and standard deviations are calculated using historical loads.
  - Capacity uncertainty is modeled using,
    - Available capacity distributions for each generator based on EFORd values. These distributions are then summed assuming that generators' forced outages are random and **independent** of each other.
    - **Perfect load foresight** in scheduling planned outages.

LOLE Studies – RTO Weekly Values

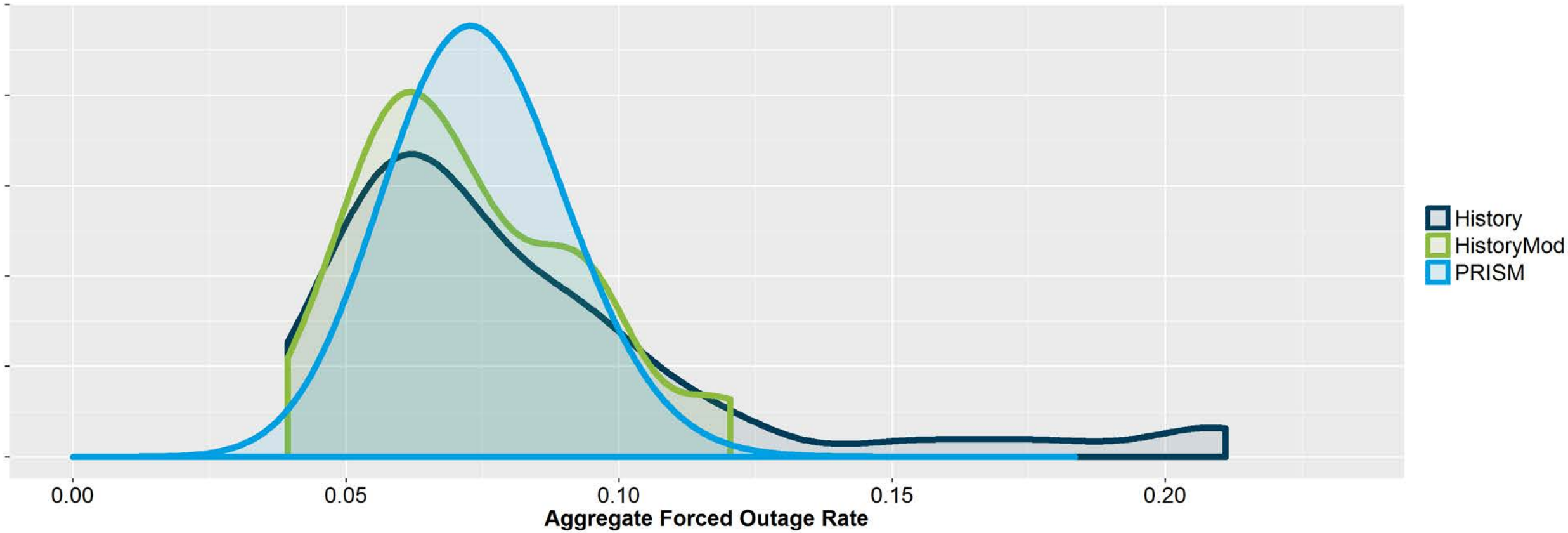


Winter Resource Adequacy and Capacity Requirements - Problem Statement

- Available at http://www.pjm.com/~/media/committees-groups/committees/mrc/20161117/20161117-item-09-winter-reliability-requirement-ps-ic-clean.ashx
- Approved by MRC in November 2016
- Key Work Activities in Issue Charge:
  - Winter peak load forecasting (to be completed)
  - Winter season resource adequacy
  - Winter season reliability requirements

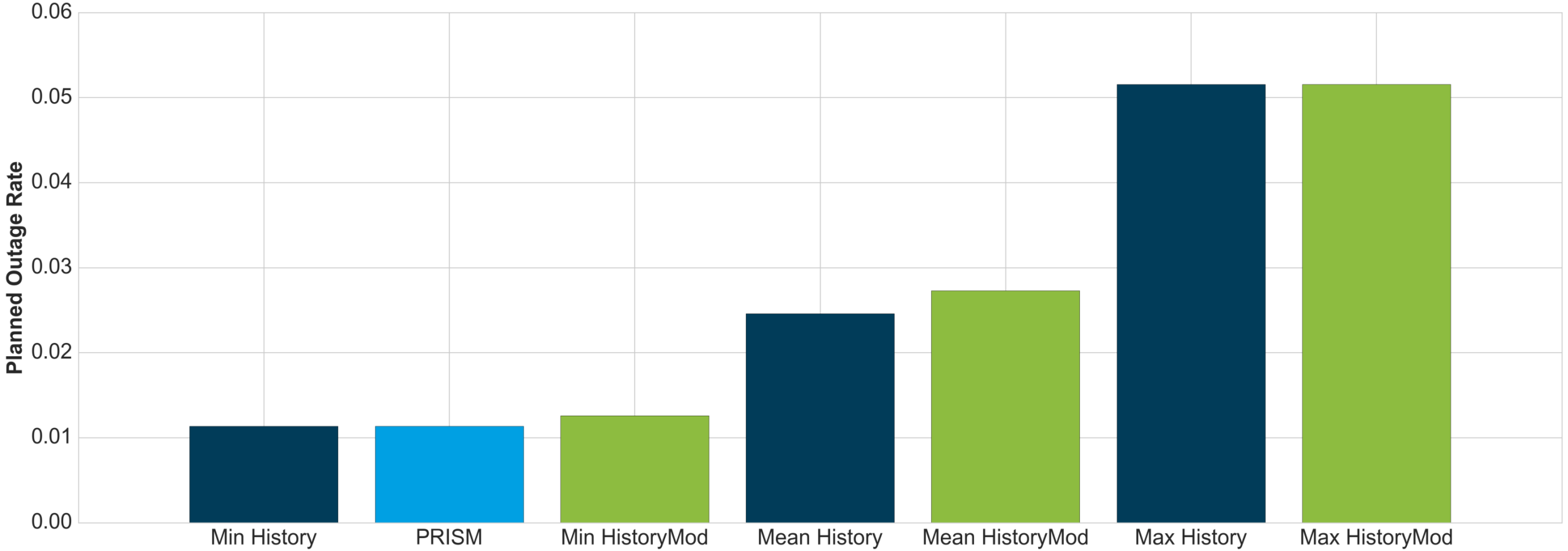
- At the winter peak, are forced outages independent of each other?
  - PRISM assumes forced outages are independent
  - To investigate assumption, historical aggregate forced outages data during past winter peaks was collected
    - History: 9-yr period (DY07-DY15) data totaling 45 observations (5 weekdays in each of the 9 winter peak weeks)
    - HistoryMod: identical to History but 5 observations from Winter 14/15 (first polar vortex) are removed and replaced with 5 observations from Winter 15/16 (second polar vortex)

- RTO Aggregate Forced Outages at Winter Peak - Density/Frequency plot



- At the winter peak, what amount of planned outages should be scheduled?
  - PRISM assumes perfect foresight of peak loads and schedules around 1.1% of the total ICAP on planned outage during the winter peak.
  - To investigate the accuracy of this value, historical aggregate planned outages data during past winter peaks was collected
    - History: 9-yr period (DY07-DY15) data totaling 45 observations (5 weekdays in each of the 9 winter peak weeks)
    - HistoryMod: identical to History but 5 observations from Winter 14/15 (first polar vortex) are removed and replaced with 5 observations from Winter 15/16 (second polar vortex)

- RTO Aggregate Planned Outages at Winter Peak



- Scenario Development
  - Empirical Aggregate Forced Outages Distributions at Winter Peak
    - History (both polar vortices, 2014 and 2015, are included)
    - HistoryMod (2014 polar vortex excluded)
  - Amount of Planned Outages scheduled at Winter Peak
    - PRISM
    - History
    - HistoryMod
    - Zero

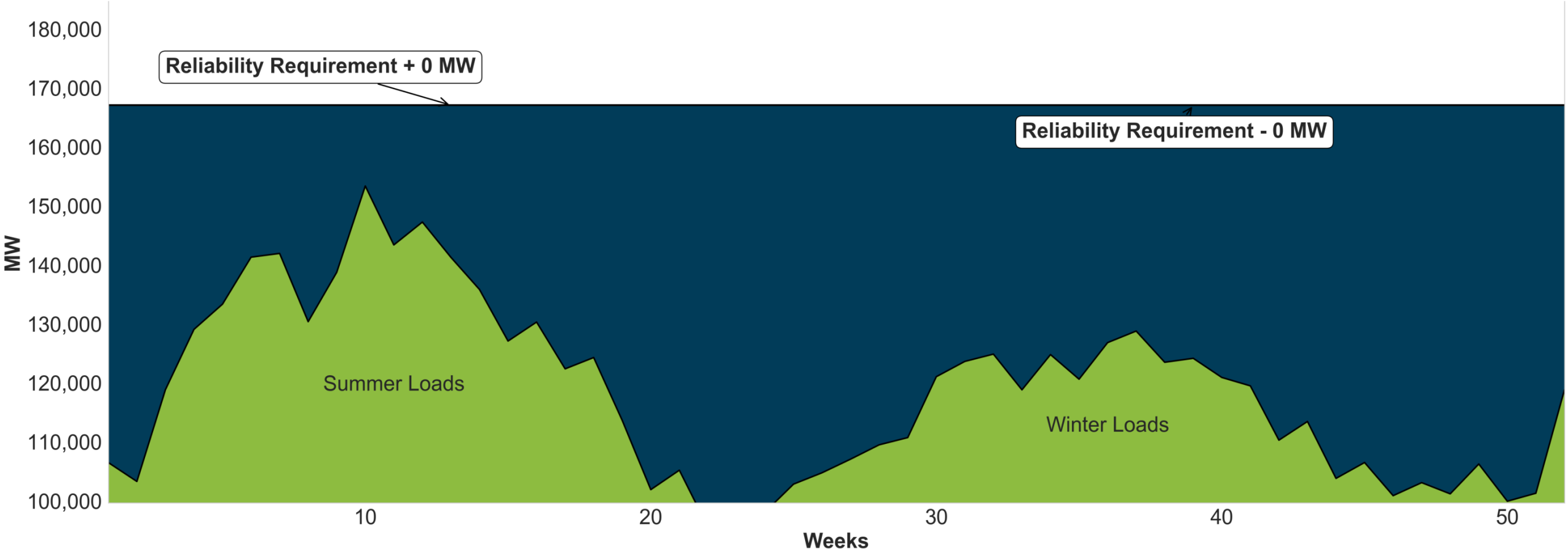
- Scenario Development

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 2A	Scenario 3A	Scenario 4A	Scenario 5A
Forced Outages Winter Peak	PRISM	History	History	History	History	HistoryMod	HistoryMod	HistoryMod	HistoryMod
Planned Outages Winter Peak	PRISM	PRISM	Mean History	Max History	Zero	PRISM	Mean History	Max History	Zero

- LOLE Allocation
  - Requested in problem statement / issue charge
  - From an LOLE perspective, it is a mathematical exercise (which does not account for any practical market considerations)
  - Winter is defined as a 6-month period from November - April

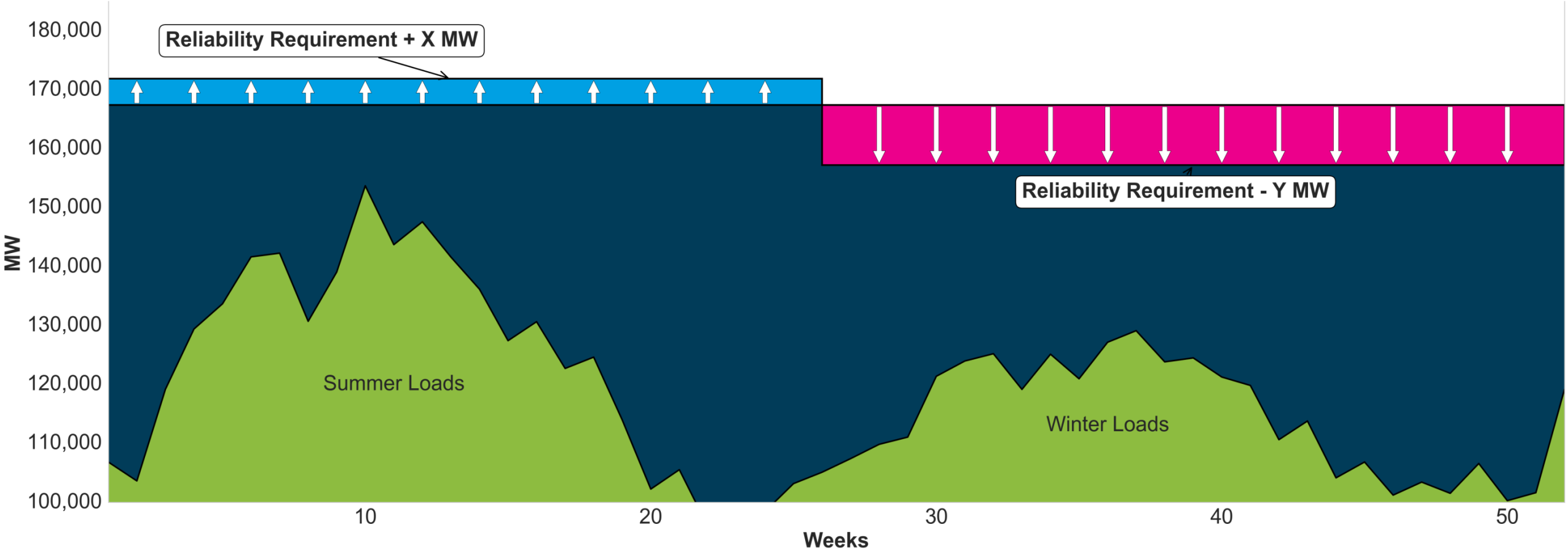
Summer LOLE Share (%)	Winter LOLE Share (%)	Summer LOLE (days/year)	Winter LOLE (days/year)	Total Annual LOLE (days/year)
100	0	0.1	0.0001	0.1001
90	10	0.09	0.01	0.1
80	20	0.08	0.02	0.1
70	30	0.07	0.03	0.1

Capacity Performance



LOLE Allocation

Our task, as defined by the Problem Statement, was to determine the values of X and Y below.



Results

- Based on 2020 BRA
- Only shown for Scenarios 2A, 3A, 4A, 5A (rest of scenarios available in RAAS slides)
- Only shown at RTO level (LDA results available in RAAS slides)
  - In RPM, RTO values represent the ultimate constraint
    - A statement such as “the winter reliability requirement of an LDA can decrease by 9,000 MW while the winter reliability requirement of the RTO can decrease by 5,000 MW” does not make practical sense.
- A zero in a “Change in Winter RelReq” column means that the Winter reliability requirement cannot be decreased (because if it is decreased the Summer LOLE plus Winter LOLE violates the LOLE criterion)

RTO Results 100/0 LOLE Allocation

Scenario 2A		Scenario 3A		Scenario 4A		Scenario 5A	
Change in Summer RelReq	Change in Winter RelReq	Change in Summer RelReq	Change in Winter RelReq	Change in Summer RelReq	Change in Winter RelReq	Change in Summer RelReq	Change in Winter RelReq
0	-1,674	0	0	0	0	0	-3,472

Note: Based on RTO UCAP requirement of 167,393 MW. All units are in UCAP

Scenario Definition Cheat Sheet:

	Scenario 2A	Scenario 3A	Scenario 4A	Scenario 5A
Forced Outages Winter Peak	HistoryMod	HistoryMod	HistoryMod	HistoryMod
Planned Outages Winter Peak	PRISM	Mean History	Max History	Zero

RTO Results 90/10 LOLE Allocation

Scenario 2A		Scenario 3A		Scenario 4A		Scenario 5A	
Change in Summer RelReq	Change in Winter RelReq	Change in Summer RelReq	Change in Winter RelReq	Change in Summer RelReq	Change in Winter RelReq	Change in Summer RelReq	Change in Winter RelReq
+433	-11,980	+433	-9,202	+433	-7,548	+433	-13,538

Note: Based on RTO UCAP requirement of 167,393 MW. All units are in UCAP

Scenario Definition Cheat Sheet:

	Scenario 2A	Scenario 3A	Scenario 4A	Scenario 5A
Forced Outages Winter Peak	HistoryMod	HistoryMod	HistoryMod	HistoryMod
Planned Outages Winter Peak	PRISM	Mean History	Max History	Zero

RTO Results 80/20 LOLE Allocation

Scenario 2A		Scenario 3A		Scenario 4A		Scenario 5A	
Change in Summer RelReq	Change in Winter RelReq	Change in Summer RelReq	Change in Winter RelReq	Change in Summer RelReq	Change in Winter RelReq	Change in Summer RelReq	Change in Winter RelReq
+913	-13,942	+913	-11,798	+913	-9,212	+913	-15,066

Note: Based on RTO UCAP requirement of 167,393 MW. All units are in UCAP

Scenario Definition Cheat Sheet:

	Scenario 2A	Scenario 3A	Scenario 4A	Scenario 5A
Forced Outages Winter Peak	HistoryMod	HistoryMod	HistoryMod	HistoryMod
Planned Outages Winter Peak	PRISM	Mean History	Max History	Zero

RTO Results 70/30 LOLE Allocation

Scenario 2A		Scenario 3A		Scenario 4A		Scenario 5A	
Change in Summer RelReq	Change in Winter RelReq	Change in Summer RelReq	Change in Winter RelReq	Change in Summer RelReq	Change in Winter RelReq	Change in Summer RelReq	Change in Winter RelReq
+1,461	-14,990	+1,461	-12,635	+1,461	-10,461	+1,461	-16,172

Note: Based on RTO UCAP requirement of 167,393 MW. All units are in UCAP

Scenario Definition Cheat Sheet:

	Scenario 2A	Scenario 3A	Scenario 4A	Scenario 5A
Forced Outages Winter Peak	HistoryMod	HistoryMod	HistoryMod	HistoryMod
Planned Outages Winter Peak	PRISM	Mean History	Max History	Zero

- RAAS Presentations
  - http://www.pjm.com/-/media/committees-groups/subcommittees/raas/20170804/20170804-winter-season-resource-adequacy-analysis.ashx
  - http://www.pjm.com/-/media/committees-groups/subcommittees/raas/20170706/20170706-winter-season-resource-adequacy-analysis.ashx