PVcase

Integrating 3D PV design and yield simulation: challenges and opportunities

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We are PVcase

Our focus on automation and accuracy from the earliest stages of planning, incorporating 3D topographical data points to simulate the actual location of the solar plant, allows our customers to be able to compete for and win more projects by delivering greater yields.

GROUND MOUNT PVcase

10GW+
Projects designed

500+
Clients

50+
Countries

Agenda

01 Digital interoperability

02 PVcase Yield

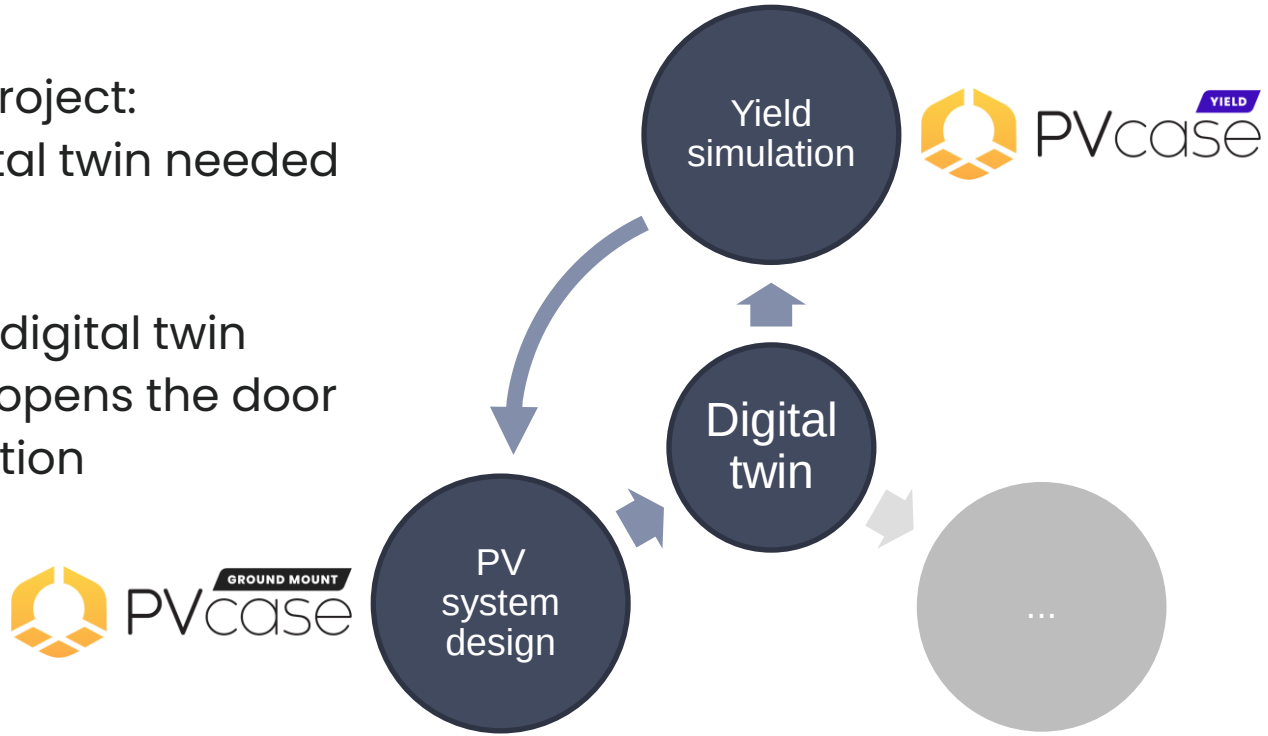
03 Bifacial PV simulation examples

04 Conclusions & Future dev

Digital interoperability in PV

PVcase: from design to Yield

- H2020 TRUST-PV project:
  interoperable digital twin needed
- Our view:
  Sharing the same digital twin
  across processes opens the door
  to process integration



TRUSTPV
SOLAR PV, PERFORMANCE & RELIABILITY

TRUST-PV consortium, “Building Information Model (BIM) requirements and design for the operational phase,” Deliverable report, 2021. [Online]. Available: https://trust-pv.eu/wp-content/uploads/2021/10/TRUST-PV_T3p4_report_Final.pdf

Goals of integration

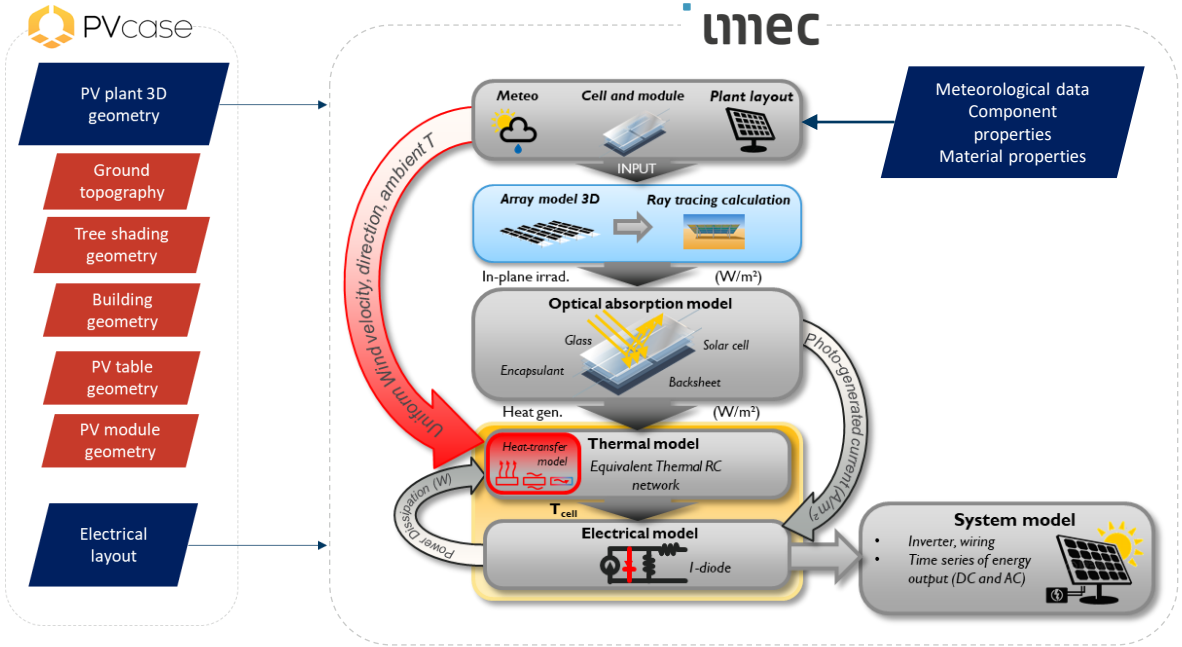
- Easy access to energy yield assessment in the engineering & design phase:
  - **Unlock *energy yield* as a quantitative design variable**

- Create technology-agile, software to drive PV technology innovation
  - Physics-based models (as opposed to empirical ones) have a large range of validity
    - 3D ray tracing enables bifacial irradiance simulations and extension to Agri-PV
    - Circuit-based electrical simulations enable mismatch simulation (non-uniformity)

Introduction to PVcase Yield

Technology background

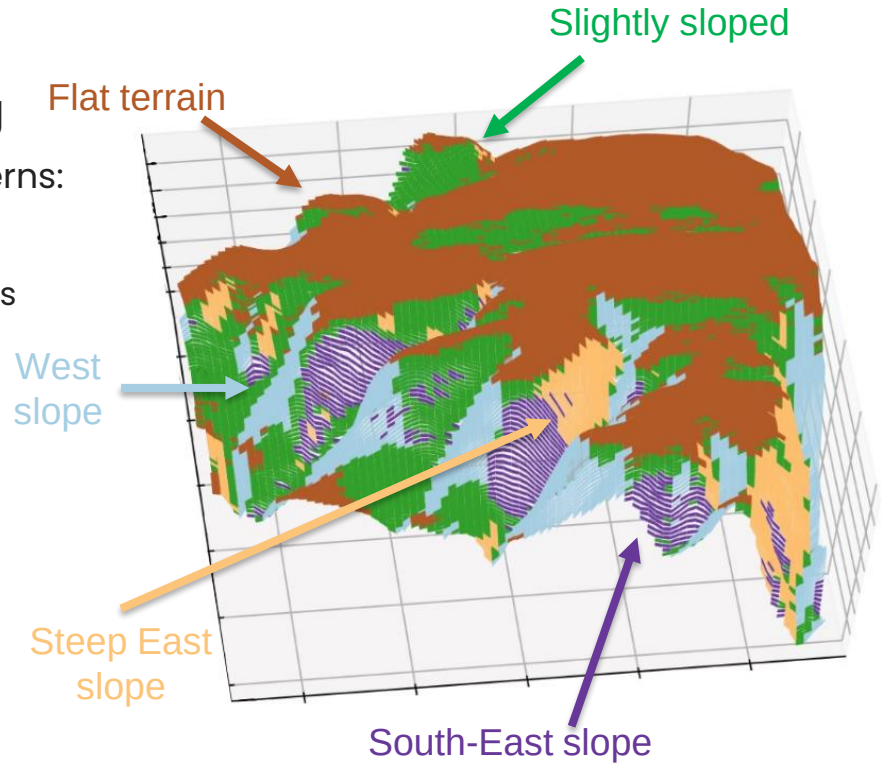
- PV energy yield simulation software based on Imec's technology



- Optical simulations: ray tracing
- Thermal-electrical simulations: coupled, equivalent RC network
- ML-based model reduction algorithm

Model reduction algorithm

- Reduction → simulation → upscaling
  - Group strings with similar irradiance patterns:
    - Technology (e.g. bifacial), tilt, azimuth, shading conditions, reflection conditions
  - Perform simulation on each group
  - Combine results, scale to original plant
- Large reduction in computing time
- Limited impact on end-result (yield)

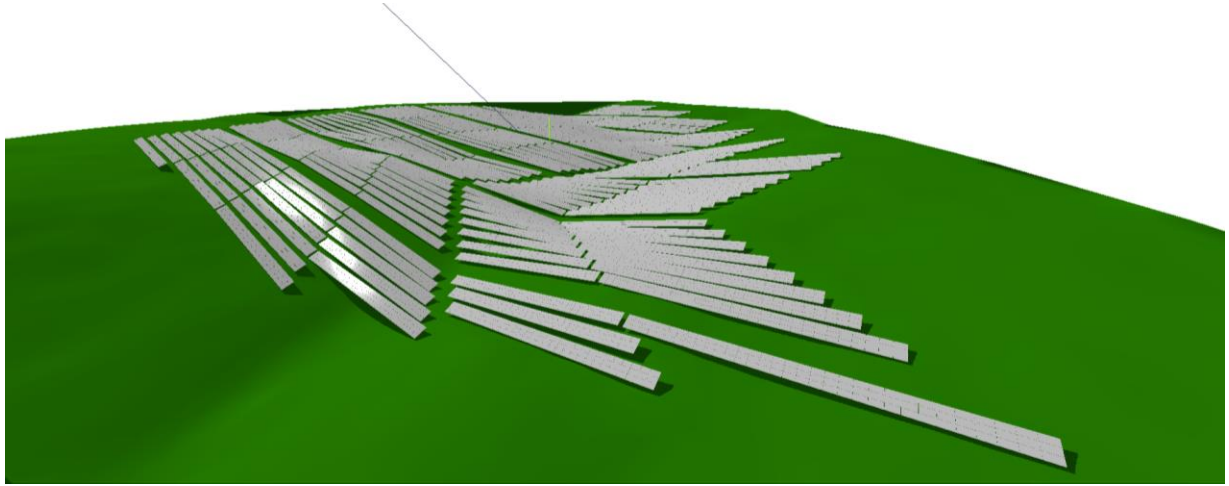


PVcase Yield main features (1/3)

- Import 3D PV plant models directly from PVcase Ground Mount
  - Varying readiness and detailing

PVcase Yield main features (2/3)

- Lighting simulation using 3D ray tracing
  - Effects of 3D frames, 3D terrain, arbitrary shading objects, reflection (bifacial)
  - First in industry for large-scale PV systems



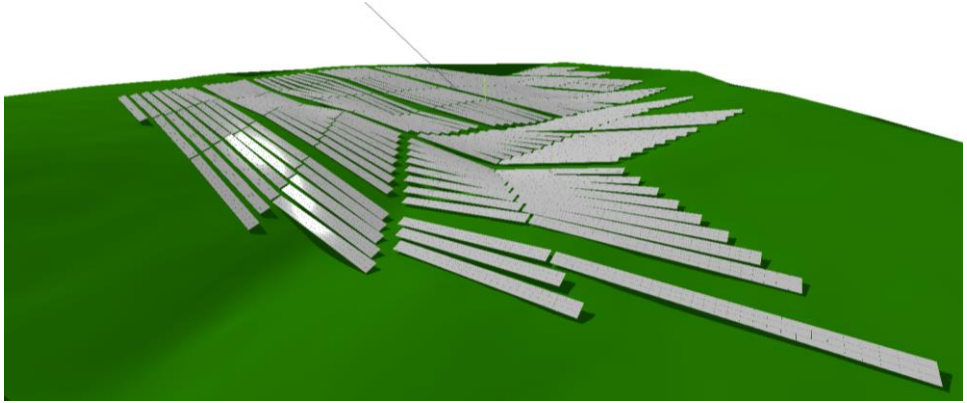
PVcase Yield main features (3/3)

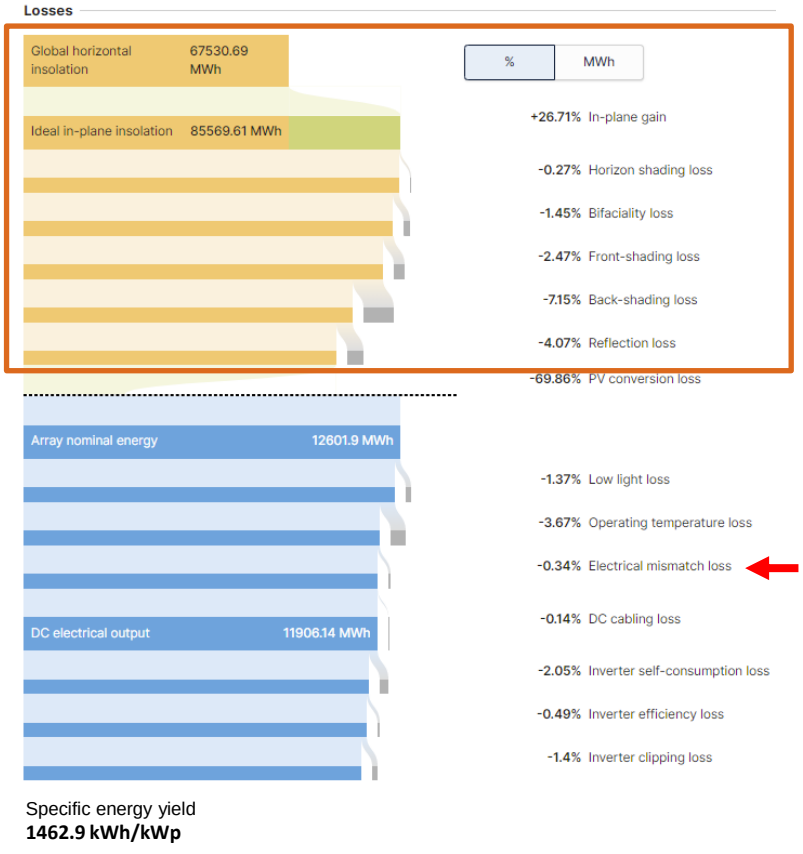
- Thermal-electrical modelling at module-level resolution
  - Using electrical information (incl. cabling) designed in CAD
  - Or proposing optimal arrangements
  - Solved for each individual inverter and MPPT
    - Providing spatio-temporal performance and loss insight
- Cloud-based computing
  - No need for user-side supporting hardware resources and infrastructure
- Convenient user interface
- Product status: user trials

Case studies

Bifacial PV system simulations (1/4)

- Equator-facing, tilted bifacial PV
  - 3D simulation with hilly terrain
  - Detailed irradiance losses
  - Detailed electrical design
  - Simulated electrical mismatch loss

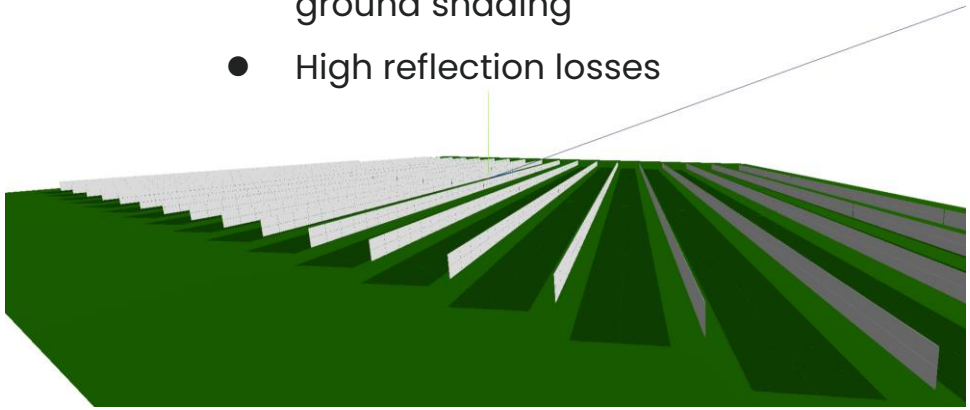




Specific energy yield
1462.9 kWh/kWp

Bifacial PV system simulations (2/4)

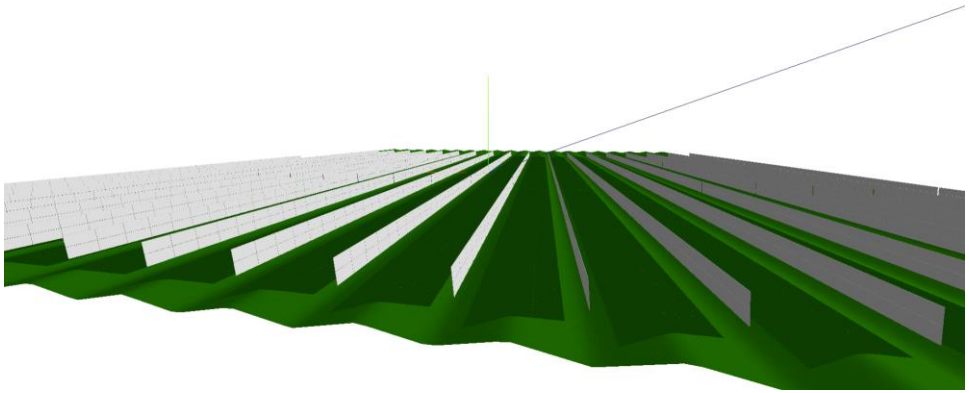
- East-West-facing, vertical bifacial PV
  - Optionally without electrical design
  - Detailed irradiance losses
    - Loss caused by bifaciality factor (60%)
    - Shading losses (front+back) incl. ground shading
    - High reflection losses

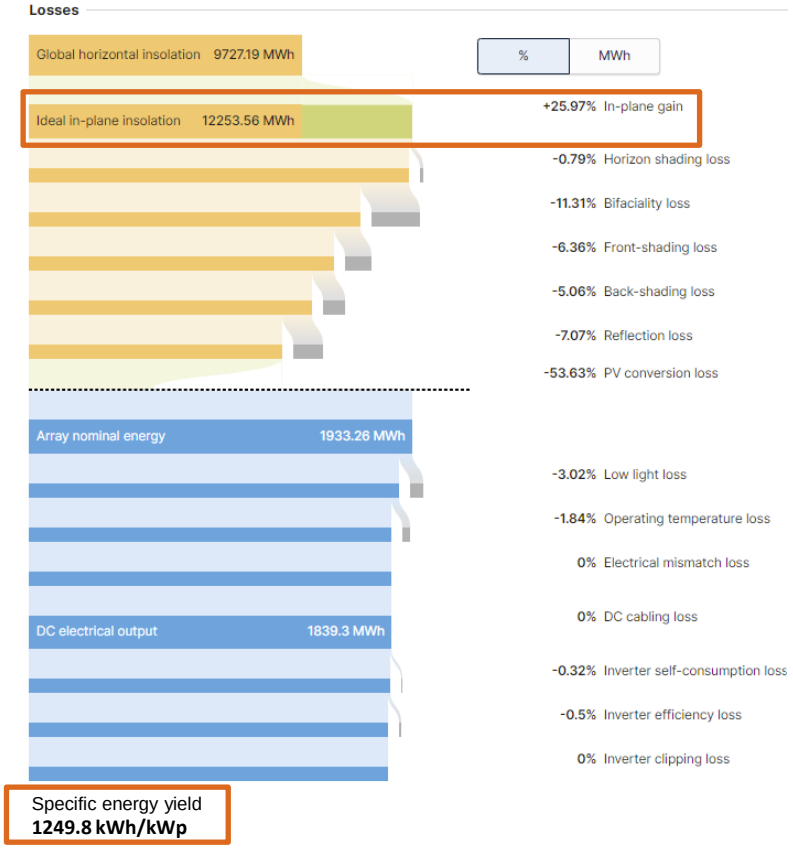


Specific energy yield
1255.0 kWh/kWp

Bifacial PV system simulations (3/4)

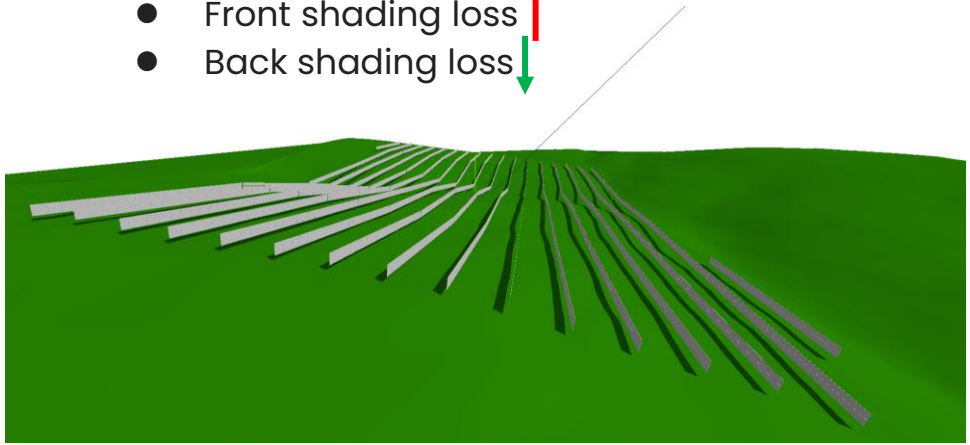
- Vertical bifacial PV + ground shaping
  - Causes losses in this particular case
  - Less ground-reflected irradiance

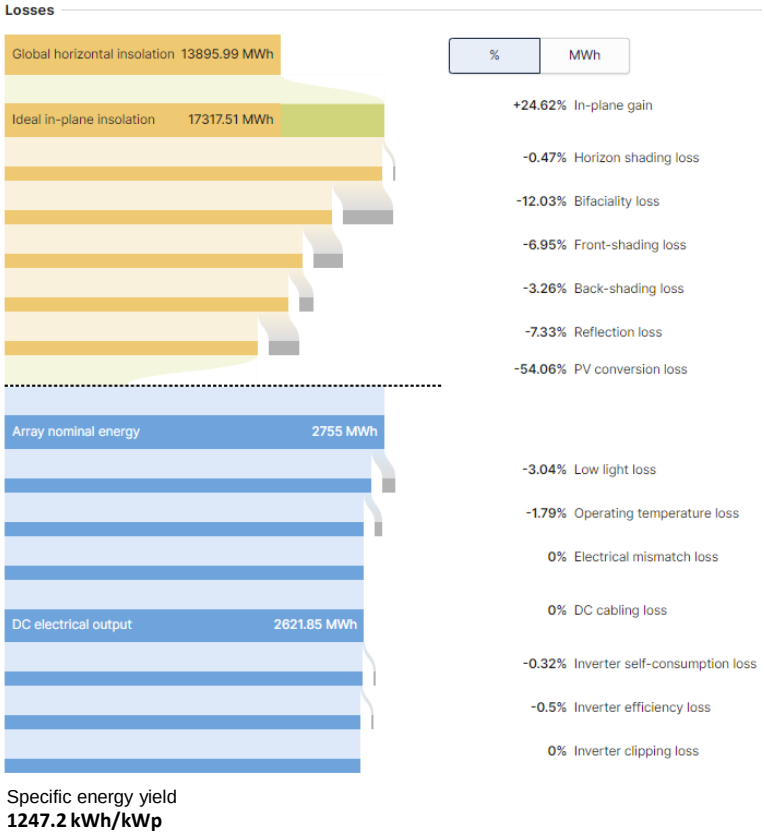




Bifacial PV system simulations (4/4)

- Vertical bifacial PV on hilly terrain
  - Assessment of loss due to terrain
  - East-facing slope
  - Module front side towards West (uphill)
- Comparison to flat terrain
  - Front shading loss ↑
  - Back shading loss ↓





Specific energy yield
1247.2 kWh/kWp

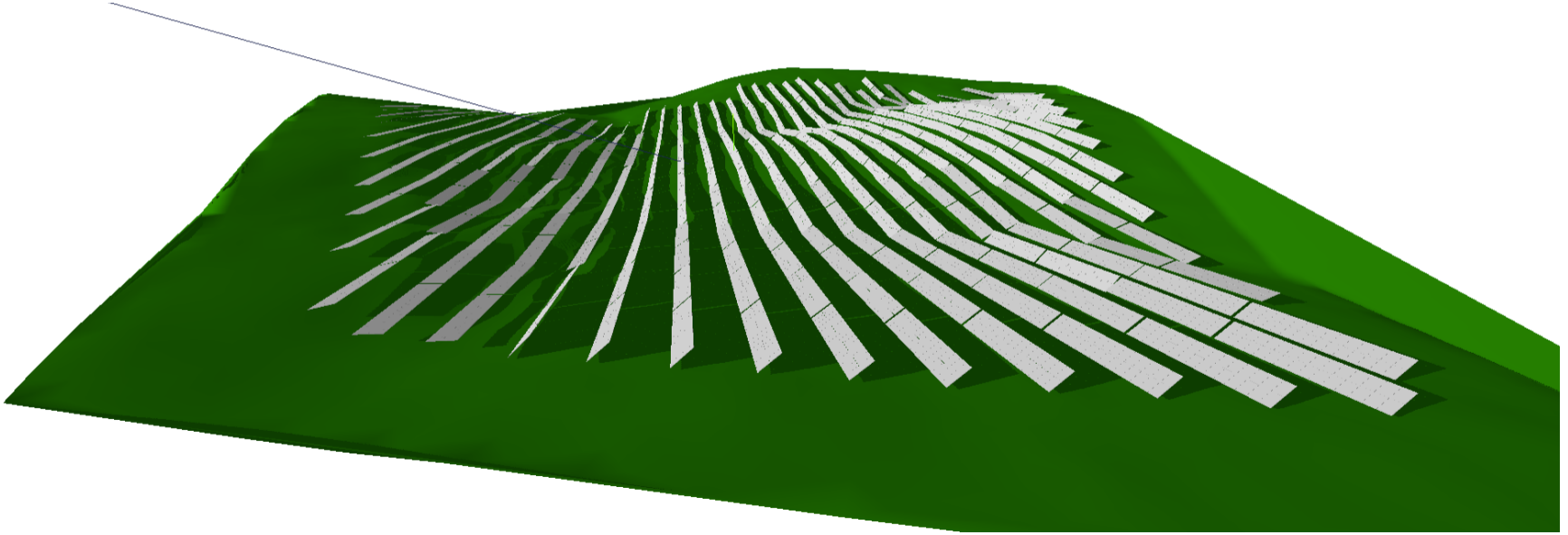
Summary

Conclusions

- PVcase Ground Mount
  - Better PV plant designs, more accurate cost estimates, accelerated engineering process
- PVcase Yield
  - Energy yield simulation based on 3D ray tracing and physics-based models
  - Technology-agile software
- Integrating PV plant design and yield simulation through digital twin
  - Enable energy yield as design variable, provide quantitative inputs for decisions
  - Versatile, 3D simulations for large-scale, bifacial PV systems
- Next up
  - 3rd party due diligence, **we are looking for partnerships**

Future work

- Simulating **3D bifacial trackers** on uneven terrain, using shade-avoiding tracking strategies



Thank you

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