

# HarvestIT

Open Source Software für Performance-Nachweise  
und Betriebsüberwachung von solarthermischen  
Großanlagen

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Daniel Tschopp & HarvestIT Projektteam

# Agenda

- 1** HarvestIT *Motivation, Zielsetzung*
- 2** SunPeek *Anlagenerfassung, Web-UI*
- 3** Methoden *Performance Check (ISO 24194:2022)*
- 4** Ausblick *Einladung zur Zusammenarbeit*

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

- FFG – FastTrackDigital 1st Call
- Projektlaufzeit: 2021-11 bis 2023-10

### Fördergeber



### Projektpartner



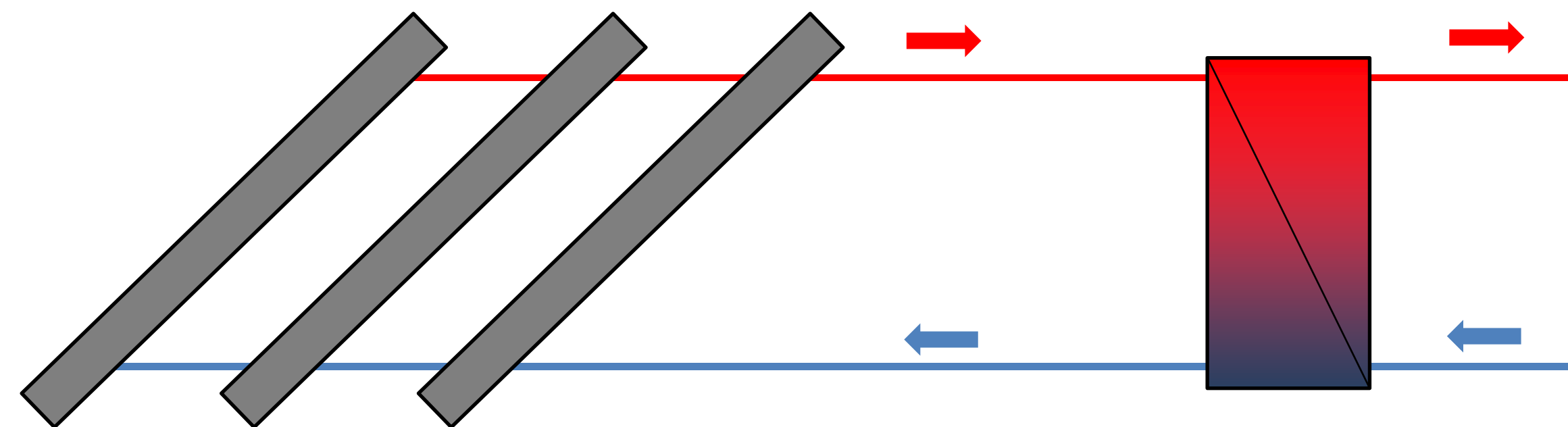
# Herausforderung Monitoring Solare Großanlagen

- 1) CAPEX: Solare Großanlagen haben **hohe Anfangsinvestition**.
- 2) OPEX: Amortisation über Laufzeit von 20-30 Jahren. Betreiber muss **langfristig hohen Solarertrag** sicherstellen.
- 3) Bewertung der Anlagenperformance selbst für Expert\*innen anspruchsvoll.
- 4) Es gibt am Markt **keine Standard-Software** für **Performance-Nachweise** und detailliertes **Anlagen-Monitoring**.

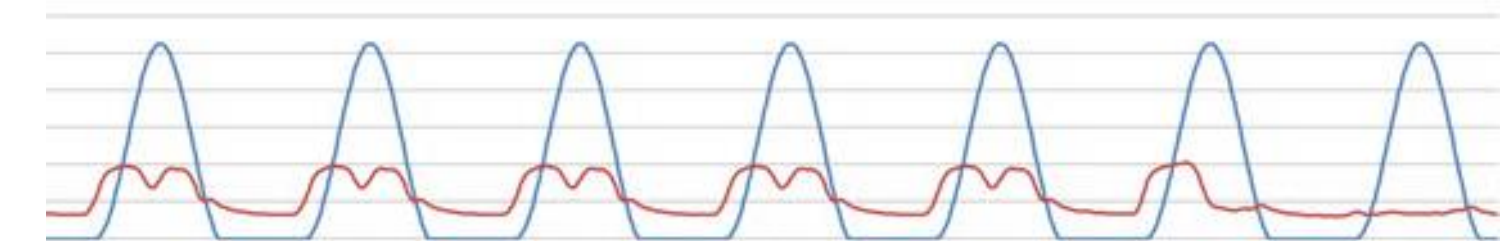
Wetter



Komponenten, Design, Regelung

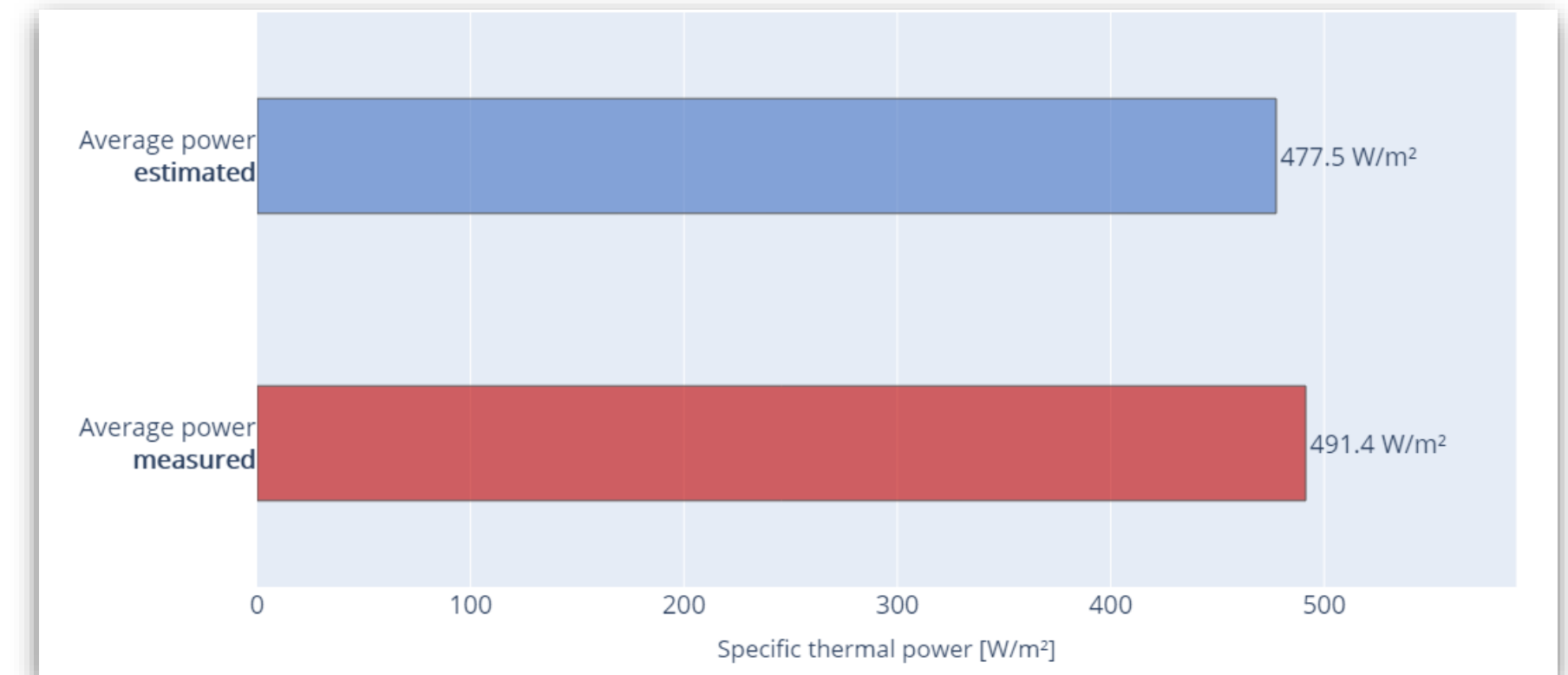


System, Randbedingungen

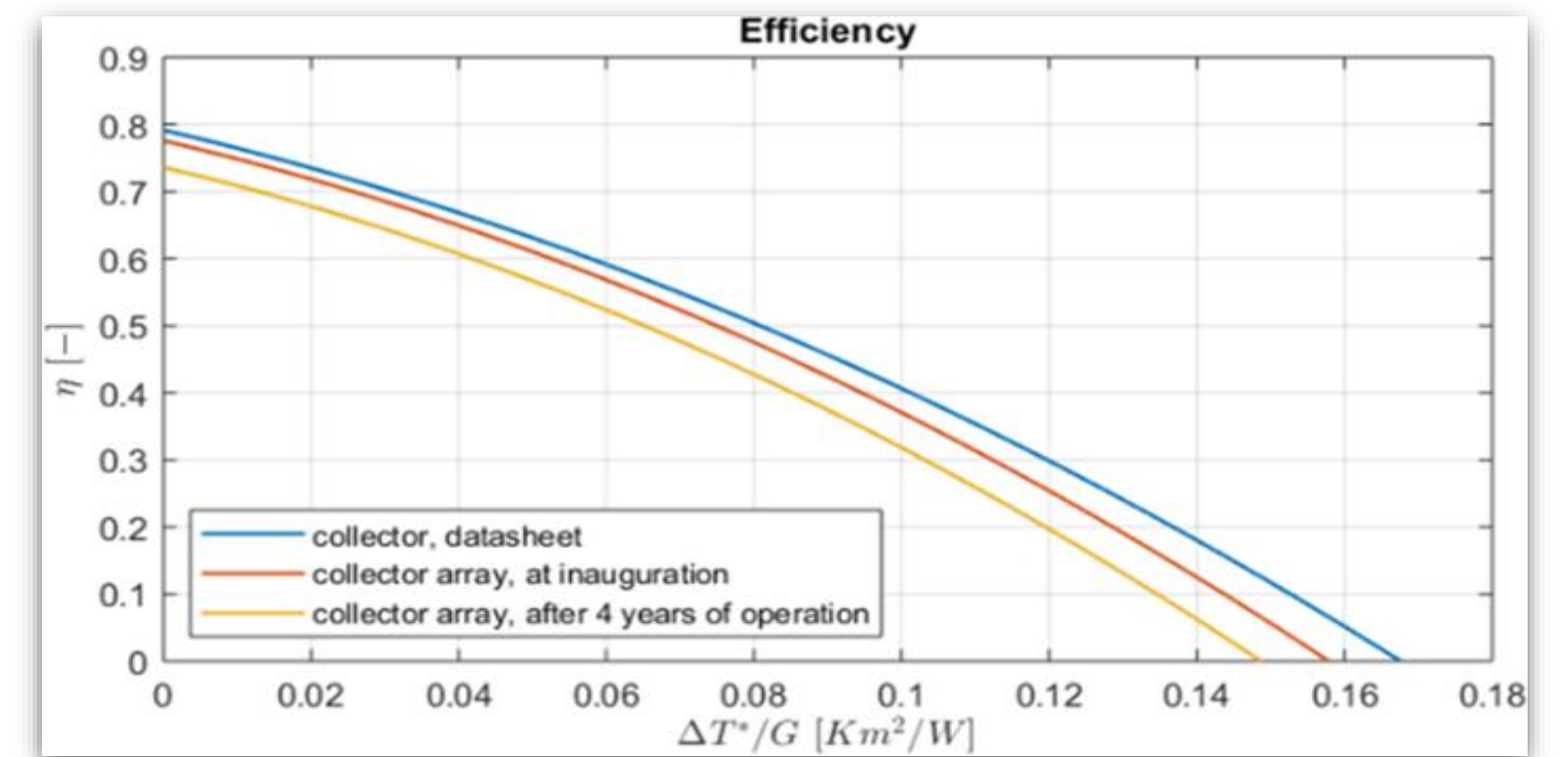


- 1) Transparente Klärung der Frage „Anlagenperformance ok?“  
(Performance-Nachweise, laufende Betriebsüberwachung)
- 2) **Wissenschaftliche Verfahren:**  
Performance Check (ISO 24194:2022),  
D-CAT (Dynamic Collector Array Test)
- 3) **Open Source:** Transparenz für alle Stakeholder,  
Branchenlösung, freie kommerzielle Nutzung.
- 4) **Günstiges Monitoring** durch Automatisierung.

## Performance Check



## D-CAT (Dynamic Collector Array Test)





# SunPeek

**Nice work!**

You have successfully launched SunPeek.  
Add a new system to check its performance  
and monitor guarantees.

[ADD NEW SYSTEM](#)

[OR TRY THE DEMO](#)

New Plant

- 1 Add Plant
- 2 Add Arrays
- 3 Add Sensors
- 4 Map Sensors
- 5 Set Details
- 6 Add Data

## Plant

Please enter required information about the solar thermal plant

[EDIT](#)

**Basics**

Plant Name(\*) DemoPlant\_20230508T101410 ⓘ

**Position**

Latitude(\*) 47.047201 degrees ⓘ

Longitude(\*) 15.436428 degrees ⓘ

Altitude 344 meter ⓘ

**Optional Information**

Owner SOLID ⓘ

Operator SOLID ⓘ

Description Arcon South sub-array of Fernheizwerk plant. Volume flow and ⓘ

[BACK](#) [NEXT](#)


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## Collector Arrays

Configure which collector arrays are installed at the solar thermal plant

ADD ARRAY

Name	Collector Area	Tilt	Azimuth	Collector Type	Edit
Arcon South	515.66 m <sup>2</sup>	30°	180°	Arcon 3510	

### Further Information

Fluid   ⓘ

For more information see the [CoolProp](#) library.

BACK

NEXT



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# Array Details

Please enter required information about the collector array

 EDIT

### Basics

Array Name(\*)  

Gross Area(\*)  m<sup>2</sup> 

### Position

Tilt(\*)  degrees 

Azimuth(\*)  degrees 

Row Spacing  m 

### Collector Type

Collector Type(\*)  

eta0hem=0.737; a1=2.067[W/m<sup>2</sup>.K]; a2=0.009[W/m<sup>2</sup>.K<sup>2</sup>]; a5=7313.000[J/m<sup>2</sup>.K]; SP  
SC0843-14; QDT


BACK

New Plant

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## Add Sensors

Please provide a measurement data file to register available sensors



Separator

11 sensors saved in plant  
insert a file to register new sensors

**List of Sensors**
















is shadowed rd\_bti rd\_dni rd\_dti rd\_gti rh\_amb te\_amb te\_in te\_out ve\_wind vf

New Plant

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## Sensor Mapping

Configure which sensor belongs to which part of the system.

Part	Element	Channel	Sensor
 plant	 Basics	Thermal power	<span style="background-color: #ffe0e0; padding: 2px;">missing</span> 
		Volume flow	<span style="border: 1px solid #ccc; padding: 2px;">vf</span> 
		Mass flow	<span style="background-color: #ffe0e0; padding: 2px;">missing</span> 
		Inlet temperature	<span style="border: 1px solid #ccc; padding: 2px;">te_in</span> 
		Outlet temperature	<span style="border: 1px solid #ccc; padding: 2px;">te_out</span> 
		Ambient temperature	<span style="border: 1px solid #ccc; padding: 2px;">te_amb</span> 
		Wind speed	<span style="border: 1px solid #ccc; padding: 2px;">ve_wind</span> 
		Relative humidity	<span style="border: 1px solid #ccc; padding: 2px;">rh_amb</span> 
		Air pressure	<span style="background-color: #ffe0e0; padding: 2px;">missing</span> 
		Dew point temperature	<span style="background-color: #e0e0e0; padding: 2px;">calculated</span> 
		Global radiation input	<span style="background-color: #ffe0e0; padding: 2px;">missing</span> 
		Direct radiation input	<span style="background-color: #ffe0e0; padding: 2px;">missing</span> 
		Diffuse radiation input	<span style="background-color: #ffe0e0; padding: 2px;">missing</span> 
















BACK
NEXT

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## Sensors

Configure the sensor details so SunPeek can interpret the data.

Sensor	Sensor Type	Unit	Info	Status
is shadowed 	bool	dimensionless		✓
rd_bti 	direct_radiation	watt / meter ** 2	EDIT 	✓
rd_dni 	dni_radiation	watt / meter ** 2		✓
rd_dti 	diffuse_radiation	watt / meter ** 2	EDIT 	✓
rd_gti 	global_radiation	watt / meter ** 2	EDIT 	✓
rh_amb 	float_0_1	dimensionless		✓
te_amb 	ambient_temperature	kelvin		✓
te_in 	fluid_temperature	kelvin		✓
te_out 	fluid_temperature	kelvin		✓
ve_wind 	wind_speed	meter / second		✓
vf 	volume_flow	meter ** 3 / second	EDIT 	✓

BACK
NEXT


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## Data Upload

Please use the input below to upload the measurement data

Separator: ;    Decimal: .    Index: 0    Encoding: latin1    Timezone: Europe/Vienna    Date-Order: day\_month\_year    Date-Format:

[EDIT](#) 

 Choose files or drag them here

File	Size	Datapoints	Status
------	------	------------	--------

[BACK](#) [NEXT](#)

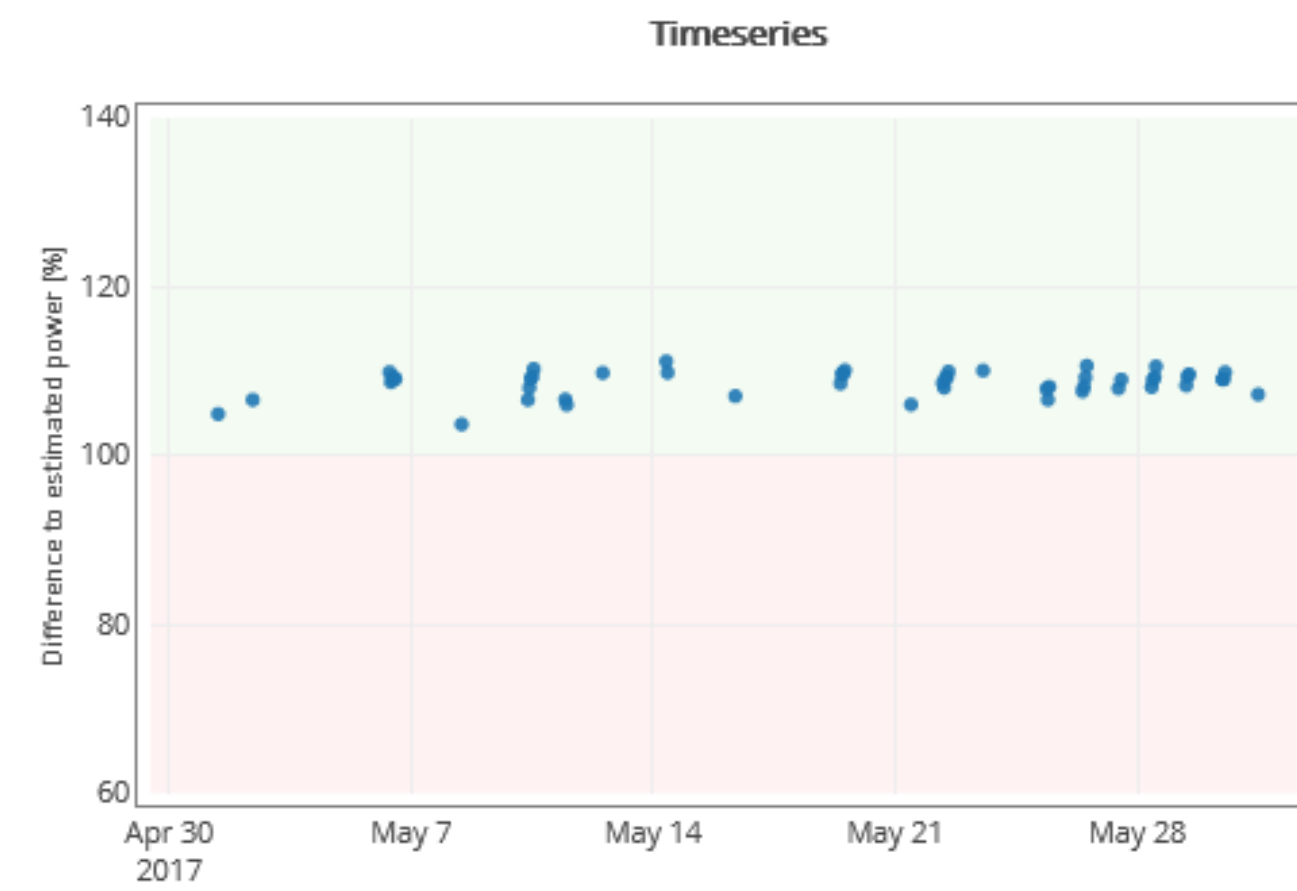
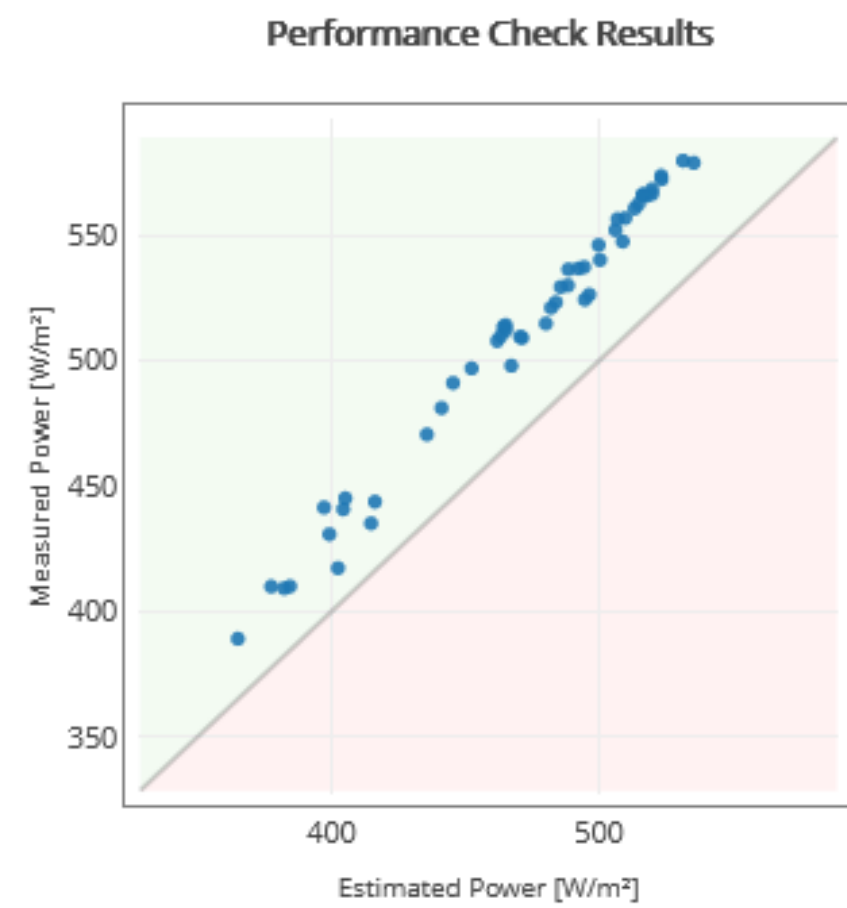
- 1 DemoPlant\_20230...
- Configuration
- Data Upload
- Performance Check**

## Thermal Power Check <sup>i</sup>

Method ISO <sup>i</sup>    Equation 1 <sup>i</sup>    Safety Factors:  $f_u$  95 % <sup>i</sup>     $f_p$  95 % <sup>i</sup>     $f_o$  95 % <sup>i</sup>

RUN DEMO

● PC-Guarantee fulfilled (with 108.6 %)



Array Name	Measured Power	Estimated Power <sup>i</sup>	Ratio <sup>i</sup>
Arcon South	No Data	23,500.9 [W/m²]	No Data
<b>Plant Total</b>	<b>25,525.6 [W/m²]</b>	<b>23,500.9 [W/m²]</b>	<b>108.6 %</b>

# Performance Check (PC)

ISO 24194:2022

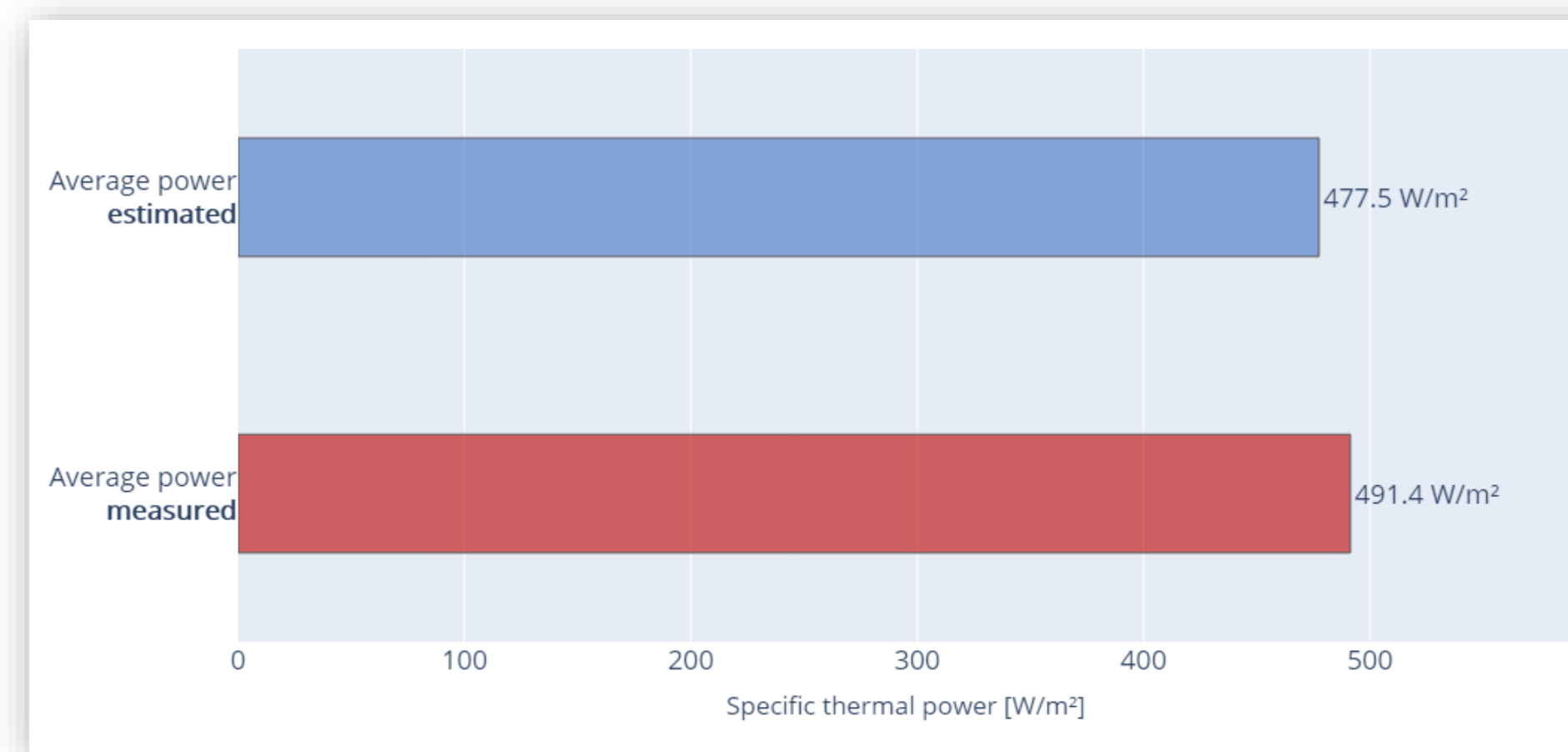
- **Neue Norm** für Performance-Überprüfung von Kollektorfeldern, seit 2022-05 im Status „Published 60.60“
- Performance Check – Thermische Leistung
  - **Soll-Ist Vergleich** für Betriebspunkte mit **hoher Leistung, geringen** Temperaturschwankungen, **ohne** Verschattung (1h Intervalle)
  - **Soll-Leistung** mit Hilfe von ISO 9806 Parametern berechnet

Now

Published  
ISO 24194:2022  
Stage: 60.60 v

Soll-Wert

Ist-Wert



# Adaptionen ISO 24194:2022 in der Praxis (1)

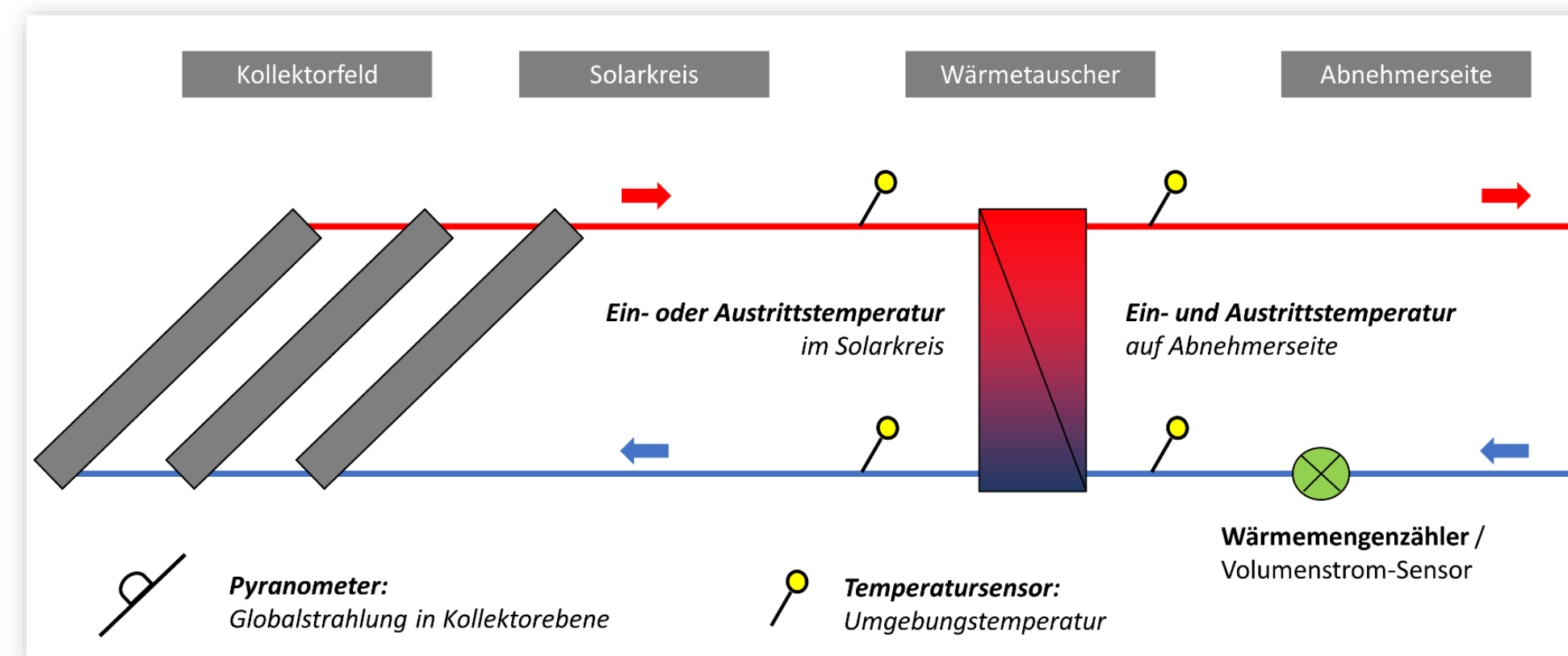
## 1) Mehrere Kollektorfelder, mehrere Kollektortypen

- ✓ Berechnung Soll-Leistung pro Teilfeld, Summation Soll-Leistungen

$$\dot{Q}_{estimate} = A_{GF} \cdot [\eta_{0,hem} K_{hem}(\theta_L, \theta_T) G_{hem} - a_1(\vartheta_m - \vartheta_a) - a_2(\vartheta_m - \vartheta_a)^2 - a_5(d\vartheta_m/dt)] \cdot f_{safe}$$

## 2) Unterschiedliche Messausstattungen

- ✓ Virtuelle Sensoren, Stoffwerte Wärmeträgerfluid





# Adaptionen ISO 24194:2022 in der Praxis (2)

## 3) Strahlungsmodellierung

- Unterschiedliche Ausrichtungen Kollektorfelder
- Interne Verschattung
- Korrekte Diffusstrahlung für faire Bewertung

✓ Strahlungsalgorithmen

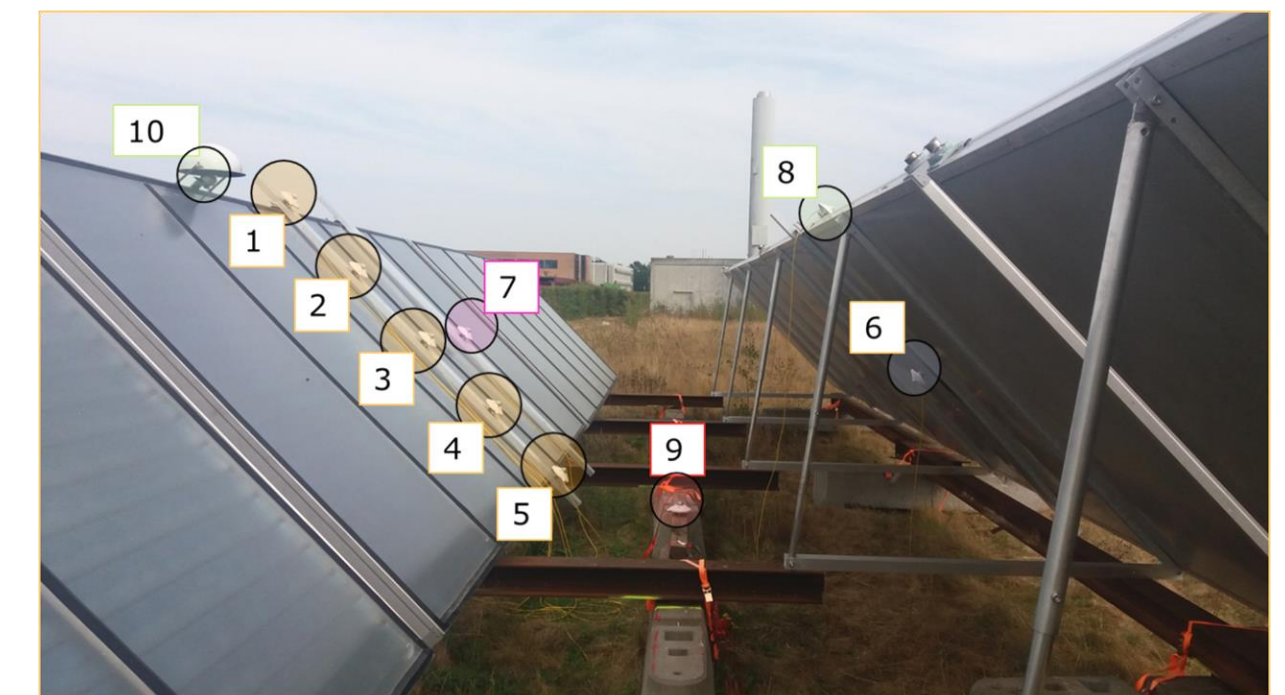
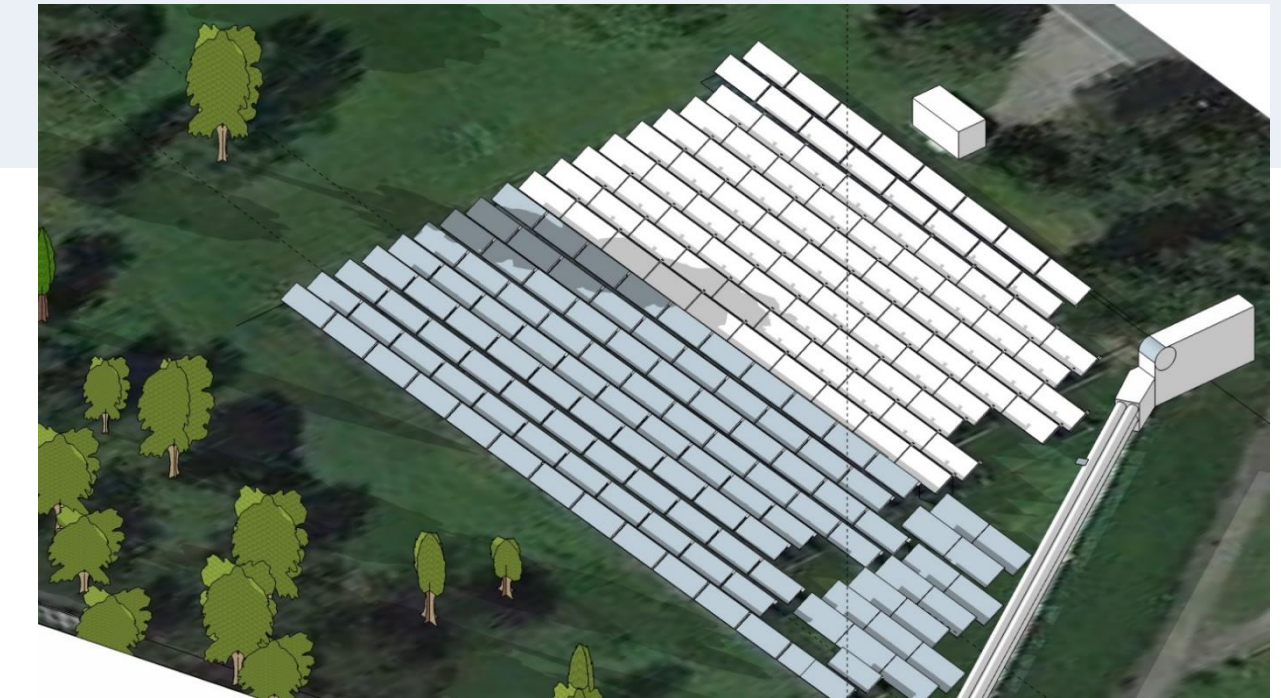
## 4) Vordefinierte Kollektoren

✓ Anbindung an Solar Keymark Datenbank

## 5) Datenverfügbarkeit

✓ Mehr Intervalle (im Teillast-Bereich) durch verbesserte Datenfilterung

## 6) Vollautomatische Datenaufbereitung & Datenanalyse



# Exemplarische Ergebnisse

## Beispiel-Anlage „FHW Graz“

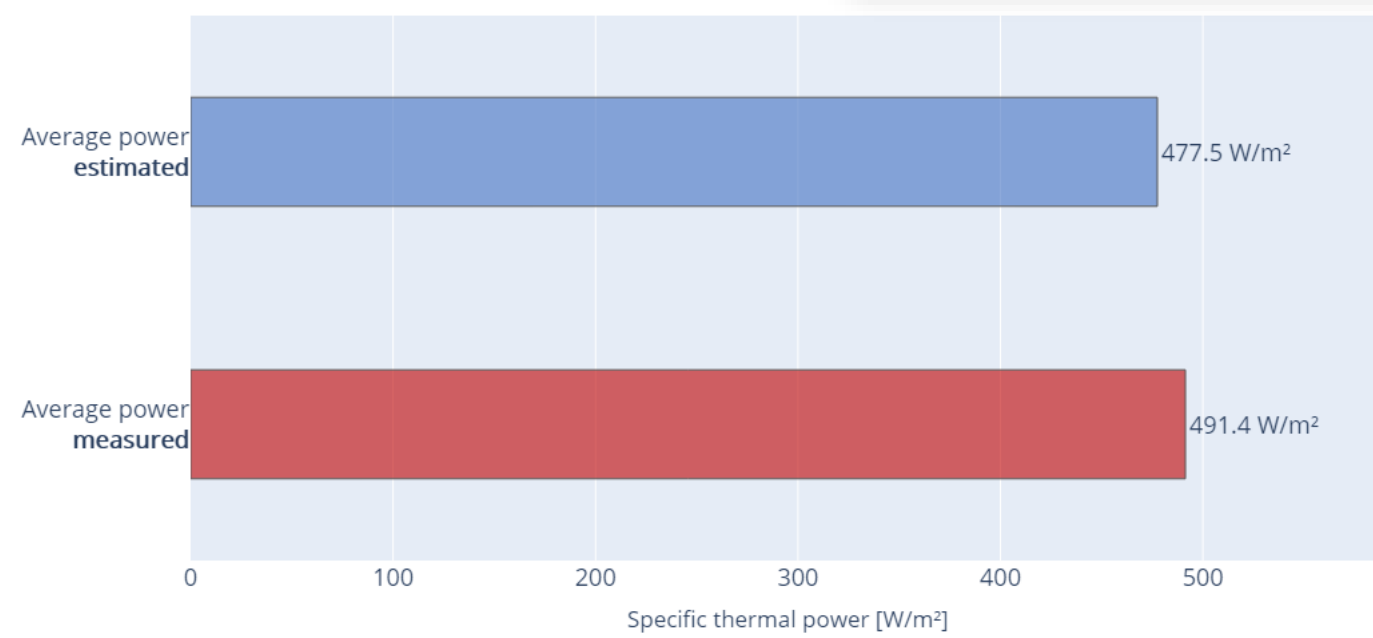


### Performance Check nach „ISO“ 1h Intervalle für volle Stunden

n = 274  
Soll vs. Ist: 102.9%

Check of Performance (PC Method 'ISO DIS 24194', Equation: 1).  
Data from 2017-04-15 12:00:00+00:00 to 2017-10-31 12:00:00+00:00.  
n=274 intervals, interval duration 1 hour.

Soll-Wert



Ist-Wert

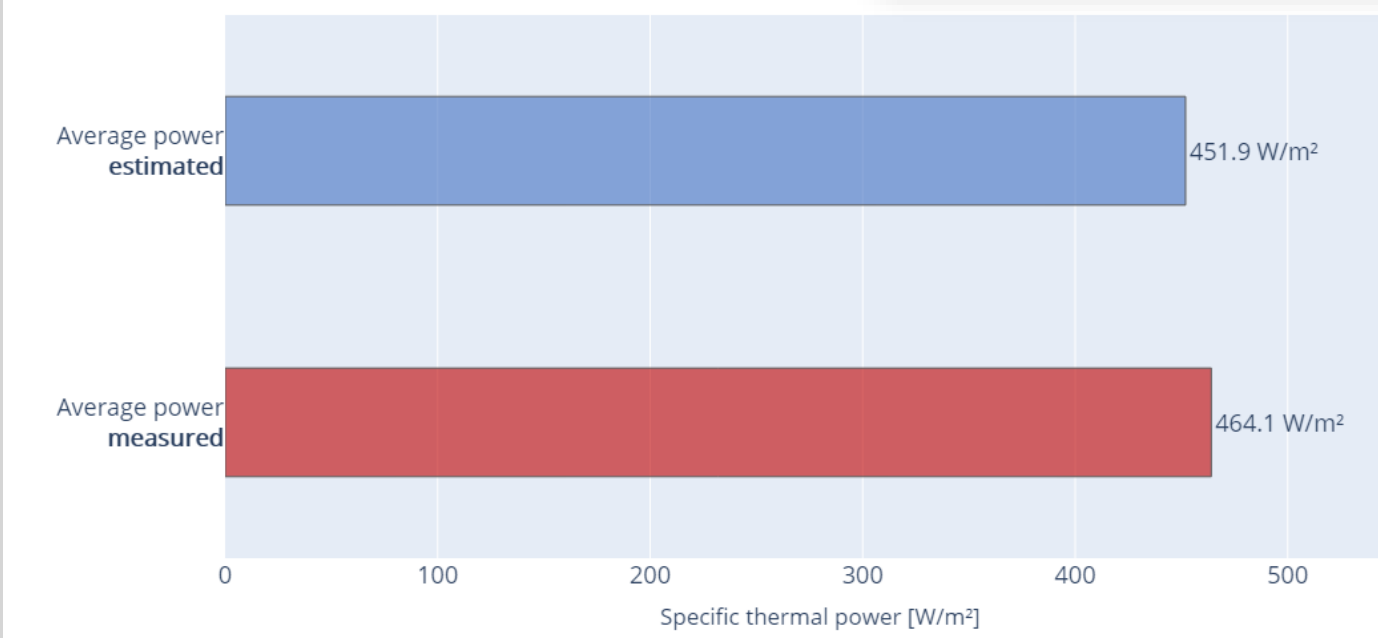


### Performance Check „Erweitert“ 1h Intervalle flexible Grenzen

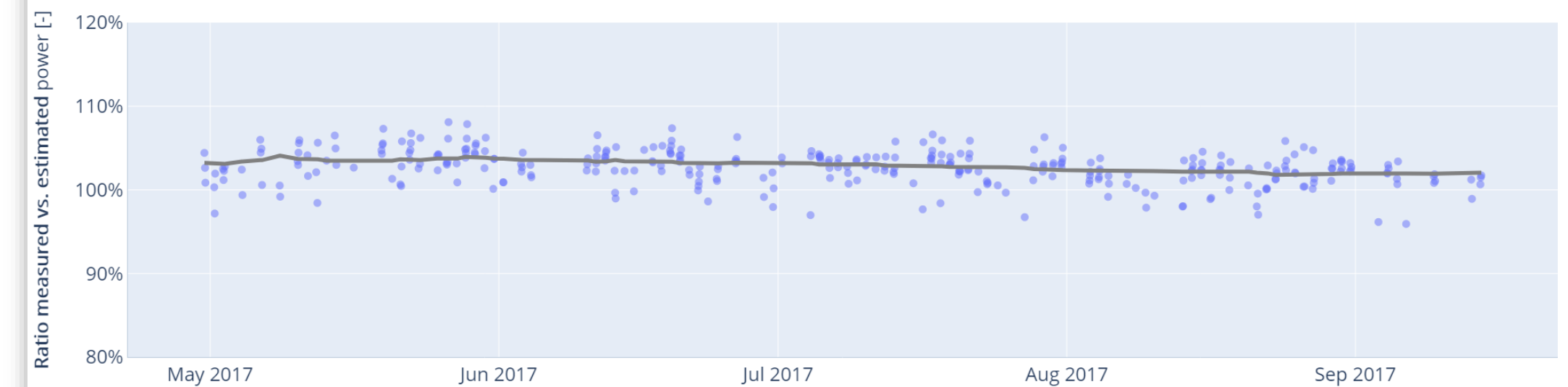
n = 334  
Soll vs. Ist: 102.6%

Check of Performance (PC Method 'ISO DIS 24194' extended, Equation: 1).  
Data from 2017-04-15 12:00:00+00:00 to 2017-10-31 12:00:00+00:00.  
n=334 intervals, interval duration 1 hour.

Soll-Wert



Ist-Wert



## Open Innovation

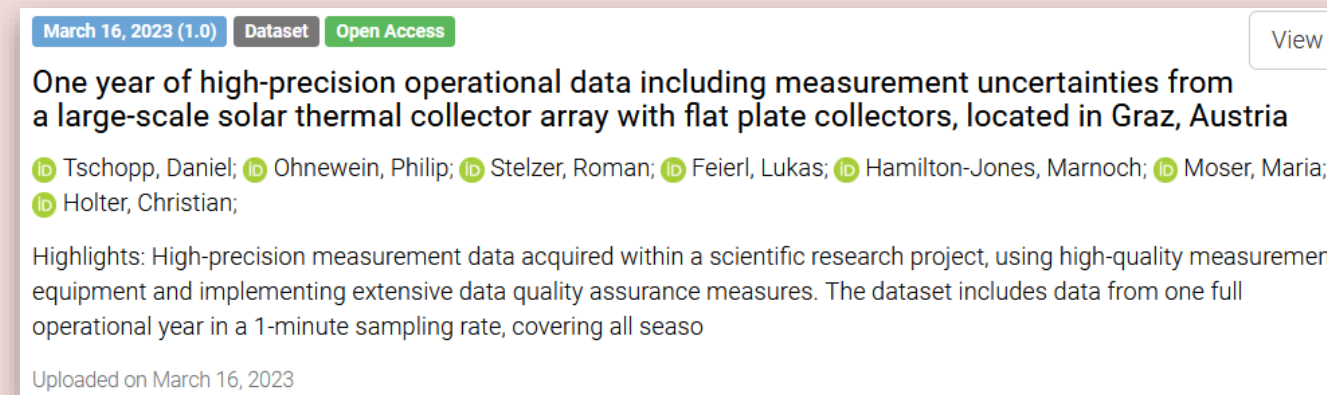
- Open Innovation Kampagnen mit Betreibern solarer Großanlagen (Herausforderungen & Monitoring Tools)
- MentiMeter Umfrage

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



## Open Data

- Veröffentlichung Messdaten auf **Zenodo** & **Data-in-Brief Artikel**



March 16, 2023 (1.0) Dataset Open Access View

One year of high-precision operational data including measurement uncertainties from a large-scale solar thermal collector array with flat plate collectors, located in Graz, Austria

Tschopp, Daniel; Ohnewein, Philip; Stelzer, Roman; Feierl, Lukas; Hamilton-Jones, Marnoch; Moser, Maria; Holter, Christian;

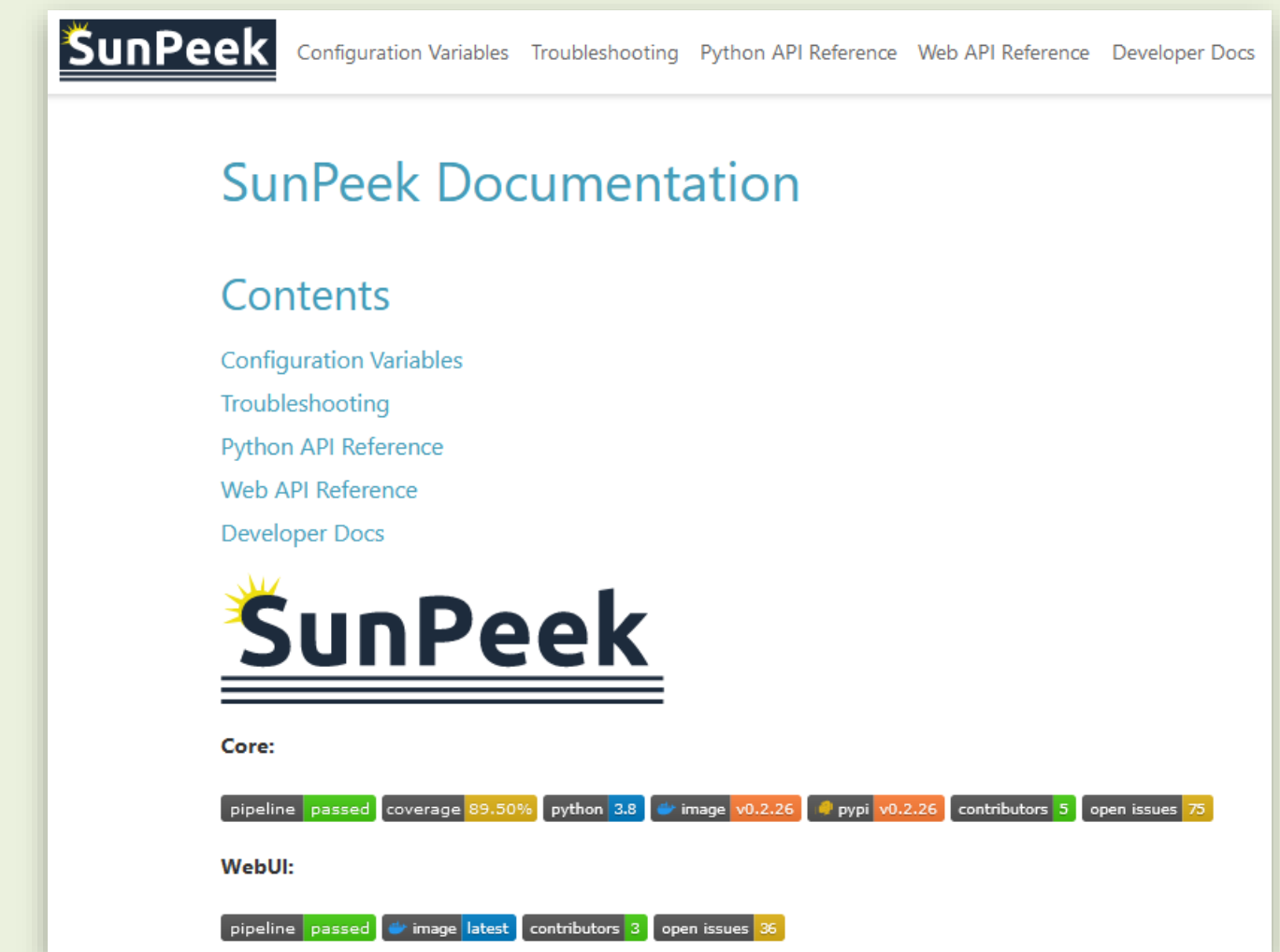
Highlights: High-precision measurement data acquired within a scientific research project, using high-quality measurement equipment and implementing extensive data quality assurance measures. The dataset includes data from one full operational year in a 1-minute sampling rate, covering all seasons

Uploaded on March 16, 2023



## Open Development

- Transparente Entwicklung auf Public Repository <https://gitlab.com/sunpeek/>



SunPeek Configuration Variables Troubleshooting Python API Reference Web API Reference Developer Docs

### SunPeek Documentation

Contents

- Configuration Variables
- Troubleshooting
- Python API Reference
- Web API Reference
- Developer Docs

# SunPeek

Core:

- pipeline: passed
- coverage: 89.50%
- python: 3.8
- image: v0.2.26
- pypi: v0.2.26
- contributors: 5
- open issues: 75

WebUI:

- pipeline: passed
- image: latest
- contributors: 3
- open issues: 36

## Outcomes



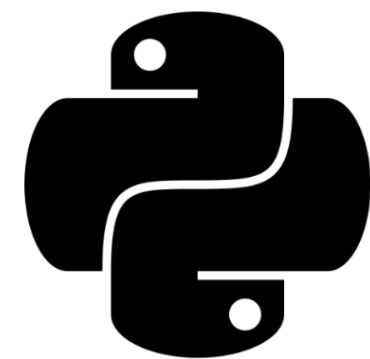
### web UI

Grafische Oberfläche,  
Interaktive Nutzung



### web API

Restful API. Integration in  
eigene Software Tools.



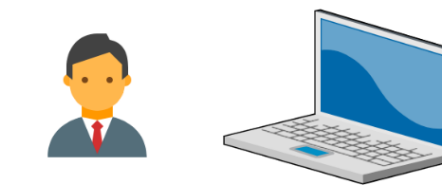
### Python package

Nutzung mit anderen  
Projekten. Weiterentwicklung

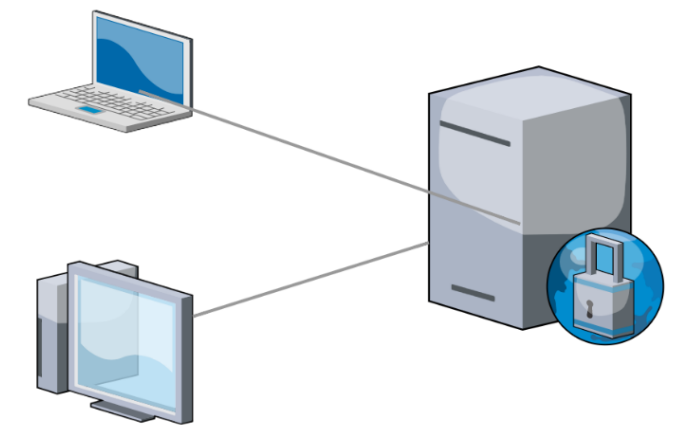
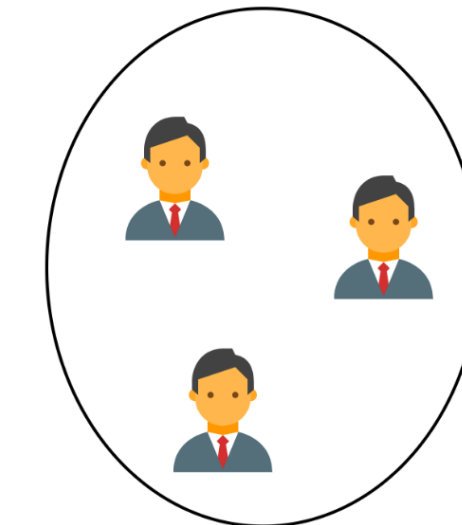


## Usages

**1 User**  
Lokale Nutzung



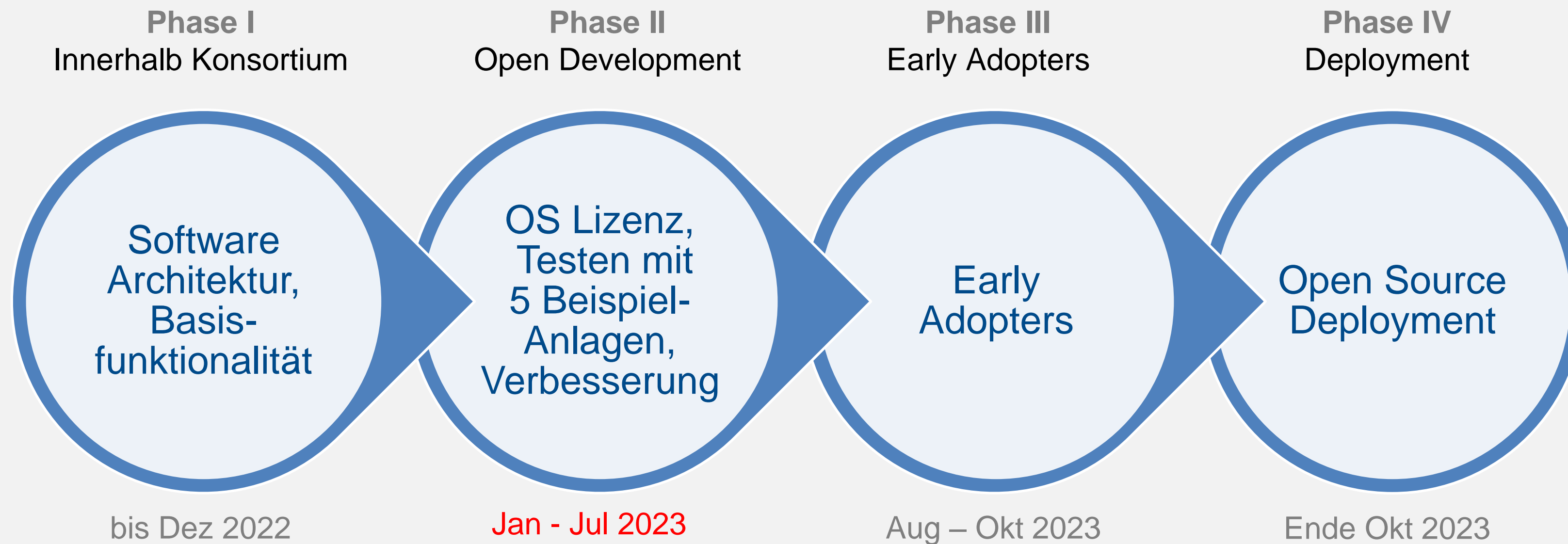
**Betreiber / Firma**  
Gehostet im eigenen  
Firmennetzwerk



**Öffentlichkeit**  
Förderstellen, Open Data

**Forschung & Entwicklung**  
Forschungsinstitute,  
Industrie

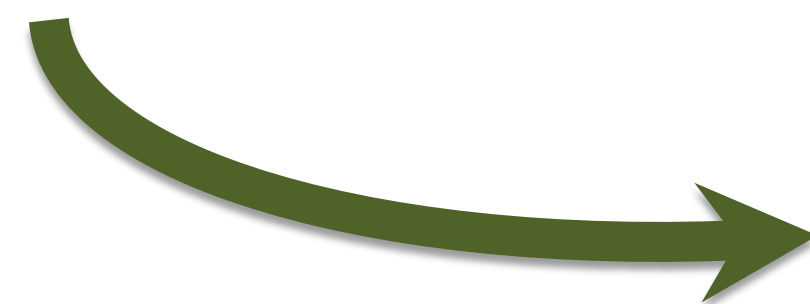
# Roadmap & Perspektiven



Interesse?

Möglichkeiten zur Mitarbeit:

- Auswertung eigener Anlagen
- Mitentwicklung / Developer
- Entwicklungsprozess einsehen & mitgestalten



- **Bündelung Branchenaktivitäten:** IEA SHC Task 68, ISO/TC 180/SC 4, Solar Keymark, Europäische/internationale Forschungsprojekte
- **Transparenz:** Open Data, Auswertepattform, Anlagen-Benchmarking
- **Methodische Weiterentwicklungen:** D-CAT (Dynamic Collector Array Test), Strahlungsmodellierung, Messunsicherheit, Verbesserungen Usability & Performance

# Besten Dank für Ihre Aufmerksamkeit! Fragen?

## Links

- Projektwebsite: <https://www.collector-array-test.org>
- GitLab Repository: <https://gitlab.com/sunpeek/>
- Zenodo Datensatz: <https://zenodo.org/record/7741084#.ZFmGYc7P17M>

## Publikationen

- Tschopp, D. et al. (2023) One year of high-precision operational data including measurement uncertainties from a large-scale solar thermal collector array with flat plate collectors, located in Graz, Austria, Data in Brief (in press)
- Tschopp, D. et al. (2021) Application of Performance Check (PC) Method to Large Collector Arrays. IEA SHC FACT SHEET 55 B-D1.1. Available at: <https://task55.iea-shc.org/Data/Sites/1/publications/IEA-SHC-T55-B-D.2-FACT-SHEET-Collector-Fields-Check-of-Performance.pdf>
- Fahr, S. et al. (2019) 'Review of in situ Test Methods for Solar Thermal Installations', in Proceedings of SWC 2019/SHC 2019. International Solar Energy Society, pp. 1–10. Available at: <https://doi.org/https://doi.org/10.18086/swc.2019.06.02>.



**AEE INTEC**

**IDEA TO ACTION**

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