Financial Implications of Module Degradation Uncertainty for Utility-Scale Solar Facilities

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Introduction

Uncertainty in module degradation rates can greatly impact the value of utility-scale crystalline solar projects. Through Monte Carlo analysis and PVsyst(1) system models, we explore the impacts of module degradation rate uncertainty on the overall uncertainty in the value of plant production.

Methods

Modeling Data

- PVsyst models developed during the financing or sale phase of the respective projects were used as generation models, with only the DC:AC ratio modified.
- Meteorological data from the NSRDB(2).

Production Value:

- Production value was determined by applying the Power Purchase Agreement energy value for a 25 year period to the project .

Uncertainty Calculation:

- Uncertainty was developed using Monte Carlo simulation with ~45 years of NSRDB GHI data representing inter-annual resource variation, a normal distribution representing model uncertainty and Initial degradation rate d istribution from 1,920 published degradation rates(3).

Degradation Model:

- Degradation was assumed to be linear, and was applied annually.

Projects

Annual Global Horizontal Irradiance		
Location	(kW/m2)	Racking Type
Boise, ID	1,709	Single-Axis Tracking
Imperial Valley, CA	2,142	Single-Axis Tracking
Toledo, OH	1,404	20-degree Fixed Tilt

1. A. Mermoud, “PVsyst: Photovoltaic Software,” Retrieved October 23, 2014 from www.pvsyst.com/en
2. “National Solar Radiation Database,” Retrieved December 6, 2011 from http://rredc.nrel.gov/solar/old_data/nsrdb/
3. D. Jordan, S. Kurtz “Photovoltaic Degradation Rates—an Analytical Review,” Progress in Photovoltaics: Research and Applications, vol. 21 pp. 12–29, 2013.

BOISE, ID

Figure 1. Boise, ID. AC:DC ratio of 1.1

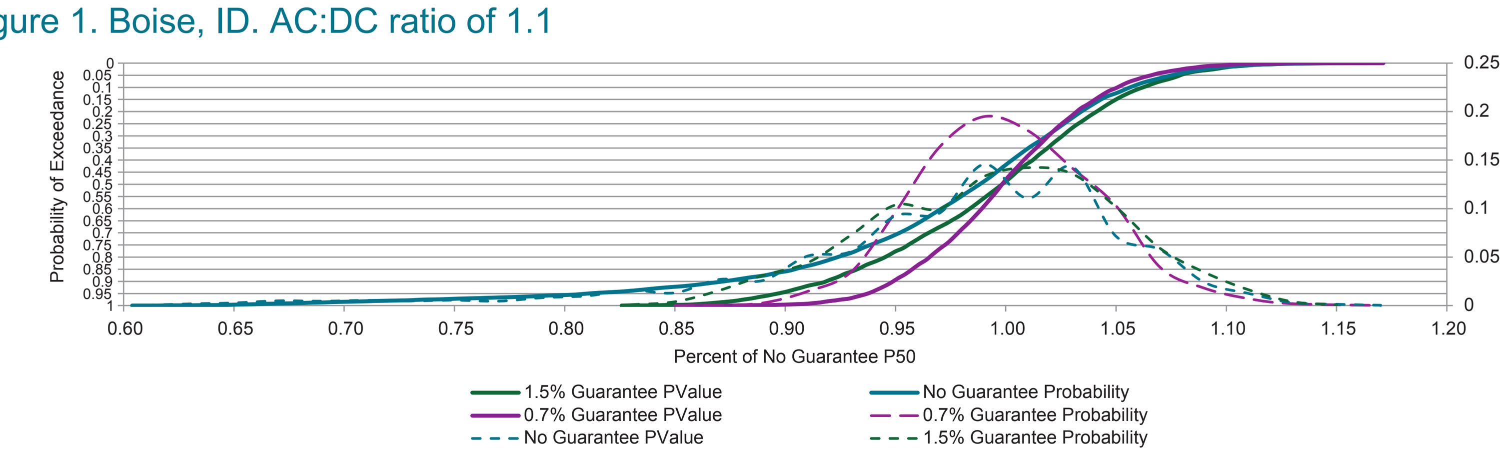
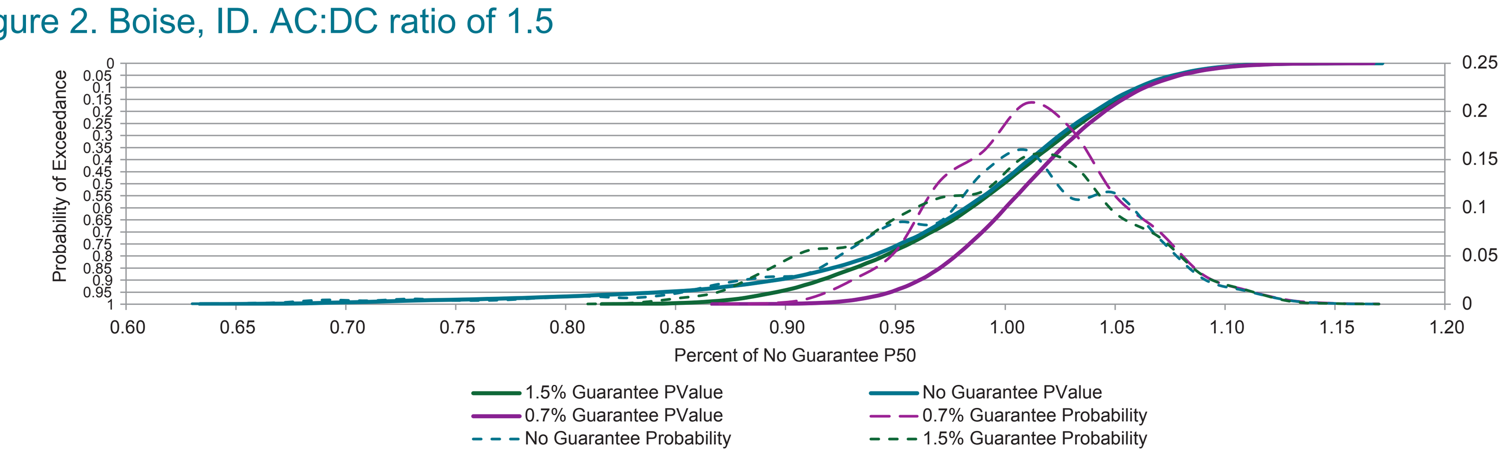


Figure 2. Boise, ID. AC:DC ratio of 1.5



IMPERIAL VALLEY, CA

Figure 3. Imperial Valley, CA AC:DC ratio of 1.1

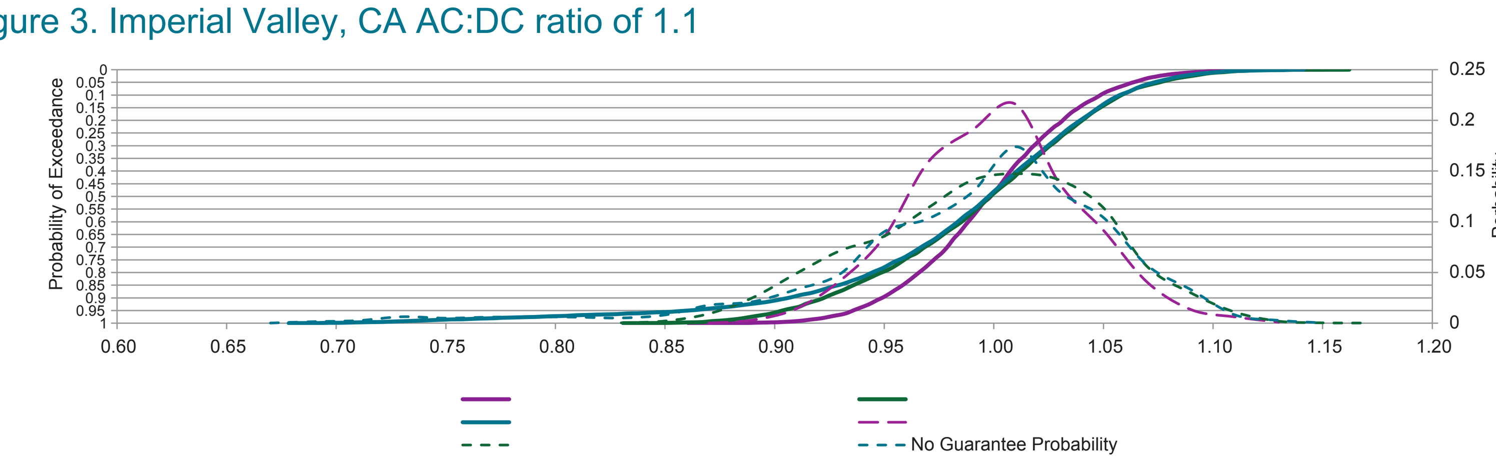
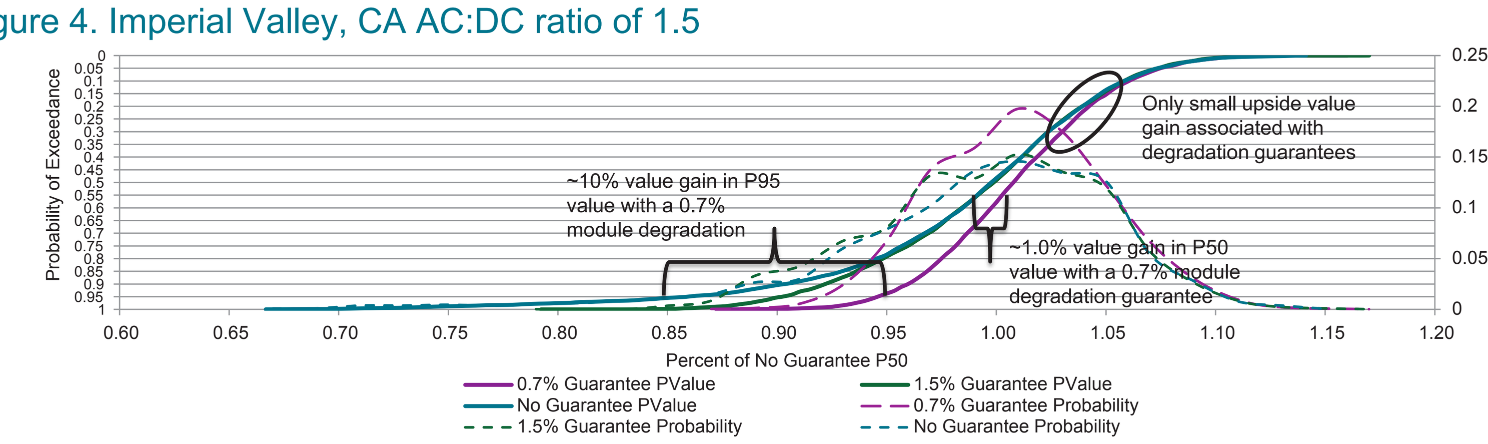


Figure 4. Imperial Valley, CA AC:DC ratio of 1.5



TOLEDO, OH

Figure 5. Toledo, OH. AC:DC ratio of 1.1

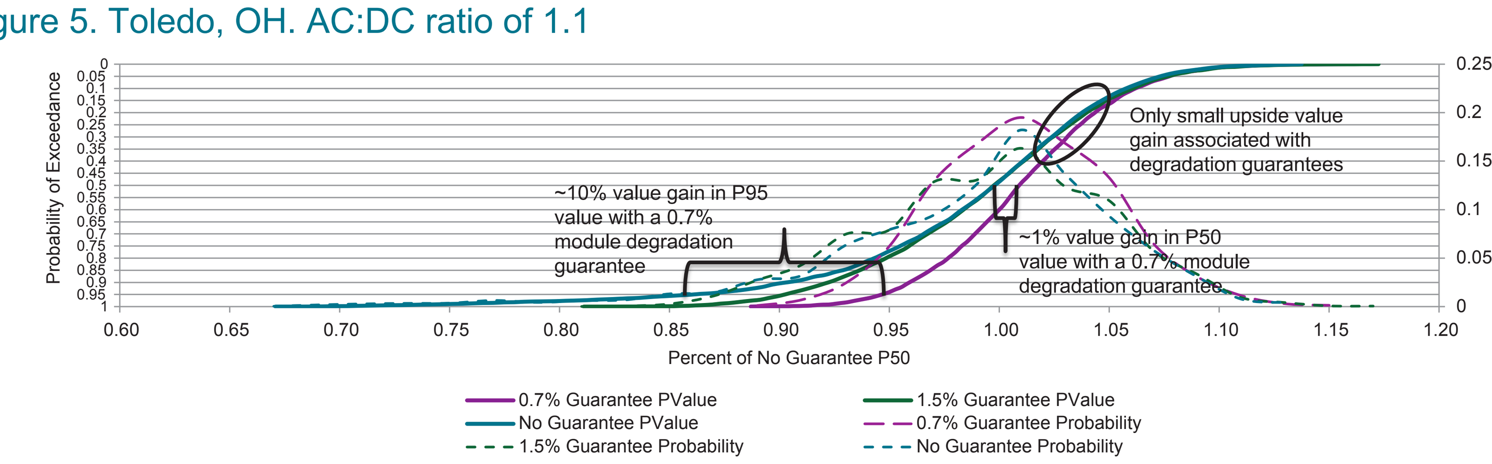
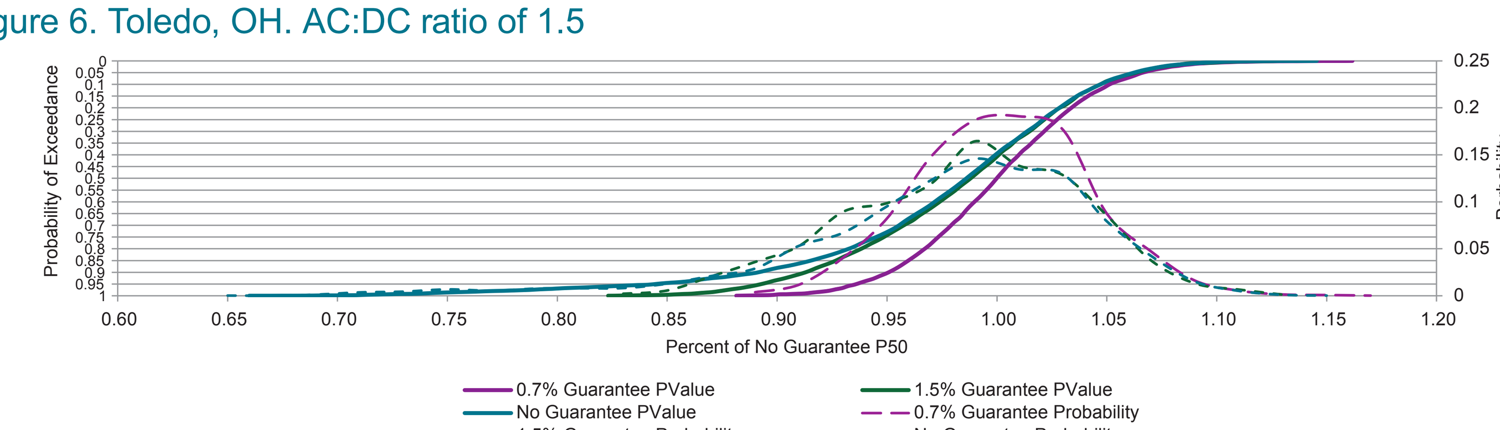


Figure 6. Toledo, OH. AC:DC ratio of 1.5



Selected Value Comparisons

Location	DC:AC Ratio	Guaranteed Deg. Rate (%/yr.)	PValue	Value Gain Respective to no warranty (%)
Boise, ID	1.1	0.7	P5	0.3
		0.7	P50	1.1
		0.7	P95	9.8
		1.5	P5	0.3
		1.5	P50	0.1
		1.5	P95	4.6
Boise, ID	1.5	0.7	P5	0.0
		0.7	P50	1.1
		0.7	P95	5.0
		1.5	P5	-0.1
		1.5	P50	1.1
		1.5	P95	5.3
Imperial Valley, CA	1.1	0.7	P5	0.0
		0.7	P50	1.0
		0.7	P95	9.7
		1.5	P5	0.0
		1.5	P50	0.0
		1.5	P95	4.6
Imperial Valley, CA	1.5	0.7	P5	0.0
		0.7	P50	1.0
		0.7	P95	9.7
		1.5	P5	0.0
		1.5	P50	1.0
		1.5	P95	4.9

Discussion

Limitations:

In this study, the we do not consider the cost of monitoring module degradation or enforcing the associated module warranties. Furthermore, it should be noted that the value of any guarantee is dependent on the stability and longevity of the entities backing the guarantee. We note that the pool of module degradation rates used to develop the distribution are not manufacturer or model specific. This is by design as module manufacturers are often not specified until late phase design. Similarly, the pool of degradation rates was developed over multiple decades, and may therefore, not represent the most contemporary modules.

Observations

We note that the greatest value of the module warranties occurs at the highest Probability of Exceedance Values (“PValues”) across all of the projects studied. This is significant as most projects are financed at PValues significantly larger P50. Conversely, there is much less upside gain as a result of the module warranties. Regarding the 95 percent PValues, we note the largest gains in value due to module warranty are generally at the lowest DC:AC ratio, except at the Imperial Valley site, where it is relatively consistent. The value gained at the 50 percent PValue is significantly less. These observations are indicated graphically on fig. 4-5. We therefore conclude that the study indicates that the value of module warranties will be best captured during the financing phase of the project because warranties significantly reduce the project risk, but have less effect on the 50 Percent PValue and project upside potential.

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