Variable Generation UCAP determination

Eligibility WG – September 12, 2017

Overview

Examination of UCAP Methodologies for Variable Energy Resources.

This presentation will cover UCAP methodology for wind resources- solar will be dealt within a separate presentation

<u>Outline</u>

- High level definition UCAP for Wind Resources
- Jurisdictional Review Capacity contribution methodologies for Wind and Solar
  - Example UCAP calculation for Wind Resources
- Modeling Assumptions
- Capacity Factor Calculations Methodologies
  - Peak Load Summer
  - Peak Load Winter
  - Top 10 Summer Peak Hours
  - Top 10 Winter Peak Hours
- Methodology Considerations
- Wind UCAP methodology in a capacity market

Overview

- System stress conditions occur when the supply of energy and reserves is inadequate to meet the real-time demand for energy.
- Accurately estimating the amount of capacity that may be available during a range of potential system conditions is critical for maintaining system reliability.
- Different capacity resources have statistically different probabilities of being available during periods of system stress conditions. Differences in performance are driven by the technology type, variable vs non-variable generation and by outage rates.
- Variable renewable resources provide clean energy, have minimal variable costs, but generation follows wind and sun patterns rather than patterns of system need.
- Additional Wind generation is expected to be added through the Renewable Energy Program (REP).

Overview

- "Wind generators only generate electricity when the wind is blowing, wind's availability rate (the rate that power and energy can be provided) is a function of the wind speed throughout the year." (2)
- There is a negative correlation between wind generation and system peak load; wind resources may have very little capacity value during Alberta's system peak load conditions.
- The effective forced outage rate for wind generation may be relatively high when recognizing the variable availability of wind.
- North American capacity market jurisdictions establish a capacity rating for wind resources based either on historical wind output during peak periods or capacity contribution during reliability events.

(2) Source: NREL Determining the Capacity Value of Wind: http://www.nrel.gov/docs/fy08osti/43433.pdf

Jurisdictional Review: Capacity Contribution Methodologies for Wind and Solar

Survey of Renewable Capacity Counting Practices

Capacity Market Jurisdictional Reviews

Market	Resource	Rating Frequency	Capacity Contribution Method	Annual PK Hours Used	Historical Data	Difference by Location
ISO-NE	Wind, Solar	Summer, Winter	Median during peak hours	610 (summer) 486(winter)	Avg 5 years	by facility
MISO	Wind	Annual	Annual ELCC study, all hours	8760	Avg 10 years	by class then facility adjust
MISO	Solar	Summer	Seasonal peak hours	276	Avg 3 years	
NYISO	Wind, Solar	Summer, Winter	Capacity factor during peak hours	368 (summer) 360(winter)	Current year	by facility
PJM	Wind, Solar	Summer	Capacity factor during peak hours	368	Avg 3 years	by facility

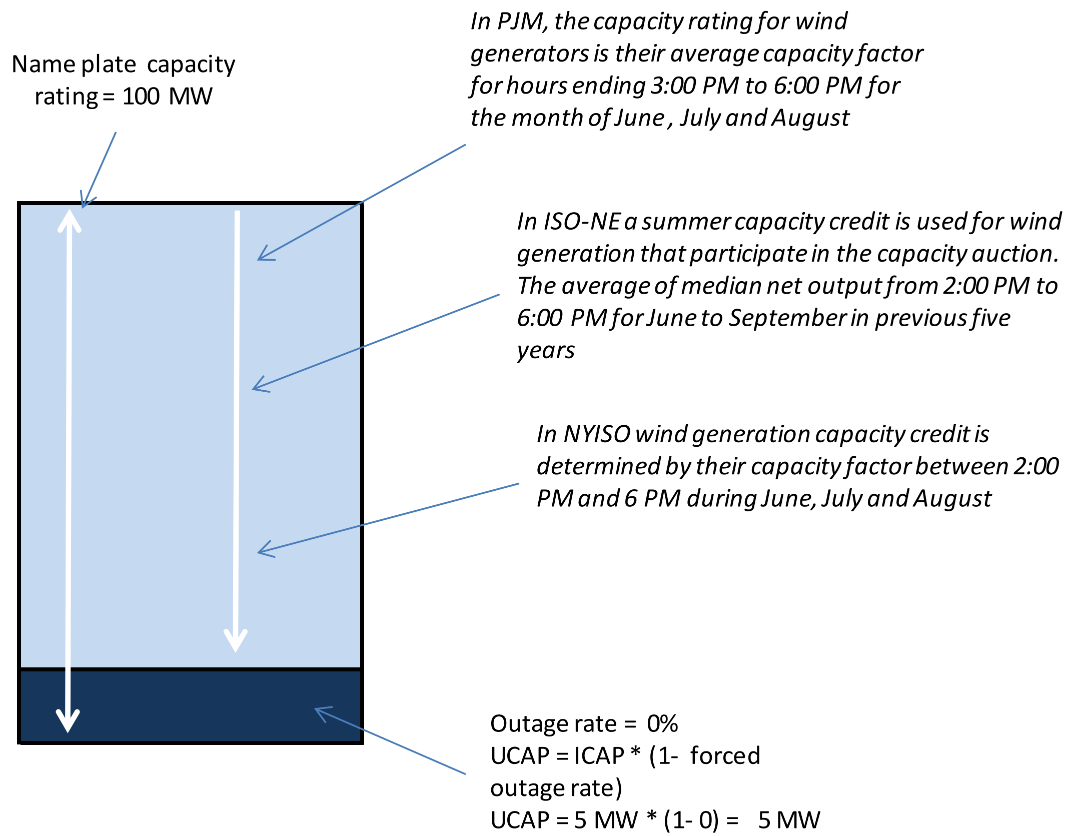
Non Capacity Market Jurisdictional Reviews

Market	Resource	Rating Frequency	Capacity Contribution Method	Annual PK Hours Used	Historical Data	Difference by Location
CAISO	Wind, Solar	Monthly	Level reached 70% of monthly peak hours	140-155 per month	Avg 3 years	By facility, class adjusted
entso	Wind, Solar	Annual	50th percentile (normal), 10th (extreme)	35 per year around peak	14 year	by country
ERCOT	Wind	Summer, Winter	Average during 20 highest load hours	20(summer) 20(winter)	Avg 10 years	two regions
ERCOT	Solar	Summer, Winter	100 % until 200 MW then like wind			all same
IESO	Wind, Solar	Summer, Winter, Shoulder monthly	Capacity factor: top 5 contiguous demand hours		Median 10 years	all same

System Adequacy with Intermittent Resources: Capacity Value and Economic Distortions- Johns Hopkins University

Example Calculation for a Variable Resource

- No jurisdiction applies nameplate capacity to variable resources.
- Generally, UCAP = ICAP for variable resources.
- For variable generation the UCAP is evaluated based on its actual historical generation during peak load hours.
- Example:
- PJM's ICAP accounts for wind's historical operating data during summer peak hours.
- Example: Wind Farm with a nameplate capacity of 100 MW.
- In PJM the outage rate (EFORd) of solar and wind resources is set to zero, since outage information is not collected. (ICAP=UCAP)



Modeling Assumptions

The objective of AESO's analysis is to determine historical patterns of wind capacity factors.

<u>Modeling Assumptions</u>

- Capacity Factor (CF): A proxy for UCAP for wind assets. Capacity factor is calculated as an hourly wind generation of an asset divided by the maximum capability (MC) of the asset.
- Average capacity factor for each wind asset was calculated using hourly generation for the particular months and Hour Ending (HE) outlined.
  - Illustrative Example: Wind asset's MC: 100MW (from Current Supply Demand Report)
  - Wind production of asset during Hour Ending (HE)18: 25 MW
  - Capacity Factor: 25/100 = 0.25 or 25% capacity factor for HE 18
- Newer wind assets (>5 years of generation data) are excluded from the analysis; this may lead to a lower capacity factor for the wind class average since new technologies have the potential to achieve higher outputs under same weather conditions.
- Time frame: January 1st, 2012 to December 31st, 2016.

Capacity Factor Calculation Methodologies

Methods to Assess Wind Capacity Credit in Alberta

Peak Load Summer

- This calculation provides average capacity factors during hours when high summer load typically occurs. Capacity factor during peak load hours in the summer season was calculated using the assumption listed below.
  - Year: January 1st, 2012 to December 31st, 2016 - 5 year interval.
  - Months: Historically, July and August are the highest load months in summer.
  - Hour Ending: HE 12 to HE 18 during summer months.

Peak Load Winter

- This calculation provides average capacity factors during hours when high winter load typically occurs. Capacity factor during peak load hours in the winter season was calculated using the assumption listed below.
  - Year: January 1st, 2012 to December 31st, 2016 - 5 year interval.
  - Months: Historically, November, December, January, and February are the winter months with the highest load.
  - Hour Ending: HE 16 and ends at HE 23 during winter months.

Capacity Factor Calculation Methodologies

Methods to Assess Wind Capacity Credit in Alberta

Top 10 Summer Peak Load Hours

- This measure calculates the average capacity factor for the ten highest load hours during summer months. Capacity factor during peak load hours in the summer season was calculated using the assumption listed below.
  - Year: January 1st, 2012 to December 31st, 2016 - 5 year interval.
  - Months: July and August.
  - HE: The top ten hours with the highest summer peak load (10 highest peak hours per year X 5 years).

Top 10 Winter Peak Load Hours

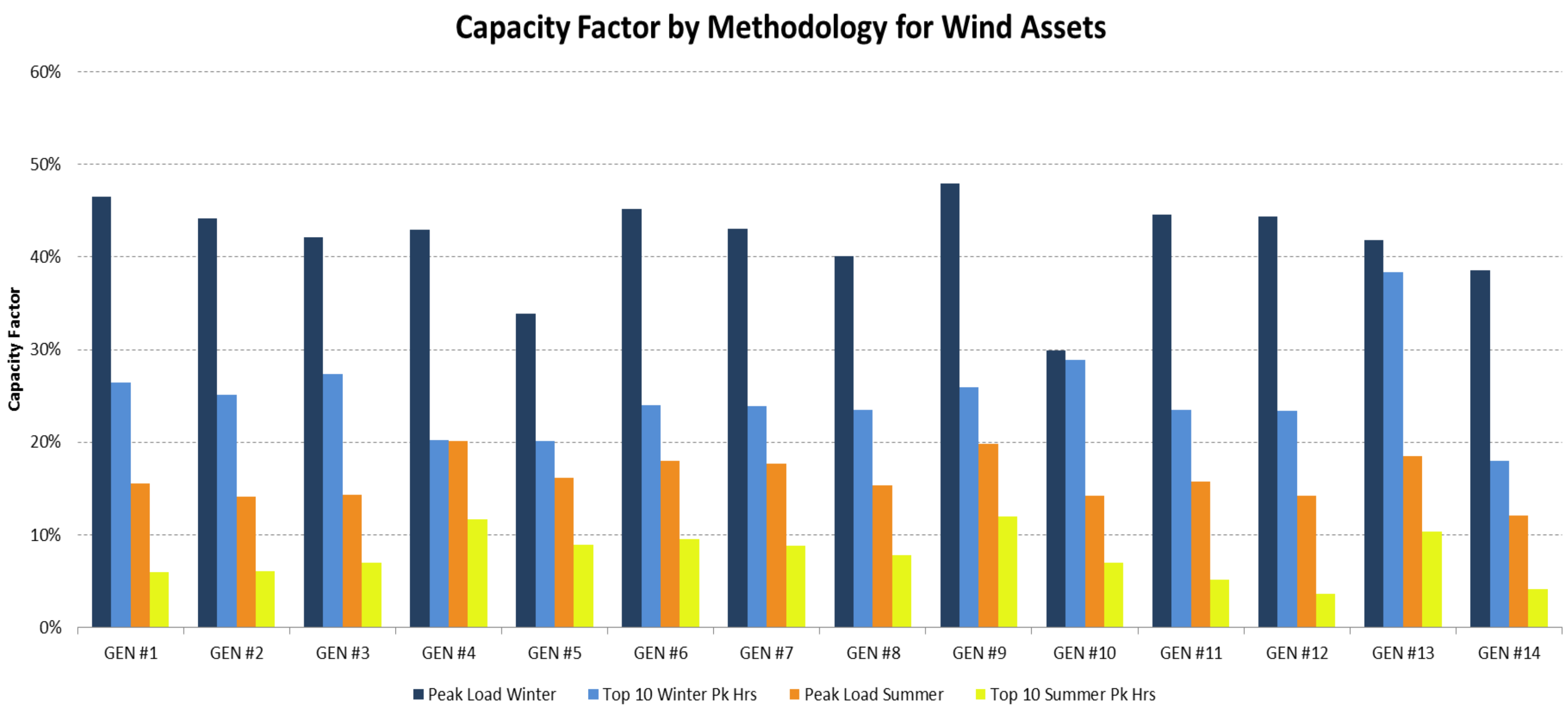
- This measure calculates the average capacity factor for the ten highest load hours during winter months. Capacity factor during peak load hours in the winter season was calculated using the assumption listed below.
  - Year: January 1st, 2012 to December 31st, 2016 - 5 year interval.
  - Months: November, December, January, and February.
  - HE: The top ten hours with the highest winter peak load (10 highest peak hours per year X 5 years).

Methodology considerations

- “In the context of a capacity market, a UCAP (unforced capacity) rating represents the amount of capacity that a resource can be expected to provide, on average, during periods of system stress.”(1)
- Reliability focused: UCAP Methodology should provide an accurate estimate of wind’s contribution to resource adequacy during performance events.
- Wind assets have limited control over their generation. A Methodology that provides a higher UCAP translates to an obligation to perform to a higher output during performance events.
  - Inability to perform during scarcity events may translate into significant penalties.
- UCAP methodology should include a robust sample size of wind generation.
- Alignment with a principle that loss of load probability should account for the relationship between peak demand and wind availability near absolute peak demand hours.
- Wind generation contribution to system reliability should be examined holistically.
  - Choosing only high load hours might not capture contribution to reliability.

1 Ontario Capacity Auction Draft High Level Design/ IESO/ December 11, 2014

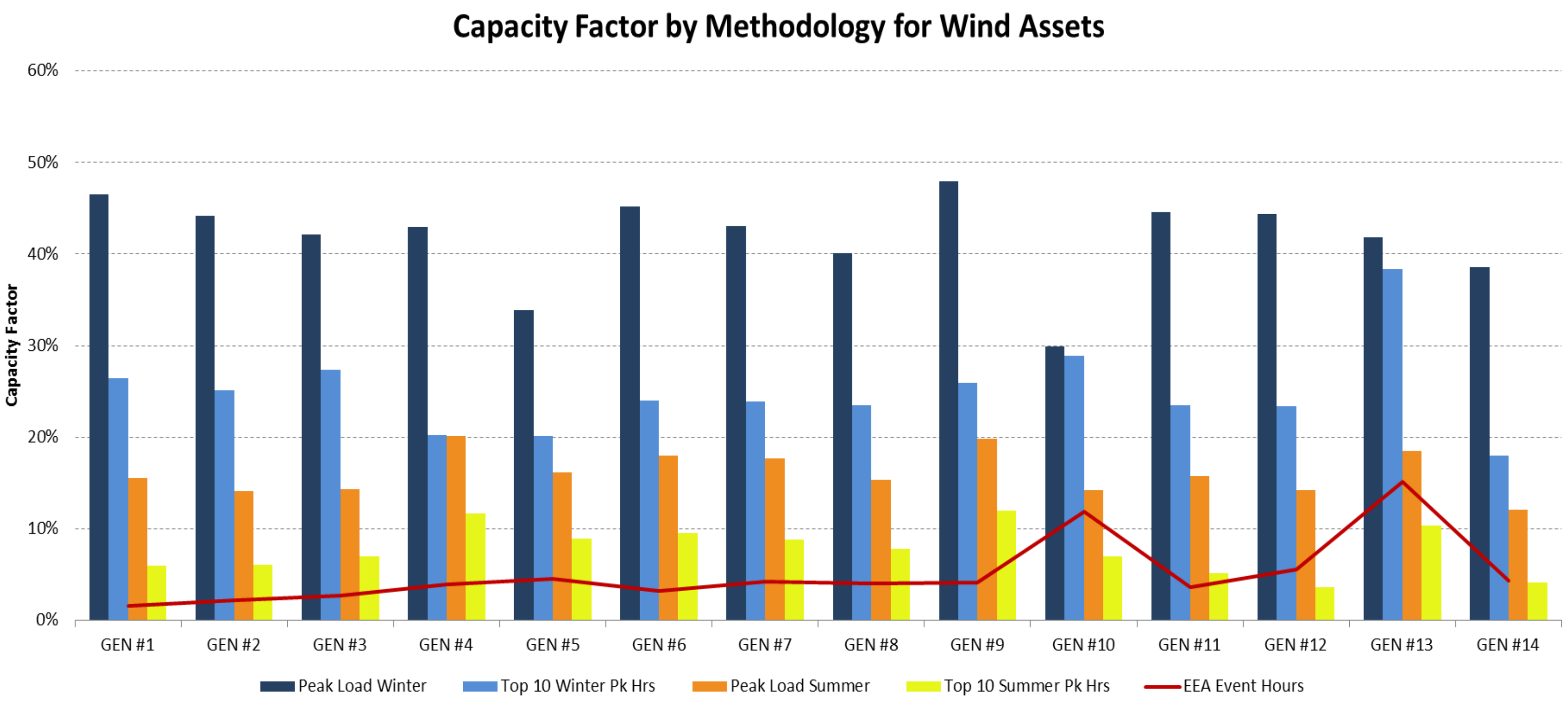
Capacity Factor by Methodology



Capacity Factor by Methodology

Asset	Capacity Factor			
	Peak Load Summer	Top 10 Summer Pk Hrs	Peak Load Winter	Top 10 Winter Pk Hrs
GEN #1	16%	6%	47%	26%
GEN #2	14%	6%	44%	25%
GEN #3	14%	7%	42%	27%
GEN #4	20%	12%	43%	20%
GEN #5	16%	9%	34%	20%
GEN #6	18%	9%	45%	24%
GEN #7	18%	9%	43%	24%
GEN #8	15%	8%	40%	24%
GEN #9	20%	12%	48%	26%
GEN #10	14%	7%	30%	29%
GEN #11	16%	5%	45%	23%
GEN #12	14%	4%	44%	23%
GEN #13	18%	10%	42%	38%
GEN #14	12%	4%	39%	18%

Capacity Factor by Methodology



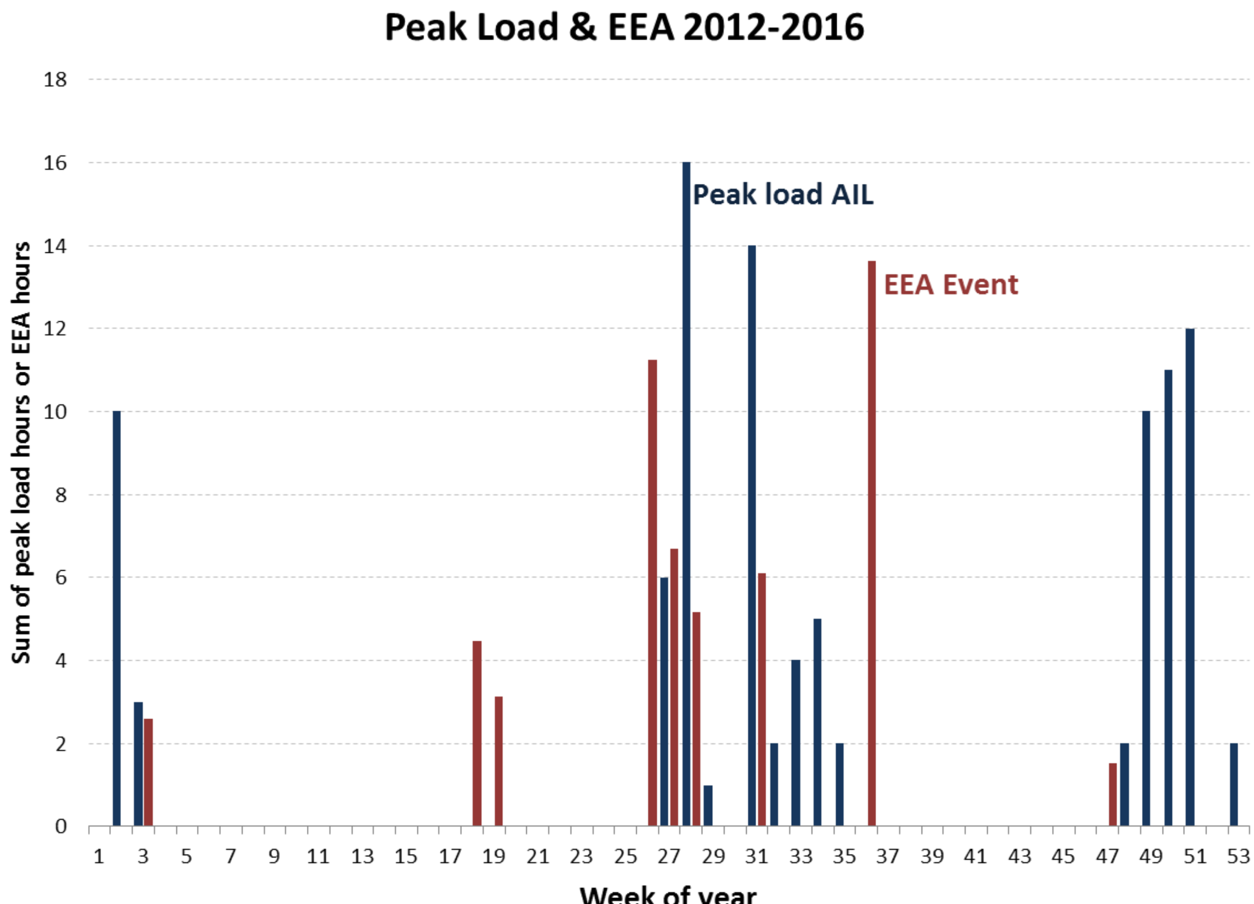
Energy Emergency Alert (EEA) Event Hours: Wind Capacity Factor during all HEs with instances of EEA events during the time frame of the analysis. [please see appendix 5]

Capacity Factor by Methodology

Asset	Capacity Factor Peak Load Summer	Top 10 Summer Pk Hrs	Peak Load Winter	Top 10 Winter Pk Hrs	EEA Hours
GEN #1	16%	6%	47%	26%	2%
GEN #2	14%	6%	44%	25%	2%
GEN #3	14%	7%	42%	27%	3%
GEN #4	20%	12%	43%	20%	4%
GEN #5	16%	9%	34%	20%	5%
GEN #6	18%	9%	45%	24%	3%
GEN #7	18%	9%	43%	24%	4%
GEN #8	15%	8%	40%	24%	4%
GEN #9	20%	12%	48%	26%	4%
GEN #10	14%	7%	30%	29%	12%
GEN #11	16%	5%	45%	23%	4%
GEN #12	14%	4%	44%	23%	6%
GEN #13	18%	10%	42%	38%	15%
GEN #14	12%	4%	39%	18%	4%

- If winter or summer capacity factor (Wind UCAP) is below its capacity commitment during a performance period = penalties for non-performance for the difference in volume.
- Illustrative example: if winter peak load methodology vs EEA performance event:
- GEN #2 Maximum Capability is 80MW.
- If use a winter peak load methodology GEN #2 UCAP obligation is 44% or a 35.2 MW UCAP
- Performance during EEA : 80 MW X 2% = 1.6 MW   Penalty Amount:??

Peak load vs EEA events



- All years 2012-2016 are shown on the chart, grouped by the week in the year
- Peak load hours are the top ten load hours for each of the summer and winter periods
- EEA events include EEA1, EEA2 and EEA3 events

Wind UCAP methodology in a capacity market

- For wind generators, performance incentivized capacity market present increased risk.
- A more conservative methodology, to estimate wind generation UCAP, may help mitigate penalty losses that wind assets might face during performance events.
- A conservative UCAP estimate for wind generators can potentially provide new monetary opportunities from over- performance during performance periods.
- Illustrative example on next slide.

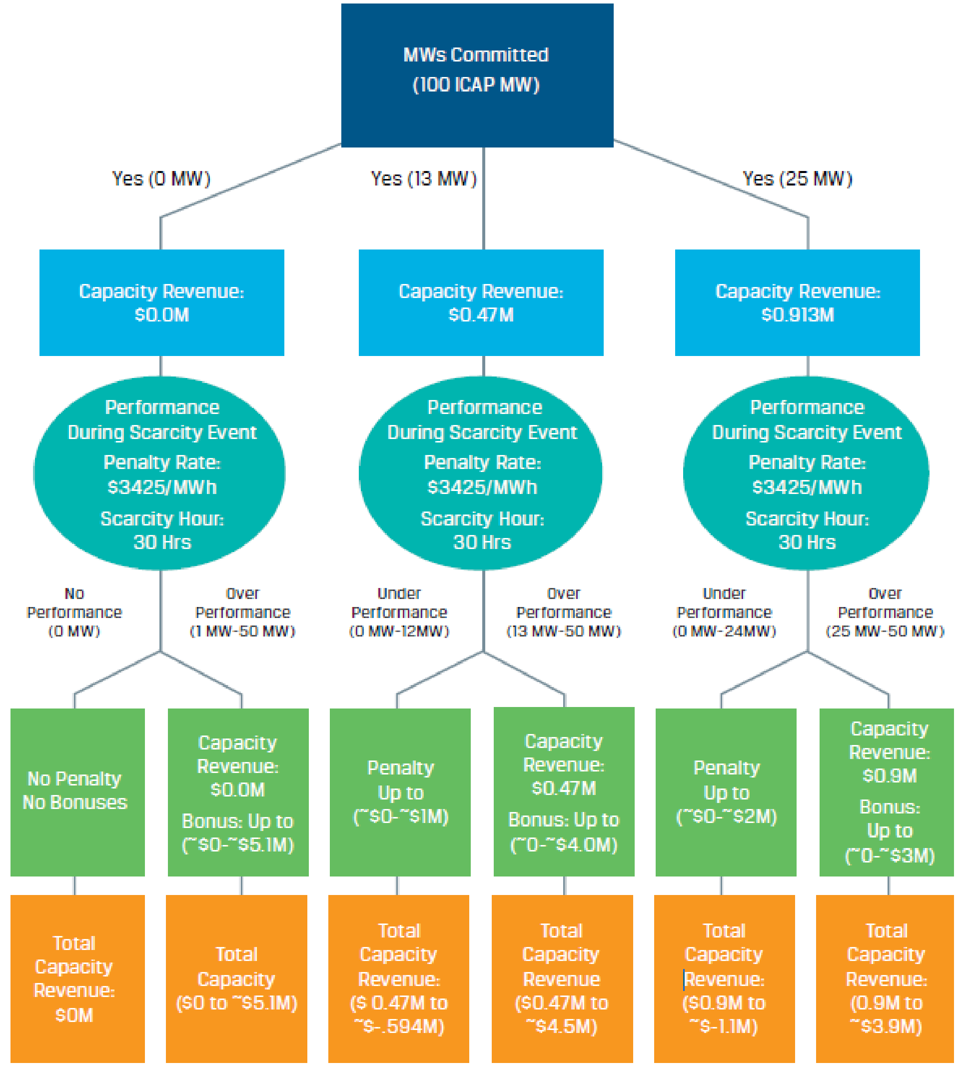


Chart Source: Renewables in Performance Incentivized Markets, by Josh Ghosh, Himanshu Pande, George Katsigiannakis, and Judah Rose, ICF

The table contains a rounding factor of $0.2-$0.3M

Wind UCAP methodology in a capacity market

Illustrative Example from previous slide

Calculations for the middle branch of the graph from previous slide:

13 MW UCAP (committed)

- Perform at 13 MW during each performance event (30 hours)
- No penalty / No over performance bonus
- Capacity Revenue $0.47M

13 MW UCAP (committed)

- Perform at 0 MW during each performance event (30 hours)
- Penalty (13 MW) X 30hrs X $3425 = $1,33M
- Capacity Revenue = $0.47 M – $1.33M = -$0.86M

13 MW UCAP (committed)

- Perform at 50 MW during each performance event (30 hours)
- Over performance bonus 37 X 30hrs X $3425 = $3.8M
  - 50 MW-13 MW = 37 MW of over performance
- Capacity Revenue = $0.47 M + $3.8M = $4.27M

Chart Source: Renewables in Performance Incentivized Markets, by Josh Ghosh, Himanshu Pande, George Katsigiannakis, and Judah Rose, ICF

Appendix 1

Asset	Capacity Factor Summer 2012	2013	2014	2015	2016	Capacity Factor Winter 2012	2013	2014	2015	2016
GEN #1	17%	13%	14%	18%	15%	50%	54%	39%	43%	47%
GEN #2	15%	11%	13%	17%	15%	43%	48%	38%	43%	49%
GEN #3	14%	12%	11%	18%	17%	42%	45%	34%	41%	47%
GEN #4	18%	16%	18%	27%	22%	46%	47%	37%	40%	44%
GEN #5	13%	13%	16%	19%	19%	36%	36%	33%	32%	33%
GEN #6	17%	13%	17%	25%	18%	48%	51%	38%	41%	48%
GEN #7	14%	15%	16%	24%	20%	44%	44%	38%	44%	45%
GEN #8	13%	12%	14%	20%	17%	43%	43%	33%	39%	42%
GEN #9	21%	16%	18%	26%	18%	51%	54%	42%	44%	49%
GEN #10	16%	13%	12%	16%	14%	29%	32%	32%	27%	30%
GEN #11	16%	12%	15%	19%	16%	46%	50%	38%	43%	45%
GEN #12	15%	11%	11%	17%	16%	47%	46%	42%	42%	45%
GEN #13	20%	17%	16%	24%	15%	38%	45%	45%	38%	43%
GEN #14	11%	11%	11%	14%	14%	37%	39%	37%	39%	41%
Fleet Avg. *	16%	13%	14%	20%	16%	42%	45%	38%	40%	44%

- Fleet average is the capacity factor for all the analyzed assets normalized for size differences.
- All capacity factor calculations are based on calendar year

Appendix 2

Asset	Top 10 Summer Pk Hrs					Top 10 Winter Pk Hrs				
	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016
GEN #1	4%	3%	2%	8%	13%	45%	35%	30%	19%	3%
GEN #2	6%	2%	1%	7%	13%	37%	36%	29%	17%	6%
GEN #3	3%	6%	2%	8%	16%	46%	35%	30%	20%	6%
GEN #4	14%	14%	6%	11%	14%	45%	14%	26%	17%	0%
GEN #5	10%	14%	5%	11%	3%	38%	13%	36%	13%	0%
GEN #6	7%	4%	8%	9%	20%	43%	31%	26%	17%	4%
GEN #7	9%	9%	5%	12%	9%	41%	31%	32%	15%	0%
GEN #8	9%	4%	7%	9%	11%	42%	34%	27%	14%	0%
GEN #9	12%	6%	11%	10%	21%	52%	27%	30%	19%	1%
GEN #10	2%	14%	0%	10%	9%	14%	43%	21%	28%	38%
GEN #11	5%	3%	2%	5%	9%	39%	8%	32%	29%	9%
GEN #12	0%	15%	0%	3%	0%	33%	11%	44%	15%	14%
GEN #13	1%	38%	1%	3%	9%	20%	57%	35%	32%	48%
GEN #14	1%	14%	0%	4%	2%	23%	8%	31%	14%	15%
Fleet Avg. *	6%	10%	4%	8%	11%	37%	27%	31%	19%	10%

* Fleet average is the capacity factor for all the analyzed assets normalized for size differences.

Appendix 3

Asset	Capacity Factor					
	10 hours		5 Hours		1 Hours	
	Summer	Winter	Summer	Winter	Summer	Winter
GEN #1	5.9%	26.5%	6.0%	26.6%	3.5%	17.4%
GEN #2	6.0%	25.1%	6.5%	27.0%	3.0%	21.3%
GEN #3	7.0%	27.4%	6.8%	29.2%	4.4%	21.0%
GEN #4	11.6%	20.3%	14.5%	18.2%	11.2%	0.3%
GEN #5	8.9%	20.1%	11.0%	20.6%	9.6%	2.6%
GEN #6	9.5%	24.0%	11.5%	23.8%	10.6%	17.1%
GEN #7	8.8%	23.9%	12.3%	27.0%	8.0%	18.2%
GEN #8	7.8%	23.5%	10.7%	26.7%	11.0%	18.0%
GEN #9	12.0%	26.0%	14.2%	26.5%	14.9%	7.3%
GEN #10	7.0%	28.8%	8.2%	25.4%	7.7%	28.3%
GEN #11	5.1%	23.5%	5.2%	22.7%	0.2%	3.4%
GEN #12	3.7%	23.3%	3.8%	25.1%	2.8%	5.9%
GEN #13	10.3%	38.4%	14.8%	37.1%	14.0%	36.5%
GEN #14	4.2%	18.0%	5.2%	19.8%	4.3%	3.2%

Appendix 4

- Capacity Factor for wind assets calculated during Energy Emergency Alert (EEA) periods.
- EEA periods are indicative of capacity market performance event.
- Penalties are a significant risk for wind assets if underperform below obligation.

	EEA		
Asset	2012	2013	2014
GEN #1	2%	1%	3%
GEN #2	2%	2%	2%
GEN #3	3%	3%	2%
GEN #4	3%	4%	5%
GEN #5	3%	5%	4%
GEN #6	5%	2%	9%
GEN #7	4%	4%	5%
GEN #8	6%	3%	8%
GEN #9	6%	2%	12%
GEN #10	6%	15%	0%
GEN #11	5%	3%	4%
GEN #12	4%	7%	1%
GEN #13	8%	19%	0%
GEN #14	3%	5%	0%

Appendix 5

Energy Emergency Alerts (EEA) used for analysis of wind capacity factors

Year	Month	Quarter	EEA Start	EEA End	Type
2012	January	Q1	2012-01-17 17:20	2012-01-17 19:27	EEA1
2012	January	Q1	2012-01-18 17:44	2012-01-18 18:12	EEA1
2012	July	Q3	2012-07-09 13:37	2012-07-09 14:10	EEA1
2012	July	Q3	2012-07-09 14:10	2012-07-09 17:04	EEA3
2012	July	Q3	2012-07-09 17:04	2012-07-09 17:41	EEA2
2012	July	Q3	2012-07-09 17:41	2012-07-09 18:48	EEA1
2012	November	Q4	2012-11-20 16:43	2012-11-20 18:15	EEA1
2013	May	Q2	2013-05-04 9:41	2013-05-04 14:09	EEA1
2013	May	Q2	2013-05-09 14:51	2013-05-09 17:58	EEA1
2013	June	Q2	2013-06-28 10:28	2013-06-28 19:00	EEA2
2013	June	Q2	2013-06-29 11:08	2013-06-29 13:51	EEA2
2013	July	Q3	2013-07-02 11:22	2013-07-02 18:04	EEA3
2013	September	Q3	2013-09-03 14:49	2013-09-03 18:05	EEA1
2013	September	Q3	2013-09-04 12:47	2013-09-04 18:50	EEA2
2013	September	Q3	2013-09-05 13:41	2013-09-05 18:00	EEA2
2014	July	Q3	2014-07-30 10:36	2014-07-30 10:54	EEA1
2014	July	Q3	2014-07-30 10:54	2014-07-30 16:42	EEA2

No EEA events in 2015 & 2016

Appendix 6

Top 10 Summer and Winter hours – AIL load

	Winter			Summer		
Year	Date	HE	AIL	Date	HE	AIL
2012	16-Jan-2012	18	10,609	09-Jul-2012	14	9,885
2012	10-Dec-2012	18	10,599	07-Aug-2012	14	9,878
2012	19-Dec-2012	18	10,594	12-Jul-2012	16	9,849
2012	18-Dec-2012	18	10,572	07-Aug-2012	15	9,845
2012	17-Dec-2012	18	10,533	09-Jul-2012	13	9,842
2012	11-Dec-2012	18	10,524	12-Jul-2012	17	9,836
2012	13-Dec-2012	18	10,509	12-Jul-2012	15	9,836
2012	12-Dec-2012	18	10,507	11-Jul-2012	16	9,822
2012	16-Jan-2012	19	10,505	11-Jul-2012	17	9,815
2012	17-Jan-2012	18	10,494	10-Jul-2012	16	9,801
2013	02-Dec-2013	18	11,139	02-Jul-2013	16	10,063
2013	05-Dec-2013	18	11,134	02-Jul-2013	15	10,034
2013	19-Dec-2013	18	11,045	02-Jul-2013	14	9,982
2013	05-Dec-2013	19	11,030	02-Jul-2013	13	9,889
2013	04-Dec-2013	18	11,020	02-Jul-2013	17	9,876
2013	06-Dec-2013	18	10,984	14-Aug-2013	17	9,835
2013	12-Dec-2013	18	10,950	29-Aug-2013	17	9,825
2013	02-Dec-2013	19	10,943	14-Aug-2013	16	9,820
2013	10-Dec-2013	18	10,935	29-Aug-2013	16	9,808
2013	05-Dec-2013	20	10,912	02-Jul-2013	12	9,805
2014	29-Dec-2014	18	11,169	30-Jul-2014	16	10,419
2014	15-Dec-2014	18	11,092	29-Jul-2014	16	10,413
2014	01-Dec-2014	18	11,076	30-Jul-2014	15	10,395
2014	08-Dec-2014	18	11,033	29-Jul-2014	17	10,393
2014	28-Nov-2014	18	11,020	30-Jul-2014	17	10,371
2014	29-Dec-2014	19	11,016	29-Jul-2014	15	10,350
2014	30-Nov-2014	18	10,998	30-Jul-2014	14	10,337
2014	15-Dec-2014	19	10,982	29-Jul-2014	18	10,300
2014	27-Nov-2014	18	10,981	15-Jul-2014	17	10,299
2014	02-Dec-2014	18	10,959	30-Jul-2014	13	10,294

Thank you