

Prof. Dr. Grit Behrens

Prof. Dr. Frank U. Hamelmann

Activities of Solar Computing Lab- Photovoltaic Research at Campus Minden

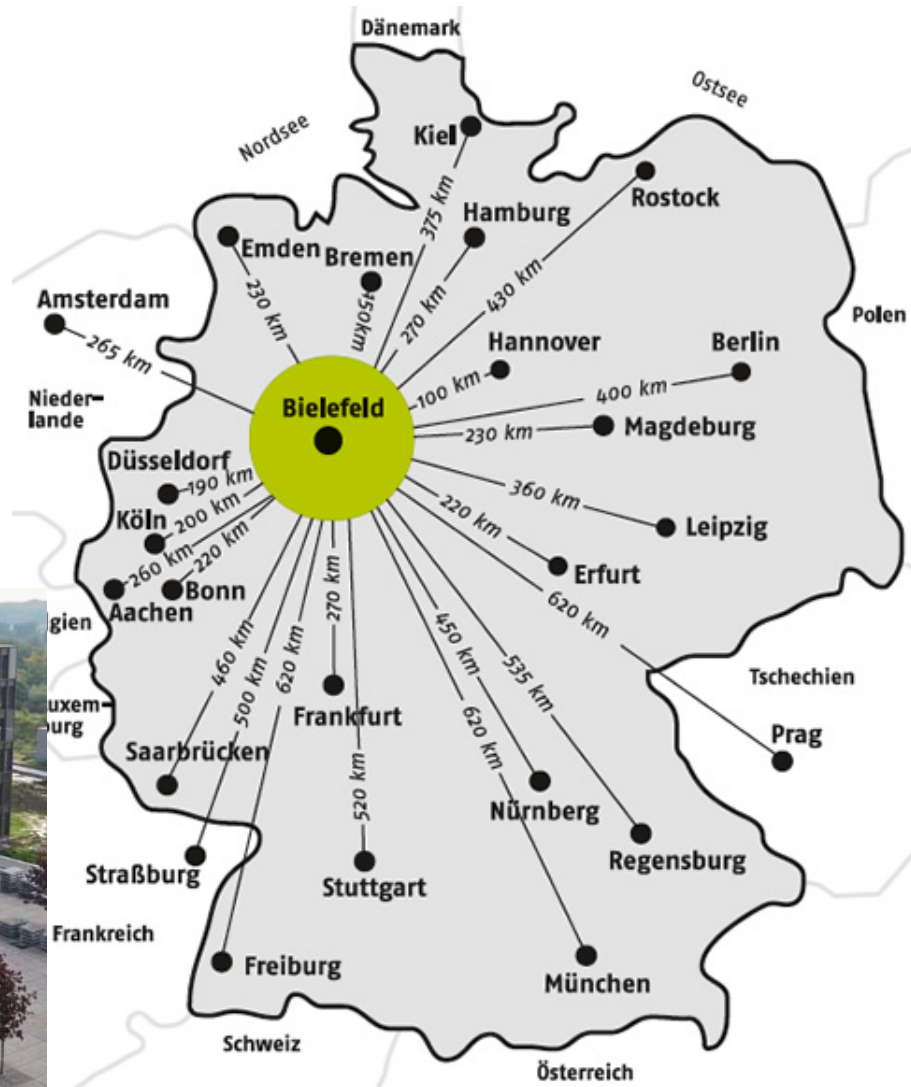
April 2016



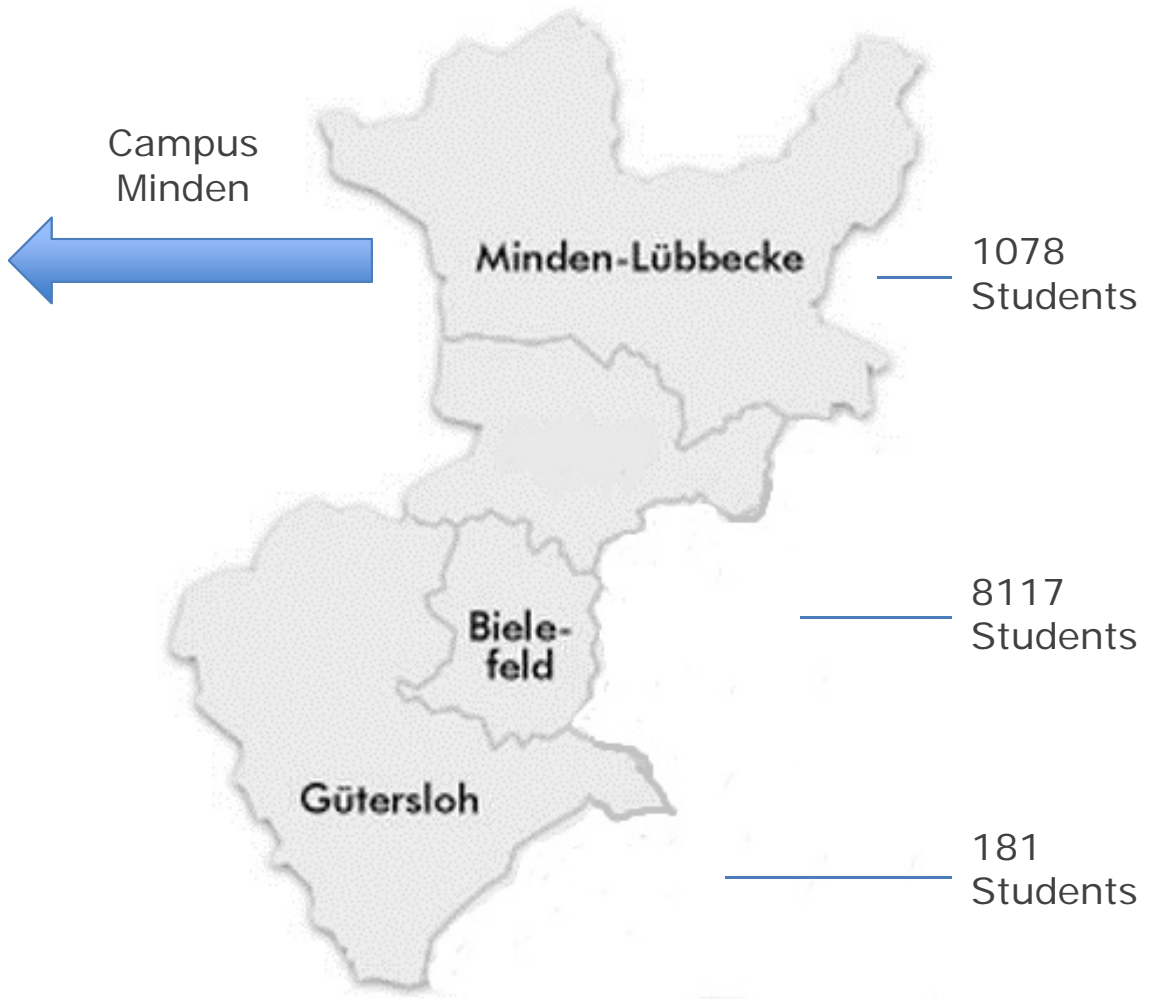
FH Bielefeld
University of
Applied Sciences

- 1. Location at Campus Minden**
2. Solar Computing Lab – persons and facilities
3. Solar Computing Lab – projects and activities

Bielefeld University of Applied Sciences



Bielefeld University of Applied Sciences – 3 Locations



1. Location at Campus Minden
2. **Solar Computing Lab – persons and facilities**
3. Solar Computing Lab – activities



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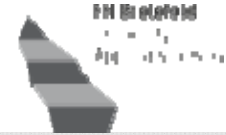
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- **Interdisciplinary cooperation between physics and computer sciences in research and education**
- **Outdoor test facility** for PV-modules
- **Weather** station
- **Pyrheliometer** (insolation diffuse, direct)
- PV-field on roof top for study and research
- Redox-Flow-storage
- Taylormade **efficient database** for all measurements
- Web based **Monitoring System** for vizualisation and **scientific data analysis (Maschine Learning Algorithms)**
- **IR- Camera, EL-Camera -system**
- **Kopters**



Outdoor-Test -Laboratory: PV-Modules

Continuously measurements of

- U/I-curve for MPP tracking every minute
- Current, voltage, performance, module-temperature every 10 sec.





Outdoor-Test-Laboratory : Weather Station

- Every 10 seconds
- humidity , wind force, rainfall, air pressure, air temperature
- Irradiation: global, direct, diffuse

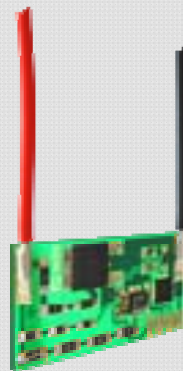
Anlagenstatus - Wetterstation

Systemzeit: 03.07.2013 12:15:08

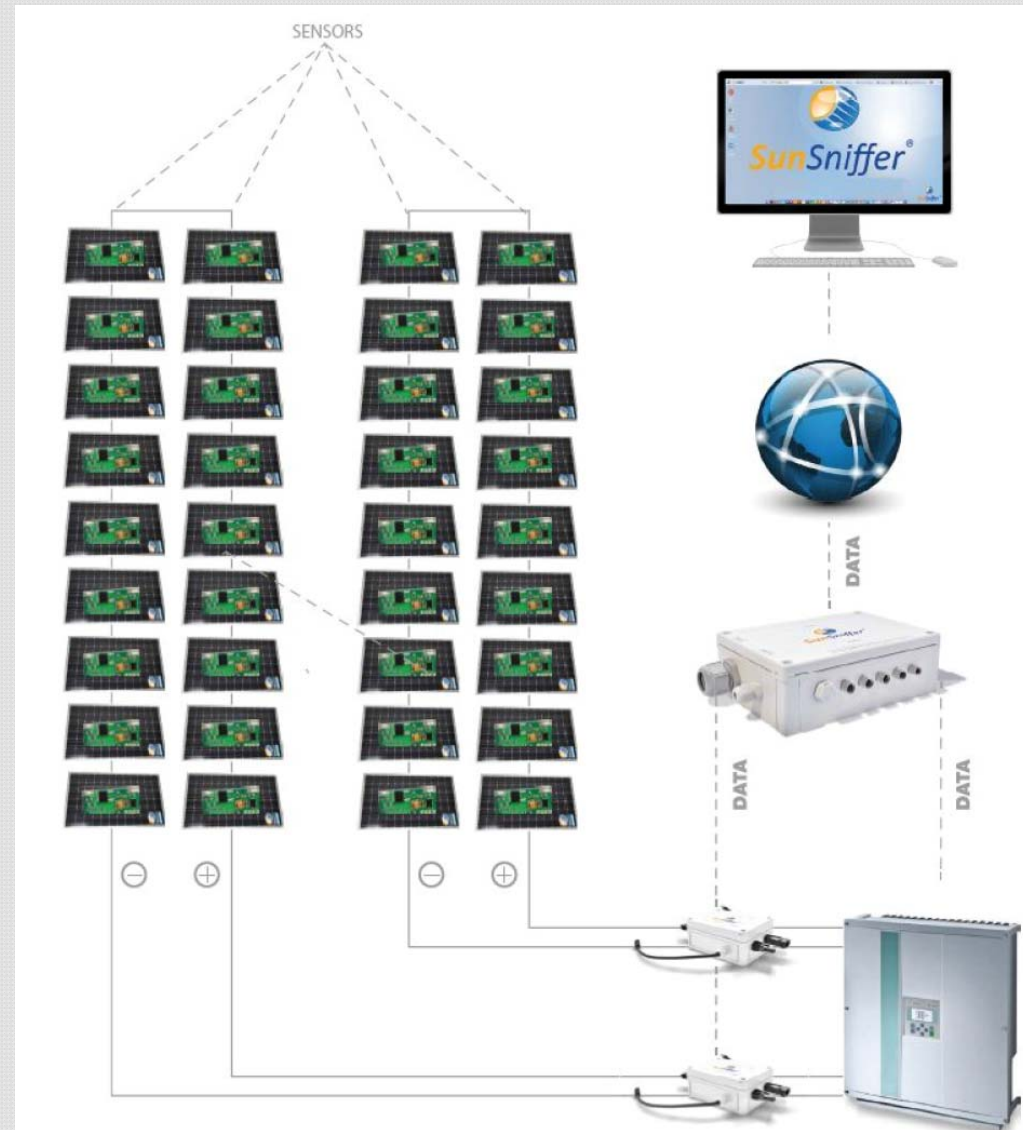
Name	H1420026
Zeitstempel	03.07.2013 12:14:18
Seriennummer	H1420026
Windrichtung min.	239 °
Windrichtung avg.	239 °
Windrichtung max.	239 °
Windgeschw. min.	0,6 m/s
Windgeschw. avg.	0,6 m/s
Windgeschw. max.	0,7 m/s
Luftdruck	1 000,7 hPa
Aussentemperatur	22,6 °C
Gerätetemperatur	23,8 °C
Luftfeuchtigkeit	63,1 %
Regenmenge (Tag)	2,4 mm
Regendauer (Tag)	1 260 s
Regenintensität	0 mm/h
Hagelmenge (Tag)	0 hits/cm ²
Hageldauer (Tag)	0 s
Hagelintensität	0 hits/cm ² h
Max. Regenintensität	36,5 mm/h
Max. Hagelintensität	0 hits/cm ² h



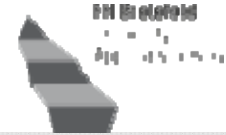
AEG
perfekt in form und funktion



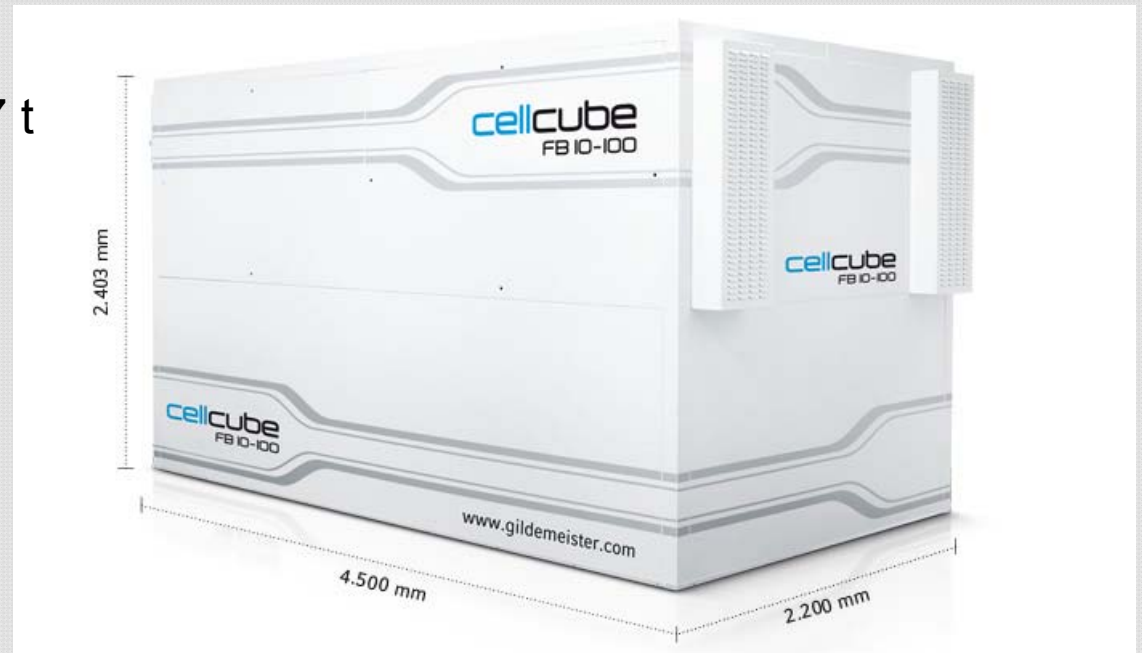
- Polykristallines Modul von AEG
- 16% Wirkungsgrad
- **Sunsniffer®-Technologie**
 - Modulgenaue Leistungs- und Temperaturmessung
 - Datenversand per DC-Verkabelung
 - Integriert in Anschlussdose

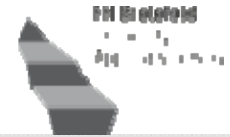


Der Vanadium Redox-Flow-Speicher

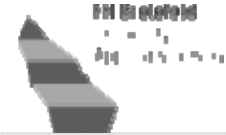


- Typ: Gildemeister CellCube FB 10-100
- performance: 10 kW
- capacity: 40 kWh
- control : Bus-System, TCP/IP
- efficiency factor: until 80%
- no Self-discharge in the vanadium tanks
- resistant on deep discharge
- cykles: over 100.000
- Size : 4,66 x 2,20 x 2,42 m
- weight (incl. Vanadium liquid): 7 t

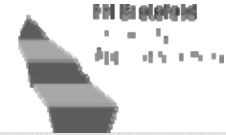




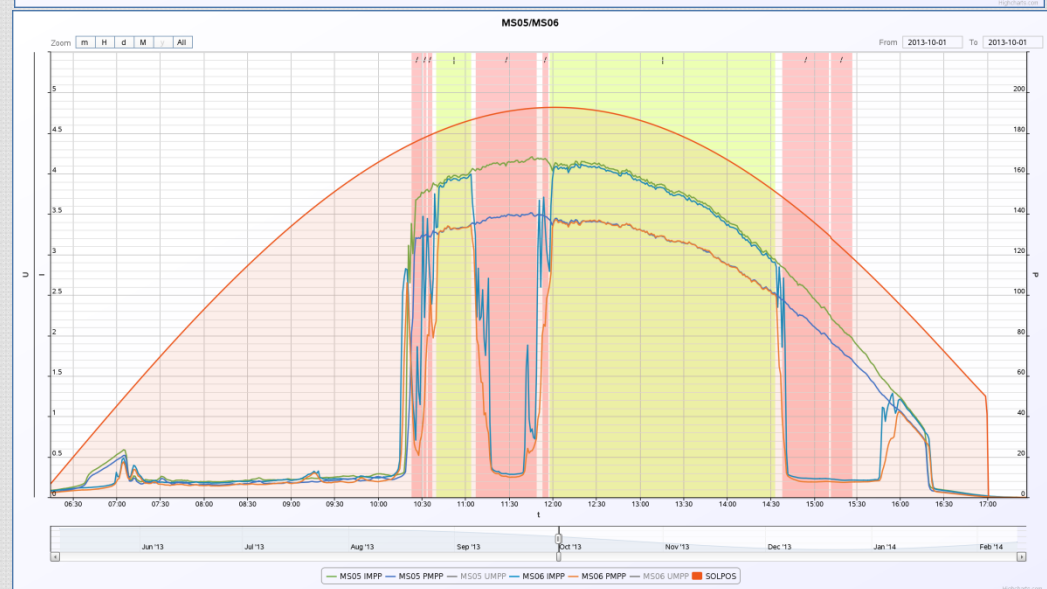
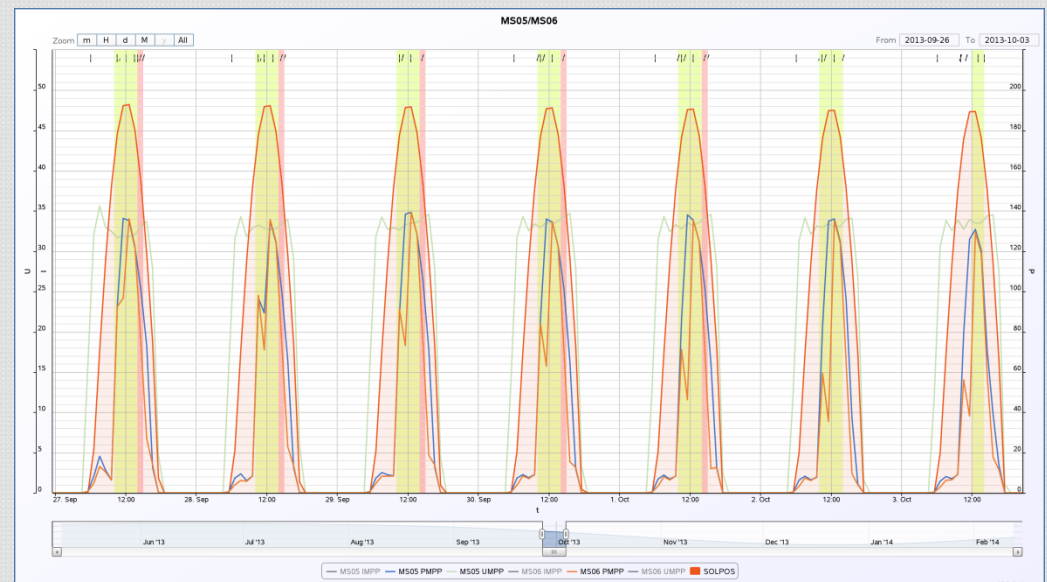
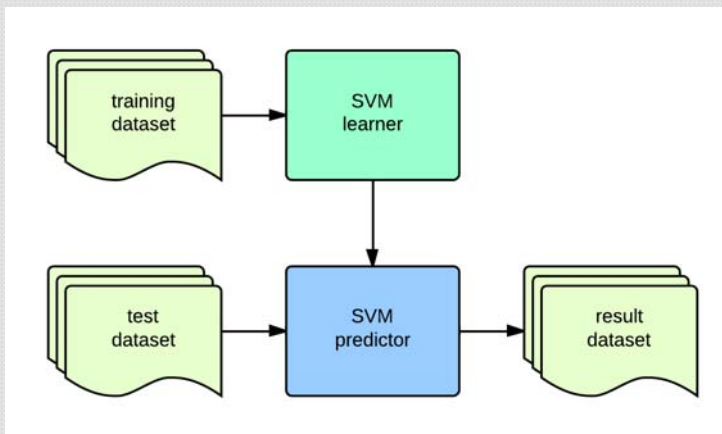
1. Location at Campus Minden
2. Solar Computing Lab – persons and facilities
3. **Solar Computing Lab – projects and activities**



- Simulation of **long term yield prediction**
- Short term yield prediction **based on weather forecast**
- Development of **automatic fault detection** with methods of **Maschine learning with Big Data Technology**
- **Image Processing and pattern recognition on IR and EL images** and videos
- **3D-Thermography**
- **Flight assistance** for IR and EL-copters
- **Low Cost Electroluminescence- picturing by daylight** in industrial PV-fields
- **Development of mobile application on control, inspection, monitoring of PV-fields**
- **Persuasive Programming** for Climate protection
- **energy efficiency in buildings**
- **energy management (PV, Storage)**
- **Students and Lecturer's Exchange**



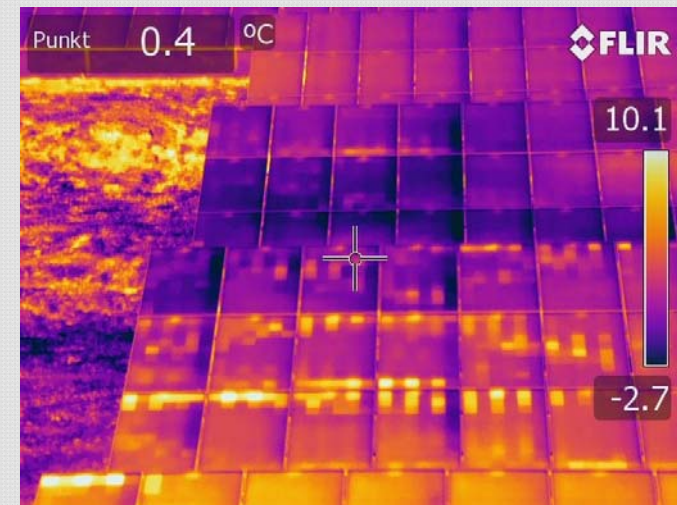
- Bachelorthesis „Recognition of shadowing on PV-Modules with methods of Maschine Learning“
- Neuronale Network classifier
- Support vector maschine
- 98% recognitions rates on laboratory test site





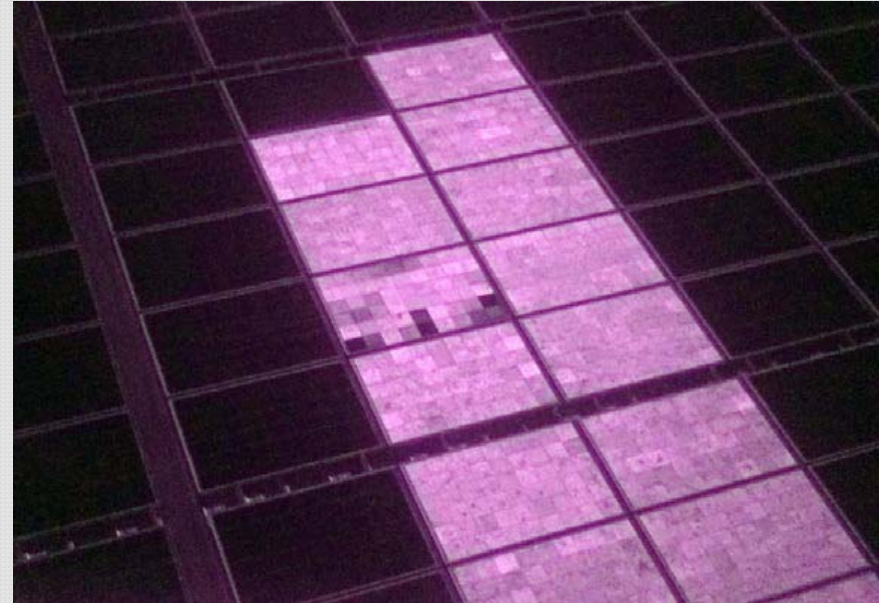
Outdoor-Test-Laboratory: Thermo-Drone

- Thermo-Drone for taking HR-infrared pictures from modules under working conditions
- Flight assistance over PV-modules on plants
- Image processing and recognition of failures like
 - shadowing, hot spots, wiring errors, surface crackings, and others





Detection of defect by-passdiode



Detection of defect by-passdiode

Outdoor-Test-Laboratory: Electroluminescence

- EL-Drone flying 15 m for taking pictures from PV-modules powered by switching string charging box
- Flight assistance over PV-modules on plants
- Image processing and recognition of failures like
 - PID (Potential induced degradation), defect bypass diodes, cell cracks, hailstorm damage





Integration of laboratory activities in student lessons projects at Technical Faculty

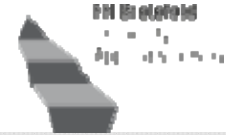
- Computer science
- Industrial engineering
- Maschine engineering
- Electrical engineering

Internationality – ERASMUS exchange

- Internship students of Ecole Polytechnique Marseille, FRANCE (2012, 2013, ...2014)
- Solar Lab Technical University of Wroclaw (POLAND) docent and student exchange
- This Year from IZMIR, Turkey



Scientific publications I:



G. Behrens, F. Hamelmann, L. Niemann, J. Weicht, S. Yilmaz, L. Kruse „ Universal location based data sets for monitoring and scientific data analysis on PV-systems”, *PVSEC 2013*

J. Weicht, G. Behrens, F. Hamelmann, „Light induced degradation of a-Si/ μ c-Si thin film solar cells under different climate conditions and its influence on the performance”, *PVSEC 2013*

Bamberg, S. & Rees, J. (2013). “Climate protection needs societal change! – Introducing a tripartite model of intention to engage in collective climate action.”, Special issue “The social psychology of climate change” des *European Journal of Social Psychology*

Rees, J., Klug, S., & Bamberg, S. (2013). Guilty conscience: Motivating pro-environmental behavior without evoking reactance. Sonderausgabe “Multi-disciplinary perspectives on climate ethics“ des *Journals „Climatic Change“*

J.A. Weicht, F. Hamelmann, A. Domnik, G. Behrens „Changes in the serial resistance of a-Si, a-Si/ μ c-Si and monocrystalline PV modules during the year”, *IEEE-PV 2014*

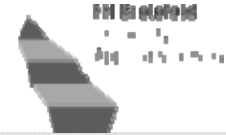
G. Behrens, A. Domnik, S. Hempelmann, J. Weicht, F. Hamelmann, S. Yilmaz, L. Kruse „Machine Learning Methods for Partial Shading Detection in Monitoring Data on PV-Systems ”, *PVSEC 2014*

J.A. Weicht, F. Hamelmann, G. Behrens „Weak light efficiency of a-Si, a-Si/ μ c-Si compared to c-Si PV-modules under field conditions”, *PVSEC 2014*

J. A. Weicht, F. U. Hamelmann, G. Behrens, “Parameter variation of the one-diode model of a-Si and a-Si/ic-Si solar cells for modeling light-induced degradation.”, *Journal of Physics: Conference Series, IOP Publishing, 559 (2014), 12017*

J. A. Weicht, J. Zielinski, A. Domnik, F. U. Hamelmann, G. Behrens „Characterization of shadowing on c-Si PV-modules and irradiation sensors by the serial resistance using Artificial Neural Network “, *Proceedings WCPEC 6, 2014*

Scientific publications II:



Rasch, Behrens, Hamelmann, Hantelmann, Dreimann, Weicht: „*Thermal imaging for Fault Detection on PV-Systems*“, **PVSEC2015, Hamburg**

Weicht, Hamelmann, Behrens: „Changing in weak-light behavior and temperature-coefficient variation caused by light-induced degradation of a-Si/ μ c-Si solar cells“, **IEEEPV2015, New Orleans**

Weicht, Rasch, Behrens, Hamelmann: „Changing of parameters of the three-diode-model by light-induced degradation of different degradation temperatures of a-Si/ μ c-Si solar cells“, **PVSEC2015, Hamburg**

A. Domnik, S.Ertelt, F.Steckel, F. Witthaus, G. Behrens "Classification of consumption data for energy management with smart meeting", **EnviroInfo 2015, Kopenhagen**

T. Kilper, I. Kruse, C.Feser, U.Kirstein, D. Peters, M.Tapia, K.v.Maydell, S.Yilmaz, G.Behrens "A new generation of PV Monitoring system with high-grade remote diagnostics based on module level monitoring and integrated yield simulation", Vortrag, **EUPVSEC 2015, Hamburg**

Hempelmann, Leunig, Behrens, Kruse, Nasse "Intelligentes Monitoring mit modulgenauer Fehlererkennung für PV-Anlagen im Feld", **31.Symposium Photovoltaische Solarenergie**, Kloster Banz, Bad Staffelstein

Kilper, Feser, Kirstein, Peters, Tapia, v.Maydell, Yilmaz, Kruse, Behrens: "Potentiale des PV-Anlagen Monitorings auf Modul-Ebene mit integrierter Echtzeit-Simulation des zu erwartenden Ertrags.", **31.Symposium Photovoltaische Solarenergie**, Kloster Banz, Bad Staffelstein

Mertens, Arnds, Behrens, Domnik, Diehl, Fladung "LowCost-Outdoor-EL: Die Bilder lernen laufen...", **31.Symposium Photovoltaische Solarenergie**, Kloster Banz, Bad Staffelstein