CSP METROLOGY TOOL LIST BASED ON NREL SCOPING STUDY

Version 1.1, 2025 (this list is intended to be comprehensive, but if anything is missing, contact HelioCon)

Tool	Supplier	Claimed Accuracy	Application	Status
Solar Irradiance and Sun Shape				
Rotating Shadowband Irradiometer (RSI) Based Measurement System	CSP Services GmbH	< 3 %	Sun shape measurement and global solar irradiance (GSI)	Commercially available
Solar Circumsolar radiation camera (CSR)	Fraunhofer ISE	unknown	Sun shape measurement	Under development
Sun Tracker + CHP Pyrheliometer	Kipp & Zonen	< 0.2 %	Direct Solar Irradiance (DNI)	Commercially available
Pyranometer			Global Solar Irradiance (GSI)	Commercially available
Atmospheric Attenuation				
Vaisala FD70 Scatterometer	Vaisala	< 0.05 %	Atmospheric attenuation, aerosol and particle count and sizing, visibility	Commercially available
Long-path transmissometer LPV4	Optec	5 %	Atmospheric attenuation, visibility	Commercially available
ATMOS	ZEPREN Solutions	1 %	Atmospheric attenuation	Commercially available
BCB solar attenuation measurement system	CIEMAT	2 %	Atmospheric attenuation	Under development
Heliostat Reflectance				
410 Solar	Surface Optics	0.5 %	Portable directional-hemispherical reflectance across 7 wavelength bands, acceptance angle φ > 100 mrad	Commercially available
15R-reflectometer	Device & Services Co.	0.2 %	Portable specular reflectance at discrete wavelengths and defined acceptance angles φ = 3.5 – 23 mrad	Commercially available
LAMBDA 1050	PerkinElmer	0.03 %	Bench-top spectrophotometer, full spectrum hemispherical, specular & diffuse components of reflectance & transmittance with appropriate accessory	Commercially available

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SSR 6	Devices & Services Co.	< 0.2 %	Bench-top, semi-portable for solar weighted hemispherical/directional reflectance at 20 deg incidence, using diffuse illumination of solar spectrum	Commercially available
CM-700d/600d CM 26d/26dG	Konica Minolta	Not available	Portable reflectance, designed to evaluate color of materials, acceptance angle φ undefined	NOT recommended for CSP
IR Emissivity				
ET100 Emissometer	Surface Optics	0.03 %	Portable directional-hemispherical absorptance/reflectance in the IR spectrum	Commercially available
SOC-100 HDR	Surface Optics	< 0.2 %	Bench-top, high-end FTIR hemispherical-directional reflectometer, diffuse Black body illumination, IR wavelength spectrum λ = 2-25 µm	Commercially available
Soiling				
pFLEX	Fraunhofer ISE	< 0.5 %	Portable reflectance & cleanliness factor for measuring degree of soiling at 3 wavelengths and acceptance angle φ = 67 mrad	Commercially available
Condor	Abengoa	0.2 %	Portable reflectance at discrete wavelengths with large acceptance angle φ > 100 mrad	Commercially available, not recommended for reflectance, only for soiling
TraCS	CSP-Services	1.8 %	Portable, in field soiling measurement with acceptance angle φ = 27.2 mrad	Commercially available
DustTrack DRX Aerosol Monitor	TSI	5 %	In-field dust sampler	Commercially available

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Dust Master Pro 7000	Thomson Environmental Systems	1 %	In-field dust sampler	Commercially available
Heliostat Surface Shape				
Close range photogrammetry	Metrology service providers	< 1 mm	Surface shape reconstruction from multiple images of a grid of reference points. Accuracy is less than from direct slope measurements	Commercial, well established
Dynamic photogrammetry	Metrology service providers	< 2 mm	Surface shape reconstruction from multiple images of a grid of reference points. Accuracy is less than from direct slope measurements	Commercial, well established
LiDAR scanner (e.g. S70)	FARO or API	< 2 mm	Automated scanning of object to create a point cloud of 3D coordinates. Needs diffuse surface. Accuracy is less than from slope measurements	Laser scanner is commercially available, method is under development
Leica Total Station TS07	Leica	< 2 mm	Creates 3D coordinates of object points in space at long distance, to support photogrammetry and slope measurement systems	Commercially available
Heliostat Slope and Opto-Mechanical Errors				
NIO	NREL	~ 0.5 mrad	Drone based, in-field scanning deflectometry using the tower edge as a target. Can detect tracking errors plus canting and slope characteristics.	Under development
Q-Scan	CSP-Services/DLR	< 0.2 mrad	Drone based, in-field inspection of parabolic trough collectors. Detects tracking, intercept factor, alignment etc.	Commercial service
SOFAST	Sandia	< 0.2 mrad	Fringe & static deflectometry in a lab setting for measurement of slope characteristics	Pre-commercial

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Tool	Supplier	Claimed Accuracy	Application	Status
AIMFAST	Sandia	< 0.25 on dish systems	Static deflectometry	Pre-commercial
??	Fraunhofer ISE	< 0.2 mrad	Fringe deflectometry in a lab setting for measurement of slope characteristics	Pre-commercial
VISpro	ENEA	< 0.2 mrad	Different versions of deflectometery in a lab setting for measurement of slope characteristics	Pre-commercial
Q-Dec	CSP-Services/DLR	< 0.2 mrad	Fringe deflectometry in a lab setting for measurement of slope characteristics	Commercial service
ReTNA	NREL	< 0.2 mrad	Static deflectometry in outdoor and lab settings for measurement of slope characteristics	Pre-commercial
SHOT / VSHOT	Sandia	< 0.3 mrad	Laser-based	Outdated / obsolete
Heliostat Beam Quality and Tracking				
Beam Characterization System (BCS)	Various	unknown	In-field beam evaluation by imaging the focal spot on a target. Used for tracking calibration. Can be used for beam quality evaluation.	Commercial for tracking calibration, under development for BQ evaluation
Heliostat wind loads				
Strain gauges (Vishay LWK-06-W250D-350,-W250B-350)	Micro-measurements	5 %	Measurement of axial strain (forces), bending moments and torques on heliostat components	Commercially available
Accelerometers (2460-10)	Silicon Designs	0.25-0.6 %	Three-axis micro-electro-mechanical system (MEMS) DC acceleration measurements on heliostat facet surface	Commercially available
Laser displacement sensor (OM30-L0350)	Baumer	0.1-0.15 %	One-dimensional laser displacement	Commercially available
Dynamic inclinometer (2 GiG BH1-1800-0-2M)	2GiG	0.05°	Elevation angle measurement	Commercially available

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Rotary encoder (CE-65-M)	TR Electronic	0.05°	Elevation and/or azimuth angle measurement	Commercially available
Differential pressure sensors	Tasseron Sensors and Controls	1 %	Differential pressure measurement between front and back facet surfaces	Commercially available