Generator Deliverability Test Modifications: Light Load & Winter

PJM©2021

- Consider the evolving resource mix in PJM’s planning process
- Support operational flexibility
- Incorporate other miscellaneous improvements to the existing light load and winter generator deliverability tests

PJM©2021

- PJM will be proposing modifications to each of the generator deliverability tests starting with the light load and winter generator deliverability procedures.
  - Procedures have been relatively unchanged for many years.
  - Multiple reasons for an update including a need better account for expected higher variability in dispatches under increased renewable penetration.
- Efforts to improve voltage testing to better account for operational concerns to be incorporated in separate, future efforts.

PJM©2021

Light Load – Review of Existing Procedure

- Load level
  - 50% of annual peak
  - Representative of November through April 12AM-5AM
- Base case dispatch: Historic capacity factors by resource type
- Interchange:
  - Historical values from/to each external zone connected to PJM
  - Historical values inside PJM
- MISO wind: 100% output
- Generator ramping procedure: Wind units inside PJM ramp from 40 to 80% output based on electrical proximity to flowgate under study and all remaining online units are scaled down uniformly to compensate.

PJM©2021

Light Load – Review of Existing Procedure

Network Model	Current year + 5 base case
Load Model	Light Load (50% of 50/50 summer peak)
Capacity Factor for Base Generation Dispatch for PJM Resources (Online in Base Case)	Nuclear – 100% Coal >= 500 MW – 60% Coal < 500 MW – 45% Oil – 0% Natural Gas – 0% Wind – 40% All other resources – 0% Pumped Storage – full pump
Capacity Factor for Base Generation Dispatch for MISO Resources (Online in Base Case)	Wind – 100%
Interchange Values	Historical values
Contingencies	NERC P0, P1, P2, P4, P5 and P7
Monitored Facilities	All PJM market monitored facilities

Exhibit 5: Table 1 – Light Load Base Case Initial Target Dispatch

Table 2 – Light Load Study Generation Ramping Limits

Fuel Type	Ramping Limits (% of Pmax)
Nuclear	100%
Wind	80%
Coal >=500 MW	60%
Coal < 500 MW	45%
All other resources	0% (not ramped)

PJM©2021

Winter – Review of Existing Procedure

- Load level
  - Representative of December through February 5AM-9AM & 4PM-8PM
- Base case dispatch: Historic capacity factors by resource type
- Interchange:
  - Firm from/to each external zone connected to PJM
  - Historical values inside PJM
- MISO wind: From MMWG case
- Generator ramping procedure: Based on proximity to flowgate, and all remaining online units are scaled down uniformly to compensate
  - Wind units ramp from 33 to 80%
  - Solar ramp from 5 up to 10%
  - All other units ramp up to 100%

PJM©2021

Winter – Review of Existing Procedure

Network Model	Current year + 5 base case
Capacity Factor for Base Generation Dispatch for PJM Resources (Online in Base Case)	Solar – 5% Wind – 33% Water – 38% Nuclear – 98% Coal < 500 MW – 51% Coal >= 500 MW – 73% Landfill Gas – 46% Natural Gas – 25% Other Biomass Gas – 111% Oil (Distillate Fuel)– 1% Oil (Black Liquor)– 74% Oil (Kerosene)– 0% Oil (Residual Fuel)– 2% Municipal Solid Waste – 79% Wood Waste – 66% Waste Coal – 75% Petroleum Coke – 75% Other Solid – 19%
Interchange Values	Yearly long term firm (LTF) transmission service (except MAAC which will use historical averages)
Contingencies	NERC Category P0, P1, P2, P3, P4, P5, P6, and P7
Monitored Facilities	All PJM market monitored facilities

Exhibit 6: Table 1 – Winter Peak Base Case Initial Target Dispatch

Table 2 – Winter Peak Study Generation Ramping Limits

Fuel Type	Ramping Limits (% of Pmax)
Solar	10%
Wind	80%
All other resources	100%

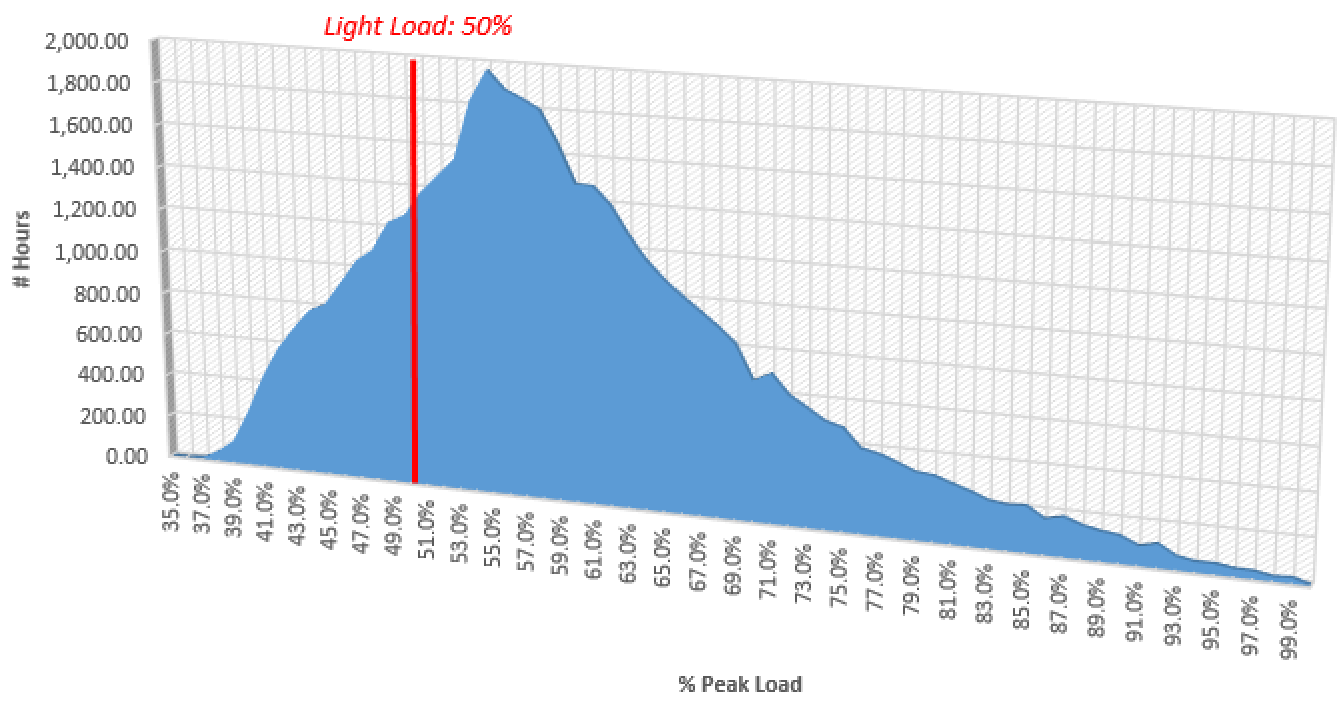
PJM©2021

- **Load Level**
  - Proposal
    - Winter: No change
    - Light load
      - Keep 50% of annual peak
      - Use load hours between 40% and 60% of the annual peak for historical generation data necessary to represent the 50% load level
  - Justification for change
    - Want to consider both daytime and nighttime hours
    - Also considered using minimum load level but that is extremely rare condition compared to 50% of peak which is a load level much closer to the range of load levels that occurs most frequently in PJM

PJM©2021

Light Load – Proposed Modifications

Frequency Of RTO Load As a % of Peak
5/1/2016 - 4/30/2021



PJM©2021

- **Ratings**
  - Proposal
    - Winter: No change
    - Light load: Use temperature adjusted ratings for light load period, e.g. over the past year 59 deg F was the average temperature across PJM during the proposed light load hours
  - Justification for change
    - Currently use summer ratings, e.g. 95 deg F, for light load which is too conservative

PJM©2021

Light Load & Winter – Proposed Modifications

- **Base Case Dispatch**
  - Proposal #1: Use Block Dispatch. <u>The following approach is under review</u>.
    - Block 1: Nuclear, wind, solar, hydro, pumped storage
      - Nuclear at PMAX * (1 – PJM EEFORd)
      - Pumped storage at historic capacity factor in light load and PMAX * (1 – PJM EEFORd) in winter
      - Wind, solar and hydro at historic capacity factors
    - Block 2: Coal, combined cycle gas
      - Turn on all units and scale up uniformly to meet system needs up to PMAX * (1 – EEFORd)
    - Block 3: IC/CT/ST oil and gas
      - Turn on all units and scale up uniformly to meet system needs up to PMAX * (1 – EEFORd)
  - Justification for change
    - Adopt a simplified dispatch that seeks to simulate economic conditions
    - Appears to match well with historical regional dispatch patterns
    - Status quo relies only on historic capacity factors and therefore can't keep up with rapidly evolving resource mix

PJM©2021

Light Load & Winter – Proposed Modifications

- **External Interchange**
  - Proposal
    - Maintain firm interchange in base case
    - Examine variations in interchange transactions based on historical transactions.
      - Light load: Include directly in generator deliverability testing (similar to status quo)
      - Winter: Test on base case for common mode outages only (new)
    - Consider condensing external systems outside PJM into three regions, e.g. North, West and South similar to PJM CIL Study external supply regions.
  - Justification for change
    - Status quo light load approach applies historical tie line flow to individual zones bordering PJM directly in the base case.
      - Does not properly account for the external source/sink of the transaction and loop flow.
      - By not including this tie flow directly in the base case, this proposed change will not allow historical non-firm transactions to relieve future planning problems.
    - No consideration is currently made for variations in PJM interchange under common mode outages in winter studies.
    - Condensing multiple external border regions to three large external regions is sufficient to capture a broad range of historical transactions for sensitivity analysis in planning studies.

PJM©2021

- **Internal Interchange**
  - Proposal
    - #1: Do not hold internal interchange between PJM regions at historical levels and instead allow the block dispatch approach to dictate the PJM light load internal interchange.
    - #2: Will likely require procedure to ensure no area is exceeding its annual CETO in the base dispatch.
  - Justification for change
    - #1: Using historical internal interchange in a future planning model will not properly account for the rapidly evolving resource mix.
    - #2: Using planning CETO levels has been a common practice in generator deliverability testing to ensure dispatch is not creating emergency conditions.

PJM©2021

Light Load & Winter – Proposed Modifications

- **Generator Ramping**
  - Proposal #1
    - Allow all resource types in Block 1 and Block 2 to ramp up to near maximum expected seasonal net output, e.g. 95th percentile, for the resource type. For winter also allow Block 3 to ramp even if offline in base dispatch.
      - Nuclear, coal, combined cycle units ramp to 100%
      - Wind, solar and hydro ramp to highest expected PJM-wide output levels for the resource type achieved during study period
      - Pumped storage
        - Light Load: ramps to near maximum/minimum expected PJM-wide output levels
        - Winter: ramps to 100% PMAX
      - Batteries ramp to +/-100%
    - Justification for change
      - More closely matches operational reality
      - Improve operational flexibility to support evolving resource mix

PJM©2021

- **Generator Ramping**
  - Proposal #2
    - Have variable resources ramp down on receiving end of a constraint to represent lower than expected PJM-wide output levels during historical light load periods. For example, wind, solar, and hydro on receiving end of a constraint assumed to be at bottom 20th percentile for the resource type achieved during historical light load periods.
  - Justification for change
    - More closely matches a stressed dispatch that would be seen in operations rather than just maintaining average expected outputs on the receiving end of a constraint
    - Improve operational flexibility to support evolving resource mix

PJM©2021

Light Load & Winter – Proposed Modifications

- **Generator Ramping**
  - Proposal #3
    - Instead of modeling Facility Loading Adders at 85% of peak output, model them at the same % output that the resource type is modelled in the base case block dispatch.
      - Facility Loading Adders are offline units electrically just outside of the 50/50 dispatch
  - Justification for change
    - The use of the 85% level to model Facility Loading Adders was a legacy number carried over from the original summer peak generator deliverability test and is inappropriate for light load and winter where units are modelled at various output levels based on their resource type.

PJM©2021

Light Load & Winter – Proposed Modifications

- **Generator Ramping**
  - Proposal #4
    - 4a: Assign wind and solar units an EEFORd
      - Use PJM average EEFORd until NERC starts reporting this metric
    - 4b: Do not assign generators < 50 MW an EEFORd
  - Justification for change
    - 4a: Currently wind and solar units have a 0 EEFORd and therefore are assumed to have unlimited availability.
    - 4b: With the proliferation of smaller units, larger units are often not being ramped to full output.

PJM©2021

- **Generator Ramping**
  - Proposal #5
    - Instead of capping ramping to online PMAX * PJM Avg EEFORd (status quo approach), cap it at online PGEN * PJM Avg EEFORd.
      - PMAX is the maximum MW output of a generator
      - PGEN is the actual MW output of a generator
  - Justification for change
    - This metric attempts to restrict the ramping supply to an amount that may realistically be needed during the period under study. Using PMAX does not make sense when many of the units are dispatched well below that level.

PJM©2021

- **Generator Ramping**
  - Proposal #6: Establish same procedures for single and common mode analysis
    - 6a: Instead of using 80/20 for single contingency ramping and 50/50 for common mode ramping use 50/50 for both.
    - 6b: Ramp generators to same output levels for both tests.
  - Justification for change
    - 6a: With declining EEFORds the number of generators in the 80/20 excluding wind and solar now averages around 28, whereas the number of generators in the 50/50 averages around 12. With removal of EEFORd for units less than 50 MW dispatches will be more concentrated with higher MW machines.
    - 6b: Change will allow the removal of operational contingencies and greatly simplify analysis.

PJM©2021

Light Load & Winter – Proposed Modifications

- **Generator Ramping**
  - Proposal #7: Establish local deliverability for each Capacity Resource
    - Make sure each Capacity Resource can individually be ramped to it's Maximum Facility Output in the base case under contingency conditions.
  - Justification for change
    - While large numbers of variable resources will not to be simultaneously tested at 100% MFO because of the negligible likelihood of such an occurrence, individual variable resources are much more likely to achieve such levels and should therefore individually be turned on at full output in the base case to ensure their MFO is deliverable.

PJM©2021

- **MISO Wind**
  - Proposal
    - Do not modify MISO wind dispatch in base case, but instead use generator deliverability tool to ramp MISO wind to same value as PJM wind is ramped
    - Sink MISO wind to the northern part of MISO since MISO does not perform a centralized dispatch and most of the wind is located in the North
  - Justification for change
    - Allows testing over a range of expected and extreme MISO wind levels

PJM©2021

Next Steps

- Discuss preliminary results on RTEP baseline
- Finalize proposal assumptions
- Conduct additional analysis with final assumptions
- Update Manual 14B
- Bring to PC for first read

PJM©2021

Contact

SME / Presenter:

Jonathan Kern,

jonathan.kern@pjm.com

Generator Deliverability Test Modifications: Light Load & Winter

Member Hotline

(610) 666 – 8980

(866) 400 – 8980

custsvc@pjm.com

Appendix

Average RTO Output (2016-2020)

Resource Type / Period*	Summer	Winter	Light Load
Onshore Wind	16%	39%	33%
Solar Fixed	34%	2%	12%
Solar Tracking	47%	5%	17%
Hydro	36%	48%	36%

RTO Output As % MFO (2016-2020): 99th Percentile

Resource Type / Period*	Summer	Winter	Light Load
Onshore Wind	62%	84%	82%
Solar Fixed	75%	27%	74%
Solar Tracking	93%	50%	92%
Hydro	66%	70%	67%

RTO Output As % MFO (2016-2020): 20th Percentile

Resource Type / Period*	Summer	Winter	Light Load
Onshore Wind	4%	18%	14%
Solar Fixed	3%	0%	0%
Solar Tracking	5%	0%	0%
Hydro	22%	36%	17%

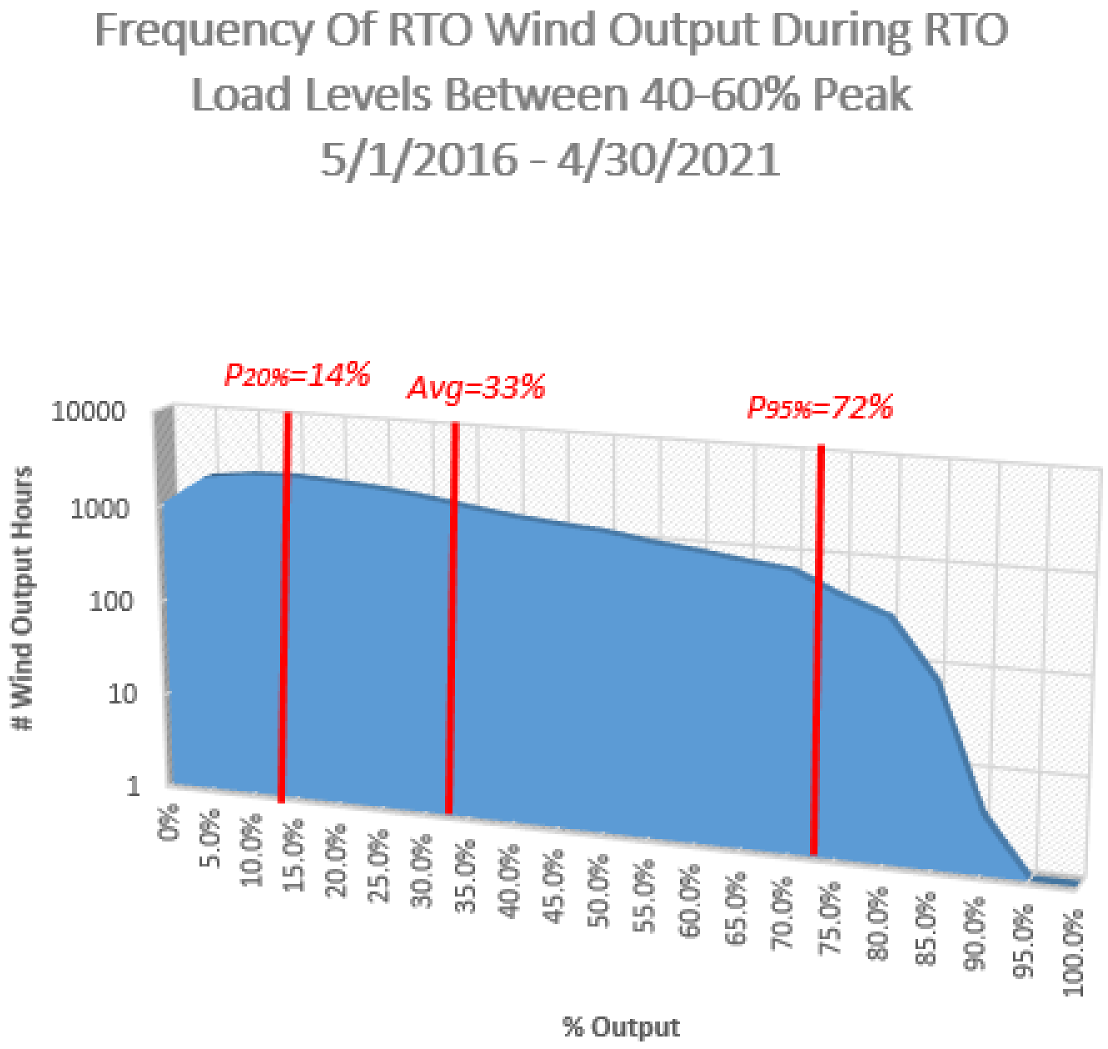
RTO Output As % MFO (2016-2020): 95th Percentile

Resource Type / Period*	Summer	Winter	Light Load
Onshore Wind	46%	77%	72%
Solar Fixed	70%	15%	60%
Solar Tracking	89%	30%	78%
Hydro	61%	67%	64%

***Period Definitions**

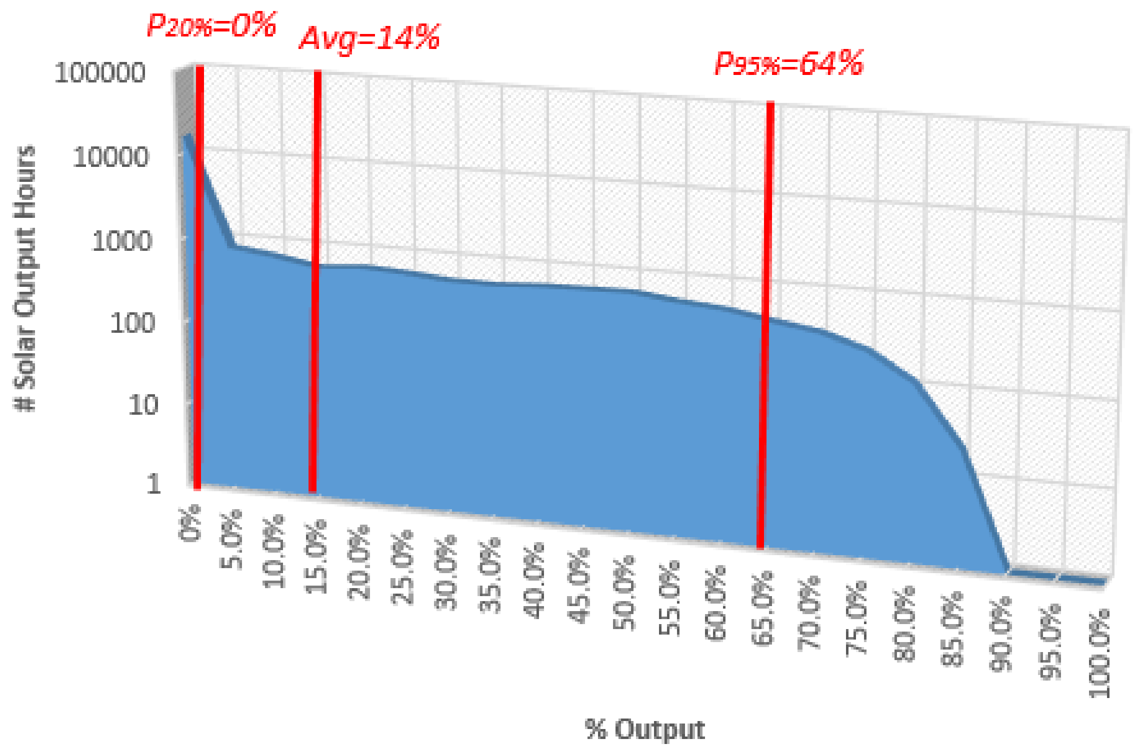
Summer: Jun - Aug 10AM-10PM
Winter: Dec - Feb 5-9AM, 4-8PM
Light Load: Load Hours Between 40-60% Peak

PJM©2021

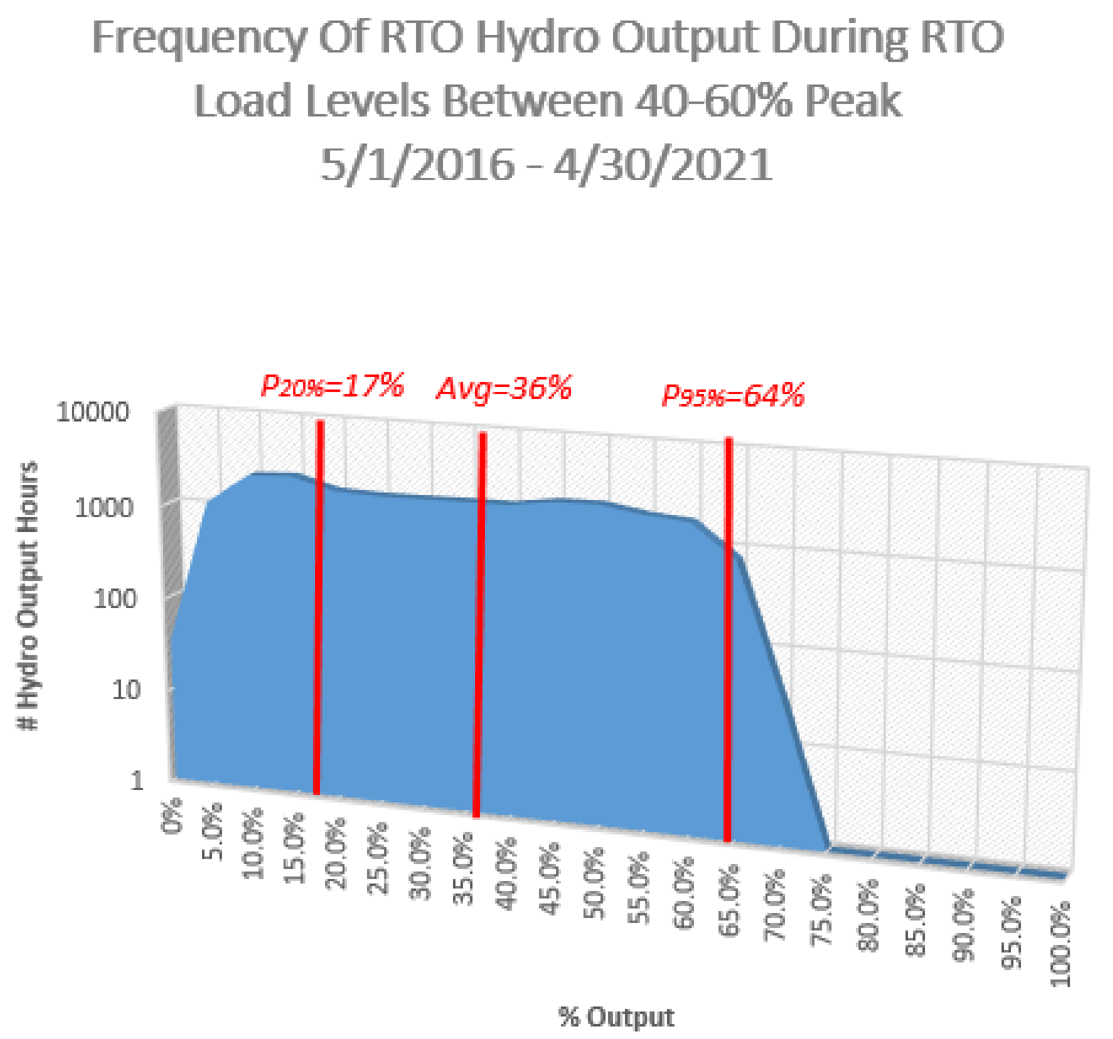


Frequency Of RTO Wind Output During RTO
Load Levels Between 40-60% Peak
5/1/2016 - 4/30/2021
P20%=14%
Avg=33%
P95%=72%
10000
1000
100
10
1
Wind Output Hours
0%
5.0%
10.0%
15.0%
20.0%
25.0%
30.0%
35.0%
40.0%
45.0%
50.0%
55.0%
60.0%
65.0%
70.0%
75.0%
80.0%
85.0%
90.0%
95.0%
100.0%
% Output

Frequency Of RTO Solar Output During RTO Load Levels Between 40-60% Peak 5/1/2016 - 4/30/2021

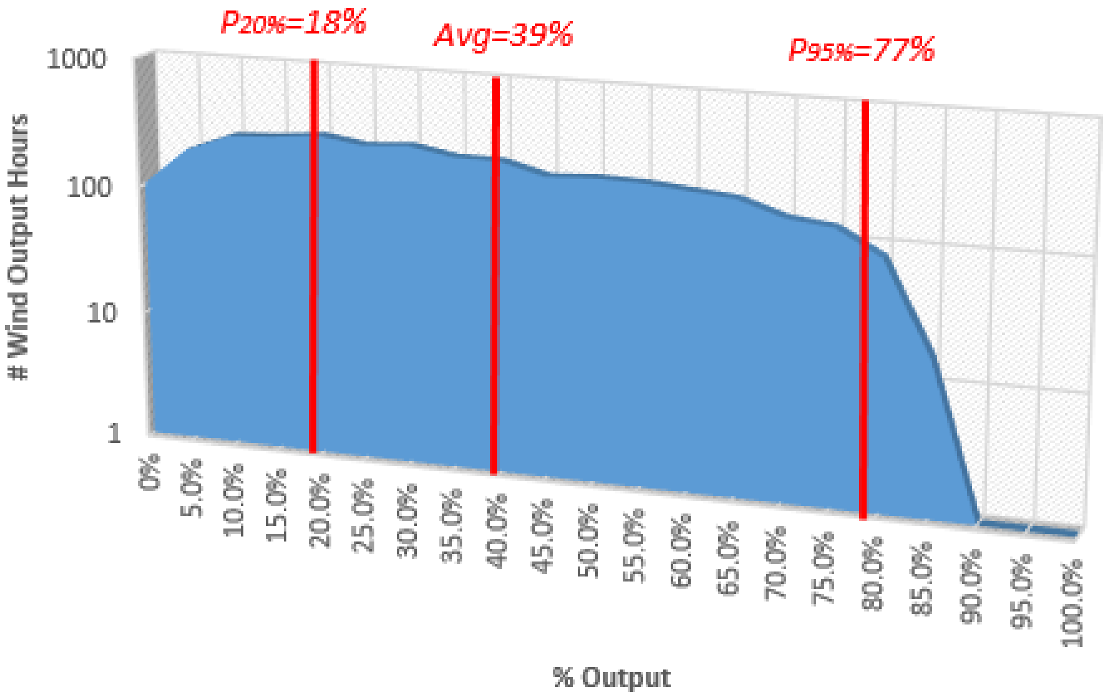


PJM©2021

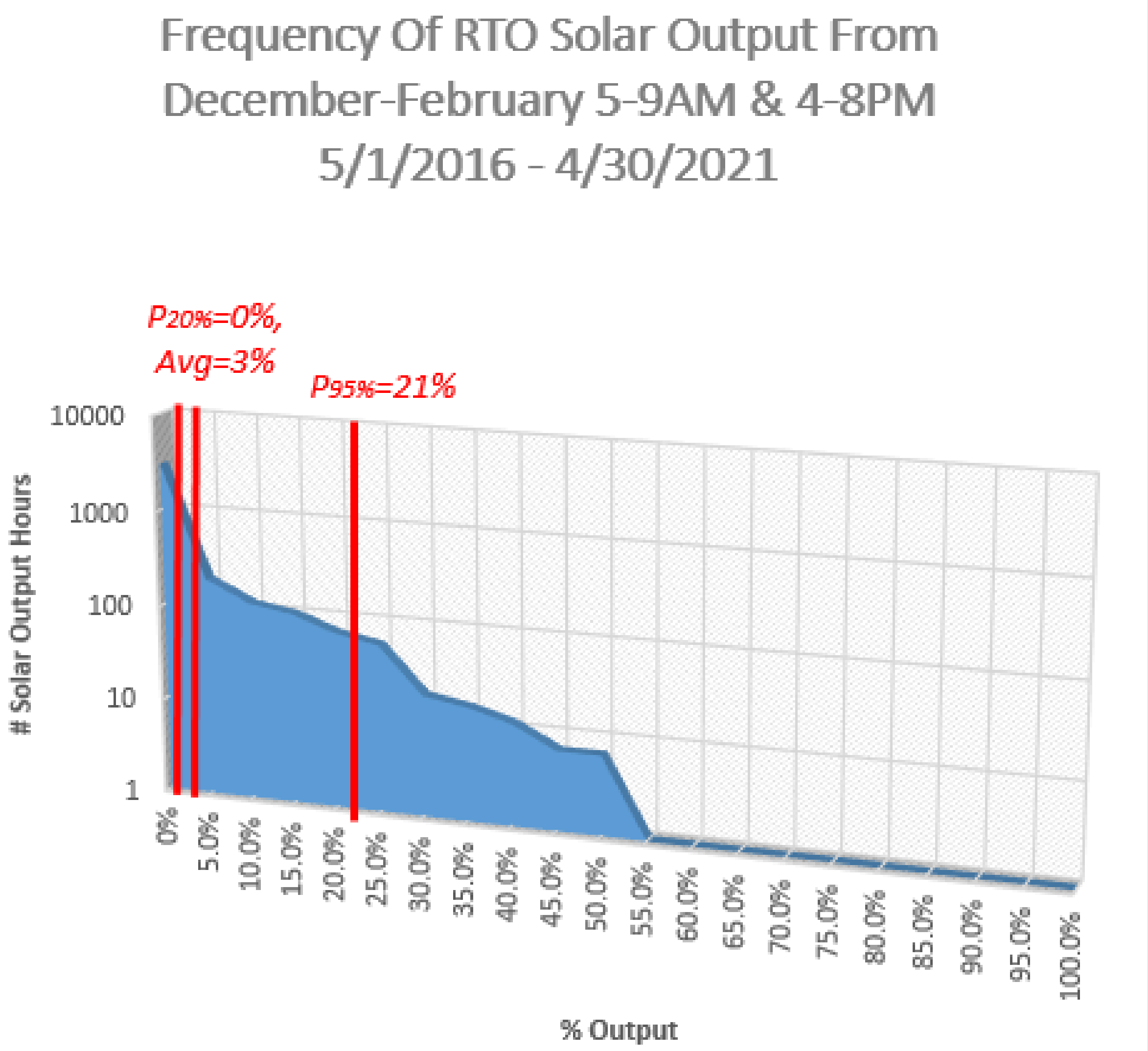

Frequency Of RTO Hydro Output During RTO
Load Levels Between 40-60% Peak
5/1/2016 - 4/30/2021
P20%=17%
Avg=36%
P95%=64%
10000
1000
100
10
1
Hydro Output Hours
0%
5.0%
10.0%
15.0%
20.0%
25.0%
30.0%
35.0%
40.0%
45.0%
50.0%
55.0%
60.0%
65.0%
70.0%
75.0%
80.0%
85.0%
90.0%
95.0%
100.0%
% Output

PJM©2021

Frequency Of RTO Wind Output From December-February 5-9AM & 4-8PM 5/1/2016 - 4/30/2021



PJM©2021



Frequency Of RTO Solar Output From
December-February 5-9AM & 4-8PM
5/1/2016 - 4/30/2021
P20%=0%,
Avg=3%
P95%=21%
10000
1000
100
10
1
Solar Output Hours
0%
5.0%
10.0%
15.0%
20.0%
25.0%
30.0%
35.0%
40.0%
45.0%
50.0%
55.0%
60.0%
65.0%
70.0%
75.0%
80.0%
85.0%
90.0%
95.0%
100.0%
% Output

PJM©2021

Frequency Of RTO Hydro Output From December-February 5-9AM & 4-8PM 5/1/2016 - 4/30/2021