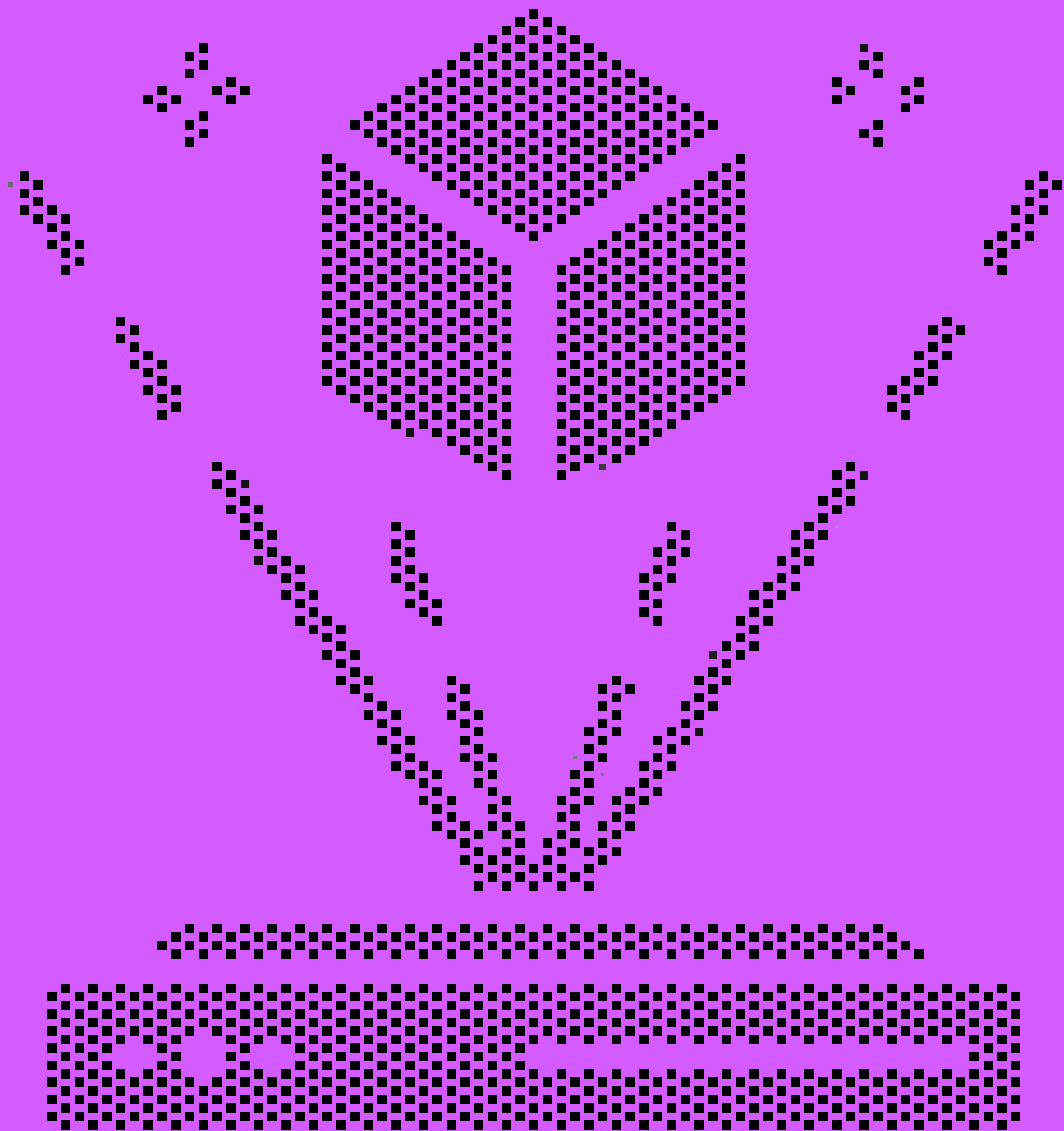
PVCASE YIELD

PRODUCT GUIDE

Revolutionizing solar energy modeling with advanced technology



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Introduction

The solar energy industry is experiencing rapid growth, driven by increasing demand for clean and sustainable power generation. As the sector expands, developers, investors, and operators require accurate tools to estimate the energy yield of photovoltaic (PV) power plants and make informed decisions about project design and financial returns. However, conventional energy yield simulation software often relies on simplified models and manual adjustments, leading to potential inaccuracies and inefficiencies.

That's where comprehensive PVcase Yield emerges as a game-changer in this landscape, offering a cutting-edge solution that combines 3D designs with physics-based energy yield estimation models. This product guide explores the key features, benefits, and validation of PVcase Yield and demonstrates how it revolutionizes solar energy prediction and optimizes PV plant design and operation.

The pitfalls of conventional yield modeling

Traditional energy yield modeling approaches often have limitations that can compromise the accuracy and efficiency of solar project estimations. The oversimplification of PV plant models, particularly for bifacial and single-axis tracker systems on undulating terrain, can lead to inaccurate energy yield predictions. Furthermore, the reliance on manual adjustments and tweakable parameters introduces the risk of human error and makes it challenging to reproduce simulation results.

Introducing PVcase Yield: digital twin-based PV performance simulation

PVcase Yield addresses the shortcomings of conventional methods by directly integrating with detailed PV asset digital twins. A digital twin is a virtual representation of a physical asset that contains all the necessary information to simulate its behavior and performance. By leveraging digital twin technology, PVcase Yield streamlines the simulation process, minimizes manual input, and reduces the risk of errors.

Key features and benefits

PVcase Yield boasts a range of powerful features that set it apart from traditional solar energy modeling software:

1. Digital twin integration: seamlessly imports data from design files, including 3D models, topography, electrical design, and component characteristics. This capability eliminates the need for manual data entry and ensures that the simulation model accurately reflects the real-world PV plant.

2. Physics-based modeling: PVcase Yield employs a "grey-box" approach using physics-based models, eliminating the need for prior experimental calibration. Therefore, PVcase Yield is adaptable to various PV technologies and site conditions without extensive customization.

3. Advanced ray tracing: accurately calculates incident irradiance on both the front and back sides of modules, considering partial shading and ground-reflected irradiance. Thanks to this level of detail, users can accurately predict the energy yield of bifacial systems and optimize plant layouts.

4. Integrated electrical-optical-thermal model: runs simulations at fine-grain temporal and spatial resolutions to capture non-stationary and non-uniform effects. A comprehensive model accounts for the interplay between electrical, optical, and thermal factors, providing a more realistic representation of PV plant performance.

5. Machine learning for efficiency: utilizes machine learning algorithms to analyze layouts and eliminate redundant calculations, resulting in up to 10x faster computation times. This allows for rapid simulation of even large utility-scale PV plants without compromising accuracy.

These features translate into significant benefits for solar project developers, investors, and operators:

01

Better accuracy

Reduces reliance on tweakable parameters and manual adjustments, leading to more precise energy yield estimations.

02

Increased efficiency

Streamlines the simulation process which ultimately saves time and resources.

03

Enhanced transparency

Clearly displays all simulation parameters on reports, improving reproducibility and facilitating collaboration.

04

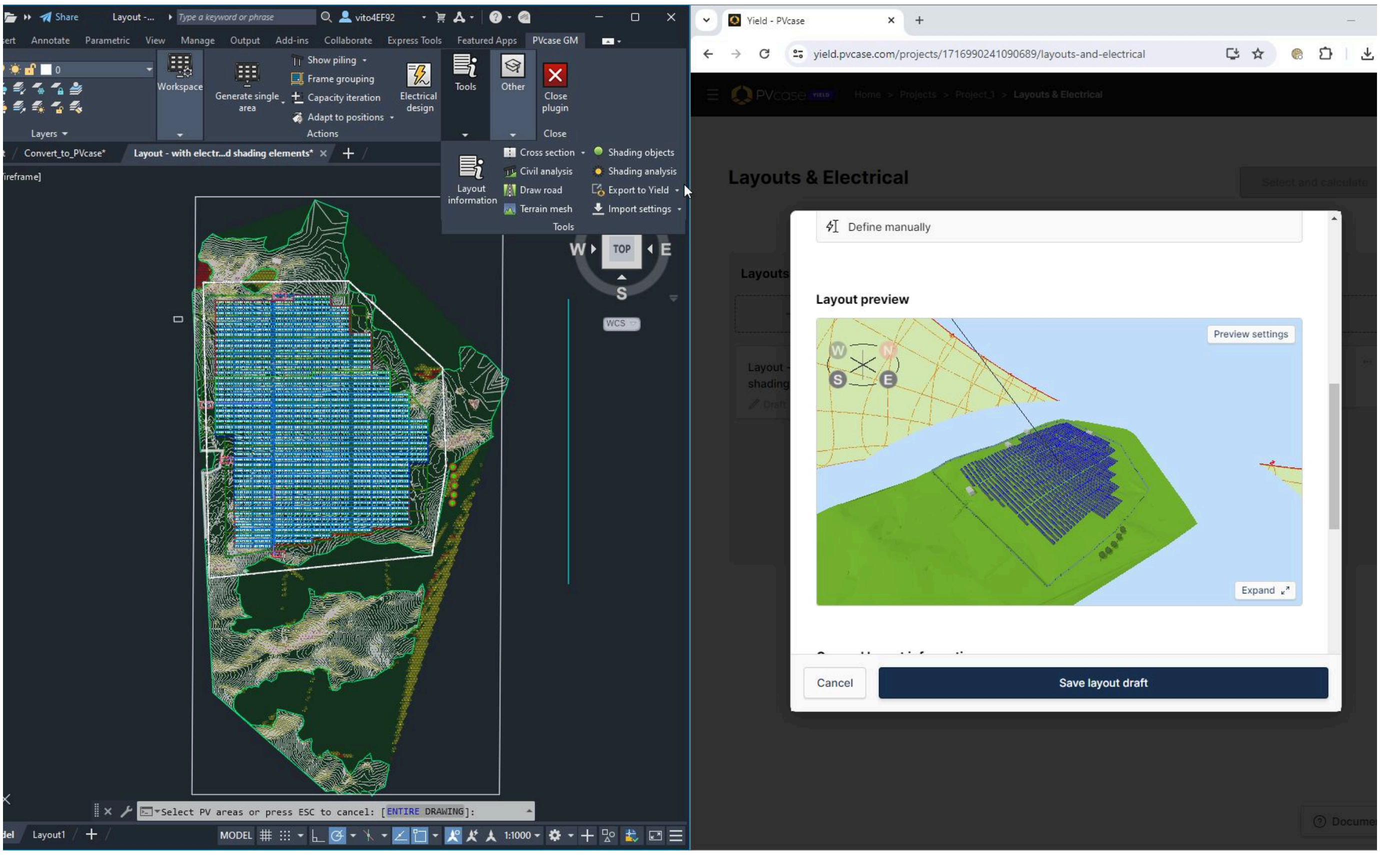
Enhanced transparency

Suitable for different project stages, from early-stage feasibility studies to detailed design.

05

Flexibility

Supports various PV technologies, including mono-facial and bifacial modules, fixed-tilt and tracking systems, crystalline silicon, and thin-film PV technologies.



Intuitive user interface and cloud computing

PVcase Yield features an intuitive and straightforward web-based user interface that makes it easy for solar engineers and developers to set up and run simulations. The cloud computing capabilities further enhance the user experience by enabling multiple simulations to be launched simultaneously without consuming local device resources. This allows for efficient exploration of different design configurations and optimization strategies.

Advanced ray tracing for accurate shading analysis

Ray tracing is a lighting simulation technique that follows individual light rays between the sky and the solar cell surfaces, taking interactions with the detailed 3D scene into account.
PVcase Yield leverages ray tracing to accurately simulate how different aspects of a 3D PV plant model affect energy generation. This includes the impact of localized shading on string illumination and electrical mismatch losses, the influence of terrain-following frame placement on module orientation and row-to-row shading, and the effect of frame geometry, torque tubes, sun position, and ground albedo on bifacial performance.

Compared to 2D view factor-based models, 3D ray tracing-based modeling offers several advantages:

Preserves 3D layout information:

simulates the PV plant as it is designed without reducing it to a 2D representation.

Handles complex terrain:

accurately accounts for hilly terrain.

Efficient computation:

computation time is unaffected by geometry complexity.

Versatile reflection models:

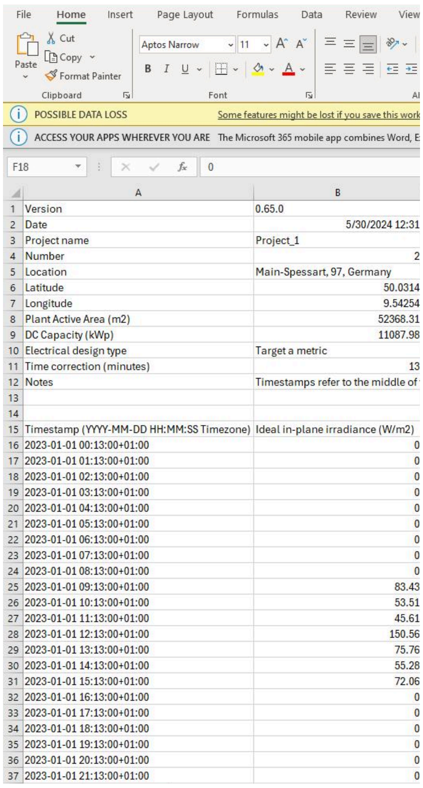
can incorporate a variety of surface reflection models for more realistic simulations.

Validation and benchmarking

PVcase Yield has undergone rigorous validation and benchmarking studies to ensure its accuracy and reliability.

Validation

The software has been validated against real-world data from various sources, including:



	A	B
1	Version	0.65.0
2	Date	5/30/2024 12:31
3	Project name	Project_1
4	Number	2
5	Location	Main-Spessart, 97, Germany
6	Latitude	50.0314
7	Longitude	9.54254
8	Plant Active Area (m2)	52368.31
9	DC Capacity (kWp)	11087.98
10	Electrical design type	Target a metric
11	Time correction (minutes)	13
12	Notes	Timestamps refer to the middle of
13		
14		
15	Timestamp (YYYY-MM-DD HH:MM:SS Timezone)	Ideal in-plane irradiance (W/m2)
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17	2023-01-01 01:13:00+01:00	0
18	2023-01-01 02:13:00+01:00	0
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37	2023-01-01 21:13:00+01:00	0

1. **Large utility-scale PV plant in Spain:** this study demonstrated good agreement between simulated and measured results, with an nMBE of -0.5% (underestimation) and nRMSE of 9.2% at 15-minute resolution.

2. **Outdoor lab-scale installation in Italy:** it showed an nMBE of 1.13% (overestimation) and nRMSE of 3.27% at 1-hour resolution.

3. **Datasets from Denmark Technical University (DTU):** PVcase Yield's irradiance and temperature simulations closely matched measurements from four systems combining fixed tilt, HSAT, monofacial, and bifacial technologies.

4. **Datasets from National Renewable Energy Laboratory (NREL):** the software showed high accuracy in irradiance and temperature simulations, with minor biases observed in module temperature estimation.

These studies confirm that PVcase Yield can accurately predict the energy yield of various PV systems under different conditions.

Benchmarking

PVcase Yield has been benchmarked against PVsyst, an established industry-standard software, in a **Black & Veatch Benchmarking Study.**

This third-party study compared PVcase Yield and PVsyst on four separate design/technology cases, including fixed tilt and single-axis tracker configurations with monofacial and bifacial modules.

- **Comparable performance:** the results showed comparable performance between the two software packages, with differences mainly attributed to variations in input data and specific model assumptions.

- **Differences in energy yield:** the differences between the energy injected into the grid for the first year of operation computed by Yield and PVsyst ranged from 0.24% to 2.4%.

- **Consistent differences:** some consistent differences were observed in specific loss terms, such as front side transposition gain, front side near shading, IAM losses, low light losses, and transformer losses.

Overall, the benchmarking study confirmed the accuracy and reliability of PVcase Yield compared to an industry-standard tool.

Collaboration with Imec

PVcase Yield was co-developed with Imec, a world-leading research and innovation hub in nanoelectronics, leveraging their extensive R&D expertise in physics-based PV energy yield simulation. This collaboration ensures that PVcase Yield is built on a solid foundation of scientific knowledge and benefits from the latest advancements in PV modeling technology.

Conclusion

PVcase Yield represents a paradigm shift in solar energy prediction, offering a user-friendly, accurate, and efficient solution for optimizing PV power plant design and operation. By seamlessly integrating with digital twins, utilizing physics-based models, and leveraging advanced ray tracing and machine learning techniques, PVcase Yield empowers solar project developers, investors, and operators with the tools they need to make informed decisions and maximize the potential of their solar assets.

References

- **PVPMC workshop in 2023**
- **B&V independent benchmarking report**
- **TRUST-PV**

About PVcase

PVcase is moving solar forward with an alternative to the traditional labor-intensive, time-consuming, and error-prone solar project development process. Our end-to-end solar development platform connects site selection, PV design, and yield estimation. In doing so, we're not only helping solar teams achieve maximum results in a fraction of the time, we're accelerating the global transition to clean energy. PVcase ends clunky processes and corrupted data to clear the path to a net-zero economy.

Whether you use a single product or plug into the entire platform, PVcase makes you faster, more precise, and more productive at every stage of solar project development. PVcase is a leading choice for solar energy professionals, and the results speak for themselves. Our platform supports over 1,500 customers in 75+ countries, powering the development of more than 4 TW of projects a year.

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