New York ISO
Independent System Operator

Defining and Determining the "Worst Year" by Analyzing Wind and Solar Data

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Project Background

- **Current studies:** Resource Adequacy study models the intermittent resources using 5-years' actual production data.
- **Concern:** the past 5-years' data does not necessarily capture the weather impact on the lower availability of both wind and solar.
- **Improvement:** Using longer horizon of data to identify the year with the lowest production performance.

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Project Background

- **Objectives**
  - Create a methodology to identify poor production years in a longer horizon by analyzing weather-related renewable energy output – solar & wind.
  - Recommend repeatable process for inclusion of poor weather into Resource Adequacy modeling.

- **Core Assumption**
  - Wind and solar output are correlated and are driven by weather. Adding output together and analyzing patterns should yield reasonable representation underlying weather driven performance.

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Data Overview

- **Resources:** NYISO retained DNV Energy USA Inc. (DNV) to develop hourly Land Based Wind (LBW), Offshore Wind and Solar generation profiles of the existing and proposed wind and solar generation projects across New York state (2000-2022). The data is generated by DNV by their modeling and validation of the wind and solar generators.
- Types of Solar Trackers: Fixed Tilt, Single Axis (Rotated)
- Types of Wind Turbines: Class 1, Class 2, Class 3
- 6 Total Combinations of Solar and Wind data.

Table 2-5 IEC 61400 Wind design class

Class	Wind Resource Type	Annual Average Wind Speed Range (at hub height)
1	High wind	10 m/s
2	Medium wind	8.5 m/s
3	Low Wind	7.5 m/s
4	Very low wind	6.0 m/s

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Data Overview

- Hourly normalized production data from 2000-2022 (8760 hours each year) for each generator.
- Capacity for each generator (station) unit is provided.
- 2 generator unit types: 77 Solar Farms,79 Wind Farms (Land-based Wind & Off-shore Wind).

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Definition of “Poor Performance”

- Definition of “Bad Hours”: Production / Capacity <= 10% (5%, 15%).
- Calculate and record the consecutive “Bad Hours” for each generator on a 24h daily base.
  - E.g. Solar Farm 1: 2018 – [8, 4, 4, 12, 7, 12, …]
- Methods: Average Hours vs. Count of Cases.
- Interested in worse cases like hours > 5, hours > 12.
- Show the results in Histograms (distributions).

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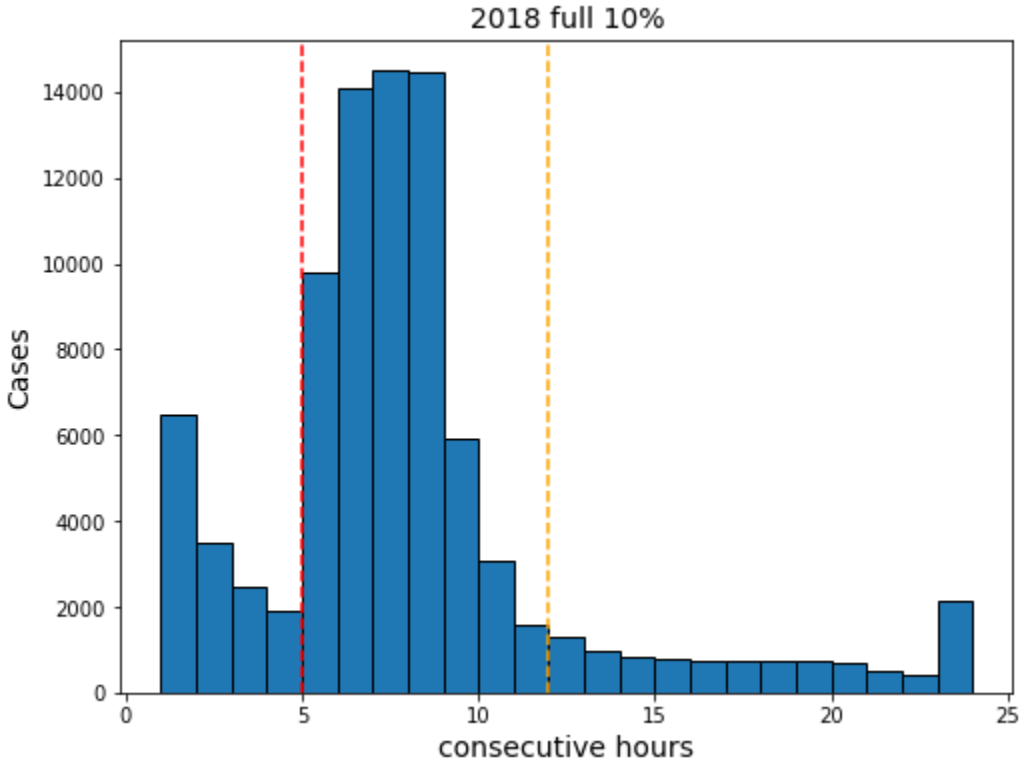
Definition of “Poor Performance”



- Histogram of Consecutive Bad Hours of all the solar & wind farms
- Most of the cases last for 5 – 10 hours
- Red line: 5 hours
- Orange line: 12 hours
- Compare the distribution among 22 years

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Definition of “Poor Performance”

- Separate Daytime & Nighttime based on sunrise & sunset times at different months. Daytime are counted as hours after the latest sunrise and before the first sunset time.
- Daytime: maximum 10 hours. Apply the same algorithm as full day.
- Nighttime: maximum 14 hours. Nighttime across dates are considered as continuous. Only wind data is used.
- Set > 3 hours and > 6 hours to be the threshold for both day and night.

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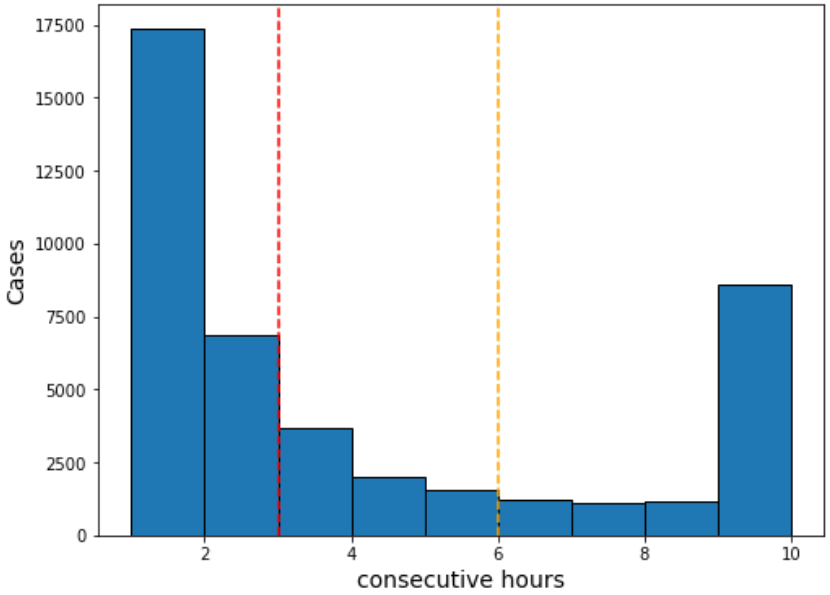
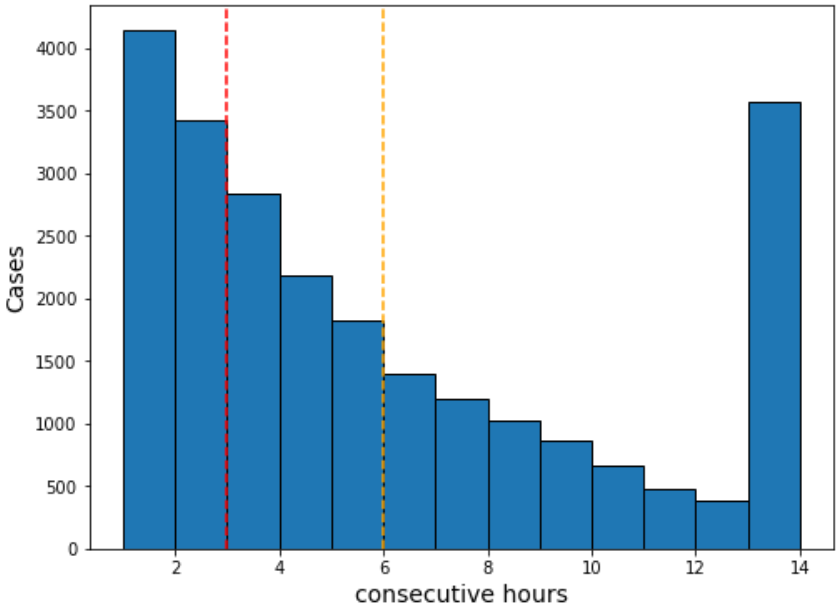
Definition of “Poor Performance”

2018 Daytime 10%



2018 Nighttime 10%



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Analysis Results

year	Average	Count	>5 Average	>5 Count	>12 Average	>12 Count
2000	7.57853	87282	9.157205444	64139	18.68044199	9050
2001	7.47049	87763	9.12504956	63055	18.58291681	9003
2002	7.48124	86362	9.14217979	62217	18.47491166	8490
2003	7.65706	87865	9.248923408	65020	18.84309557	9407
2004	7.66083	87923	9.260215716	64900	18.76913618	9759
2005	7.60216	89139	9.243648943	64753	18.93044273	9848
2006	7.37922	87236	8.999984078	62806	18.65493301	8210
2007	7.52482	87066	9.170032729	62635	18.74452715	9136
2008	7.47148	89323	9.087722815	64852	18.65924102	8933
2009	7.57085	89141	9.201866352	65261	18.58027761	9654
2010	7.40961	86639	9.097409427	61801	18.72686123	8395
2011	7.5296	89502	9.29920348	63903	18.66475316	9581
2012	7.64752	88249	9.332768282	63711	18.72904058	10079
2013	7.50104	87328	9.124258952	63255	18.62127516	8893
2014	7.4464	86662	9.048894747	62972	18.85515421	8333
2015	7.5408	87215	9.122999012	63781	18.65198711	9310
2016	7.61239	87359	9.31611064	62437	18.84716381	9749
2017	7.50323	87099	9.073755465	63819	18.88147123	8673
2018	7.56724	88230	9.203688978	64137	18.5199013	9321
2019	7.55338	87724	9.19410767	63676	18.63579594	9448
2020	7.41138	88373	9.086845425	62617	18.29515012	8660
2021	7.63354	89815	9.264543673	65819	18.9246221	9857
2022	7.54268	87042	9.229703479	62289	18.88890103	9154

- Example data summary of full-day using 10% threshold.
- Find the “worst year” with the highest number at all methods.
- Do the same for day and night data.
- Summary the “worst years” with different methods.
- Repeat the process for all 6 groups of data.

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Analysis Results

year	Average	Count	>5 Average	>5 Count	>12 Average	>12 Count	
Solar1 & Wind1	2004	2021	2012	2021	2005	2012	
Solar1 & Wind2	2004	2021	2016	2021	2021	2012	
Solar1 & Wind3	2003	2021	2011	2021	2021	2012	Full
Solar2 & Wind1	2021	2009	2021	2021	2018	2021	
Solar2 & Wind2	2021	2005	2021	2021	2021	2021	
Solar2 & Wind3	2021	2005	2021	2021	2021	2021	
year	Average	Count	>3 Average	>3 Count	>6 Average	>6 Count	
Solar1 & Wind1	2005	2011	2019	2009	2019	2012	
Solar1 & Wind2	2005	2011	2019	2012	2016	2012	
Solar1 & Wind3	2005	2011	2019	2012	2016	2012	Day
Solar2 & Wind1	2005	2011	2019	2009	2019	2012	
Solar2 & Wind2	2005	2011	2019	2009	2016	2012	
Solar2 & Wind3	2005	2011	2019	2012	2016	2012	
Solar1 & Wind1	2021	2009	2021	2021	2018	2021	
Solar1 & Wind2	2021	2005	2021	2021	2021	2021	
Solar1 & Wind3	2021	2005	2021	2021	2021	2021	Night
Solar2 & Wind1	2021	2009	2021	2021	2018	2021	
Solar2 & Wind2	2021	2005	2021	2021	2021	2021	
Solar2 & Wind3	2021	2005	2021	2021	2021	2021	

- Table of the worst year results for all 6 groups of data in 3 time periods using 6 methods.
- Determine a method which could help identify a consistent ‘worst year’ for all 6 data.
- Full: 2021
- Day: 2005, 2011, 2019, 2012
- Night: 2021

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Analysis Results

- **Findings**
  - 2021 has poor performance for most of the methods at nighttime. 2021 also shows the worst in many case for full day data.
  - 2021 never shows the worst at daytime.
  - Daytime surprisingly has valid results which varies among methods.

- **Conclusion**
  - Determining a method is challenging.
  - Day (Solar & Wind) and Night (Wind) patterns show segregation.
  - A full-day failure might result from night wind failures.

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Conclusions & Recommendations

- **Recommendation**
  - Focus on daytime: When the risk of the lost of load on our system mainly happens. Nighttime data could only be affected by wind.
  - Focus on Extreme bad cases: Count of Hours > 6. Count values have a higher standard deviation than average methods.
  - We would propose 2012 to be the worst year based on our analysis.

year	Average	Count	>3 Average	>3 Count	>6 Average	>6 Count	
Solar1 & Wind1	2005	2011	2019	2009	2019	2012	
Solar1 & Wind2	2005	2011	2019	2012	2016	2012	
Solar1 & Wind3	2005	2011	2019	2012	2016	2012	Day
Solar2 & Wind1	2005	2011	2019	2009	2019	2012	
Solar2 & Wind2	2005	2011	2019	2009	2016	2012	
Solar2 & Wind3	2005	2011	2019	2012	2016	2012	

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Future Improvements

- Try different thresholds (5%, 15%) defining the “Bad Hours”.
- Better division of daytime & nighttime.
- Identify the reason of high tail values.
- The conclusions are not invariant. Apply the methodology for future data repeatably.
- A separate study is needed to understand the correlation between wind and solar effects.

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Vision

Working together with stakeholders to build the cleanest, most reliable electric system in the nation

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