A New Generation of PV Monitoring System with High-Grade Remote Diagnostics Based on Module Level Monitoring and Integrated Yield Simulation

T. Kilper[1], I. Kruse[2], C. Feser[1], U. Kirstein[1], D. Peters[1], M. Tapia[1], K. von Maydell[1], S. Yilmaz[2], G. Behrens[3]

30th EUPVSEC Hamburg

15 September 2015

2 STORM® Wir lieben unsere Anlagen!

3 FH Bielefeld University of Applied Sciences

Solar Computing Lab

1 NEXT ENERGY EWE-Forschungszentrum für Energietechnologie e.V.

supported by:

Federal Ministry for Economic Affairs and Energy

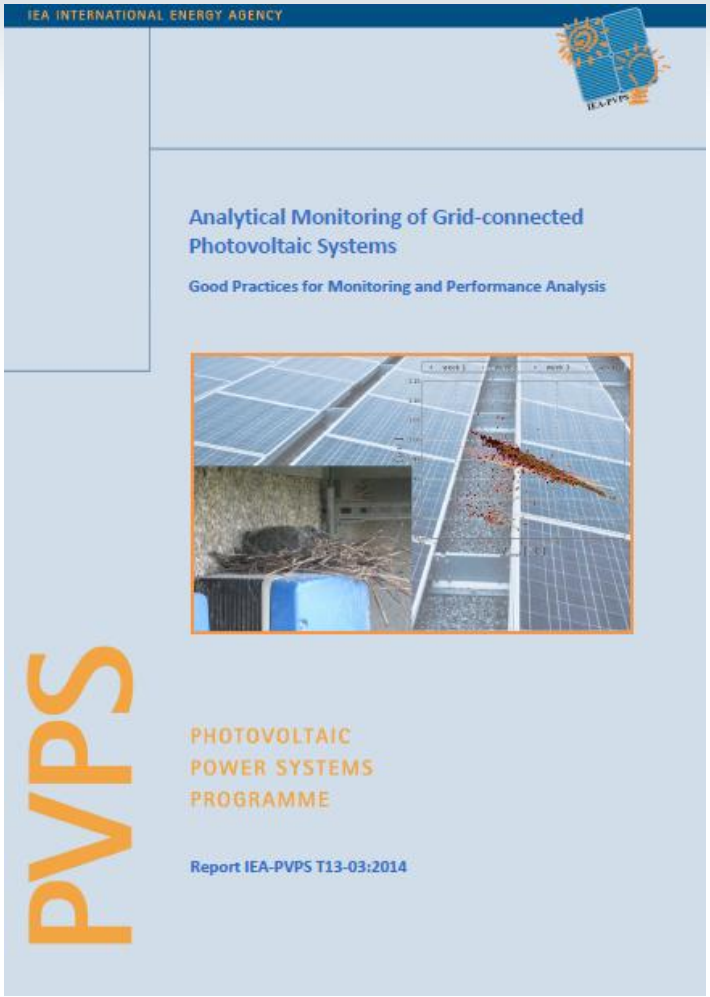
Outline

NEXT ENERGY
EWE-Forschungszentrum für Energietechnologie e.V.

- Motivation of our PV Monitoring Approach
- Experimental Setup
- Current Status of Research Project InSeMo
  - » Automated error detection via nominal-actual value comparison
  - » Automated fault analysis
- Conclusion and Outlook

1. Motivation of our PV Monitoring Approach

NEXT ENERGY
EWE-Forschungszentrum für Energietechnologie e.V.



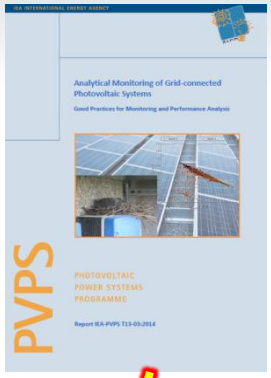
Report IEA-PVPS T13-03:2014

- By now PV plants are performing at a satisfactory level **but could achieve higher** levels of **output**
- **Essential recommendation**
  - **(a)** Fault finding and trouble-shooting must be carried out **in greater depth**

1. Motivation

NEXT ENERGY
EWE-Forschungszentrum für Energietechnologie e.V.

Report IEA-PVPS T13-03:2014



» By now PV plants are performing at a satisfactory level but could achieve higher levels of output

» **Essential recommendation**

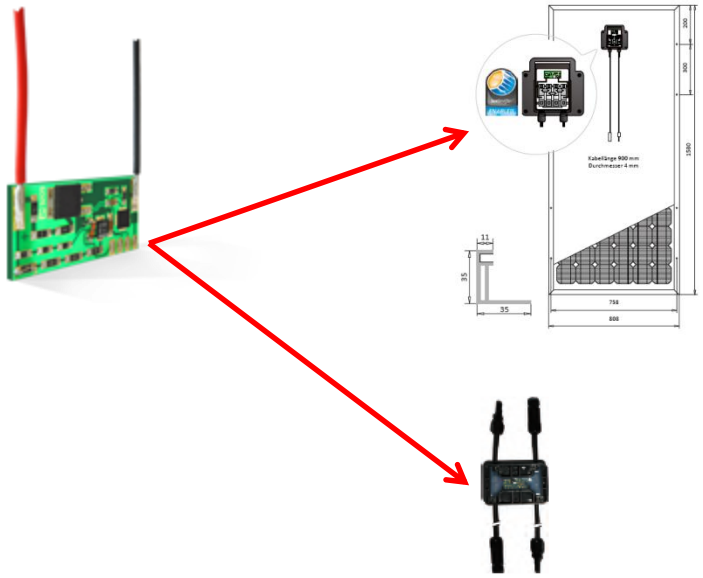
- (a) Fault finding and troubleshooting must be carried out in greater depth
- **(b) Monitoring at least on the junction box level is strongly recommended**

For more advanced monitoring the power or current on the junction box level or the string currents should be measured. The additional cost for advanced monitoring depends on the PV plant layout and capacity. The economic benefit of advanced monitoring compared to the simple inverter monitoring depends very much on the individual project. The economic benefit is higher when more energy is produced per installed power plant and results in a higher price per kWh. In case the PV plant produces less energy than expected, junction box or string based monitoring reduces the time and cost significantly for detecting the failure. If the PV plant is sold to a new owner, advanced monitoring gives more security about the quality of the plant. For these reasons, monitoring that registers the DC production at least on the junction box level is strongly recommended.

2. Experimental Setup

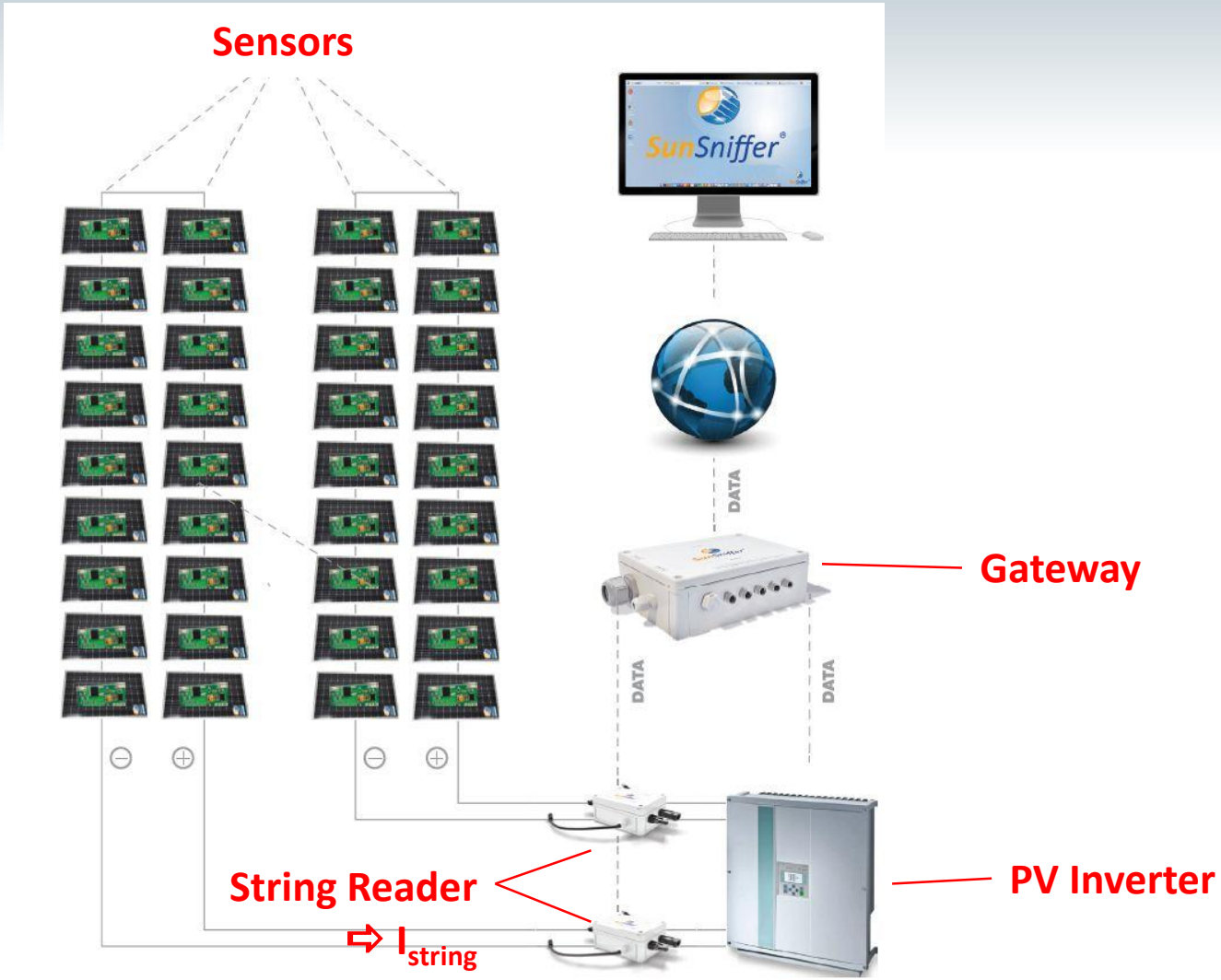
SunSniffer® PV Monitoring System

- Company **STORM Energy**, Nuremberg (Germany)
- **SunSniffer® Sensor**
  - Core of the system
  - Continuous measurement of
    - **Module voltage**
    - **Junction box temperature**



SunSniffer ® PV Monitoring System

NEXT ENERGY
EWE-Forschungszentrum für Energietechnologie e.V.



3. Research Project InSeMo

NEXT ENERGY
EWE-Forschungszentrum für Energietechnologie e.V.

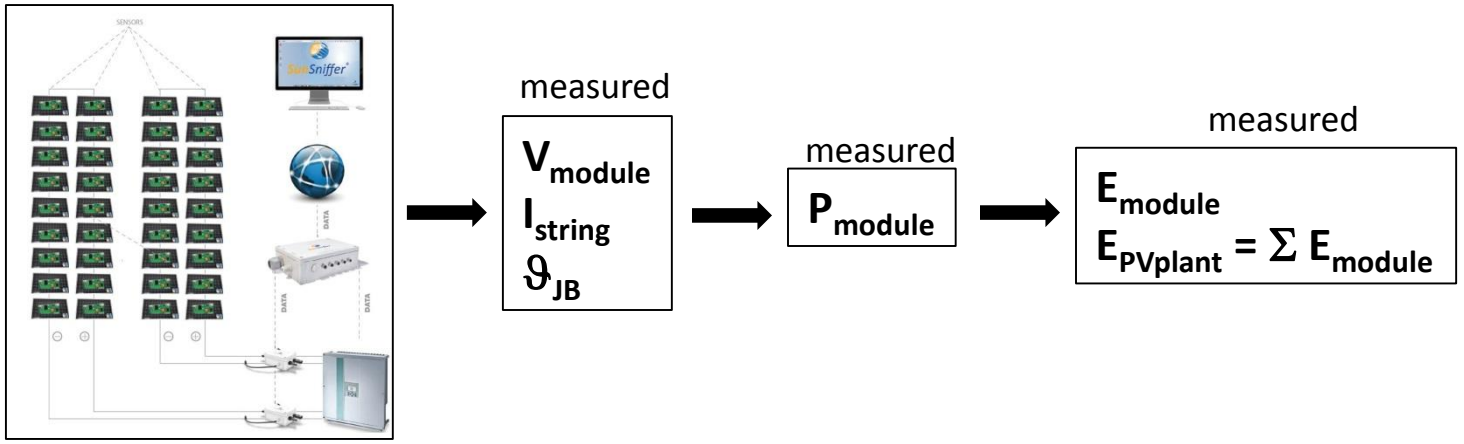
- Consortium
  - » STORM Energy
  - » NEXT ENERGY
  - » University of Applied Sciences Bielefeld

- **Project aim**: Distinct **extension of functionalities** of SunSniffer® PV Monotoring System

3. BMWi-E Joint Research Project InSeMo

NEXT ENERGY
EWE-Forschungszentrum für Energietechnologie e.V.

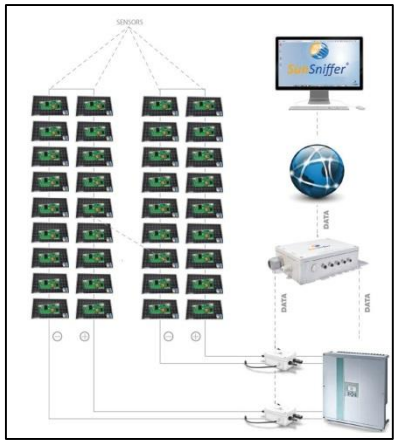
Project aim: Distinct **extension of functionalities** of SunSniffer® PV Monotoring System



3. BMWi-E Joint Research Project InSeMo

NEXT ENERGY
EWE-Forschungszentrum für Energietechnologie e.V.

Project aim: Distinct **extension of functionalities** of SunSniffer® PV Monotoring System



measured
V_{module}
I_{string}
ϑ_{JB}
G_{sensor}

measured
P_{module}

measured
E_{module}
$E_{PVplant} = \Sigma E_{module}$

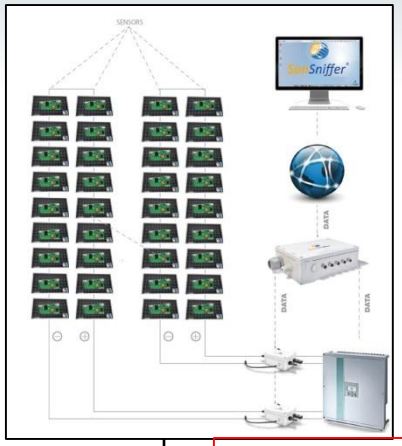
nominal-actual value comparison

simulation engine
::insel®

simulated
$E_{PVplant}$
E_{module}

Extension of SunSniffer ® Functionalities

NEXT ENERGY
EWE-Forschungszentrum für Energietechnologie e.V.



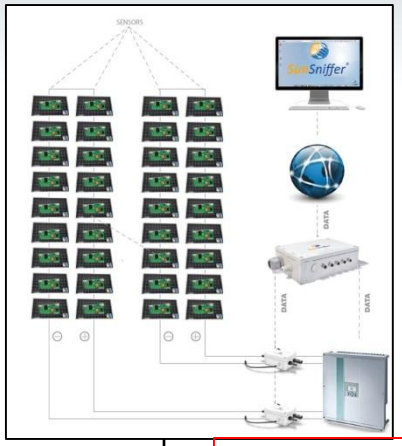
integrated simulation engine

(1) automated **error detection**

$\Delta = E_{PV,meas} - E_{PV,sim}$ → PV performance problem? → yes / no

Extension of SunSniffer ® Functionalities

NEXT ENERGY
EWE-Forschungszentrum für Energietechnologie e.V.



integrated simulation engine

$\Delta = E_{PV,meas} - E_{PV,sim}$

PV performance problem?

(1) automated **error detection**

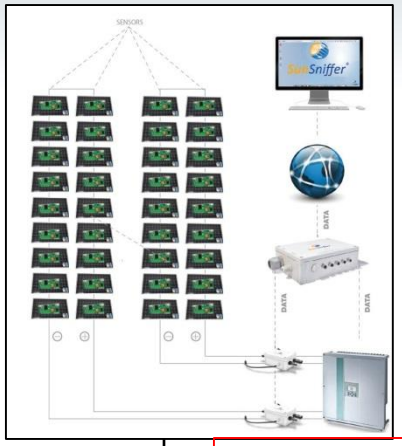
yes

(2) automated **fault analysis**

no

Extension of SunSniffer ® Functionalities

NEXT ENERGY
EWE-Forschungszentrum für Energietechnologie e.V.



integrated simulation engine

$\Delta = E_{PV,meas} - E_{PV,sim}$

PV performance problem?

(1) automated **error detection**

yes

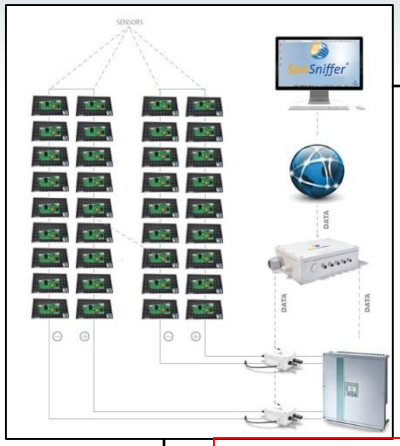
no

(2) automated **fault analysis**

(3) automated **recommendation for action** based on ROI considerations

Extension of SunSniffer ® Functionalities

NEXT ENERGY
EWE-Forschungszentrum für Energietechnologie e.V.



(4) automated **prediction** of imminent PV plant performance deterioration

integrated simulation engine

(1) automated **error detection**

(3) automated **recommendation for action** based on ROI considerations

$\Delta = E_{PV,meas} - E_{PV,sim}$ → PV performance problem? → yes → (2) automated **fault analysis**

PV performance problem? → no

Current Status of Research Project InSeMo

NEXT ENERGY
EWE-Forschungszentrum für Energietechnologie e.V.

Already implemented

- **Simulation engine integrated into SunSniffer® Internet Platform ☑**
  - prio to this simulation accuracy was evaluated
  - comparison between measured and simulated annual PV energy yield
    ⇨ simulation accuracy **down to 0.4 %** achieved

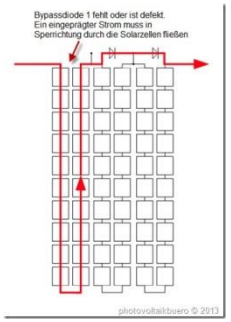
- **Automated error detection via nominal-actual value comparison ☑**

- **Automated fault analysis** (started but not just yet completed)

Automated Fault Analysis

NEXT ENERGY
EWE-Forschungszentrum für Energietechnologie e.V.

- Distinction between
  - **Soiling**
  - **Shadowing**
  - **PID**
  - **Wire insulation issues**
  - **Defect bypass diodes**
  - **Cell cracks**
  - **…**



M. Diehl, photovoltaikbuero GbR, www.pvbuero.de

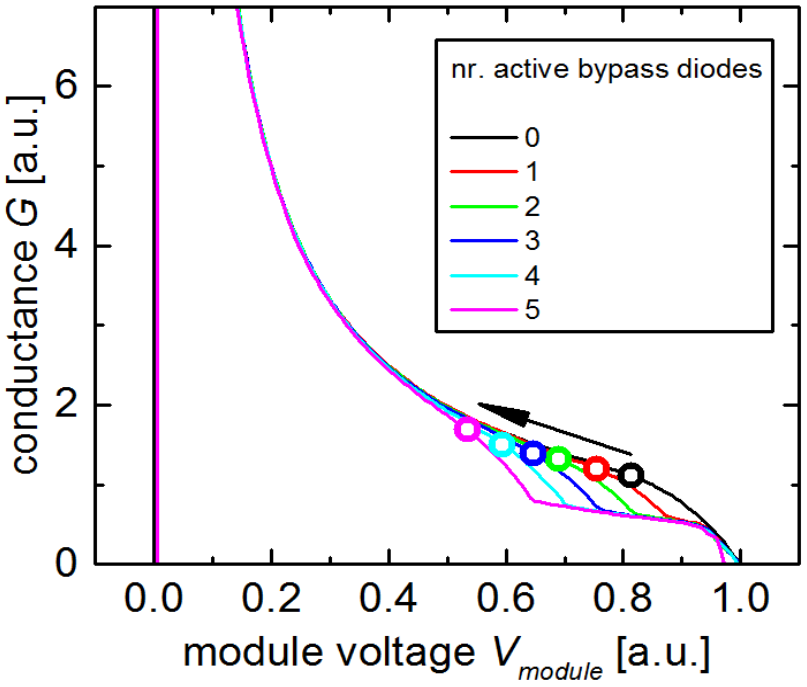
- **Pattern matching** as approach

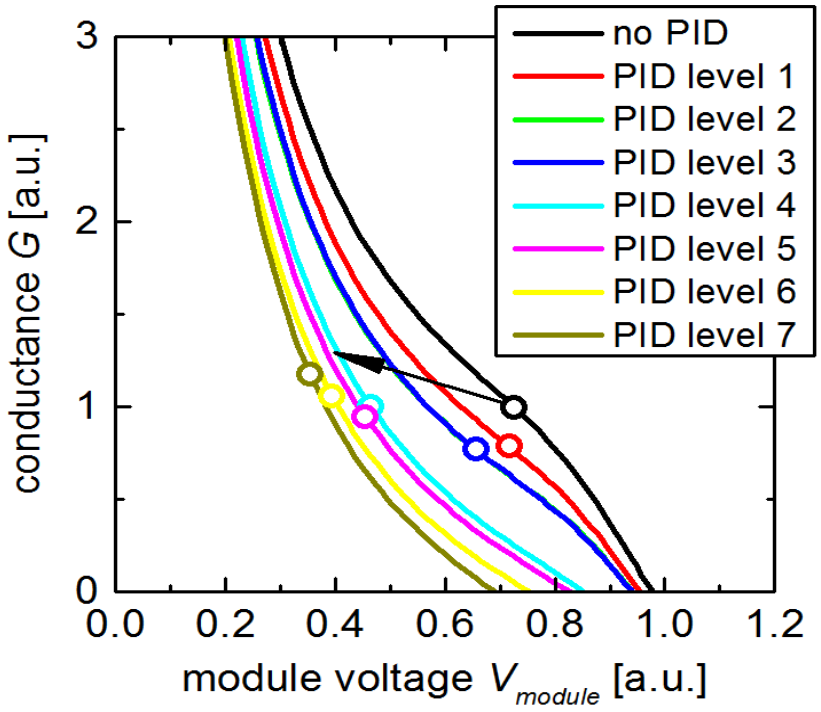
Pattern matching

NEXT ENERGY
EWE-Forschungszentrum für Energietechnologie e.V.

- Distinction between **partial shadowing** and **PID**

$$G = \frac{I_{string}}{V_{module}}$$





Conclusion and Outlook

NEXT ENERGY
EWE-Forschungszentrum für Energietechnologie e.V.

- Research Project aims to **distinctly extend functionalities** of **SunSniffer® PV monitoring system**
  - » Integration of **PV yield simulation engine** after evaluating simulation accuracy
  - » **Automated error detection** developed based on **nominal-actual value comparison**
  - » **Automated fault analysis** development started based on **pattern matching**
- **Further work**
  - » **Automated recommandations for action** based of ROI considerations
  - » **Automated prediction** of imminent PV plant performance deterioration
  - » **Long-term field test** ⇨ evaluate reliability of all new SunSniffer® functionalities

Acknowledgement

NEXT ENERGY
EWE-Forschungszentrum für Energietechnologie e.V.

- Thanks to
  - » Colleagues at NEXT ENERGY
  - » Partners at
    - STORM Energy
    - University of Applied Sciences Bielefeld
- Public funding by German Federal Ministry of Economics and Energy (BMWi-E)

Federal Ministry for Economic Affairs and Energy