SOLAR RATING & CERTIFICATION CORPORATION™

An ICC Evaluation Service Program

OG-100 Solar Thermal Collector Certification

No./2007044A

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CERTIFICATION HOLDER:	**EVALUATION SUBJECT**	
SunDrum Solar, LLC 15 Hillside Road Northborough, MA 01532 USA www.sundrumsolar.com	**BRAND:**	SunDrum
	MODEL:	SDM 100
	TYPE:	Photovoltaic-Thermal Hybrid Collector (PVT), Unglazed, Separable

PRODUCT CERTIFICATION SYSTEM:

The ICC-SRCC OG-100 certification program includes evaluation and performance ratings for solar thermal collectors as established in the *ICC-SRCC Rules for Solar Heating & Cooling Product Listing Reports.* The program also includes periodic factory inspections and surveillance of the manufacturer's quality management system.

COMPLIANCE WITH THE FOLLOWING STANDARD(S): *ICC 901/SRCC 100 - 2015, Solar Thermal Collectors Standard*

OG-100 THERMAL PERFORMANCE RATINGS:

ICC-SRCC OG-100 thermal performance ratings provided for the collector are calculated for a 24-hour period using OG-100 standard conditions using collector parameters measured through laboratory testing. Actual performance will vary with local conditions, installation details and usage.

OG-100 STANDARD DAILY PRODUCTION TABLE

Kilowatt-hours (thermal) per Collector per Day				**Thousands of BTU per Collector per Day**			
Climate → **Category (T_i-T_a)**	High Radiation (6.3 kWh/m²•day)	Medium Radiation (4.7 kWh/m²•day)	Low Radiation (3.1 kWh/m²•day)	**Climate →** **Category (T_i-T_a)**	High Radiation (2 kBTU/ft²•day)	Medium Radiation (1.5 kBTU/ft²•day)	Low Radiation (1 kBTU/ft²•day)
A (-5˚C)	3.9	3.1	2.3	**A (-9˚F)**	13.4	10.7	7.9
B (5˚C)	2.1	1.4	0.6	**B (9˚F)**	7.3	4.7	2.1
C (20˚C)	0.3	0.0	0.0	**C (36˚F)**	1.0	0.0	0.0
D (60˚C)	0.0	0.0	0.0	**D (90˚F)**	0.0	0.0	0.0
E (80˚C)	0.0	0.0	0.0	**E (144˚F)**	0.0	0.0	0.0

A – Pool Heating (Warm Climate) **B** – Pool Heating (Cool Climate) **C** – Water Heating (Warm Climate) **D** – Space & Water Heating (Cool Climate) **E** – Commercial Hot Water & Cooling

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THERMAL EFFICIENCY:

The efficiency of solar thermal collectors is determined using test methods set in ICC 901/SRCC 100, based on ISO 9806 procedures. Results are processed to provide unique coefficients for efficiency equations, provided in several forms below. For the simplified equations, instantaneous power at normal incidence is given by $\dot{Q} = \eta_{hem} A_G G$. Incident Angle Modifiers (IAMs) are also provided to indicate the change in output as the angle of solar irradiance changes in the transverse and longitudinal planes of the collector. The forms should provide similar results, but the extended form is considered the most accurate. Users should select the equation to be used based the application and available data.

T_i: Temperature of the fluid entering the collector.
T_m: Average temperature of the fluid within the collector (between the inlet and outlet).
T_a: Temperature of the ambient air around the collector.
G: Hemispherical solar irradiance. Comprised of beam (b) and diffuse (d).
G": Net solar irradiance.
E_L: Longwave (infrared) irradiance.
ε/α: Collector emissivity/absorptance ratio.

RATING CONDITIONS	
Gross Collector Area (A_G)	1.57 m²
Fluid Mass Flowrate ($\dot{m}$)	0.020 kg/(m²s)
Test Fluid	Water
Performance Test Standard	ISO 9806-2013

Thermal efficiency performance determined using the conditions and test methods in the standard listed above. All forms of efficiency equations are based on the rating conditions above.

SIMPLIFIED THERMAL PERFORMANCE EQUATIONS (ISO 9806-2013, T_i, A_G)

Unglazed Thermal Efficiency Equation*

$$\eta_{hem} = \eta_{0,hem}(1 - b_u u) - (b_1 + b_2 u)\left(\frac{T_i - T_a}{G"}\right) \quad \text{where} \quad G" = G + \frac{\varepsilon}{\alpha}(E_L - \sigma T_a^4)$$

UNITS	$\eta_{0,hem}$	b_u	b_1	b_2	σ
SI	0.337	0.0755 s/m	10.112 W/(m2K)	0.2417 W/(m2K2)	5.670 x 10^{-8} W/(m²K⁴)
IP	0.337	0.0230 s/ft	1.782 BTU/(h ft2°F)	0.0236 BTU/(h ft2°F2)	1.713 x 10^{-9} BTU/(hft²R⁴)

** Thermal efficiency equations per ISO 9806-2013 using inlet (Ti) fluid temperature for normal incidence.*

GENERAL THERMAL PERFORMANCE EQUATION (ISO 9806-2017, T_m, A_G)

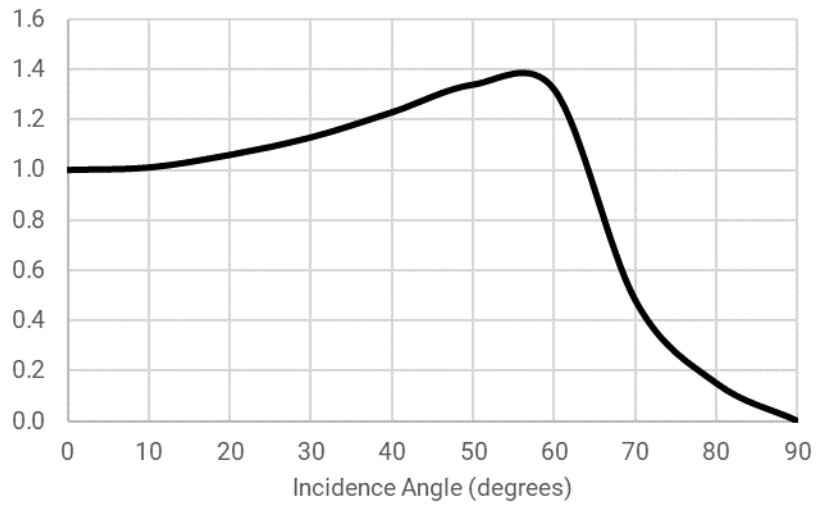
Extended Thermal Efficiency Equation**

$$\dot{Q} = A_G(\eta_{0,b}K_b(\theta_L,\theta_T)G_b + \eta_{0,b}K_d G_d - a_1(T_m - T_a) - a_2(T_m - T_a)^2 - a_3 u'(T_m - T_a) + a_4(E_L - \sigma T_a^4) - a_5\left(\frac{dT_m}{dt}\right) - a_6 u' G - a_7 u'(E_L - \sigma T_a^4) - a_8(T_m - T_a)^4$$

	$\eta_{0,b}$	K_d	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8
VALUE	0.272	1.146	10.074	0.000	0.000	0.000		0.026	0.000	0.000
UNITS	-	-	W/(m²K)	W/(m²K²)	J/(m³K)	-	J/(m²K)	s/m	W/(m²K⁴)	W/(m²K⁴)

*** General thermal efficiency equation for mean (T_m) fluid temperature provided in accordance with ISO 9806-2017. Where data measured using a standard other than ISO 9806-2017, additional assumptions may be applied to determine extended equation coefficients. Reduced surrounding air speed (u') is defined as u'=u-3 m/s. See ISO 9806-2017 for other coefficient definitions.*

DIRECT INCIDENT ANGLE MODIFIERS (IAM)



Angle (θ)	Overall (K(θ))
0°	1.00
10°	1.01
20°	1.06
30°	1.13
40°	1.23
50°	1.34
60°	1.32
70°	0.48
80°	0.15
90°	0.00

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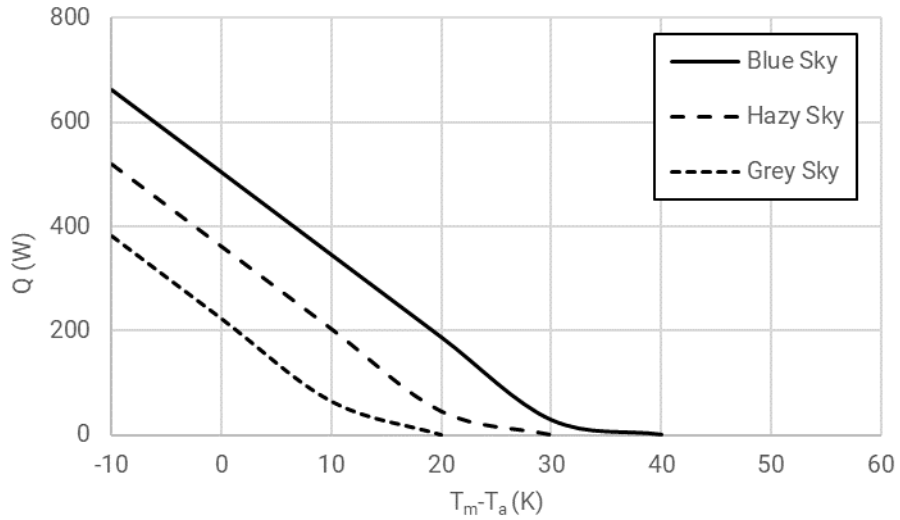
POWER OUTPUT:

The instantaneous power output of the collector under different conditions is calculated at the Standard Reporting Conditions (SRC) defined by ISO 9806-2017 using the measured performance coefficients above.



STANDARD COLLECTOR POWER OUTPUT (W) – THERMAL ONLY			
Based on Standard Rating Conditions (SRC) and mean temperature (T_m) in accordance with ISO 9806-2017			
T_m-T_a (°C)	**Blue sky** G_b = 850, G_d = 150 (W/m²)	**Hazy sky** G_b= 440, G_d= 260 (W/m²)	**Grey sky** G_b=0, G_d= 400 (W/m²)
-10	661	519	380
0	502*	361	222
10	344	203	64
20	186	45	0
30	28	0	0
40	0	0	0
50	0	0	0
60	0	0	0
**Peak Power is defined by ISO 9806 as the Blue Sky irradiance condition at T_m-T_a =0 and normal incidence.*			

TEST SAMPLE SPECIFICATIONS:

The specifications of the collector sample submitted for testing are provided below.

TEST & SAMPLE SPECIFICATIONS					
Gross Length:	1.65 m	5.4 ft	**Maximum Design Temperature:**	71 °C	159.8 °F
Gross Width:	0.95 m	1.81 ft	**Maximum Design Pressure:**	41 kPa	5.9 psi
Gross Depth:	46.0 mm	1.3 in	**Standard Stagnation Temperature[1]:**	83.3°C	181.9°F
Empty Weight:	31.2 kg	58 lb	**Tested PV Module Specifications[2] (@STC):**	Evergreen Spruce P_{MPP}: 195 W I_{SC}: 8.2 ADC V_{OC}: 32.9 VDC	
Fluid Capacity:	2.3 L	0.6 gal			
Notes:	1: Standard stagnation at 1000 W/m² and 30 °C as defined by ISO 9806 – 2017. 2: PV power production not included in published OG-100 performance ratings. Thermal performance testing conducted with two different PV modules. Thermal performance ratings provided are valid for a PVT assembly using either PV module.				

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IDENTIFICATION:

Certified systems must be identified with the OG-300 certification mark below in accordance with the *Rules for Certification Mark and Certificate Use* and labeled in with the information below per *ICC 901/SRCC 100*:

1. Manufacturer's name and model number.
2. OG-100 collector certification number
3. Maximum operating pressure
4. Dry weight
5. Fluid volume
6. Compatible heat transfer fluids
7. Standard stagnation temperature
8. Year of manufacture and/or serial number.

CONDITIONS:

1. Collector must be installed and operated in accordance with the solar thermal and PV manufacturer's published instructions and local codes and regulations. Solar thermal panel must be assembled with the photovoltaic module in accordance with the solar thermal manufacturer's installation requirements.
2. Photovoltaic thermal collector (PVT) assemblies using the specified solar thermal panel are compliant with the ICC 901/SRCC 100-2015 standard where both of the following conditions are satisfied:
    1. PV module is listed and labeled to UL 1703 or UL 61730 and installed in accordance with solar thermal panel and PV module manufacturer's specifications and listing criteria.
    2. PV module must meet all criteria established by the solar thermal panel manufacturer. PV module is assembled with the solar thermal panel in accordance with the solar thermal panel manufacturer's installation requirements.
3. OG-100 Standard Performance Ratings and Standard Collector Power Output have been calculated for the tested components using standardized conditions established by the OG-100 program and associated test standards. OG-100 performance ratings and power output values do not include electrical power production for PVTs. Actual performance will vary based on the specific usage, installation and local environmental conditions. Performance ratings will differ if a qualifying PV module is substituted.
4. The collector listed in this ICC-SRCC OG-100 certification must be labeled in accordance with the *ICC-SRCC Rules for Mark and Certificate Use*.
5. OG-100 certifications do not include mounting hardware and fixtures.
6. Solar thermal collectors and mounting hardware and appurtenances must comply with all applicable local requirements for fire resistance. Solar thermal collectors must be mounted in accordance with the requirements of the collector and mounting hardware manufacturers to comply with local codes for structural loading for wind, seismic, snow and other loads.
7. Solar thermal collectors must be used with the heat transfer fluids listed in this document.
8. All electrical wiring, connections, components, and labeling shall comply with the National Electrical Code (NFPA 70) and other local regulations and as specified by the manufacturer. OG-100 certification does not address electrical safety and durability.
9. Solar thermal collector manufactured under a quality control program subject to periodic evaluation in accordance with the requirements of ICC-SRCC.
10. This document must be reproduced in its entirety.
11. Certification status should be confirmed on the ICC-SRCC Directory at www.solar-rating.org

Vincent Chui, S.E. VP of Evaluation Services

ACCREDITED
CERTIFICATE # 3299.01, 3299.03

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