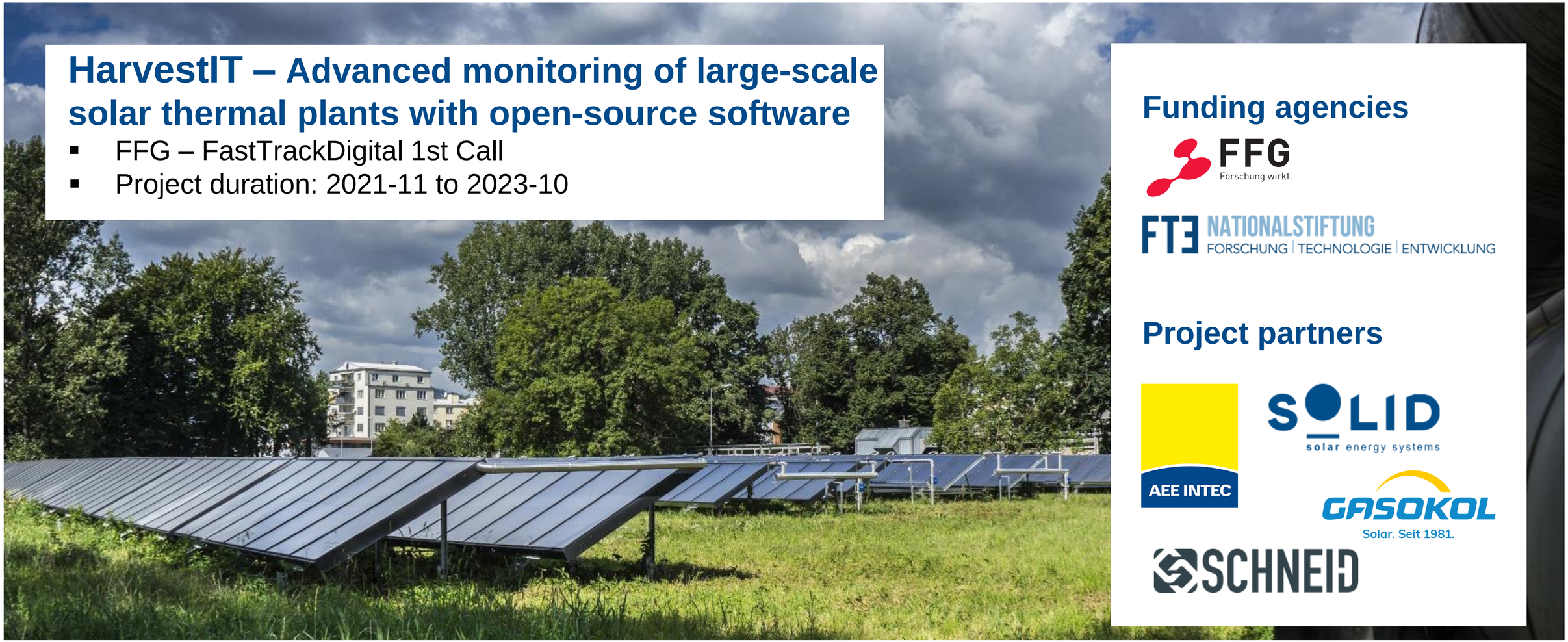
SunPeek

Open source software for performance check and advanced monitoring of large-scale solar thermal plants

Daniel Tschopp & HarvestIT project team

R&D project HarvestIT



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

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

Funding agencies

FFG Forschung wirkt.

FTE NATIONALSTIFTUNG FORSCHUNG | TECHNOLOGIE | ENTWICKLUNG

Project partners

AEE INTEC

SOLID solar energy systems

GASOKOL Solar. Seit 1981.

SCHNEID

Source: Picfly.at Thomas Eberhard

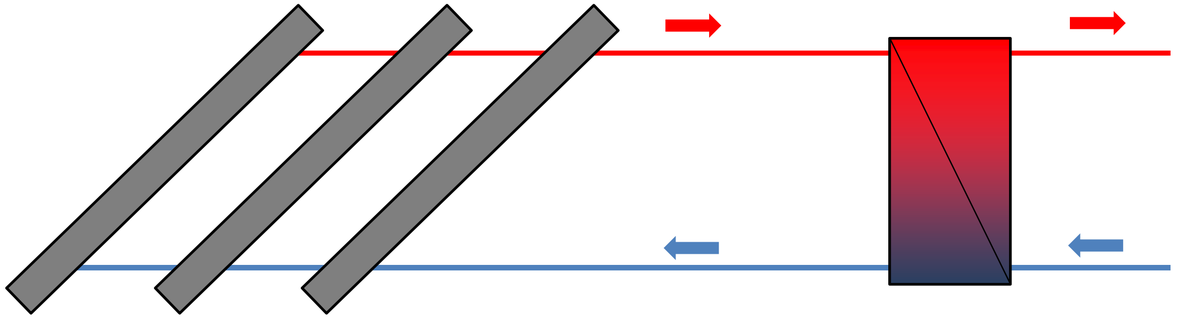
Background and Need

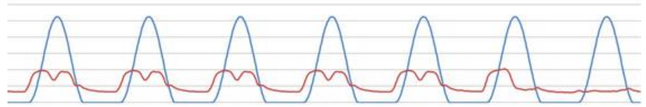
- **CAPEX**: Plants have high initial investment costs.
- **OPEX**: Amortization over 20-30 years. Consistently high solar yield / good plant performance is essential.
- **Performance assessment** is difficult, even for experts.
- **More and more data** is collected, we should make use of it!
- **No common standard evaluation software** for power / yield guarantees and advanced monitoring available.

weather conditions

components, design, control

load, boundary conditions





SunPeek Software

Goals, Methods

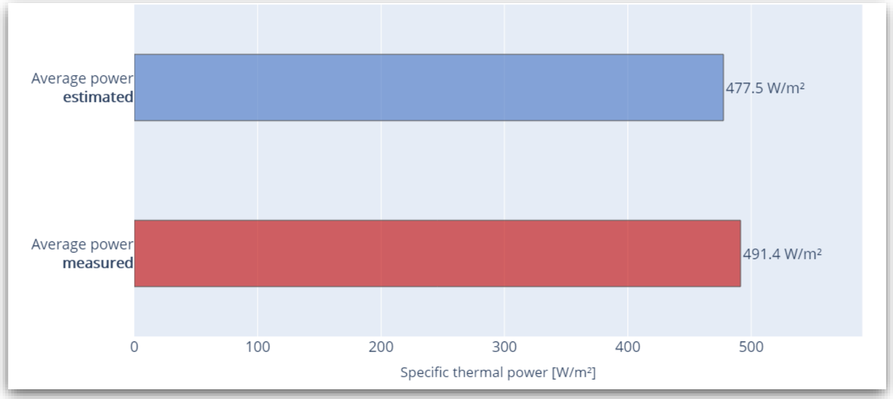
1) Clear and transparent answer to question
   „Plant performance ok?“
   (performance check, on-going monitoring)

2) **Implemented procedures**:
   Performance Check (ISO 24194:2022)
   D-CAT (Dynamic Collector Array Test)

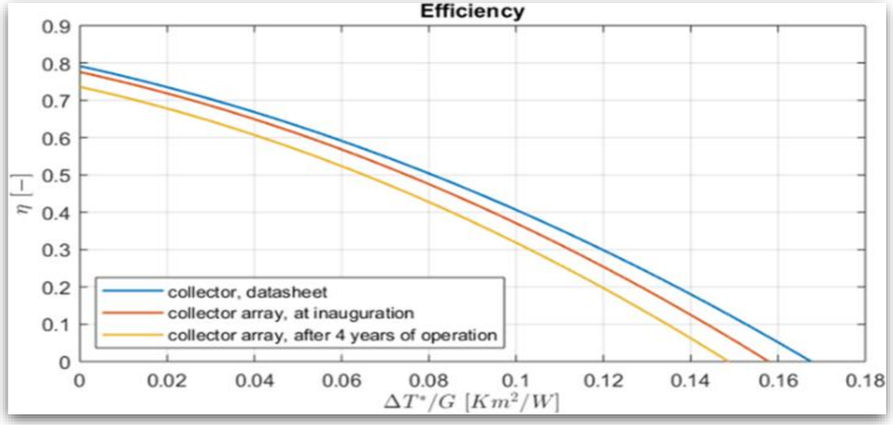
3) **Open source**: Transparency for all stakeholders, solution for whole solar thermal industry, free commercial use

4) **Inexpensive monitoring** through automation

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

New Plant

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

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 m²	30°	180°	Arcon 3510	

Further Information

Fluid — Fluid Type: Pekasolar_FHW (Fluid used in plant FHW, Pekasolar. Fixed concentration as used in plar

For more information see the CoolProp library.

BACK NEXT

New Plant

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

Array Details

Please enter required information about the collector array

EDIT

Basics

Array Name(*)	Arcon South
Gross Area(*)	515.66 m²

Position

Tilt(*)	30 degrees
Azimuth(*)	180 degrees
Row Spacing	3.1 m

Collector Type

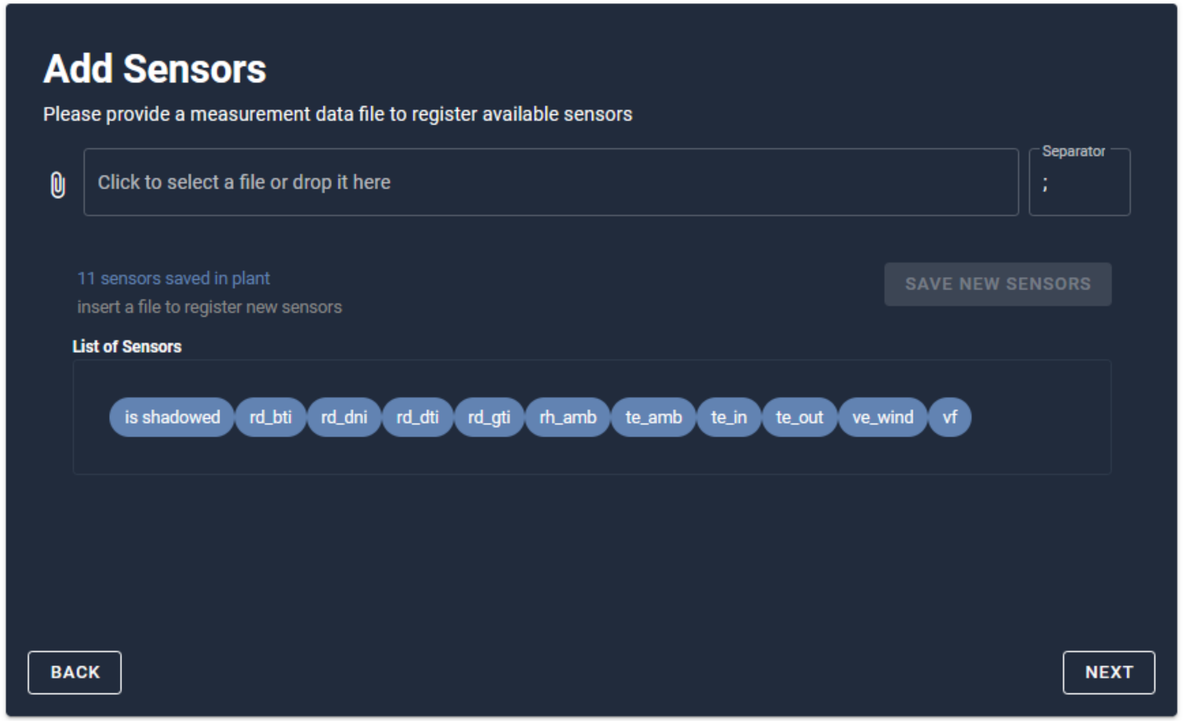
Collector Type(*)	Arcon 3510

eta0hem=0.737; a1=2.067[W/m².K]; a2=0.009[W/m².K²]; a5=7313.000[J/m².K]; SP SC0843-14; QDT

BACK

New Plant

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



New Plant

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

Sensor Mapping

Configure which sensor belongs to which part of the system.

Part	Element
plant	Basics
array	

Channel	Sensor
Thermal power	missing
Volume flow	vf
Mass flow	missing
Inlet temperature	te_in
Outlet temperature	te_out
Ambient temperature	te_amb
Wind speed	ve_wind
Relative humidity	rh_amb
Air pressure	missing
Dew point temperature	calculated
Global radiation input	missing
Direct radiation input	missing
Diffuse radiation input	missing

BACK NEXT

New Plant

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

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

New Plant

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

Data Upload

Please use the input below to upload the measurement data

EDIT

Separator	Decimal	Index	Encoding	Timezone	Date-Order	Date-Format
;	.	0	latin1	Europe/Vienna	day_month_year	

Choose files or drag them here

File	Size	Datapoints	Status

BACK

NEXT

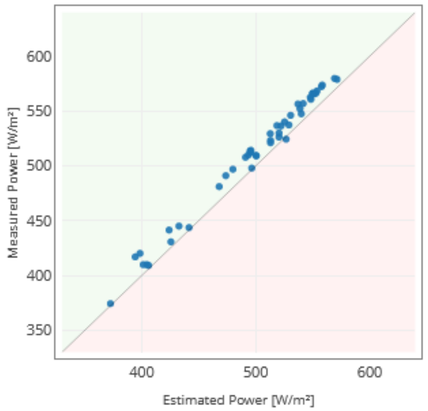
Thermal Power Check

Method: ISO | Equation: 2 | Safety Factors: f_u 95 % | f_p 98 % | f_o 99 % | RUN

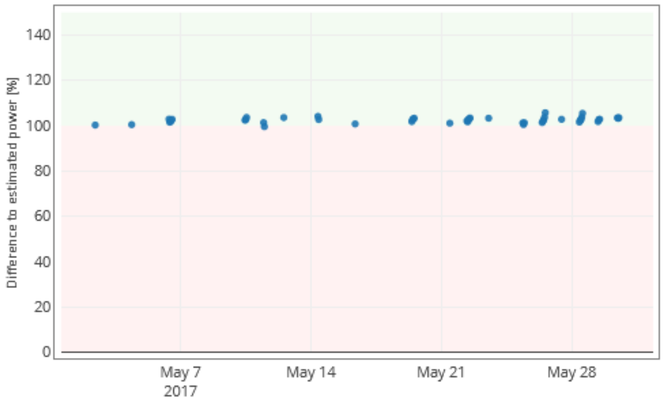
PC-Guarantee fulfilled (with 102.4 %)

DOWNLOAD RESULTS

Performance Check Results



Timeseries

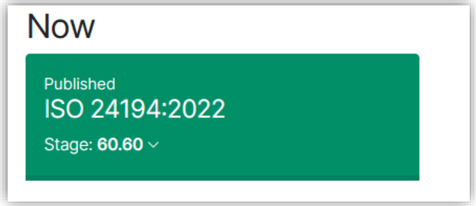


Array Name	Ø Measured Power	Ø Estimated Power	Ratio	Valid Intervals
Arcon South	No Data	499.88 [W/m²]	No Data	47
Plant Total	**512.12 [W/m²]**	**499.88 [W/m²]**	**102.4 %**	**47**

Performance Check (PC)

ISO 24194:2022

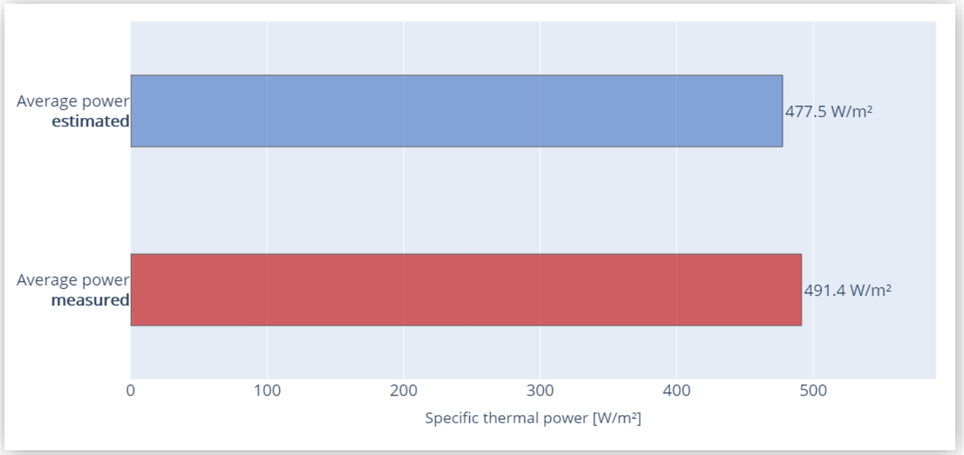
- **New standard** for performance check of solar thermal collector arrays, since 2022-05 in status **"Published 60.60"**



- Performance Check – Thermal power
  - **Estimated-measured** comparison for close to **stable full power operation**, **no** shadows (1h intervals)
  - Estimated thermal power calculated based on **ISO 9806** parameters

Estimated

Measured



Adaptions of ISO 24194:2022 in SunPeek (1)

From „paper“ to „software implementation“

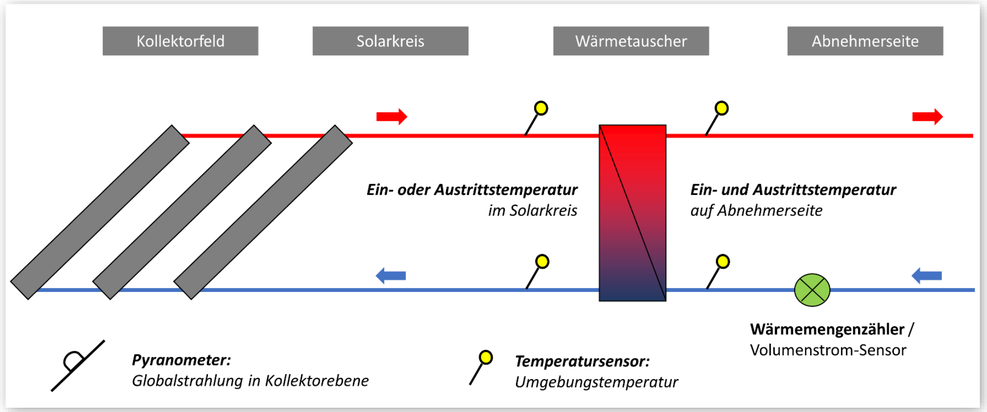
1) **Multiple collector arrays**, multiple collector types

✓ Estimation of thermal power output per sub-array, sum up results

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

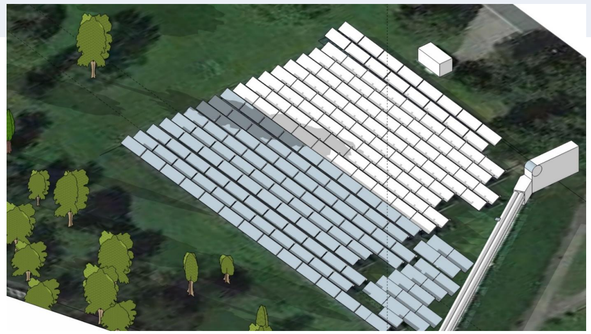
2) **Different measurement instrumentations**

✓ Virtual sensors, heat transfer fluids



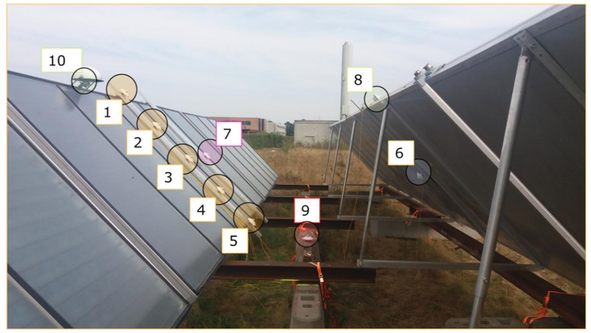
Adaptions of ISO 24194:2022 in SunPeek (2)

From „paper“ to „software implementation“



3) **Radiation modeling**
   - Different tilt/azimuth of sub-arrays
   - Internal shading
   - Diffuse irradiance masking

   ✓ radiation conversion algorithms



4) **Pre-defined** collectors

   ✓ Connection to Solar Keymark Database (planned)

5) **Data availabilty**

   ✓ Find more intervals for partial load conditions, due to improved data filtering

The Solar Keymark
CEN Keymark Scheme

6) Fully automated **data pre-processing & analysis**

Example results

Demo plant „FHW Graz – Arcon South“

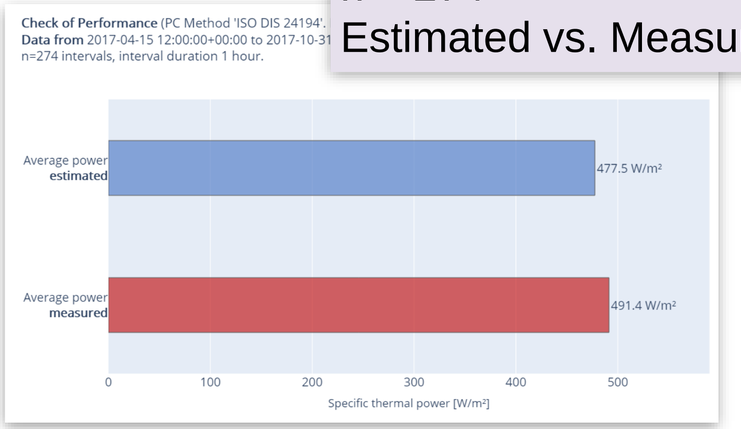
Performance Check „ISO“

1h intervals for full hours

n = 274
Estimated vs. Measured: 102.9%

Estimated

Measured



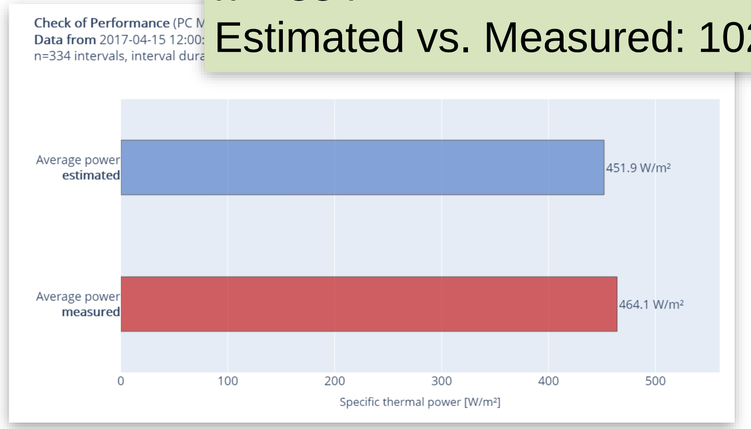
Performance Check „Extended“

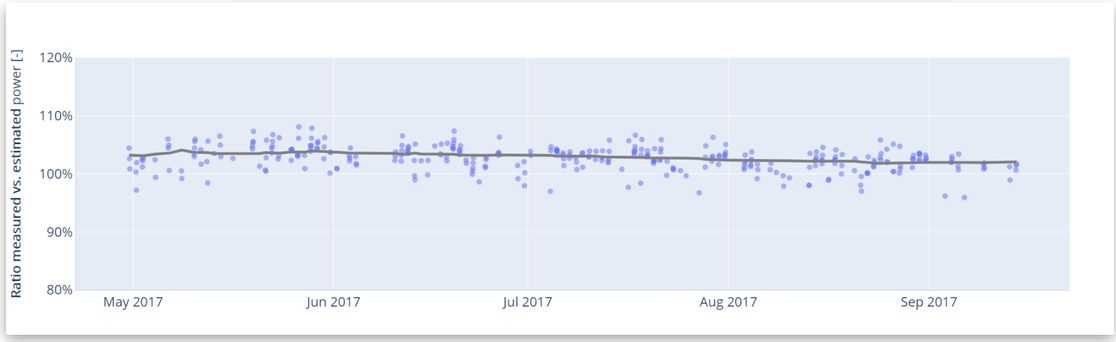
1h intervals with rolling windows

n = 334
Estimated vs. Measured: 102.6%

Estimated

Measured





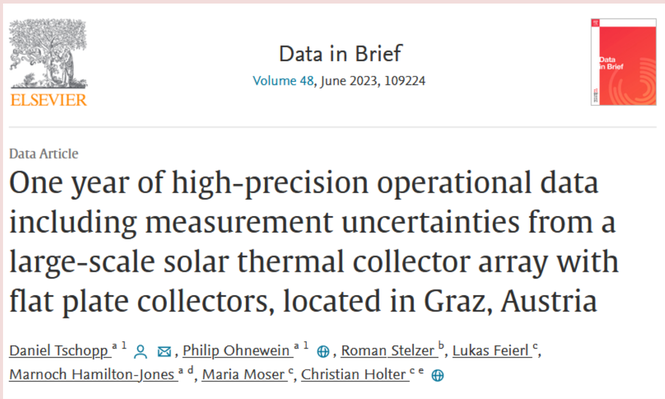
Collaborative Development

Open Innovation

- **Open innovation** campaigns (Challenges & Monitoring tools)
- MentiMeter **Questionnaire**

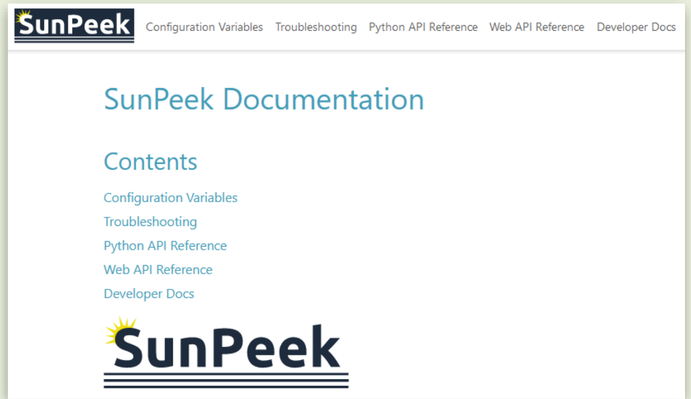
Open Data

- Measurement data on **Zenodo** & **Data-in-Brief article** **https://doi.org/10.1016/j.dib.2023.109224**



Open Development

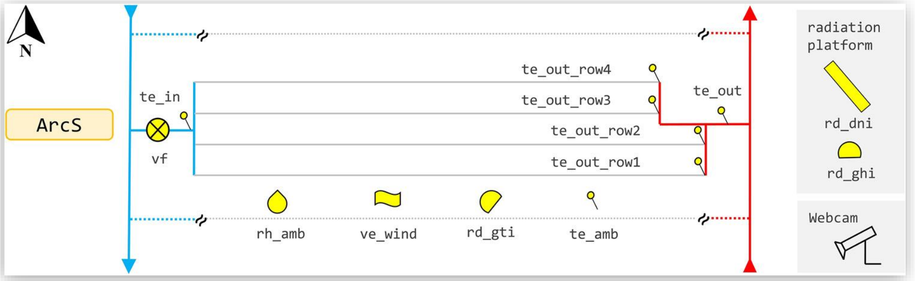
- Transparent development on public repository **https://gitlab.com/sunpeek/**



Measurement data on Zenodo / Data-in-Brief article

- Operational data of a large-scale solar thermal collector array (516 m^2 A_{gr}), located in Graz, Austria
- One full operational year (2017) of **high-precison data**, 1-minute sampling, measurement uncertainty calculation
- Zendo data set: https://doi.org/10.5281/zenodo.7741084
- GitLab Repository (for easy use): https://gitlab.com/sunpeek/zenodo-fhw-arconsouth-dataset-2017
- Data in Brief article: https://doi.org/10.1016/j.dib.2023.109224
- Please use the dataset **for your projects** and **share your data as well!**

Source: Picfly.at Thomas Eberhard



How to use SunPeek?

Outcomes

web UI
Grafische Oberfläche,
Interaktive Nutzung

web API
Restful API. Integration in eigene Software Tools.

Python package
Nutzung mit anderen Projekten. Weiterentwicklung

open source initiative
Approved License®

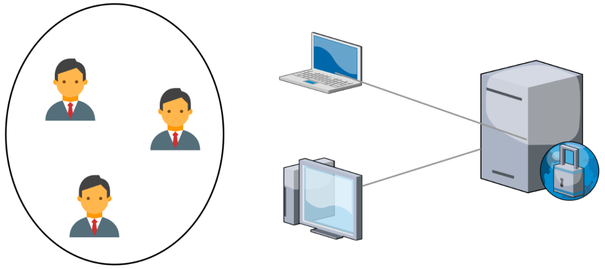
Commerical use explicitly allowed

docker

Usages

1 User
Lokale Nutzung

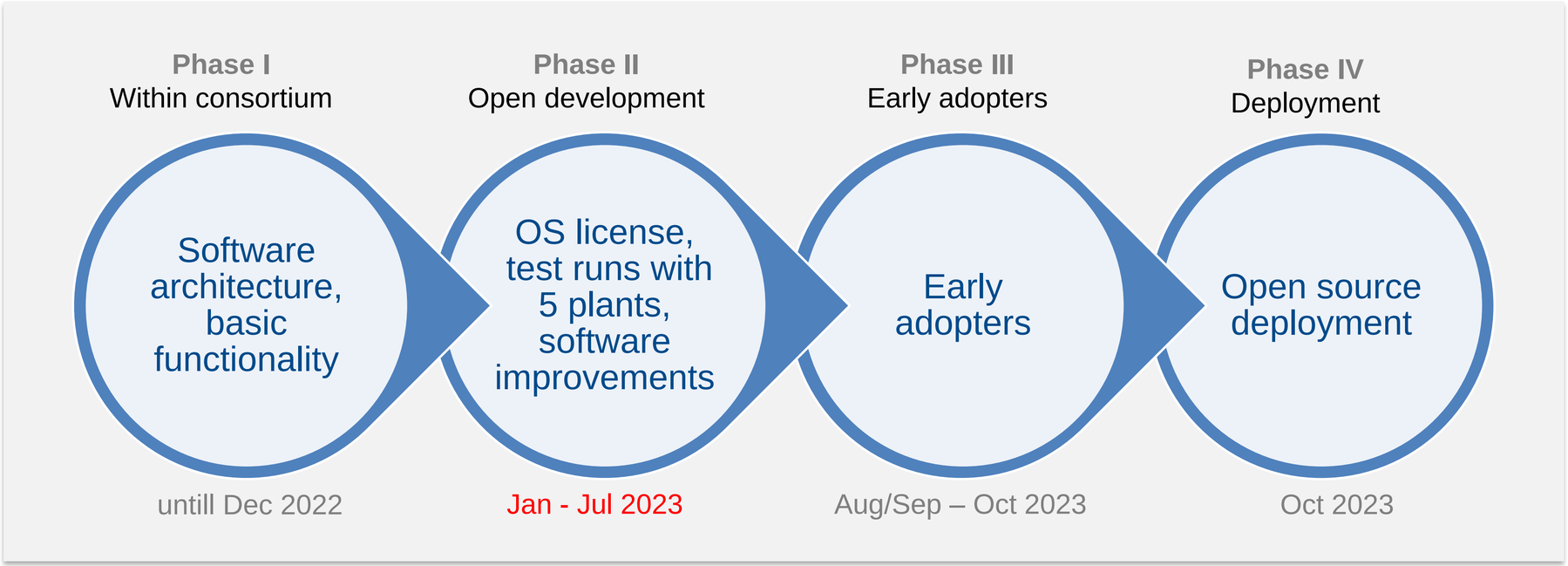
Betreiber / Firma
Gehostet im eigenen Firmennetzwerk



Öffentlichkeit
Förderstellen, Open Data

Forschung & Entwicklung
Forschungsinstitute, Industrie

Roadmap & perspectives



Vision

Make SunPeek the **reference implementation** for the ISO 24194 Performance Check.

Have the **scientific community** use the tool in their projects and develop it further.

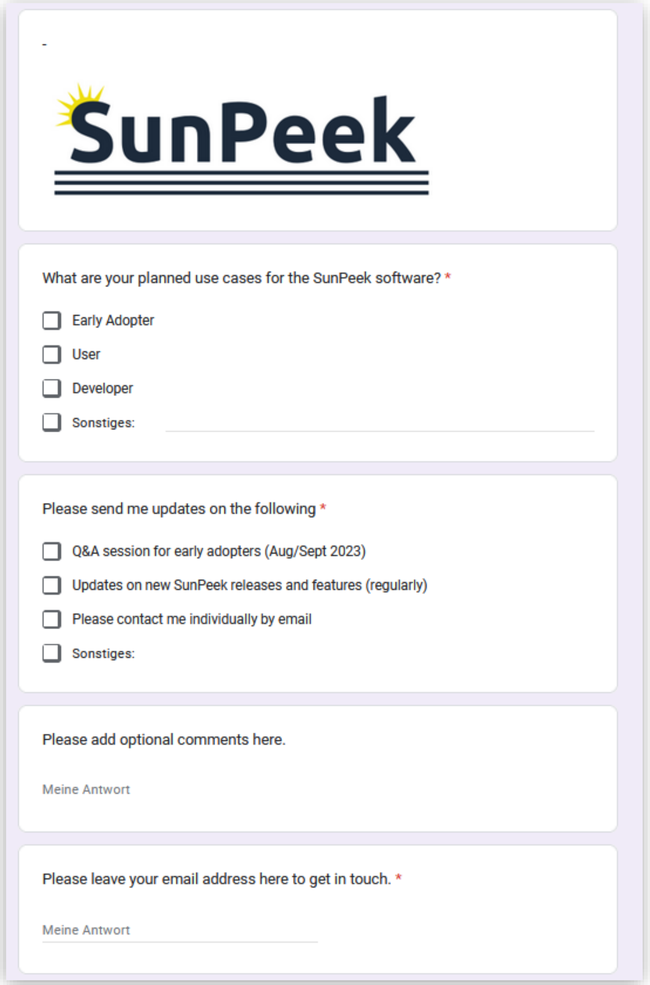
- How to get SunPeek? Just go to https://gitlab.com/sunpeek/ and follow the installation instructions!
- Feel free to try out the tool already now, official „early adopter“ use will start in Aug/Sep 2023!

How to participate?

Google Forms:
https://forms.gle/gv7bFDN4skmedf4M9

GitLab

- Become an **Early Adopter**
  → Online Q&A meeting in Aug/Sep 2023
- Become a **User** and evaluate your own plants
  → get regular updates/newsletter
- Become a **Developer** and use SunPeek in your own projects
  → regular exchange with the team of maintainers



SunPeek

What are your planned use cases for the SunPeek software? *

- [ ] Early Adopter
- [ ] User
- [ ] Developer
- [ ] Sonstiges:

Please send me updates on the following *

- [ ] Q&A session for early adopters (Aug/Sept 2023)
- [ ] Updates on new SunPeek releases and features (regularly)
- [ ] Please contact me individually by email
- [ ] Sonstiges:

Please add optional comments here.

Meine Antwort

Please leave your email address here to get in touch. *

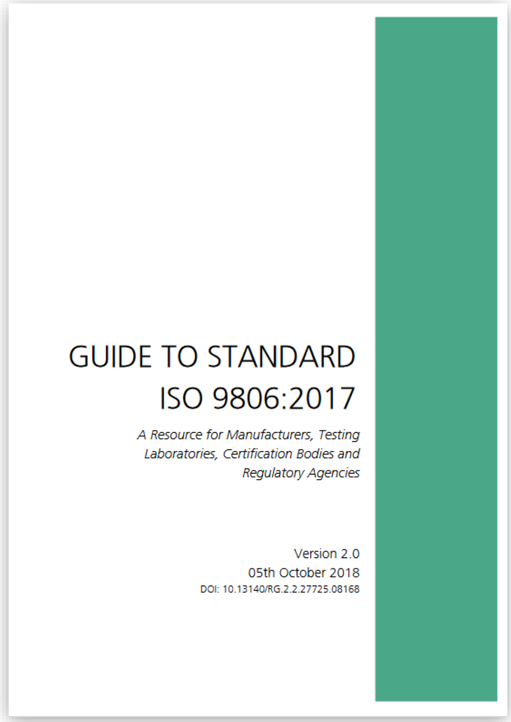
Meine Antwort

Discussion for joint work within IEA SHC Task 68

- Collect **experiences / improvements** from application of ISO 24194:2022 and formulate joint recommendation of IEA SHC Task 68 experts to ISO/TC 180/SC 4

- Create a **short guide to ISO 24194:2022** for practioners (similar to „Guide to standard ISO 9806:2017“, but much shorter)

- Create a handbook on **„Digital Tools for Solar Thermal Plant Monitoring”** (upcoming project at AEE INTEC)



Thank you for your attention!

Links

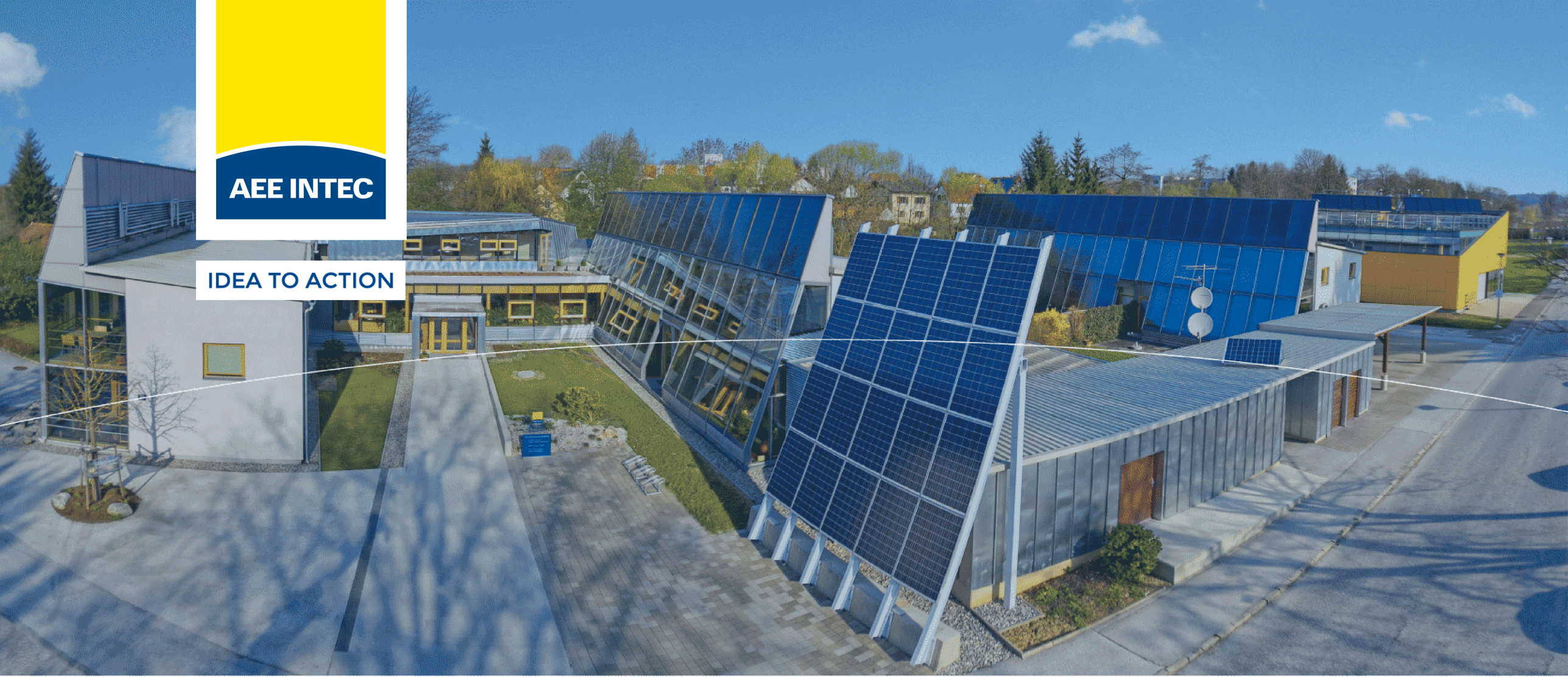
- Project Website: https://www.collector-array-test.org
- GitLab Repository SunPeek: https://gitlab.com/sunpeek/
- Zenodo Dataset: https://doi.org/10.5281/zenodo.7741084

Publications

- 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 48, 109224, https://doi.org/10.1016/j.dib.2023.109224
- 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



AEE – Institute for Sustainable Technologies (AEE INTEC)
8200 Gleisdorf, Feldgasse 19, Austria

Website: www.aee-intec.at
Twitter: @AEE_INTEC

Daniel Tschopp
d.tschopp@aee.at
+43 (0)3112 5886

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