



PV Module Benchmarking – an Outlook

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PV Module Benchmarking – What's that?



- System monitoring → well known
- Module monitoring → some specialists
- **Benchmarking** → **NEW**
- Energy rating → IEC 61853
- Yield predictions → well known



Our definition:

- Precise benchmarking for PV modules using a combination of measurements in the "CalLab PV Modules", energy rating calculations and field measurements for product characterization, parameter identification and validation
- Covering established and new generations of PV modules (bifacial cells, tandem cells, perovskite cells, ...)
- Covering established and new applications of PV modules (new environmental conditions, e.g. with Agri-PV, Floating PV, new system requirements like 1500 V DC, ...)

PV Module Benchmarking – Features



Indoor and outdoor measurements may complement each other:

- Precise indoor solar simulators
 - Controlled irradiance level
 - Controlled temperature
- Precise outdoor performance monitoring
 - Natural solar spectrum
 - Perfect homogeneity
 - Continuous measurement of module power, acquisition of IV curves in regular intervals

PV Module Benchmarking – Features



Energy rating and validation measurements:

- Indoor module characterization according to IEC 61853-1 and -2
- Calculation of climate specific energy rating (CSER) according to IEC 61853-3 and -4
- Validation of CSER results under real life conditions
- Validation for periods shorter than one year may be possible

PV Module Benchmarking – Features



Investigation of module degradation:

- Repeatable preconditioning in our TestLab PV Modules
- Accelerated ageing in climate chambers, followed by outdoor monitoring
- Early identification of technology-, material- and design-specific degradation risks



Comparison to other modules and in other climates:

- Benchmarking against reference modules with defined differences in the bill of materials (BOM)
- Realistic comparisons to a fixed module inventory of Fraunhofer ISE
- Benchmarking against competitor products
- Measurements in different climates
 - Moderate (Freiburg, Germany)
 - Arid (Negev, Israel)
 - Maritime (Gran Canaria, Spain)

PV Module Benchmarking – Benefits



Benefits arise for various user groups:

- R&D companies and institutions
- Material and component manufacturers
- Module manufacturers
- Investors, insurance companies
- Plant operators

Our New Solar TestField – an Outlook



The current site(s):

- Several roof areas in Freiburg
- Capacity: some 100 test samples

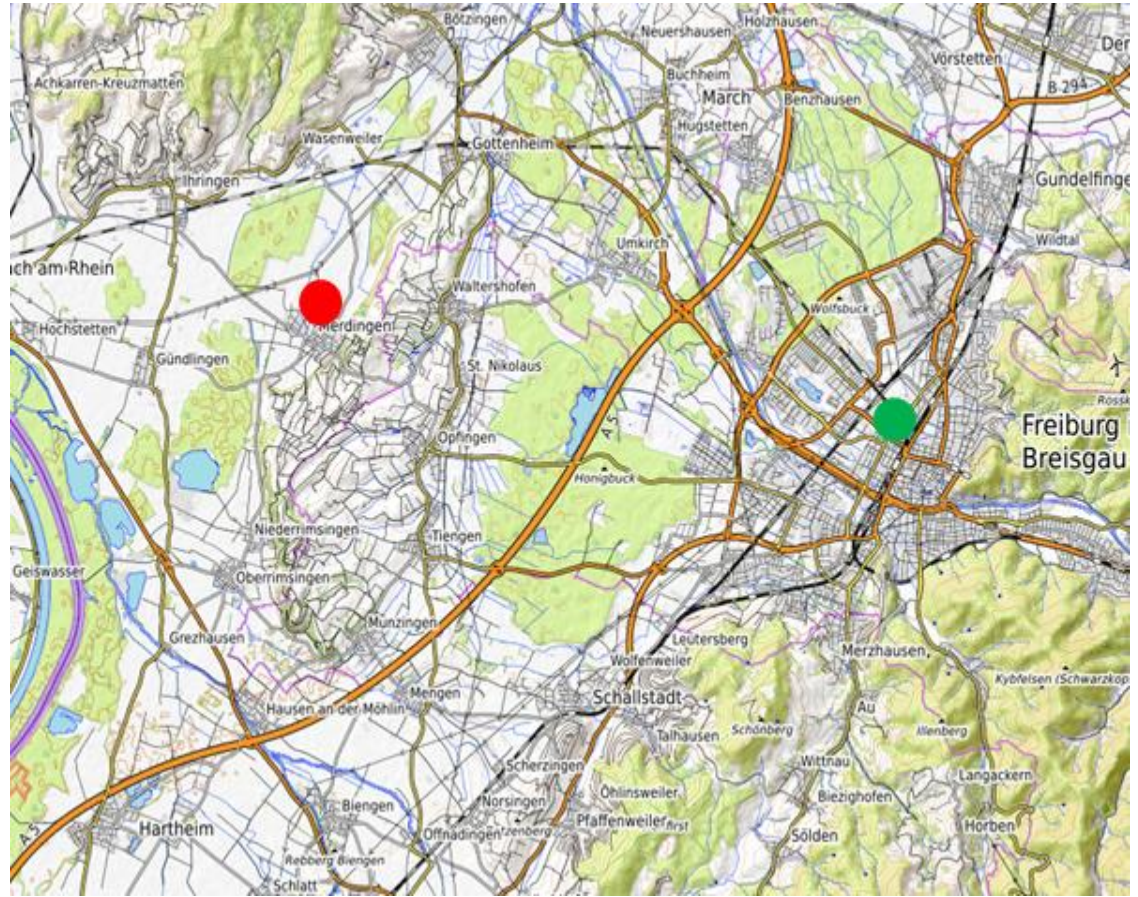


Our New Solar TestField – an Outlook



The new site:

- Located in Merdingen, some 12 km West of Freiburg
- Capacity: at least 500 test samples



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Our New Solar TestField – an Outlook



- Fixed, single-axis or dual-axis tracked installation
- High-frequency recording of IV characteristics and meteorological data
- ...
- Tests of inverters and battery storage systems

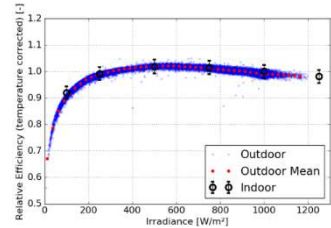
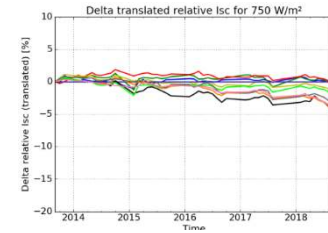
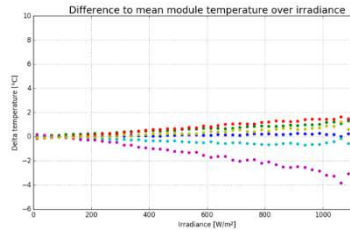
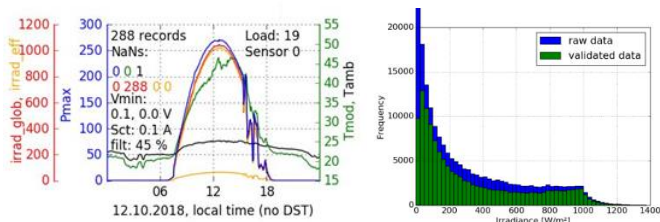


Our New Solar TestField – an Outlook



Evaluation tools:

- Advanced post-processing routines for quality control and parameter extraction
- Data analysis using a powerful Python framework and a high-performance database:
 - Combination of outdoor and indoor data
 - Comparative performance analysis, customer-specific evaluations
 - Durability studies

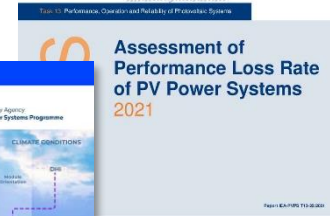
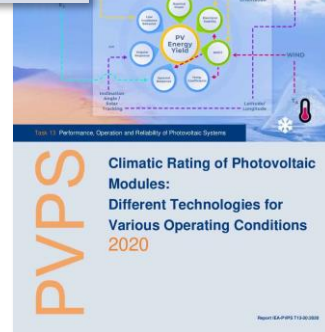
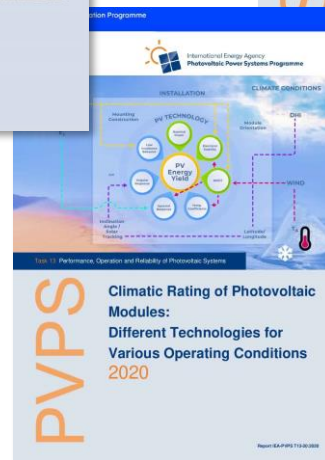
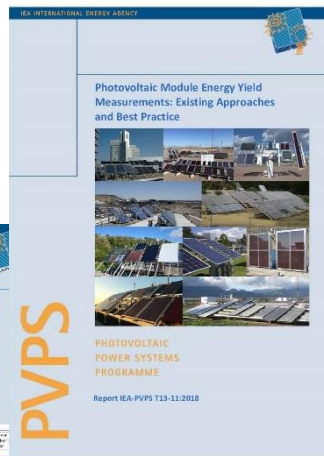
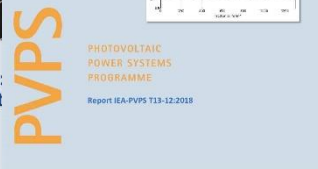
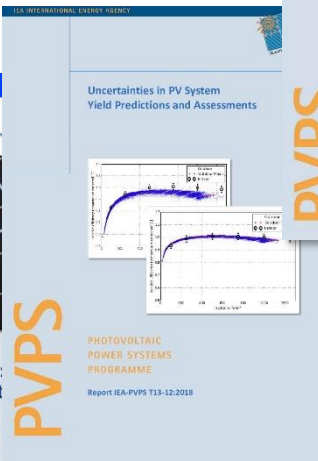
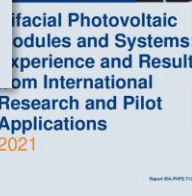
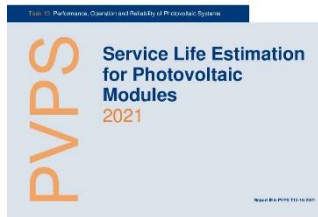


Our New Solar TestField – an Outlook



The Task 13 experience:

PVPS



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