

# Monitoring und Garantieverfahren für Solare Großanlagen

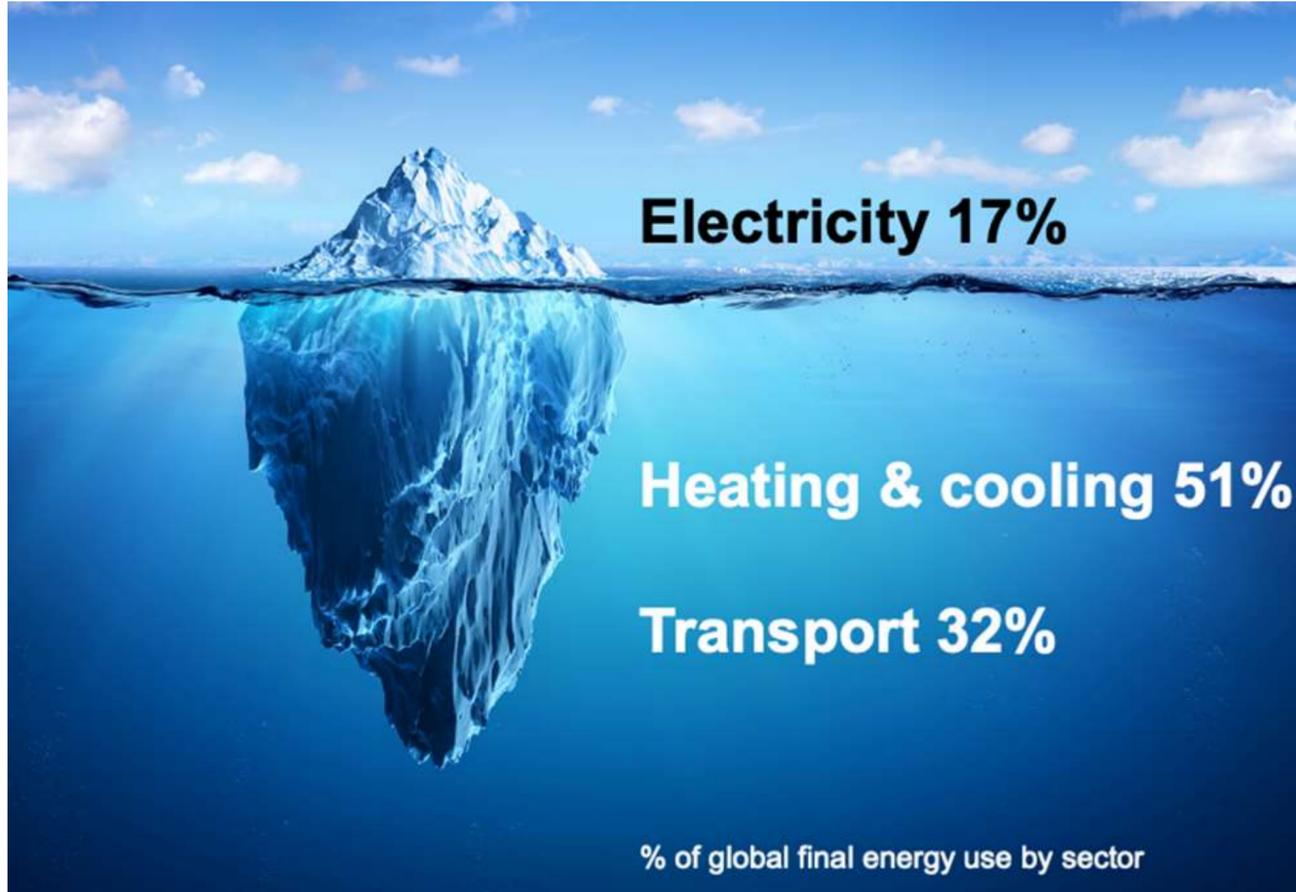
Neue digitale Methoden und aktuelle Entwicklungen

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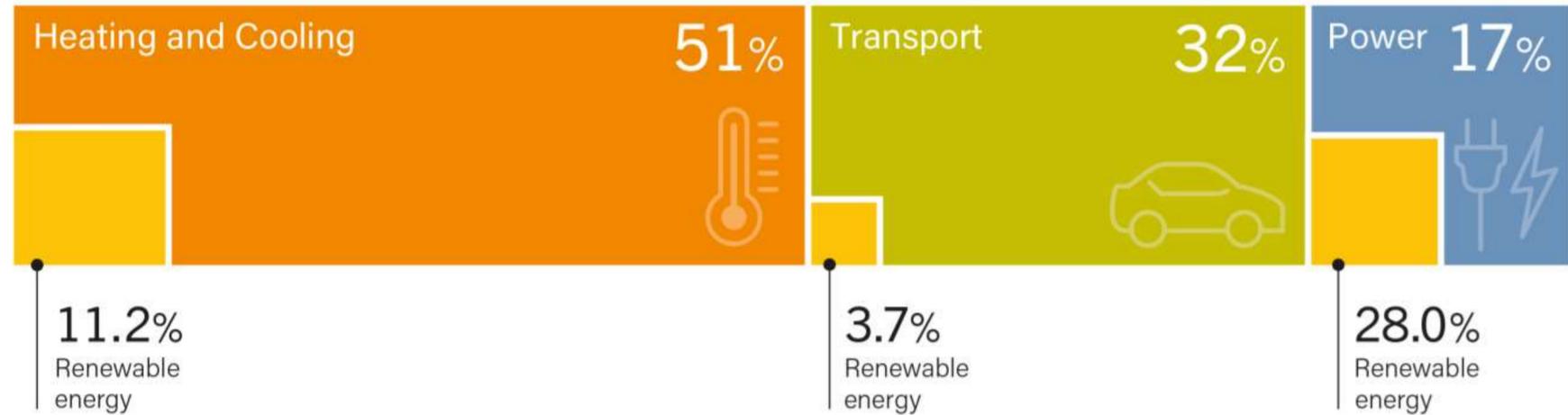
Philip Ohnewein

# Agenda

- 1 *Kontext* **Markt & Chancen**
- 2 *Monitoring* **Status Quo & interaktiver Teil**
- 3 *HarvestIT* **Garantieverfahren & Software**
- 4 *Ausblick* **D-CAT**



 Renewable Energy in Total Final Energy Consumption, by Final Energy Use, 2019



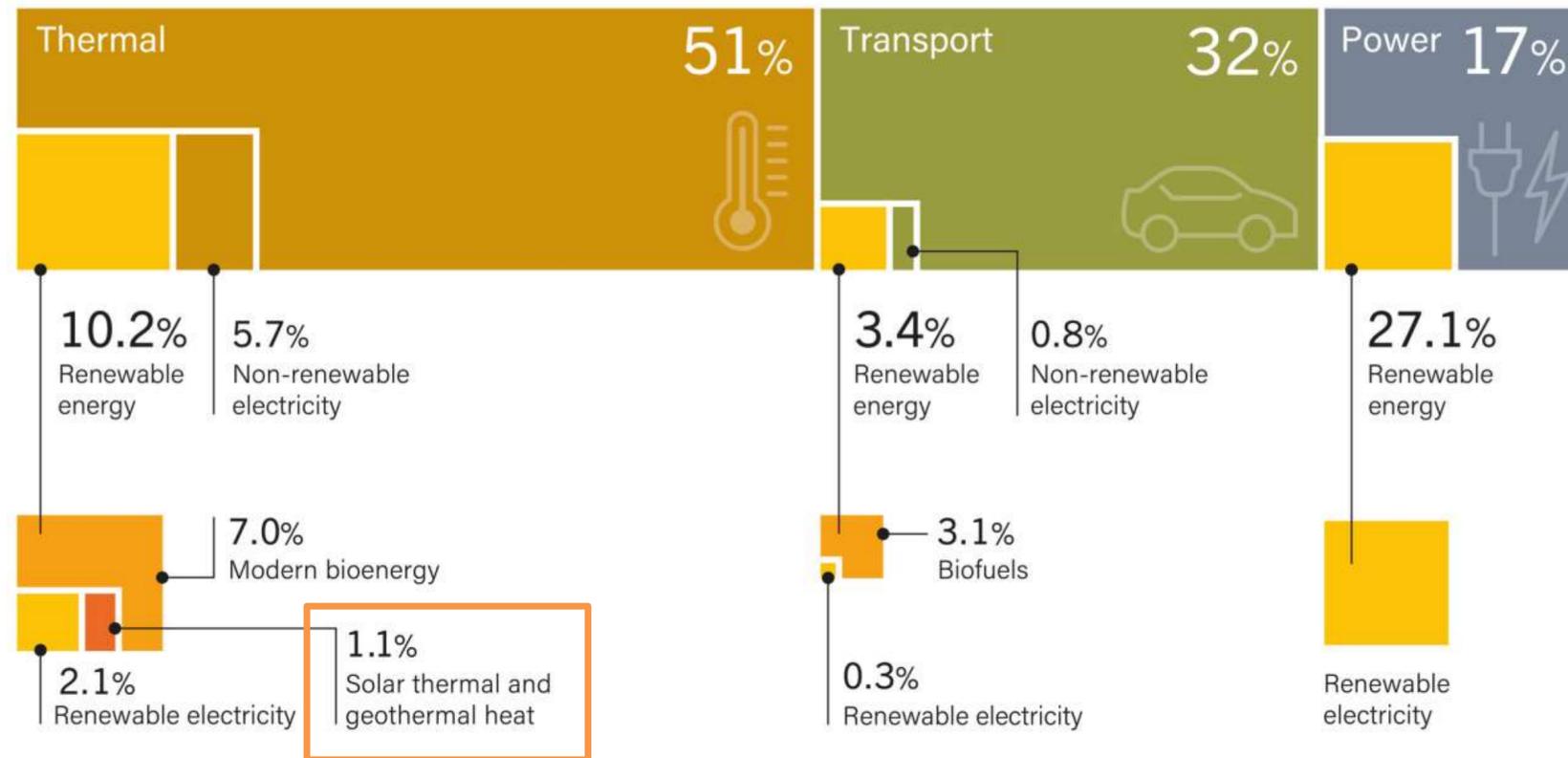
Note: Data should not be compared with previous years because of revisions due to improved or adjusted methodology.

Source: Based on IEA data.

Source: <https://twitter.com/janrosenow>

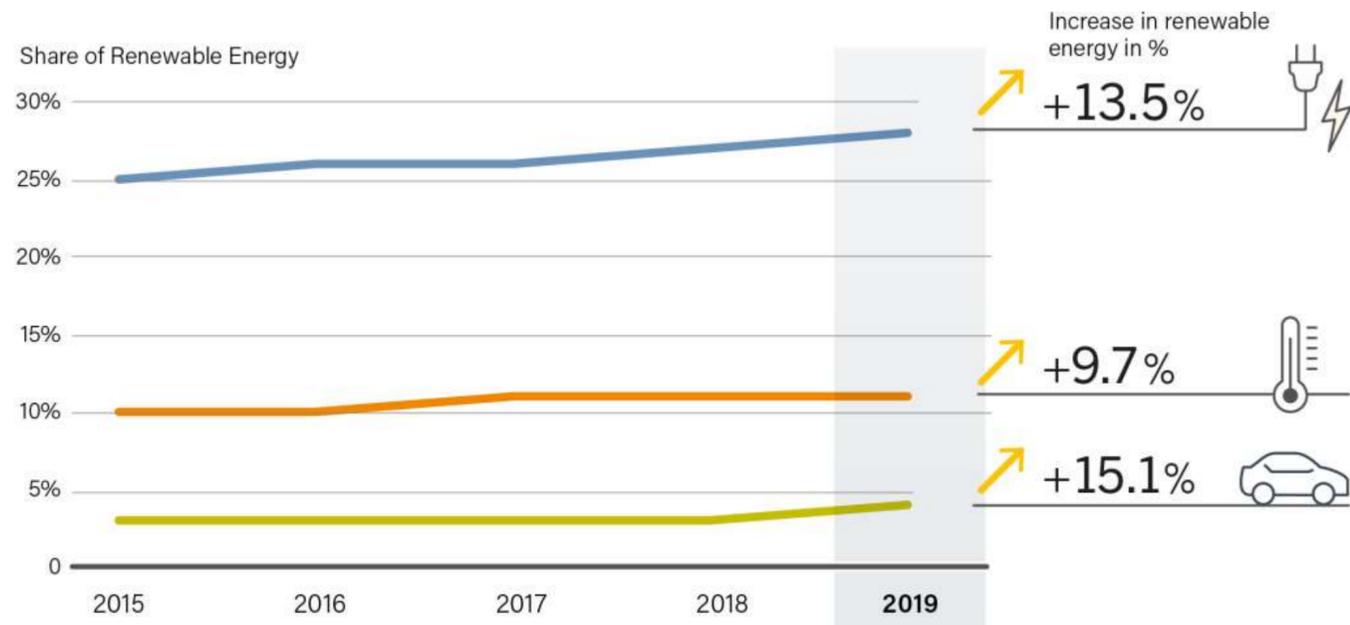
Source:  REN21 RENEWABLES 2022 GLOBAL STATUS REPORT

 **Renewable Energy in Total Final Energy Consumption**  
by Final Energy Use, 2018



Note: Data should not be compared with previous years because of revisions due to improved or adjusted methodology.  
Source: Based on IEA data.

 **REN21** RENEWABLES 2021 GLOBAL STATUS REPORT



## POLITISCHE RAHMENBEDINGUNGEN IN EUROPA

EU-Mitgliedsstaaten sollen den Anteil erneuerbarer **WÄRME** bis 2030 jedes Jahr um **1.3%** erhöhen.

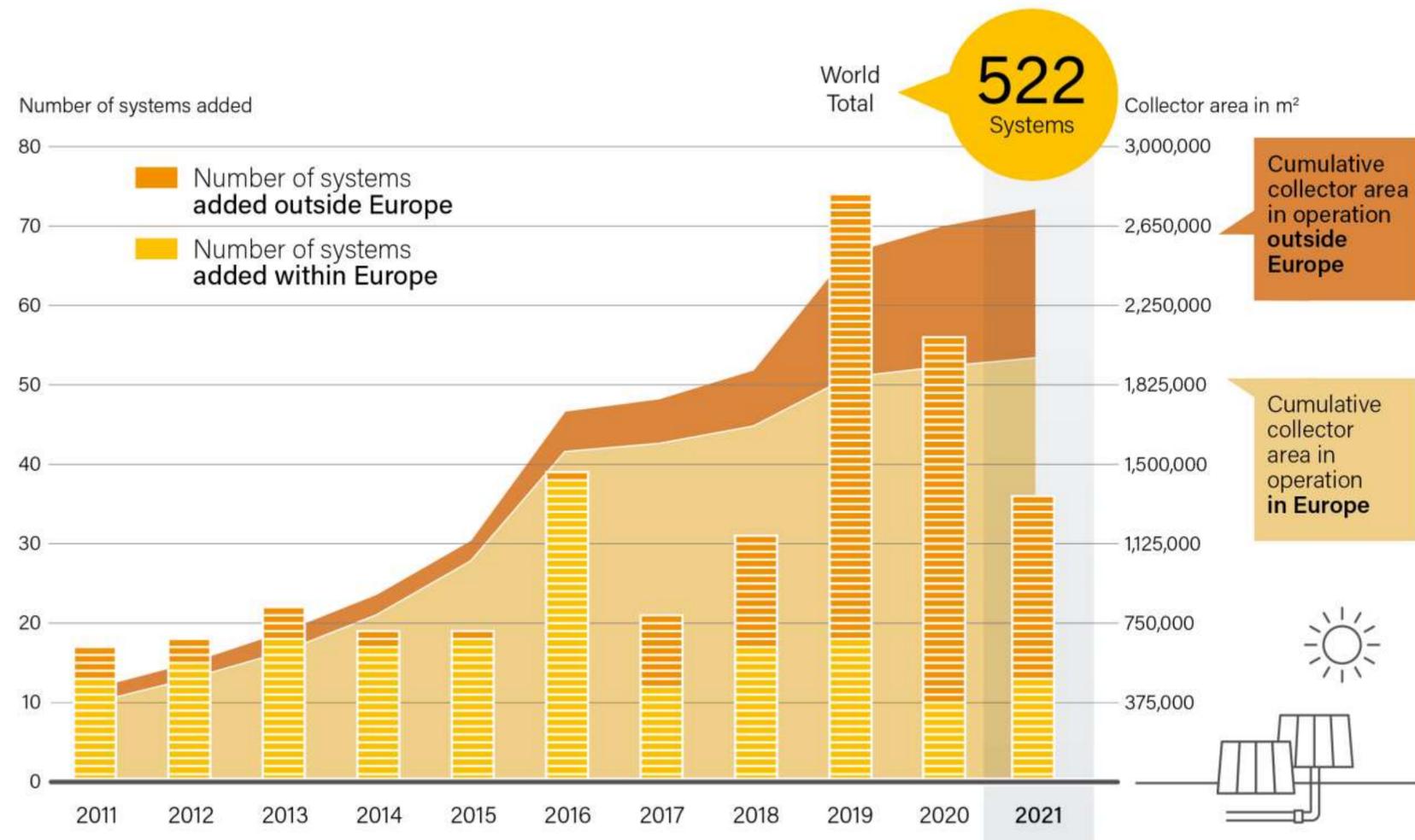


► **SOLARE FERNWÄRME HILFT, DIESES ZIEL ZU ERREICHEN.**



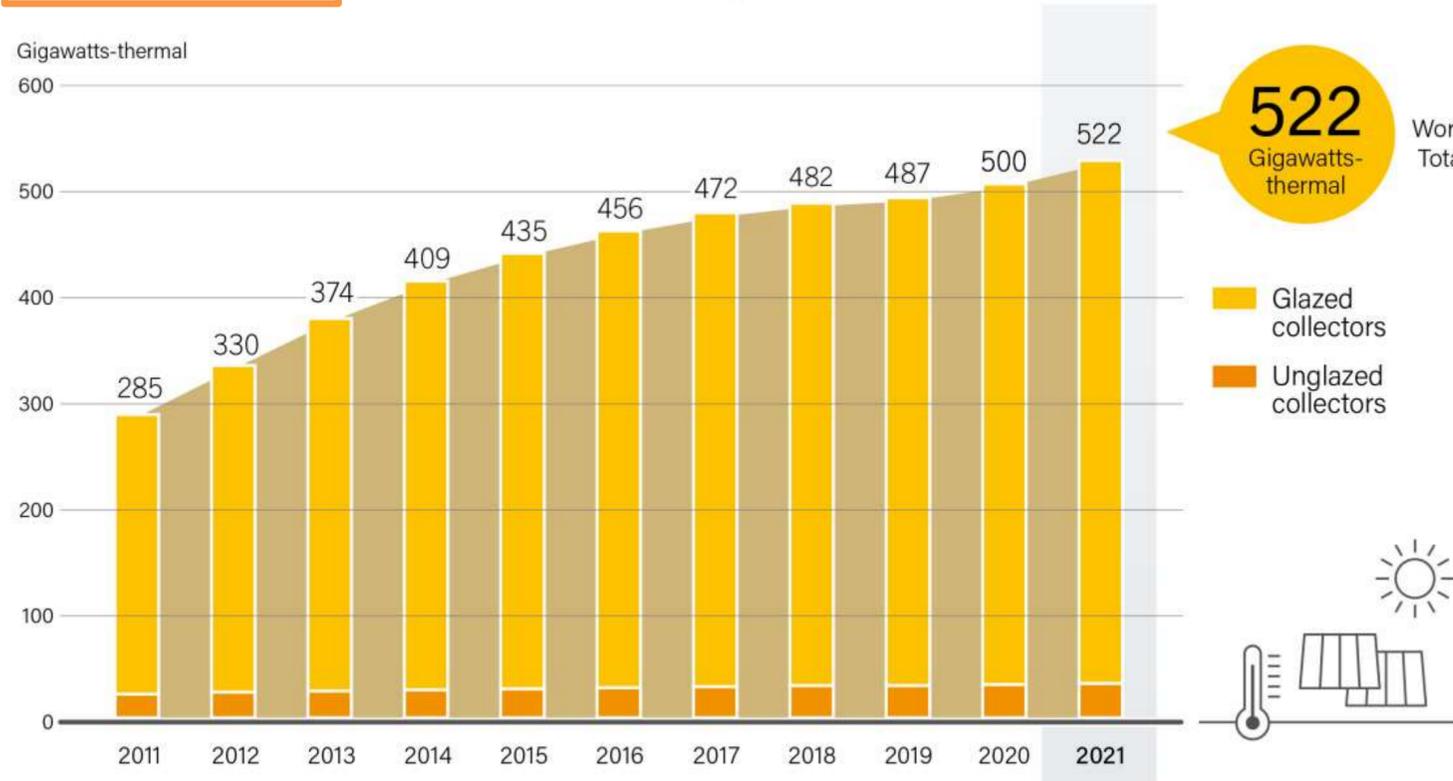
# LST: Large Solar Thermal

 **Large Solar Heat Plants, Global Annual Additions and Total Area in Operation, 2011-2021**



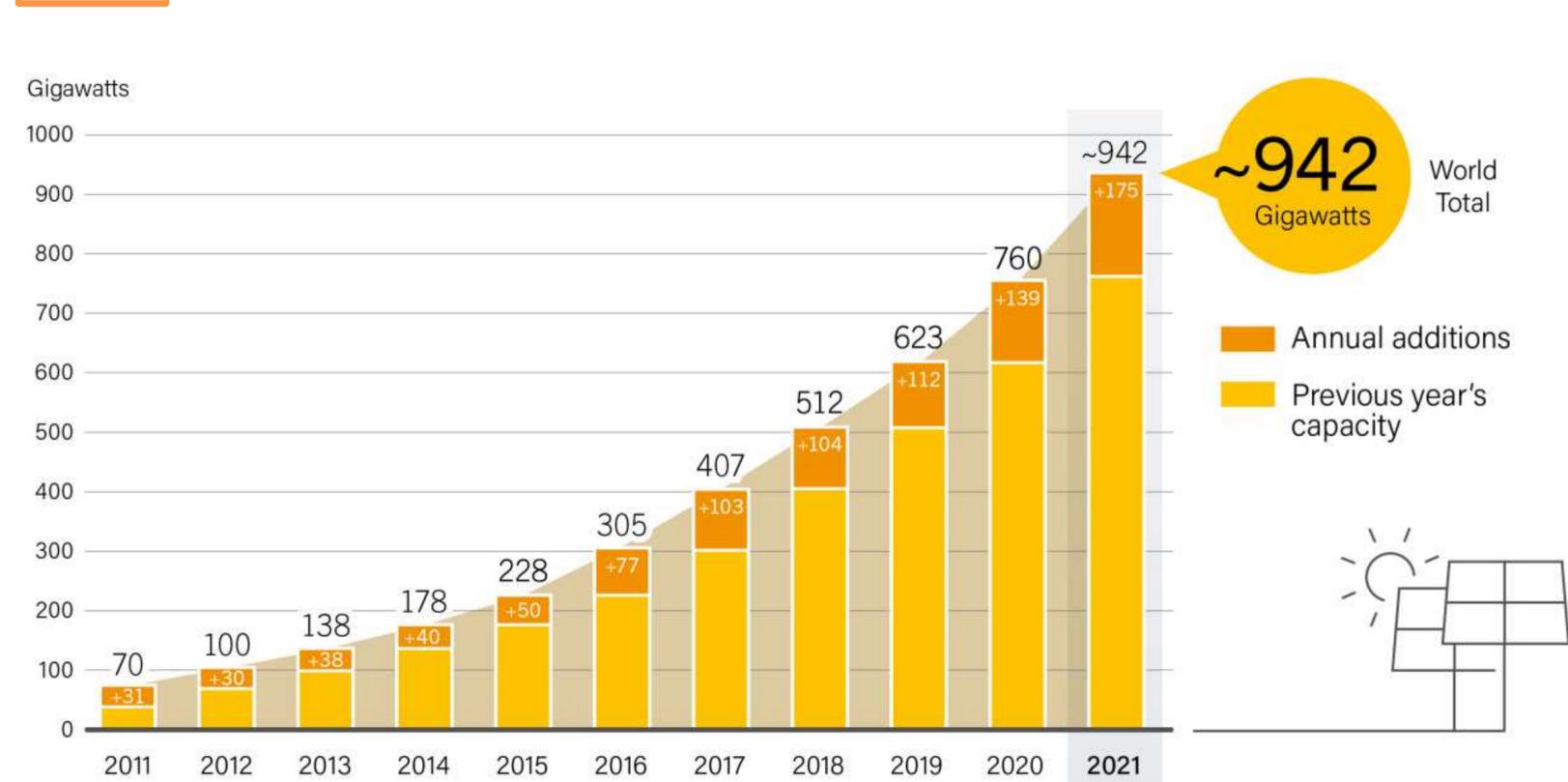
Source: Based on IEA SHC.  
 Note: Figure includes plants with collector fields of at least 350 kilowatts-thermal (kWth) (500 m²), either for solar district heating or for solar hot water and/or solar space heating of residential, commercial and public buildings. Data are for solar water collectors and concentrating collectors.

**Solar Water Heating Collectors Global Capacity, 2011-2021**



Source: Based on IEA SHC.  
 Note: Data are for glazed and unglazed solar water collectors and do not include concentrating, air or hybrid collectors.

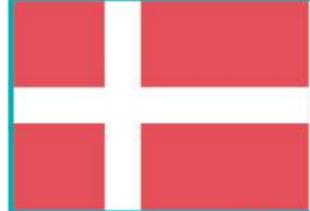
**Solar PV Global Capacity and Annual Additions, 2011-2021**



Source: Based on IEA PVPS.



IEA SHC TASK 55



## ERFOLGSFAKTOREN VON SOLARER FERNWÄRME IN DÄNEMARK

**MAXIMALE TRANSPARENZ**



Öffentlich zugängliche Ertragsdaten der solaren Fernwärme erzeugen Vertrauen.

**INVESTOREN-DENKEN**



Bürgerfinanzierte Energieerzeugung verfolgt langfristige Investitionsstrategien.

**AUSSTIEG AUS FOSSILEN ENERGIEN**

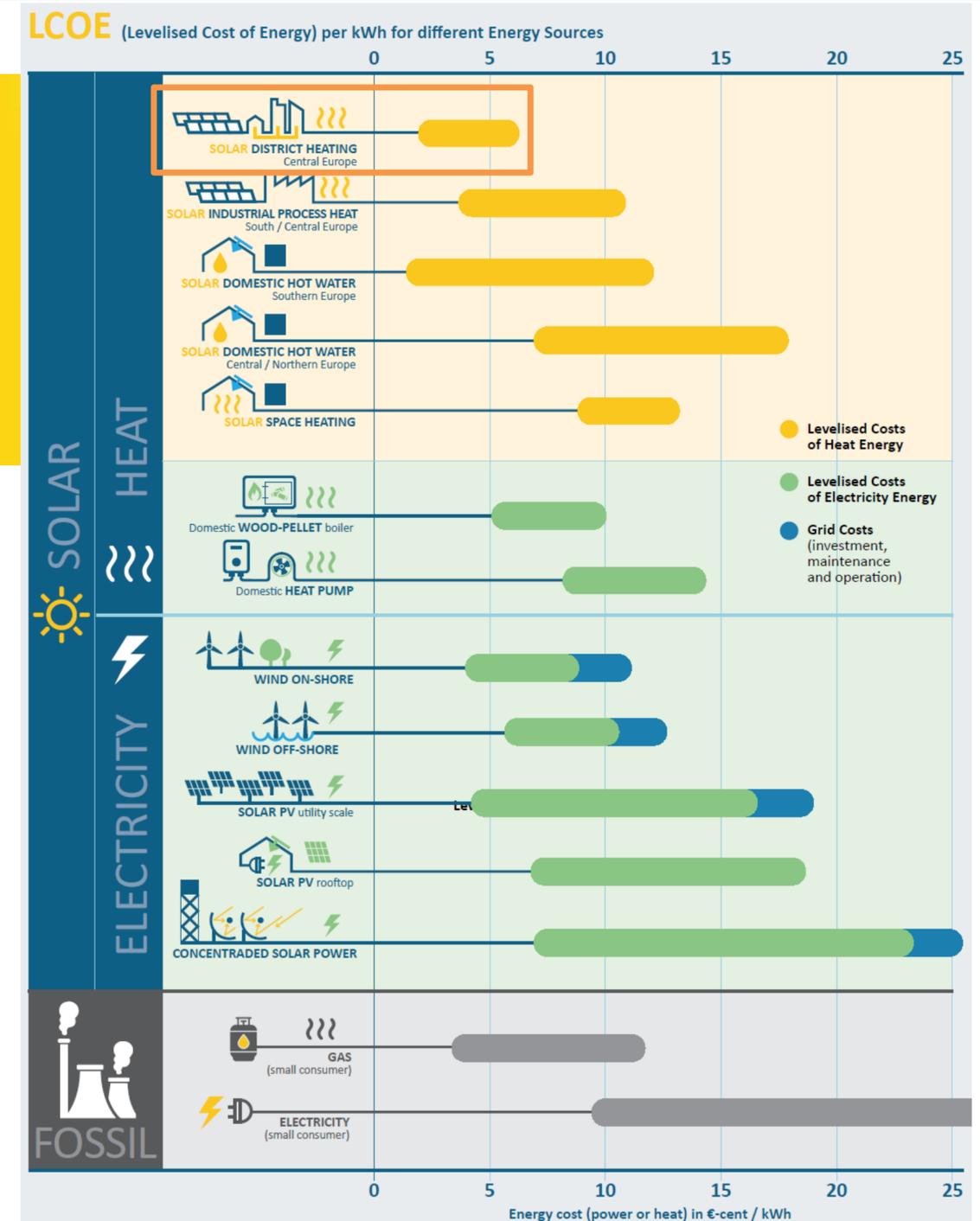


Hohe Steuern auf fossile Energieträger machen Solarwärme wettbewerbsfähig gegenüber Erdgas.

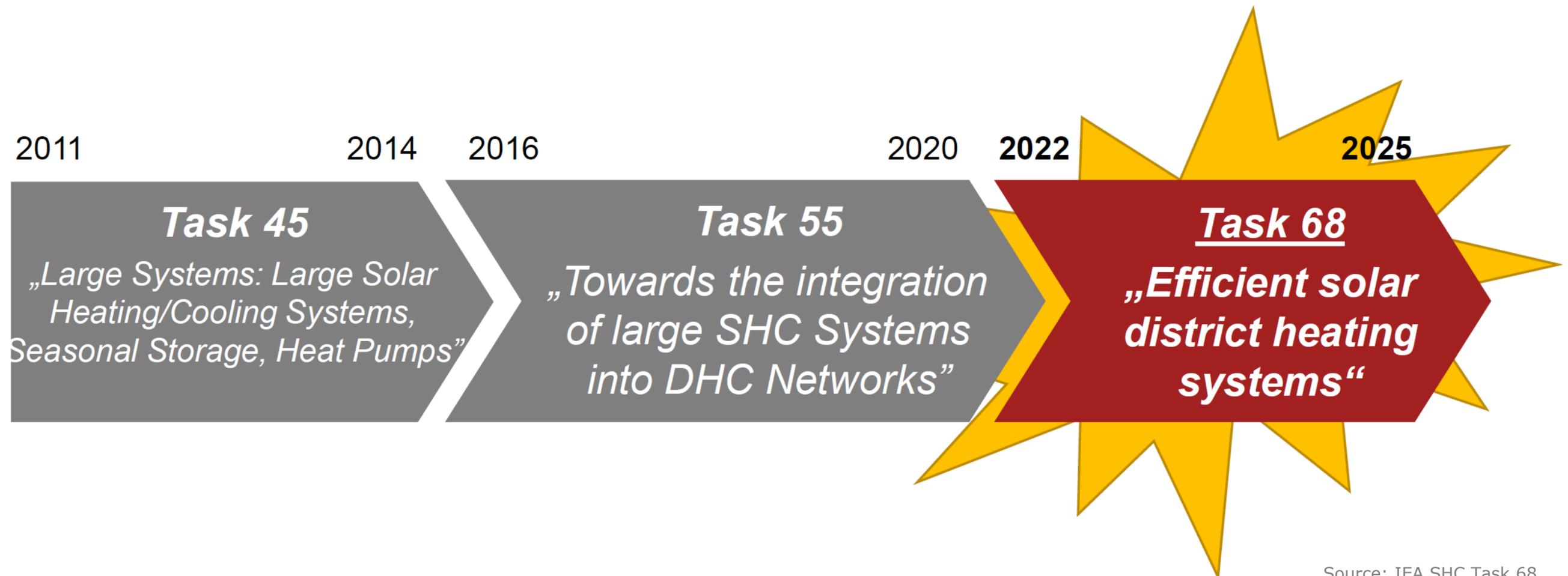
IEA SHC TASK 55

<https://solvarmedata.dk>

## Energising Europe with Solar Heat A Solar Thermal Roadmap for Europe



## History of tasks in the context of solar district heating (SDH) systems



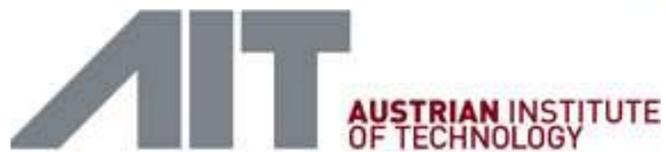
Source: IEA SHC Task 68

# Agenda

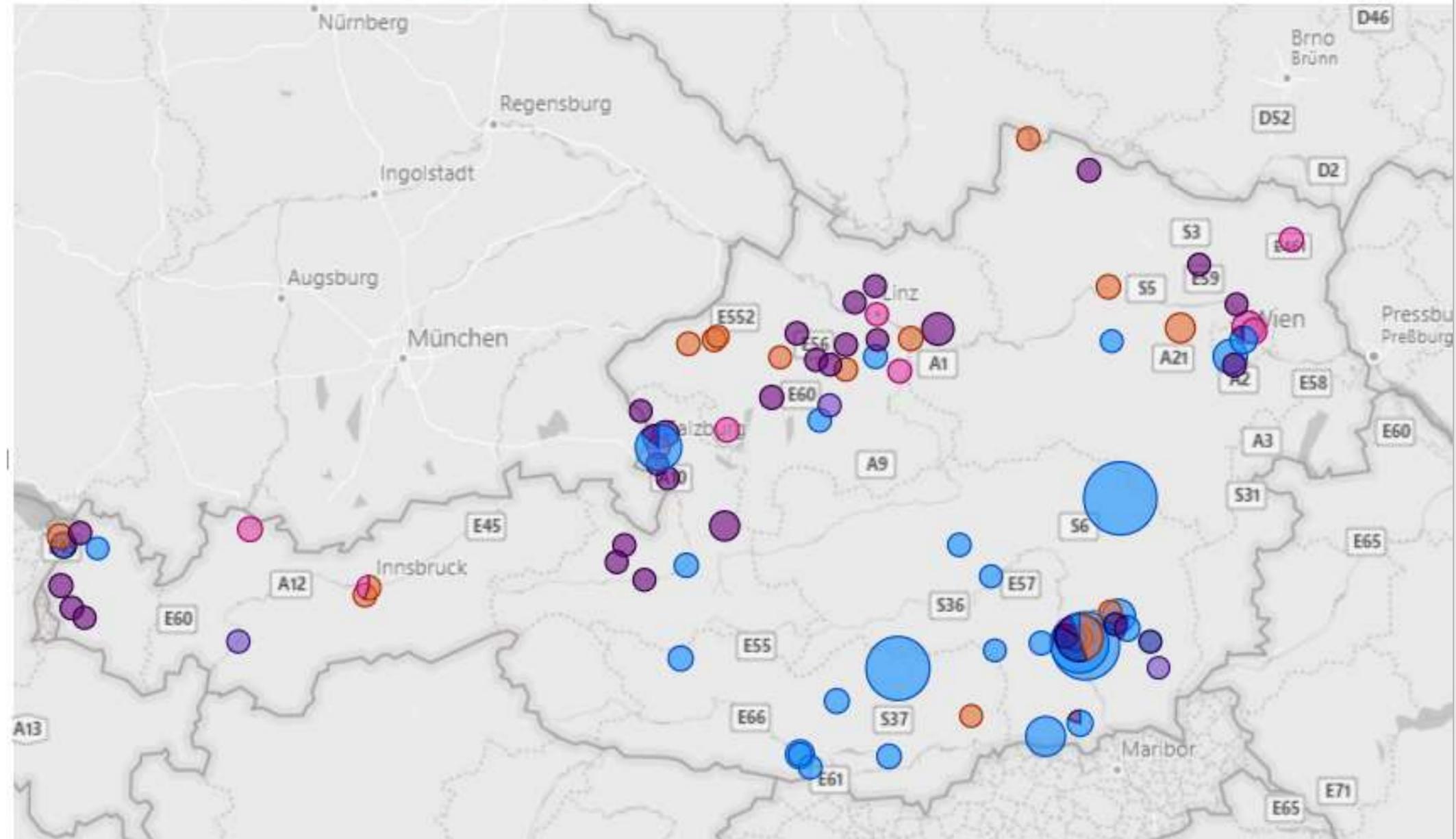
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# Begleitforschung 2010 – 2019

- Special funding program since 2010 for solar thermal plants > 100 m<sup>2</sup>
- Investment incentive of 40-50% of the eligible costs
- Accompanying research: Consulting, Monitoring, Knowledge Transfer

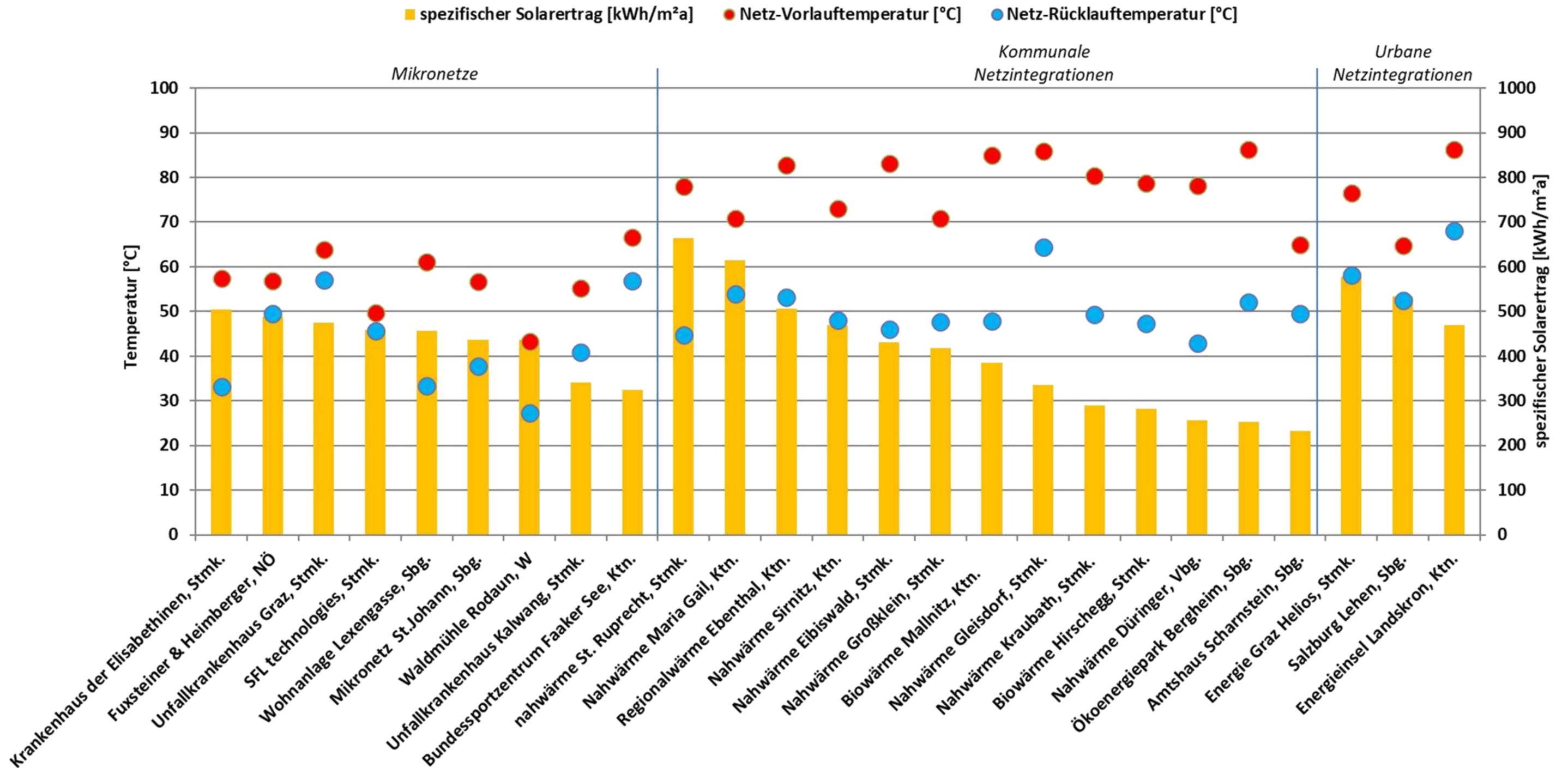


Kategorie ● Klim. ● NT ● PrW ● SD ● WN ● WP



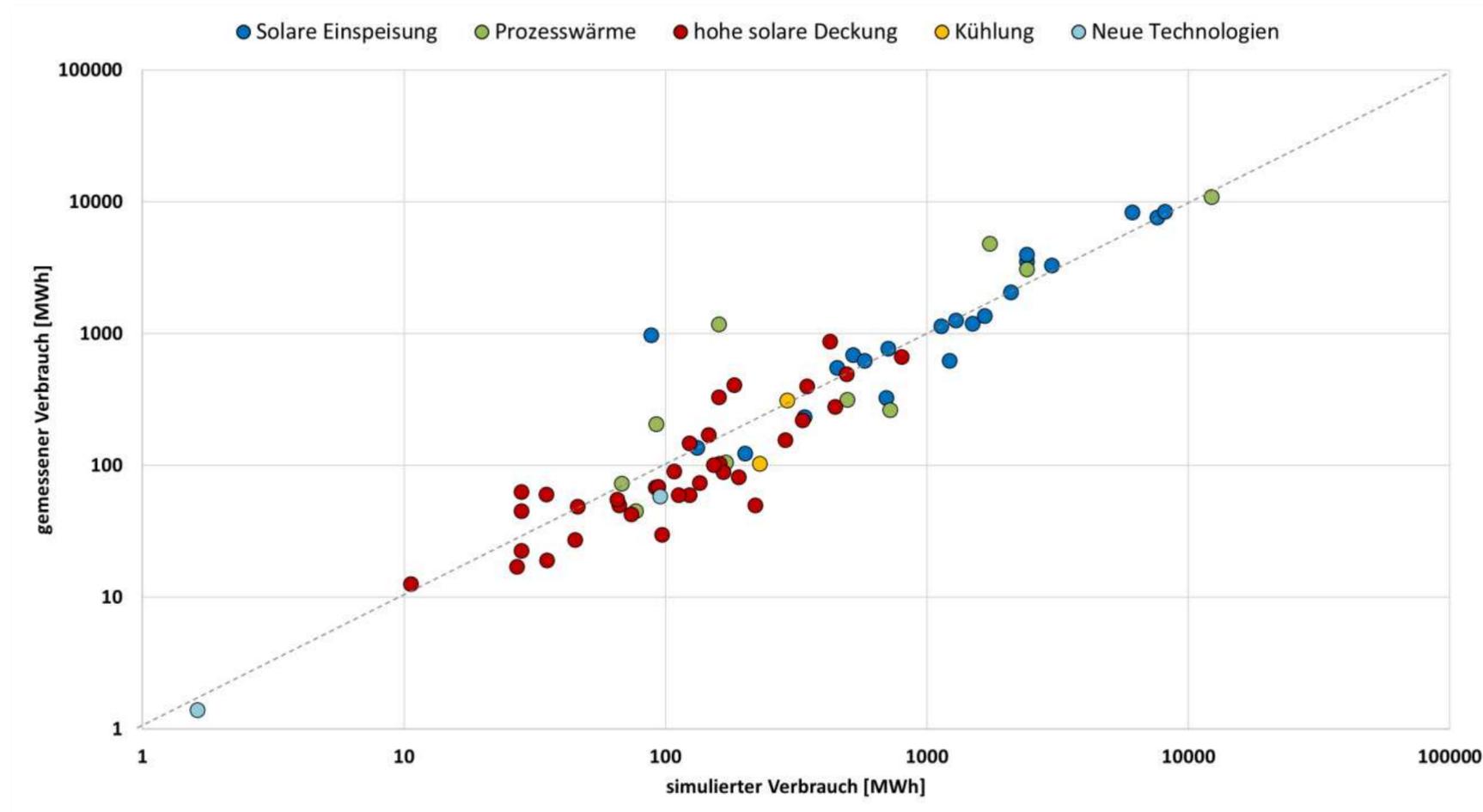
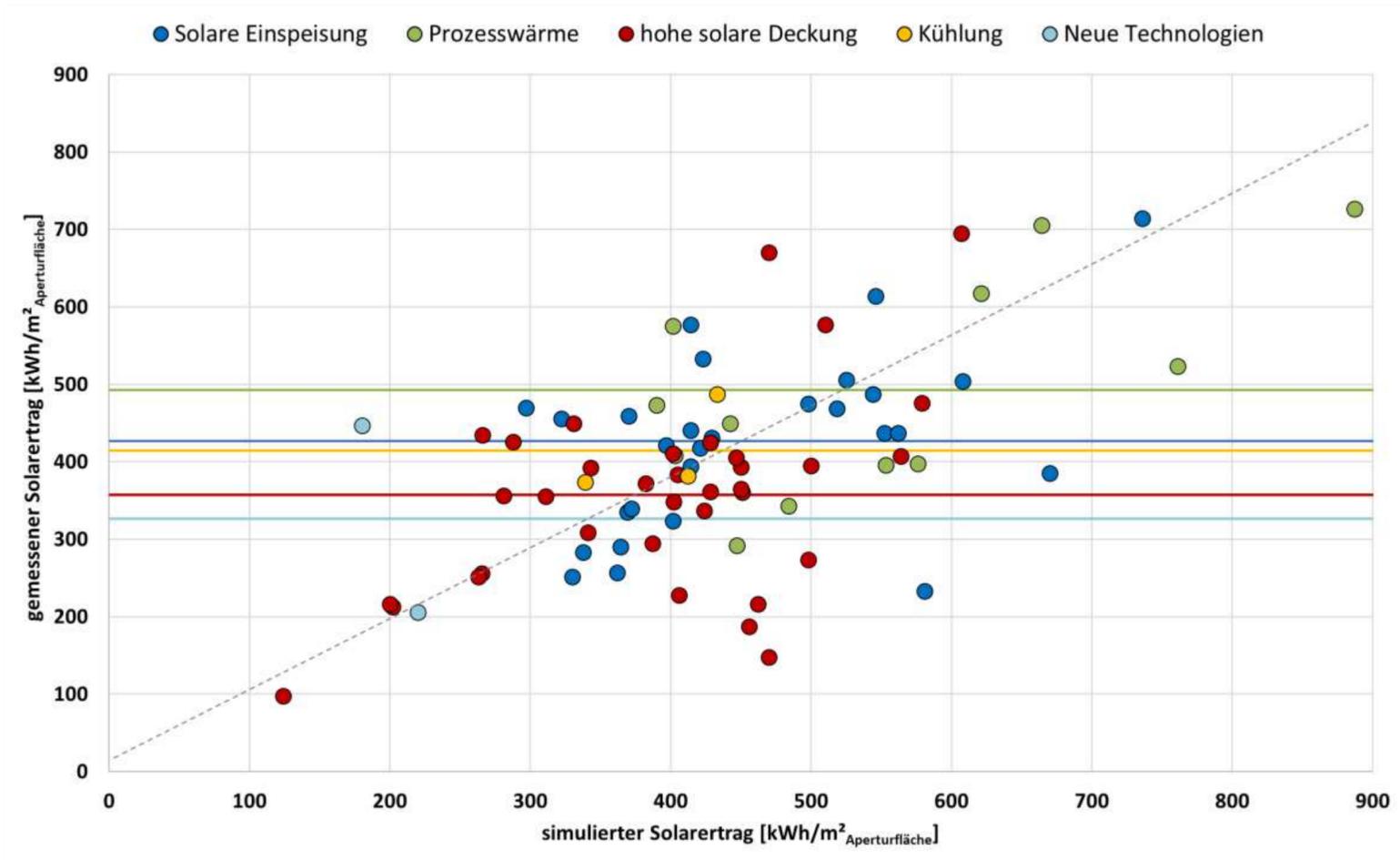
Bubble size == plant size [100 m<sup>2</sup> ... 6.922 m<sup>2</sup>]

# Solare Netzeinspeisung



## Abweichung Ertrag Simulation vs. Messung

## Abweichung Verbrauch Simulation vs. Messung



# Garantieverfahren

Motivation für praktische Anwendung

## Umfeld

- a) Es gibt am Markt **keine Standard-Software** für Solarthermie-Garantien.
- b) Garantie & Performance-Bewertung ist **schwierig**, auch für Experten.
- c) **Big Data**. Daten stehen zur Verfügung, nutzen wir sie.

## Finanzierung

- CAPEX: Solare Großanlagen haben **hohe Investitionskosten**.
- OPEX: Betreiber muss **langfristig hohen Solarertrag** sicherstellen, damit sich die Investition rechnet.

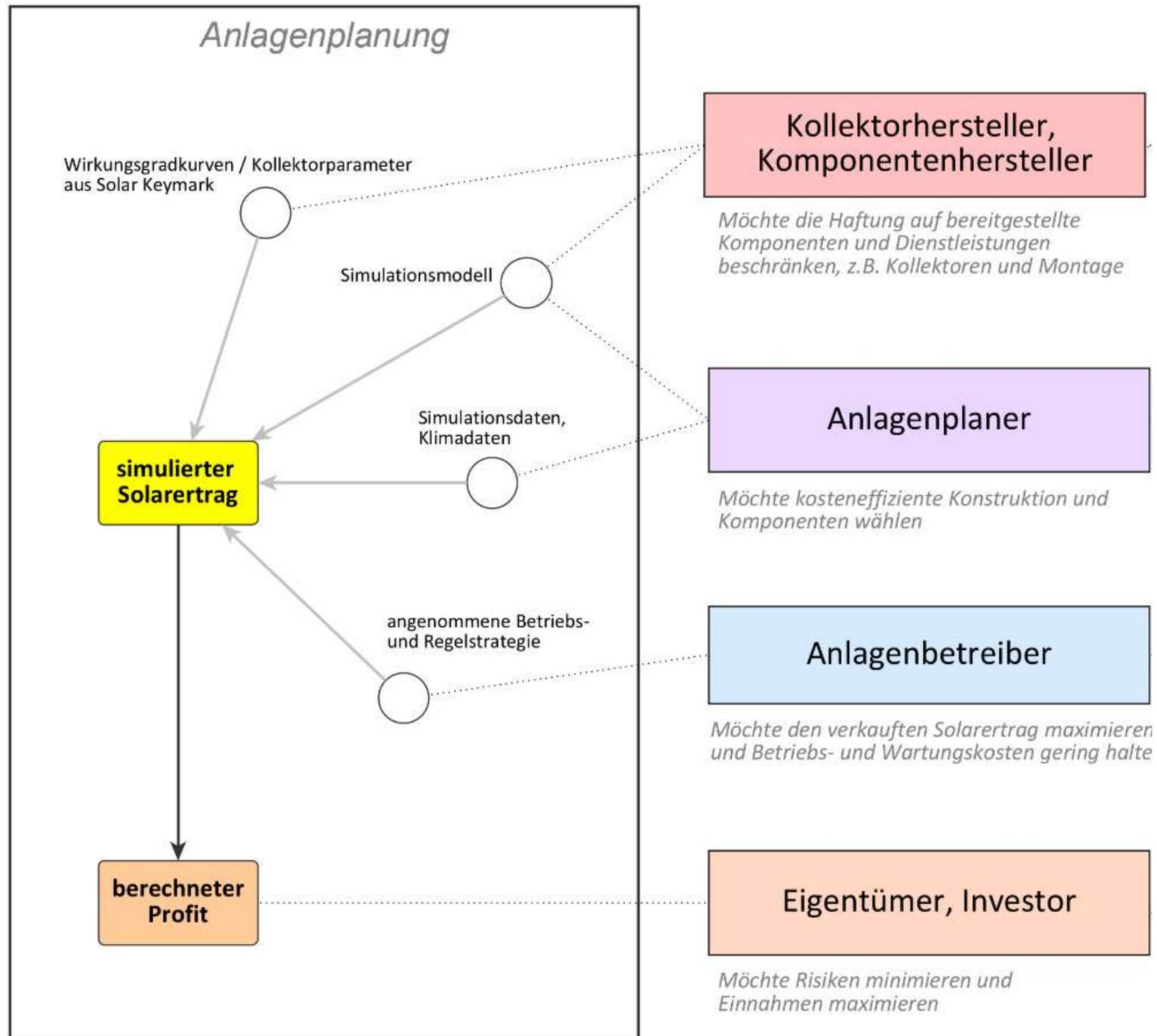
## Garantieverfahren

Kernfragen & Ziele HarvestIT:

- 1) **Leistungs- und Ertragsgarantie** für Kollektorfelder
- 2) **Bewertung der Kollektorfeldperformance** unter Berücksichtigung des Anlagenbetriebs (Temperaturen, Verbrauch etc.)
- 3) **Anwendung für kommerzielle Anlagen im Betrieb**

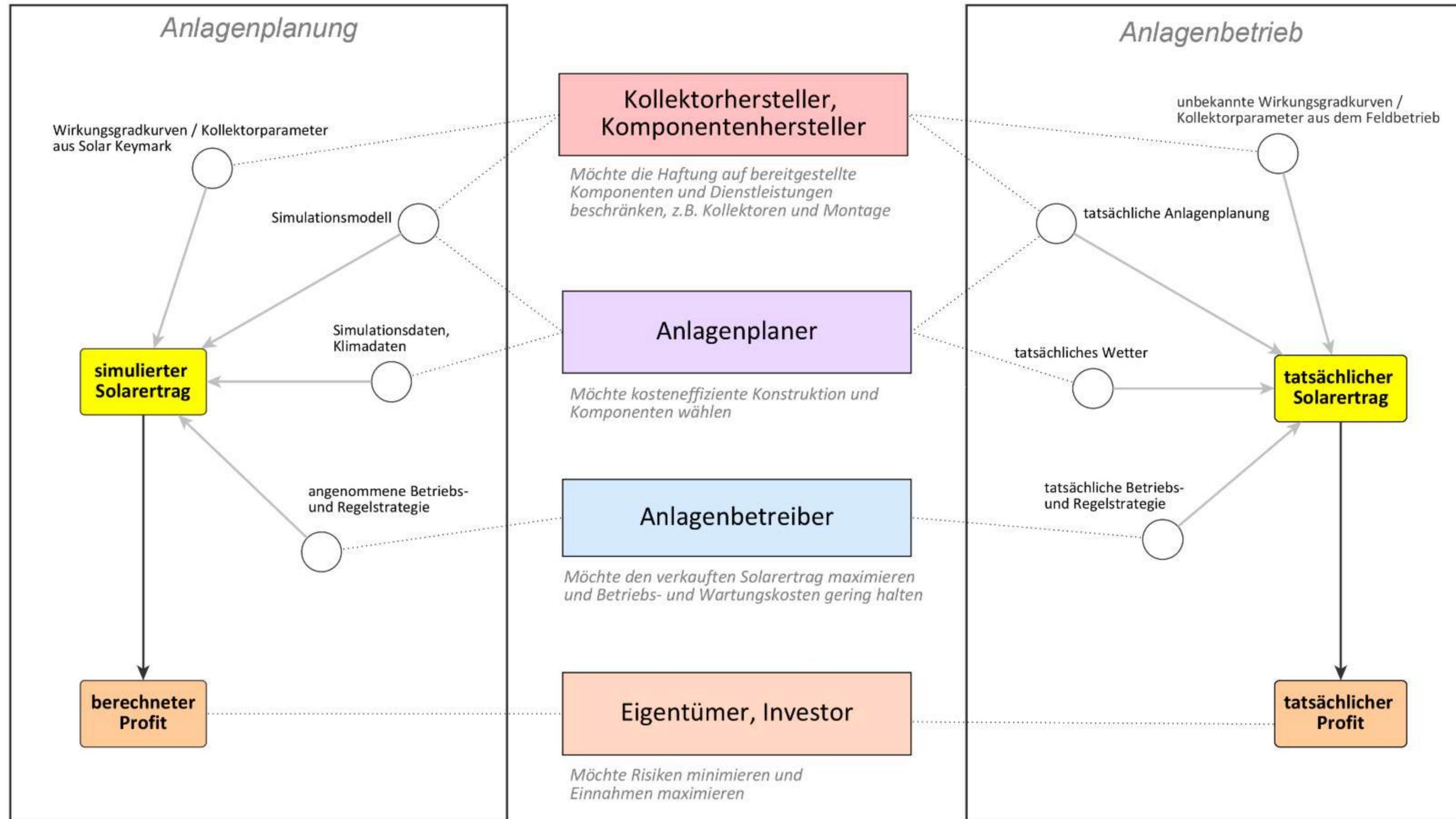
# Garantieverfahren

## Rollen & Verantwortung



# Garantieverfahren

## Rollen & Verantwortung



# Garantieverfahren

## Bedeutung

- 1) Klärung der Frage „Anlagenperformance ok?“
- 2) **Glaubwürdigkeit & Vertrauen** in Technologie Solarthermie / LST
- 3) **Eindeutigkeit durch Normen:** Beruht auf **ISO 24194 & Solar Keymark / ISO 9806**
- 4) Günstiges Monitoring durch **Automatisierung / HarvestIT Software**
- 5) Hoher Output durch Monitoring: **Niedriger Energiepreis/ LCOE**
- 6) **Bankability:** Vereinfachte Verträge & Finanzierung



## HarvestIT: Advanced monitoring of large-scale solar thermal plants with open-source software

- FFG – FastTrackDigital 1st Call
- Project duration: 2021-11 to 2023-10



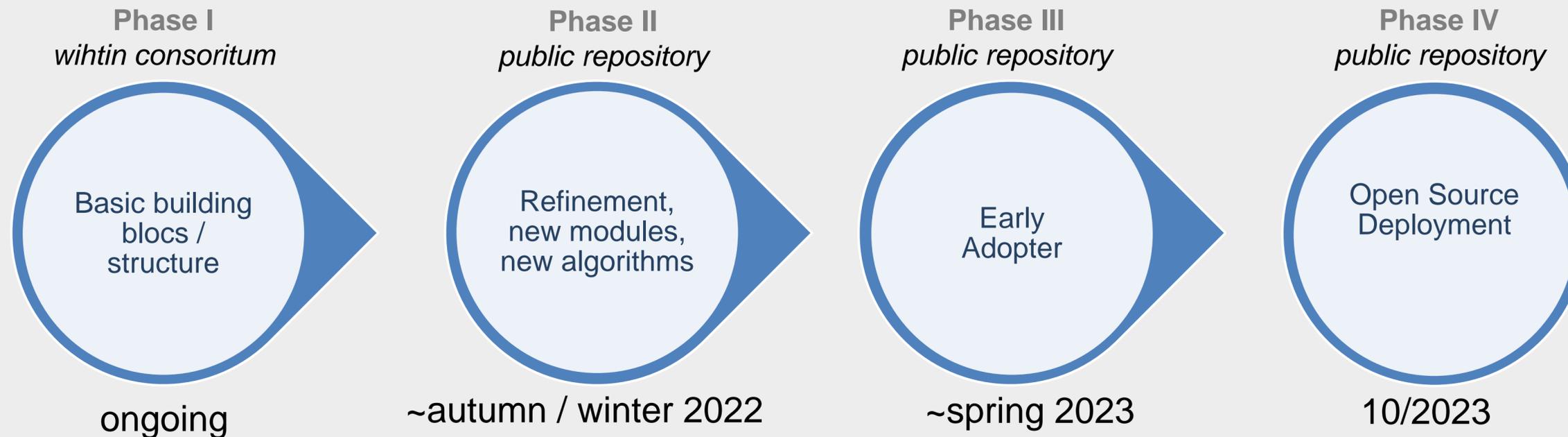
Source: Picfly.at Thomas Eberhard



# HarvestIT Software

## Roadmap to Deployment

### Tool development



# HarvestIT: Bitte mitmachen



**WE WANT YOU**

## Questionnaire Monitoring Tools

<https://www.menti.com>

code 2742 8296



## Development Phase II – IV Early Adopter oder Developer ab Ende 2022

Write to [d.tschopp@aee.at](mailto:d.tschopp@aee.at)

## HarvestIT Projekt Updates Any feedback welcome!

[www.collector-array-test.org](http://www.collector-array-test.org)

# Fragebogen Monitoring

26 Teilnehmer (19 davon Großteil der Fragen beantwortet)



## HarvestIT

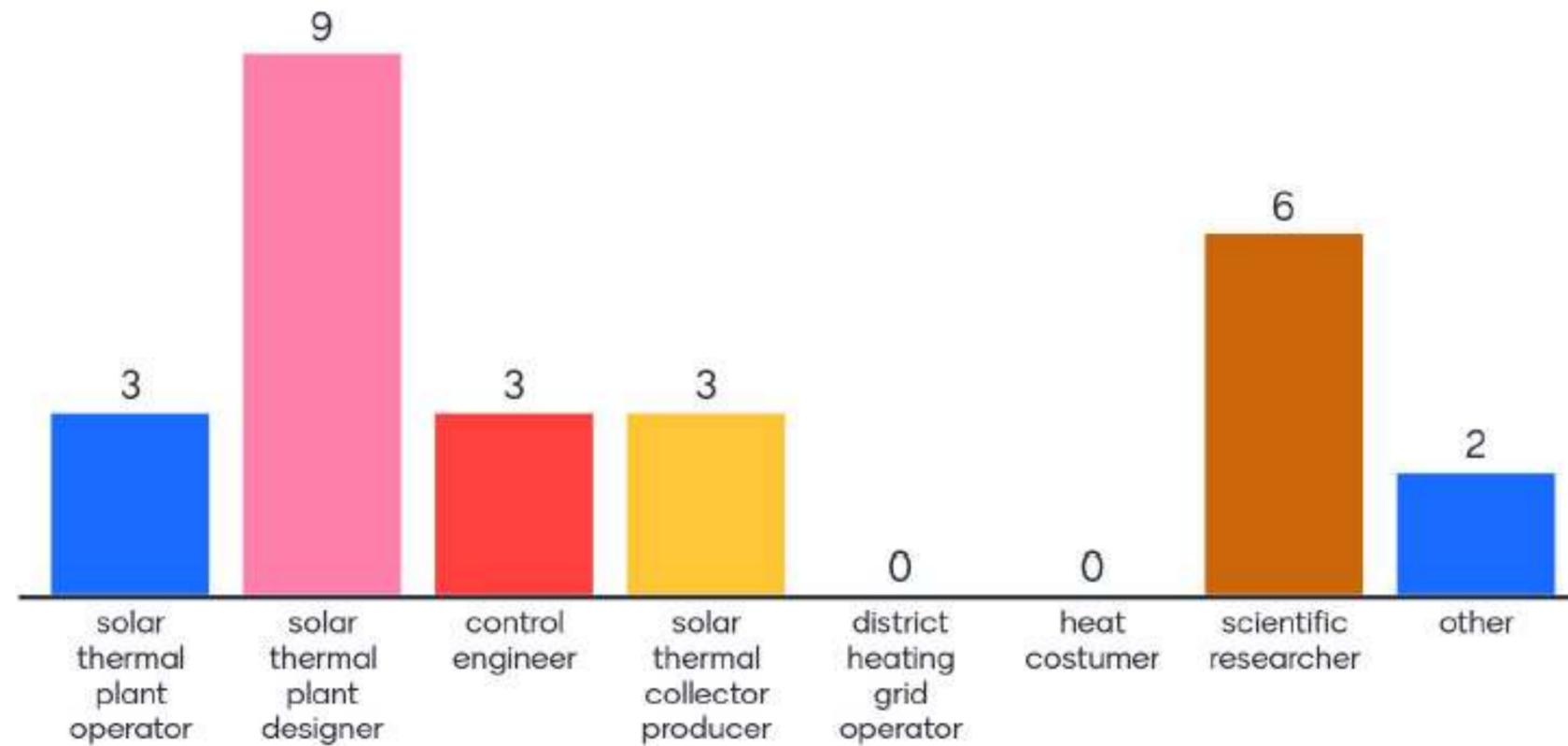
- In the project HarvestIT a freely available open source software will be developed for advanced monitoring of solar thermal systems.
- With this questionnaire you can help us to design a good software tool.
- The questionnaire may take about 5-10 minutes.
- Multiple answers are possible.
- If several systems are being considered, please provide us with typical answers!



[Next](#)

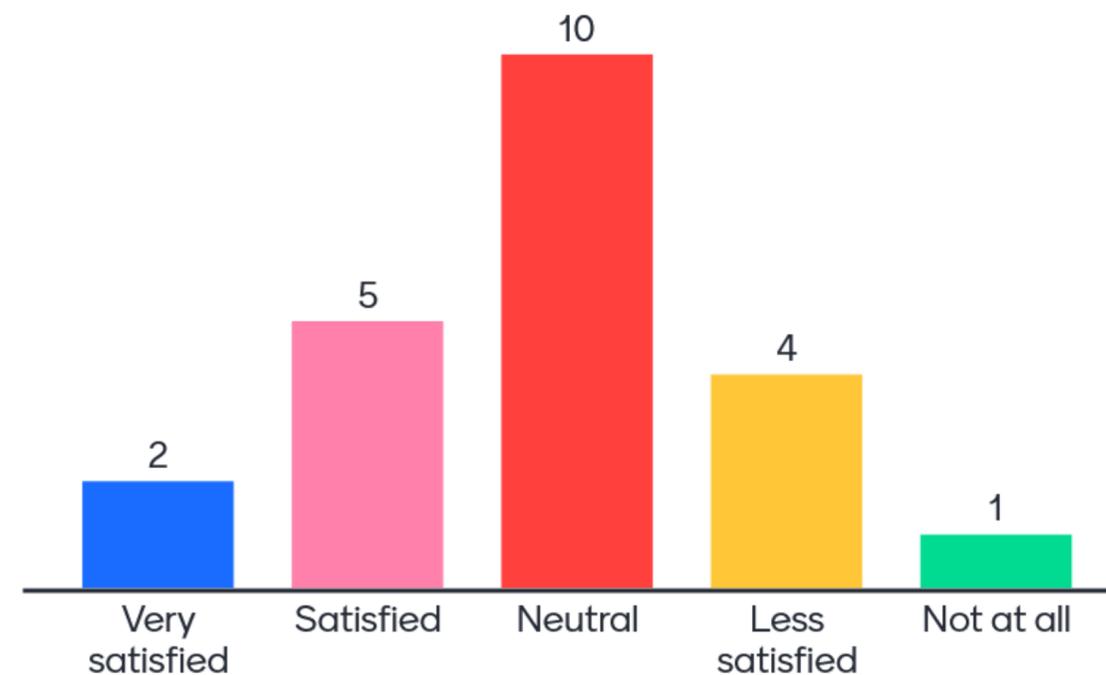
# Fragebogen Teilnehmer

I am a ...



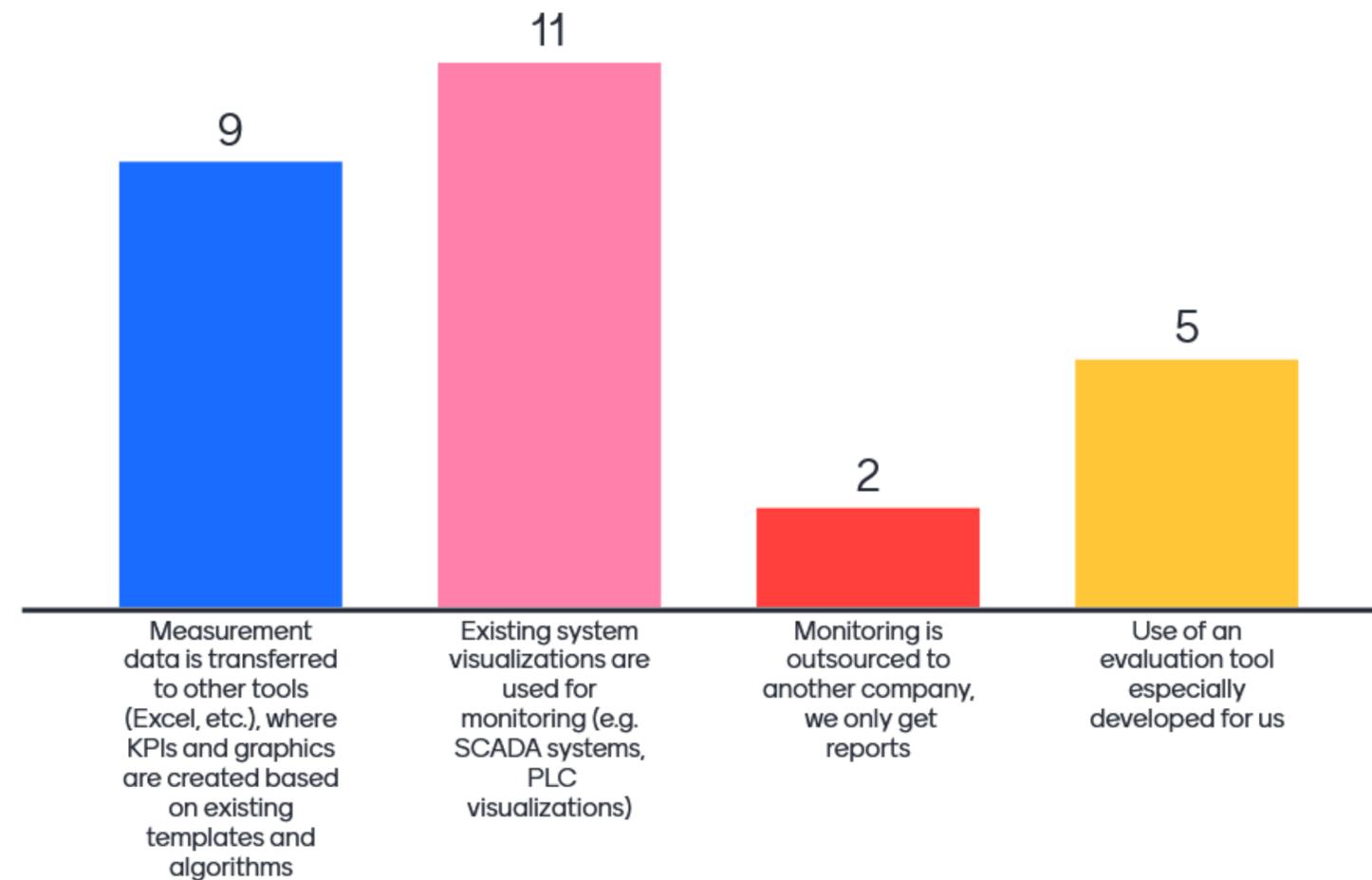
# Zufriedenheit Monitoring

**1 Satisfaction: How satisfied are you with the current monitoring procedures of the solar thermal plants you operate or deal with?**

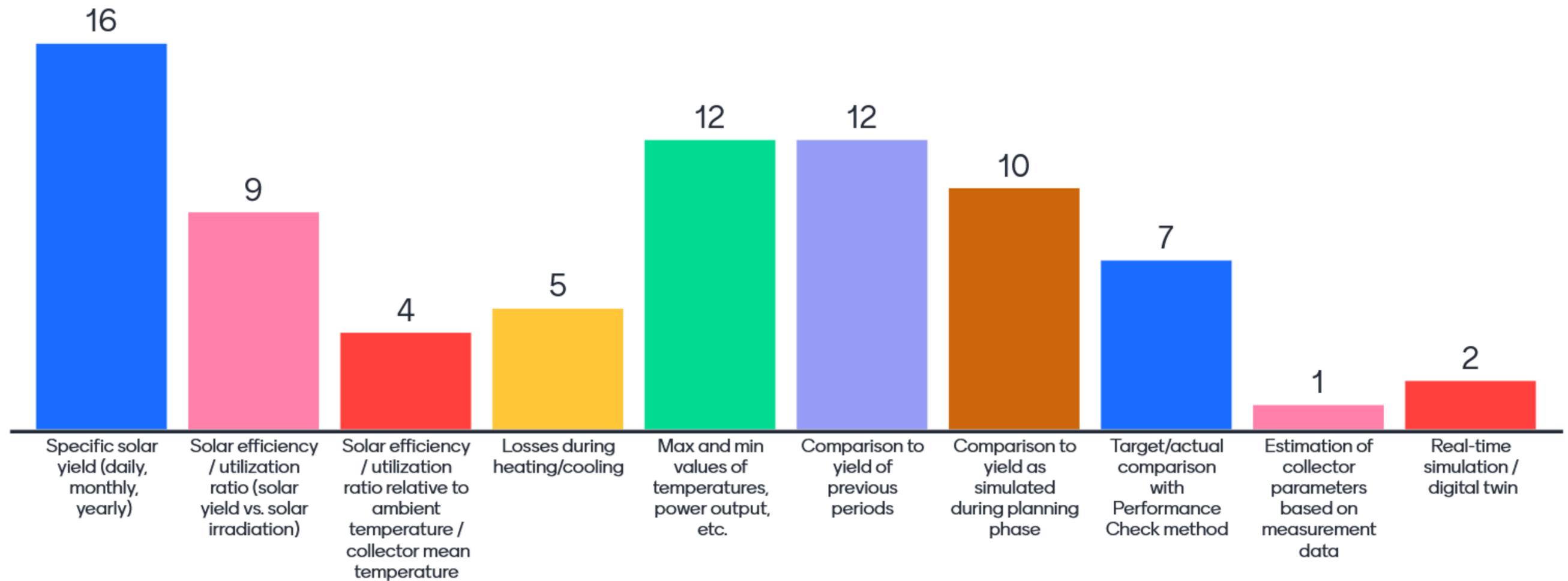


# Monitoring aktuell

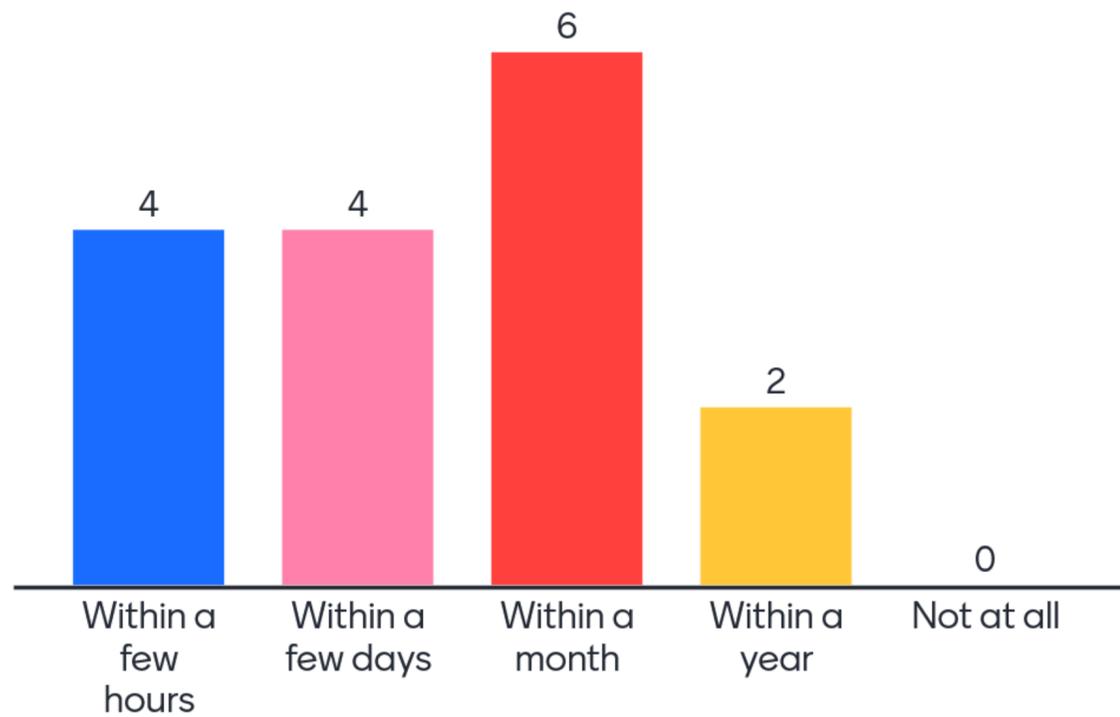
## 4 Tool: Which tools do you use to analyse the system?



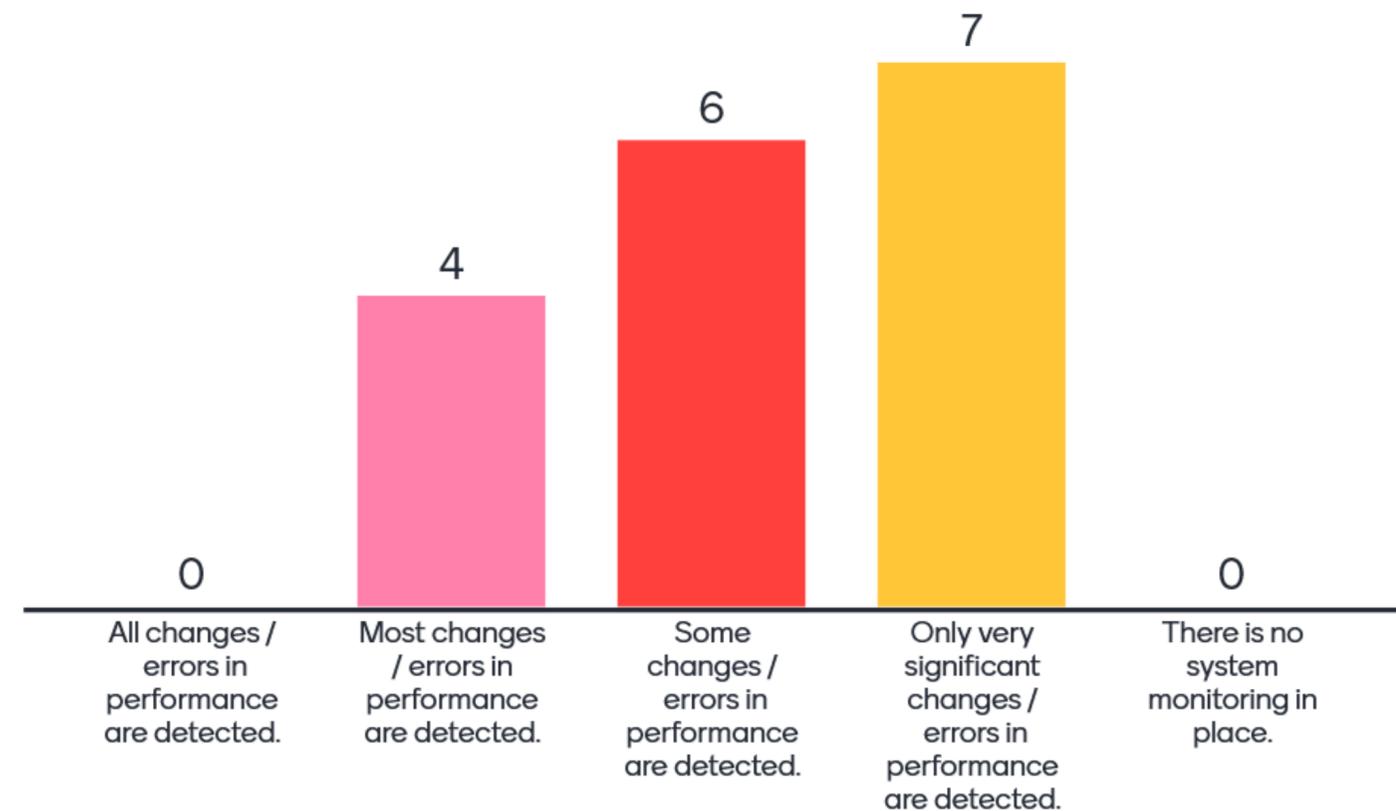
# Performance indicators used



## 8 Detection time frame : How quickly are performance changes and errors detected?

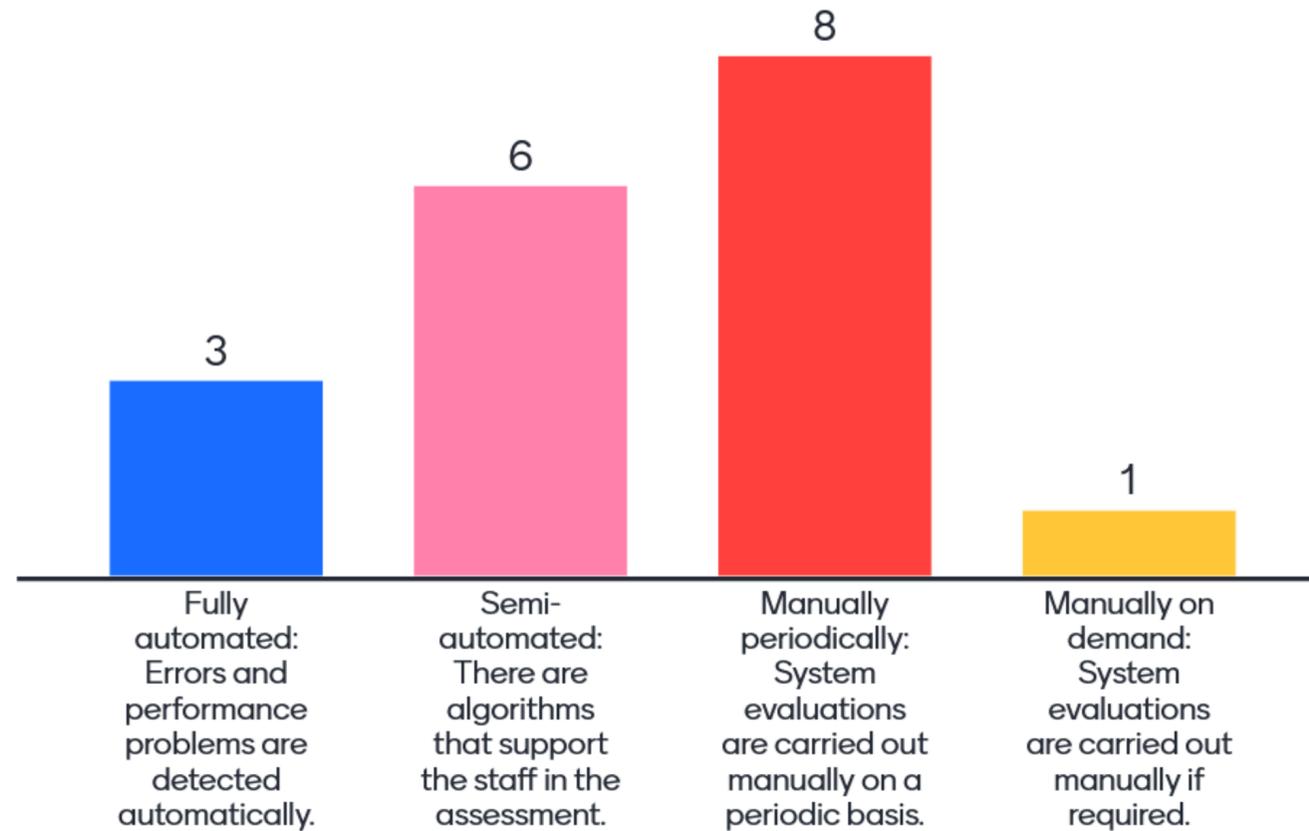


## 7 Plant performance: How well are performance changes and errors detected?



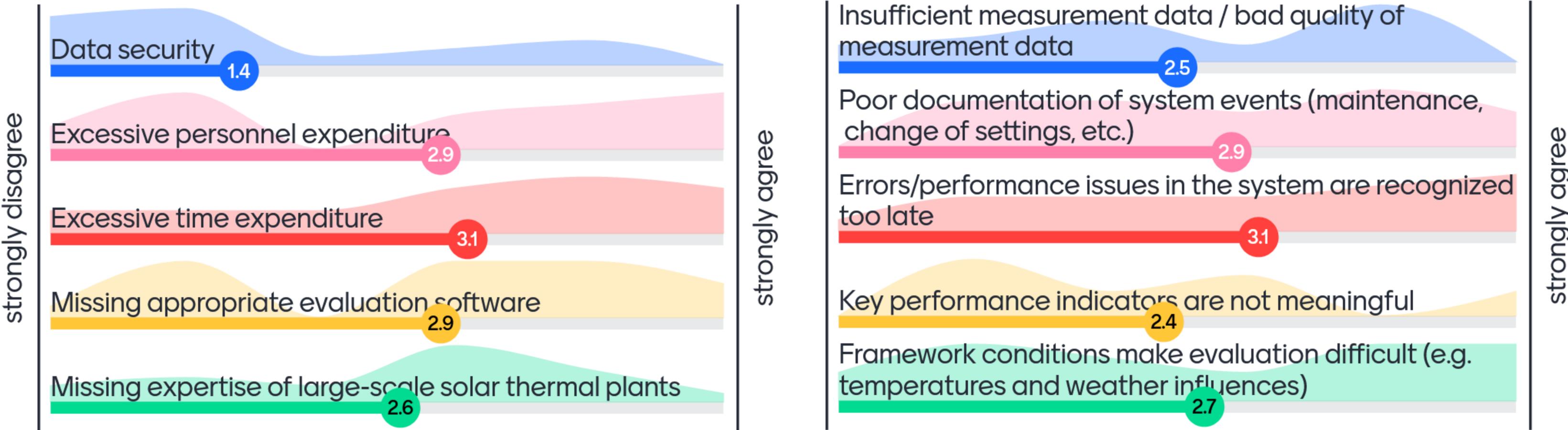
# Monitoring aktuell

## 3 Process: How is the monitoring of the system achieved in your field of work?



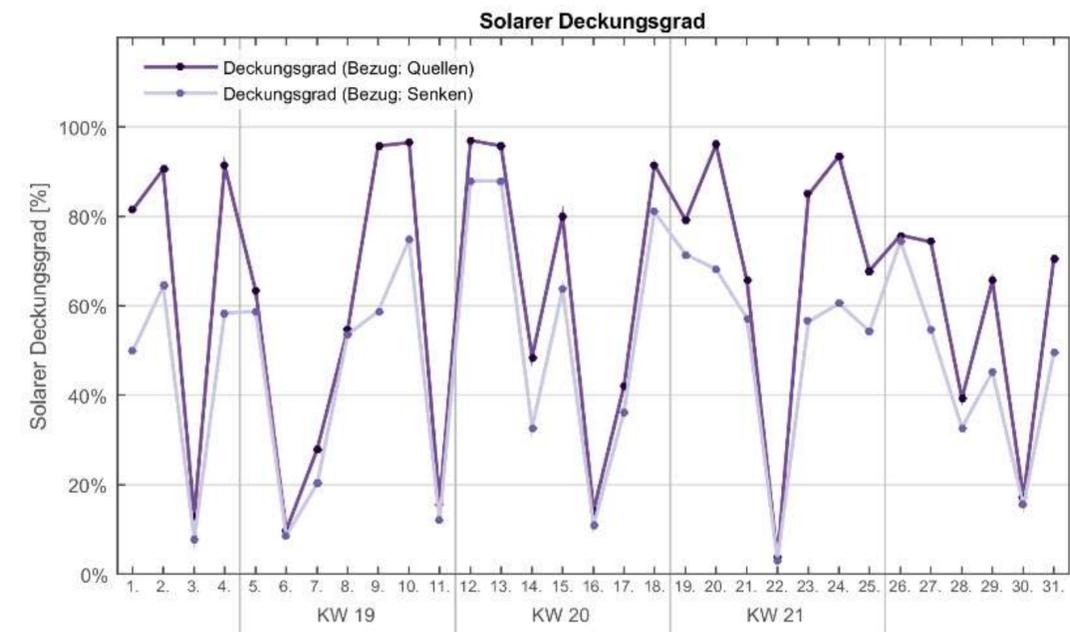
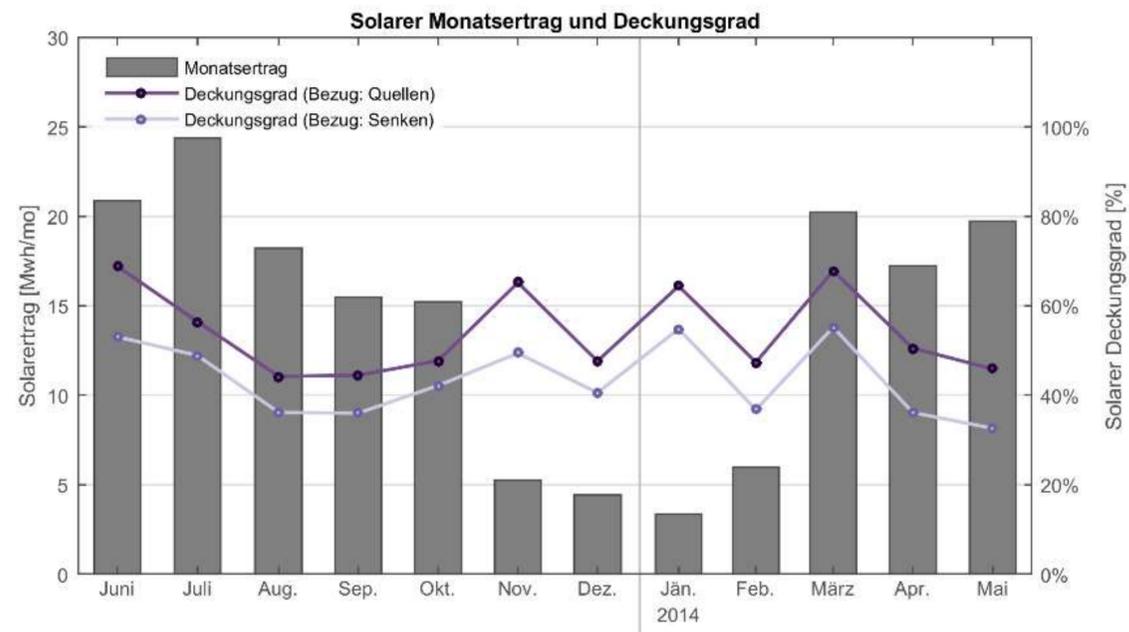
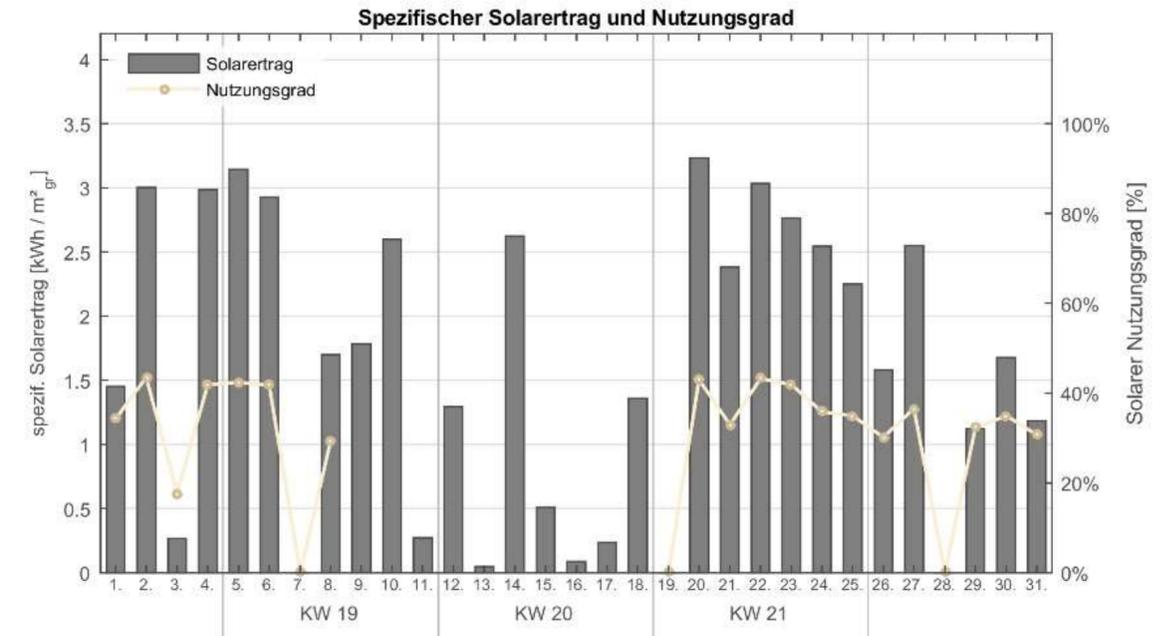
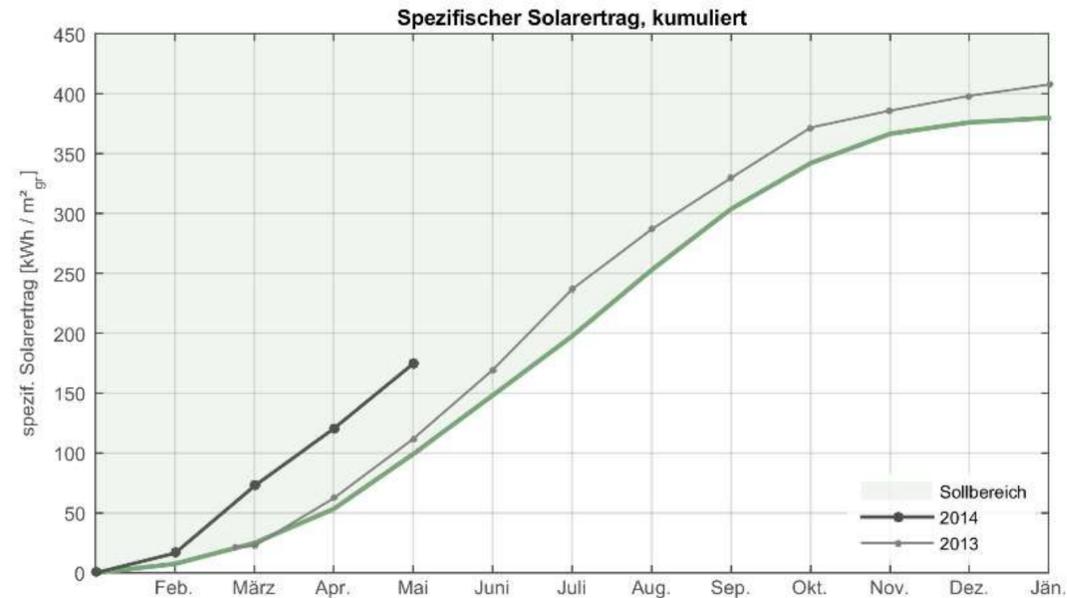
# Challenges

What are the biggest challenges?



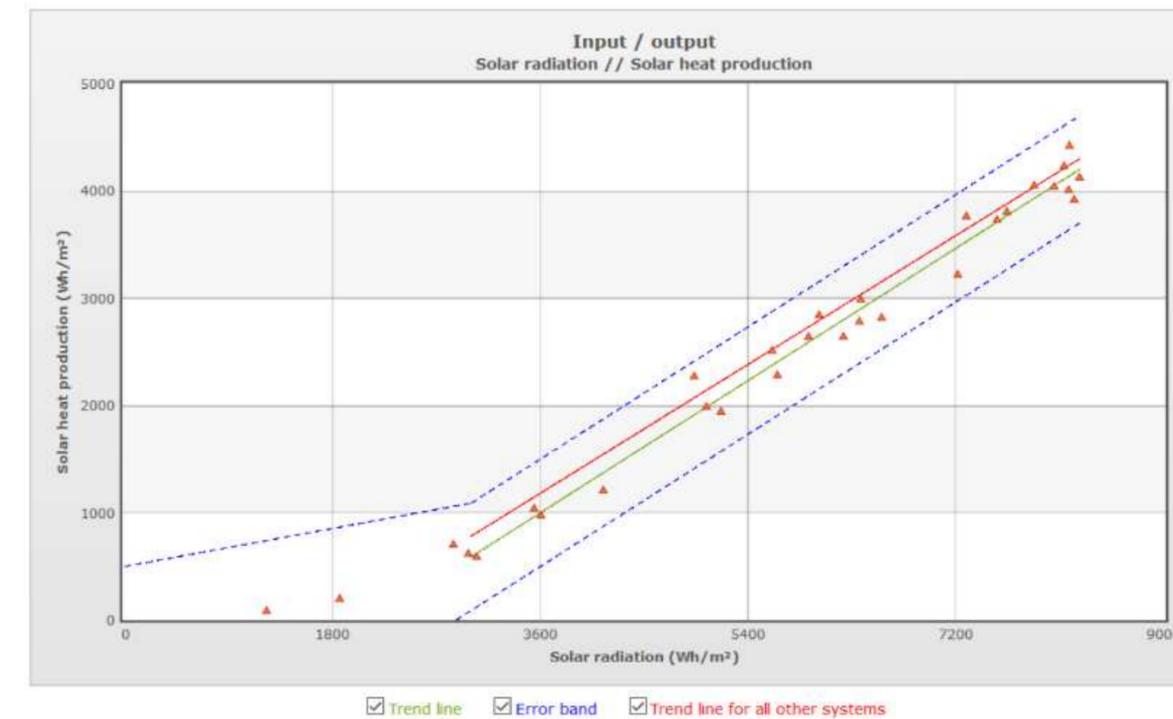
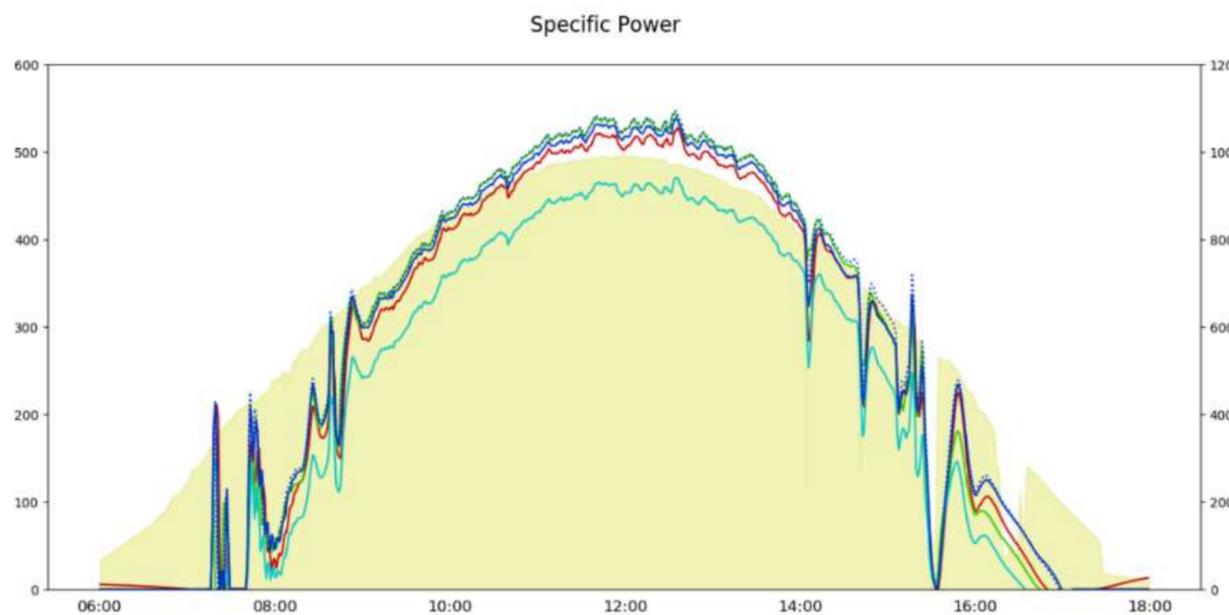
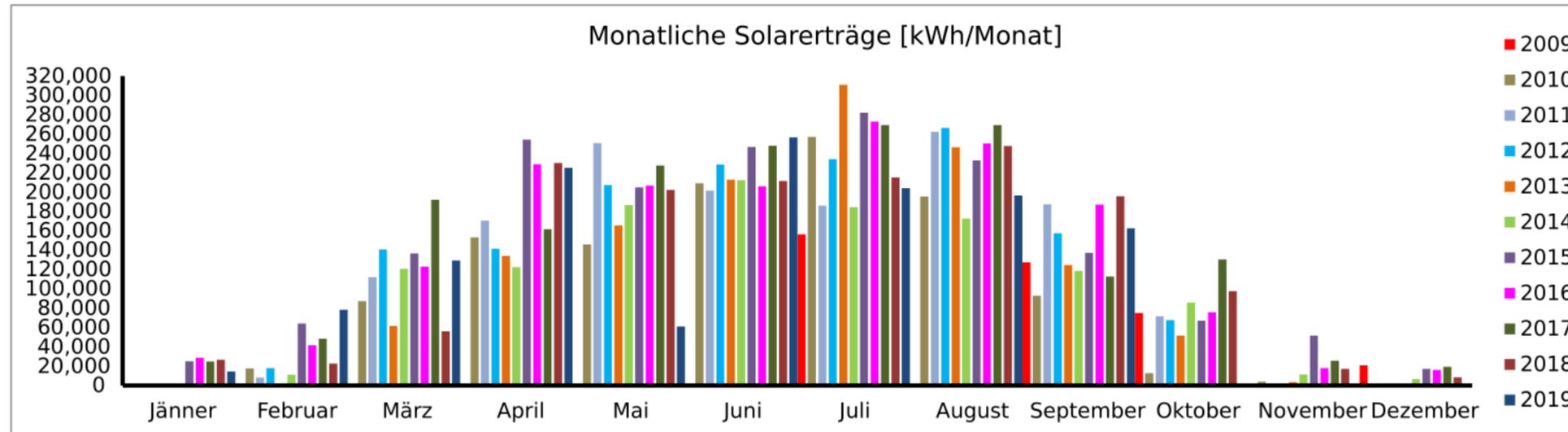
# Typische Auswertungen

## Kollektorfeld-Performance



# Typische Auswertungen

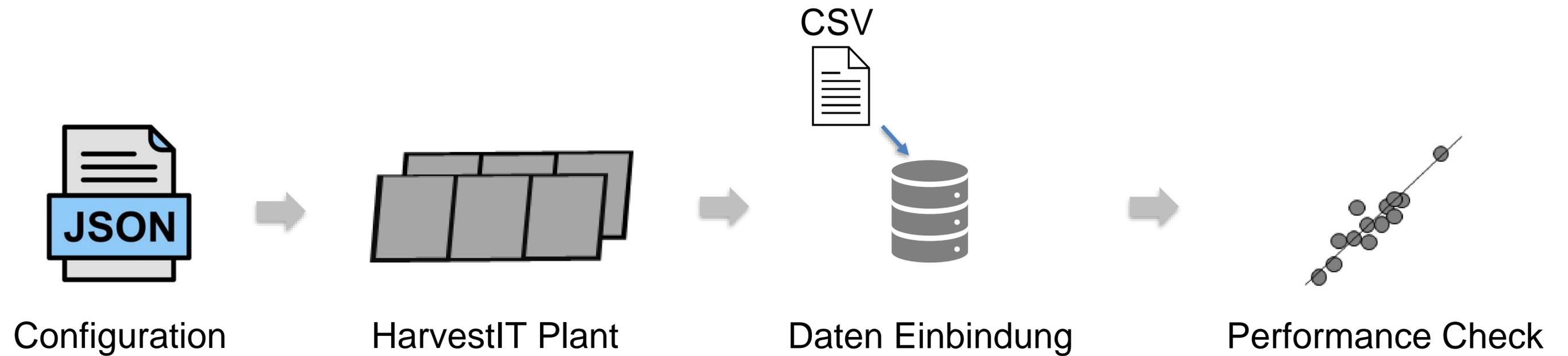
## Kollektorfeld-Performance



# Agenda

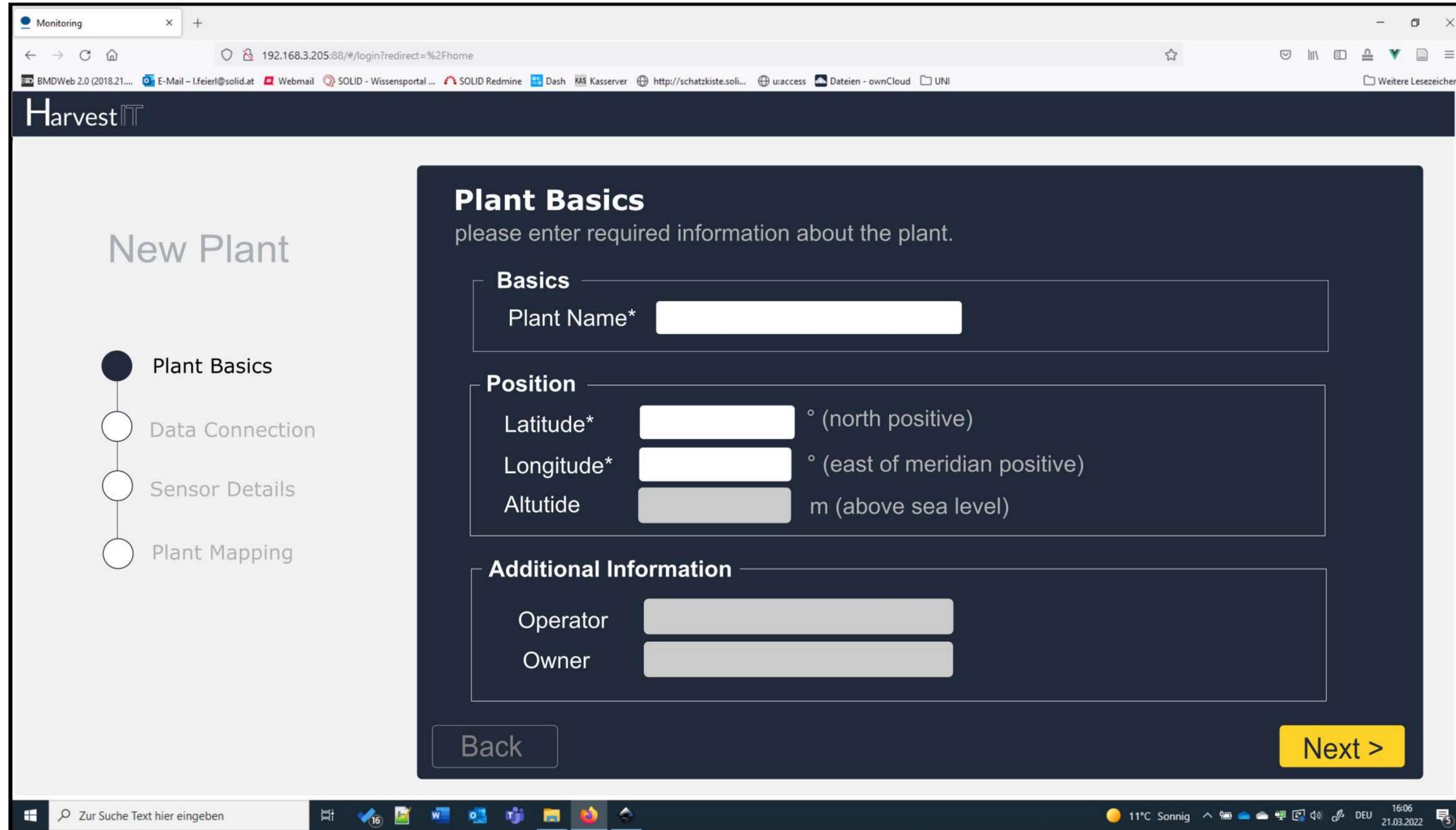
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# Performance Check Anwendung



# Web Front-End

## Plant Basics



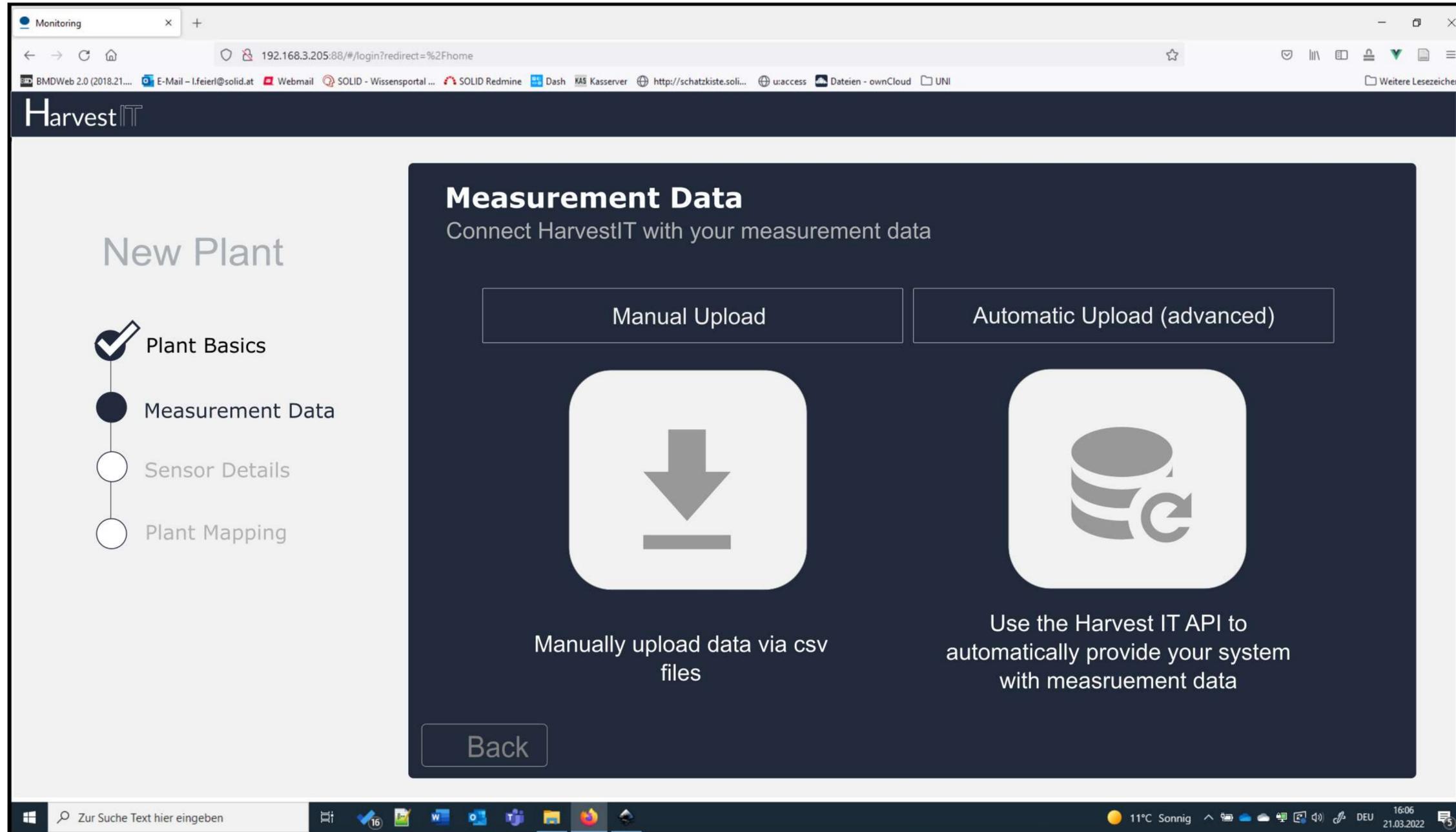
The screenshot shows a web browser window with the URL `192.168.3.205:88/#/login?redirect=%2Fhome`. The page title is "Monitoring". The main content area is titled "New Plant" and features a sidebar with four steps: "Plant Basics" (selected), "Data Connection", "Sensor Details", and "Plant Mapping". The "Plant Basics" form is displayed in a dark blue box and includes the following fields:

- Basics**
  - Plant Name\*
- Position**
  - Latitude\*  ° (north positive)
  - Longitude\*  ° (east of meridian positive)
  - Altitude  m (above sea level)
- Additional Information**
  - Operator
  - Owner

Navigation buttons "Back" and "Next >" are located at the bottom of the form. The Windows taskbar at the bottom shows the date and time as 16:06 on 21.03.2022.

# Web Front-End

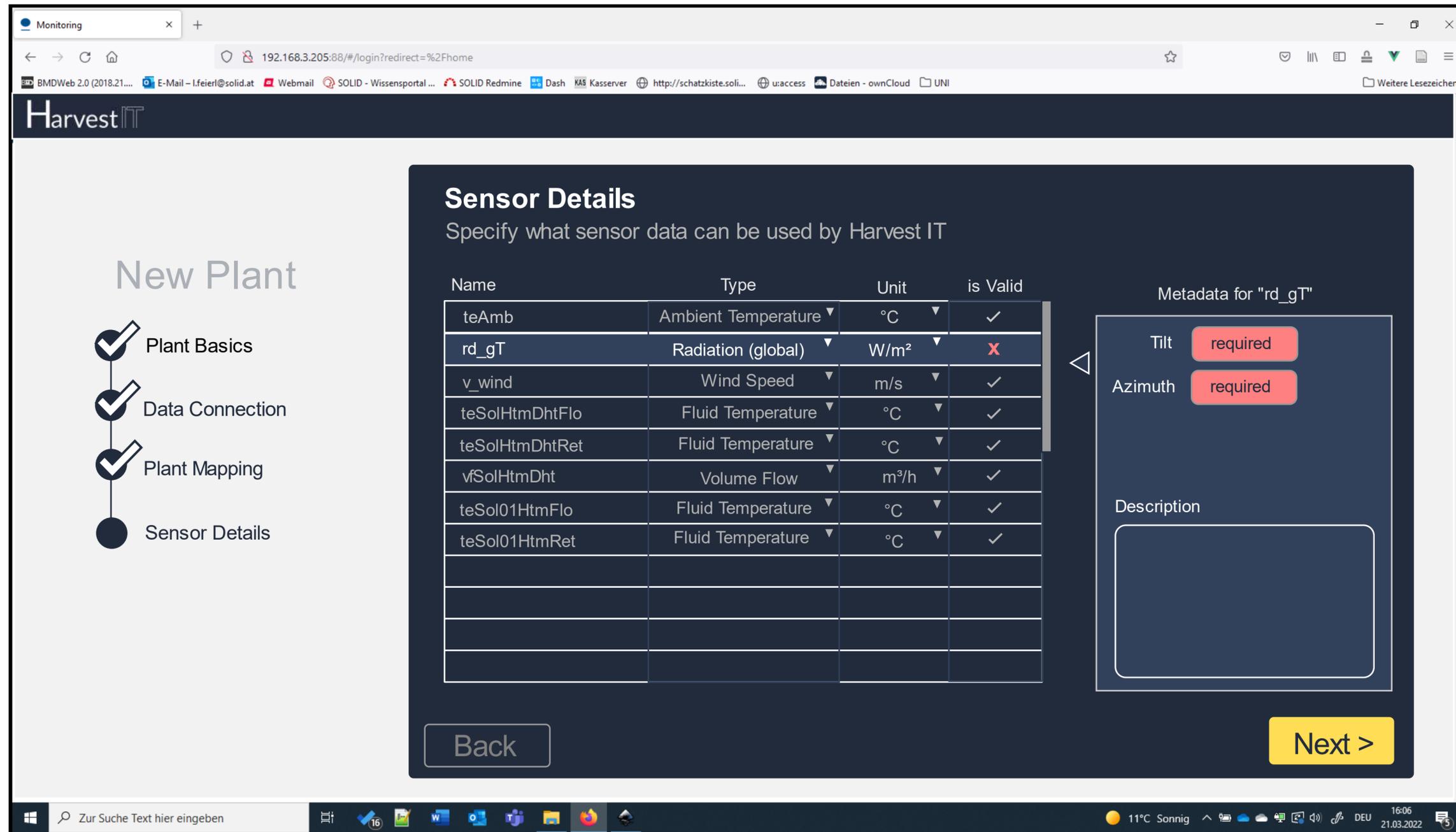
## Measurement Data



The screenshot shows a web browser window displaying the HarvestIT interface. The browser's address bar shows the URL `192.168.3.205:88/#/login?redirect=%2Fhome`. The page title is "Monitoring". The HarvestIT logo is visible in the top left corner. The main content area is titled "Measurement Data" and includes the subtitle "Connect HarvestIT with your measurement data". On the left side, there is a navigation menu with the following items: "New Plant", "Plant Basics" (checked), "Measurement Data" (selected), "Sensor Details", and "Plant Mapping". The "Measurement Data" section contains two main options: "Manual Upload" and "Automatic Upload (advanced)". The "Manual Upload" option features a large downward arrow icon and the text "Manually upload data via csv files". The "Automatic Upload (advanced)" option features a database icon with a refresh symbol and the text "Use the Harvest IT API to automatically provide your system with measruement data". A "Back" button is located at the bottom left of the "Measurement Data" section. The Windows taskbar at the bottom shows the system tray with the date and time: "16:06 21.03.2022".

# Web Front-End

## Sensor Details



**Monitoring** | 192.168.3.205:88/#/login?redirect=%2Fhome

**Harvest IT**

**New Plant**

- Plant Basics
- Data Connection
- Plant Mapping
- Sensor Details**

### Sensor Details

Specify what sensor data can be used by Harvest IT

| Name           | Type                | Unit              | is Valid |
|----------------|---------------------|-------------------|----------|
| teAmb          | Ambient Temperature | °C                | ✓        |
| rd_gT          | Radiation (global)  | W/m <sup>2</sup>  | ✗        |
| v_wind         | Wind Speed          | m/s               | ✓        |
| teSolHtmDhtFlo | Fluid Temperature   | °C                | ✓        |
| teSolHtmDhtRet | Fluid Temperature   | °C                | ✓        |
| vSolHtmDht     | Volume Flow         | m <sup>3</sup> /h | ✓        |
| teSol01HtmFlo  | Fluid Temperature   | °C                | ✓        |
| teSol01HtmRet  | Fluid Temperature   | °C                | ✓        |
|                |                     |                   |          |
|                |                     |                   |          |
|                |                     |                   |          |
|                |                     |                   |          |

Metadata for "rd\_gT"

Tilt **required**

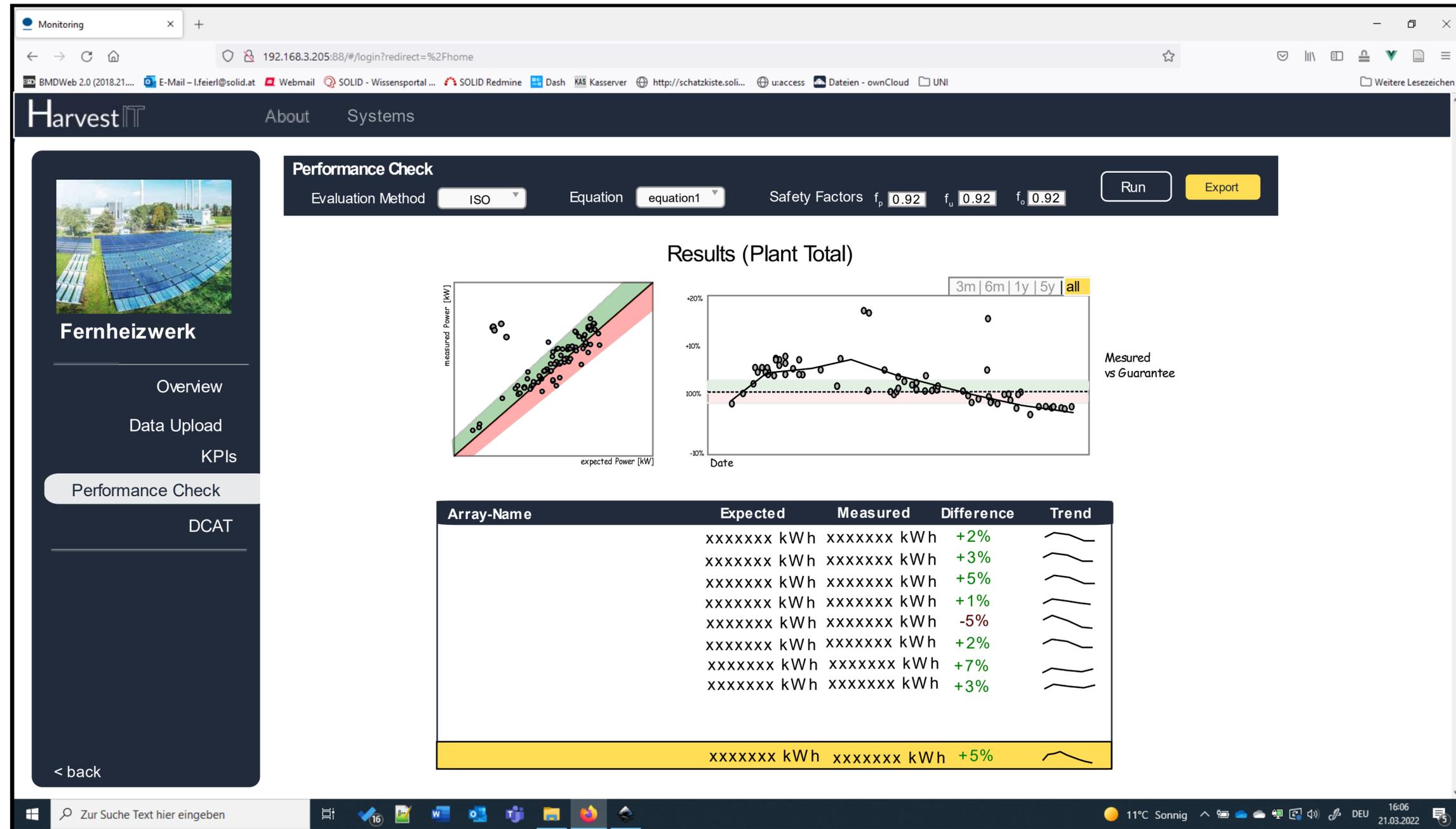
Azimuth **required**

Description

**Back** | **Next >**

Windows taskbar: 11°C Sonnig, 16:06, 21.03.2022

# Web Front-End Results



**Harvest IT** About Systems

**Performance Check**

Evaluation Method:  Equation:  Safety Factors:  $f_p$  0.92  $f_u$  0.92  $f_o$  0.92 Run Export

**Results (Plant Total)**

3m | 6m | 1y | 5y | all

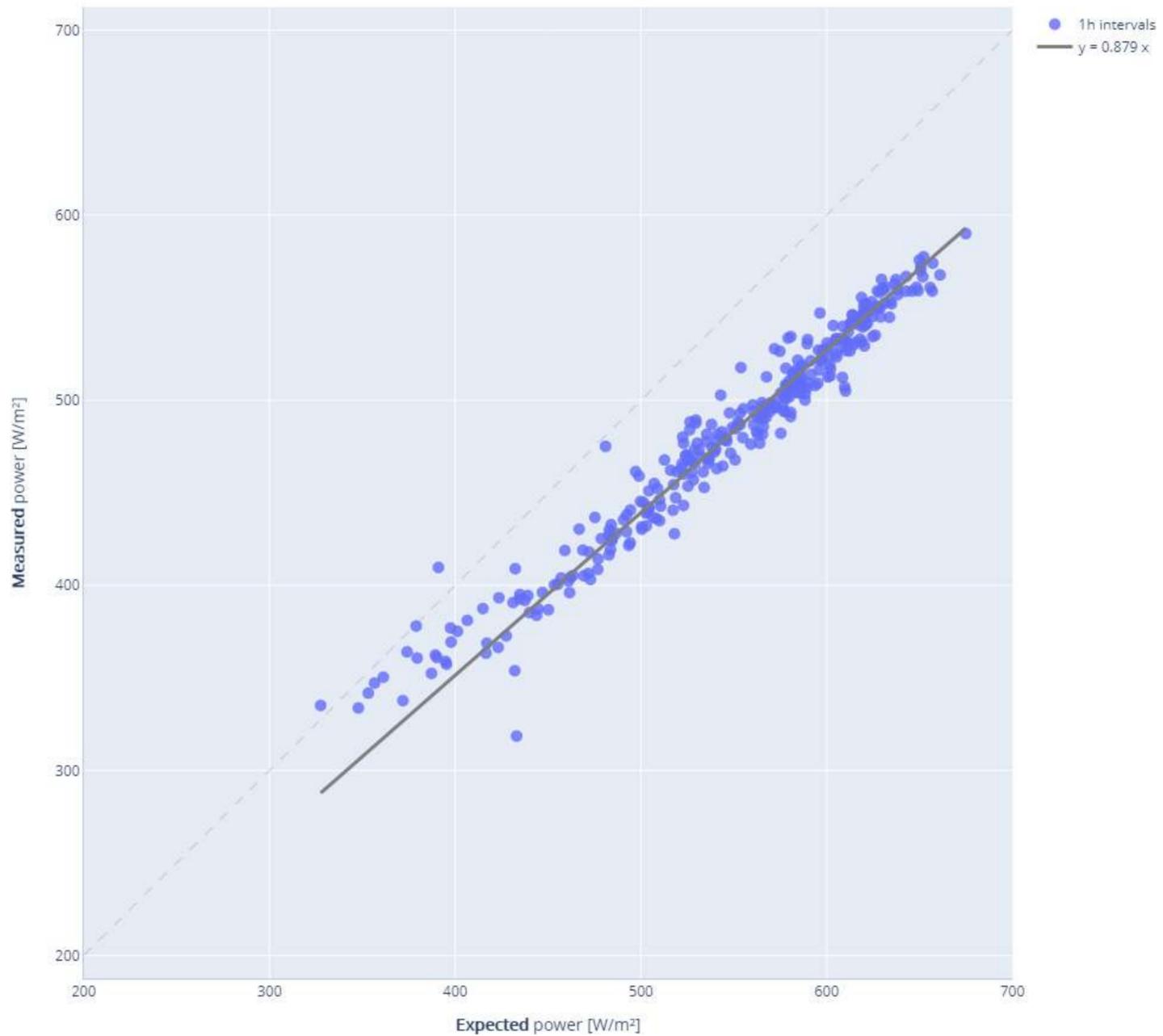
Measured vs Guarantee

| Array-Name | Expected    | Measured    | Difference | Trend |
|------------|-------------|-------------|------------|-------|
|            | xxxxxxx kWh | xxxxxxx kWh | +2%        | ~     |
|            | xxxxxxx kWh | xxxxxxx kWh | +3%        | ~     |
|            | xxxxxxx kWh | xxxxxxx kWh | +5%        | ~     |
|            | xxxxxxx kWh | xxxxxxx kWh | +1%        | ~     |
|            | xxxxxxx kWh | xxxxxxx kWh | -5%        | ~     |
|            | xxxxxxx kWh | xxxxxxx kWh | +2%        | ~     |
|            | xxxxxxx kWh | xxxxxxx kWh | +7%        | ~     |
|            | xxxxxxx kWh | xxxxxxx kWh | +3%        | ~     |
|            | xxxxxxx kWh | xxxxxxx kWh | +5%        | ~     |

# Performance Check Methode

## Grafischer Output, Beispiel

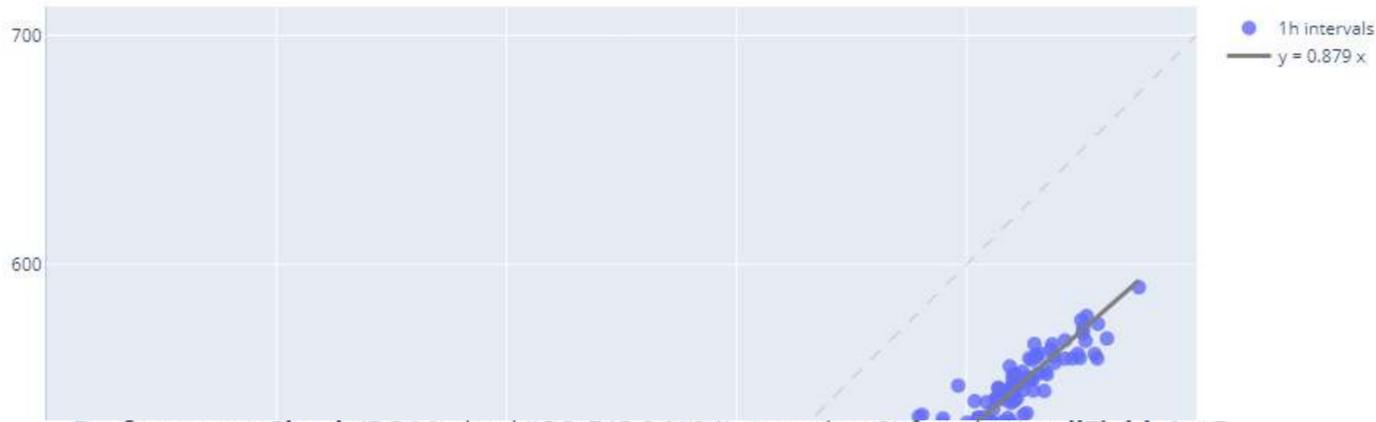
Performance Check (PC Method 'ISO DIS 24194', equation 2) for plant collField\_ArcS,  
data 2017-03-01 to 2017-10-31, n=328



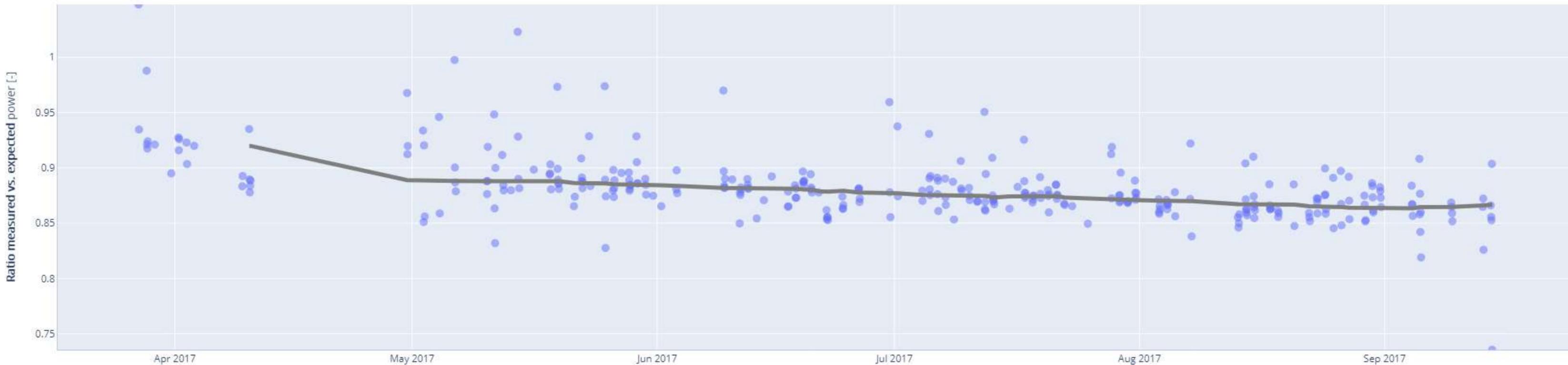
# Performance Check Methode

## Grafischer Output, Beispiel

Performance Check (PC Method 'ISO DIS 24194', equation 2) for plant collField\_ArcS,  
data 2017-03-01 to 2017-10-31, n=328



Performance Check (PC Method 'ISO DIS 24194', equation 2) for plant collField\_ArcS,  
data 2017-03-01 to 2017-10-31, n=328



# Open Source License

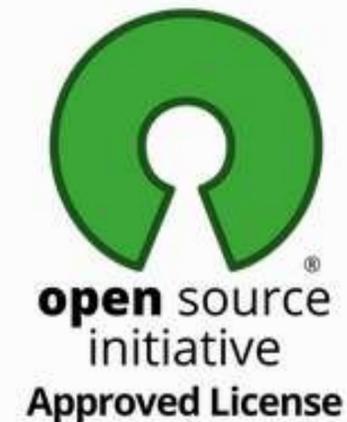
- All partners committed to releasing HarvestIT under an OSI approved license.
- Most likely the permissive “**3-Clause BSD**” → enables **commercial use**.
- **No need to share / upload data to the “cloud”**. Open Source <> Open Data.

*Note: This license has also been called the "New BSD License" or "Modified BSD License". See also the 2-clause BSD License.*

Copyright <YEAR> <COPYRIGHT HOLDER>

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# Performance Check Methode



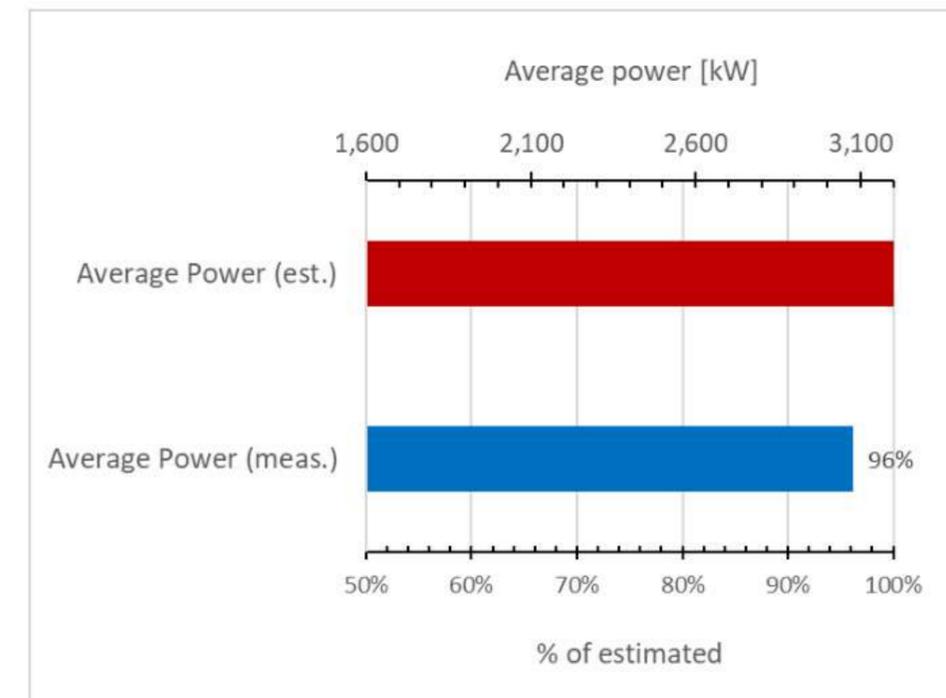
- Soll-Ist-Vergleich für stationäre Zustände
- Neue ISO Norm für Kollektorfelder:  
**ISO/DIS 24194 Solar energy — Collector fields — Check of performance**
- Aktueller Status: 60.60 = [International Standard Published](#)

**DRAFT INTERNATIONAL STANDARD  
ISO/DIS 24194**

|                                 |                                     |
|---------------------------------|-------------------------------------|
| ISO/TC 180/SC 4                 | Secretariat: SAC                    |
| Voting begins on:<br>2021-04-14 | Voting terminates on:<br>2021-07-07 |

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**Solar energy — Collector fields — Check of performance**



# Performance Check Methode

## Stationäre Zustände

### Stationäre Zustände

- nur in diesen Zuständen gilt die Gleichung
- 1h Mittelwerte der Messwerte als Input

| Operation condition                  | Limits                          |                          |                          | Comments   |
|--------------------------------------|---------------------------------|--------------------------|--------------------------|--|
|                                      | Eq.1                            | Eq.2                     | Eq.3                     |  |
| Shadows                              | No shadows                      |                          |                          | See section 5.4  |
| Incidence angle                      | $\leq 30^\circ$                 | -                        |                          | See section 5.5  |
| Change in collector mean temperature | $\leq 5 \text{ K}$              |                          |                          | To avoid big change in collector temperature during one hour   |
| Ambient temperature                  | $\geq 5 \text{ }^\circ\text{C}$ |                          |                          | To avoid snow, ice, condensation on solar radiation sensors  |
| Wind velocity                        | $\leq 10 \text{ m/s}$           |                          |                          | To be measured so it is representative for the wind velocity 1 - 3 m above highest point of collectors |
| $G_{hem}$                            | $\geq 800 \text{ W/m}^2$        | -                        |                          |  |
| $G_b$                                |                                 | $\geq 600 \text{ W/m}^2$ | $\geq 600 \text{ W/m}^2$ |  |

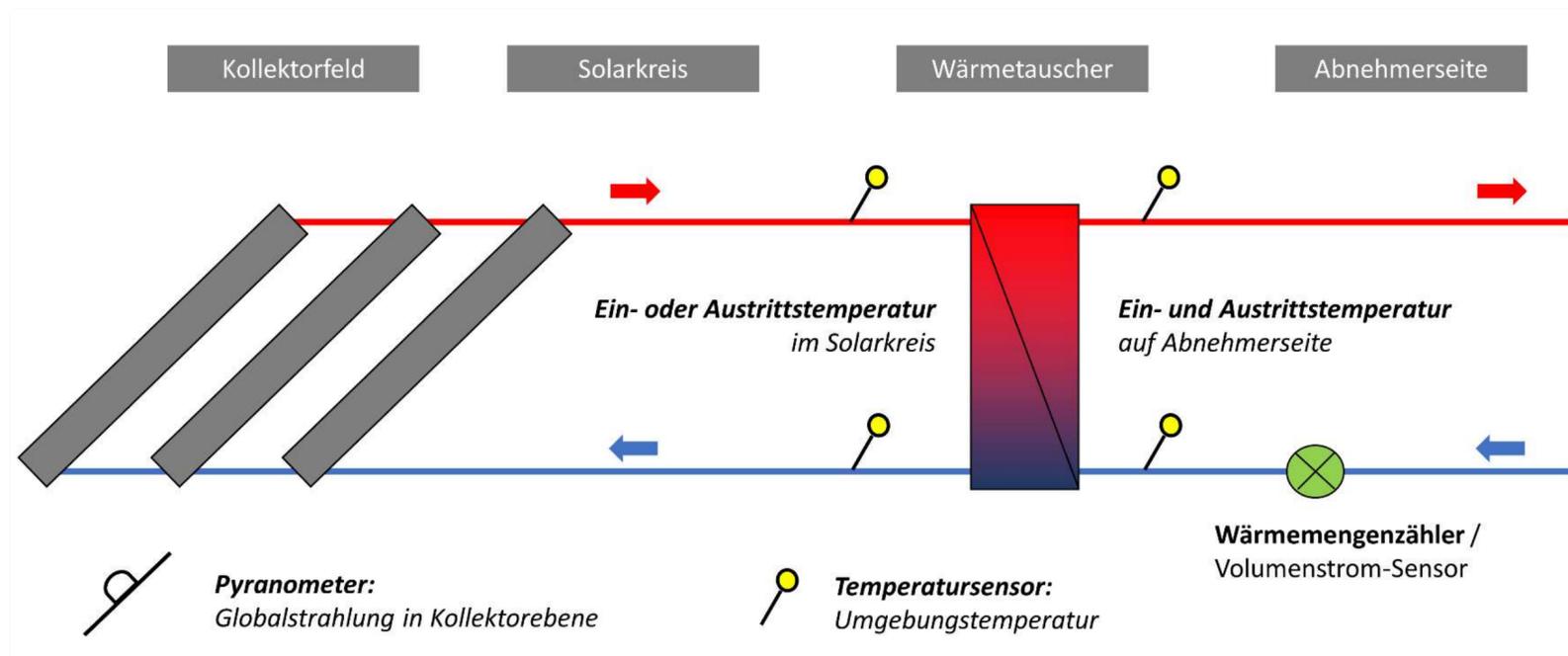
*Table 1. Restrictions on operation conditions (power method). Measured and calculated power shall only be compared for data fulfilling restrictions above.*

Quelle: ISO/DIS 24194:2021(E)

# Performance Check Methode

ISO Norm 24194: **ein** Kollektorfeld, gleiche Kollektoren, gleiche Aufständering

$$\dot{Q}_{est} = n_{col} \cdot A_{G,col} \cdot \left[ \eta_{0,hem} G - a_1(\bar{T} - T_a) - a_2(\bar{T} - T_a)^2 - a_5 \frac{d\bar{T}}{dt} \right] \cdot f_{safe}$$



## Anwendungsvoraussetzungen

1. Kollektorparameter
  - Solar Keymark / ISO 9806
2. Berechnung Soll-Leistung (Gl. 1)
3. Messung Leistung
  - $G$  Gesamtstrahlung Kollektorebene
  - $\bar{T}$  Vor- und Rücklauftemperaturen
  - $T_a$  Außentempertur

# Performance Check Methode

Weiterentwicklung HarvestIT: mehrere Kollektorfelder

## Anwendung auf mehrere Teilfelder

- unterschiedliche Kollektoren
- unterschiedliche Ausrichtung und Aufständigung
- in der Regel Strahlungsmessung nur für 1 Teilfeld



## Anwendungsvoraussetzungen

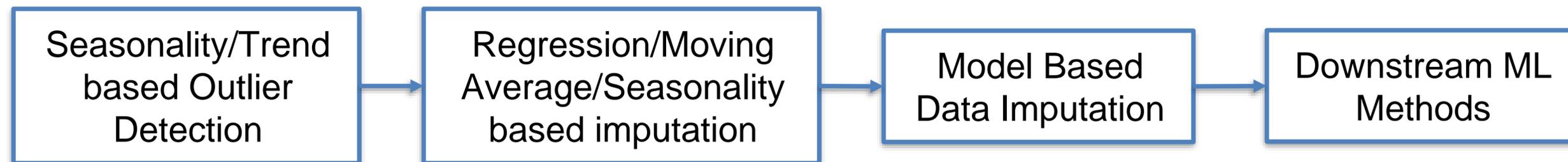
1. Kollektorparameter → pro Kollektortyp
2. Berechnung Soll-Leistung (Gl. 1)
  - $G$  Gesamtstrahlung Kollektorebene → pro Teilfeld → Algorithmus für Strahlungsumrechnung
  - $\bar{T}$  Vor- und Rücklauftemperaturen → pro Teilfeld
  - $T_a$  Außentemperatur → 1x pro Anlage
  - Wind → optional
3. Messung Leistung
  - gesamt pro Anlage (optional auch pro Teilfeld)
  - Stoffwerte (Datenblatt, CoolProp)

# EnableDigitalDH

AEE INTEC

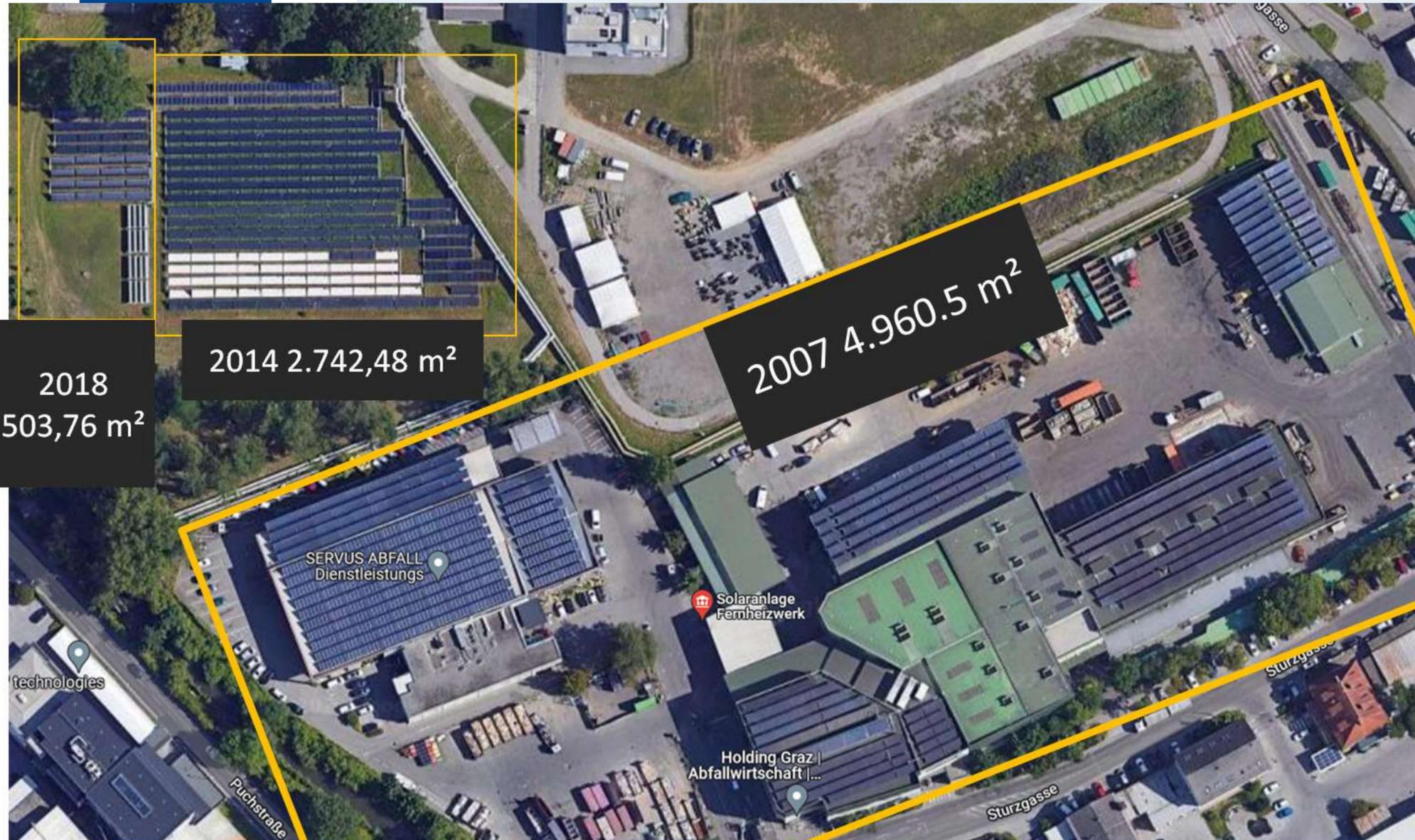
KNOW  
Center

- Bad data is a major barrier to ML applications in energy sector.
- Statistical / ML based outlier detection and imputation pipeline
  - Based on seasonality, trend detection and imputation.
  - Not possible to fully automate, good results with some manual input.
- Further imputation of longer missing periods using physical component models.
  - Only works with specific types of missing data, hard to apply to arbitrary data.
- Sample implementation code to be released later in 2022.



# HarvestIT Testanlagen

## Fernheizwerk Graz



**Bruttofläche: 8.206 m<sup>2</sup> / 5,7 MWp**  
Bauzeit 2007 - 2018

Solare Fernwärme  
7 verschiedene Kollektorhersteller  
Unterschiedliche Technologien.



# HarvestIT Testanlagen

## Nahwärme St. Ruprecht a.d. Raab



**Bruttofläche: 1.590 m<sup>2</sup> / 1,1 MWp**

117 Stk. Großflächenkollektoren á 13,6 m<sup>2</sup>  
13 Reihen mit je 9 Kollektoren

Gesamtes Kollektorfeld: ca. 60m x 60m

Pufferspeicher: 100 m<sup>3</sup>

# HarvestIT Testanlagen

AVL Graz



**Bruttofläche: 3.463 m<sup>2</sup> / 2,4 MWp**  
Solarthermische Prozesswärme & Kälte

Spezif. Solarertrag: 358 kWh/m<sup>2</sup>

Absorptionskältemaschine: 650 kW

Speicher: 70 m<sup>3</sup> (auch Lastmanagement)

CO<sub>2</sub> Einsparung: 320 Tonnen pro Jahr

# HarvestIT Testanlagen

## Desert Mountain High School



**Bruttofläche: 4.935 m<sup>2</sup> / 3,5 MWp**  
Solare Kühlung

Spezif. Solarertrag: 757 kWh/m<sup>2</sup>  
Ökotech und Arcon Sunmark Kollektoren  
Kühlung JAZ: 0,57  
Absorptionskältemaschine: 1.750 kW  
Kühlturm: 4.250 kW  
Speicher: 34,5 m<sup>3</sup>

# HarvestIT Testanlagen

Nahwärme Friesach

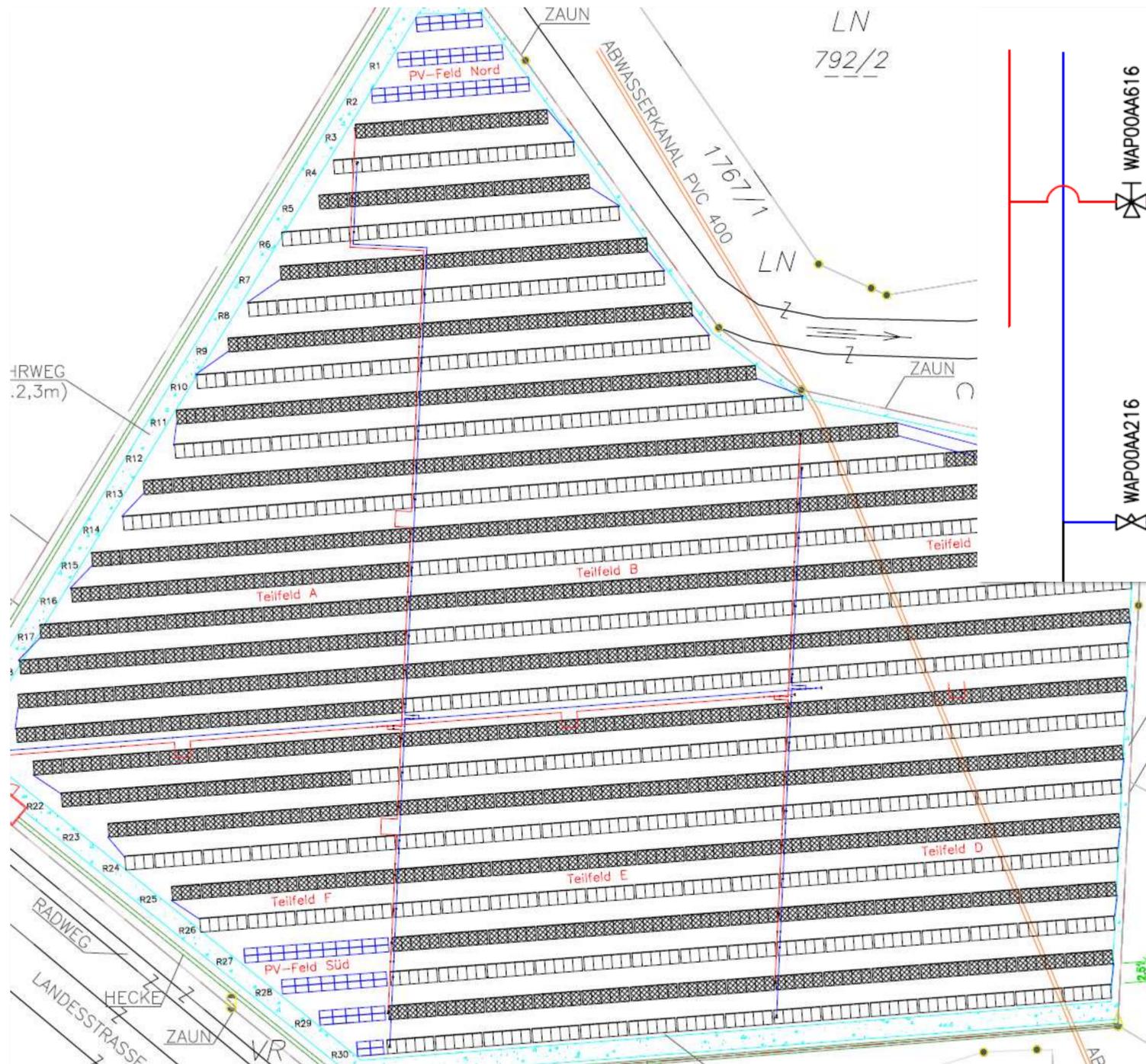


**Bruttofläche: 5.750 m<sup>2</sup> / 4 MWp**  
Pufferspeicher: 1.000 m<sup>3</sup>

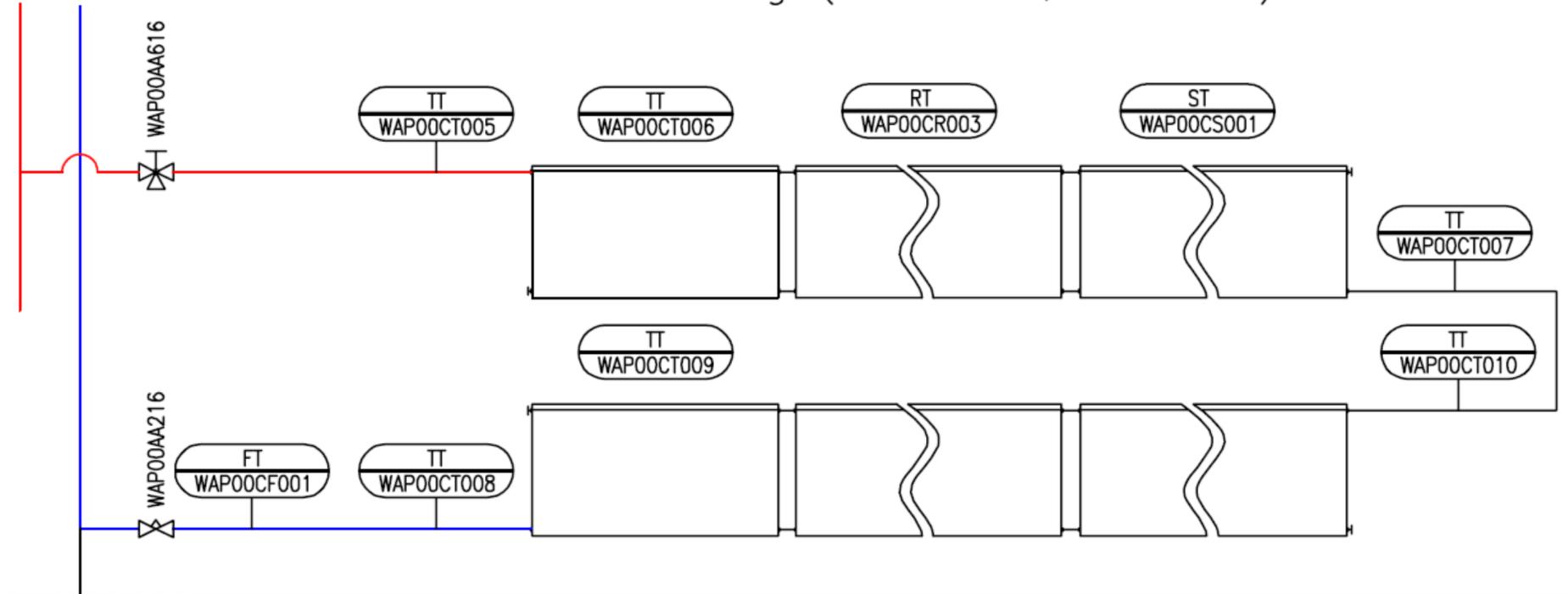
Inbetriebnahme: 2021, Betreiber: KPV  
GreenOneTec Großflächenkollektoren  
GK3133S / GK3133D

# HarvestIT Testanlagen

## Nahwärme Friesach



Detail Garantiemessung (Teilfeld B, R19+20)



# Agenda

- 1 *Kontext* **Markt & Chancen**
- 2 *Monitoring* **Status Quo & interaktiver Teil**
- 3 *HarvestIT* **Garantieverfahren & Software**
- 4 *Ausblick* **D-CAT**

# D-CAT

## Dynamic Collector Array Test

### Einzelkollektoren

- Normtest ISO 9806 / QDT / Solar Keymark Datenblatt
- Laborsetting

### Kollektorfeld

|                          |  |
|--------------------------|--|
| <b>Kollektoren</b>       | Kennlinie, Verschmutzung, Wärmedämmung                     |
| <b>Anlage</b>            | Design, Hydraulik<br>Abstände, Aufständigung, Verschattung |
| <b>Betrieb</b>           | Betrieb, Regelstrategie, Volumenströme                     |
| <b>Externe Einflüsse</b> | Wetter; Abnahme Temperaturen, Volumenstrom                 |
| <b>Messung</b>           | Wind- & Strahlung repräsentativ? Messunsicherheit?         |

**Kein standardisiertes Testverfahren.**

#### Anforderungen D-CAT:

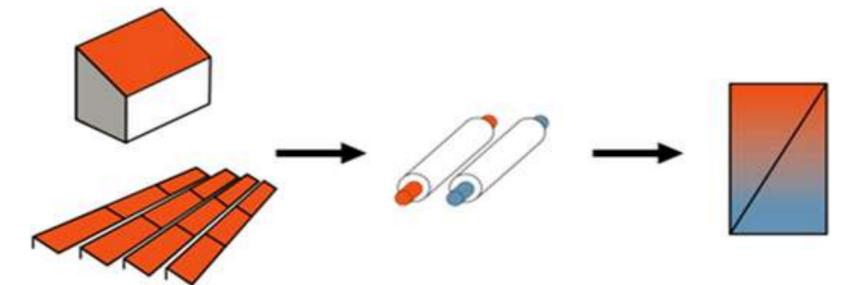
- 1) In-situ = Kollektorfeld unter realen Betriebsbedingungen
- 2) Kein Eingriff in den laufenden Anlagenbetrieb!
- 3) Automatisierung: Betriebsdaten → Parameter ~Solar Keymark



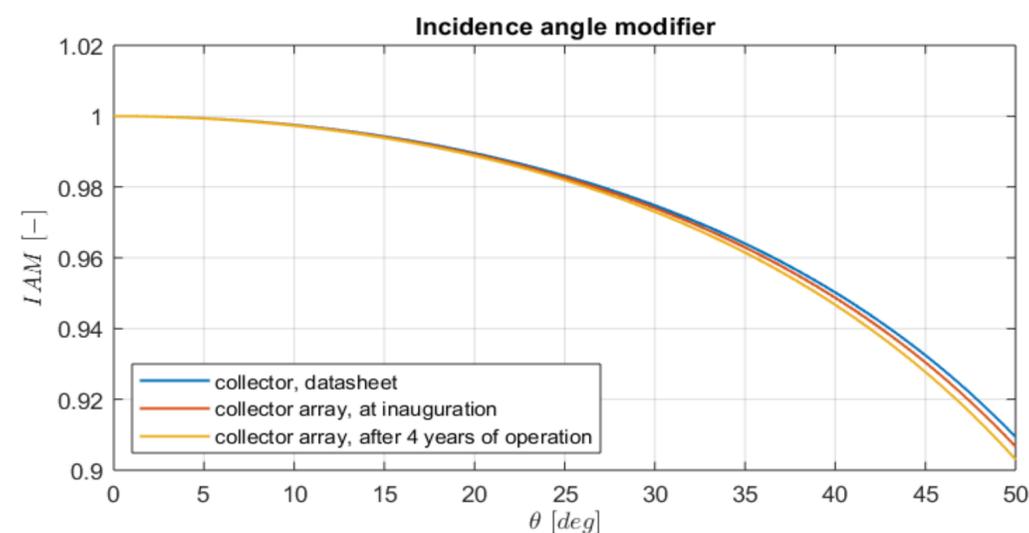
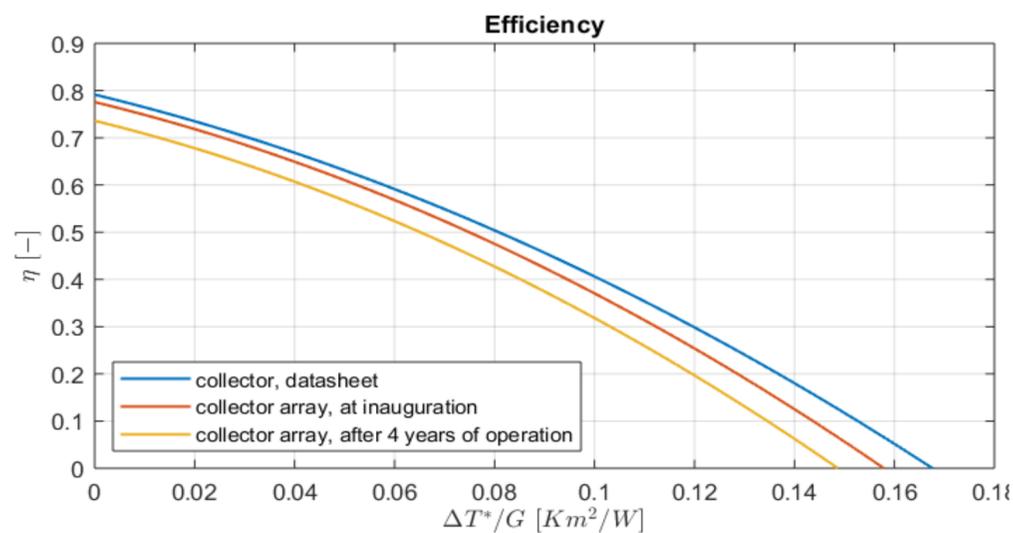
# D-CAT

## Vision beispielhafte Resultate

|  |                         |  |                                    |      |      |      |      |      |      |      |
|--|-------------------------|--|------------------------------------|------|------|------|------|------|------|------|
| Performance parameters related to aperture area                  | $\eta_0$                | a1   | a2                                 |      |      |      |      |      |      |      |
| Units  | -                       | W/(m <sup>2</sup> K)                                       | W/(m <sup>2</sup> K <sup>2</sup> ) |      |      |      |      |      |      |      |
| Test results - Flow rate and fluid see note 1                    | 0.769                   | 2.67   | 0.009                              |      |      |      |      |      |      |      |
| Bi-directional incidence angle modifiers?                        | No                      | <i>K<math>\theta</math> values are obligatory for 50°.</i> |                                    |      |      |      |      |      |      |      |
| Incidence angle modifiers K $\theta$ ( $\theta$ )                | Angle                   | 10°  | 20°                                | 30°  | 40°  | 50°  | 60°  | 70°  | 80°  | 90°  |
|  | K $\theta$ ( $\theta$ ) | 1.00   | 0.99                               | 0.98 | 0.95 | 0.91 | 0.84 | 0.69 | 0.24 | 0.00 |
| Incidence angle modifier not bi-directional - leave fields blank |                         |  |                                    |      |      |      |      |      |      |      |



| Yield datasheet                        | Yield in-situ                                  |
|--|--|
| 431 kWh/m <sup>2</sup> <sub>Aggr</sub> | 417 kWh/m <sup>2</sup> <sub>Aggr</sub> (-3.2%) |



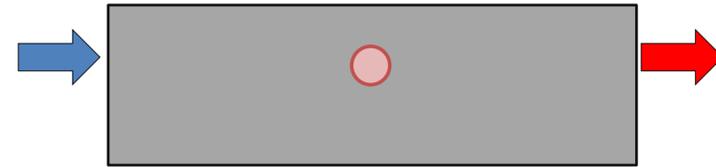
### D-CAT

- 1) Bewertung Energie-Ertrag
- 2) Vorhersage Energiepreis / LCOE
- 3) Predictive / on-demand Maintenance z.B. Reinigung

# Kollektorfeldmodelle

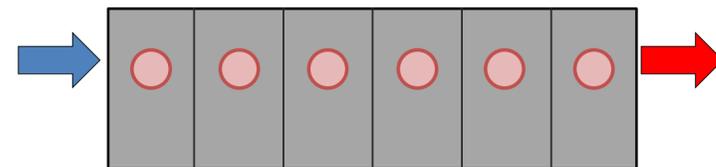
## Erweiterungen für D-CAT

A) Single collector model  
ISO 9806 (QDT)



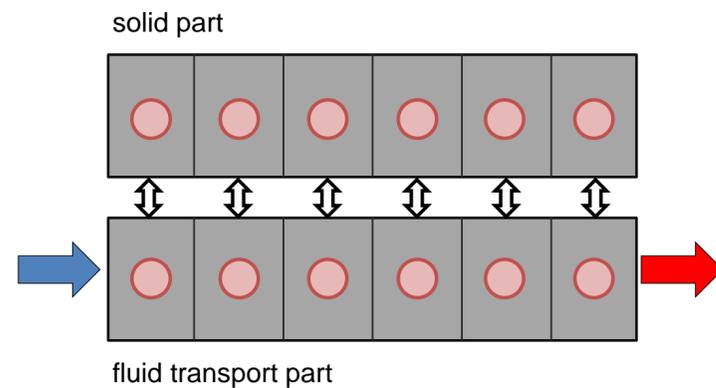
only 1 temperature  $T_m$ :  $T_m = (T_{in} + T_{out}) / 2$   
 - Assumes 0 travel time, instantaneous power

B) MeQuSo 1N model



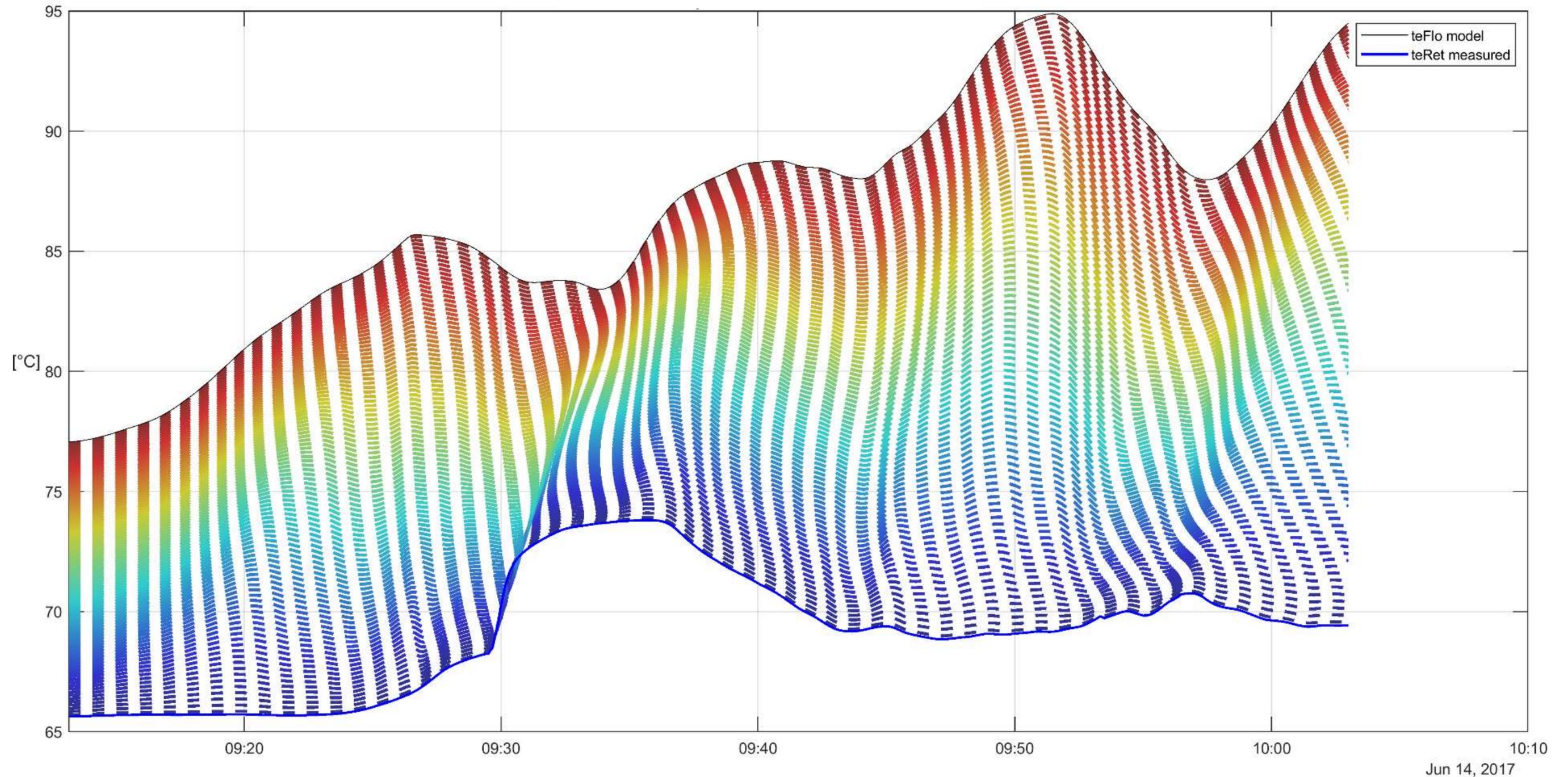
**N** temperatures, 1 for each compartment  
 - Takes travel time into account  
 - Simplest extension of classic QDT to collector arrays

C) MeQuSo 2N model



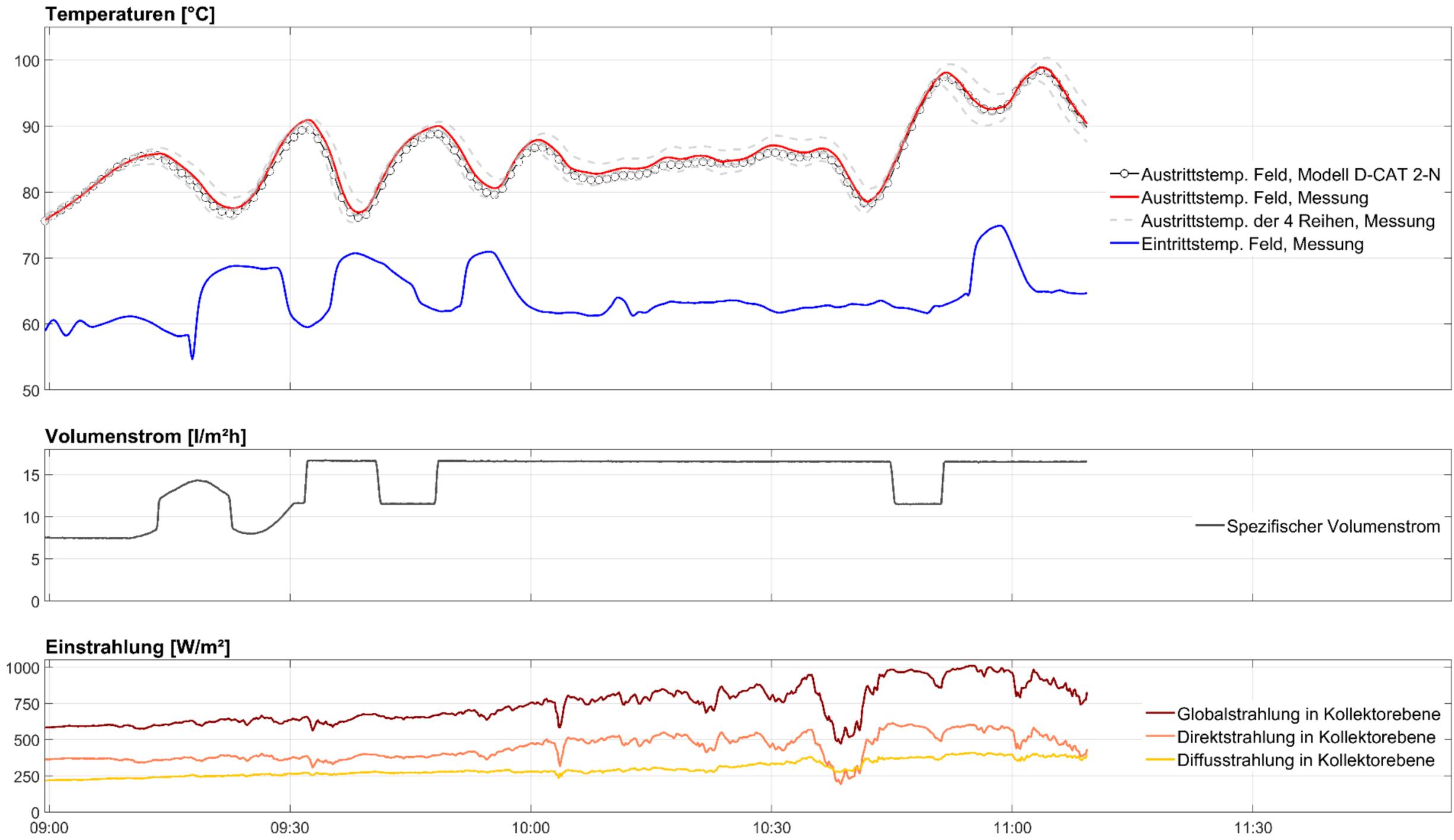
**2N** temperatures  
 - 1 for each solid compartment (radiation, heat loss)  
 - 1 for each fluid compartment  
 - Realistic modeling of collector array temperatures

# D-CAT Kollektortemperaturen in Strömungsrichtung für mehrere Segmente



# D-CAT

## Vergleich mit Messdaten

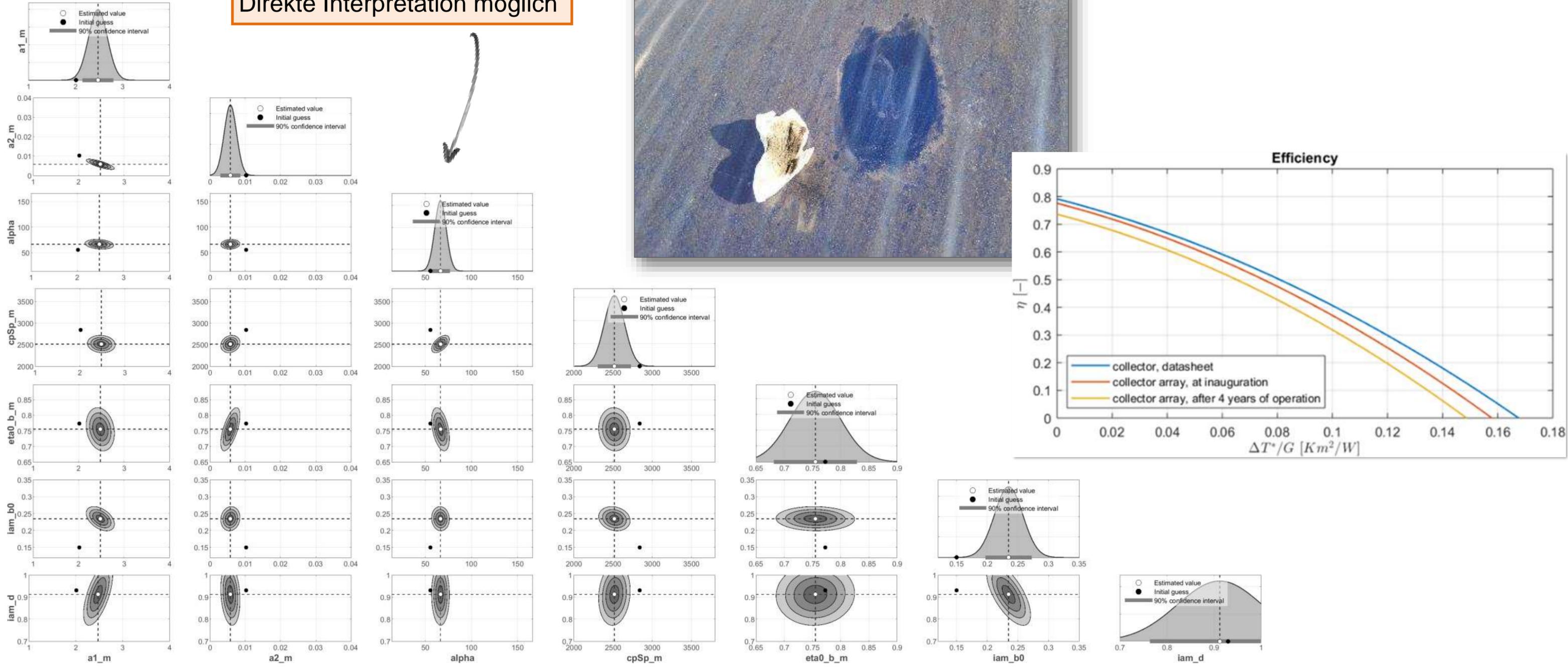


Mar 24, 2017

# D-CAT

## Parameter + Unsicherheiten

Direkte Interpretation möglich



# D-CAT

## Exemplarische Ergebnisse

| Parameter | Info                                 | Solar Keymark     |                             | Umrechnung Modell<br>1-N → 2-N                                  | Parameter | Ergebnis<br>aus FHW-Daten |  |
|-----------|--------------------------------------|-------------------|-----------------------------|---|-----------|---------------------------|--|
|           |                                      | Bezug:<br>Apertur | Umrechnung<br>Bezug: Brutto | Rahmenbedingungen:<br>bei $dT=55\text{ K}$ , $rdE=500\text{ W}$ |           |                           |  |
| a1        | Umrechnung Datenblatt                | 2.2261            | 2.0670                      | 2.0120  | a1        | 2.4768                    |  |
| a2        | Umrechnung Datenblatt                | 0.0097            | 0.0090                      | 0.0102  | a2        | 0.0058                    |  |
|           | Berechnung bei<br>Rahmenbedingungen  |                   |                             | 2.573   | a_eff     | 2.796                     | <b>+8.7%</b>   |
| eta0      | Umrechnung Datenblatt                | 0.8024            | 0.7450                      | 0.7729  | eta0      | 0.7550                    | <b>-2.3%</b>   |
| iam_b0    | ohne Umrechnung                      | 0.1501            |                             | 0.1501  | iam_b0    | 0.2348                    | <b>30°: -1.3%</b><br><b>45°: -3.7%</b><br><b>60°: -10.0%</b> |
| iam_d     | ohne Umrechnung                      | 0.93              |                             | 0.93  | iam_d     | 0.9120                    | <b>-1.9%</b>   |
| cp        | Umrechnung Datenblatt &<br>Schätzung | 7876              | 7313                        | 2838  | cp_m      | 2516                      |  |
| F'        | Schätzung                            | 0.95              |                             | 55.5  | alpha     | 66.5                      |  |

**Parameterumrechnung:** Umrechnung der Parameter von Datenblatt / Solar Keymark 1-N → 2-N unter folgenden Rahmenbedingungen:

- Typical temperature difference absorber – ambient:  $dT = 55\text{ K}$
- Effective radiation:  $rdE = 500\text{ W/m}^2$
- Volumenstrom =  $16\text{ lit/m}^2\text{h}$

# ACR Innovationspreis 2021

für D-CAT an SOLID + AEE INTEC



# Related publications

|                             |   |                                 |
|-----------------------------|---|---------------------------------|
| <b>IEA Fact Sheet</b>       | Tschopp, D. et al. (2021) Application of Performance Check (PC) Method to Large Collector Arrays. IEA SHC FACT SHEET 55 B-D1.1. IEA SHC.  | <a href="#"><u>Download</u></a> |
| <b>IEA Fact Sheet</b>       | Nielsen J. E., “Guarantee of annual output. IEA-SHC TECH SHEET 45.A.3.2”, 2014. Available online: <a href="http://task45.iea-shc.org/fact-sheets">http://task45.iea-shc.org/fact-sheets</a>   | <a href="#"><u>Download</u></a> |
| <b>Project Final Report</b> | Ohnewein, P. et al. (2020) Dynamic Collector Array Test (D-CAT). Final Report FFG Project 848766 - MeQuSo. Development of methods for quality assessment of large-scale solar thermal plants under real operating conditions. Gleisdorf: AEE INTEC.                               | <a href="#"><u>Download</u></a> |
| <b>Journal paper</b>        | Tschopp, D. et al. (2022) ‘Measurement and modeling of diffuse irradiance masking on tilted planes for solar engineering applications’, Solar Energy, 231, pp. 365–378. <a href="http://doi.org/10.1016/j.solener.2021.10.083">http://doi.org/10.1016/j.solener.2021.10.083</a> . | <a href="#"><u>Download</u></a> |
| <b>Journal Review Paper</b> | Tschopp, D. et al. (2020) ‘Large-scale solar thermal systems in leading countries: A review and comparative study of Denmark, China, Germany and Austria’, Applied Energy, 270, p. 114997. doi:doi.org/10.1016/j.apenergy.2020.1149970.   | <a href="#"><u>Download</u></a> |



# Projekt HarvestIT

FFG Fast Track Digital, 1. Ausschreibung: Projekt 887648  
„Advanced monitoring of large-scale solar thermal plants  
with open source software solution“.

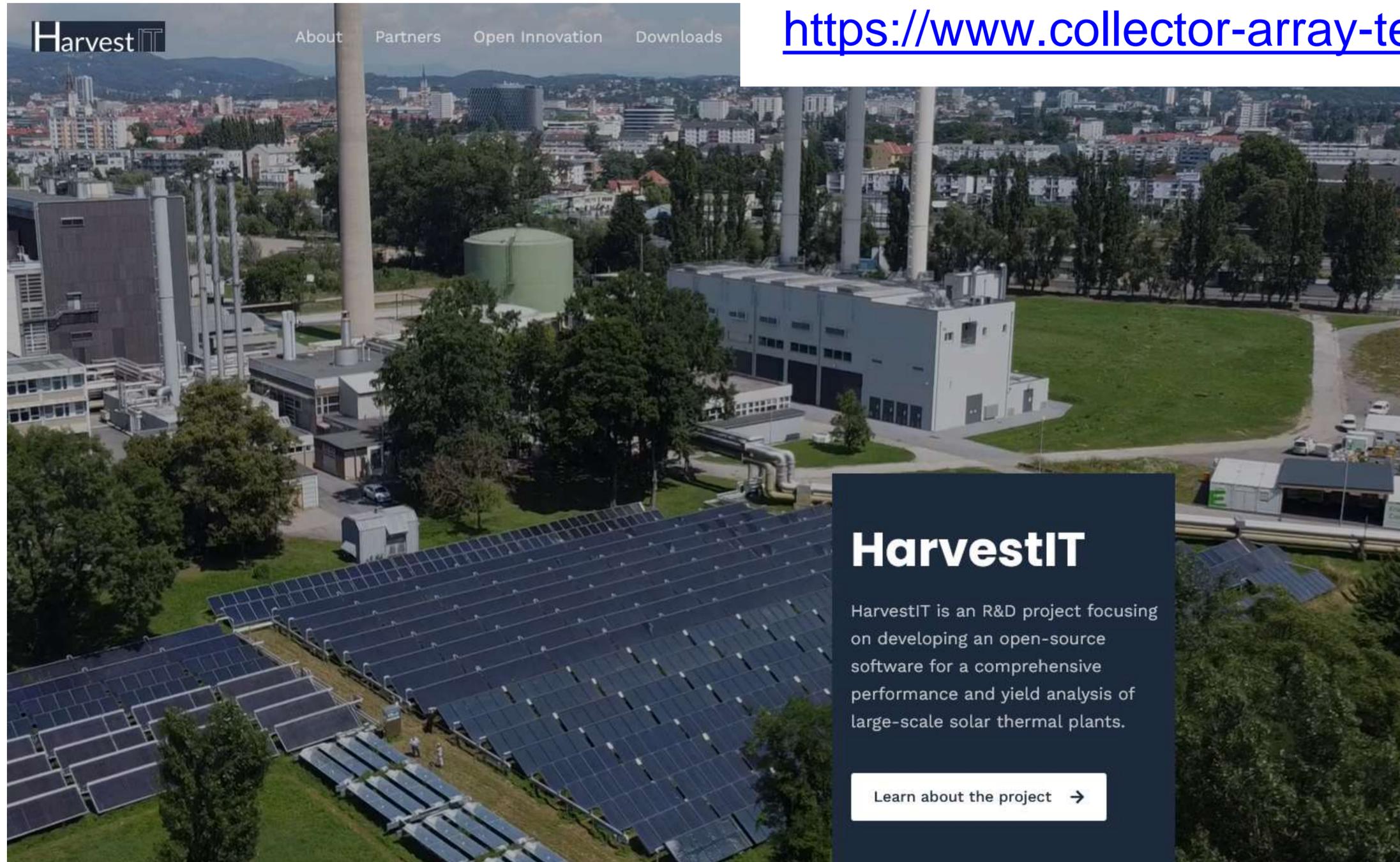
Dieses Projekt wird aus Mitteln des Klima- und  
Energiefonds gefördert.



Der DIH Süd wird gefördert und unterstützt von FFG,  
Land Steiermark und Land Kärnten.



# HarvestIT





**AEE INTEC**

**IDEA TO ACTION**

AEE – Institut für Nachhaltige Technologien (AEE INTEC)  
8200 Gleisdorf, Feldgasse 19, Österreich

Website: [www.aee-intec.at](http://www.aee-intec.at)  
Twitter: @AEE\_INTEC

**DI Philip Ohnewein**  
[p.ohnewein@aee.at](mailto:p.ohnewein@aee.at)  
+43 (0) 3112 5886 255

<https://www.collector-array-test.org>