

# Comparative Assessment of ASTM E2848 and Temperature-Normalized Solar PV Capacity Testing Protocols

Shail Bajpai | Black & Veatch

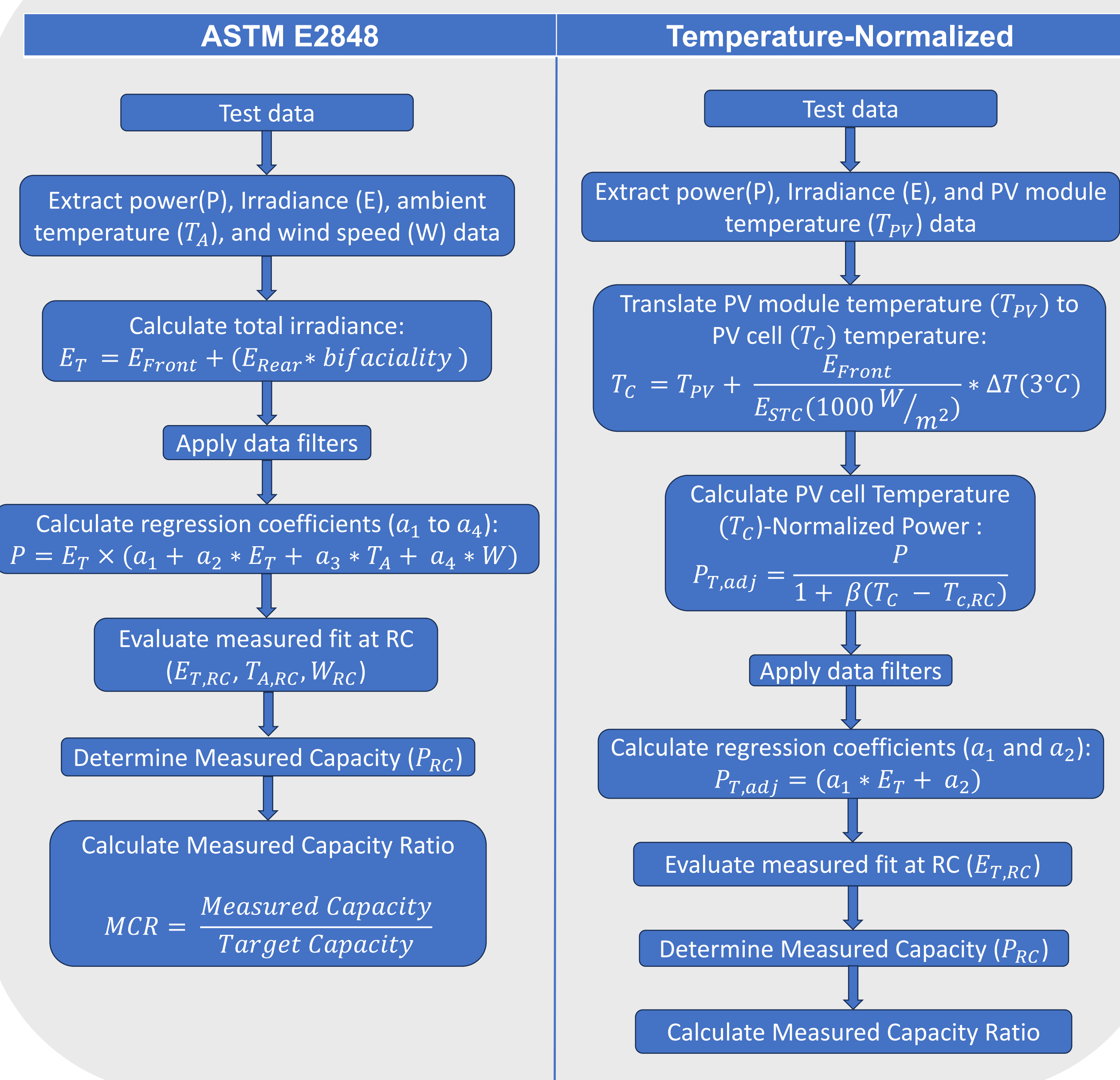
## Introduction

- Capacity test is the industry standard for evaluating performance guarantees between project stakeholders. Although the overall framework of capacity testing is well established, the industry commonly employs two distinct methods.
- The first method follows ASTM E2848, wherein a multiple linear regression of output power as a function of plane-of-array irradiance, ambient air temperature, and wind speed is utilized to generate capacity curves. This approach assumes that PV cell temperature is directly influenced by ambient temperature and wind speed.
- The second method is a modified version of the ASTM E2848 protocol. In this approach, a linear regression of PV module cell temperature-normalized output power as a function of plane-of-array irradiance is utilized to generate capacity curves. By directly incorporating cell temperature rather than its influencing parameters, this method addresses the key assumption of the first method. However, accurately measuring PV module temperature with standard monitoring systems remains a challenge.
- Selecting an appropriate test method is therefore essential to ensure accurate and representative performance evaluations.

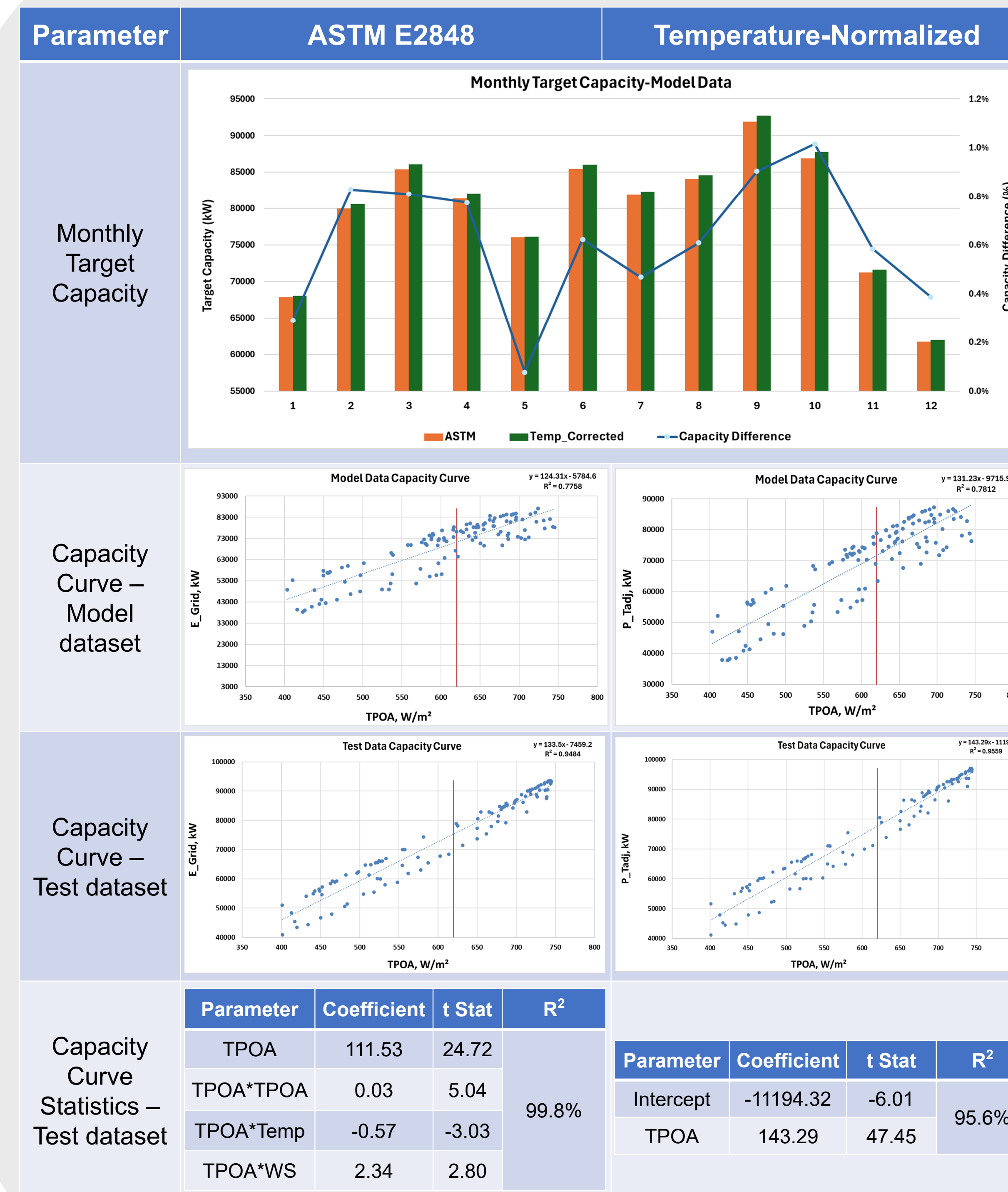
## Comparison methodology

This presentation presents an overview of the test methodologies and governing mathematical equations, followed by the application of both methods to a common modeled and measured dataset using consistent data filtering criteria. The resulting capacity curves and statistical indicators of fit quality are compared, along with an evaluation of monthly target capacity to assess seasonal effects. The methodologies are ultimately assessed based on the test results to evaluate the representativeness of each approach.

## Test Methodology Overview



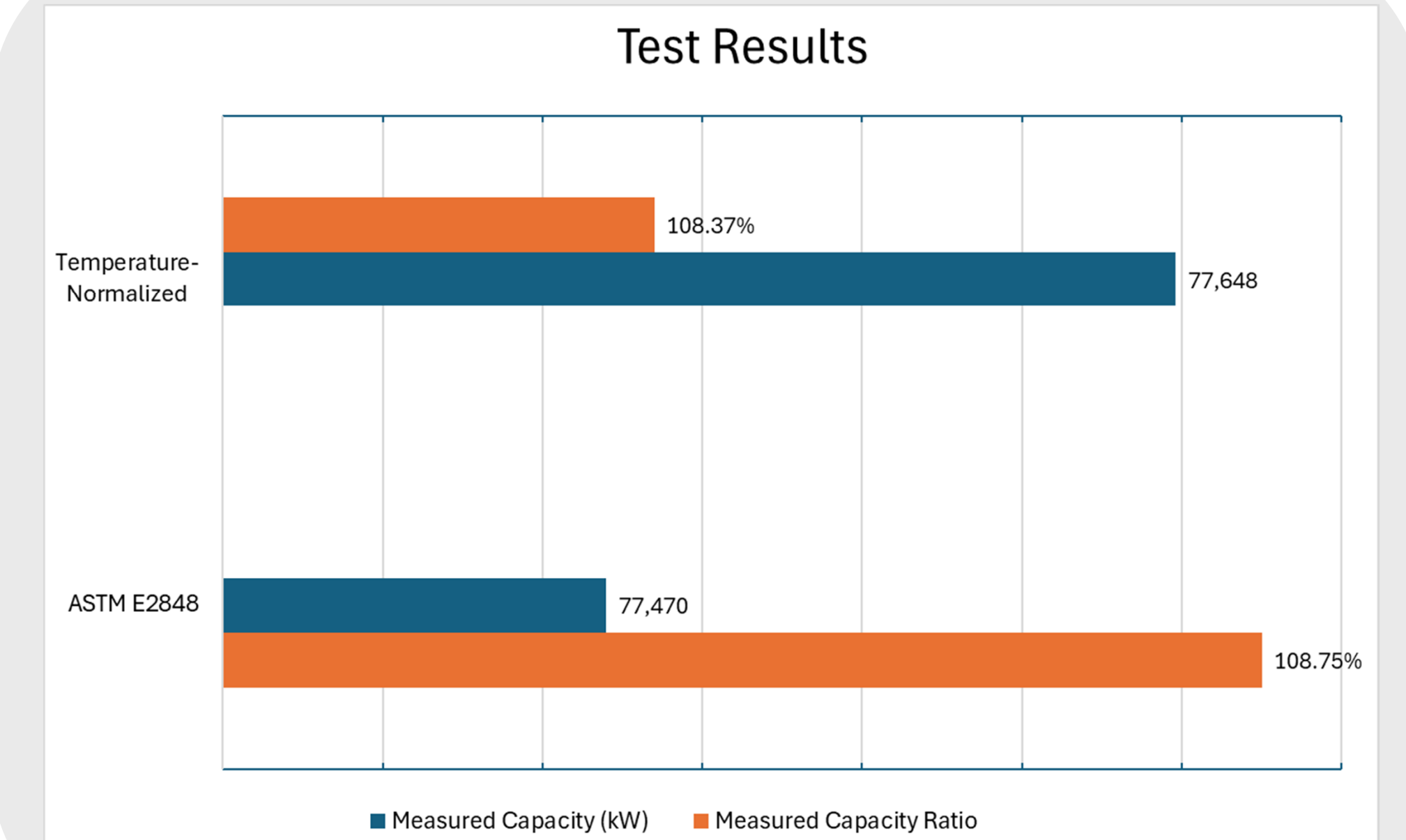
## Comparison Plots



## Project Details and Test Data Filters

Sr.No	Parameter	Value
<b>PROJECT DETAILS</b>		
1.	Location	Eastern Kentucky, USA
2.	PV module technology/Racking	Bifacial N-type TOPCon crystalline silicon/SAT
<b>DATA FILTERS</b>		
1.	Primary minimum irradiance exclusion	400 W/m <sup>2</sup>
2.	POI clipping threshold	98%
3.	Secondary exclusion Irradiance range	50%
4.	POAI spatial variability	25 W/m <sup>2</sup>
5.	POAI temporal variability	50 W/m <sup>2</sup>
6.	Inverter power factor	0.98
7.	Test month	November (11)

## Test Results



## Conclusions

- Both test methods generate different monthly target capacity based on the same energy model data. The temperature-normalized test protocol generates higher capacities than the ASTM test approach by 0.1% to 1.0%. While there is no specific pattern in the magnitude of the differences with respect to seasons, additional investigations are required to determine the correlation.
- The ASTM test method, with a model R<sup>2</sup> of 99.3% and a test R<sup>2</sup> of 99.8%, generates a better-fit regression for the model and test data compared to the temperature-normalized test, which has a model R<sup>2</sup> of 78.1% and a test R<sup>2</sup> of 95.6%.
- Regarding the regression coefficients of the ASTM test, the temperature term is negative, indicating an inverse relationship between power production and temperature, consistent with PV module characteristics.
- Regarding the t-Stat parameters of the ASTM test, TPOA exhibits the strongest relationship with power production, followed by ambient temperature, and then wind speed.
- The temperature-normalized test yields a 0.2% higher measured capacity compared to the ASTM test, while exhibiting a 0.3% lower Measured Capacity Ratio.

## References

- ASTM Subcommittee E44.09, "Standard Test Method for Reporting Photovoltaic Non-Concentrator System Performance," American Society for Testing and Materials, ASTM E2848-13, 2018.
- D. King, W. Boyson, and J. Kratochvil, "Photovoltaic Array Performance Model," Sandia National Laboratories, SAND2004-3535, Dec. 2004.
- Waters, Martin, Chris Deline, Johan Kemnitz, and Jeffrey Webber. 2019. "Suggested Modifications for Bifacial Capacity Testing"

## Acknowledgements

- Black & Veatch for supporting this research and travel to the conference.
- Steve Block and Jay Miller for encouraging and facilitating the topic submission.