

DNV's Solar Energy Assessment Validation using SolarFarmer

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Agenda

Objectives

SolarFarmer

Energy Assessment Validation Methodology

Past Energy Assessment Validation Work

Current Energy Assessment Validation Work

Conclusions

Future Work

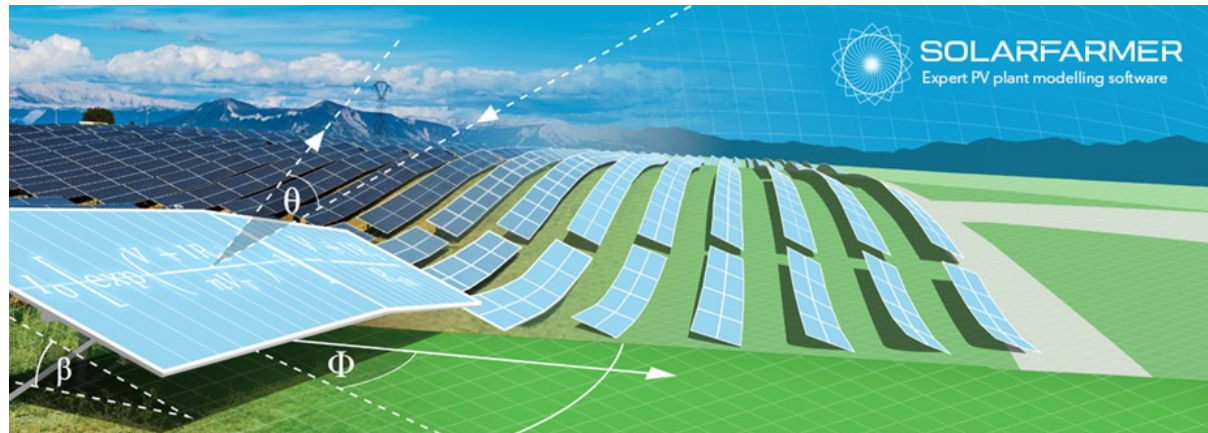
Objectives

- Continuously improve energy assessment methodology and aid in global energy transition
- Validate our energy assessment methodology every year
- Rerun validation using SolarFarmer instead of PVsyst as the solar modeling software



SolarFarmer

- SolarFarmer software combines thoroughly validated PV simulation algorithms with a user-friendly, modern interface allowing quick configuration and simulation of PV designs
- Need something that we can scale with increasing solar energy demand
 - Programmable – the back-end is available to us
 - API access
 - Batch processing abilities



DNV's EA Validation Methodology

- Gather Energy Information Administration (EIA) production data and/or project owner provided data
- Run pre-construction energy assessment on DNV's side
- Adjust actual production with irradiance correction

$$\text{Irradiance Correlation} = \frac{\sum_{i=1}^{12} \text{TMY Irradiation } \left(\frac{\text{kWh}}{\text{m}^2}\right)_i}{\sum_{i=1}^{12} \text{Historical Irradiation } \left(\frac{\text{kWh}}{\text{m}^2}\right)_i}$$

$$\text{Irradiance Adjusted Production (kWh)} = \text{Irradiance Correction} \times \text{Actual Production (kWh)}$$

where i = integer month

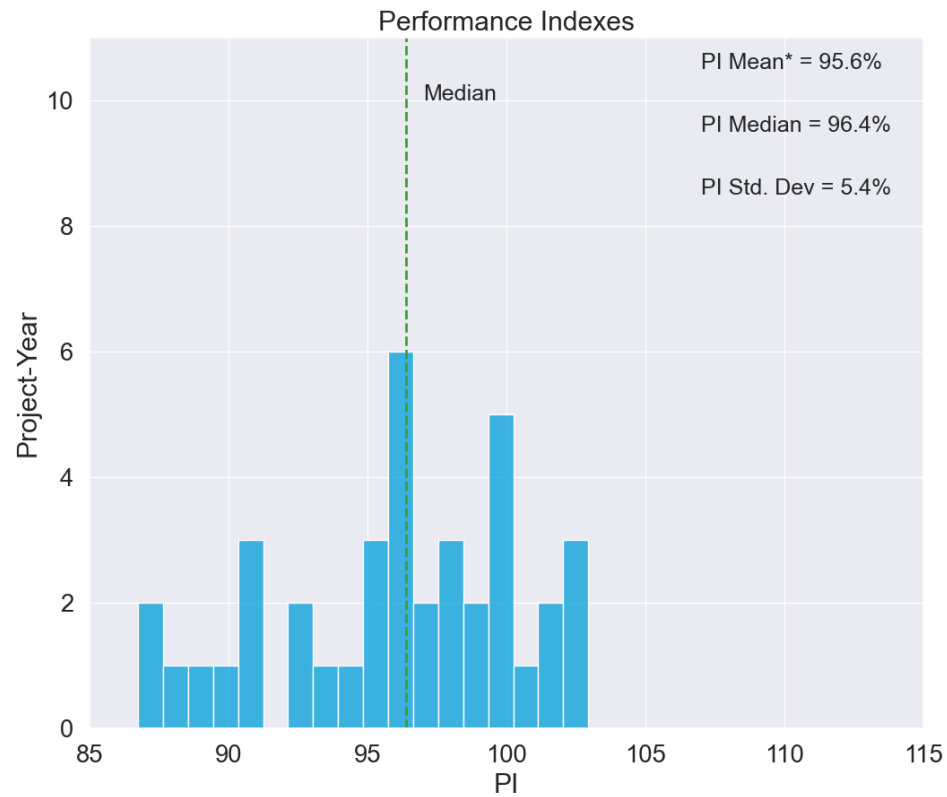
- Compare actual irradiance-corrected production data to DNV's own preconstruction energy estimates using a performance index to identify discrepancies in our modeling process

$$\text{Performance Index} = \frac{\text{Irradiance Adjusted Production (kWh)}}{\text{Estimated Production (kWh)}}$$

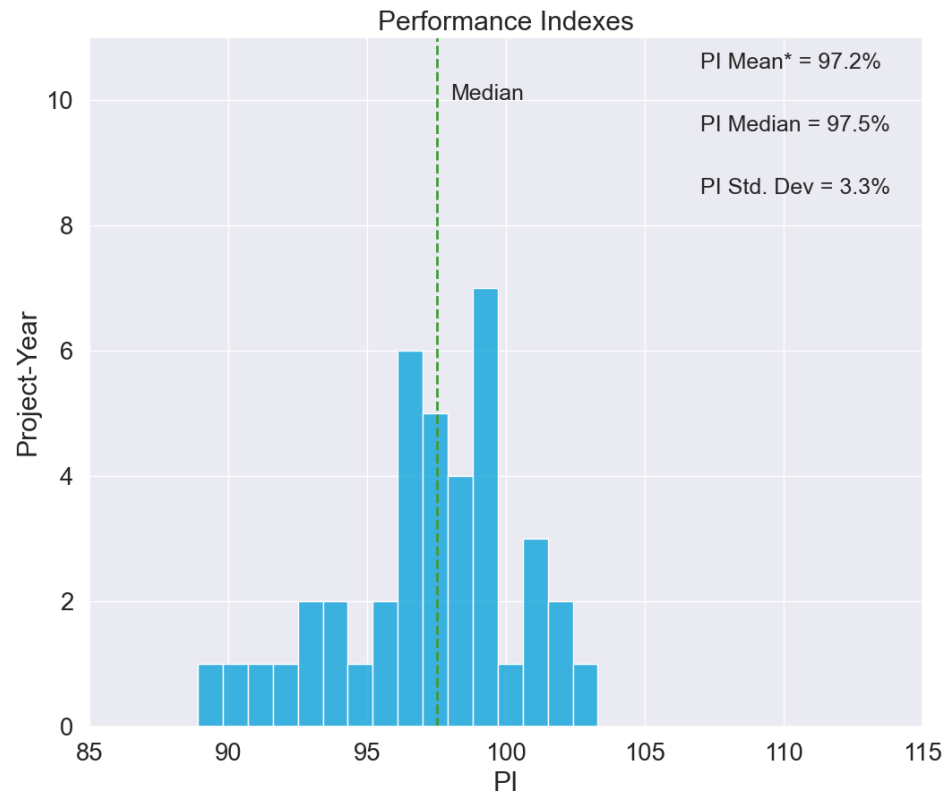
Past EA validation work

Validation	Sample Size (project years)	Median PI	Standard Deviation
2019 Validation	67 years	96.4%	5.4%
2019 Validation Addendum	67 years	97.5%	3.3%
2021 Validation	40 years	100.3%	3.2%
2021 Validation Addendum	43 years	99.9%	2.3%

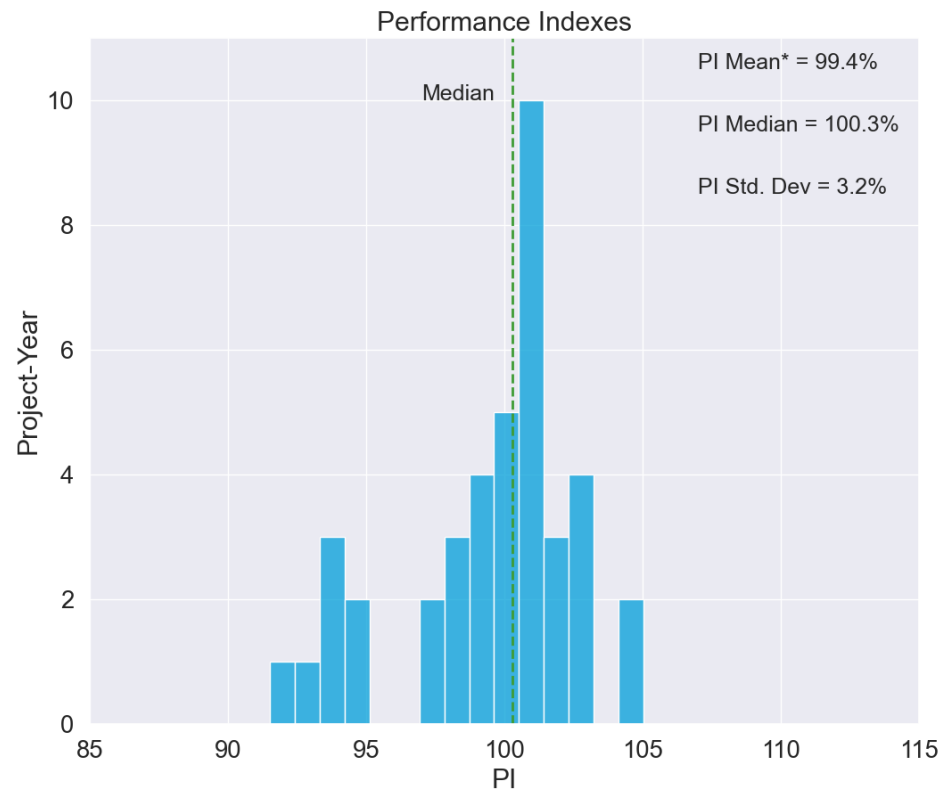
Past work – 2019 EA Validation



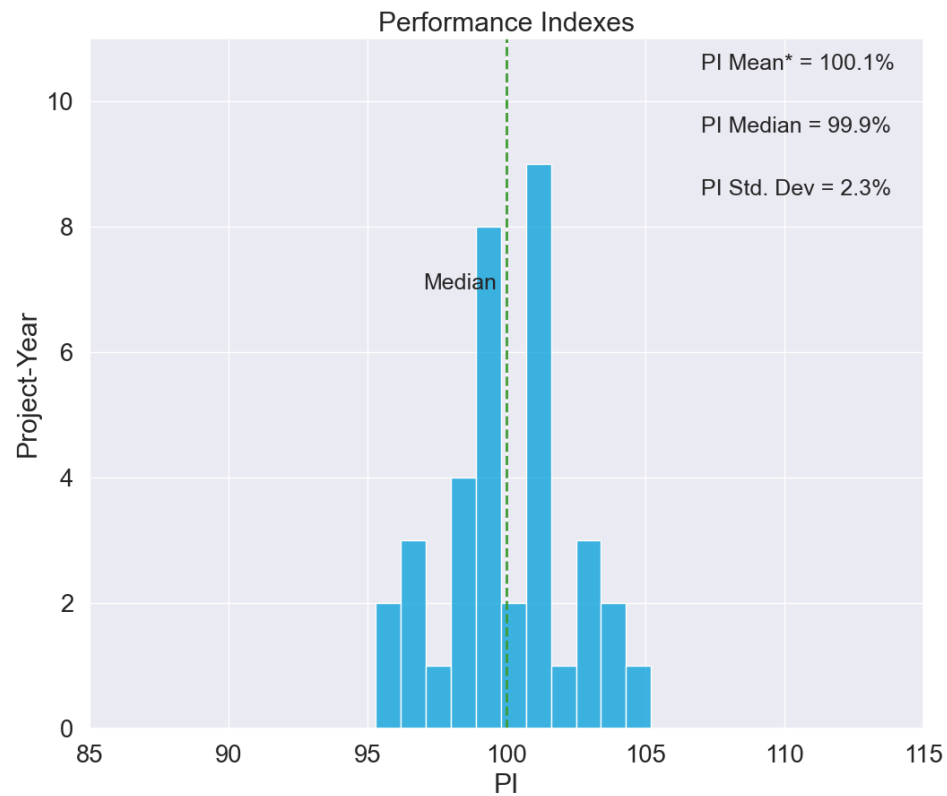
Past work – 2019 EA Validation Addendum



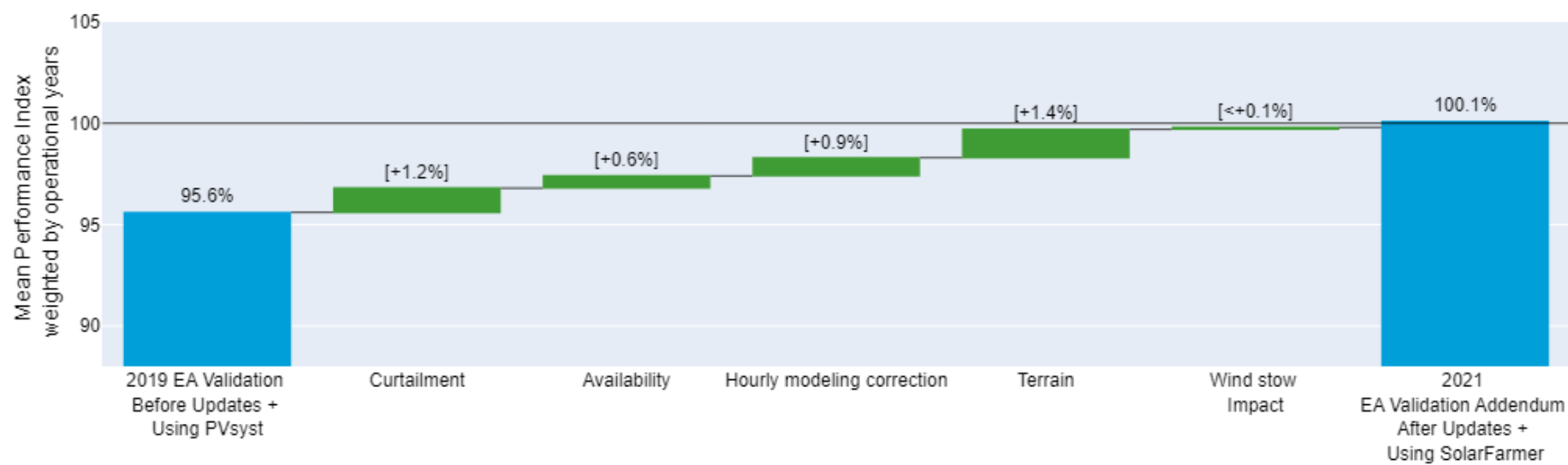
Past work – 2021 EA Validation



Addendum to 2021 EA Validation



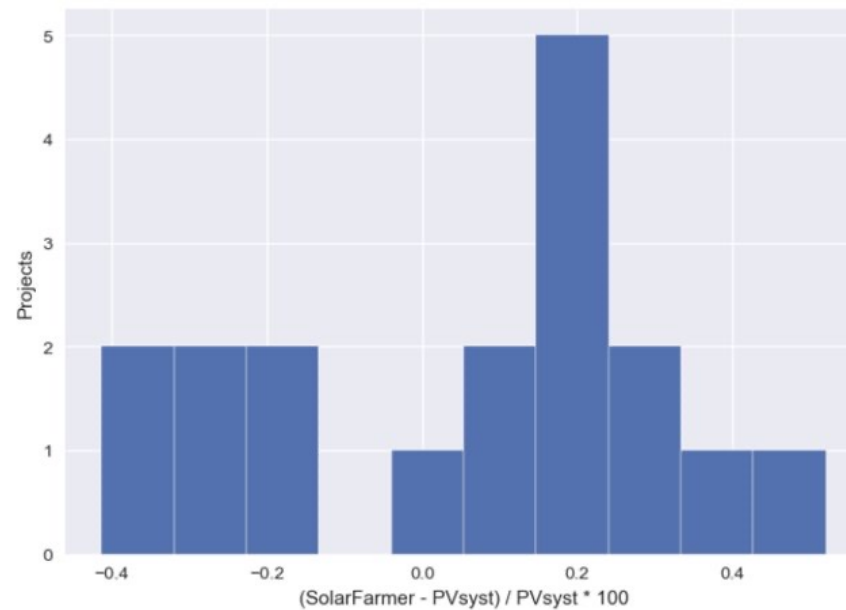
DNV EA Validation Updates



EA using SolarFarmer vs. EA using PVsyst

EA count	Mean	Median	Min / Max
18	0.06%	0.17%	-0.4% / 0.5%

- Project called for “base case” EA with variations for specific parameters:
 - Module (type + bifaciality)
 - Inverter
 - Ground tilt
 - Bifaciality factor
 - Albedo



	PAN 1	PAN 2	PAN 3	OND 1	OND 2	OND 3	1degN	1degS	2degN	2degS	3degN	3degS	50bi	60bi	75bi	10alb	25alb	30alb
Global incident in coll. Plane	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Far Shading/Horizon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Near Shading	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.1	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.0	-0.2	-0.2
IAM factor	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.2	0.3	0.2	0.3	0.3	0.3	0.2	0.3	0.3
Soiling/snow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bifacial contribution	0.0	0.0	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.3	0.1	0.4	0.5
Irradiance level	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
Temperature	-0.1	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Electrical effect	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Module Quality Factor	-0.2	-0.1	-0.0	-0.1	-0.1	-0.1	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Light induced degradation	0.0	0.0	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mismatch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DC Ohmic	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Inverter efficiency	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
Inverter over nominal inverter power	0.0	0.0	0.1	-0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.1	0.2	0.1	-0.1	0.0	-0.0	-0.1
Inverter due to power threshold	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
Inverter over nominal inverter voltage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Inverter due to voltage threshold	-0.0	-0.0	-0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
Inverter night consumption	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Inverter post-process losses	0.1	0.1	0.0	0.0	-0.0	-0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	-0.1	0.0	-0.1	-0.1
AC Ohmic	0.0	0.0	0.0	-0.0	-0.0	-0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.0	0.0	-0.0	-0.0
Transformer (1st level)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Transformer (2nd level)	-0.0	-0.0	-0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	0.0	0.0	0.0	0.0
Auxiliary Loads	-0.0	-0.0	-0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	0.0	0.0	0.0	0.0
Plant controller	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hourly modeling correction	-0.0	-0.0	-0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	0.0	-0.0	0.0	0.0
Availability loss	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gen-tie loss	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Year 1 - Generation [GWh/year]	0.4	0.3	0.1	-0.2	-0.3	-0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.5	0.1	-0.4	-0.0	-0.3	-0.4

Conclusions

- Median PI reduced by 0.4% from 2021 EA validation results
- Standard deviation reduced from 3.2% to 2.3%
- Tighter distribution with a smaller median PI gives DNV confidence in moving to using SolarFarmer exclusively in solar EAs

Future work

- Build confidence in SolarFarmer as bankable tool
 - Run SolarFarmer in parallel with PVsyst
- Incorporate SolarFarmer's sub-hourly and complex terrain abilities
- Continue EA validations
 - Increase number of projects, geographical and meteorological diversity
 - Automating validation process and continue to scale and improve
- DNV Solar EA exclusively uses SolarFarmer

WHEN TRUST MATTERS

Thank you!

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Addendum to 2021 EA validation – bifacial trackers

- 10 years of production data used
- Irradiance data measured at site – no irradiance correction

