Solar Capacity Factor Research and Recommendation

Rhode Island DG Board Meeting
March 30, 2021

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Why did we do this study?

Capacity factor is a percent number that the peak AC value of a electric generator is generating over the course of a year.

In RE Growth and Net Metering, DG resource size in RI is limited to produce the annual historic average usage of the customer.

Capacity factor is used to determine system size, and concern had been raised that the standardized use of 14% DC-to-AC does not allow some customers to size DG systems to their historic usage. The standard formula is:

Usage (kWh) / Capacity Factor / 8760 = System Size (kW-dc)

Key Findings

- **The use of a calculator like PV Watts does provide more customized CF results, as expected.**
- **The average of the sample in PV Watts using project specific inputs resulted in an average CF essentially the same as 14%.**
- **Both the standard 14% and PV Watts, however, overestimate the production of systems compared to actual meter readings.**
- **National Grid is exploring the use of a table based on actual averages and PV Watts guidance to capture angle and azimuth variation of output, once implemented.**

Study Details

- Compared PV Watts estimates with NG Estimated Generation and actual generation reads for 303 roof mounted RE Growth projects <25 kW
- PV Watts Inputs: Tilt, Azimuth, DC-AC Ratio, type = roof mounted
- NG Estimate pulled from GridForce, actuals from billing system
- 95% confidence interval with a 5.4% +/- margin of error based on sample size
    - With an average capacity factor of 12.78%, this means we can be 95% sure that the actual number is between 12.09% and 13.47%.

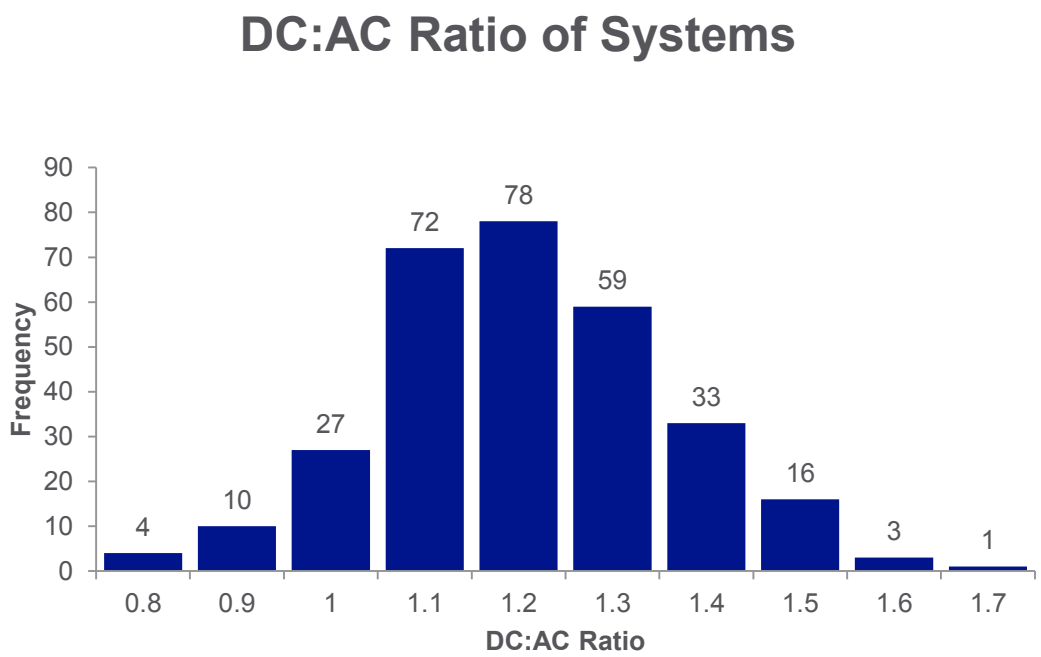
Sample Angle and Azimuth of Arrays

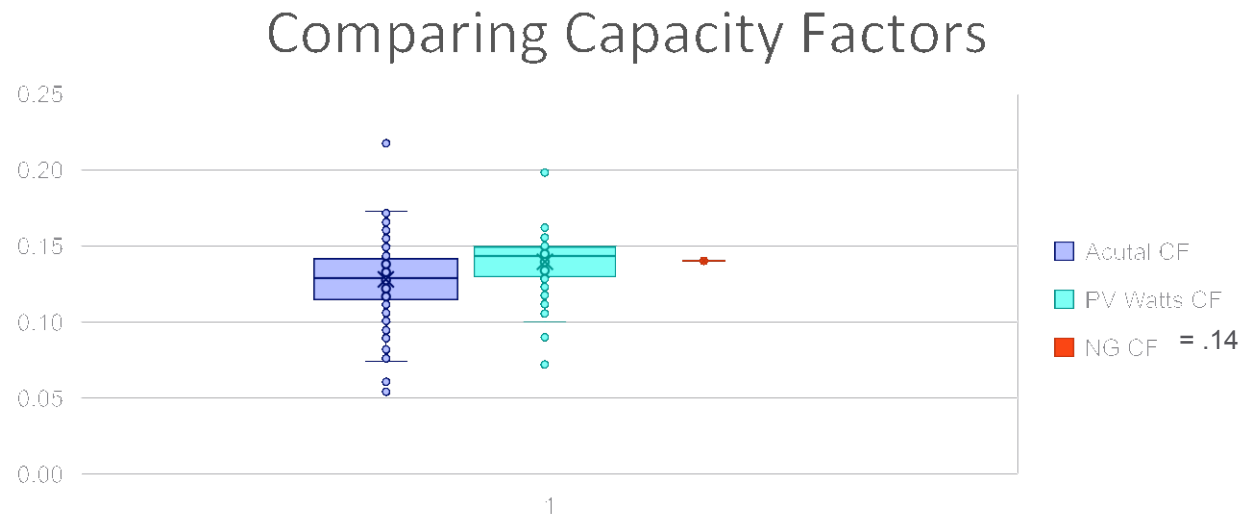
- **65% of systems fall between 120 and 239 degrees, southerly**
  - 25% of sample systems at 180˚
- **Optimal tilt is ~41.45 +/-15 depending on the season**
- **72% of sample systems fall in the ideal range for RI**
- **Table: Darker green = higher count of systems meeting these conditions**

Count of Input Ranges	Tilt				
Azimuth	0-9'	10-19'	20-29'	30-39'	40-50'
0-39		1			1
40-79		1	3	1	
80-119	2	3	26	4	6
120-159		6	13	12	3
160-199	2	17	59	34	13
200-239	1	7	15	9	6
240-279		10	20	17	7
280-319		1	2		
320-360					1

DC:AC Ratio

- 49% of projects have DC:AC ratios between 1.1 and 1.2
- 13% systems with a ratio less than 1
- 7% systems with a ratio greater than 1.5
- Higher ratio systems can produce more kWh per $ of installed cost, but have lower capacity factors



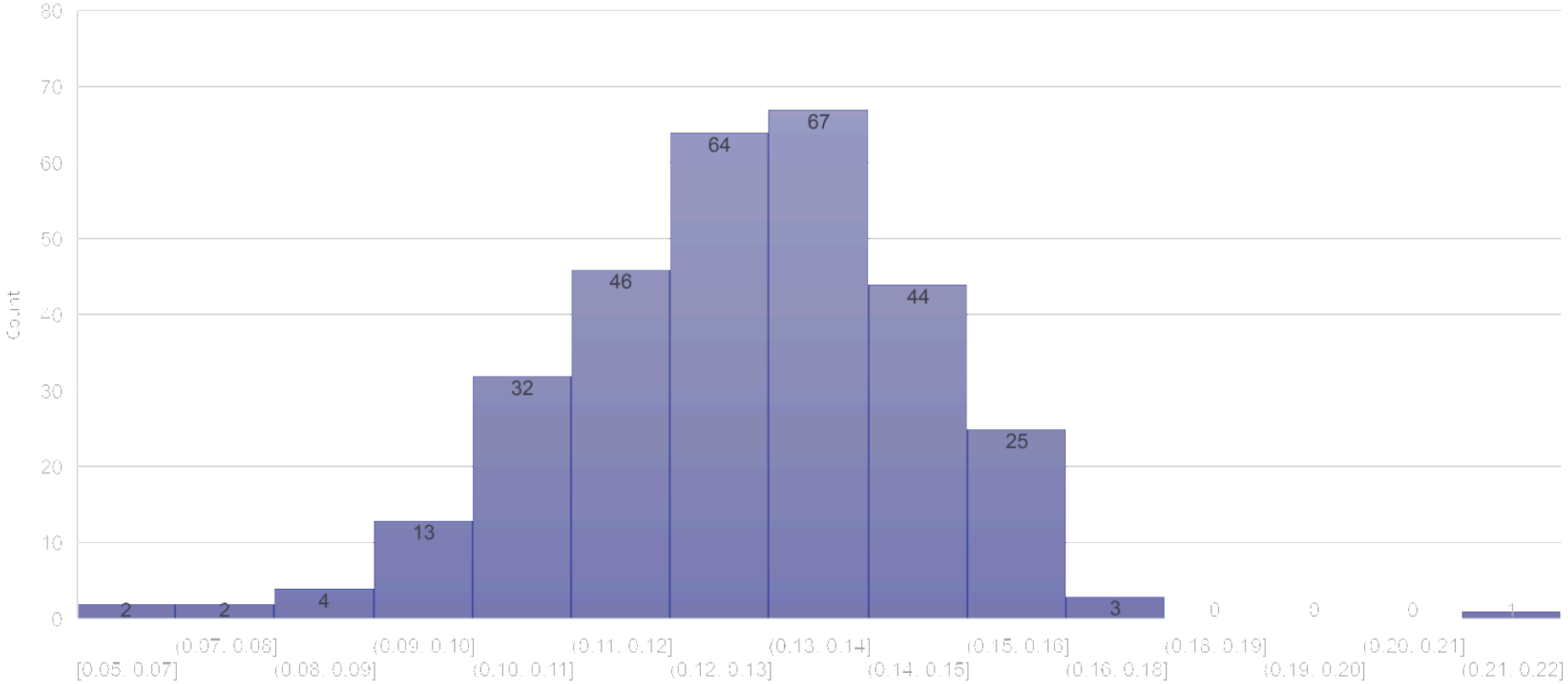


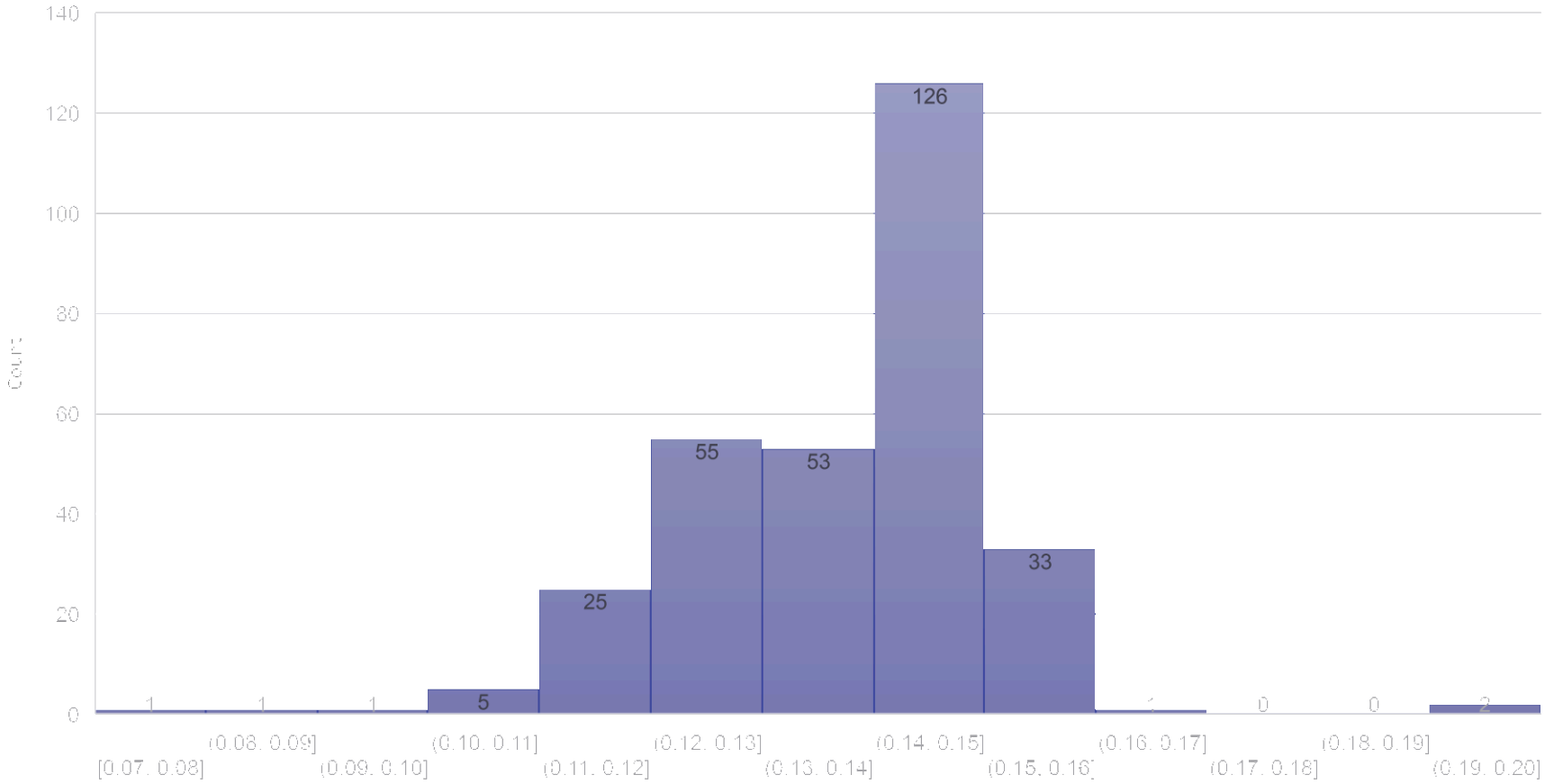
Actual CF	
Mean	.1278
Median	.1287
Min	.0541
Max	.2172

PV Watts CF	
Mean	.1394
Median	.1432
Min	.0718
Max	.1987

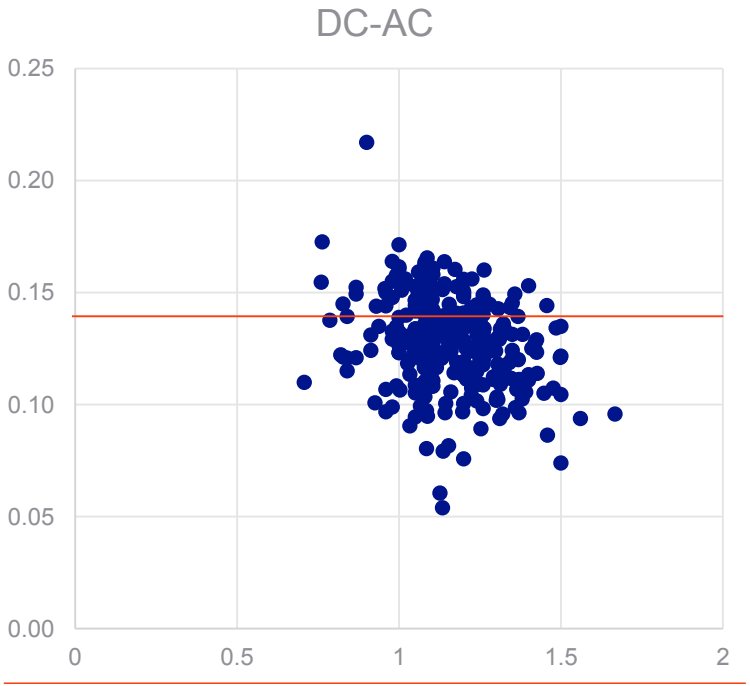
- **NG Estimate and PV Watts both appear to be overestimates**
- **Actual CF mean is 8.7% lower than 14%**
- **Actual CFs are more diverse and skewed downward, vs tighter and skewed upward with PV Watts**

Actual Generation Capacity Factor Distribution

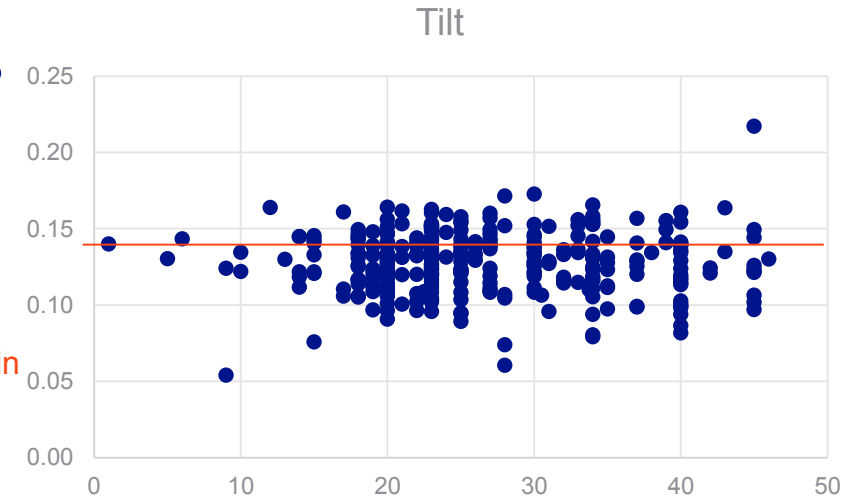


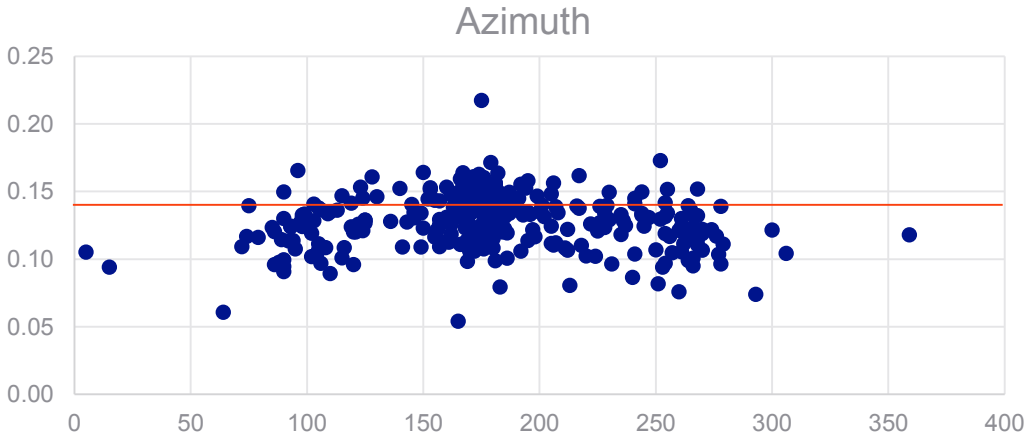

PV Watts Capacity Factor Distribution
Count
140
120
100
80
60
40
20
0
1
1
1
5
25
55
53
126
33
1
0
0
2
[0.07, 0.08]
(0.08, 0.09]
(0.09, 0.10]
(0.10, 0.11]
(0.11, 0.12]
(0.12, 0.13]
(0.13, 0.14]
(0.14, 0.15]
(0.15, 0.16]
(0.16, 0.17]
(0.17, 0.18]
(0.18, 0.19]
(0.19, 0.20]

How do inputs affect actual CF?



NG Estimate in orange





Suggested Approach is a Table with CFs for Ranges of Angle and Azimuth

ACTUAL CFs	Tilt		
Direction	0-20	20-40	40-60
North	10.51%	9.37%	10.59%
East	12.76%	12.15%	11.50%
West	12.25%	12.15%	11.50%
SW & SE	12.54%	12.90%	13.21%
Due South	13.11%	13.57%	13.67%

PV WATTS	Tilt		
Direction	0-20	20-40	40-60
North	9.98%	8.37%	8.09%
East	12.80%	12.89%	12.60%
West	13.00%	12.83%	12.45%
SW & SE	14.15%	14.63%	14.38%
Due South	14.31%	15.14%	15.21%

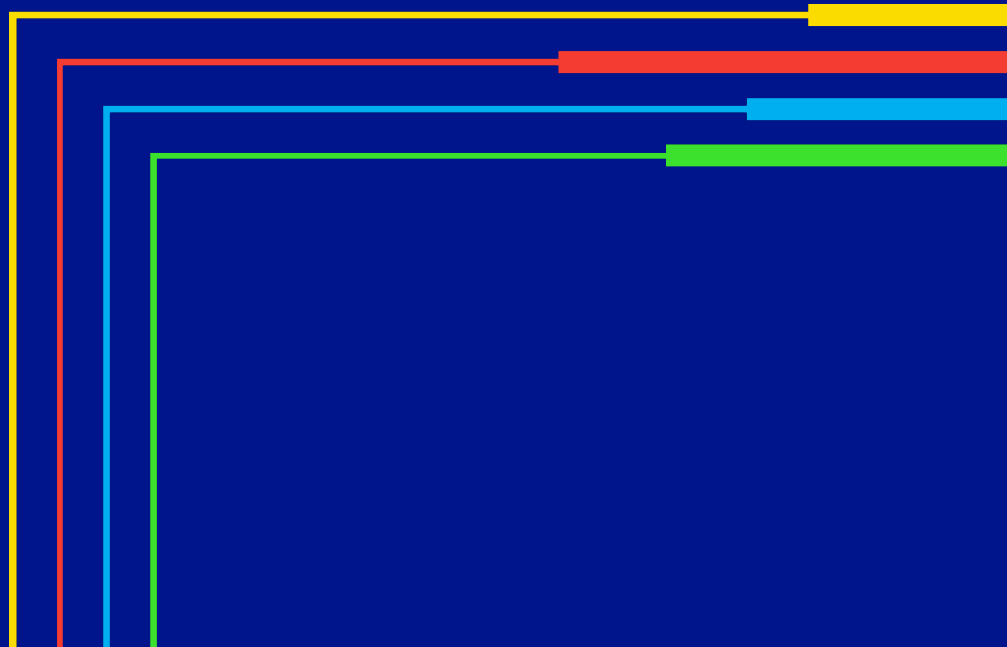
- **Actuals vary from PV Watts with modest variation**
- **Need to investigate higher CFs for northerly systems**
- **May suggest a minimum CF to account for shading, snow and other factors**

Difference	Tilt		
	0-20	20-40	40-60
North	-0.53%	-1.00%	-2.50%
East	0.04%	0.74%	1.10%
West	0.75%	0.68%	0.95%
SW & SE	1.61%	1.73%	1.17%
Due South	1.20%	1.57%	1.54%

Takeaways and Next Steps

- Other factors outside of angle and azimuth likely drive the downward measures of actual CFs vs PV Watts
- Use of lower CFs like in table above will generally allow for larger systems at customer locations
- Further analysis of outliers, use of a potential minimum CF, and adjustment of the bands/ranges will further refine this
- Use of an installer supplied CF, validated with the table, is another approach under consideration – CF is currently not collected
- NG is investigating the technical requirements to automate the use of CF based on angle and azimuth inputs in Grid Force

Appendix



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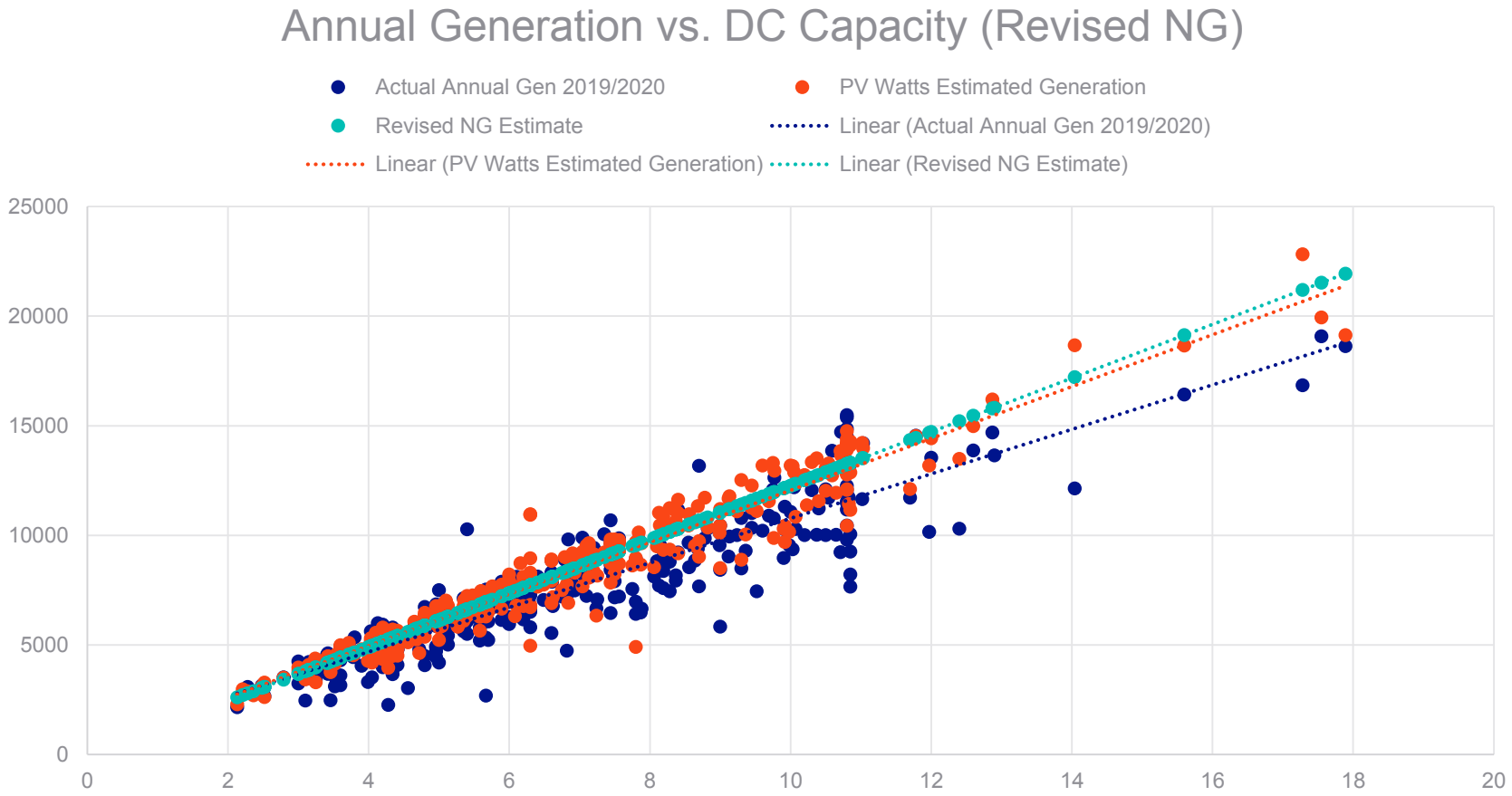
Annual Generation vs. DC Capacity (Revised NG)
Actual Annual Gen 2019/2020
PV Watts Estimated Generation
Revised NG Estimate
Linear (Actual Annual Gen 2019/2020)
Linear (PV Watts Estimated Generation)
Linear (Revised NG Estimate)
25000
20000
15000
10000
5000
0
0
2
4
6
8
10
12
14
16
18
20

How do inputs affect actual CF for large systems? (systems > 10 kw)