PV energy yield estimates

How to calculate P75, P90, P95, and P99 energy yield estimates.

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Meet the host

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Agenda for today

01 Introduction

02 The Importance of Probabilistic Analysis

03 Calculating P75, P90, P95, and P99

04 Incorporating Uncertainty into Energy Yield: calculations

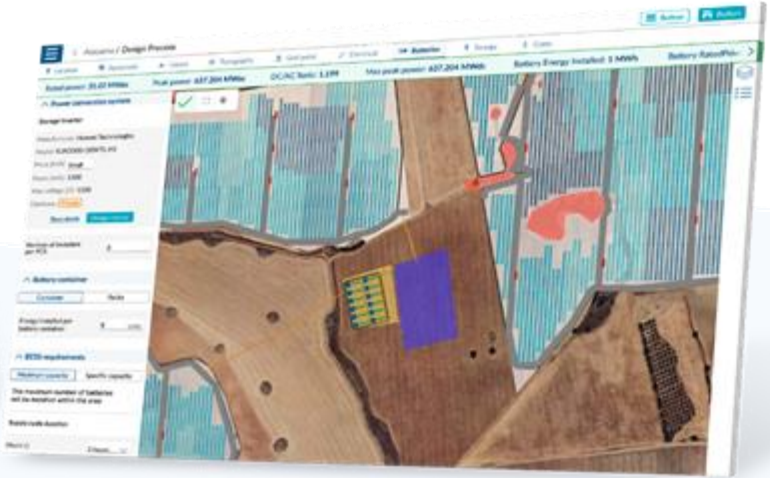
05 Conclusion

06 Q&A

Introduction

01

Overview of pvDesign



The Importance of Probabilistic Analysis

02

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Probabilistic Analysis

- More accurate and comprehensive understanding of potential energy yields
- Acknowledges and quantifies the inherent uncertainties associated with solar energy generation
- Empowers project developers to make informed decisions based on a range of possible outcomes
- It allows project developers to assess the project's performance under different scenarios, identify potential risks, and optimize project parameters to maximize energy production

Calculating P75, P90, P95, and P99

03

Energy Yield Estimates with pvDesign

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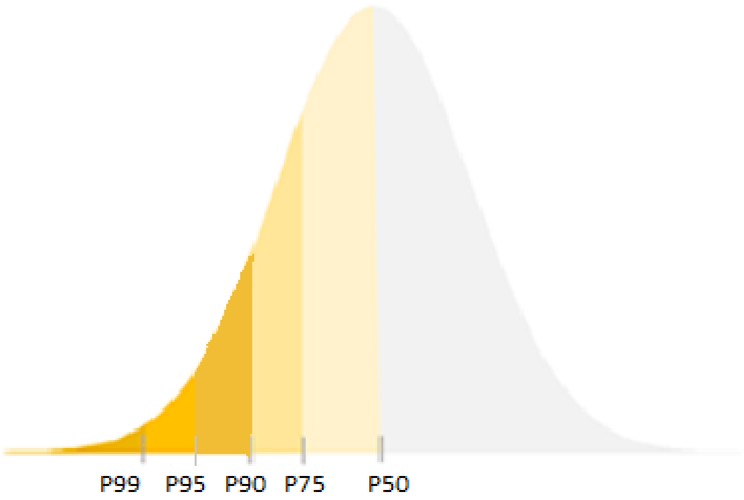
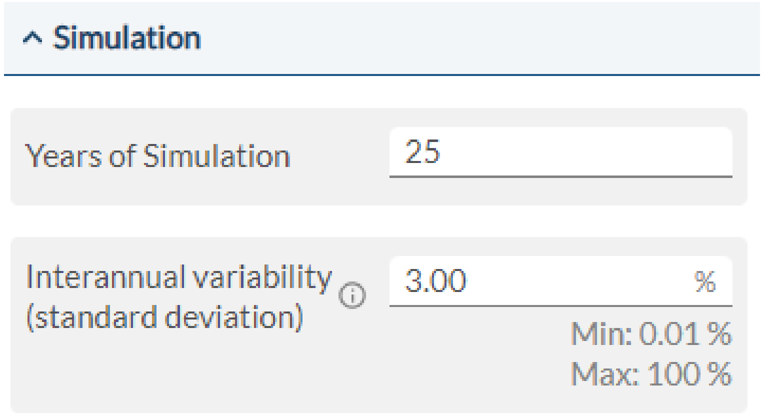
How pvDesign calculates P75, P90, P95, and P99 Energy Yield Estimates

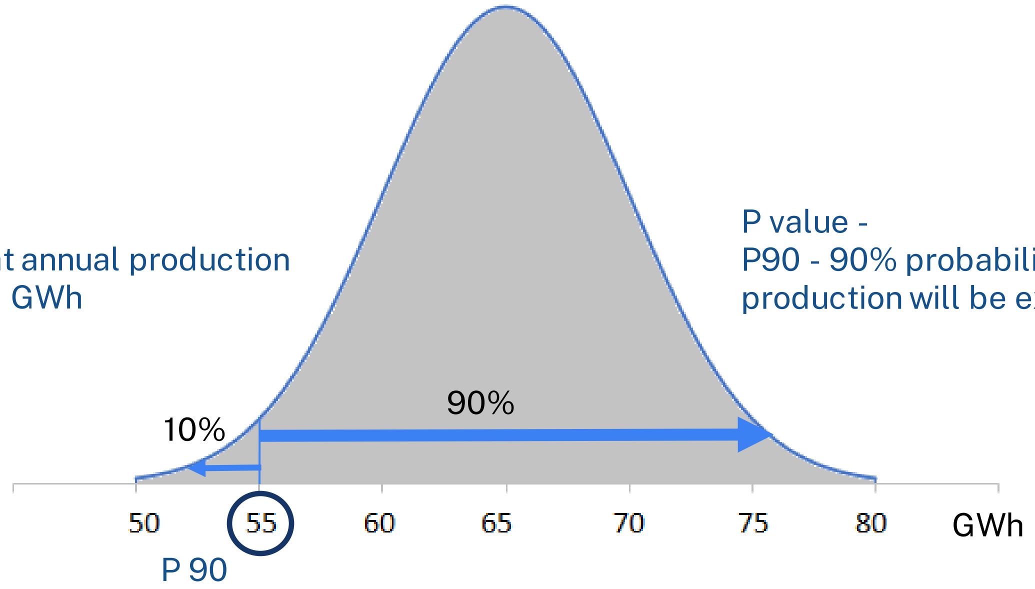




Mean value : P50
Standard deviation: input %

P value Vs. Probability

Probability -
10% probability that annual production will be less than 55 GWh



P value -
P90 - 90% probability that 55 GWh annual production will be exceeded

P-Value = (1- Probability)

Z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.50000	.50399	.50798	.51197	.51595	.51994	.52392	.52790	.53188	.53586
0.1	.53983	.54380	.54776	.55172	.55567	.55962	.56356	.56749	.57142	.57535
0.2	.57926	.58317	.58706	.59095	.59483	.59871	.60257	.60642	.61026	.61409
0.3	.61791	.62172	.62552	.62930	.63307	.63683	.64058	.64431	.64803	.65173
0.4	.65542	.65910	.66276	.66640	.67003	.67364	.67724	.68082	.68439	.68793
0.5	.69146	.69497	.69847	.70194	.70540	.70884	.71226	.71566	.71904	.72240
0.6	.72575	.72907	.73237	.73565	.73891	.74215	.74537	.74857	.75175	.75490
0.7	.75804	.76115	.76424	.76730	.77035	.77337	.77637	.77935	.78230	.78524
0.8	.78814	.79103	.79389	.79673	.79955	.80234	.80511	.80785	.81057	.81327
0.9	.81594	.81859	.82121	.82381	.82639	.82894	.83147	.83398	.83646	.83891
1.0	.84134	.84375	.84614	.84849	.85083	.85314	.85543	.85769	.85993	.86214
1.1	.86433	.86650	.86864	.87076	.87286	.87493	.87698	.87900	.88100	.88298
1.2	.88493	.88686	.88877	.89065	.89251	.89435	.89617	.89796	.89973	.90147
1.3	.90320	.90490	.90658	.90824	.90988	.91149	.91309	.91466	.91621	.91774
1.4	.91924	.92073	.92220	.92364	.92507	.92647	.92785	.92922	.93056	.93189
1.5	.93319	.93448	.93574	.93699	.93822	.93943	.94062	.94179	.94295	.94408
1.6	.94520	.94630	.94738	.94845	.94950	.95053	.95154	.95254	.95352	.95449
1.7	.95543	.95637	.95728	.95818	.95907	.95994	.96080	.96164	.96246	.96327
1.8	.96407	.96485	.96562	.96638	.96712	.96784	.96856	.96926	.96995	.97062
1.9	.97128	.97193	.97257	.97320	.97381	.97441	.97500	.97558	.97615	.97670
2.0	.97725	.97778	.97831	.97882	.97932	.97982	.98030	.98077	.98124	.98169
2.1	.98214	.98257	.98300	.98341	.98382	.98422	.98461	.98500	.98537	.98574
2.2	.98610	.98645	.98679	.98713	.98745	.98778	.98809	.98840	.98870	.98899
2.3	.98928	.98956	.98983	.99010	.99036	.99061	.99086	.99111	.99134	.99158
2.4	.99180	.99202	.99224	.99245	.99266	.99286	.99305	.99324	.99343	.99361
2.5	.99379	.99396	.99413	.99430	.99446	.99461	.99477	.99492	.99506	.99520
2.6	.99534	.99547	.99560	.99573	.99585	.99598	.99609	.99621	.99632	.99643
2.7	.99653	.99664	.99674	.99683	.99693	.99702	.99711	.99720	.99728	.99736
2.8	.99744	.99752	.99760	.99767	.99774	.99781	.99788	.99795	.99801	.99807
2.9	.99813	.99819	.99825	.99831	.99836	.99841	.99846	.99851	.99856	.99861
3.0	.99865	.99869	.99874	.99878	.99882	.99886	.99889	.99893	.99896	.99900
3.1	.99903	.99906	.99910	.99913	.99916	.99918	.99921	.99924	.99926	.99929
3.2	.99931	.99934	.99936	.99938	.99940	.99942	.99944	.99946	.99948	.99950
3.3	.99952	.99953	.99955	.99957	.99958	.99960	.99961	.99962	.99964	.99965
3.4	.99966	.99968	.99969	.99970	.99971	.99972	.99973	.99974	.99975	.99976

	Formula
P75 uncertainty	0.675*STDEV
P90 uncertainty	1.282*STDEV
P99 uncertainty	2.326*STDEV

	Probability of exceedance	Formula
P75 value	75%	P50 value *(1- P75 uncertainty)
P90 value	90%	P50 value *(1- P90 uncertainty)
P99 value	99%	P50 value *(1-P99 uncertainty)

Incorporating Uncertainty into Energy Yield

Calculations

04

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Sources of uncertainty in energy yield calculations

Interannual Variability

- While the Typical Meteorological Year (TMY) provides a representative or "typical" year for solar resource assessment, actual meteorological conditions can vary from year to year.
- The standard deviation quantifies the extent of this variability, reflecting the instability of weather patterns. This interannual variability is a primary source of uncertainty and contributes significantly to the overall uncertainty in energy yield estimates

Uncertainty of the Energy Simulation Model

- Energy simulation models used to estimate energy yields rely on various assumptions and empirical equations.
- The standard deviation represents the acceptable level of error or uncertainty associated with the simulation model's methodologies.
- This includes factors such as equipment performance estimation, losses due to shading, soiling, and other operational aspects.
- The standard deviation encompasses the range of potential deviations from the expected energy yield due to these uncertainties.

Sources of uncertainty in energy yield calculations

Uncertainty of the Meteorological Data Model:

- The methodology used to calculate Global Horizontal Irradiance (GHI), a critical parameter for solar energy estimation, has inherent limitations and potential errors.
- The standard deviation captures the permissible margin of error in the meteorological data model employed for GHI calculations. It accounts for uncertainties related to data collection, measurement techniques, and interpolation methods used in generating the meteorological dataset.

$$U_{total} = \sqrt{U_{model}^2 + U_{simulation}^2 + U_{interannual}^2}$$

Uncertainties input in pvDesign

Meteo data

How to

Upload meteo

Currently selected

- TMY_B — GHI: 1749 kWh/m2 — Show details

Rest of the meteo

- TMY_A — GHI: 1757.63 kWh/m2 — Show details
- PVGIS — GHI: 1757.63 kWh/m2 — Show details
- NASA_POWER — GHI: 1659.2 kWh/m2 — Show details
- NASA_SSE — GHI: 1663.72 kWh/m2

PV module losses

First Year Degradation	0.30	%
Yearly Degradation	0.30	%
Module Quality	-0.70	%
Light Induced Degradation (LID)	2.00	%
Mismatch	1.00	%
Bifacial Mismatch	10.00	%

Simulation

Years of Simulation	25	
Interannual variability (standard deviation)	3.00	%

Min.: 0.01 %
Max.: 100 %

Soiling losses

Front face

- Yearly soiling losses: 2.00 %
- Monthly soiling losses

Back face

- Yearly soiling losses: 0.00 %
- Monthly soiling losses

pvDesign probabilistic yield output

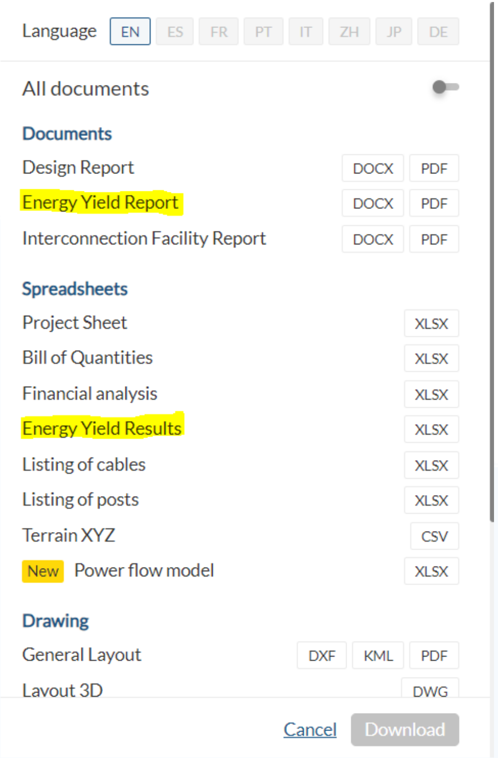


Table 23. Probabilistic yield estimation

Probability	Energy yield [GWh]
P50	80.0
P75	77.5
P90	75.3
P95	73.9
P99	71.4

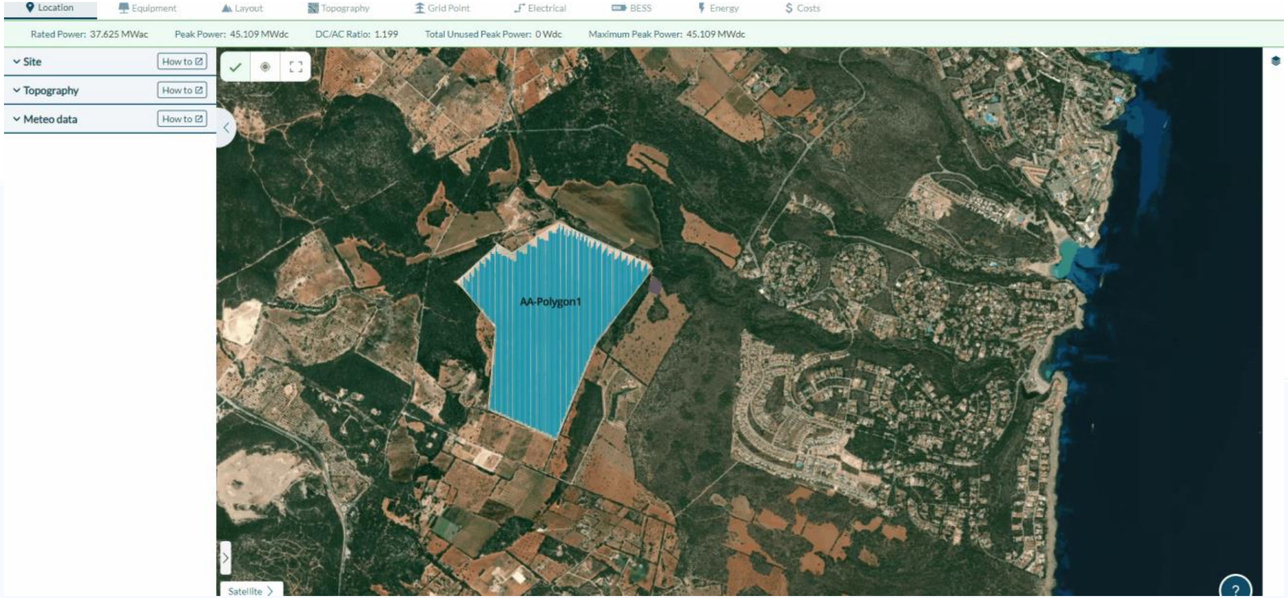
ENERGY YIELD - PROBABILISTIC STUDY, σ = 3.00 %

Probability	Energy
P50	79.50 GWh
P75	77.90 GWh
P90	76.40 GWh
P95	75.60 GWh
P99	74.00 GWh

Example Project: Solar Power Plant with Uncertainty Analysis

1. Project Overview:

- **Location:** Choose a location with known variability in weather conditions.
- **System Capacity**: Select a suitable system capacity.



Example Project: Solar Power Plant with Uncertainty Analysis

2. Data Selection and simulation:

- **Input Meteorological Data**: Select two different Models for the Metorological data.

Model A: TMY_A with a standard deviation of **10.0%**

Results:

ENERGY YIELD - PROBABILISTIC STUDY, σ = 10.00 %

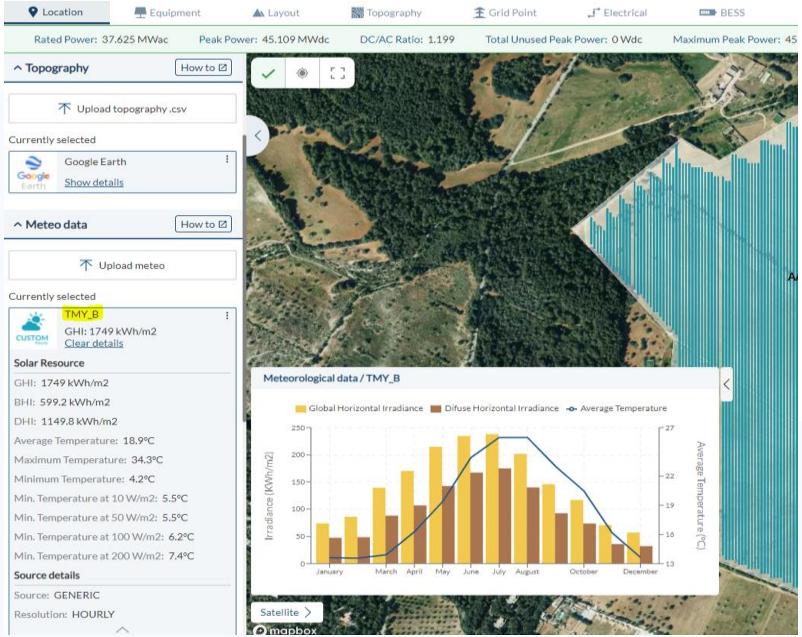
Probability	Energy
P50	84.30 GWh
P75	78.60 GWh
P90	73.50 GWh
P95	70.50 GWh
P99	64.70 GWh

Example Project: Solar Power Plant with Uncertainty Analysis

2. Data Selection and simulation:

- **Input Meteorological Data**: Select two different Models for the Metorological data.

Model B: TMY_B with a standard deviation of **4.60%**



Results:

ENERGY YIELD - PROBABILISTIC STUDY, σ = 4.60 %

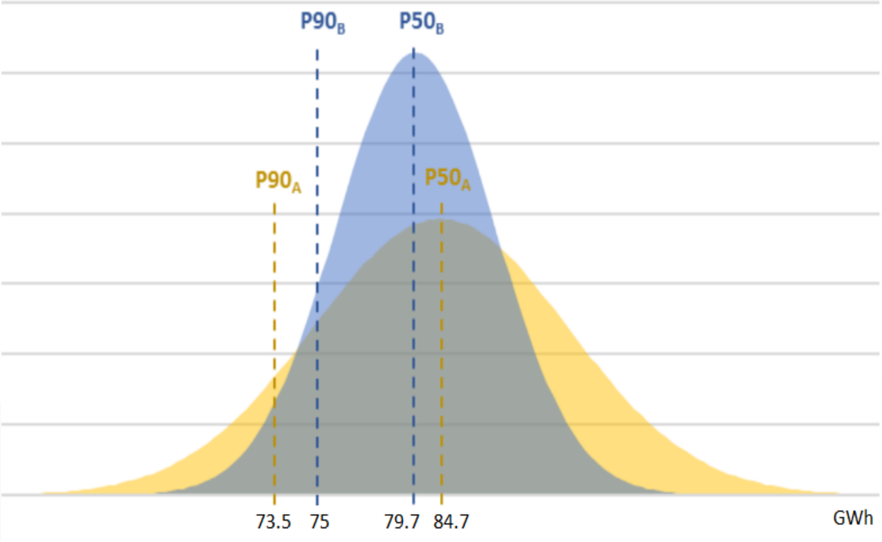
Probability	Energy
P50	79.70 GWh
P75	77.20 GWh
P90	75.00 GWh
P95	73.60 GWh
P99	71.10 GWh

Example Project: Solar Power Plant with Uncertainty Analysis

3. Comparison

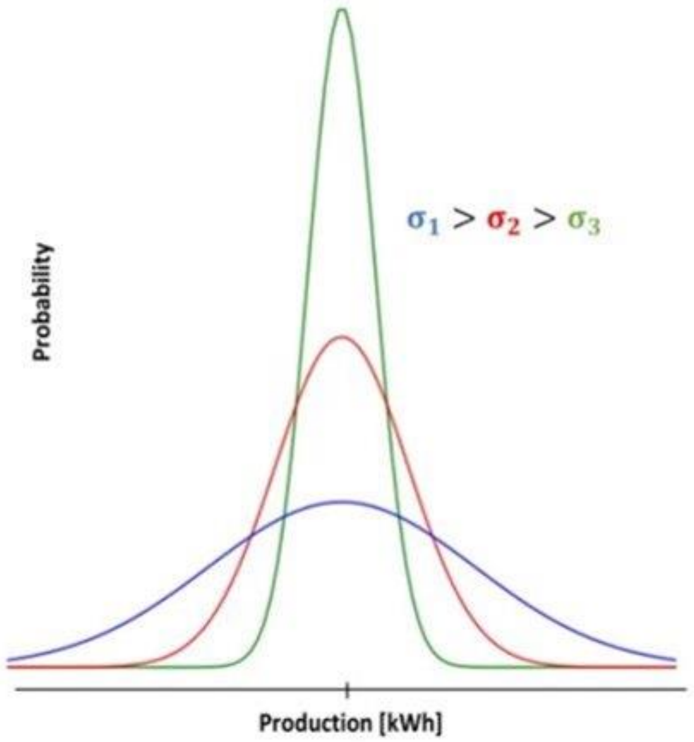
The sample shows that even in the case that **P50 value provided by model B is lower than model A**, the difference **in terms of uncertainty** results in **model B providing more favorable financial conditions** for the project, with a **P90 value that is higher.**

Model	A	B
TMY	Source A	**Source B**
Standard deviation	**10.0%**	4.6%
Most expected value (P50)	**84.3 GWh**	79.70 GWh
P90	73.5 GWh	**75.00 GWh**



Discussion and analysis

- The lower your sigma, the narrower the Gauss bell will be.
- Good models have known and lowest possible uncertainty.
- Performance Optimization
- Importance of uncertainties
- Financial Considerations



Conclusion

05

Q&A

06

Questions? We're all ears

Please, use the questions box in the GoToWebinar control panel to ask me any doubt you may have.