

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Guide to ISO 24194:2022

Lukas Feierl (SOLID)

Stefan Mehnert (Fraunhofer ISE)

Daniel Tschopp (AEE INTEC)

Philip Ohnewein (AEE INTEC)

4th IEA SHC Task 68 Expert Meeting, 2023-10-10

Guide to ISO 24194:2022

- Joint work by „IEA SHC Task 68 Working Group“
- Seeking more T68 experts to elaborate and improve this document!



Table of Content	
About this guide	4
A. Power Check ISO 24194:2022	5
A.1 Overview	5
A.2 Scope	6
A.3 Stating an estimate for the thermal power output of a collector field	6
A.4 Calculating power output	6
A.5 Stating a performance estimate	9
A.6 Restrictions on operating conditions	10
A.7 Shading	11
A.8 Checking collector field power performance	12
A.9 Measurement needed	12
A.10 Extension to multiple arrays	18
B. Demo application with Open Source software SunPeek	22
B.1 About SunPeek	22
B.2 Overview	22
B.3 Demo plant	24
B.4 Plant configuration	24
B.5 Data handling	24
B.6 Sample results	25
B.7 Extended Power Check Method	25
C. Appendix	26
C.1 Classification of system configurations	26
C.2 List of abbreviations	28
C.3 List of symbols	28
C.4 List of figures	28
C.5 List of tables	28
D. References	29

About ISO 24194:2022

- New standard for **performance check of solar thermal collector fields**, first edition in **2022-05**
- Previous versions of the method were developed in Denmark 10-20 years ago and used for **guarantee procedures** for SDH plants
- Further development within **IEA SHC Task 45** and **IEA SHC Task 55** (Fact sheets: [45.A.3.1](#); [45.A.3.1](#); [B-D2](#); [B-D1.1](#))
- **DRAFT ISO/DIS 24194** Solar energy Collector fields — Check of performance (2020 / 2021)

INTERNATIONAL
STANDARD

ISO
24194

First edition
2022-05

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

*Energie solaire — Champs de capteurs — Vérification de la
performance*

Main methods ISO 24194:2022

Contents	Page
Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Symbols	1
5 Procedure for checking the power performance of solar thermal collector fields	5
5.1 Stating an estimate for the thermal power output of a collector field	5
5.2 Calculating power output	5
5.2.1 General	5
5.2.2 Non-concentrating collectors — Formula (1)	6
5.2.3 Non- or low-focussing collectors — Formula (2)	7
5.2.4 Focussing collectors with high concentration ratio — Formula (3)	7
5.3 Stating a performance estimate	7
5.4 Restrictions on operating conditions	7
5.5 Shadows	8
5.5.1 Shadows on fixed collectors in rows	8
5.5.2 Shadows on one-axis tracking collectors in row	9
5.6 Collector incidence angle	11
5.7 Example of setting up an equation for calculating performance estimate	11
5.8 Determination of potential valid periods	12
5.9 Checking collector field power performance	12
6 Procedure for checking the daily yield of solar thermal collector fields	14
6.1 Stating an estimate for the daily yield of a collector field	14
6.2 Calculating daily energy yield	14
6.2.1 General	14
6.2.2 Non-tracking and non-concentrating collectors — Formula (20)	15
6.3 Stating a performance estimate	15
6.4 Restrictions on operating conditions	16
6.5 Shadows	16
6.6 Collector incidence angle	16
6.7 Example of setting up an equation for calculating performance estimate	16
6.8 Determination of potential valid periods	17
6.9 Checking collector field daily yield performance	18
7 Measurements needed	18
7.1 General	18
7.2 Requirements on measurements and sensors	20
7.2.1 Accuracy	20
7.2.2 Time	21
7.2.3 Solar radiation measurement	22
7.2.4 Temperature measurements	23
7.2.5 Flow rate measurement	24
7.2.6 Power measurement/calculation	24
7.2.7 Measurement of wind speed	24
7.3 Valid data records	24
Annex A (informative) Recommended reporting format — Power method	26
Annex B (informative) Recommended reporting format — Daily yield method	29
Bibliography	30



Procedure for checking the **power performance** of solar thermal collector fields (Power Method)



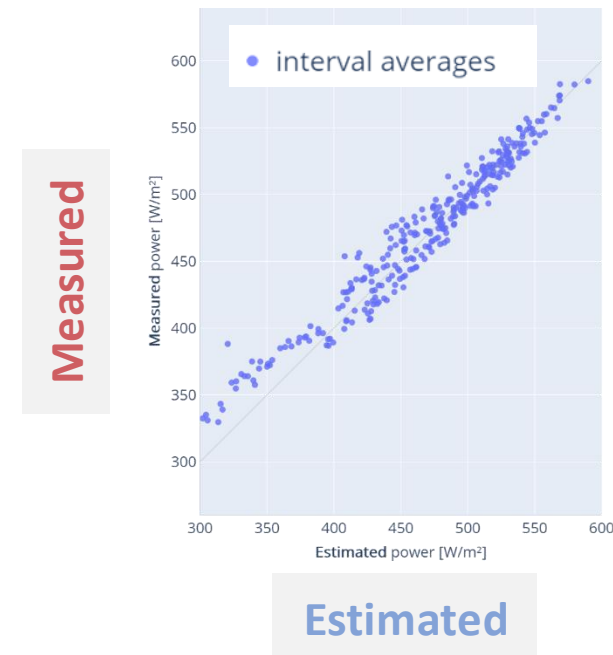
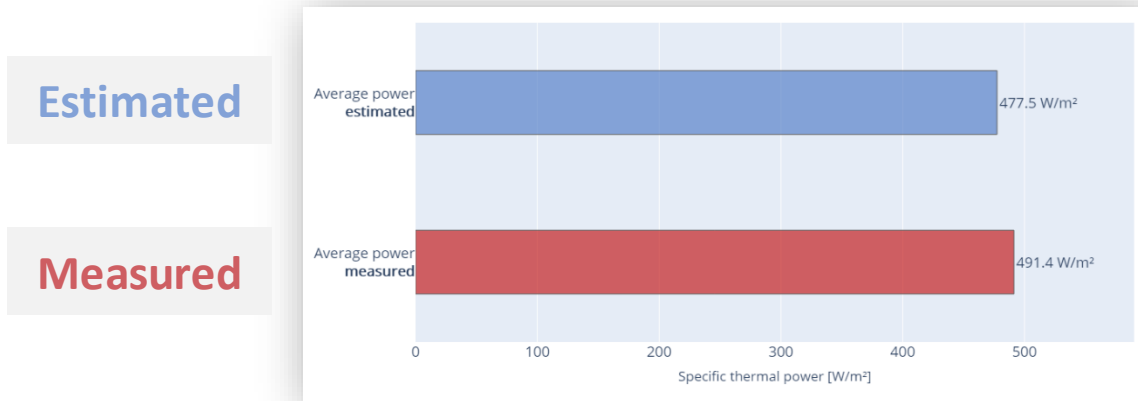
Procedure for checking the **daily yield** of solar thermal collector fields (Daily Yield Method)



Measurements needed

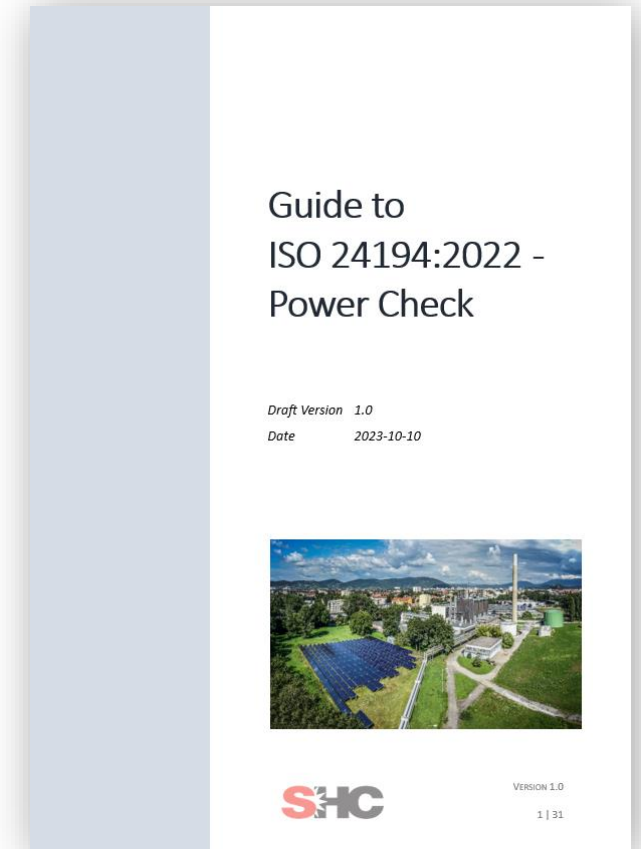
Power Method / Power Check

- **Measured/Estimated comparison** for thermal power output
- Conditions close to **full power operation** (high irradiance levels, minor change in collector mean temperature, no shadows), based on **1 hour intervals**
- Power output is calculated using **ISO 9806 collector parameter**



Motivation

- ISO 24194 is the first standard of its kind by targeting **solar thermal collector fields**
- **Practical application** shows need for **clarification**, further **improvements**, and additional **background information** for users
- **Additional use cases** require some adaptations (from guarantee procedure to on-going plant surveillance)
- Inspired by „Guide to Standard ISO 9806:2017“



Aims

- Make ISO 24194 more **accessible** and foster **widespread** use in the solar community
- Summarize **learnings** and **experiences** from T68 experts
- Outline software implementation / automated application with **SunPeek**
- Main target group: **plant operators**



Content of the Guide

Table of Content

About this guide	4
A. Power Check ISO 24194:2022	5
A.1 Overview	5
A.2 Scope	6
A.3 Stating an estimate for the thermal power output of a collector field	6
A.4 Calculating power output	6
A.5 Stating a performance estimate	9
A.6 Restrictions on operating conditions	10
A.7 Shading	11
A.8 Checking collector field power performance	12
A.9 Measurement needed	12
A.10 Extension to multiple arrays	18
B. Demo application with Open Source software SunPeek	22
B.1 About SunPeek	22
B.2 Overview	22
B.3 Demo plant	24
B.4 Plant configuration	24
B.5 Data handling	24
B.6 Sample results	25
B.7 Extended Power Check Method	25
C. Appendix	26
C.1 Classification of system configurations	26
C.2 List of abbreviations	28
C.3 List of symbols	28
C.4 List of figures	28
C.5 List of tables	28
D. References	29



Power Check ISO 24194:2022

- Summary
- Remarks and recommendations

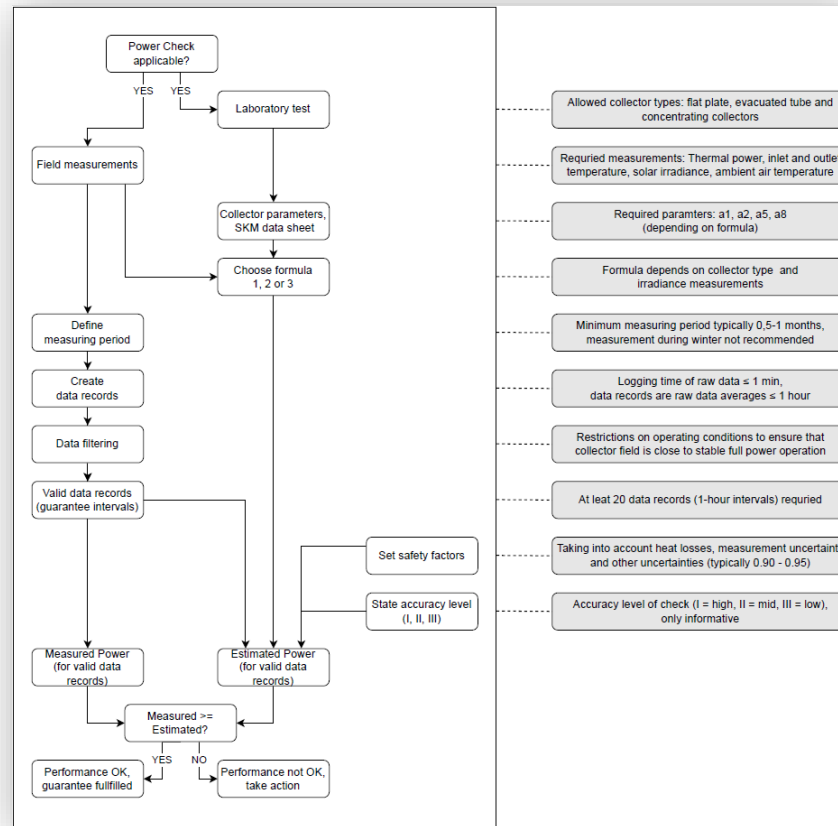


Demo application with Open Source software

Limited to Power Method / Power Check.
Daily Yield Method not covered (TBD)

Example (1) – Summary

Overview



Accuracy Levels

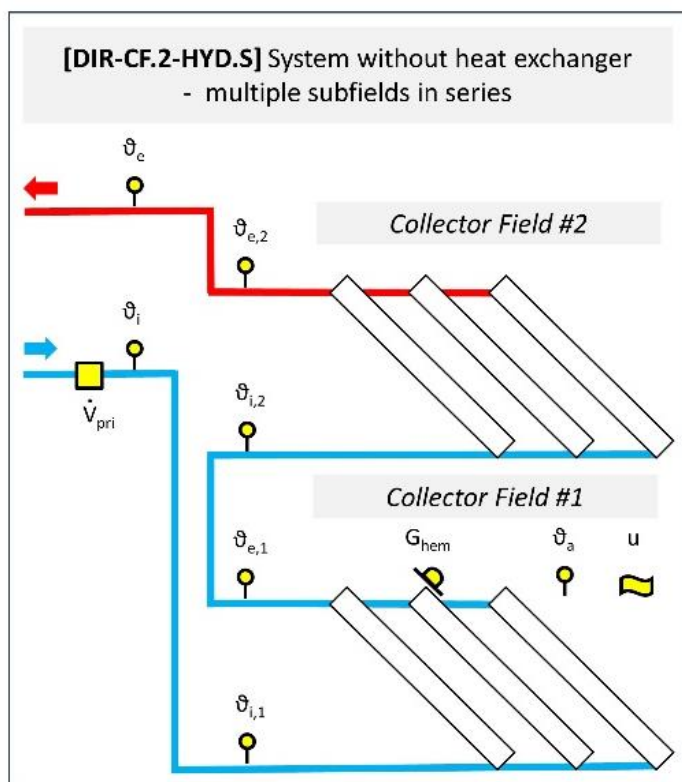
Table 9: Sensor specifications and measurement uncertainties for accuracy level I-III.

Measured quantity	Level I	Level II	Level III	ISO 24194:2022
Global irradiance	Pyranometer Class 2 or better (ISO 9060, recommendations of ISO/TR 9901)	Sensors with accuracy $\pm 5\%$ in the range 600 W/m ² - 1000 W/m ²	Sensors with accuracy $\pm 5\%$ in the range 600 W/m ² - 1000 W/m ²	7.2.3.2
Beam / DNI and diffuse irradiance	Pyranometer for G _{hem} plus either Pyranometer Class 1 or better with shading ring for G _d or Pyrsheliometer for G _b	Not defined	Not defined	7.2.3.2
DNI	Pyrheliometer Class 2 or better (ISO 9060) for highly concentrating, tracking collectors (C _k > 3); field of vision $\leq 6^\circ$; tracking errors $\leq \pm 1^\circ$			7.2.3.1
Fluid temperature		<0,35 K (Class A)		7.2.4.2
Ambient air temperature		<0,35 K (Class A)		7.2.4.3
Volume flow rate	< 1 %	standard uncertainty in relevant range < 2 %	< 2 %	7.2.5
Power (measured or calculated)	< 2 %	standard uncertainty in relevant range < 3 %	< 3 %	7.2.6
Wind speed			< 1 m/s	7.2.7

[1] ISO 24194:2022, Chapter 7.2.3.2, says that satellite data can be used for Level II/III, but 7.2.3.3 and 7.2.3.4 only mention satellite data in connection with Level III. The latter seems to follow the intention of the standard, as all other criteria regarding solar sensors are the same for Level II and III.

Example (2) - Remarks / Recommendations

Extension to multiple collector fields

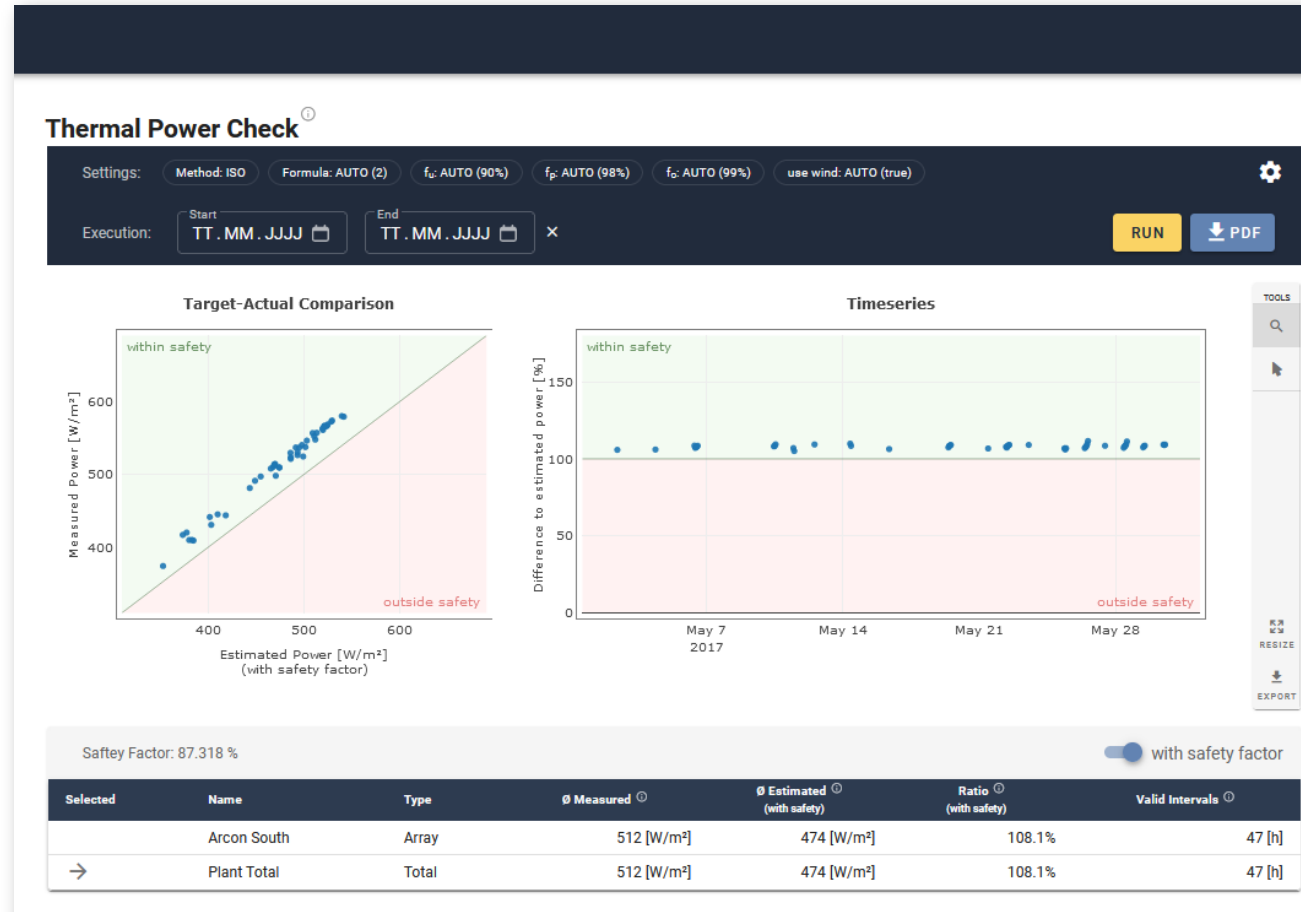


Parameter conversion

Table 3: Parameter conversion for QDT (Quasi-dynamic) and SST (Steady state) tests.

Collector test	Source
QDT (Quasi-dynamic test) Given parameter: $\eta_{0,b}, K_b, K_d$ Derived parameter: $\eta_{0,hem}, K_{hem}$	
$\eta_{0,hem} = \eta_{0,b}(0.85 + 0.15 K_d)$	ISO 9806:2017 Annex B, Formula (B.2), (B.5)
$K_{hem}(\theta_L, \theta_T) = \frac{\eta_{0,b}}{\eta_{0,hem}}(0.85 K_b(\theta_L, \theta_T) + 0.15 K_d)$	Derived from ISO 9806:2017 Annex B Formula (B.2), (B.5)
SST (Steady-state test) Given parameter: $\eta_{0,hem}, K_{hem}$ Derived parameter: $K_b, K_d, \eta_{0,b}$	
$K_b(\theta_L, \theta_T) = K_{hem}(\theta_L, \theta_T)$	ISO 9806:2017 Annex B, Formula (B.1)
$K_d = \frac{1}{W} \sum_{\theta, \gamma=0^\circ}^{90^\circ} K_b(\theta, \gamma) \sin(\theta) \cos(\gamma)$ $W = \sum_{\theta, \gamma=0^\circ; steps=10^\circ}^{90^\circ} \sin(\theta) \cos(\gamma)$	ISO 9806:2017 Annex B, Formula (B.3), (B.4)
$\eta_{0,b} = \frac{\eta_{0,hem}}{0.85 + 0.15 K_d}$	ISO 9806:2017 Annex B (B.5)

Demo application SunPeek



Status Quo & Next Steps

Join at [menti.com](https://www.menti.com) use code **3648 9439**

- **Status quo:** Draft version for Part A. „Power Check ISO 24194:2022” available, including discussion how to apply method to multiple arrays
- **Next Steps**
 - Discussion / MentiMeter Survey (**today!**)
 - Seeking **T68 experts** for further elaboration / review / use cases – coordination by Daniel Tschopp (d.tschopp@aee.at)
- **Timeline**
 - First draft: **2023-10-31**
 - Review: **2023-11-30**
 - Final version: **2023-12-22**

Guide to ISO 24194:2022 - Power Check

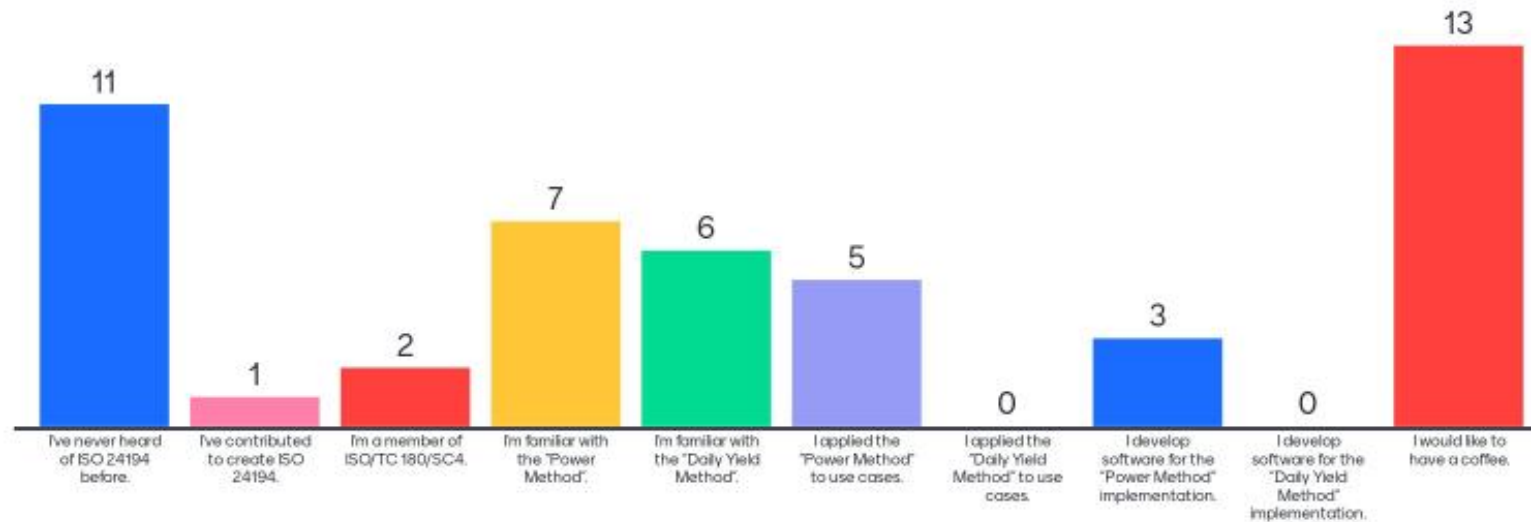
Draft Version 1.0
Date 2023-10-10



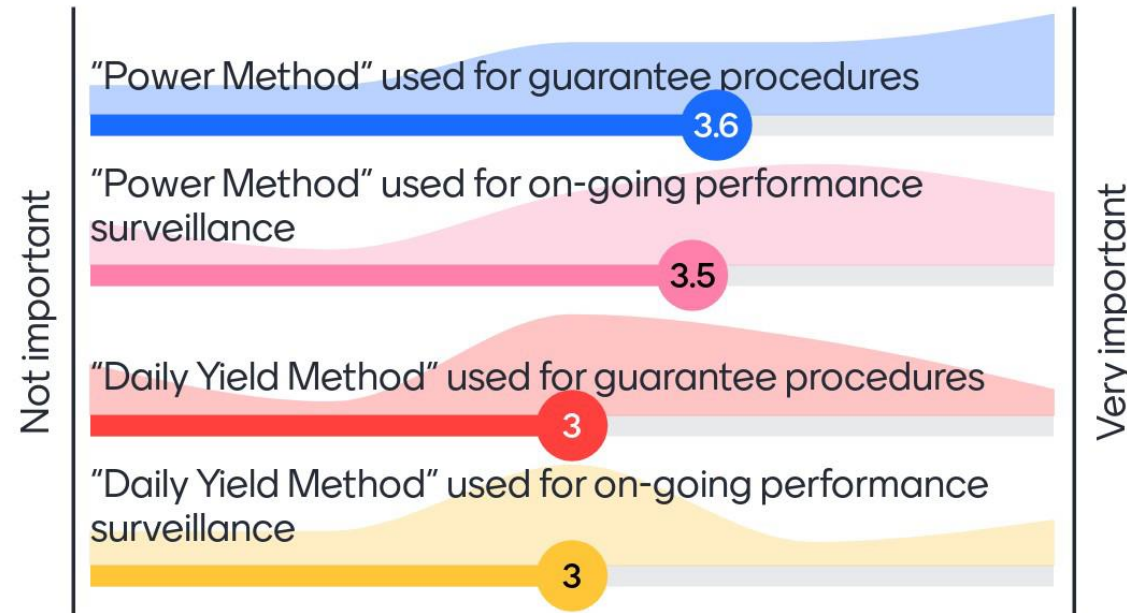
SHC

VERSION 1.0
1 | 31

Please indicate how familiar you are with ISO 24194 (Performance Check for Solar Collector Fields).



Which importance do you assign the "Power Method" and "Daily Yield Method"?




Questions?



www.iea-shc.org

 @IEASHC

 IEA Solar Heating and Cooling Programme
(group 4230381)