AEE INTEC

SOLID solar energy systems

SunPeek & ISO 24194

Open-Source Software for Large Solar Thermal Plants: Monitoring and Guarantees

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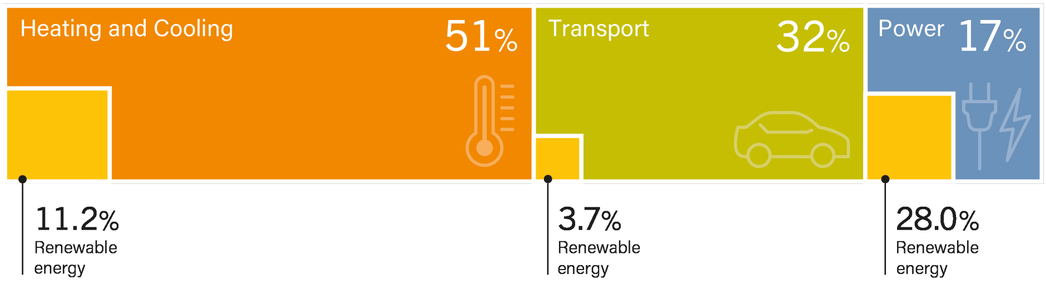
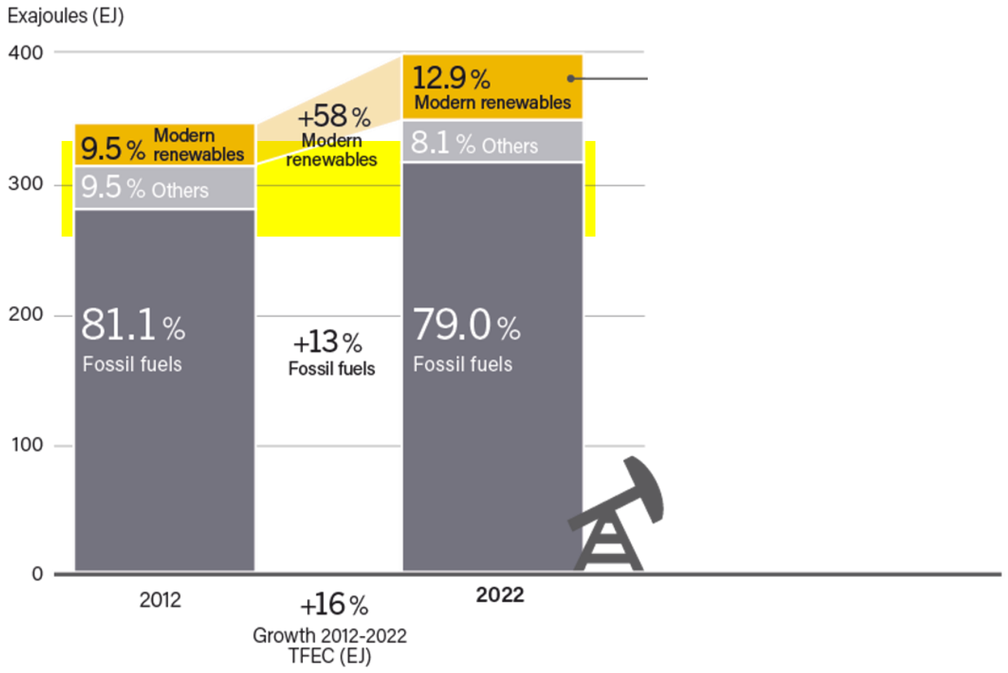
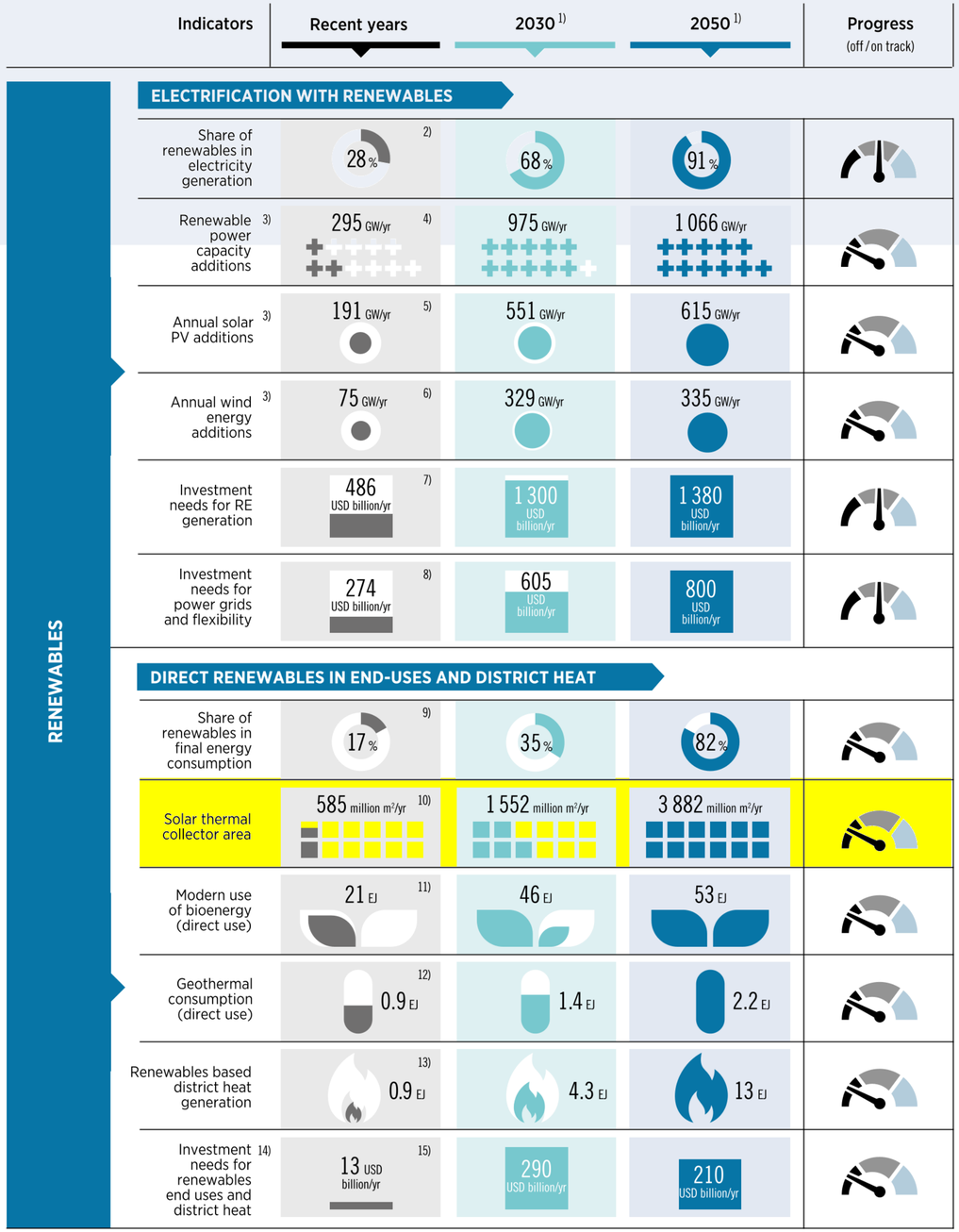
Motivation





Source: REN21 Renewables 2024 GSR

Source: REN21 Renewables 2023 GSR



Source: **IRENA** World Energy Transitions Outlook 2022

How to Decarbonize?

Friesach,
Source: Solar Engineering Guggenberger

Fernheizwerk Graz (FHW)
Source: Picfly.at Thomas Eberhard

Högslätten Härnösand
Source: Absolicon

St. Ruprecht an der Raab,
Source: Gasokol GmbH

Fernwärme Ettenheim
Source: Peter Blaser

Stadtwerke Greifswald
Source: Ritter XL Solar

Challenges Monitoring Solar thermal plants

Plant Design
Manufacturing

Operation
Commissioning, Production

ISO 9806
EN 12975
EN 12976

ISO 24194 **Power Check** & more

20-30 years

SunPeek

ISO 24194:2022 “Check of Performance”

- New ISO standard for assessing performance of solar thermal collector fields / plants.
  - ✓ **In-situ**, for plants in operation!
  - ✓ Refers to ISO 9806 (single collector lab tests)
  - ✓ Refers to ISO 9060 (instruments for solar radiation)
  - ✓ Refers to ISO 9488 (solar vocabulary)

- Defines **2 methods** on paper:
  - ✓ *Power Check*
  - ✓ Daily Yield Check
- Applicable **Collector types**:
  - ✓ Glazed flat plate collectors
  - ✓ Evacuated tube collectors
  - ✓ Tracking, concentrating collectors

Solar energy — Collector fields — Check of performance

(ISO 24194:2022)

Sonnenenergie — Kollektorfelder — Überprüfung der Leistungsfähigkeit
(ISO 24194:2022)

Energie solaire — Champs de capteurs — Vérification de la performance
(ISO 24194:2022)

Life cycle

Now

Published
ISO 24194:2022
Stage: **60.60**

Corrigenda / Amendments

Under development
ISO 24194:2022/Amd 1

General information

Status : Published
Publication date : 2022-05
Stage : International Standard published [60.60]

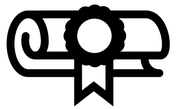
Edition : 1
Number of pages : 30

Technical Committee : ISO/TC 180/SC 4
ICS : 27.160

Usage & Application

of SunPeek & ISO 24194 Power Check

- **Answers** the fuzzy question:
  - „How well is a solar thermal plant working?“ → „How well should it work?“
- Standardized performance. **Corrects for main influence factors.**
  - *Factors out:* Weather, temperatures, collectors used, location, field design etc.
  - *Quantitative:* Percentage “ratio measured vs. estimated output”
  - *Comparable:* Performance becomes *comparable* among plants & over time.

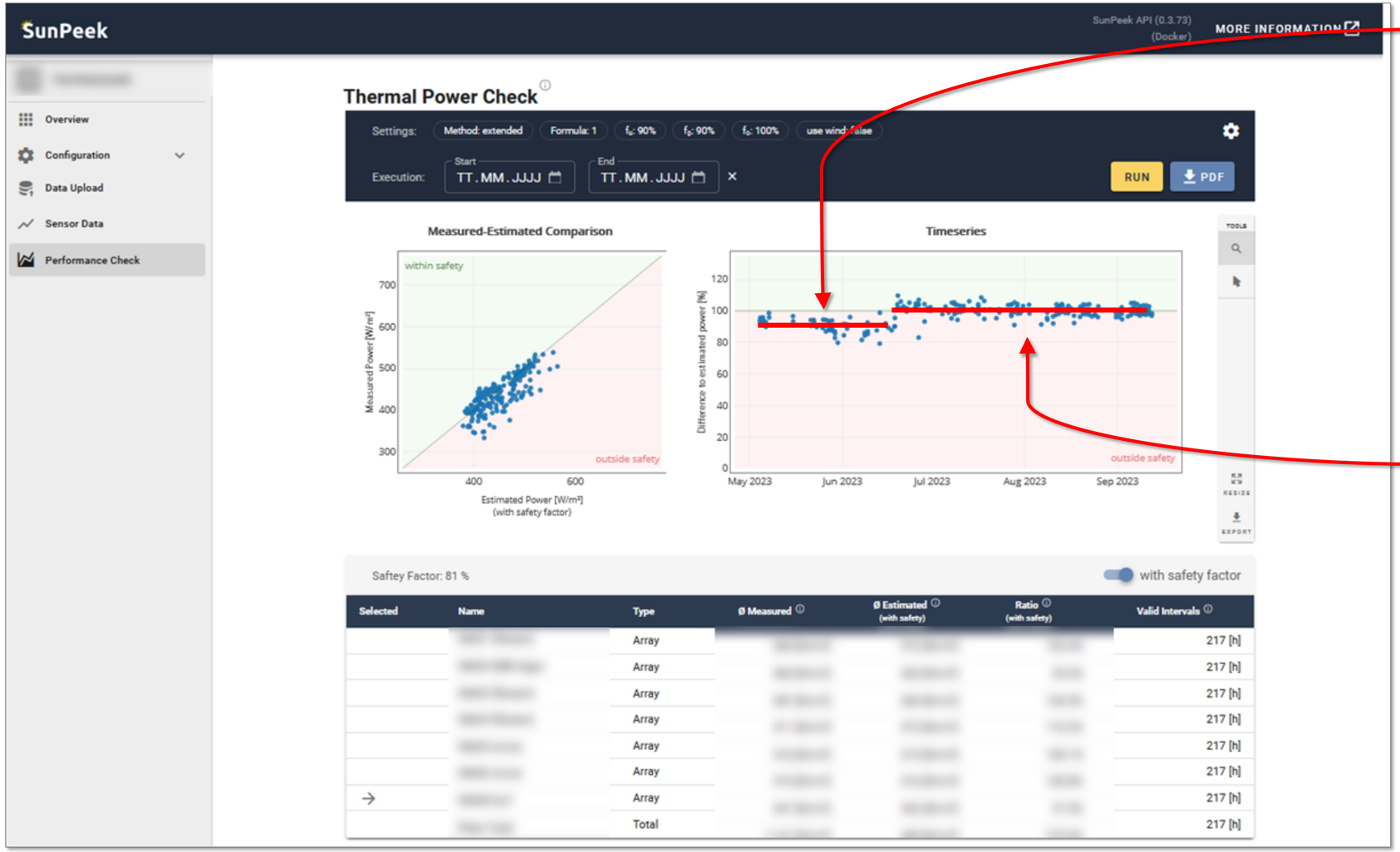


- Usage1: **Guarantee Procedure** (plant commissioning etc.)
  - Question: "Does the plant meet some guaranteed performance?“

- Usage 2: **Performance Monitoring** (operating phase, ongoing)
  - Question: How to Detect performance degradation / plant problems+ Act predictively

SunPeek Example 1: Ongoing Monitoring

Before / After Cleaning Collectors



Before cleaning

After cleaning

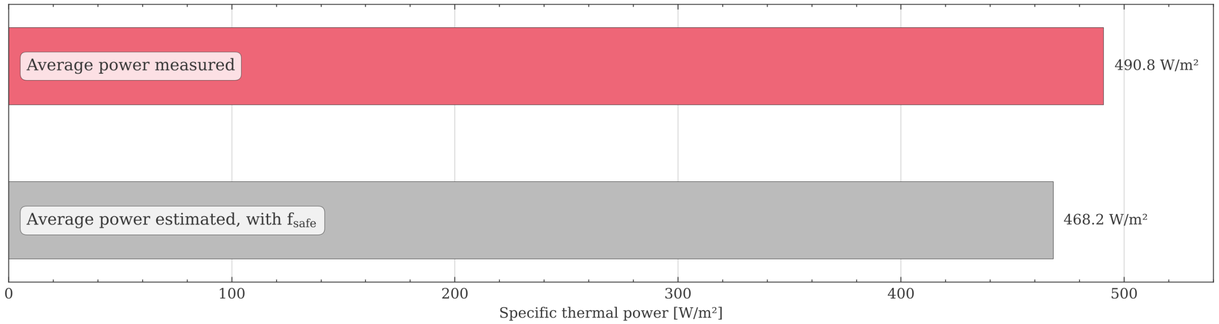
SunPeek Example 2: Power Guarantees

Measured vs. Estimated Power

Power Check according to ISO 24194:2022

Power Check fulfilled:

Ratio measured / estimated power = 104.8%
This takes a combined safety factor $f_{safe} = 0.9$ into account.
The minimum number of intervals (20, defined in ISO 24194:2022) has been reached: n=64 intervals found, each 1 hour long.



Notes

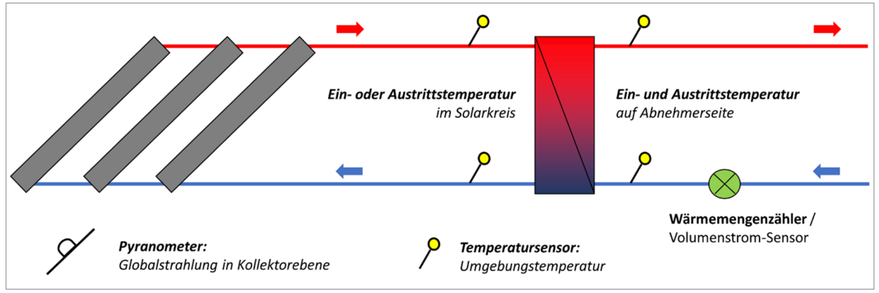
Plant name: "FHW Arcon South _Test_".
Included arrays: "Arcon South".
Data from 2017-05-01 00:00 (UTC+1) to 2017-05-31 23:59 (UTC+1).

Power Check according to ISO 24194:2022
Algorithm details: Formula: 2. Wind: Used. Averaging mode: Extended.

How to Calculate the Estimated Power

ISO 24194 Power Check

1 Different Measurement Data



2 Data selection / filtering

Operation condition	Limits			Comments
	Formula (1)	Formula (2)	Formula (3)	
Shadows	No shadows			See 5.5
Change in collector mean temperature	≤5 K			To avoid big change in collector temperature during one hour
Ambient temperature	≥5 °C			To avoid snow, ice, condensation on solar radiation sensors
Wind velocity	≤10 m/s			To be measured so it is representative for the wind velocity 1 m to 3 m above highest point of collectors
G_{hem}	≥800 W/m²	-	-	
G_b	-	≥600 W/m²	≥600 W/m²	

3 1-Hour Averages

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

4 3 Formulae: Non-concentrating, low-, high-concentrating collectors

$$\dot{Q}_{estimate} = A_{GF} \cdot \left[\eta_{0,hem} K_{hem}(\theta_L, \theta_T) G_{hem} - a_{1,\Delta Q}(\vartheta_m - \vartheta_a) - T_{\Delta Q}(\vartheta_m - \vartheta_a)^2 - a_5(d\vartheta_m / dt)\right] \cdot f_{safe}$$

$$\dot{Q}_{estimate} = A_{GF} \cdot \left[\eta_{0,b} K_b(\theta_L, \theta_T) G_b + \eta_{0,b} K_d G_d - a_{1,\Delta Q}(\vartheta_m - \vartheta_a) - T_{\Delta Q}(\vartheta_m - \vartheta_a)^2 - a_5(d\vartheta_m / dt)\right] \cdot f_{safe}$$

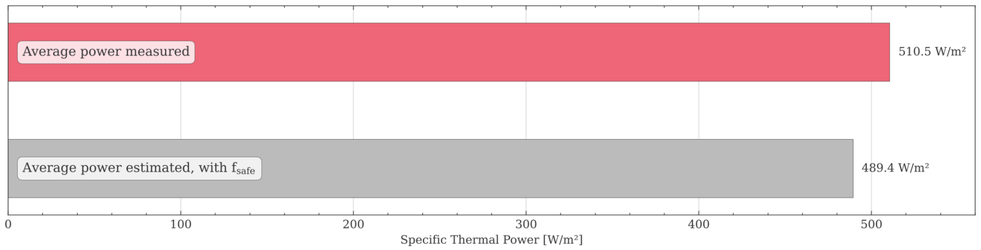
$$\dot{Q}_{estimate} = A_{GF} \cdot \left[\eta_{0,b} K_b(\theta_L, \theta_T) G_b - a_{1,\Delta Q}(\vartheta_m - \vartheta_a) - a_5(d\vartheta_m / dt) - a_8(\vartheta_m - \vartheta_a)^4\right] \cdot f_{safe}$$

5 "Safety Factor"

f_{safe} Combined safety factor

$$f_{safe} = f_P \cdot f_U \cdot f_O$$

6 Target – Actual Comparison



SunPeek pdf Report
of ISO 24194 Power Check

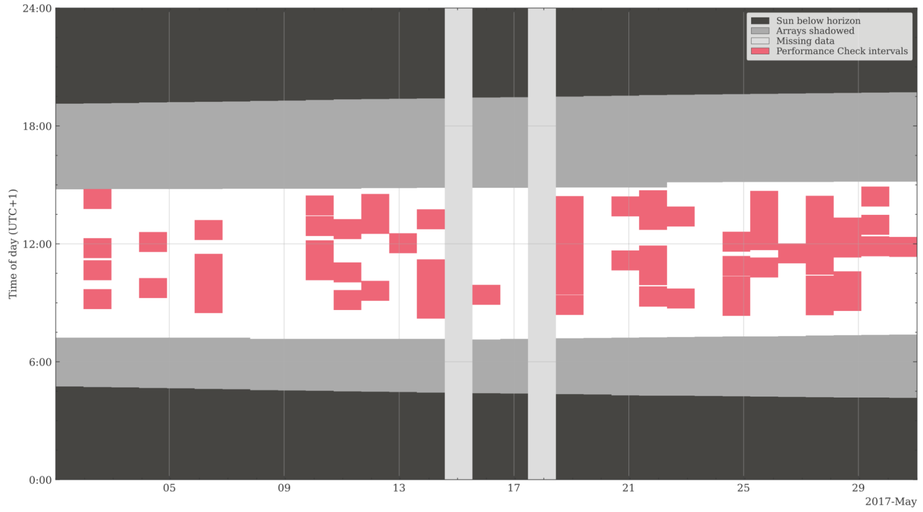
Power Check according to ISO 24194:2022

Power Check fulfilled:

Ratio measured / estimated power = 104.8%
This takes a combined safety factor $f_{safe} = 0.9$ into account.
The minimum number of intervals (20, defined in ISO 24194:2022) has been reached: n=64 intervals found, each 1 hour long.

Intervals used for Power Check

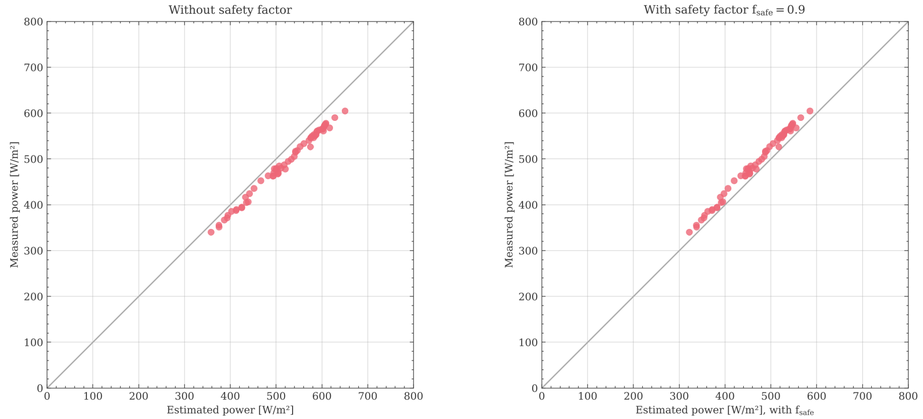
n=64 intervals, each 1 hour long. Total interval duration: 64 hours 0 minutes.
Algorithm details: Formula: 2. Wind: Used. Averaging mode: Extended.



Power Check according to ISO 24194:2022

Thermal Power Output: Measured vs. Estimated

Plant FHW Arcon South _Test_
Included arrays Arcon South

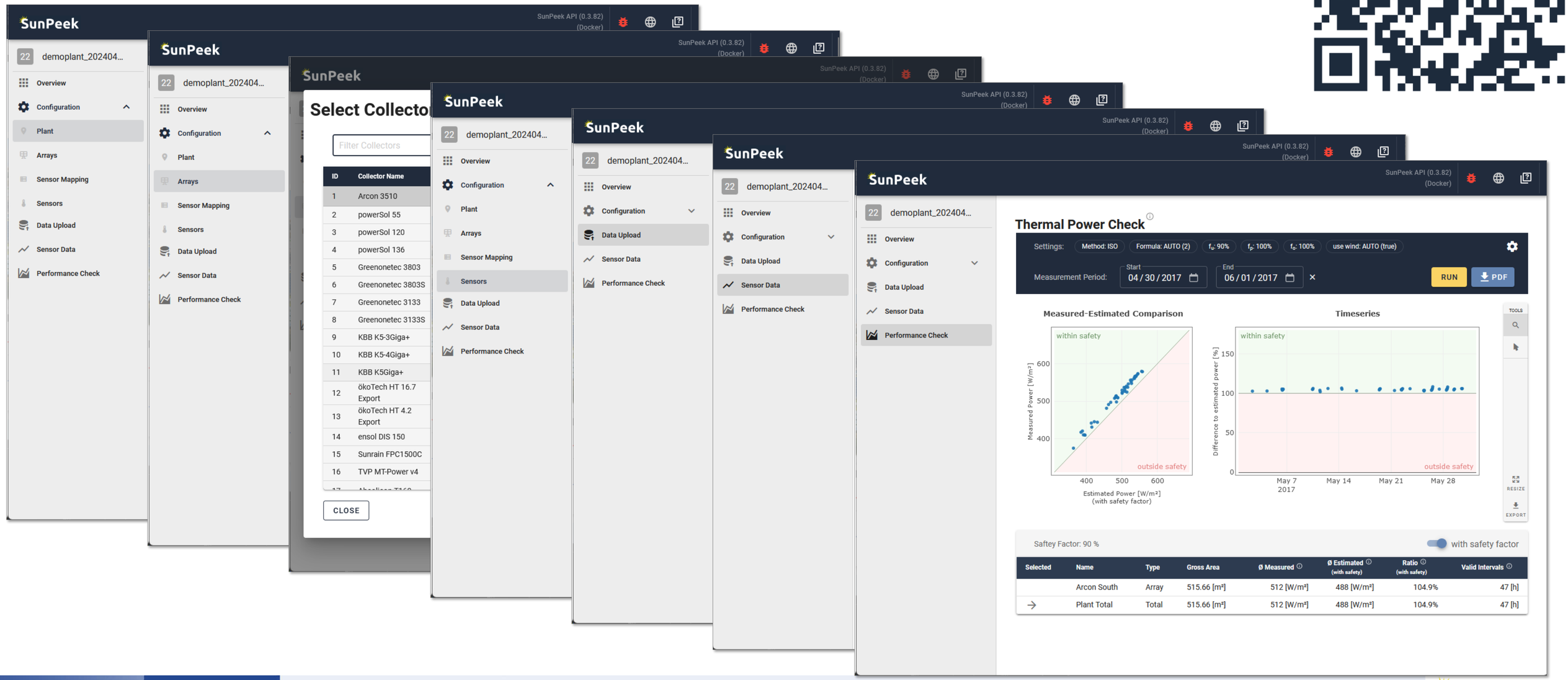


Notes

Each dot in the plots is the average thermal power output of a 1 hour interval.
The left plot is based on estimated and measured data without safety factor. The right plot takes the combined safety factor $f_{safe} = 0.9$ into account.
Algorithm details: Formula: 2. Wind: Used. Averaging mode: Extended.

SunPeek GUI, Graphical User Interface

https://demo.sunpeek.org



SunPeek: Practical Extensions
of ISO 24194:2022 Power Check

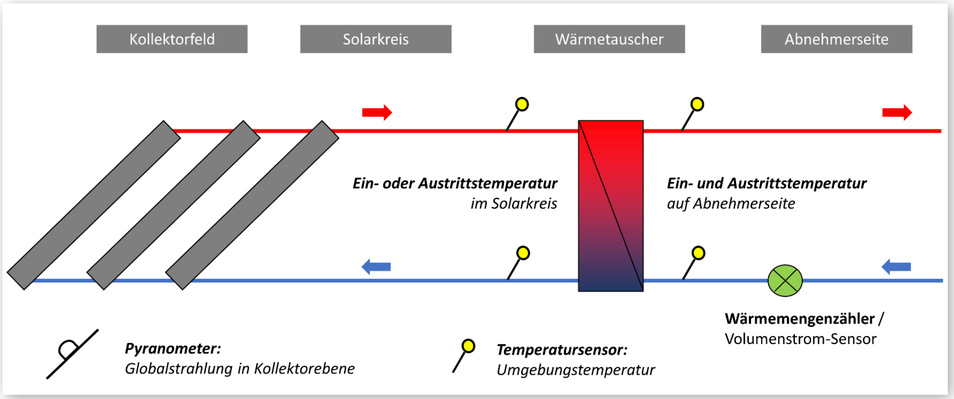
1) More than 1 collector field / array
- ✓ Data treatment & estimated power per array

2) Mixed collectors
- ✓ E.g. single & double glazed, flat-plate & concentrating
- ✓ Differences in collector data sheets (SST/QDT, IAM,…)

3) Non-standardized measurements
- ✓ E.g. Heat transfer fluid properties, database

4) Nasty data
- ✓ Auto-treat data formats, valid data, time zones, …

5) Extended filtering method
- ✓ More modern data analysis
- ✓ Faster results, more partial loads



SunPeek: Platform

Open-source, web-based software

- *Designed as Reference Implementation of ISO 24194, and more.*
- **Objective:** Simplify operation of solar thermal plants → **Reduce LCOH**
- **Features:** Transparency, Automation, High quality implementation

Platform / Development Hub

- *Governed by community / Research, Industry, Associations.*
- **Objective:** Discuss & **Extend** methods & implementations where necessary.
- **Objective:** Efficient development, exchange with **TC 180 / ISO 24194**

Contributors are Welcome.

- *First developed by AEE INTEC, SOLID, GASOKOL, Schneid.*
- **Objective: Participation**
- **How?** Project Governance Basics (“How to be SunPeek?”) are defined.

SunPeek: Software & Licenses

https://demo.sunpeek.org/

web UI

Graphical user interface.
Interactive use in browser.

web API

Restful API. Automate
with other software tools.

Python package

Algorithm development.
Integrate with other projects.

Docker

Standardized distribution
and installation.

BSD-3 Clause

- „Permissive“, virtually no restrictions
- Used in similar open-source projects (e.g. pvlib).
- Simplifies integration with own software.

Summary

- ✓ SunPeek is **free** to use, also **commercially**, free to modify and distribute.
- ✓ **Open Data is optional**. No need to share measurement data!

Backend: LGPL (GNU General Public License)

- „Weakly Protective“
- Must release changes under same license.
- Ensures *consistent implementation* of ISO 24194.

SunPeek: Planned Features

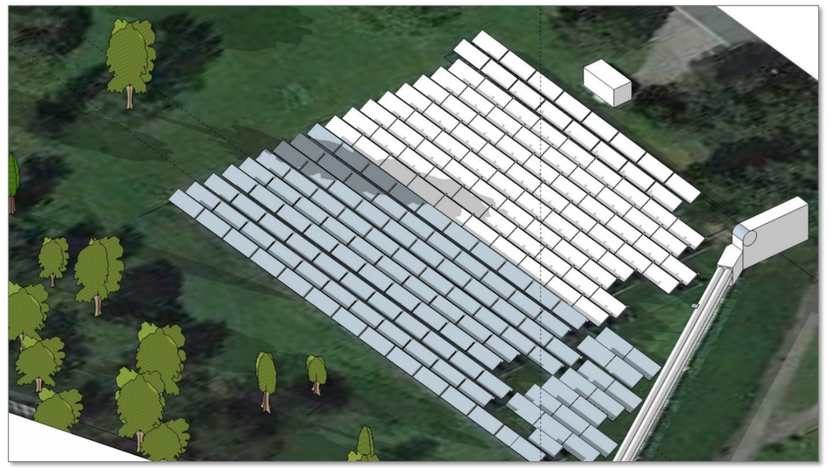
1) Link to Solar Keymark Database

- Predefined Collectors

2) More Automation

3) Radiation modelling

- Correction of diffuse radiation masking for fair assessment
- Multiple collector arrays with different orientation
- Tracking collectors
- ✓ Internal Shading (done)



Feedback to ISO

- Inputs to ISO 24194 via TC 180 / SC4

Who is SunPeek?

Steering Committee Maintainers





Initiators

AEE INTEC

SOLID solar energy systems

GASOKOL Solar. Seit 1981.

SCHNEID

Funding

klima+ energie fonds

acr

Community, Users & Enablers

Fraunhofer ISE

GitLab

DLR Deutsches Zentrum für Luft- und Raumfahrt

LESAT

ISFH

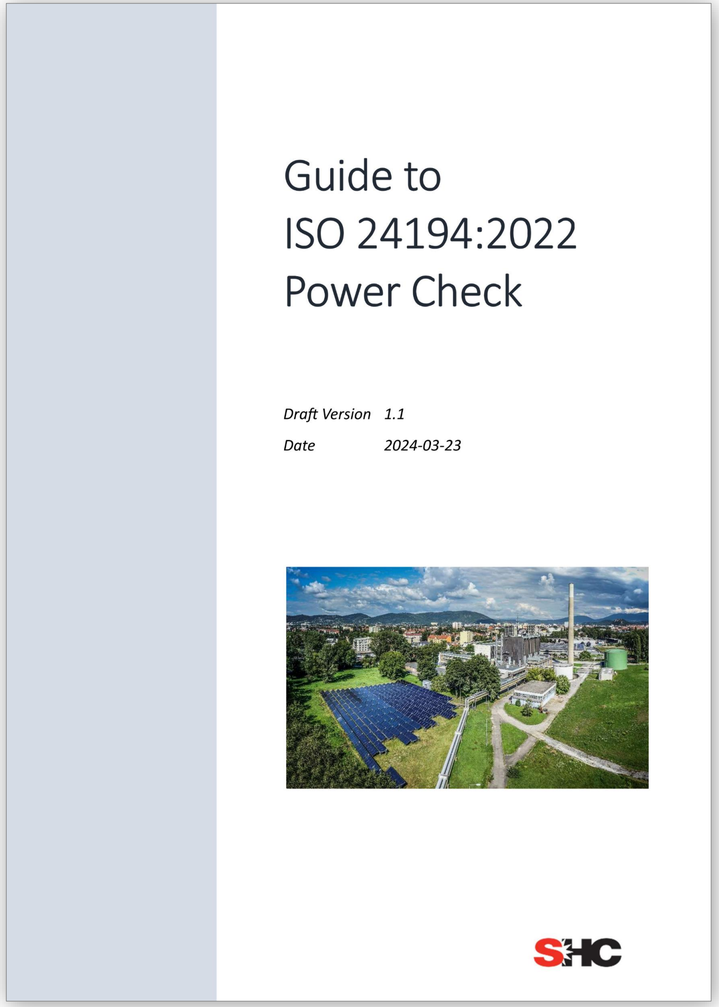
SolarEngineering GUGGENBERGER

nahwärme ST. RUPRECHT

Technische Hochschule Ingolstadt

“Task 68 Guide” t

to ISO 24194 Power Check



Cooperation from „SHC Task 68“

Efficient Solar District Heating Systems

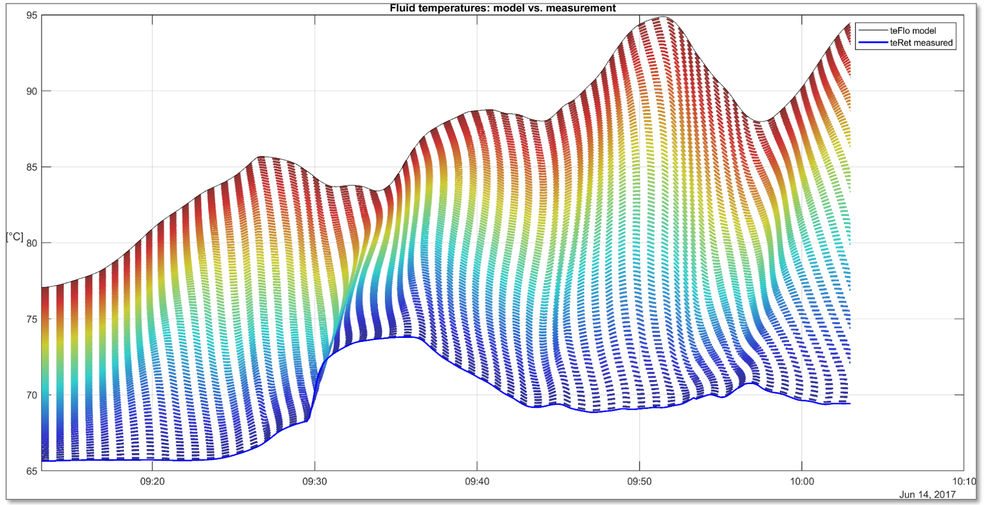
- **Task 68 Deliverable**
- **Practical application** of ISO 24194 underpins need for clarification, background information and some practical amendments / tweaks.
- **SunPeek software:** ISO 24194 Reference implementation. Automated & transparent Power Check.
- **Target groups:** Plant operators, Plant designers, Collector manufacturers, Researchers.

Inputs from industry & research welcome!

Contact us if interested!

AEE INTEC

SunPeek



Open-Source Software for Optimized Operation of Large Solar Thermal Plants.

APPLIED CPS

Open-Source Scientific Development Platform

SunPeek Information

https://www.sunpeek.org

✓	**Support**	support@sunpeek.org
✓	**Software Repository**	https://gitlab.com/sunpeek/
✓	**Public Demo**	https://demo.sunpeek.org/

✓	**Open Dataset**	https://doi.org/10.5281/zenodo.7741083
✓	**Data-in-Brief Article**	https://doi.org/10.1016/j.dib.2023.109224
✓	**Zenodo Community**	https://zenodo.org/communities/sunpeek

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