Anexo I Ejemplo de datos proporcionados PVGIS para el municipio de Vitigudino Salamanca

Rendimiento del sistema FV conectado a red

PVGIS estimación de la producción de electricidad solar

Lugar: 41°0'41" Norte, 6°26'3" Oeste,Elevación: 766 m.s.n.m,
Base de datos de radiación solar empleada: PVGIS-CMSAF

Potencia nominal del sistema FV: 1.0 kW (silicio cristalino)
Pérdidas estimadas debido a la temperatura y niveles bajos de irradiancia: 9.5% (utilizando la temperatura ambiente l
Pérdidas estimadas debido a los efectos de la reflectancia angular: 2.6%
Otras pérdidas (cables, inversor, etc.): 14.0%
Pérdidas combinadas del sistema FV: 24.3%

	Sistema fijo: inclinación=34 grados, orientación=-2 grados			
Mes	**Ed**	**Em**	**Hd**	**Hm**
Ene	2.53	78.5	3.12	96.9
Feb	3.56	99.6	4.46	125
Mar	4.20	130	5.47	169
Abr	4.44	133	5.85	175
Mayo	4.67	145	6.27	195
Jun	5.11	153	7.03	211
Jul	5.39	167	7.47	231
Ago	5.18	161	7.14	221
Sep	4.70	141	6.33	190
Oct	3.67	114	4.78	148
Nov	2.78	83.5	3.49	105
Dic	2.45	75.9	3.01	93.4
Año	4.06	123	5.37	163
Total para el año		1480		1960

	Sistema de seguimiento eje inclinado inclinación=0°			
Mes	**Ed**	**Em**	**Hd**	**Hm**
Ene	2.27	70.3	2.73	84.7
Feb	3.58	100	4.37	122
Mar	4.87	151	6.18	192
Abr	5.72	172	7.40	222
Mayo	6.53	203	8.67	269
Jun	7.62	229	10.30	310
Jul	8.04	249	11.00	341
Ago	7.04	218	9.55	296
Sep	5.65	169	7.42	223
Oct	3.86	120	4.89	152
Nov	2.54	76.3	3.11	93.4
Dic	2.09	64.7	2.52	78.3
Año	4.99	152	6.53	199
Total para el año		1820		2380

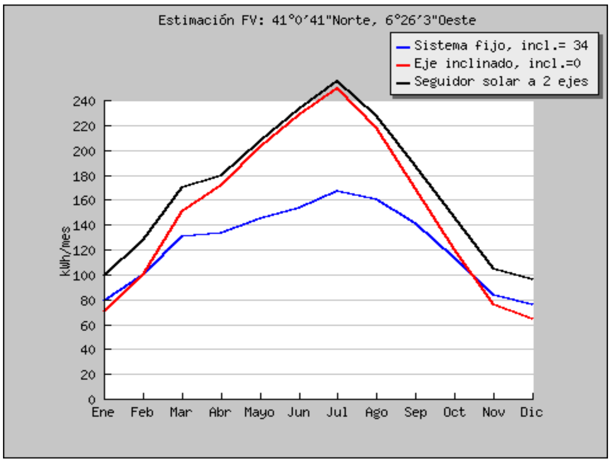
	Seguidor solar 2 ejes			
Mes	**Ed**	**Em**	**Hd**	**Hm**
Ene	3.19	99.0	3.99	124
Feb	4.55	127	5.74	161
Mar	5.47	170	7.13	221
Abr	6.00	180	7.87	236
Mayo	6.69	207	8.93	277
Jun	7.79	234	10.60	318
Jul	8.24	256	11.30	350
Ago	7.35	228	10.10	312
Sep	6.24	187	8.37	251
Oct	4.70	146	6.14	190
Nov	3.50	105	4.42	132
Dic	3.10	96.0	3.86	120
Año	5.57	170	7.37	224
Total para el año		2030		2690

Ed: Producción de electricidad media diaria por el sistema dado (kWh)

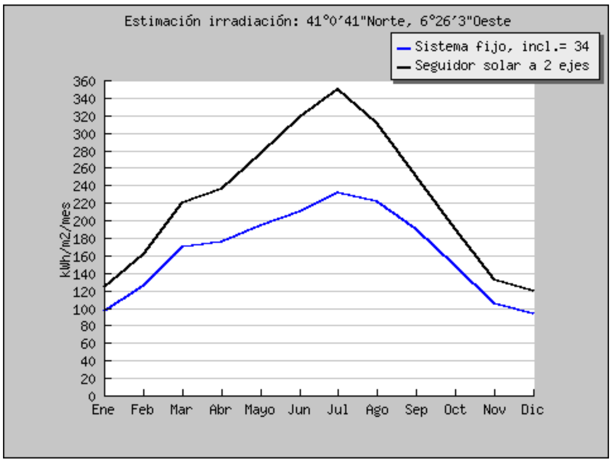
Em: Producción de electricidad media mensual por el sistema dado (kWh)

Hd: Media diaria de la irradiación global recibida por metro cuadrado por los módulos del sistema dado (kWh/m2)

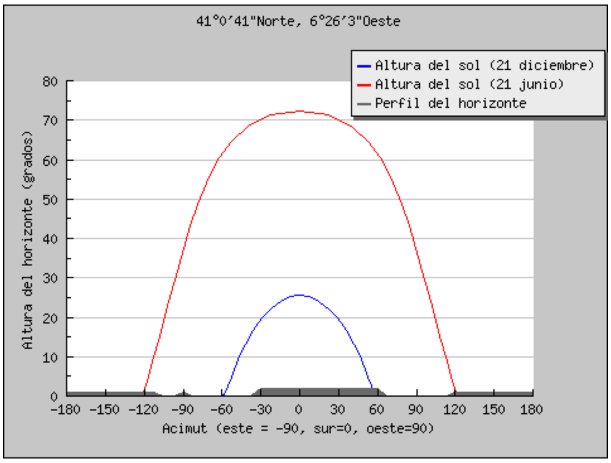
Hm: Suma media de la irradiación global por metro cuadrado recibida por los módulos del sistema dado (kWh/m2)



Producción mensual de energía de un sistema FV con ángulo fijo



Irradiación mensual sobre un plano con ángulo fijo



Perfil del horizonte con la trayectoria solar para el solsticio de invierno y verano

Irradiación global en el emplazamiento seleccionado

Lugar: 41°0'41" Norte, 6°26'3" Oeste,Elevación: 766 m.s.n.m,

El ángulo de inclinación óptimo es: 34 grados

Irradiación anual perdida a causa de las sombras (horizontal): 0.0 %

Mes	Hh	Hopt	H(90)	Iopt	T24h	NDD
Ene	1900	3130	3160	63	5.6	355
Feb	2970	4460	4070	56	7.0	297
Mar	4310	5470	4090	44	10.0	212
Abr	5380	5850	3370	28	11.6	176
Mayo	6420	6270	2830	16	15.3	49
Jun	7570	7030	2600	7	20.3	7
Jul	7850	7470	2830	11	22.2	1
Ago	6770	7140	3580	23	22.0	4
Sep	5170	6330	4300	39	18.5	61
Oct	3380	4790	4080	52	14.3	170
Nov	2190	3490	3420	61	8.9	331
Dic	1750	3010	3150	65	6.1	373
Año	4650	5370	3450	34	13.5	2036

Hh: Irradiación sobre plano horizontal (Wh/m2/dia)

Hopt: Irradiación sobre un plano con la inclinación óptima (Wh/m2/dia)

H(90): Irradiación sobre plano inclinado:90grados (Wh/m2/dia)

Iopt: Inclinación óptima (grados)

T24h: Temperatura media diaria (24h) (°C)

NDD: Número de grados día de calefacción (-)

Irradiancia solar media diaria

PVGIS estimación de los perfiles medios diarios

Lugar: 41°0'41" Norte, 6°26'3" Oeste,Elevación: 766 m.s.n.m,

Inclinación del plano: 35 grados

Orientación (acimut) del plano: 0 grados

Estimación de la radiación

Hora	G	Gd	Gc	DNI	DNIc	A	Ad	Ac
07:37	87	39	140	135	307	190	52	373
07:52	136	62	225	182	414	271	84	524
08:07	176	74	298	222	502	321	94	624
08:22	214	85	369	253	573	363	103	705
08:37	250	95	437	278	631	397	110	769
08:52	285	104	501	299	677	424	117	822
09:07	317	111	562	316	716	448	122	865
09:22	346	118	619	330	748	467	127	900
09:37	373	124	671	342	775	484	131	930
09:52	398	130	719	352	797	497	135	954
10:07	420	134	762	360	816	509	137	974
10:22	439	138	800	367	832	518	140	991
10:37	456	141	833	373	845	526	142	1000
10:52	470	144	861	377	855	532	143	1020
11:07	481	146	883	381	864	537	144	1020
11:22	489	147	900	383	869	541	145	1030
11:37	495	148	911	385	873	543	146	1030
11:52	497	149	917	386	875	544	146	1040
12:07	497	149	917	386	875	544	146	1040
12:22	495	148	911	385	873	543	146	1030
12:37	489	147	900	383	869	541	145	1030
12:52	481	146	883	381	864	537	144	1020
13:07	470	144	861	377	855	532	143	1020
13:22	456	141	833	373	845	526	142	1000
13:37	439	138	800	367	832	518	140	991
13:52	420	134	762	360	816	509	137	974
14:07	398	130	719	352	797	497	135	954
14:22	373	124	671	342	775	484	131	930
14:37	346	118	619	330	748	467	127	900
14:52	317	111	562	316	716	448	122	865
15:07	285	104	501	299	677	424	117	822
15:22	250	95	437	278	631	397	110	769
15:37	214	85	369	253	573	363	103	705
15:52	176	74	298	222	502	321	94	624
16:07	136	62	225	182	414	271	84	524
16:22	87	39	140	135	307	190	52	373
16:37	20	20	13	0	0	10	8	7

G: Irradiancia global sobre un plano fijo (W/m2)

Gd: Irradiancia difusa sobre un plano fijo (W/m2)

Gc: Irradiancia global cielo claro sobre un plano fijo (W/m2)

DNI: Irradiancia directa normal (W/m2)

DNIc: Irradiancia directa normal cielo claro (W/m2)

A: Irradiancia global sobre un plano con seguimiento a 2 ejes (W/m2)

Ad: Irradiancia difusa sobre un plano con seguimiento a 2 ejes (W/m2)

Ac: Irradiancia global cielo claro sobre un plano con seguimiento a 2 ejes (W/m2)

Rendimiento de un sistema solar autónomo

Lugar: 41°0'41" Norte, 6°26'3" Oeste,Elevación: 766 m.s.n.m,

Potencia nominal del sistema FV: 50 W
Inclinación de los módulos: 35 grados
Tamaño de la batería: 12 V, 50 Ah
Límite de descarga (%) 40 %
Consumo diurno: 300 Wh

Número de días utilizados para el cálculo: 1801

Porcentaje de días con la batería cargada completamente 0.39%
Energía media no capturada debido a batería llena: 225.29Wh
Porcentaje de días en los que la batería se descarga por completo: 99%
Energía media perdida: 113Wh

Mes	**Ed**	**Ff**	**Fe**
Ene	131.0	0	99
Feb	170.0	0	98
Mar	196.0	0	100
Abr	216.0	2	94
Mayo	217.0	0	100
Jun	251.0	0	100
Jul	259.0	2	97
Ago	241.0	0	96
Sep	212.0	0	100
Oct	143.0	0	98
Nov	114.0	0	100
Dic	85.0	0	100

Ed: Producción de energía media al día (Wh/día)

Ff: Porcentaje de días en los que la batería se carga completamente (%)

Fe: Porcentaje de días en los que la batería se descarga completamente (%)

Cs	**Cb**
40-46	59
46-52	11
52-58	9
58-64	8
64-70	9
70-76	0
76-82	0
82-88	0
88-94	0
94-100	0

Cs: Estado de carga al final de cada hora (%)

Cb: Porcentaje de horas con este nivel de carga (%)

Anexo II Modelo numérico para la generación de mapas de radiación solar.

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MODELO NÚMERICO PARA LA GENERACIÓN DE MAPAS DE RADIACIÓN SOLAR.

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Palabras clave: Radiación Solar, reflejada, difusa, directa, sombras y mapas.

Resumen. *En este trabajo se construye un modelo numérico para la elaboración de mapas de radiación solar mediante mallas 2D adaptadas. Estas mallas se obtienen haciendo uso de un proceso de refinamiento y desrefinamiento de triángulos en función de las variaciones en la orografía y el albedo de la superficie del terreno. El modelo tiene en cuenta el efecto de las sombras, que son simuladas analizando la interposición de triángulos de la malla en la trayectoria del haz de luz. En el modelo de radiación solar se realiza un cálculo de radiación en clear-sky (cielo limpio) donde se consideran los diferentes tipos de radiación: la directa, la difusa y la reflejada. A partir de los resultados de clear-sky y de medidas experimentales disponibles en distintos puntos de la zona de estudio se calcula la radiación en real-sky (cielo en condiciones normales: nubes). Los mapas de radiaciones, tanto mensuales como anuales, se obtienen por la integración de los resultados puntuales. Para ilustrar el funcionamiento del modelo se presentan algunos experimentos numéricos relativos a zonas de las Islas Canarias.*

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1. INTRODUCCIÓN

Actualmente la energía solar es una de las fuentes de energía que se encuentran en pleno auge a nivel mundial, por ese motivo se plantea un modelo que intente optimizar la captación de la radiación solar.

La energía solar incidente en una parte de la superficie terrestre se divide en tres tipos diferentes: radiación directa, difusa y reflejada. La radiación directa, es aquella que llega directamente del Sol sin haber sufrido cambio alguno en su dirección. Este tipo de radiación se caracteriza por proyectar una sombra definida de los objetos opacos que la interceptan. La radiación difusa, es la parte de la radiación que atraviesa la atmósfera y es reflejada por las nubes o absorbida por éstas. Esta radiación va en todas direcciones, como consecuencia de las reflexiones y absorciones tanto por parte de las nubes como las partículas de polvo atmosférico, montañas, árboles, edificios, el propio suelo, etc. Se caracteriza por no producir sombra alguna respecto a los objetos opacos interpuestos. Esta energía puede suponer aproximadamente un 15 % de la radiación global en los días soleados, mientras que en los días nublados, en los que la radiación directa es muy baja, la radiación difusa supone un porcentaje más elevado. Por otro lado, las superficies horizontales son las que más radiación difusa reciben, puesto que ven toda la semiesfera celeste, mientras que las superficies verticales reciben menos porque solo ven la mitad de la semiesfera celeste. El último tipo es la radiación reflejada por la superficie terrestre. Esta cantidad de radiación depende del coeficiente de reflexión de la superficie, también llamado albedo. Las superficies horizontales no reciben ninguna radiación reflejada, ya que sólo ven superficie terrestre, mientras que las superficies verticales son las que reciben más cantidad de este tipo de radiación.

Para el aprovechamiento de esta energía se usan paneles solares cuyo objetivo principal es la captación de la radiación solar, energía que se forma partiendo del calor.

En el desarrollo del modelo de generación de mapas de radiación solar que permita tener en cuenta todos los tipos de radiación y distintas circunstancias, se parte en primer lugar de los datos de la superficie del terreno, los cuales se presentan mediante mallas en 2D adaptadas que nos permitirán conocer las características, altimetría y topografía del terreno. Este punto se verá de una manera más detallada en la segunda sección. En la tercera sección, se procede a la determinación de sombras en función de la hora solar y las características del terreno. A partir de las condiciones de sombra se puede llevar a cabo una estimación de la radiación en condiciones de clear sky, teniendo en cuenta la radiación directa, difusa y reflejada.

Mediante el uso de datos experimentales proporcionados por distintas fuentes (medidas experimentales, resultados de modelos predictivos) y los resultados obtenidos en clear-sky se estudia el cálculo de la radiación real sky. A continuación en la quinta sección, se presenta una aplicación para validar el modelo presentado. Finalmente se establecen conclusiones y líneas futuras.

2. MALLAS

La idea básica para la construcción de las mallas es la utilización de un algoritmo de refinamiento y desrefinamiento para dominios bidimensionales, con un posterior proceso de optimización.
La dificultad del proceso radica en la irregularidad de la superficie del terreno. Para resolver el problema solamente se dispone de la información digitalizada del terreno. El objetivo es conseguir una malla adaptada, es decir, que exista una densidad de nodos mayor donde sea necesario para definir las características geométricas de nuestro dominio a partir de una interpolación lineal a trozos.
En primer lugar se determinan los nodos situados sobre la superficie del terreno. Su distribución debe estar adaptada a las características orográficas con la finalidad de minimizar el número total de nodos necesario. Estos nodos serán los vértices de los triángulos que conforman la malla. Inicialmente, se construye una triangulación con una distribución uniforme de puntos.
Esta malla bidimensional puede ser obtenida a partir de la realización de un cierto número de refinamientos globales sobre una malla simple o puede también construirse realizando una triangulación de Delaunay sobre la distribución uniforme de puntos establecida. Consideraremos la malla obtenida como el nivel más bajo de la secuencia que define la distribución de los puntos en el resto de los niveles. Sobre esta malla regular aplicamos a continuación el algoritmo de refinamiento y desrefinamiento para definir la distribución de los nodos de la malla de la superficie del terreno. Para ello, primero se construye una función que interpola las cotas obtenidas a partir de una digitalización de la topografía de la zona rectangular estudiada. En segundo lugar, realizamos una serie de refinamientos globales sobre la malla uniforme hasta conseguir una malla regular capaz de captar la variación de la topografía del terreno. El máximo grado de discretización viene definido por el nivel de detalle de la digitalización. Posteriormente, se realizará un desrefinamiento sobre estos últimos niveles de malla utilizando como parámetro de desrefinamiento el máximo error de cotas permitido entre la superficie real del terreno y la superficie definida mediante la interpolación a trozos obtenida con la malla resultante.

3. DETECCIÓN DE SOMBRAS

Para poder llevar a cabo las consideraciones acerca de las sombras hemos de tener claro determinadas características. Debido a la necesidad de determinar si una cierta zona de la superficie se encuentra en sombra o no, se desarrolla un procedimiento en el cual se parte del conocimiento del instante (la hora, día y mes) para el cual se desea obtener la distribución de las sombras así como una malla de triángulos adaptada. En este proceso previamente debemos realizar varios cálculos. Los pasos a seguir para el cálculo son los siguientes.
- Determinar la dirección de la radiación solar a partir de la hora local.

- Calcular los ángulos de inclinación y orientación de una superficie, mediante los cuales se estima la matriz de rotación.
- Calcular la máxima de las distancias desde el centro de cada triángulo a sus nodos, para posteriormente poder estimar la dimensión de una cuadrícula que contenga al dominio. A cada rectángulo de la cuadrícula se le asocia un conjunto de triángulos cuyo centro esté contenido en él.
-Cuarto, se determinan los triángulos que dentro del dominio pueden hacer sombra al punto que esté siendo objeto de estudio.

Una vez terminado estos pasos previos se realiza el cálculo de la distribución de las sombras. Consideraremos que un triángulo está en sombra o no dependiendo del estado en que se encuentra cada uno de los vértices. Cada vértice tendrá un coeficiente de sombra de 0 ó $1/3$ según si está en sombra o no, respectivamente.

Un vértice estará en sombra o no si se cumplen simultáneamente dos condiciones. La primera es una comparación entre el vértice y cada uno de los triángulos que están dentro de los rectángulos que le pueden hacer sombra. Esta comparación está basada en la comprobación de si el vértice se encuentra dentro del espacio comprendido entre los vectores que definen dos aristas del triángulo y el vector suma de los mismos. La segunda condición es que la coordenada z del nodo sea menor que la coordenada z del centro del triángulo considerado. Si se cumplen las dos condiciones se considera que el vértice está en una posición de sombra. En caso contrario, el vértice no está en sombra.

Una vez tenemos determinada la distribución de las sombras en los vértices, definimos el estado de cada triángulo como la suma del coeficiente de sombra de cada uno de sus vértices, pudiendo variar los valores entre 0 si se encuentra en sombra, $1/3$ si se encuentran dos vértices en sombra, $2/3$ si posee un solo vértice en sombra y 1 si se encuentra completamente iluminado.

4. RADIACIÓN SOLAR

La interacción de la radiación solar con la superficie y la atmósfera viene determinada por tres tipos de factores que hemos tenido en cuenta para el desarrollo del modelo. El primero de ellos es la geometría de la tierra, revolución y rotación (declinación, latitud, hora solar, ángulo) que determina la radiación extraterrestre disponible basada en la posición del sol sobre el horizonte. El segundo factor es el terreno: la elevación sobre el nivel del mar que determina la atenuación de la radiación por grosor de la atmósfera, la inclinación, orientación y las sombras. Por último la atenuación atmosférica, cuyo valor viene estimado según el índice de turbidez. Este modelo de radiación solar se basa en el propuesto por M.Suri,J. Hofierka [2], donde hemos añadido el concepto de sombra y la utilización de mallas adaptadas, con el objetivo de proporcionar una mayor precisión.

4.1. Cielo limpio (Clear Sky)

Fuera de la atmósfera, La radiación directa, también conocido como constante solar I_o es 1,367 (W/m^2). La órbita terrestre es ligeramente excéntrica y la distancia entre el sol y la tierra varía ligeramente a lo largo del año. Por lo tanto hemos tenido en cuenta un factor de corrección, que permite cambiar la distancia solar. Así, la irradiancia extraterrestre normal resulta,

$$G_o = I_o \epsilon \tag{1}$$

donde $\epsilon = 1 + 0{,}03344 \cos(j' - 0{,}048869)$, siendo j' el ángulo diario representado en radianes, cuyo valor es,

$$j' = \frac{2\pi j}{365{,}25} \tag{2}$$

donde j es el número del día que varía desde 1 hasta 365. El rayo de irradiancia normal del rayo solar $B_{oc}(W/m^2)$ es atenuado por la nubosidad de la atmósfera.

$$B_{oc} = G_o \; exp\{-0{,}8662 T_{LK} m \delta_R(m)\} \tag{3}$$

El término $-0{,}8662T_{LK}$ es la masa de aire del factor de turbidez.EL factor de Turbidez se ha obtenido del The European Solar Radiation Atlas. El parámetro m es el relativo a la masa óptica de aire calculado usando la fórmula (Kasten and Young 1989),

$$m = (p/p_o)/\sin h_o^{ref} + 0{,}050572(h_o^{ref} + 6{,}07995)^{-}1{,}636 \tag{4}$$

donde h_o^{ref} es la altitud solar en grados corregidos por la componente de refracción atmosférica Δh_o^{ref},

$$\Delta h_o^{ref} = 0{,}061359(0{,}1594 + 1{,}123h_o + 0{,}065656h_o^2)/(1 + 28{,}9344h_o + 277{,}397h_o^2) \tag{5}$$

$$h_o^{ref} = \Delta h_o^{ref} + h_o \tag{6}$$

y p/p_o es una corrección según una elevación z dada, es decir,

$$p/p_o = exp(-z/8434{,}35) \tag{7}$$

El parámetro $\delta_R(m)$ es la anchura óptica de Rayleigh de la masa de aire m y la hemos calculado de acuerdo con la fórmula de Kasten(1996), para valores de $m \leq 20$ como,

$$\delta_R(m) = 1/(6{,}6296 + 1{,}7513m - 0{,}1202m^2 + 0{,}0065m^3 - 0{,}00013m^4) \tag{8}$$

mientras que para $m > 20$

$$\delta_R(m) = 1/(10{,}4 + 0{,}718) \tag{9}$$

La radiación directa en una superficie horizontal B_{hc} resulta,

$$B_{hc} = B_{oc} \sin h_o \tag{10}$$

donde h_o es el ángulo de altitud solar cuyo valor se define más adelante, mientras que la radiación directa para una superficie inclinada B_{ic} se obtiene de,

$$B_{ic} = B_{oc} \sin \delta_{exp} \tag{11}$$

siendo δ_{exp} es el ángulo de incidencia solar medido entre el sol y la superficie inclinada.
Hemos tenido en cuenta que la posición del sol con respecto a la superficie horizontal viene dado por dos coordenadas, la altitud solar h_o y el Azimuth solar A_o, que es el ángulo horizontal entre la dirección de la radiación y el meridiano medido desde el Este. Ambos son calculados de la forma siguiente (Krcho 1990,Jenco 1992),

$$\sin h_o = C_{31} \cos T + C_{33} \tag{12}$$

$$\cos A_o = (C_{11} \cos T + C_{13})/((C_{22} \sin T)^2 + (C_{11} \cos T + C_{13})^2)^{1/2} \tag{13}$$

donde $C_{11} = \sin\varphi \cos\delta$,$C_{13} = -\cos\ varphi \sin\delta$, $C_{22} = \cos\delta$, $C_{31} = \cos\varphi\cos\delta$, $C_{33} = \sin\varphi\sin\delta$. El ángulo horario T (radianes) es calculado a partir de la hora local t expresada en horas decimales en las 24 horas del reloj como:

$$T = 0{,}261799(t - 12) \tag{14}$$

Una vez conocemos el grado de inclinación de un triángulo, calculamos los dos ángulos necesarios para definir la superficie inclinada. El primero de ellos es el azimuth A_N de cada triángulo (ángulo entre la proyección de la normal en la horizontal con el Este), para ello hacemos uso del producto vectorial entre la proyección horizontal de la normal de cada triángulo y el Este (eje x positivo). El segundo ángulo es γ_N, el cual calculamos a partir del producto escalar de la normal de cada triángulo por su proyección sobre el plano horizontal.
El ángulo solar de incidencia δ_{exp} entonces se define partiendo del producto escalar entre el vector de la dirección del sol y el vector normal de cada triángulo. Con este ángulo determinamos la radiación directa para una superficie inclinada. A continuación calculamos la radiación difusa. La estimación de la componente difusa en el horizonte de la superficie $D_{hc}(W/m^2)$ se expresa de la siguiente forma,

$$D_{hc} = G_o T_n(T_{LK}) F_d(h_o) \tag{15}$$

Siendo D_{hc} una función de transmisión difusa T_n que depende solamente de el factor de turbidez T_{LK}, y una función de altitud solar difusa F_d que depende únicamente de la

altitud solar h_o.
La estimación de la función de transmisión $T_n(T_{LK})$ da una irradiancia difusa teórica en una superficie horizontal con la vertical del solo por encima de la masa de aire. El polinomio de segundo orden usado es,

$$T_n(T_{LK}) = -0{,}015843 + 0{,}030543T_{LK} + 0{,}0003797T_{LK}^2 \tag{16}$$

La función de altitud solar la hemos evaluado usando,

$$F_d(h_o) = A_1 + A_2 \sin h_o + A_3 \sin^2 h_o \tag{17}$$

Donde los valores de los coeficientes A_1 ,A_2 y A_3 sólo dependen de la turbidez T_{LK} quedando definidos con las siguientes expresiones.

$$\begin{aligned}
A_1' &= 0{,}26463 - 0{,}061581T_{LK} + 0{,}0031408T_{LK} \\
A_1 &= 0{,}0022/T_n(T_{LK}) \qquad \text{si } A_1'T_n(T_{LK}) < 0{,}0022 \\
A_1 &= A_1' \qquad \text{si } A_1'T_n(T_{LK}) \geq 0{,}0022 \\
A_2 &= 2{,}04020 + 0{,}018945T_{LK} - 0{,}011161T_{LK}^2 \\
A_3 &= -1{,}3025 + 0{,}039231T_{LK} + 0{,}0085079T_{LK}^2
\end{aligned} \tag{18}$$

El modelo para determinar la irradiancia difusa en un cielo limpio, en una superficie inclinada $D_{ic}(W/m_2)$ distingue entre sin sombra, potencialmente sin sombra y superficies en sombra. Las ecuaciones son, para el caso de superficies sin sombra, es decir, iluminadas y sin el cielo nublado (Muneer 1990). Si $h_o \geq 0{,}1$

$$D_{ic} = D_{hc}\left(F(\gamma_N)(1-K_b) + K_b\frac{\sin\delta_{exp}}{\sin h_o}\right) \tag{19}$$

Si $h_o < 0{,}1$

$$D_{ic} = D_{hc}\left(F(\gamma_N)(1-K_b) + K_b \sin\gamma_N \cos A_L/(0{,}1 - 0{,}008h_o)\right) \tag{20}$$

donde $A_{LN}^* = A_o - A_N$
si $-pi \leq A_{LN}^* \leq pi$ entonces $A_{LN} = A_{LN}^*$
si $A_{LN}^* > pi$ entonces $A_{LN} = A_{LN}^* - 2pi$
si $A_{LN}^* < -pi$ entonces $A_{LN} = A_{LN}^* + 2pi$
Para el caso de las superficies en sombra donde $\delta_{exp} < 0$ y $h_o \geq 0$.

$$D_{ic} = D_{hc}F(\gamma_N) \tag{21}$$

donde $F(\gamma_N)$ es una función aprovecha para la irradiancia difusa es calculada con la función,

$$F(\gamma_N) = r_i(\gamma_N) + (\sin\gamma_N - \gamma_N\cos\gamma_N - \pi\sin^2(\gamma_N/2))N \tag{22}$$

donde $r_i(\gamma_N)$ es una fracción de una parte del cielo vista por una superficie inclinada, es decir su valor es:

$$r_i(\gamma_N) = (1 + \cos\gamma_N)/2 \tag{23}$$

El valor de N para superficies en sombra es 0.25227, mientras que para superficies bajo cielo limpio el término N se calcula de la manera siguiente,

$$N = 0{,}00263 - 0{,}712K_b - 0{,}6883K_b^2 \tag{24}$$

K_b es una medida de la cantidad de rayo de irradiancia disponible (proporción entre el rayo de irradiancia y la irradiación solar extraterrestre en una superficie horizontal).

$$K_b = B_{hc}/G_{oh} \tag{25}$$

Donde G_{oh}

$$G_{oh} = G_o \sin h_o \tag{26}$$

Por último, para la estimación para un cielo limpio de la irradiancia reflejada en el terreno para superficies inclinadas (R_i) se parte de un supuesto isotrópico. En este caso, la irradiancia del cielo limpio reflejada en el terreno es proporcional a la irradiancia global horizontal G_{hc}, para el promedio del albedo del terreno ρ_g y una fracción del terreno visto por una superficie inclinada $r_g(\gamma_N)$ (Muneer 1997).

$$R_i = \rho_g G_{hc} r_g(\gamma_N) \tag{27}$$

donde $r_g(\gamma_N) = (1-\cos\gamma_N)/2$ y la irradiancia global en una superficie horizontal $G_{hc}(W/m^2)$, es dado como la suma de su componente directa y difusa.

$$G_{hc} = B_{hc} + D_{hc} \tag{28}$$

4.2. Cielo real (Real Sky)

La irradiación/irradiancia para cielos nublados son calculadas para un cielo limpio mediante la aplicación de un factor de parametrización de atenuación de cielo cubierto con nubes.
Para la valoración de la irradiación/irradiancia global en una superficie horizontal bajo condiciones nubladas G_h, los valores de cielo limpio son multiplicados por el índice de cielo limpio k_c .

$$G_h = G_{hc} k_c \tag{29}$$

El índice k_c representa la transmisión atmosférica expresada como el ratio entre la radiación global bajo condiciones nubladas y condiciones de cielo limpio. Puede ser calculado desde una medida de la radiación global G_{hs} y valores calculados de radiación global de cielo limpio G_{hc} .

$$k_c = G_{hs}/G_{hc} \tag{30}$$

Como una alternativa k_c puede también ser derivado desde otros datos climatológicos. Los mapas de muestreo de k_c deben ser luego interpolados en toda la zona de estudio.
Para el cálculo de B_h y D_h con el índice de cielo limpio tiene que ser tratado separadamente como se expresa a continuación.

$$D_h = D_{hc}k_c^d \tag{31}$$

$$B_h = B_{hc}k_c^b \tag{32}$$

El ratio de la difusión de la radiación global D_h/G_h para cielos limpios y cubiertos cambia acorde a la nubosidad. En Europa los valores típicos van de 0.3 a 1.
Los mapas de muestreo de D_{hs}/G_{hs} pueden ser derivados desde varios valores puntuales por interpolación horizontal, mediante la siguiente expresión,

$$k = \epsilon \frac{\sum_{n=1}^{N} \frac{k_n}{d_n^2}}{\sum_{n=1}^{N} \frac{1}{d_n^2}} + (1-\epsilon) \frac{\sum_{n=1}^{N} \frac{k_n}{|\Delta h_n|}}{\sum_{n=1}^{N} \frac{1}{|\Delta h_n|}} \tag{33}$$

El valor de k_n corresponde a la radiación medida en cada punto de grid, donde N es el número de estaciones utilizadas en la interpolación, d_n es la distancia horizontal desde la estación n hasta el punto donde estamos calculando la radiación solar, $|\Delta h_n|$ es la diferencia de altura entre la estación n y el punto de estudio, y ϵ es un parámetro que toma valores entre 0 y 1. Cuando $\epsilon \longrightarrow 1$, aumenta la importancia de la distancia horizontal de cada punto a las estaciones de medida. Esta aproximación se emplea en problemas con una orografía regular o en análisis bidimensionales. De manera análoga, si $\epsilon \longrightarrow 0$, entonces la diferencia de altura entre cada punto y las estaciones de medida resulta determinante en detrimento de la distancia horizontal. Esta segunda aproximación se usa cuando la orografía del terreno es irregular. En la práctica, la regiones geográficas estudiadas suelen combinar zonas de orografía irregular con otras orografías más regulares, por lo que tomar un valor intermedio de ϵ suele ser lo más apropiado.
Consecuentemente los mapas de muestreo de componentes del índice de radiación difusa y directa en cielo limpio es calculado de la forma siguiente,

$$D_h = G_h D_{hs}/G_{hs} \tag{34}$$

$$B_h = G_h - D_h \tag{35}$$

$$k_c^d = D_h/D_{hc} \tag{36}$$

$$k_c^b = B_h/B_{hc} \tag{37}$$

donde el subíndice s se usa para distinguir los datos medidos en estaciones meteorológicas B_{hs} y D_{hs} de los valores estimados de B_h y D_h. La radiación total en toda la superficie de estudio será la suma de las tres componente: directa, difusa y reflejada.

5. EXPERIMENTOS NÚMERICOS

El caso estudiado corresponde a una zona del noroeste de la isla de Gran Canaria cuya topografía se muestra en la figura 1. Se ha considerado un valor medio constante del albedo $\rho_g = 0{,}17$.

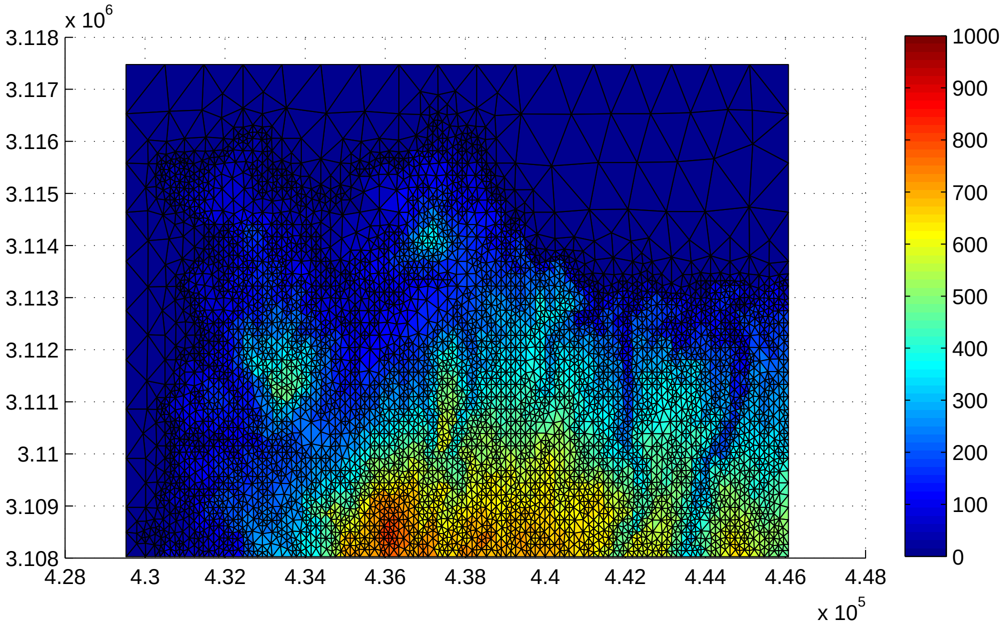

Figura 1: Mapa topográfico del noroeste de Gran Canaria.

Para el 21 de mayo de 2007 a las 18 horas, se ha estudiado la radiación en la zona. En primer lugar, se ha obtenido la distribución de las sombras en la superficie. La figura 2 representa el estado de las sombras que se obtuvo con nuestro modelo.

A continuación se ha obtenido la radiación directa (figura 3), difusa (figura 4) y reflejada (figura 5) para toda la superficie,

Finalmente, la radiación total sobre la superficie, que es la suma de las tres anteriores, se representa en la figura 6.

Para ajustar los resultados obtenidos el cielo limpio a cielo real, es necesario utilizar medidas reales de la radiación distribuidas en la zona. Dichas medidas aún están disponibles, por lo que esta parte del trabajo se propone para realizar en el futuro.

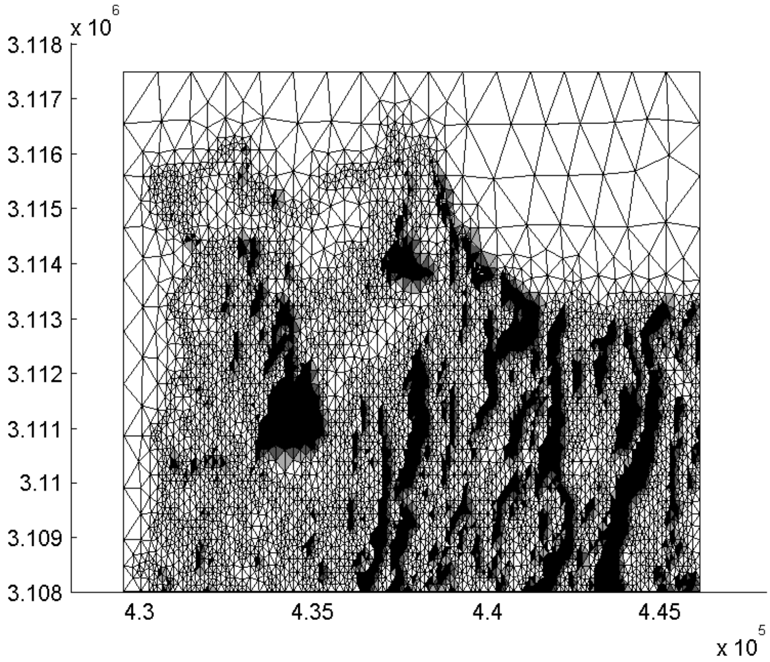

Figura 2: Distribución de las sombras.

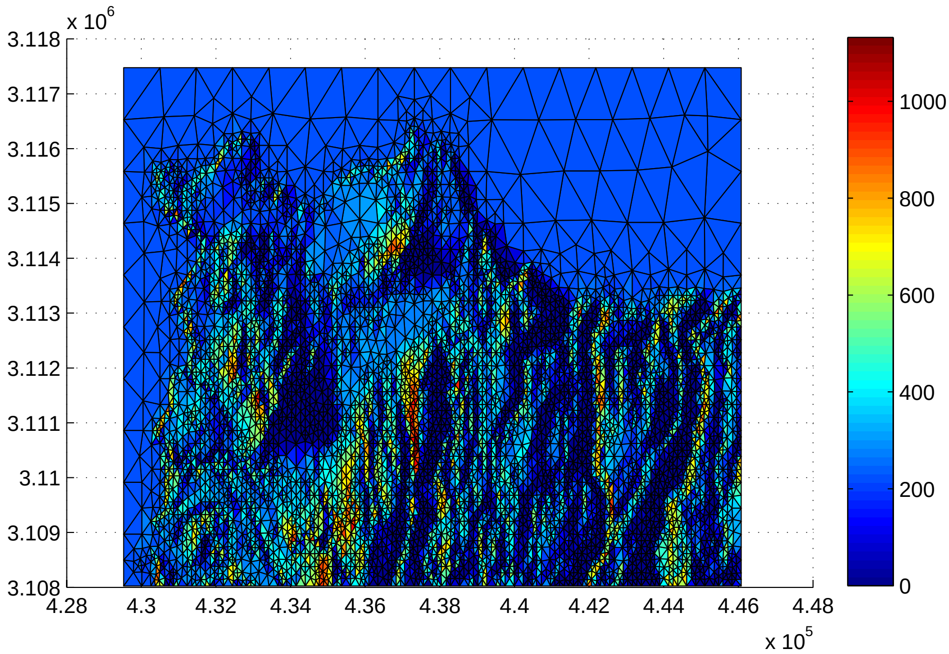

Figura 3: Distribución de la Radiación Solar Directa.

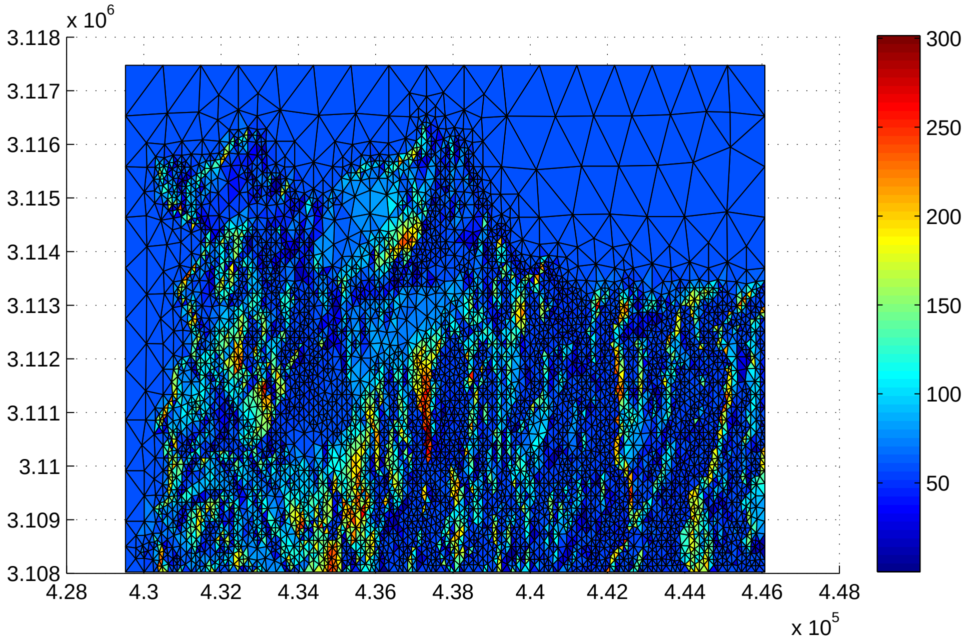

Figura 4: Distribución de la Radiación Solar Difusa.

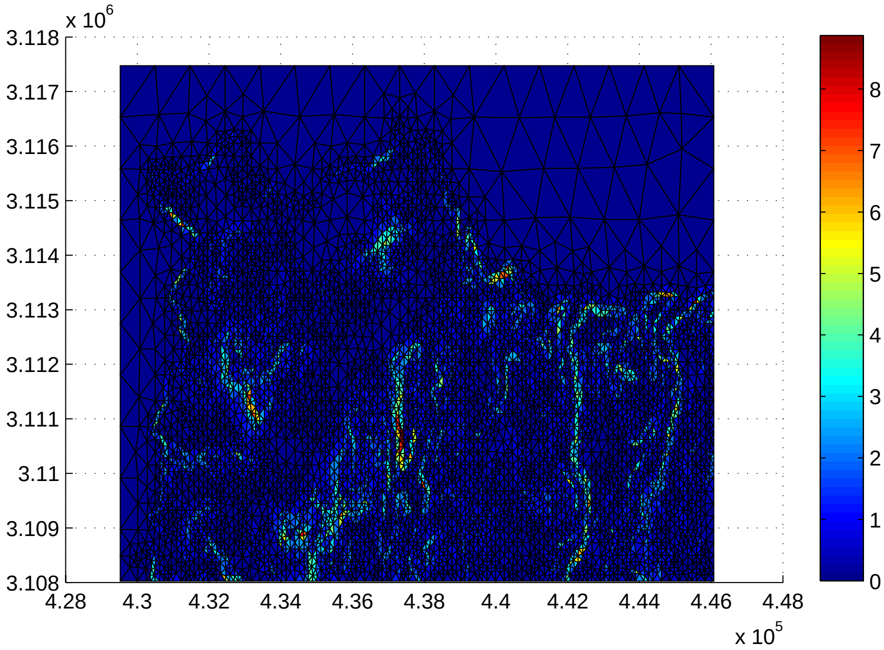

Figura 5: Distribución de la Radiación Solar Reflejada.

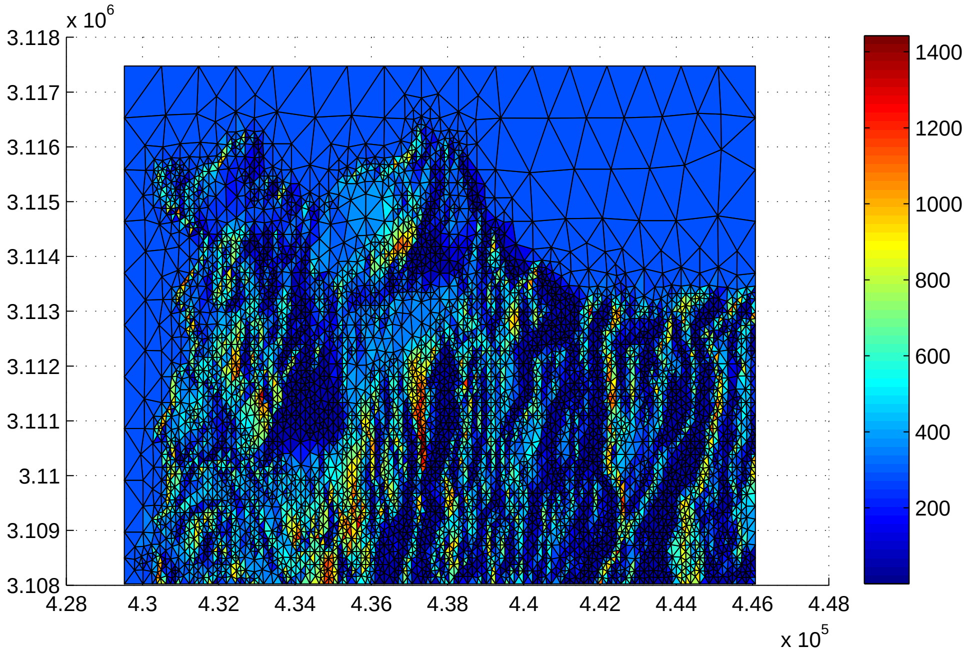

Figura 6: Distribución de la Radiación Solar Total.

6. CONCLUSIONES

Se ha presentado un modelo que permite la estimación de la radiación solar sobre una superficie, partiendo del conocimiento de la localización, topografía y albedo de la zona, para una fecha y hora determinadas. La estimación de la radiación solar para una superfice se calcula teniendo en cuenta la distribución de las sombras en el terreno según el momento del día, objeto de estudio, permitiendo de este modo estimar de forma óptima el aprovechamiento de la energía solar. La utilización de mallas adaptadas a la orografía ha permitido obtener mapas de radiación con la precisión deseada.

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Anexo III Guía usuario energía solar fotovoltaica (Junta de Castilla y León)

Guía del Usuario

Energía
Solar Fotovoltaica

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Guía del Usuario

Energía
Solar Fotovoltaica

¿Qué es la energía solar?

La energía solar es la energía contenida en la radiación solar que es transformada, mediante los correspondientes dispositivos, en forma térmica o eléctrica para su consumo posterior allá donde se necesite.

El elemento encargado de captar la radiación solar y transformarla en energía útil es el panel solar, pudiendo ser de dos clases: captadores solares térmicos y módulos fotovoltaicos.

¿Castilla y León posee suficiente radiación solar?

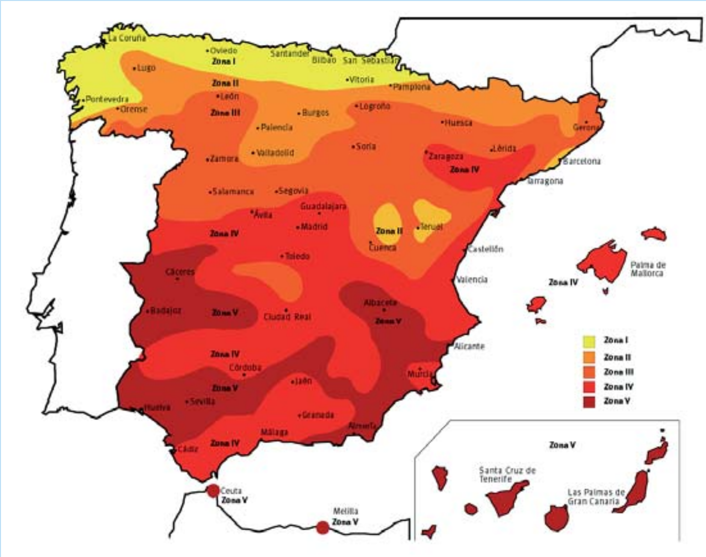
La radiación solar que llega a la tierra e incide sobre una superficie, tiene una componente directa (cuando brilla el sol) y otra difusa (cuando el cielo está nublado), siendo suficiente con la existencia de ésta última para el funcionamiento de los paneles solares.

Evidentemente, cuanto mayor radiación solar reciban los paneles, valor que depende del mes del año y la localidad, mayor energía podrán aprovechar.

Como dato orientativo, Castilla y León posee una radiación solar anual media inferior en un 10% a la registrada en Sevilla, al compensar con su mayor altitud, la posición más al sur de Sevilla.

Así pues, no parecen correctos ciertos tópicos en cuanto a la percepción que se tiene de la energía solar en nuestra Comunidad Autónoma, siendo una región que cuenta con un adecuado potencial de aprovechamiento de la radiación solar.

Además, la energía solar es gratis, inagotable y respetuosa con el medio ambiente, llegando a todos los rincones de nuestra geografía, por lo que todo consumidor de energía es, en principio, susceptible de incorporar una instalación solar en su vivienda o negocio.



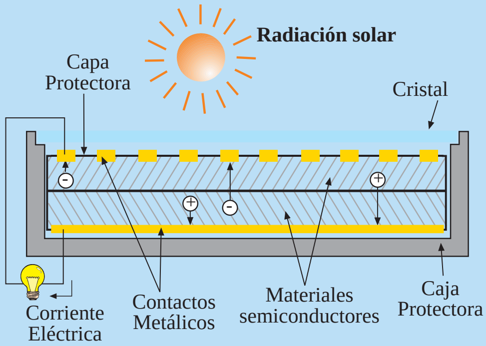
Mapa de zonas climáticas de España según el Código Técnico de la Edificación

Así, como término medio la energía que incide anualmente en Castilla y León sobre 25 m^2 de módulos fotovoltaicos puede generar más de 4.000 kWh al año.

¿Cómo funcionan los paneles solares fotovoltaicos?

En los módulos fotovoltaicos, la radiación solar recibida produce en un material semiconductor una diferencia de tensión eléctrica entre sus extremos, que, al ser conectados a un circuito, generan una corriente eléctrica en el mismo.

Para aumentar las prestaciones se dopa el material semiconductor, encapsulándole para protegerle de las inclemencias metereológicas.



Sección de un módulo fotovoltaico

Finalmente, se enmarca en un bastidor metálico con una cubierta transparente, logrando la rigidez, estanqueidad y aislamiento eléctrico necesario para su emplazamiento a la intemperie.

¿Para qué aplicaciones se puede utilizar la energía solar fotovoltaica?

La energía solar se encuentra presente en nuestras vidas en numerosas aplicaciones, calculadoras solares, señales viales, satélites, etc., por lo que no deberíamos desconfiar de su utilización.

Módulos solares fotovoltaicos

Así, las instalaciones solares fotovoltaicas pueden proporcionar cualquier demanda eléctrica, como puede ser la electrificación de bodegas, viviendas y edificios, el alumbrado público, las aplicaciones agropecuarias y ganaderas, el bombeo y tratamiento del agua, las antenas de telefonía aisladas de la red o el suministro de energía eléctrica a la red general eléctrica de distribución.

El consumo eléctrico anual medio de una vivienda en Castilla y León asciende a unos 2.500 kWh/año, representando la iluminación el 22%, la cocina el 30% y los electrodomésticos el 48% restante.

En cualquier caso, es especialmente importante destacar que las instalaciones solares son dimensionadas y diseñadas para unos consumos eléctricos determinados.

Así, cualquier utilización de estos sistemas alejada de sus márgenes de funcionamiento solo logrará acelerar el envejecimiento de la instalación, su mal funcionamiento o rotura.

Instalación eólico fotovoltaica aislada para electrificación de vivienda

Por tanto, tenga en cuenta sus necesidades actuales y/o futuras a la hora de instalar un sistema de energía solar fotovoltaica, ya que las ampliaciones posteriores de la misma pueden ser de difícil ejecución o modificar la vida útil de la instalación por incompatibilidad entre los equipos nuevos y viejos.

¿Cuando interesa incorporar una instalación solar fotovoltaica?

Las instalaciones solares fotovoltaicas permiten suplir con alta fiabilidad a las energías convencionales allí donde éstas no llegan (no existe tendido eléctrico o la electricidad se genera con combustibles fósiles), en aquellas aplicaciones en las que la demanda coincide con la producción solar (bombeos de agua para riego) o cuando la producción eléctrica generada se destina íntegramente a la venta a la red.

En el caso de instalaciones solares fotovoltaicas, se puede llegar a proporcionar toda la demanda eléctrica de una vivienda o negocio, siendo la producción media anual en Castilla y León de 160 kWh por m^2, o 1.300 kWh por kWp de módulo fotovoltaico.

¿Cuál es la instalación solar que mejor se adapta a cada necesidad energética?

En primer lugar deberá tenerse en cuenta el consumo eléctrico demandado, su horario de utilización, simultaneidad (número de aparatos que se conectan a la vez) y tipología (corriente continua, alterna o ambas a la vez), así como su distribución a lo largo del año y la "filosofía de la instalación".

Así, si lo que se desea es electrificar una vivienda, la premisa de la instalación es el aseguramiento del suministro, es decir, que la instalación solar proporcione energía en el período de mayor demanda. Ello conlleva, generalmente, a que la demanda se produzca en invierno (mayor número de horas de utilización en la iluminación), que es el periodo en el que menor radiación solar se dispone.

Módulos solares fotovoltaicos

La instalación fotovoltaica así precisada conllevará un sobredimensionado para el resto del año (va disminuyendo la demanda mientras que la radiación solar va aumentando), si bien estaría en concordancia con la "filosofía" de la misma, esto es, proporcionar electricidad durante todo el año.

Otros ejemplos de dicho tipo de instalaciones serían los repetidores de televisión y antenas de telefonía aisladas, las señales viales y de balizamiento marítimo, etc.

Por el contrario, existen otro tipo de instalaciones en las que el aseguramiento no es el factor decisivo, bien por que la energía eléctrica puede ser suministrada con otras energías (grupos electrógenos), o por que la demanda de energía se acopla a la radiación solar disponible.

De esta manera, por ejemplo, el bombeo de agua para riego permite que cuando mayor producción se pueda obtener de los módulos fotovoltaicos (verano) es cuando mayor calor hace y, por tanto, cuando más necesidad se tiene de regar.

Instalación fotovoltaica aislada para riego

Aunque en el caso en que la producción de la electricidad generada se destine íntegramente a su venta a la red, interesará maximizar la producción solar a lo largo de todo el año.

Como puede verse, cada tipo de demanda eléctrica precisará de un estudio pormenorizado de la instalación solar fotovoltaica que mejor se adapte a ella.

¿Cuánto produce una instalación Solar?, es decir, ¿son una buena alternativa?

Ha de tenerse en cuenta que, respecto a los sistemas convencionales, la energía solar fotovoltaica, considerando la vida útil de ambos sistemas, puede resultar económicamente más ventajosa.

Así, ha de considerarse la diferencia de costes totales incurridos en los dos supuestos: producir la electricidad por medios convencionales o por tecnologías solares.

De este modo, si el sistema convencional es la conexión a la red de la compañía eléctrica, se deberá tener en cuenta como coste total la suma de la inversión del acceso a la red (tendido eléctrico), más la compra de la electricidad, incluido el término de potencia y el alquiler de contador, durante toda la vida útil de la instalación solar (25 - 30 años).

Instalación
eólico-fotovoltaica aislada

Dichos costes deberán compararse directamente con la inversión de la instalación solar fotovoltaica y su mantenimiento durante la vida útil de la misma.

En instalaciones solares fotovoltaicas, si la producción solar se destina a autoconsumo, el kWh producido por la instalación solar se podría valorar entorno a 0,1006 € en instalaciones con suministro eléctrico (lo que dejaríamos de pagar a la compañía eléctrica por los kWh no consumidos, con su correspondiente impuesto) o a 0,14 € en instalaciones sin suministro eléctrico (lo que dejamos de pagar por el consumo, más el término de potencia contratada, el alquiler del contador e impuestos).

Si la instalación de referencia fuese un grupo electrógeno, el coste del kWh producido con energía solar se podría valorar entorno a 0,24 €.

Evidentemente, en los valores de referencia anteriores no se ha tenido en cuenta la evolución de los precios de los combustibles con el paso del tiempo, si bien su incremento anual futuro es más que probable.

Instalaciones solares fotovoltaicas conectadas a red

En el caso en que se vendiese toda la producción generada por los módulos fotovoltaicos a la empresa distribuidora, ésta nos abonaría hasta 0,44 € por kWh.

¿Qué ventajas proporciona la ejecución de una instalación solar?

En primer lugar, económicas, pues para unas mismas necesidades, se ahorra el pago a la compañía eléctrica por la energía consumida y se evita el coste del tendido eléctrico o el coste de adquisición del grupo electrógeno y el de compra del propio combustible, o se prima la producción solar eléctrica volcada a la red.

Asimismo y para el caso de empresas, existe la posibilidad de beneficiarse de ciertas bonificaciones fiscales en inversión por ejecución de este tipo de instalaciones.

En segundo lugar, medio ambientales, puesto que la generación de energía con sistemas convencionales posee unos costes ambientales muy importantes (emisiones de CO_2, cambio climático, vertidos, residuos nucleares, lluvia ácida, etc.) en relación a los sistemas solares.

Por último, logísticas y operacionales, dado que la energía generada por los módulos fotovoltaicos no ha de ser producida, transportada ni transformada por las infraestructuras convencionales, lo que redunda en una menor demanda en generación y una menor saturación de las líneas eléctricas.

Además, la energía solar es independiente del abastecimiento del combustible convencional y de la variación de su precio de compra, evitándose por otra parte el riesgo inherente al uso de los combustibles, con posibilidad de fugas, incendios, deflagraciones, etc., tanto en su uso, como en su generación, transporte y distribución.

Por último, la larga vida útil de las instalaciones solares fotovoltaicas, superiores a 25 años, con un mantenimiento, que si bien es necesario realizar, puede ser asumido en parte por el propio usuario de la instalación.

¿Qué inconvenientes posee?

Evidentemente, la energía solar tampoco es la panacea: se trata de instalaciones inicialmente más caras que las tradicionales y además la entrega de electricidad queda limitada por la capacidad de acumulación instalada (si se excede en el consumo puede llegar a producirse el corte de suministro eléctrico).

En cualquier caso, siempre se necesitará de un instalador que ejecute su trabajo adecuadamente, conociéndose la existencia de instalaciones que no han dado los resultados esperados únicamente debido a haber sido montadas por profesionales sin experiencia y/o conocimientos no suficientes.

Otro “inconveniente” consistiría en que el usuario debe ser consciente de la instalación que posee, es decir, que necesita de unas operaciones de vigilancia y mantenimiento, mínimas, pero que han de realizarse.

Resumiendo, ¿Realmente la energía solar funciona?

Sin lugar a dudas. El principio de funcionamiento no puede ser más sencillo y fiable, las garantías ofrecidas por los fabricantes de módulos superan los 20 años, los paneles funcionan aún cuando no hay sol directo, hay instalaciones montadas desde hace más de 20 años, existen equipos que permiten demostrar su funcionamiento y, no podemos olvidar, que España entera es el país del sol.

Y todo ello, siempre y cuando los equipos estén correctamente dimensionados, instalados y mantenidos.

Además, las instalaciones solares están formadas por los mismos componentes y equipos que las instalaciones convencionales, y éstas están suficientemente probadas y aceptadas por profesionales y opinión pública, siendo el único elemento diferenciador el módulo fotovoltaico, cuyo funcionamiento está sobradamente contrastado, con un nivel de garantía que no es alcanzado por ningún equipo convencional (superior a 20 años).

Asimismo, en ciertas aplicaciones de alta exigencia técnica su uso está ampliamente aceptado y probado (satélites espaciales).

Por último, los riesgos inherentes a las instalaciones no van más allá de una descarga eléctrica, en comparación con los ya comentados en las instalaciones convencionales.

¿Qué se necesita para realizar una instalación solar fotovoltaica?

Los componentes principales de las instalaciones solares fotovoltaicas son los módulos fotovoltaicos, el acumulador (baterías eléctricas), el regulador y el inversor (que transforma la corriente continua generada por el módulo en corriente alterna).

Así, para poder realizar una instalación solar es necesario disponer de una superficie libre de sombras y orientada al sur para ubicar los módulos fotovoltaicos, los cuales se instalan con una inclinación de 30 a 50º respecto a la horizontal dependiendo de los casos.

El elemento clave de la instalación solar, a excepción del panel solar, es el acumulador, equipo que guarda la energía producida por los paneles para que sea utilizada cuando el consumidor la demande. La cantidad de energía que ha de almacenarse depende de las horas de diferencia que existe desde que se genera en los módulos hasta que es consumida por el usuario y el grado de seguridad que se desee para la cobertura aportada por el sistema solar.

Acumuladores eléctricos y equipos electrónicos de una instalación fotovoltaica aislada

Significar que el acumulador puede llegar a representar un cierto peso concentrado y requerir ciertas medidas de seguridad para su instalación (ventilación, imposibilidad de contacto con el agua, etc.)

Apoyo Institucional a la Energía Solar

La Junta de Castilla y León apoya al mercado de la energía solar mediante lo que se conoce como Plan Solar de Castilla y León, conjunto de actuaciones de diferentes tipos que persiguen el desarrollo del sector actuando sobre las empresas instaladoras locales, la sensibilización e información a los usuarios, los programas de ayudas, etc.

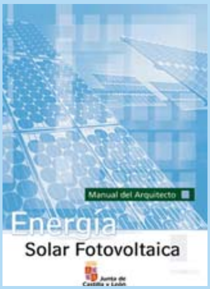
El Plan Solar de Castilla y León nace con el único objetivo de potenciar el desarrollo de la energía solar en la Comunidad Autónoma, estableciendo para ello una acción integral que aúne tanto aspectos financieros, como técnicos y administrativos.

De este modo, el aprovechamiento de los recursos propios, inagotables y sin ningún impacto ambiental se ven impulsados desde la Consejería de Economía y Empleo, de forma que se cree una cultura que favorezca la coparticipación y corresponsabilidad de los ciudadanos en la utilización de las energías renovables.

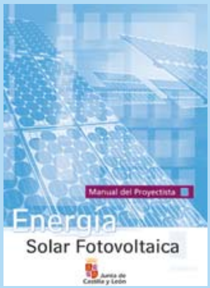
Cuantitativamente, el Plan Solar prevé que en el año 2010 nuestra Comunidad cuente con una potencia instalada de 12.000 kWp.

Para lograr dichos objetivos, la Junta de Castilla y León subvenciona, en convocatorias anuales, la adquisición de instalaciones solares fotovoltaicas y eólico - fotovoltaicas aisladas (no conectadas a la red eléctrica de distribución).

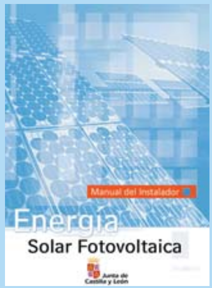
Asimismo, pone a disposición de los principales profesionales del sector (Arquitectos, Proyectistas e Instaladores) manuales de formación específica en este tipo de tecnologías.



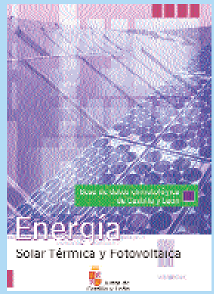
Manual del Arquitecto



Manual del Proyectista



Manual del Instalador



Base de Datos Climatológica de Castilla y León

Para más información pueden dirigirse al Ente Regional de la Energía de Castilla y León (EREN):

Ente Regional de la Energía de Castilla y León
Edificio EREN
Avda. Reyes Leoneses, nº 11
24008 León
Tfn.: 987-84.93.93
Fax: 987-84.93.90
Correo electrónico: eren@jcyl.es

Instalaciones y aplicaciones de Energía Solar Fotovoltaica. Ejemplos prácticos.

Vivienda no permanente

Instalación solar para alimentación de 4 puntos de luz de 20 W cada uno, durante dos días a la semana (bodega).

50 Wp de potencia instalada, batería monoblock de 95 Ah y regulador de 5 A.

Inversión: 1.100 Euros.

Vivienda permanente

Instalación solar con un consumo eléctrico diario de 2.000 Wh (vivienda habitual).

Potencia instalada 1.200 Wp, batería de 6 vasos de 1.500 Ah, dos reguladores de 50 A e inversor de 1.500 W de potencia.

Inversión: 14.400 Euros.

Bombeo directo

Instalación solar para bombeo diario de 28 m^3 de agua a una altura de 30 m.

1.300 Wp de potencia instalada y un inversor de 2.000 W de potencia.

Inversión: 8.800 Euros.

Instalación conectada a red de 5 kW

Instalación solar para venta de la energía generada a la red general de distribución.

Potencia instalada 5.880 Wp e inversor de 5.000 W de potencia.

Inversión: 42.500 Euros.

Producción anual estimada (primada con 0,440381 Euros/kWh): 7.650 kWh.

Instalación conectada a red de 100 kW

Instalación solar para venta de la energía generada a la red general de distribución.

Potencia instalada 104,4 kWp e inversor de 100 kW de potencia.

Inversión: 620.000 Euros.

Producción anual estimada (primada con 0,440381 Euros/kWh): 135.750 kWh.

energía solar fotovoltaica

Junta de Castilla y León

EREN
ENTE REGIONAL DE LA ENERGÍA
DE CASTILLA Y LEÓN

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Anexo IV Reconsideraciones económicas sobre energía fotovoltaica

Morgan Bazilian, IjeomaOnyeji, Michael Liebreich, Ian MacGill, Jennifer Chase, Jigar Shah, Dolf Gielen, Doug Arent, Doug Landfear, and Shi Zhengrong

Re-considering the Economics of Photovoltaic Power

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Abstract: We briefly consider the recent dramatic reductions in the underlying costs and market prices of solar photovoltaic (PV) systems, and their implications for decision-makers. In many cases, current PV costs and the associated market and technological shifts witnessed in the industry have not been fully noted by decision-makers. The perception persists that PV is prohibitively expensive, and still has not reached 'competitiveness'. We find that the commonly used analytical comparators for PV *vis a vis* other power generation options may add further confusion. In order to help dispel existing misconceptions, we provide some level of transparency on the assumptions, inputs and parameters in calculations relating to the economics of PV. The paper is aimed at informing policy makers, utility decision-makers, investors and advisory services, in particular in high-growth developing countries, as they weigh the suite of power generation options available to them.

Keywords: Photovoltaics; Energy economics; Energy policy

1. Introduction

In this paper we seek to provide a measure of clarity and transparency to discussions regarding the present status and future potential of PV system economics. In particular, we review a broad and recent range of academic, government and industry literature in order to highlight the key drivers and uncertainties of future PV costs, prices and potential, and establish reasonable estimates of these for decision makers.

Whilst recent dramatic changes in the underlying costs, industry structure and market prices of solar PV technology are receiving growing attention amongst key stakeholders, it remains challenging to gain a coherent picture of the shifts occurring across the industry value chain around the world. Reasons include: the rapidity of cost and price changes, the complexity of the PV supply chain, which involves a large number of manufacturing processes, the balance of system (BOS) and installation costs associated with complete PV systems, the choice of different distribution channels, and differences between regional markets within which PV is being deployed. Adding to these complexities is the wide range of policy support mechanisms that have been utilised to facilitate PV deployment in different jurisdictions. In a number of countries these policies have become increasingly politically controversial within wider debates on public subsidies and climate change action. As such, the quality of reporting and information on the PV industry economics can vary widely.

PV power generation has long been acknowledged as a clean energy technology with vast potential, assuming its economics can be significantly improved. It draws upon the planet's most abundant and widely distributed renewable energy resource – the sun. The technology is inherently elegant – the direct conversion of sunlight to electricity without any moving parts or environmental emissions during operation. It is also well proven; PV systems have now been in use for some fifty years in specialised applications, and for grid connected systems for more than twenty years. Despite these highly attractive benefits and proven technical feasibility, the high costs of PV in comparison with other electricity generation options have until now prevented widespread commercial deployment. Much of the deployment to date has been driven by significant policy support such as through PV feed-in tariffs (FiTs), which have been available in around 50 countries over recent years (REN 21, 2011).

Historically, PV technologies were widely associated with a range of technical challenges including the performance limitations of BOS components (e.g., batteries, mounting structures, and inverters), lack of scale in manufacturing, perceived inadequate supply of raw materials, as well as economic barriers - in particular high upfront capital costs. While the industry was in its infancy - as recently as five years ago global cumulative installation was about 16 GW - this characterisation had merit (EPIA, 2011a). Now, with rapid cost reductions, a changing electricity industry context with regard to energy security and climate change concerns, increasing costs for some generation alternatives and a growing appreciation of the appropriate comparative metrics, PV's competitiveness is changing rapidly. As an example, large drops in solar module prices have helped spur record levels of deployment, which increased 54 percent over the previous year to 28.7 GW in 2011. This is ten times the new build level of 2007.

At least some of the confusion over the economics of PV has stemmed from the way PV costs (and prices) are generally analysed and presented. Primarily, this has been done using three related metrics, namely: the price-per-watt (peak) capital cost of PV modules (typically expressed as $[1]/W), the levelized cost of electricity (LCOE) (typically expressed as $/kWh), and the concept of 'grid parity'. Each of these metrics can be calculated in a number of ways and depend on a wide range of assumptions that span technical, economic, commercial and policy considerations. Transparency is often lacking in published data and methodologies. Importantly, the usefulness of these three metrics varies dramatically according to audience and purpose. As an example, the price-per-watt metric has the virtue of simplicity and availability of data, but has the disadvantages that module costs do not translate automatically into full installed system costs, different technologies have different relationships between average and peak daily yields, and there is always the question of whether costs quoted are manufacturers' underlying costs versus wholesale costs or retail price[2].

LCOE and 'grid parity' are of special relevance to government stakeholders but require a wider set of assumptions. They vary widely based on geography and on the financial return requirements of investors, and do not allow for robust single-point estimates. Instead, sensitivities are normally required (yet rarely presented), as are explicit descriptions of system boundaries. The financial case for PV depends on the financing arrangements and terms available, as well as estimates of likely electricity prices over the system lifetime. And often the distinction between wholesale and retail prices is not made clearly. Further, the capabilities of key decision makers

[1] We use the symbol $ to mean US dollars.

[2] There are further potential complexities between cost and price – in one common definition of these terms, for a seller price is what you sell a product or service for, and cost is what you paid for it. For a buyer, price is often used to mean what you pay for a good or service while cost includes ongoing expenditure over its life. Clearly there are considerable opportunities for confusion.

vary greatly in different PV market segments, spanning utility investors for large-scale PV farms to home owners contemplating whether to install roof-top PV systems. There is, thus, a clear requirement for greater transparency in presenting metrics so that they can be usefully compared or used in further analysis.

The aim of this paper is two-fold: first, we attempt to highlight some of the issues that are most critical for decision-makers using the common metrics. Second, we aim to inform policy and investment decision-makers about the best estimates of current costs of PV. This short paper does not address the more general power system issues which need to be dealt with in order to achieve significant PV deployment (e.g., integration, ancillary service provision, or power storage), or does it address the context or impetus behind the drive for increased renewable energy usage (e.g., climate change, or energy security).

The remainder of the paper begins with Section 2, in which a narrative of the dramatic shifts the PV industry has experienced in recent years is presented. Section 3 previews the cost of PV power as described in the literature and compares this to updated estimates. In section 4 we highlight the sensitivity of the LCOE metric to input parameters and assumptions. Section 5 considers complexities surrounding the concept of PV 'grid parity'. Section 6 suggests cause for optimism in the PV industry and briefly discusses policy implications. Section 7 concludes.

2. A dramatic shift

From 2004 to Q3 2008, the price of PV modules remained approximately flat at \$3.50-\$4.00/W, despite manufacturers making continuous improvements in technology and scale to reduce their costs. Much of this can be attributed to the fact that the German, and then Spanish, tariff incentives allowed project developers to buy the technology at this price, coupled with a shortage of polysilicon that constrained production and prevented effective pricing competition. The 18 largest quoted solar companies followed by Bloomberg made average operating margins of 14.6%-16.3% from 2005 to 2008[3].

Consequently, both polysilicon companies and downstream manufacturers expanded rapidly. When the Spanish incentive regime ended abruptly at the end of September 2008, global demand stayed roughly flat at 7.7 GW in 2009, from 6.7 GW in 2008, while polysilicon availability increased at least 32%; enough to make 8.5 GW of modules, with an additional 1.6GW of thin film production. As a consequence of this sudden need to compete on price, wafer and module makers gave up some of their margins, and the price fell rapidly from \$4.00/W in 2008 to \$2.00/W in 2009. The ability of manufacturers to drop their prices by 50%, and still make a positive operating margin, was due to the reductions in costs achieved over the previous four years, driven by scale and advances in wafer, cell and module manufacturing processes, as well as to improved performance resulting from better cell efficiencies and lower electrical conversion losses (Wesoff, 2012).

Since 2004, regardless of module prices, system prices have fallen steadily as installers achieved lower installation and maintenance costs due to better racking systems (IPCC, 2012), and falling BOS costs (Bony et al., 2010). In addition, financing costs have fallen, due, in part, to an improved understanding ofand comfort with, PV deployment risk (NEA et al., 2005; WEF, 2011). It is important to highlight the impacts of recent excess production capacity. In such situations,

[3] Much of the data and graphs in this paper were provided by Bloomberg New Energy Finance (BNEF) and are not otherwise disclosed to the public.

prices can fall to the level of marginal production costs, or even below - the Coalition for American Solar Manufacturing, claimed that, "Chinese manufacturers are illegally dumping crystalline silicon solar cells into the U.S. market and are receiving illegal subsidies" and brought a case resulting in US import tariffs being levelled on China modules in 2012 (Bradsher and Wald, 2012). Regardless of the subsidy situation, there is at least 50 GW of cell and module capacity globally, and an estimated 26-35 GW of demand, for 2012. The implications for future PV pricing are potentially significant, as industry participants fail or consolidate (Sarasin, 2011). In Germany alone, two major solar companies have announced bankruptcy between December 2011 and end of April 2012 (Q-cells and Solon). US firm First Solar closed its European operations in April 2012, and the media has focused on the high profile US based thin film start-up Solyndra bankruptcy in August 2011.

For the first time, in late 2011, factory-gate prices for crystalline-silicon (c-Si) PV modules fell below the $1.00/W[4] mark (Bloomberg, 2012); moving towards the benchmark of $1.00/W installed cost for PV systems, which is often regarded in the PV industry as marking the achievement of grid parity for PV (Lushetsky, 2010; U.S. DOE, 2010, 2012; Yang, 2010; Laird, 2011)[5]. These reductions have taken many stakeholders, including industry participants, by surprise. Many policy makers and potential PV buyers have the perspective that that solar PV is still far too costly on an unsubsidized basis to compete with conventional generation options, and this confusion is exacerbated by the solar industry positions, which, when consulted by policy-makers and regulators, have generally recommended high tariffs. Some have argued that prices are currently below sustainable levels and might even have to rise slightly as the industry consolidates and seeks to return to profitability (e.g., Mints, 2012b); however technological advancements, process improvements, and changes in the structure of the industry suggest that further price reductions are likely to occur in coming years.

3. Price per watt

The most fundamental metric for considering the costs of PV is the price-per-watt of the modules. PV module factory prices (Figure 1) have historically decreased at a rate (price experience factor) of 15-24%[6][7] (IEA, 2010; Zweibel, 2010; IPCC, 2012); the higher figure refers to an inflation-indexed calculation. If one assumed a $3.00/W average 2003 price, experience curves would suggest prices might have fallen to $1.01/W by early 2012[8]. However, primarily because of silicon shortages, module prices temporarily increased to $3.88/W in 2008 before declining to below $2.00/W by December 2009 in some instances. They then fell a further 14% in 2010 (REN 21, 2011). As of April 2012, the factory-gate selling price (ex-VAT) of modules from 'bankable' or "tier 1" manufacturers was $0.85/W for Chinese multicrystalline silicon modules, $1.01/W for non-Chinese monocrystalline silicon modules, with thin film modules and those from less well-

[4] Throughout the text, W is synonymous with W_p (watt-peak), which is defined as the DC watts output of a solar module as measured under specified laboratory illumination conditions (Green, 1998). We do not discuss the varying affects of temperature on different cell technologies on PV performance.

[5] There is still at least another $1.00/W or so BOS and installation costs.

[6] This means that the price reduced by 15-24% for each doubling of cumulative sales.

[7] Production costs vary among the different PV module technologies but these cost differentials are less significant at the system level; they are expected to converge in the long-term (IEA, 2010).

[8] The anticipated experience curve is represented by the linear regression fit in Figure 1. Note, however, that in reality the data points between around 2003 and 2010 were not on that line, for the most part due to the cost impact of silicon shortages.

known suppliers even cheaper. Depending on the market, distributors of these modules can take a considerable margin, buying at the factory-gate price and selling at the highest price the market can support ('value-based pricing').

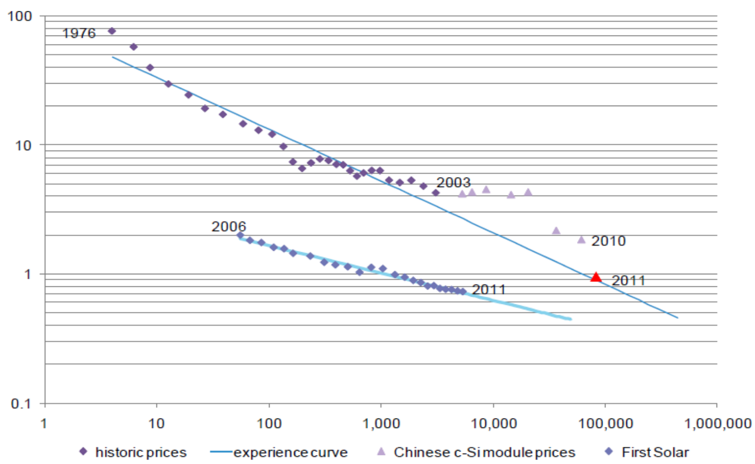

Figure 1: PV module experience curve 1976-2011 (BNEF, 2012a).

A closer look at one type of module (Chinese c-Si) shows the dramatic change in the price curve since 2008 (Figure 2). Historically, modules had a share of around 60% of the total PV system cost (Wang et al., 2011), but due to the extraordinary decline in module prices since 2008, its share in the total installed system cost has since decreased (Hoium, 2011). BOS components are now the majority share of the total capital cost-per-watt and therefore represent one of the main potential sources of further PV system cost reductions (Farrell, 2011a).

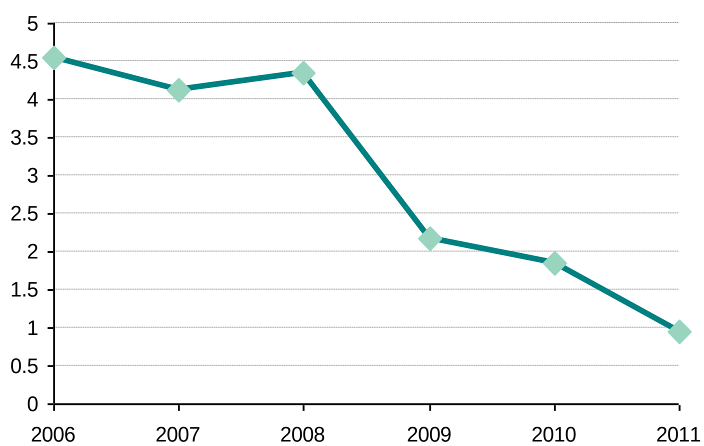

Figure 2: Chinese c-Si PV module prices ($/W): Note the change in the slope of the curve since 2008.

In order to provide further granularity, Figure 3 shows a typical breakdown of a Chinese multicrystalline silicon module in April 2012. (This price is nearly $0.10/W lower that than that of international multicrystalline silicon modules, mainly due to significantly lower processing costs per watt of ingot and wafer, cell and module.)

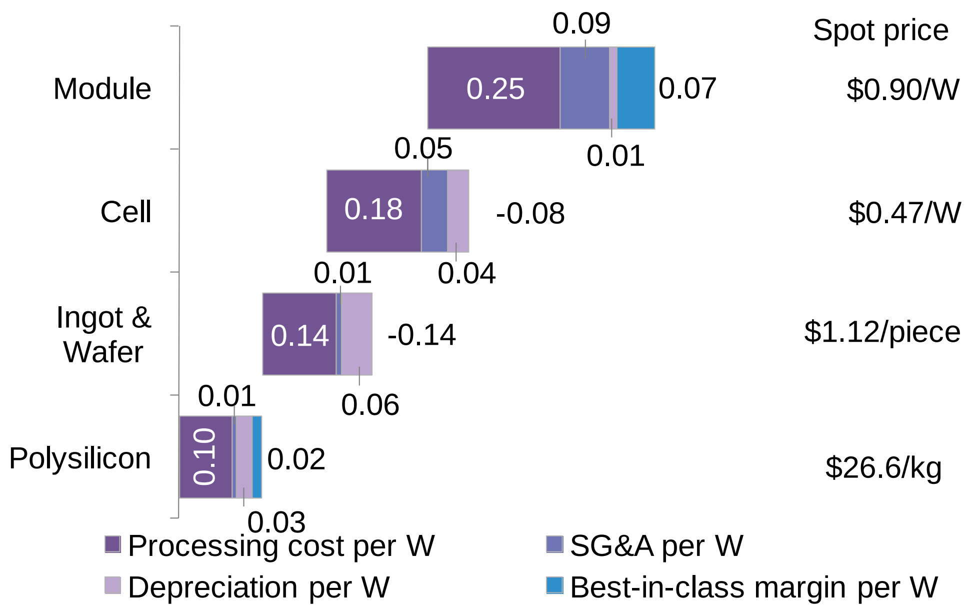

Figure 3 Chinese multicrystalline silicon module cost build-up (assuming 6.0g of silicon per watt of wafer), April 2012 (BNEF, 2012a).

Silicon costs, making up about 20% of the total module cost today, have had a significant impact on PV cost declines as they dropped from temporary highs of more than $450/kg in 2008 to currently (Q1, 2012) less than $27/kg (see Figure 4, and Fessler, 2012).

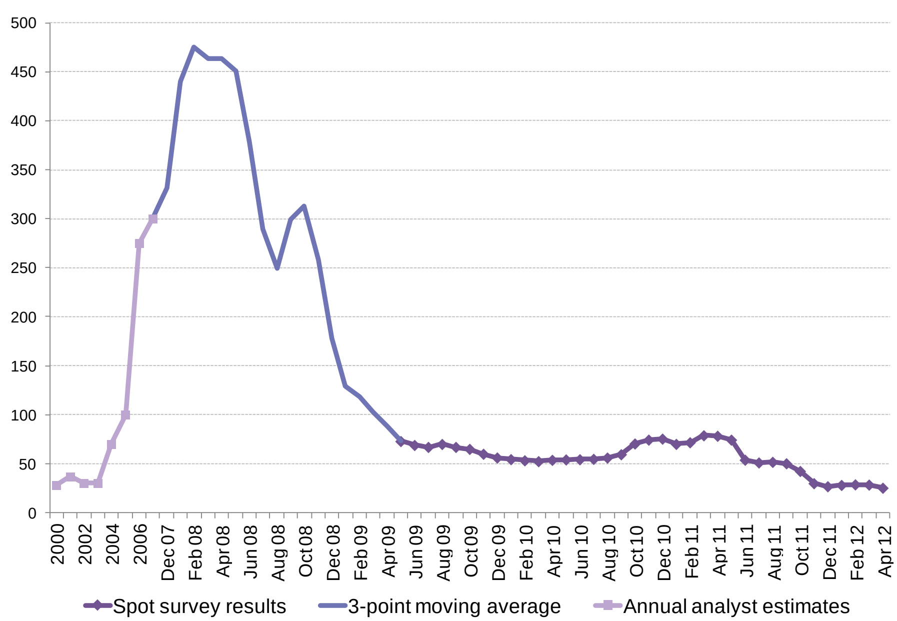

Figure 4: Spot price of solar-grade silicon ($/kg) (BNEF, 2012a).

On average, prices of wafers dropped from just below $1.00/W in 2009 to $0.35/W in Q1 2012, and those of cells declined from $1.30/W in 2009 to $0.55/W in Q1 2012. The BOS components experienced a 19% to 22% learning rate (IPCC, 2012). The price of its single largest component, the inverter, dropped from an average of $0.29/W in 2007 to under $0.20/W in some cases in Q1 2012 (IPCC, 2012; BNEF, 2012). Note the price difference in scale: inverters for a residential system currently still cost around $0.29, while those for commercial and utility scale systems cost $0.19/W and $0.18/W, respectively. According to Bony et al. (2010) the average cost of BOS (including installation) in 2010 ranged from $1.6/W for a ground-mounted system to $1.85/W for a rooftop system. The BOS cost for a 10 MW, fixed tilt, multi c-Si project in the US is reported to be $1.43/W and for a 10 MW, fixed tilt, CdTe project $1.54/W (Greentech Media, 2011). These examples show how many descriptors one needs to cite in order to provide full transparency in any presentation of this seemingly simple metric.

Our discussion so far has focused on crystalline and multicrystalline products, however the thin film PV industry raised its market share from 6% in 2005 to 20% in 2009 (IPCC, 2012). Its share was subsequently reduced to 13% in 2010 and further to 11% in 2011 (REN 21, 2011; Shiao, 2012). Thin film production increased by a record 63% to reach 2.3 GW in 2010. *PVxchange* module retail spot market reports March 2012 thin film module prices between $0.79/W for CdS/CdTe to $0.92/W for a-Si/μ-Si modules (pvXchange, 2012). Modules from First Solar, based on cadmium telluride (CdTe) and making up the bulk of global thin film shipments, have been successful due to a low cost position, but have also come under pressure in 2012 as crystalline silicon prices dropped.

4. Levelized Costs

If keeping up with fast-paced PV equipment cost and price changes is challenging, even more care is required in interpreting levelized cost of electricity calculations. There is a large literature on this subject (see e.g., Pollard, 1979; Rosenblum, 1983; Pouris, 1987; Landis, 1988; Thornton and Brown, 1992; Roth and Ambs, 2004; NEA et al., 2005; Canada et al., 2005; Moore, 2005; Simons et al., 2007; Bazilian and Roques, 2008; Bishop and Amaratunga, 2008; Myers et al., 2010; Singh and Singh, 2010; Yang, 2010; Zweibel, 2010; IEA et al., 2010; Ramadhan and Naseeb, 2011; Branker et al., 2011; Wang et al., 2011; Darling et al., 2011; Eldada, 2011; Timilsina et al., 2012; Mandhana, 2012). While the economic feasibility of a particular energy generation project is typically evaluated by metrics, such as ROI or IRR, the LCOE is most commonly used by policy makers as a long term guide to the competitiveness of technologies[9]. LCOE analysis considers costs distributed over the project lifetime and as such supposedly provides a more accurate economic picture, which system operators prefer over a simple capital cost-per-watt calculation[10]. A particularly important extension is that LCOE requires an estimate

[9]Long Run Marginal Cost (LRMC) is another metric used to calculate economic feasibility of a PV project. Many utilities use LRMC instead of LCOE. For an example of the use of LRMC, please refer to Simhauser (2010). What tool is used depends on the time horizon and perspective of the potential decision-maker. The differences between short-run and long-run marginal costs are covered in NEA et al. (2005).
[10]Useful references for recent, more elaborate work on LCOE calculation methods and/or analysis include: NEA et al. (2005); Lazard (2008); IEA et al. (2010); Singh and Singh (2010); Zweibel (2010); Branker et al. (2011); Darling et al. (2011); Wang et al. (2011).

of long-term PV system performance – a very context-specific outcome, driven by factors including solar insulation at the site, component technologies and specifications, overall system design and installation, and maintenance.

The LCOE for PV c-Si has declined by nearly 50% from an average of $0.32/kWh early 2009 to $0.17/kWh early 2012, while that for PV thin film experienced a drop from $0.23/kWh to $0.16/kWh in the same period. According to BNEF, the current (Q1, 2012) levelized cost ranges from $0.11/kWh to $0.25/kWh. Since the sharp drop in module costs in 2008, the literature on LCOE estimations for PV has grown substantially – we present some of it here. Under a range of financing assumptions and locations, the U.S. DOE estimated a PV LCOE of approximately $0.10/kWh to $0.18/kWh[11] for utility-scale, $0.16/kWh-$0.31/kWh for commercial systems and $0.16/kWh-$0.25/kWh for residential PV systems (NREL, 2009). The U.S. Energy Information Administration's (EIA) estimates range from $0.16/kWh to $0.32/kWh. Zweibel (2010) calculates a cost of PV electricity in the U.S. Southwest of $0.15/kWh. Running the Solar Advisor Model (SAM), Wang et al. (2011) obtain a LCOE of $0.11/kWh. Calculating LCOE for PV based on input parameter distributions feeding a Monte Carlo simulation, Darling et al. (2011) find an average LCOE of $0.09/kWh, $0.10/kWh and $0.07/kWh for Boston, Chicago and Sacramento, respectively. The US DOE Solar Program's Technology Plan aims at making PV-generated power cost-competitive with market prices in the USA by 2015. Their energy cost targets are $0.08-$0.10/kWh for residential, $0.06-$0.08/kWh for commercial and $0.05-$0.07/kWh for utility-scale solar PV (Asplund, 2008; IPCC, 2012). Branker et al. (2011) estimate a PV LCOE range for Ontario, Canada, of $0.10/kWh-$0.15/kWh[12]. LCOE estimates for PV in Africa by Gielen (2012) range from $0.20/kWh to $0.51/kWh. Schmidt et al. (2012) estimate PV LCOEs for six developing countries ranging from approximately $0.20-$0.35/kWh in 2010. In general, the LCOE range found in the literature extends from around $0.10/kWh to $0.30/kWh for most contexts.

Despite the substantial drop in PV costs, many commentators continue to note that PV-generated power is prohibitively expensive unless heavily supported by subsidies or enhanced prices (see e.g., Asplund, 2008; IEA et al., 2010; Singh and Singh, 2010; IPCC, 2012; Lomborg, 2012; Neubacher, 2012; Timilsina et al., 2012). Outdated numbers are still widely disemminated to governments, regulators and investors. Yang (2010), for example, calculates PV with a levelized cost of $0.49/kWh. Timilsina et al. (2012) find that the minimum values of LCOE for PV are $0.19/kWh. This sort of data often contrasts sharply with prices submitted in response to Dutch auctions for solar projects around the world, where developers bid to supply solar power at the lowest price. As an example, $0.12/kWh was bid in the Peru tender in August 2011, $0.11/kWh in China in September 2010 and $0.15/kWh in India in April 2012. At the end of March 2012, both SCE and PG&E in the US filed advice letters asking for approval of contracts: of the winning bids for 11 contracts, 9 were for PV, with the highest executed contract price of $0.09/kWh[13] (PG&E, 2012; SCE, 2012). In interpreting these auction results it is important to note that their results may reflect the impact of fiscal incentives and not be directly comparable to LCOEs. In addition, it is not always clear if the backers of these projects intend to make normal

[11] Note that some LCOE figures from the US quoted in this paper may be post-Federal tax rebates and may also include local capex rebates in some cases.

[12] The majority of estimates (presented here and) found in the literature are for the North American region. See Branker et al. (2011) for a comprehensive summary of LCOE estimates from various sources in North America.

[13] While this is the highest clearing price and individual contract prices could be even lower, note that federal tax credits likely make these prices look lower than they would otherwise be.

financial returns. As we will discuss, the fossil fuel or nuclear generation costs that are often used in comparisons may not be equivalent, for a wide range of reasons.

Standard definitions have been proposed for the LCOE method, such as those by IEA (NEA et al., 2005) or NREL (System Advisor Model (SAM)[14] and Levelized Cost of Energy Calculator[15]). Nevertheless, as discussed by Branker et al. (2011), the method "is deceptively straightforward and there is lack of clarity of reporting assumptions, justifications showing understanding of the assumptions and degree of completeness, which produces widely varying results". Darling et al. (2011) suggest using input parameter distributions rather than single numbers in order to obtain a LCOE *distribution*, rather than a single number, as a means of increasing transparency by reflecting cost uncertainty associated with solar projects. Other, more sophisticated methods exist (see e.g., Bazilian and Roques, 2008), but LCOE persists as a widely-used metric[16].

There is ample variation in the underlying LCOE assumptions found in the literature (Queen's University, 2011). For example, the capital cost for PV systems in the more current literature can range from $5.00/W[17] to $2.00/W[18]. While PV modules are generally warranted for 25 or more years (Zweibel, 2010), research suggests that a 40 year lifetime has been demonstrated and that 50 years may be within reach with today's crystalline technology (IEA, 2010). O&M costs for a utility-scale PV plant can range from $10/kW/year to $30/kW/year; this range may be partly due to differences in the scope of services provided under an O&M contract. (see e.g., Lazard, 2008; Darling et al., 2011; NREL, 2011). The Weighted Average Cost of Capital (WACC)[19] is normally used as a discount rate to determine the net present value of the PV power generation cost[20] but it can vary widely with the type of project owner, the nature and stability of regulatory regimes, and regional differences in cost of capital.

BNEF (on behalf of WEF (2011)) identify the most important determining factors of the levelized cost as being capital costs, capacity factor, cost of equity, and cost of debt. Sensitivity results presented by IEA et al. (2010) draw similar conclusions (see Figure 5), showing that levelized costs of power generated by PV exhibit a particularly high sensitivity to load factor variations, followed by variations in construction costs and discount rate. Singh and Singh (2010) analyze the impact of the choice of loan method on LCOE, identifying the loan repayment method as one high-impact assumption. The results of a rank correlation analysis undertaken by Darling et al.

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[14]https://sam.nrel.gov/.
[15]http://www.nrel.gov/analysis/tech_lcoe.html.
[16]LCOE is especially problematic for fossil fuel based generators as assumptions have to be made around future costs of fuel, and costs of associated volatility and uncertainty. Methodologies such as Real Options are beyond the scope of this paper, but are very useful in providing better understanding decision-making in power markets.
[17]Stuart (2011) reports $5.60/W on the high-end for a 5 to 20 MW system between 2008 and 2010. The summary of recent solar PV installed system costs compiled by Branker et al. (2011) ranges from $3.52/W to $5.02/W for utility-scale PV. See Goodrich et al. (2012) for a comprehensive study on residential, commercial and utility-scale PV systems in the US. Barbose and Wiser (2011) report installed costs in 2011 for large-scale PV projects in the range of $3.80/W to $4.40/W.
[18] Figures as low as $1.80/W are appearing (the reputed installed cost in India for 5MW projects according to EPC data from AnSol and SunEdison).
[19] See NEA et al. (2005) for a discussion of technology specific discount rates. For references on the cost of capital, see e.g., Ogier et al. (2004) or Pratt and Grabowski (2010).
[20] Note that this assumption is location and time-dependent as it includes prior assumptions on figures, including real risk free debt, debt risk premium, real and nominal cost of debt, equity risk premium, equity beta, real pre- and post-tax cost of equity, etc. Analyses in the literature abstracting from financing issues often assume 5% and 10% discount rates.

(2011) indicate that financial uncertainties (e.g., variation of discount rate) are a major determining factor of LCOE, followed by system performance (including geographical insolation variation), which equally represents a major contributor to the uncertainty in LCOE.

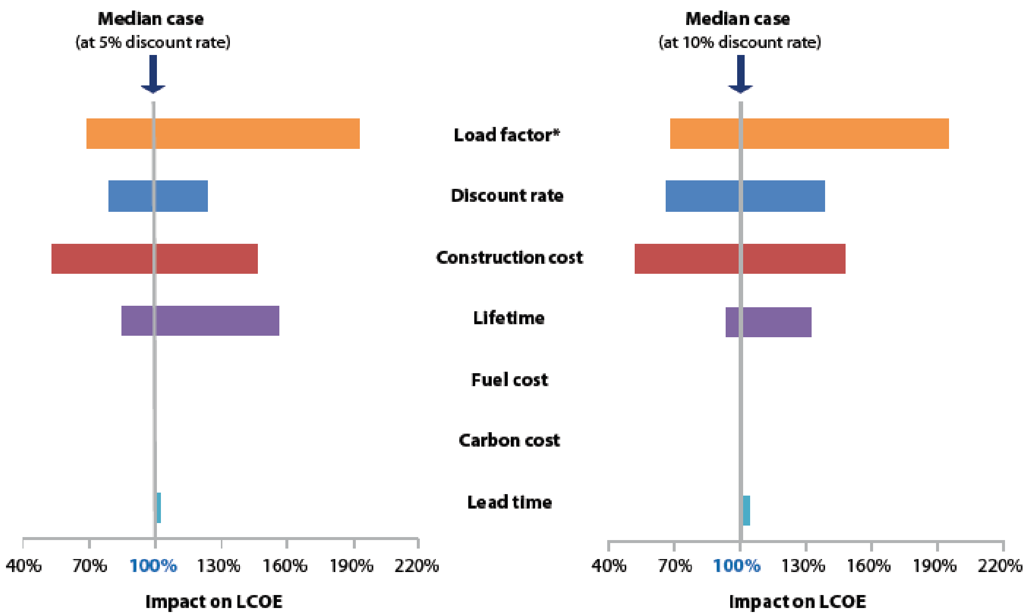

Figure 5: Tornado graph PV LCOE (IEA et al., 2010).

4.1. Power system comparisons

In addition to the complexities of providing clear PV LCOE figures, significant discrepancies between the underlying characteristics and economics of different power generating technologies, as well as of the markets they serve, make it difficult to directly compare project-by-project on a levelized basis. As an example, the Emirates Solar Industry Association (ESIA, 2012) show that based on current market rates, the LCOE from solar PV in typical MENA climates is estimated to be $0.15/kWh. At this level, PV is cheaper on a simple LCOE basis than open-cycle peaking units at gas prices higher than $5.00/MMBtu[21]. PV has, in fact, already replaced some peaking plants. In 2009, the California Energy Commission (CEC) rejected a contract for a new plant in San Diego in favour of a PV solar system that would lower the cost of electricity for ratepayers (Ahn and Arce, 2009). The key challenge lies in establishing the underlying place of different technologies within the power dispatch curve, and in the differing ways in which the resulting economics flow through into wholesale and retail electricity prices.

The primary focus within the electricity industry is on what value a particular technology brings to a power system. This can depend on the nature of demand, the network, and the mix of existing generation and its operating rules. Rapidly dispatchable peaking plant has a particularly high value for electricity networks with infrequent periods of very high demand. PV generation, in some locations, matches periods of higher demand and hence can be of high value, but its output

[21] That might appear as a surprising result given the significant investments underway in gas-fired peaking plant around the world including very sunny regions.

is generally variable and only somewhat predictable – a considerable disadvantage in an industry where supply must precisely meet demand (and losses) at all times and locations within the grid (IEA et al., 2010; Joskow, 2010; MacGill, 2010). The coherence of underlying economics and commercial returns for different technologies within an electrical grid adds further complexity for investment analysis, as italso depends on electricity market design and the design of any supporting PV policies.

Even at comparable levelized costs and with commercially proven technologies, differing risk profiles of different technologies also have a large impact on the viability of the project (NEA et al., 2005). The perceived risk of a technology is directly related to how, and at what costs of capital, projects are financed. Similarly, uncertainty in future fuel and electricity prices impacts differently on the profitability of different technologies (Bazilian and Roques, 2008). While gas-fired technologies, for instance, are particularly sensitive to fuel prices and price volatility (since fuel costs constitute the majority of generation costs), capital-intensive renewables, such as PV, are more sensitive to electricity prices, risk adjusted interest rates, maintenance costs and insolation levels[22].

5. Moving beyond grid-parity

The confusion surrounding the concept of grid parity is perhaps even more significant than either of the other two metrics we have highlighted, yet it remains a cornerstone of PV-related messaging. A new wave of discussions about grid parity has been set off by the recent non-linear price drops (See e.g., Parkinson, n.d.; Yang, 2010; Breyer and Gerlach, 2010; Baillie, 2011; Branker et al., 2011; Hickman, 2011; Seba, 2011; Farrell, 2011b; Shanan, 2012; Trabish, 2012; Carus, 2012; Goffri, 2012; Mints, 2012a). Depending on the scale of the PV project, grid parity normally refers to the LCOE of PV by comparison with alternative means of wholesale electricity provision – often an inappropriate metric as discussed previously. While for large-scale PV, these alternatives may indeed be assessed as alternative wholesale generation projects utilising different technologies, for small-scale domestic or commercial PV systems, the appropriate alternative should be the purchase of electricity at a relevant residential or commercial tariff. The latter case is where grid parity actually took its name – such PV applications are not competing against wholesale generation but, instead, the delivered price of electricity through the grid. Grid parity is not a term that is used for other generation technologies except those that are potentially deployed at small customer premises such as, for example, domestic-sized fuel cells.

As noted with LCOE, however, behind the relatively simple concept of grid parity lies considerable complexity and ambiguity. A particular challenge is the disconnect that is often seen within an electricity industry between underlying economic value, and the actual price for electricity at different points of the supply chain. For example, in wholesale electricity markets the price generally varies over time and by location, and is subject to a range of uncertainties related to the cost of ancillary services, transmission congestion, short-term load regulation, longer-term unit commitment, and contingency management. The competitiveness of large-scale PV in such markets by comparison with other generation options can then depend in large part on how well its intermittent production matches these prices by comparison with other, often dispatchable, plants, what short-term ancillary service implications it poses, and the ability to forecast future production. By contrast, the prices in many retail electricity markets are better

[22] For a detailed discussion of methodologies incorporating risk into cost calculations, see NEA et al. (2005).

described as ‘schedules of fees’ involving flat or relatively simple Time-Of-Use (ToU) tariffs that often smear energy and network costs for end-users, and smear overall costs across customer classes through simple accumulation metering and regulated pricing regimes (Elliston et al., 2010). The competitiveness of PV then depends in large part on its LCOE in particular contexts by comparison with the relevant tariffs that system owners and operators would otherwise be paying (Hoke and Komor, 2012)[23]. Additional complexities include the likely trajectory of future retail tariffs (and potentially underlying changes), and the potential challenges of financing small-scale installations by often poorly informed and relatively unmotivated energy users.

Contrary to the view that the arrival of grid parity is still decades away, numerous studies have concluded that solar PV grid parity has already been achieved in a number of countries/regions (see e.g., Breyer and Gerlach, 2010; Zweibel, 2010; Branker et al., 2011; Darling et al., 2011). This discrepancy is not difficult to understand, given the definitional issues we have presented. As mentioned, it is often difficult to ascertain whether the term refers to grid parity, also known as ‘busbar parity’ (i.e., competitiveness with wholesale prices), or ‘socket parity’ (i.e., competitiveness with electricity user prices). Calculations by Bhandari and Stadler (2009) suggested that grid parity of wholesale electricity in Germany will occur around 2013-2014. Branker et al. (2011) find that for Canada, PV grid parity is already a reality (under specific circumstances). Breyer and Gerlach (2010) estimate that grid parity of large industrial segments would start between 2011 and 2013 and occur at the same time in Europe, the Americas and Asia. Similarly, EPIA (2011) forecasts that ‘dynamic’ grid parity[24] could occur around the year 2013 in the commercial segment in Italy, after which it would spread out across the rest of Europe to reach all types of installations and market segments by 2020.

Figure 6 presents data around when certain countries reached and will reach grid parity. It shows, for example, that countries with higher electricity prices, such as Germany, Denmark, Italy, Spain and parts of Australia have already reached socket parity, defined here as the point where a household can make 5% or more return on investment in a PV system just by using the energy generated to replace household energy consumption, while countries like Japan, France, Brazil or Turkey are expected to reach it by 2015[25]. Such a ‘busy’ and non-intuitive graphic serves to demonstrate how difficult a concept it is to communicate – and this places PV at a disadvantage at a time when the industry is seeking to send clear messages on competitiveness in its political communications and government affairs.

[23] Note that although competitiveness is evaluated prior to build out and installation of PV, it has very little to do with how or when PV is dispatched into a market, if in the wholesale system, or aggregated from distributed generation (if allowed). So, while LCOE represents an average cost, the actual price that PV gets is the spot market price - unless under bilateral contracts, offsets ToU retail prices, or fixed rate prices at the distributed generation level.

[24] In EPIA (2011), ‘Dynamic grid parity’ is defined as “the moment at which, in a particular market segment in a specific country, the present value of the long-term net earnings (considering revenues, savings, cost and depreciation) of the electricity supply from a PV installation is equal to the long-term cost of receiving traditionally produced and supplied power over the grid”.

[25] For more detailed information, see Roston (2012).

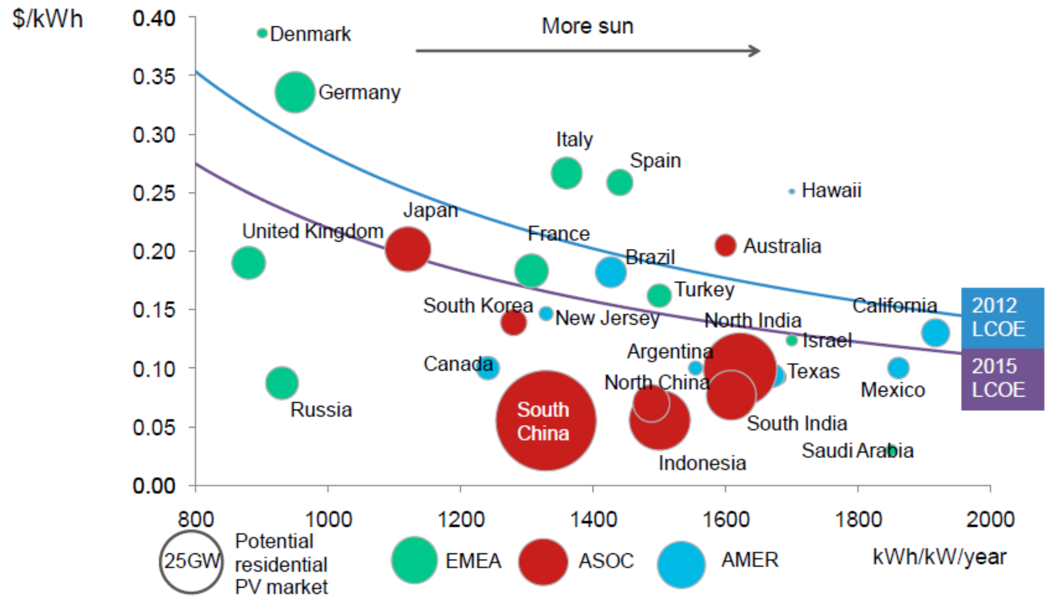

Figure 6: Residential PV price parity (size of bubbles refers to market size) (BNEF, 2012a).
Note: LCOE based on 6% weighted average cost of capital, 0.7%/year module degradation, 1% capex as O&M annually, $3.01/W capex assumed for 2012, $2.00/W for 2015.

6. Cause for optimism

Grid parity is now largely an outdated concept stemming from an industry that has traditionally been used to being an "underdog" of small scale, and constantly fighting for a "level playing field". While the term has served some usefulness as an abstract metric for R&D programmes to strive for, it is not useful in real-world power sector decisions (Mints, 2012b). Since it does not take into account the value of solar PV to the broader electrical industry, and is often used to compare a retail technology against a wholesale price, it implicitly provides a tool for proponents of other technologies to use against PV. Of course standard concepts and practices of assessing commercial viability rely on real data in contracts, financial spreadsheets and bids, remain the norm in transactions – these should replace grid parity in public discourse as well.

Developing countries in particular offer a huge potential market for PV systems. While historically the primary market for PV systems in developing countries has been off-grid applications - mainly individual solar home systems (Hoffmann, 2006; Moner-Girona et al., 2006), a larger market is expected to emerge in the near future for grid-connected PV. For decades, it has been recognised that PV was a good economic alternative in remote (off-grid) industrial applications that rely on diesel power generation, especially to power small electrical loads of up to hundreds of kilowatts (Solarbuzz, 2012). Data from IRENA now indicate that grid-connected PV in Africa has already become competitive with diesel-generated power, with an LCOE between $0.30 and $0.95/kWh, based on size, local diesel subsidies, and pilferage (IRENA, 2012). BNEF (2011) concludes that falling costs in PV technology mean that solar power is already a viable option for electricity generation in the Persian Gulf Region, where it can generate good economic returns by replacing the burning of oil for electricity generation[26].

[26]As long as the unburnt oil is valued at the international selling price, rather than extraction cost.

Similarly, power produced from PV in India is already competitive with power obtained by burning diesel (Pearson, 2012). These and other findings highlight the huge potential of PV in developing countries and indicate that, if not already competitive, PV is rapidly becoming competitive with alternative power generation technologies.

Still, the impacts of decision-makers not understanding the real costs for PV often has led to inefficiencies in, *inter alia*, tariff schemes. If PV power is perceived to be too costly, governments are less likely to take on the financial burden. This was the case in China in 2010, where the anticipated national PV FiT was dropped because solar PV costs were deemed too high[27] (EPIA, 2011b). Other governments introducing new FiT programs are confronted with the challenge of striking the right balance. The Japanese government, for instance, recently adopted a renewable FiT scheme (starting in July 2012) and faced the difficulty of picking an appropriate rate that will stimulate PV investment without overpaying for clean electricity[28] (McCrone and Nakamura, 2012). Alternative mechanisms such as tenders can offer options for addressing the dynamic cost environment, although may have higher risk for development (see e.g., Couture et al., 2010; Elliston et al., 2010; Kreycik et al., 2011). For example, the ACT government recently adopted a reverse auction process for large-scale solar through which developers will be paid their nominated FiT price less the market spot price. This means that as the spot price increases over time, the actual FiT payment will decrease. Collectively ratepayers will pay less FiT throughout the FiT period, although individual households will nonetheless incur higher energy charges as the spot rates increase (ACT Parliamentary Counsel, 2011).

7. Conclusions

The PV industry has seen unprecedented declines in module prices since the second half of 2008. Yet, awareness of the current economics of solar power lags among many commentators, policy makers, energy users and even utilities. The reasons are numerous and include: the very rapid pace of PV price reductions, the persistence of out-of-date data in information still being disseminated (occasionally by those with an interest in clouding the discussion), the misconceptions and ambiguity surrounding many of the metrics and concepts commonly used in the PV industry, and ambiguities regarding underlying PV costs due to the numerous policy support measures that have been put in place over the last decade.

We have presented a large body of academic and industry literature in an attempt to inform policy makers about the current costs and prices of PV, and to lend some clarity to those struggling with understanding the metrics generally used in assessing PV investments. Our main conclusions are that LCOE metrics in the PV industry can be misleading and should therefore be applied with caution as they require careful interpretation and transparency. Furthermore the term ‘grid parity’, the long-sought goal of the PV industry, has become outdated and is generally misleading.

Current PV module prices are considered by some to be below manufacturing cost, and consequently, as unsustainable, in large part because several leading non-Chinese firms in the industry have recently announced losses cutbacks or massive write-downs or filed for bankruptcy (Daily and Steitz, 2011; Daily and Das, 2012; Mints, 2012a, 2012b; Montgomery, 2012; Wesoff,

[27] The Chinese national PV FiT was subsequently announced in August 2011 (see e.g., Gifford (2011)).
[28] Early 2012 Japan decided that solar will receive JPY 42/kWh for 20 years (Quilter, 2012).

2012)[29]. Ultimately, the shift in prices of solar technology carries major implications for decision makers and policy designers, especially for the design of tariff, fiscal and other supporting policies (see e.g., Ahearn et al., 2011). The challenge is to elegantly transition PV from a highly promising and previously expensive option, to a highly competitive player in electricity industries around the world.

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[29] Perhaps there is an analogy to this in the telecommunications industry that experienced sharp falls in telecoms prices in the early 2000s, resulting in several major bankruptcies. Eventually, though, the excess broadband capacity paved the way for an explosive growth in the internet and communications industries. Similarly, whether prices are sustainable today or not, the abundant capacity in the PV industry may likely be laying the foundation for an enormous increase of PV power.

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Anexo V- Documentación de interés de fabricantes.

Seguidor mono-eje.

Seguidor doble eje.

Concentración.

Seguidor solar monitorización de precisión.

Instrumental medida y accesorios

Sistemas fijos e integración arquitectónica

Seguidor mono-eje.

ISOTRACKER SEGUIDOR **MONO - EJE**

Módulo **ISF-250** ISOFOTON + Seguidor **Mono - Eje** AFFIRMA Energy

La combinación de nuestros seguidores de un solo eje y los módulos ISF-250 de última generación, garantizan **un 25% más de producción** en comparación con un sistema fijo, con un sistema de seguimiento y una precisión inferior del 1º. Nuestros seguidores y módulos requieren un mantenimiento mínimo y están cubiertos por la garantía más amplia del mercado.

Módulo ISF-250

ISOTRACKER

Características principales del producto

Vidrio micro estructurado

60 células (156x156 mm)

5.400 Pa

Marco: Aluminio anodizado

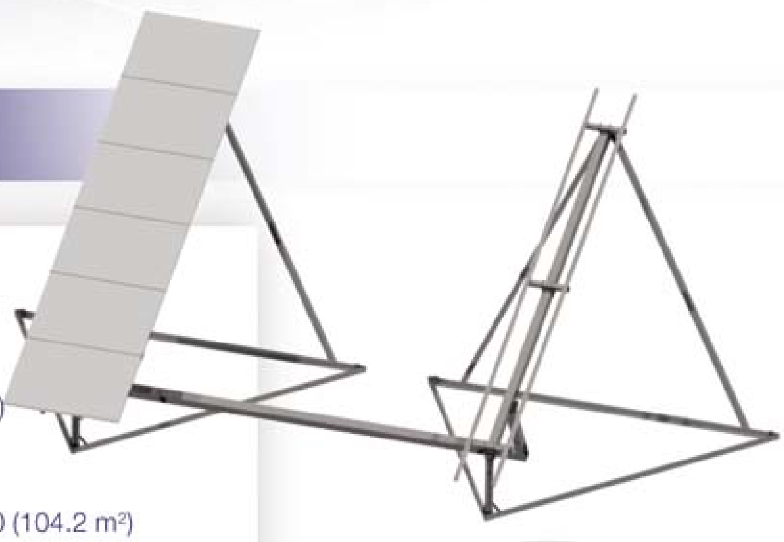
Garantía:

10 años de garantía de producto

25 años de garantía de producción lineal

Certificados de calidad y medioambiente:

Seguidor Mono-Eje



Características principales del producto

Estructura de acero galvanizado en caliente

Modelo (Potencia): V2 (3 kWp), V6 (9 kWp) , V10 (15 kWp)

Ángulo de inclinación: 30°

Superficie máxima (m^2): V2 (20.84 m^2), V6 (62.52 m^2), V10 (104.2 m^2)

Peso máximo permitido: 130 kg / unidad

Rango de movimiento rotación del eje: +/- 45 grados

Número de módulos: Hasta 60 módulos x 250 Wp

Requisitos de entrada de energía: 240VAC, 50 Hz, 3A/8A

Precisión de seguimiento: <1°

Tecnología de control de retroceso que minimiza la pérdida de sombreado

Interfaz de comunicación externa: Ethernet/TCP-IP/GSM - GPRS

Velocidad máxima del viento durante seguimiento: 70 km/h

Velocidad máxima del viento en posición de defensa: 140km/h

Rango de temperatura de funcionamiento recomendada: -20 a 50ºC

Sistema de anclaje: con y sin hormigón (Con contrapesos)

Certificados de producción:

SUNPOWER

SEGUIDOR SOLAR SUNPOWER® T0

MÁXIMA PRODUCCIÓN DE ENERGÍA POR HECTÁREA

VENTAJAS

Máximo de energía por hectárea
De todos los sistemas de seguimiento disponibles en la actualidad, es el que produce la mayor cantidad de energía por hectárea.

Utilización mínima de terreno
Requiere hasta un 20% menos de terreno que los sistemas cristalinos de inclinación fija convencionales y hasta un 60% menos que los de capa fina.

Completamente escalable
Las instalaciones pequeñas se pueden convertir con facilidad en instalaciones extensas de varios megavatios.

Diseño eficiente
El diseño funcional del seguidor solar, combinado con los paneles solares de alta eficiencia de SunPower, suponen la utilización de menos terreno, hormigón, acero y cableado por megavatio.

Fiable y probado
El diseño monoaxial patentado de acero inoxidable permite un seguimiento preciso del sol con menor cantidad de partes móviles.

SEGUIDOR SOLAR SUNPOWER® T0

En 2004, el parque solar alemán Bavaria Solarpark, con 10 megavatios de seguidores solares SunPower T0 instalados, era el más grande del mundo. Hoy en día, los seguidores solares de SunPower son los sistemas para suelo de más probada eficacia del mundo, con más de 250 megavatios de CA instalados en tres continentes.

El Seguidor Solar SunPower T0 combina un diseño monoaxial revolucionario con los paneles solares de alta eficiencia de SunPower para producir la mayor cantidad de energía por hectárea. Dado que se minimiza el sombreado y los seguidores solares se sitúan más cerca unos de otros, el Seguidor Solar T0 requiere un 20% menos de terreno que los sistemas cristalinos convencionales de inclinación fija y un 60% menos que los sistemas de capa fina.

Con un sólido historial de satisfacción o incluso superación de las expectativas de rendimiento en todo el mundo, el Seguidor Solar SunPower T0 produce la mayor cantidad de energía con la menor cantidad de terreno y requisitos de mantenimiento, lo que permite un retorno de la inversión máximo.

SUNPOWER

SEGUIDOR SOLAR SUNPOWER® T0

MÁXIMA PRODUCCIÓN DE ENERGÍA POR HECTÁREA

ESPECIFICACIONES DEL PRODUCTO	
Módulos	Paneles Solares SunPower de 96 células, Paneles Solares SunPower de 72 células o paneles solares de terceros cualificados
Tipo de seguimiento	Monoaxial (con backtracking)
Sistema de control	Sistema Avanzado de Control TMAC de SunPower; comunicaciones y control remotos en tiempo real; seguimiento astronómico con backtracking
Rango de seguimiento	De +45 a –45 grados
Tipo de transmisión	Accionadores lineales eléctricos, cada uno con posibilidad de accionar hasta 250 kWp
kWp por bloque de seguidores	Hasta 250 kWp
Materiales	Acero galvanizado en caliente, cojinetes libres de mantenimiento
Dimensiones por bloque de seguidores	Con paneles solares SunPower de 96 células: Dirección este-oeste: de 88 a 113 m; dirección norte-sur: de 35 a 38 m
Velocidad máxima del viento	177 km/h con rachas de 3 segundos
Índice de cobertura del suelo	De 0,35 a 0,50
Códigos y estándares	NEC, UL, ASCE
Garantía	Garantía total del sistema con servicio in situ

La tecnología de los seguidores solares SunPower está protegida por la patente estadounidense 6.058.930 y por las patentes internacionales 1169604 (Francia, Portugal, España y Reino Unido) y 60015950.7 (Alemania). Puede que sean de aplicación otras patentes estadounidenses o internacionales publicadas o pendientes.

Información acerca de SunPower

SunPower diseña, fabrica y suministra tecnología eléctrica solar de alto rendimiento en todo el mundo. Nuestras células solares de alta eficiencia generan hasta un 50% más de energía que las células solares convencionales. Nuestros paneles y sistemas solares, así como nuestros seguidores de alto rendimiento, generan una cantidad de energía significativamente mayor que los sistemas de la competencia.

www.sunpowercorp.es

Documento n.º 001-57088 Rev.** / A4_ES

SUNPOWER

SEGUIDOR SOLAR SUNPOWER® T20

EL SEGUIDOR SOLAR MÁS POTENTE DEL PLANETA

VENTAJAS

Más energía por seguidor

Genera hasta un 30% más de energía que los sistemas de inclinación fija para suelo.

Implementación simple y modular

Diseñado para una instalación rápida, con una configuración modular y componentes pre-ensamblados.

Bajo impacto

La opción de cimientos de hormigón prefabricados simplifica la instalación al evitar la penetración del suelo, logrando así un impacto medioambiental mínimo.

Diseño eficiente

El diseño funcional del seguidor, combinado con los paneles solares de alta eficiencia de SunPower, suponen la utilización de menos terreno, hormigón, acero y cableado por megavatio.

Fiable y probado

El diseño monoaxial patentado de acero inoxidable permite un seguimiento preciso del sol con menor cantidad de partes móviles.

SEGUIDOR SOLAR SUNPOWER® T20

Con más de 200 megavatios instalados en tres continentes, los seguidores solares de SunPower son los sistemas para suelo de más probada eficacia del mundo. Al implementarse a gran escala con los paneles solares de alta eficiencia de SunPower, el Seguidor Solar SunPower T20 es el más potente del mundo, con la mayor densidad de potencia por seguidor.

El diseño funcional monoaxial ofrece la combinación ideal de rendimiento, instalación escalable y simplicidad. Las diversas opciones de cimentación y su diseño modular con componentes pre-ensamblados facilitan una rápida instalación. El Seguidor Solar T20 minimiza el impacto medioambiental al necesitar tan sólo la mitad de terreno para producir la misma cantidad de energía que los seguidores convencionales de doble eje.

Al seguir el movimiento del sol, el Seguidor Solar T20 produce más energía por kW que cualquier otro sistema de seguimiento monoaxial disponible actualmente en el mercado, lo que permite un retorno de la inversión óptimo. Se puede supervisar y monitorizar de manera remota y en tiempo real gracias al Sistema Avanzado de Control TMAC de SunPower, y se integra perfectamente con los sistemas SCADA de los parques solares, lo que garantiza un funcionamiento de bajo coste.

SEGUIDOR SOLAR SUNPOWER® T20

EL SEGUIDOR SOLAR MÁS POTENTE DEL PLANETA

ESPECIFICACIONES DEL PRODUCTO	
Módulos	9 paneles solares SunPower de 128 células o 12 paneles SunPower de 96 células
Tipo de seguimiento	Monoaxial inclinado (con backtracking)
Ángulo de inclinación	20 grados
Sistema Avanzado de Control	TMAC de SunPower; comunicaciones y control remotos en tiempo real; seguimiento astronómico con backtracking
Rango de seguimiento	De +45 a –45 grados
Sistema de acción	Accionadores lineales eléctricos, cada uno con posibilidad de accionar hasta 48 seguidores (hasta 177,6 kWp)
kWp por seguidor	De 3,5 a 3,7 kWp
Materiales	Acero galvanizado en caliente, cojinetes libres de mantenimiento
Dimensiones: largo x ancho x alto (m)	9,7 x 2,1 x 4,4
Velocidad máxima del viento	Hasta 177 km/h con rachas de 3 segundos
Índice de cobertura del suelo	De 0,20 a 0,24
Códigos y estándares	NEC, UL, ASCE, CE
Garantía	Garantía total del sistema con servicio in situ

La tecnología de los seguidores SunPower está protegida por la patente estadounidense 6.058.930 y por las patentes internacionales 1169604 (Francia, Portugal, España y Reino Unido) y 60015950.7 (Alemania). Puede que sean de aplicación otras patentes estadounidenses o internacionales publicadas o pendientes.

Información acerca de SunPower

SunPower diseña, fabrica y suministra tecnología eléctrica solar de alto rendimiento en todo el mundo. Nuestras células solares de alta eficiencia generan hasta un 50% más de energía que las células solares convencionales. Nuestros paneles y sistemas solares, así como nuestros seguidores de alto rendimiento, generan una cantidad de energía significativamente mayor que los sistemas de la competencia.

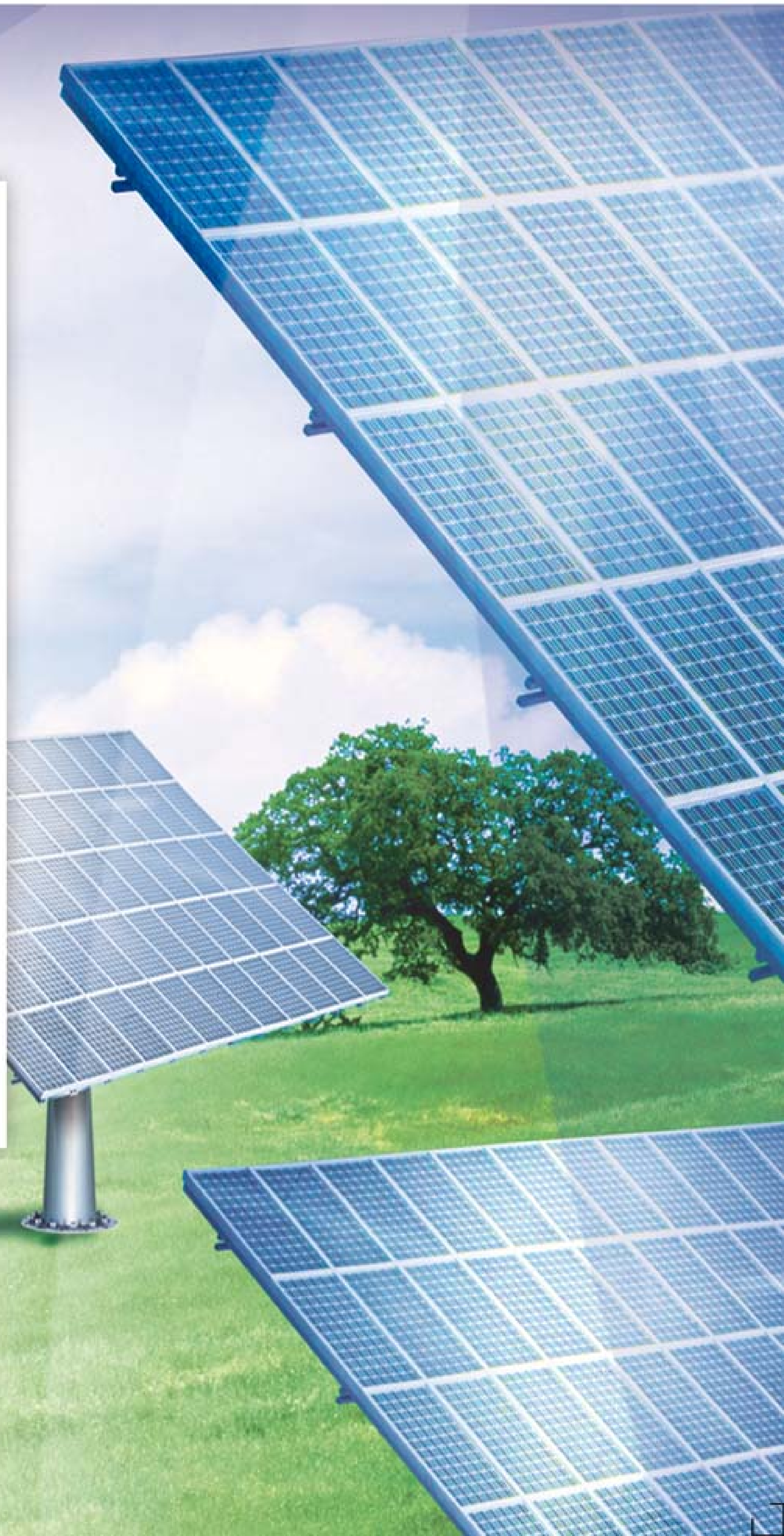
www.sunpowercorp.es

Documento n.º 001-57089 Rev.** / A4_ES

Seguidor doble eje.

ISOTRACKER SEGUIDOR DE **DOBLE- EJE**

Módulo **ISF-250** ISOFOTON + Tracker **Doble-Eje** AFFIRMA Energy



La combinación de nuestros seguidores de doble eje y los módulos ISF-250 de última generación, garantizan una **producción de energía superior en un 42%** a la que produciría un sistema fijo, con una precisión de seguimiento de menos del 1º. Nuestros seguidores y módulos requieren un mantenimiento mínimo y están cubiertos por la garantía más amplia del mercado.

Módulo ISF-250

ISOTRACKER

Características principales del producto

Vidrio micro estructurado

60 células (156x156 mm)

5.400 Pa

Marco: Aluminio anodizado

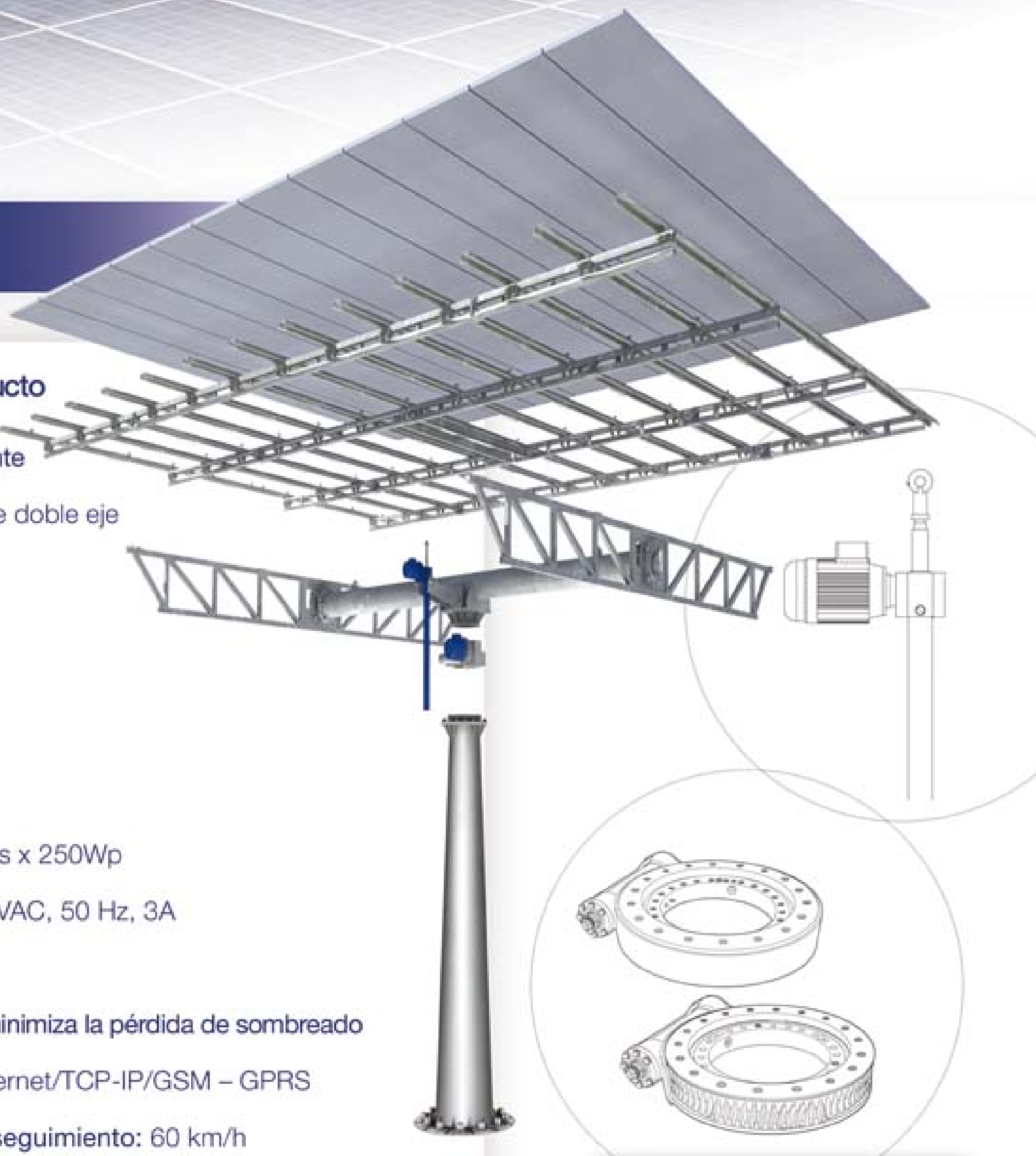
Garantía:

10 años de garantía de producto

25 años de garantía de producción lineal

Certificados de calidad y medioambiente:

Seguidor de Doble - Eje



Características principales del producto

Estructura de acero galvanizado en caliente

Tipo de seguidor: Acimut – Seguidor de doble eje

Rango de rotación Acimutal: 252º

Rango de altitud: 0-70º

Potencia total: 15 kWp

Superficie máxima: 104.2 m^2

Peso máximo permitido: 1,300 kg

Número de módulos: Hasta 60 módulos x 250Wp

Requisitos de entrada de energía: 240VAC, 50 Hz, 3A

Precisión de seguimiento: <1º

Tecnología de control de retroceso que minimiza la pérdida de sombreado

Interfaz de comunicación externa: Ethernet/TCP-IP/GSM – GPRS

Velocidad máxima del viento durante seguimiento: 60 km/h

Velocidad máxima del viento en la posición de defensa: 120 km/h

Rango de temperatura de funcionamiento recomendada: -20 a 50ºC

Sistema de anclaje: Hormigón

Certificados de producción:

Leading Tracking Technology

sonnen_system

Astronomically Controlled
Dual-Axis Solar Tracker

A product of Kirchner Solar Group

Infinite Energy

The sun provides an infinite amount of energy each day. Our mission is to use this energy for a stable climate, clean environment and sustainable growth. Towards these goals, **Kirchner Solar Group** provides solar tracking systems that convert more solar energy into much-needed distributed electricity.

Reliable, efficient and accessible.

We Follow the Sun

Our dual-axis photovoltaic tracking systems always align with the optimum angle to the sun. Optimum solar alignment is made possible by a precise astronomical control developed specifically for this purpose. Over the years thousands of **sonnen_system** trackers have demonstrated and verified maximum effectiveness.

ENERGY SURPLUS

45%

OF UP TO 45%

Setting Standards

sonnen_system is the world's most reliable and comprehensive solution for dual-axis tracking systems. It is a meticulously engineered product that includes a precise astronomical control, developed in cooperation with the photovoltaic specialists at SMA Solar Technology.

Our unique safety concept **safeguard** enables a comprehensive communications exchange, allowing **sonnen_system** to reliably produce electricity at a consistently high level.

Our tracking systems follow the course of the sun precisely, allowing for the maximum of available solar energy to be captured throughout the day. Our innovative technology generates a solar energy surplus of up to 45 % compared to fixed-mount PV installations.

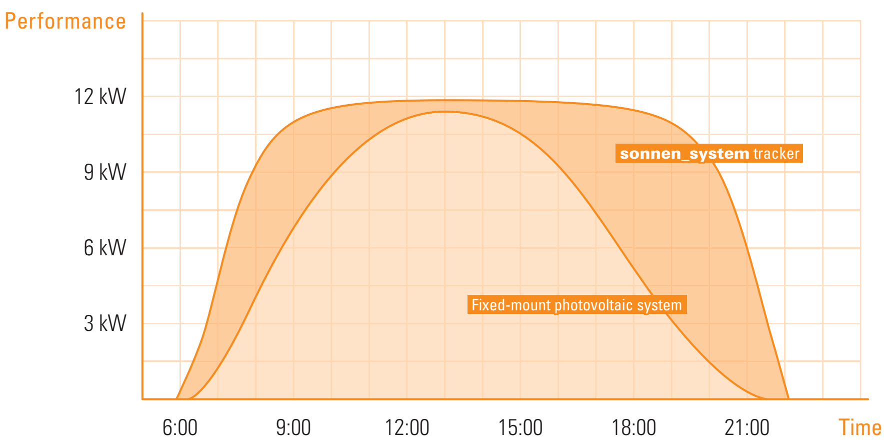
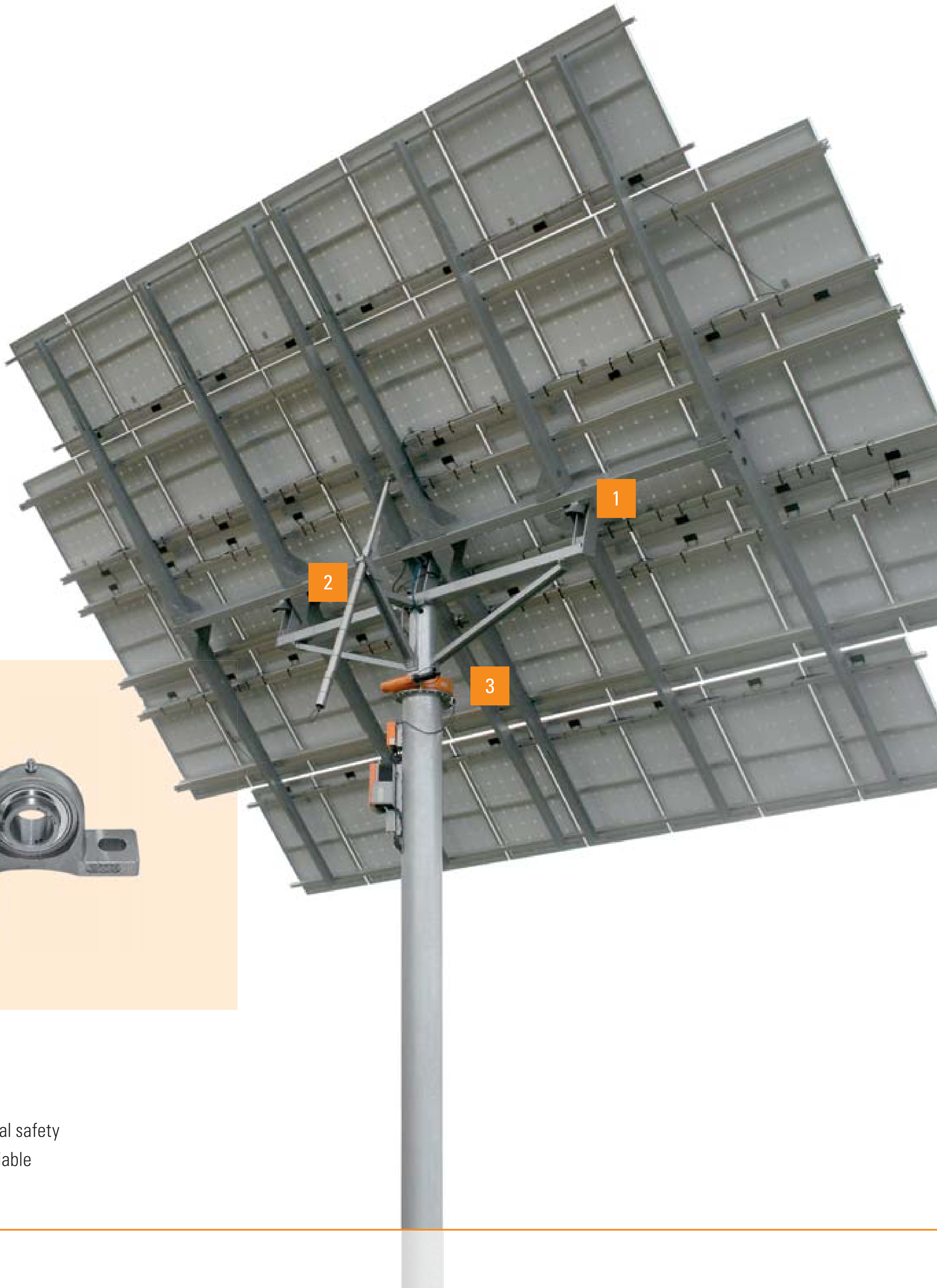


Chart: Performance of a **sonnen_system** tracking unit for 24 hrs vs. performance history of a fixed-mount photovoltaic system of the same system size.

Computer-aided welding
for exceptional precision
of the construction



1

Bearing Units

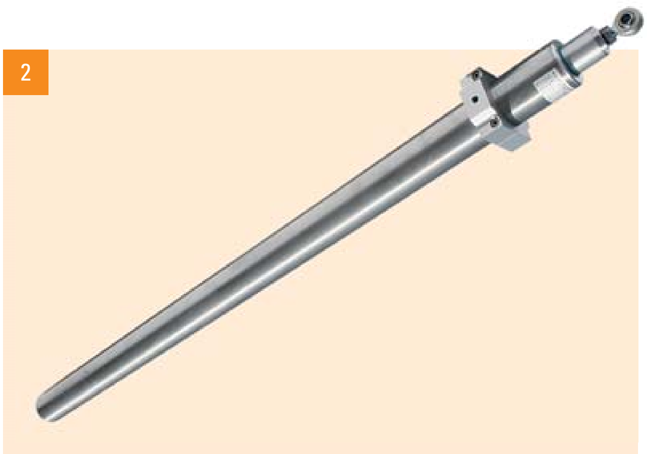
- triple-bearing panel surface mounts
- solid stainless-steel parts
- exceedingly high stability and operational safety
- maintenance-free, tried-and-tested, reliable

Next Generation of Solar Tracking Systems

The construction of our **sonnen_system** ensures safe and reliable operation. A robust and optimized structure provides stability and support throughout the lifetime of the tracking system. **sonnen_system** is designed to operate for 20+ years and is equipped and constructed with the highest-quality components and materials available on the market today.

Our tracking system was designed for the global market and is guaranteed to operate safely – even in extreme climate conditions.

You are getting incomparable technological quality, engineered in Germany.



Elevation Drive

- solid stainless-steel drive
- superior operational safety
- very low maintenance over its lifetime
- fast and simple installation

Azimuth Drive

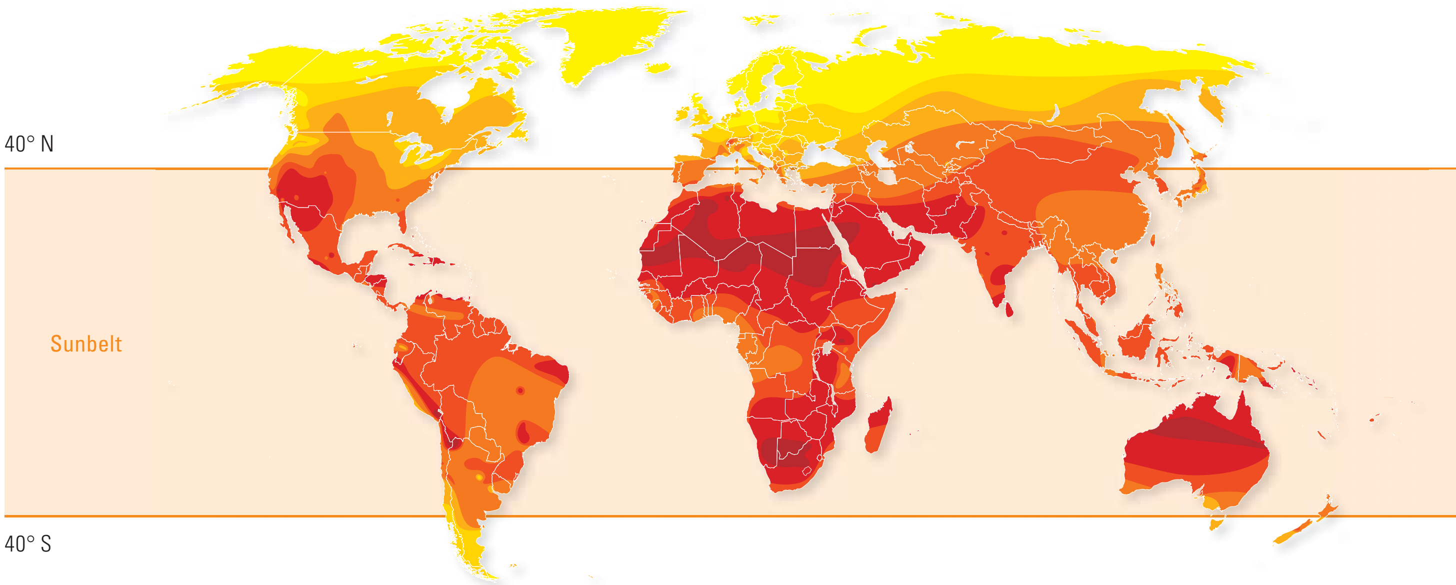
- robust and reliable slew drive
- meets highest manufacturing standards
- designed especially for heavy loads
- low maintenance, durable construction

Ready for Future PV Technologies

Concentrator Photovoltaics

Within the solar industry, CPV will be the leading edge technology with outstanding high efficiency from 30 % to 40 % in the near future. In the sunbelt CPV provides for the lowest solar electricity production cost combined with the best temperature characteristics.

sonnen_system always aligns with the optimum angle to the sun. Optimal solar alignment is made possible by a precise astronomical control developed specifically for this purpose. Our control can provide the high accuracy of up to 0.1 degrees which is an absolute necessity for concentrator module applications in high DNI regions.



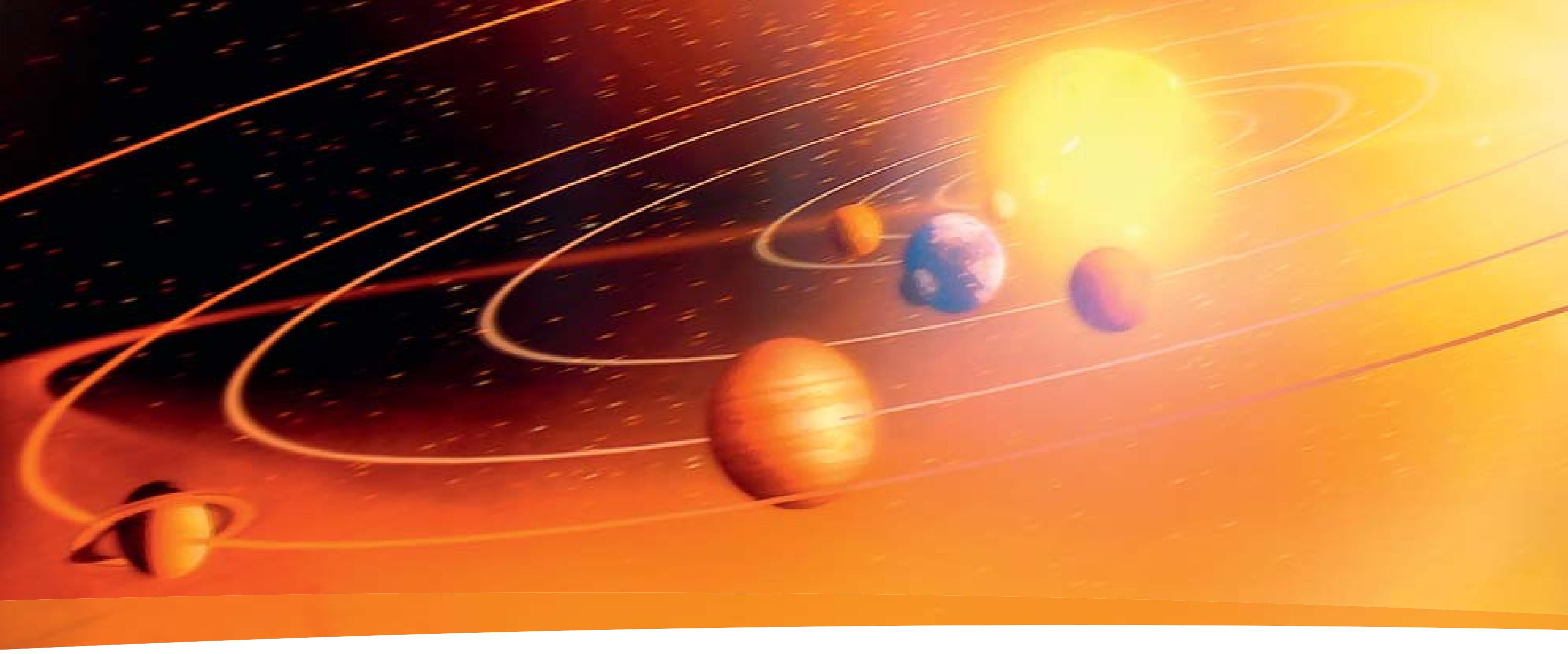
SolTrk

Each **sonnen_system** is equipped with its own control unit, so each system can be individually accessed and analyzed.

Only a supply cable, a feed-in cable and a communications cable are needed for operation. Their entry points are aligned on the bottom of **SolTrk**, designed as individual PG screwings and marked according to their **sonnen_system** configuration. This ensures a simple, fast and correct connection.

Groupings of up to 25 **sonnen_system** trackers can be made that way, and multiple groups pooled into large-scale power plants. This makes the costly laying of control wiring redundant.

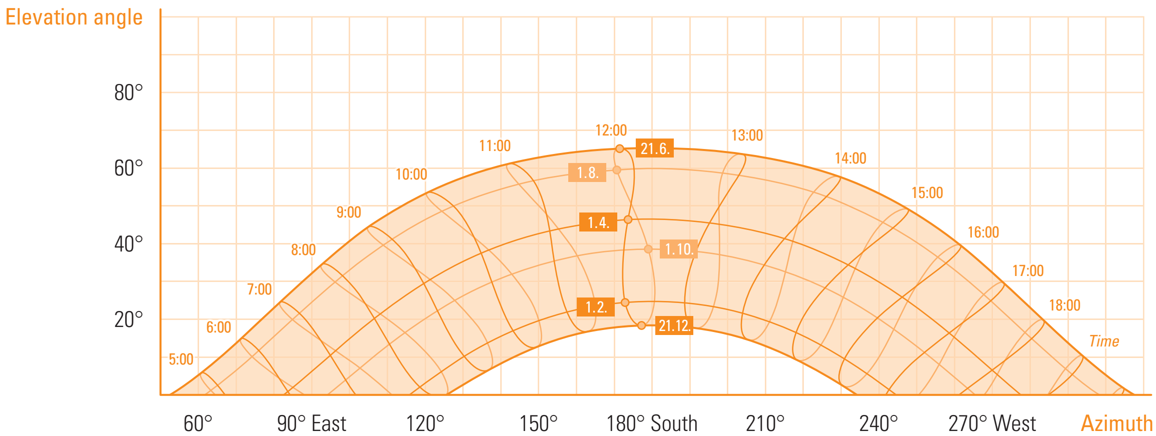
SolTrk is the control unit of **sonnen_system**



Astronomical Control

Our astronomical control unit **SolTrk** was developed in close cooperation with the photovoltaic specialists at SMA Solar Technology and offers an angular accuracy of up to 0.1 degrees. This high precision is an absolute necessity for applications such as concentrator module technology.

The control is fully integrated with the field-level SCADA and communications protocol and allows for bi-directional data exchange from anywhere in the world.



This solar altitude diagram depicts the position of the sun at any time during the year.

Stay Informed – Any Place, Any Time

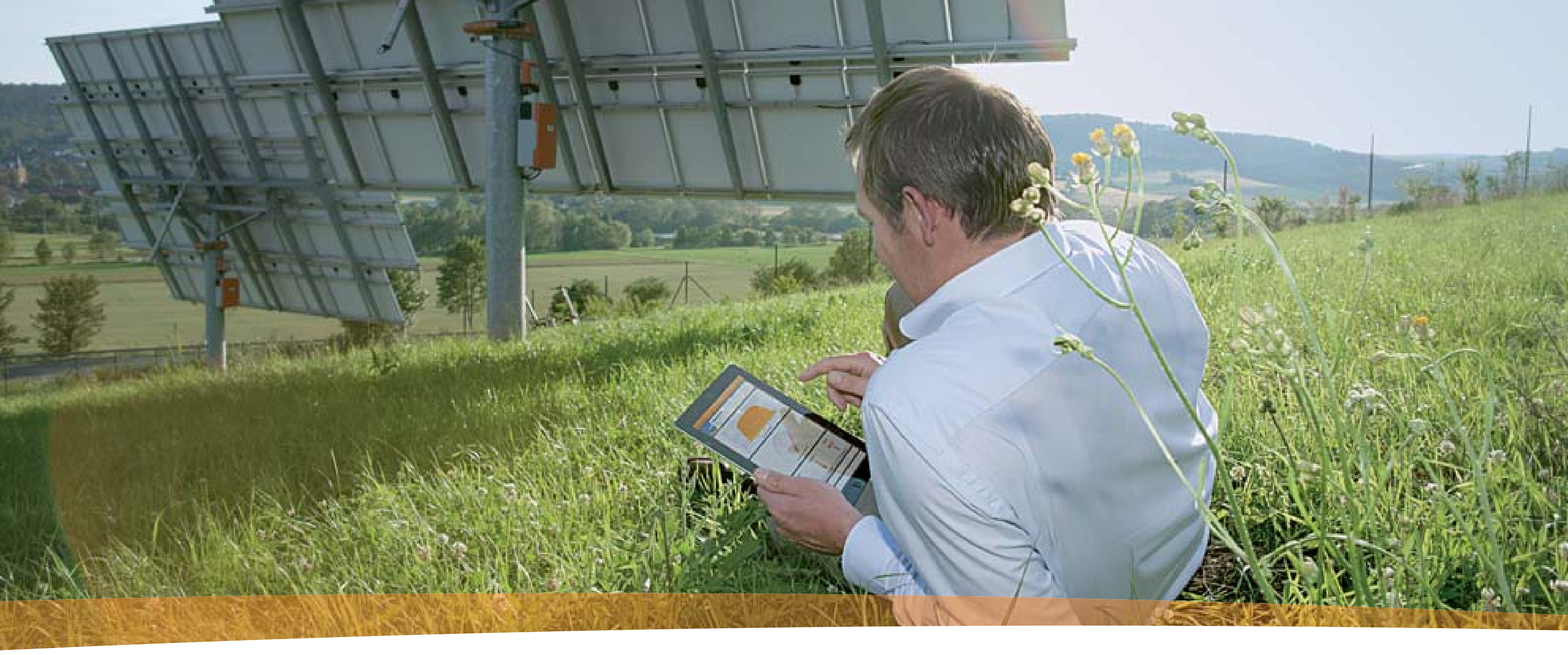
The evaluation function of our newly revised mobile application **track_app** allows for a continuous overview of your investment earnings in real time.

Output, performance and all other crucial data such as irradiance, module temperature, ambient temperature and wind speed are displayed in real time by the power indicator.

With a simple push of a key the integrated camera control allows you to view the installation directly through the webcam, while the scalable long-term evaluation will give you detailed information on the overall performance of the system.

	track_app Expert	**track_app** Basic
Platform:	**iPad** based	**iPhone** based
Customer group:	Kirchner Solar Group partners, installers, service technicians, plant operators	private owners, commercial owners
Features:		
Yield information		
Daily power curve	●	●
Monthly yield overview	●	●
Yearly yield overview	●	●
Summary yield overview	●	●
Real time performance	●	●
Weather station[1]		
Real time irradiation	●	●
Real time ambient temperature	●	●
Real time module temperature	●	●
Real time wind speed	●	●
Plant profile		
Facts overview	●	–
Plant description	●	–
sonnen_system tracker controlling		
Manual moving to East, West, 0°, 70°	●	–
Tracking mode	●	–
Clean position[2]	●	–
sonnen_system tracker monitoring		
Tracking mode	●	–
Alignment azimuth, elevation	●	–
Motor current azimuth drive, elevation drive	●	–
Inverter		
Mode	●	–
Power monitoring	●	–
Webcam[3]		
Visual inspection	●	–
Visual analysis	●	–

[1] SMA Sunny SensorBox and sensors are required [2] function is in development [3] webcam is an additional item that is supported by, but not included within track_app



Real Time Communication

The communications hub allows for continuous monitoring of the operational data and offers a significant time advantage for maintenance and support work.

The system operator receives all system messages and relevant performance data in real time. Online applications allow you to set your system into operation, service and evaluate the performance from anywhere in the world.

This feature makes it possible to avoid unnecessary on-site visits and saves both costs and valuable time.

track_app Basic for iPhone is a free application that provides real time performance data. You are always up-to-date on energy production and the power fed into the grid.

track_app Expert is a simple and intuitive application on the iPad, which allows you to set **sonnen_system** trackers into operation as well as to monitor and control those remotely.

track_app Expert supports installers and service technicians who assemble and start up trackers and inverters. A physical connection to the system's control unit is no longer necessary. This boosts speed and efficiency of the installation and contributes to considerable cost savings.

Service technicians receive timely status messages on the go and can directly log on to the systems via **track_app** Expert. Whatever the technician's location, they can process those messages and flexibly perform diagnostics.

Protection

sonnen_system is equipped with an extensive array of safety features. This allows for reliable operation in extreme conditions – protecting your investment even in the event of storms or power failures.

Safety Concept

All security features are summarized in our unique safety concept **safeguard**.
A voltage monitoring system continuously checks the charge level of the control batteries so that the secure table position can always be accessed when needed.

The wind speed indicator includes a wind sensor and a control unit. These ensure that **sonnen_system** automatically moves into the secure table position in case of high winds.

multi_use References

sonnen_system trackers provide winemakers with additional income

sonnen_system parking lot

sonnen_system multi_use Approach

The construction and carefully engineered features of **sonnen_system** allow for a wide range of uses. The unique, height-adjustable mast provides vertical clearance that other PV installations lack making **sonnen_system** a perfect fit for integration into agricultural land and parking lots.

Truly multi-functional, the area used for power generation with **sonnen_system** can, at the same time, be used profitably for a variety of additional purposes.

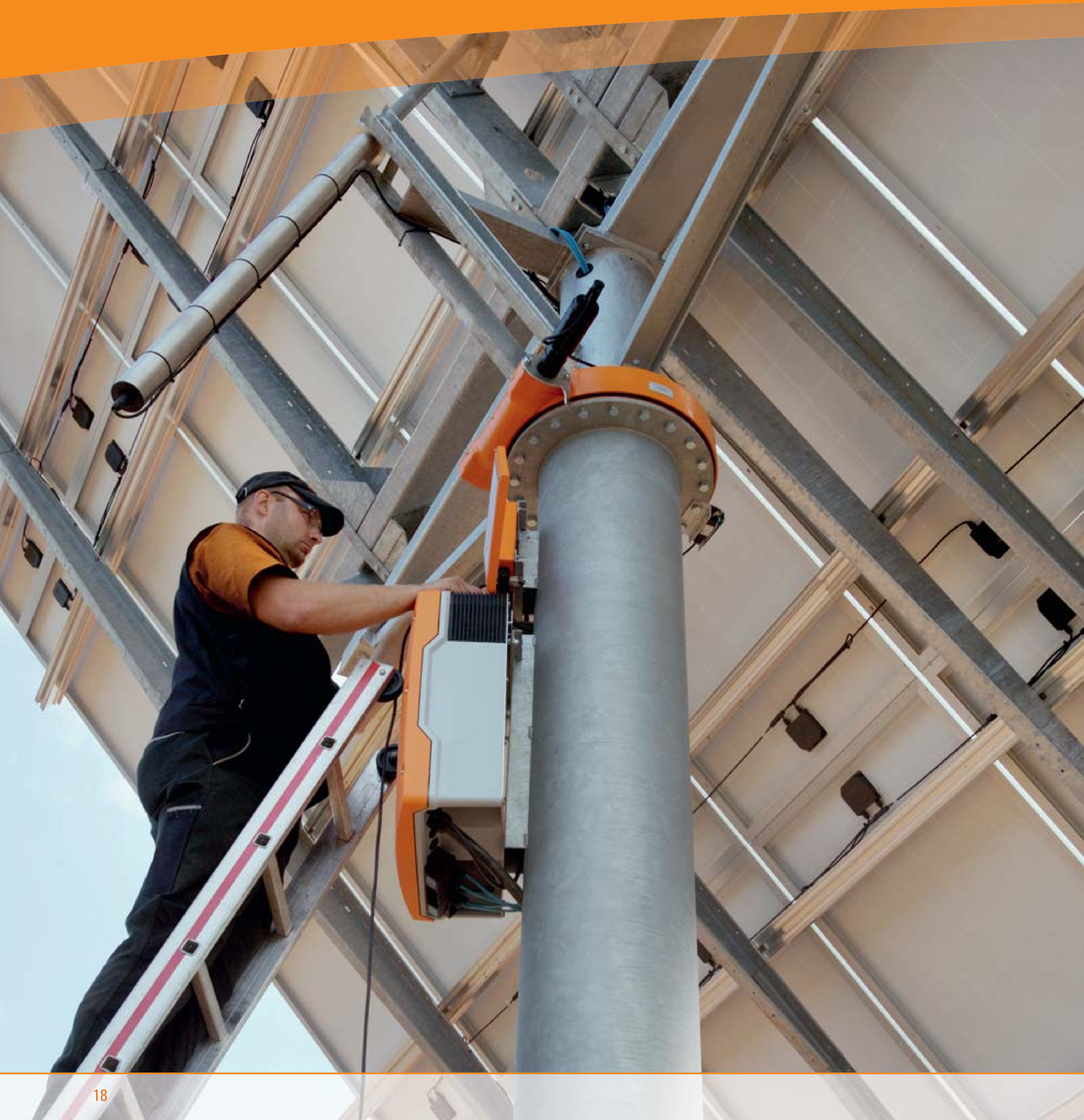

Cows grazing under **sonnen_system**


sonnen_system trackers on the roof of **Kirchner Solar Group** headquarters

EXTENDED WARRANTY

20

OF UP TO 20 YEARS



Warranty, Service, Academy

We offer our customers products they can rely on, both in terms of safety and predictability of operating costs. In addition to a modular service concept that includes regular maintenance intervals, we also offer extended warranty options of up to 20 years.

sonnen_system Academy provides the latest technological and market developments for the PV tracking industry to ensure a secure investment.

Long-term experience, outstanding service and support.

Warranties of up to 20 years, starting with the date of initial operation of each **sonnen_system**

Technical training to become a **Kirchner Solar Group** Certified Service Partner at our headquarters

Main Technical Features

- Biaxial tracking system for photovoltaic installations
- Astronomical control based on local coordinates
- Centralized monitoring via Internet
- Comprehensive safety concept **safeguard**
- Building integration feasible
- Additional yield up to 45 % compared to fixed-mount installations
- Track-back function to prevent cross-shading
- 20-year warranty (depending on service agreement)
- Suitable for all panel brands

Dimensions

	sonnen_system **3_40**	sonnen_system **3_60**
Size of panel surface	approx. 36 – 45 m²	approx. 46 – 60 m²
Size of supporting structure (without profile rails, width x height)	7 m x 5 m	7 m x 6.4 m
Maximum installation height (upper edge of panel surface above ground level)	20 m	20 m
Weight (without mast, profile rails and panels)	approx. 620 kg	approx. 670 kg
Load	approx. 1200 kg	approx. 1200 kg

Components

Control unit	astronomical with RS 485 interface
Steel construction	hot-dip galvanised according to DIN EN 1461
Azimuth	electromechanical slew drive 102 : 1
Elevation	electromechanical lifting spindle 225 : 1

safeguard

Wind alert system operates at wind speed	≥ 13 m/s	≥ 13 m/s
Type of protection	IP 54 / 65	IP 54 / 65
Voltage monitor operates at	≤ 24V / DC	≤ 24V / DC
Uninterruptible power supply		18 – 100 Ah depending on the number of sonnen_system trackers
Monitoring		monitoring system for the entire plant via SMA Sunny WebBox

Performance

Capacity of PV generator (depending on panel type)	5 – 8 kWp	8 – 12 kWp
Operating voltage	24 V / DC	24 V / DC
Nominal power	max. 110 W	max. 110 W
Angular range		azimuth 270°, elevation 70°
Angular accuracy		by 0.1° – 0.25°

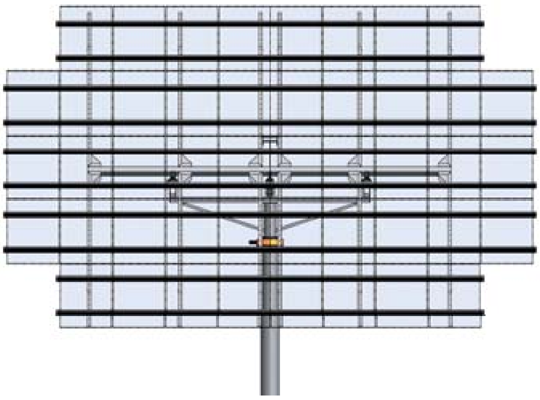
Panel Allocation

The rail rack of **sonnen_system** allows for an extremely versatile and flexible arrangement of all current PV panels. The layout of **sonnen_system** trackers can be individually adapted to the quantity and size of the applied panel type, and thus, the most different panel allocations can be realized.

Two examples for panel allocation:

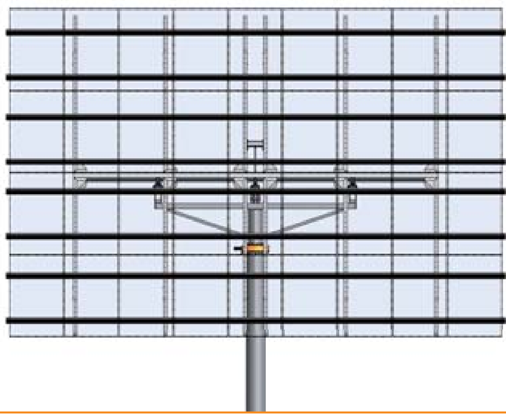
46 panels	8.74 kWp
Single panel size (width x height)	990 x 1310 mm
Total panel surface	60 m²
Total system size (without mast)	10.2 x 6.5 m

1



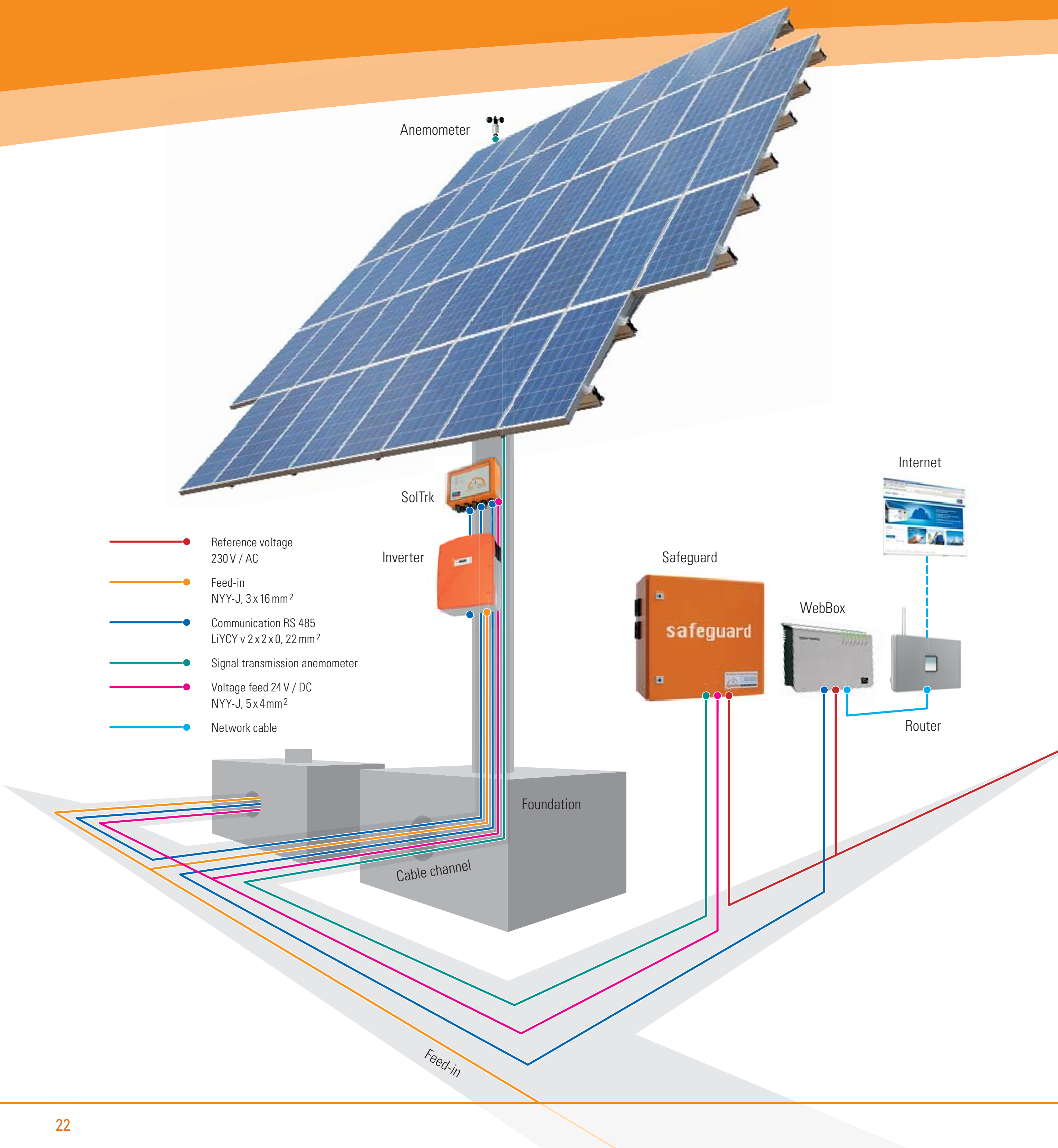
36 panels	11.99 kWp
Single panel size (width x height)	1046 x 1559 mm
Total panel surface	58.68 m²
Total system size (without mast)	9.6 x 6.4 m

2



Connections and Cabling

All devices of a **sonnen_system** tracker are connected to a Sunny WebBox via RS 485 communication bus. Every **SolTrk** is equipped with a COM-IN and COM-OUT plug-in to integrate them into the bus. The inverter is connected to the appropriate **SolTrk** control unit via branch line.

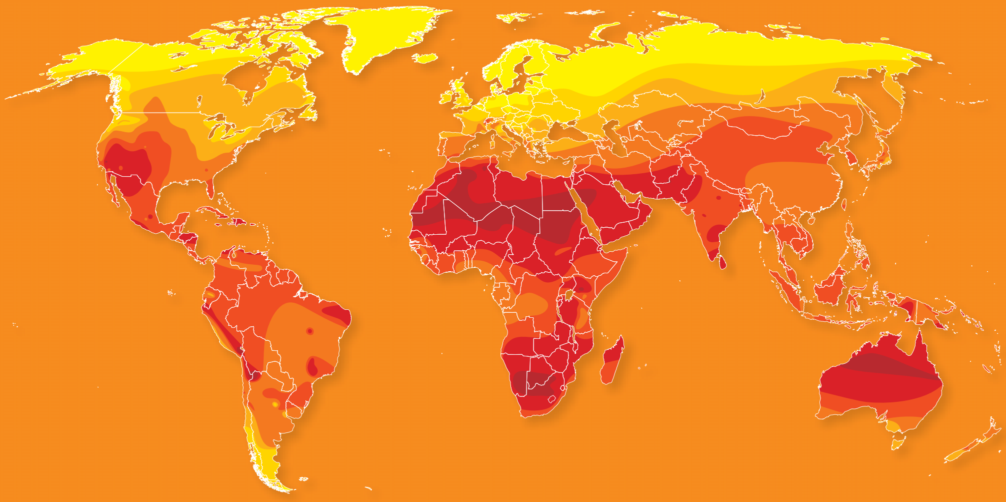


Kirchner Solar Group

Kirchner Solar Group is a pioneer in the solar industry and was founded in 1991. The company's products and services include the design and the installation of photovoltaic systems for any type of roof, the production of its own solar tracker systems **sonnen_system**, the production of independent off-grid systems, trade of high-quality PV components and public fund concepts as well as customized solar systems.

So far **Kirchner Solar Group** produced and installed more than 11,000 **sonnen_system** trackers worldwide, implemented more than 6,500 rooftop systems and solar parks.

Besides their PV systems project and implementation activities, the company has engaged in years of commitment in the field of sustainable and environmental education. **Kirchner Solar Group** was awarded the German Solar Award 2010 for their work and commitment in the PV sector.



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V05 · 2012-01 · EN

sonnen_system

A product of Kirchner Solar Group

Kirchner Solar Group

Concentración

VENTAJAS

El coste normalizado de energía (LCOE) más bajo para aplicación en grandes proyectos

Tecnología fotovoltaica de concentración (CPV) rentable con rendimiento demostrado. Materiales de máxima calidad que garantizan un rendimiento asegurado a largo plazo

Células solares fácilmente intercambiables que facilitan cualquier mejora futura del parque

La plataforma de fabricación de células solares más escalable con capacidad de generar gigavatios en parques solares de todo el mundo

Generación de puestos de trabajo locales gracias a su facilidad para desarrollar una fabricación regional

SEGUIDOR SOLAR SUNPOWER C7

ENERGÍA SOLAR RENTABLE PARA USO A GRAN ESCALA

El seguidor solar SunPower® C7, que debe su nombre a su capacidad para concentrar hasta 7 veces la energía solar, constituye hoy en día el sistema que ofrece el coste normalizado de energía (LCOE) más bajo para uso a gran escala. El C7 combina un seguidor monoaxial horizontal con filas de espejos parabólicos que reflejan la luz en las células solares de silicio más eficientes del mundo, dotadas de la tecnología única y patentada Maxeon® de SunPower®.

Esta solución de seguidor fotovoltaico de concentración que bate récords se basa en la amplia experiencia probada de SunPower en fabricación de sistemas de seguimiento para plantasfotovoltaicas, con unos 500 MW instalados a nivel mundial. Las características de fiabilidad y producción de energía que se obtienen con la tecnología Maxeon de SunPower® son punteras en la industria y están respaldadas por la experiencia probada de nuestra empresa en la fabricación y explotación de parques solares con una capacidad aproximada de 600 MW en todo el mundo.

INSTALACIÓN RÁPIDA Y PRODUCCIÓN LOCAL

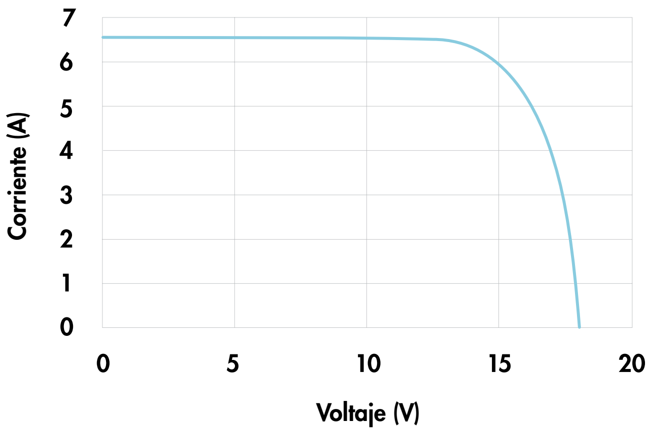
El seguidor solar SunPower C7 está concebido desde su origen para instalaciones a gran escala. Los componentes del seguidor solar SunPower C7 se pre-ensamblan en fábrica, permitiendo una ejecución rápida de la instalación, con herramientas estándar y sin que ello requiera mano de obra especializada en campo, lo cual permite reforzar el desarrollo económico local.

SEGUIDOR SOLAR SUNPOWER® C7
EFICIENCIA Y RENDIMIENTO EXCEPCIONALES

ESPECIFICACIONES DEL SEGUIDOR

Potencia pico (+/-5%)	14,7 kWp
Voltaje del sistema	1000 V
Tipo de seguimiento	Monoaxial horizontal
Rango de seguimiento	De -75° a +75°
Tipo de transmisión	Transmisión giratoria de baja reacción
Materiales	Acero galvanizado en caliente, acero inoxidable, espejos de vidrio, cojinetes sin necesidad de mantenimiento
Ráfaga de viento máxima de 3 s	40 m/s, protección predictiva contra el viento
Módulos	Módulos 108 x 136 W

CURVA I-V



Características de corriente/voltaje según irradiancia y temperatura del módulo.

ESPECIFICACIONES DEL MÓDULO

Potencia pico (+/- 5%)	136 W
Eficiencia del módulo	20,1%
Células solares	6 células solares SunPower® Maxeon®
Voltaje en el punto de máxima potencia (V_{mp})	14,2 V
Corriente en el punto de máxima potencia (I_{mp})	9,6 A
Voltaje de circuito abierto (V_{oc})	17,4 V
Corriente de cortocircuito (I_{sc})	10,3 A
Voltaje de circuito abierto (V_{oc})	-0,34 / °C

Evaluado en condiciones de ensayo estándar del concentrador 1000 W/m², irradiancia directa normal normalizada en el plano de la instalación (corrección de coseno) normalizada a 25 °C de temperatura del módulo

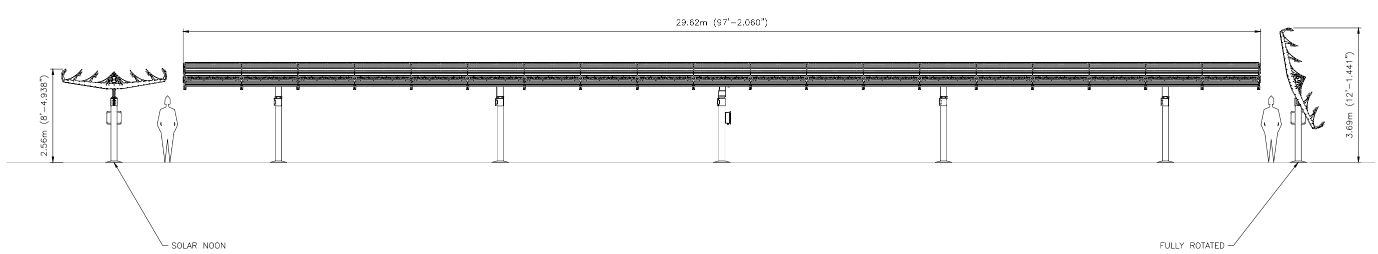
CONDICIONES DE FUNCIONAMIENTO VERIFICADAS

Temperatura	De -40 °C a +90 °C
Resistencia a impactos	Granizo de 25,4 mm a 40 m/s

GARANTÍAS Y CERTIFICACIONES

Garantías	25 años de garantía de potencia
	10 años de garantía del producto
Certificaciones pendientes	IEC 62108 calificación tecnología FV concentrada / IEC 62688 seguridad tecnología FV concentrada / UL 8703 listado tecnología FV concentrada

DIMENSIONES



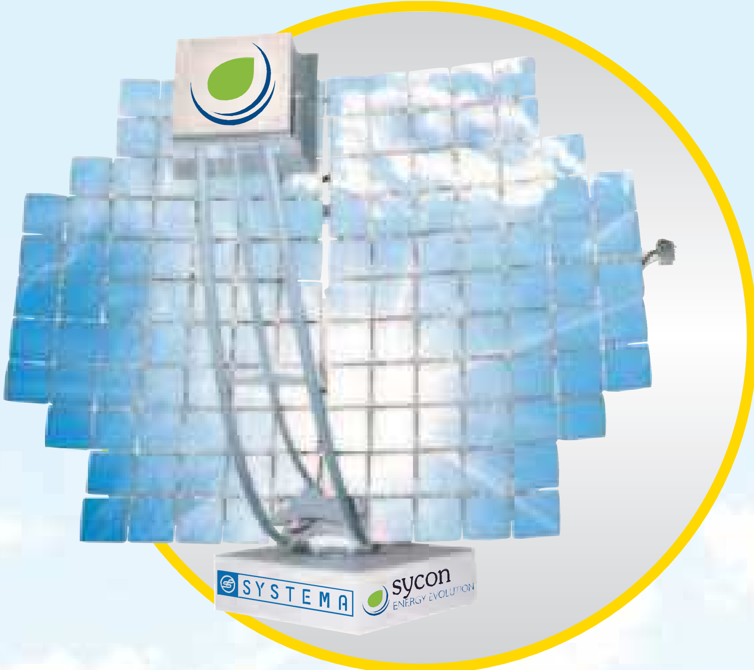
www.sunpowercorp.es
Document #001-12908 Rev *A / A4_EN
CS 11_661

SYSTEMA

imita la natura

sycon

ENERGY EVOLUTION



CONCENTRATORE SOLARE

CARATTERISTICHE FUNZIONALI

- **Generatore termico solare per produzione di acqua calda fino a 99°C o 110°C.**
- **Sistema altazimutale e zenitale di movimentazione a controllo numerico**, ad alta precisione, con rotazione di campo a velocità variabile in funzione della declinazione del sole.

- **Sistema “SPS” (Solar Posiotion Sensor)** per correzione automatica puntamento concentratore.
- **Speciale sistema di modulazione termica 0÷100%**, basato sullo scostamento proporzionale del concentratore dal puntamento ottimale e sulla variazione della portata della pompa di circolazione fluido.
- Variazione della portata della pompa di circolazione a 3 velocità automatiche, se abbinato a nostra pompa opzionale.
- Variazione della portata della pompa di circolazione tramite inverter opzionale, abbinabile a pompe standard.
- Elevata capacità di assorbimento dell’energia termica solare.
- Bassissime perdite energetiche grazie alla particolare configurazione dello scambiatore di calore (caldaia) e all’elevata coibentazione termica del circuito idraulico.

- Alta superficie captante.
- Struttura eliostatica resistente agli agenti atmosferici e alle elevate velocità del vento, con sistema automatico di spostamento nella posizione di sicurezza.
- Specchi componenti la struttura eliostatica ad alta riflessione e dotati di protezione inferiore di materiale plastico.
- Parti esterne con trattamento di **zincatura e verniciatura a caldo.**
- **Struttura eliostatica ripiegabile** per facilitare le operazioni di trasporto e di installazione.
- Solida base di appoggio ed ancoraggio dotata di fori di fissaggio.
- Bassa resistenza fluido dinamica del circuito idraulico per permettere l’uso di circolatori a basso assorbimento.

- Gestione componenti di sicurezza, pressostato o flussostato.
- Termostato di sicurezza.
- Gestione e controllo delle temperature dell’acqua calda del circuito primario e secondario.
- Consenso per termostato sul secondario
- Pannello di controllo e gestione utente del tipo Touch Screen a 4 colori (OPTIONAL)
- Quadro di comando ON-OFF (OPTIONAL)
- **Gruppo di continuità (UPS batteria di supporto)** con durata in caso di assenza di tensione di almeno 15 min (OPTIONAL) (installazione obbligatoria).
- **Software per gestione locale** del concentratore tramite pc (OPTIONAL) (sostituisce il pannello Touch Screen).
- Modem GSM per telegestione e assistenza in remoto (OPTIONAL).
- Porta per collegamento di pannello Touch Screen in caso di assistenza sul concentratore.

- **Doppio anemometro** per sistema di sicurezza **contro raffiche di vento**.
- Funzionamento in modalità “**POSIZIONATORE**” per gestione proiettore/faro, con selezione di 10 posizioni intervallate con tempi impostabili e programmazione dell’orario di funzionamento e spegnimento.
- Dotato di apposito aggancio per collegamento ai sistemi meccanici di sollevamento.

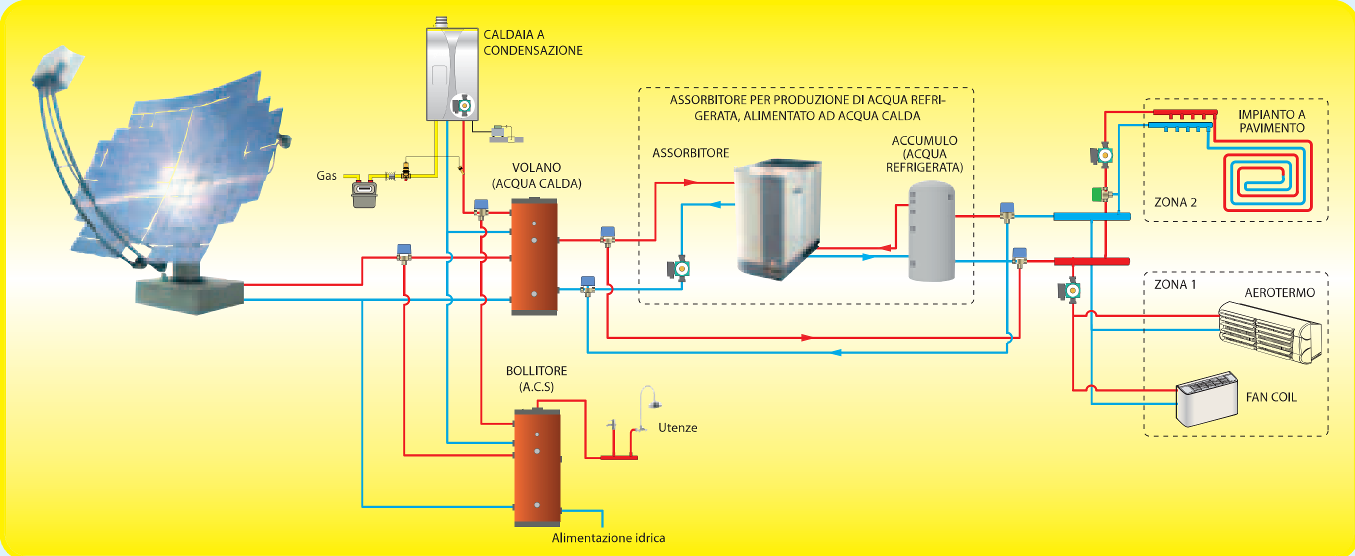
CARATTERISTICHE TECNICHE

Area captante netta della struttura eliostatica	m^2	12
Specchi ad alta riflessione	n°	132
Potenza termica massima allo scambiatore di calore	kW	9,85
Energia giornaliera media cedibile all'accumulatore di calore (**piena estate soleggiata**) 37° Latitudine Nord	kWh	100
Energia giornaliera media cedibile all'accumulatore di calore (**nel mese di marzo**) 37° Latitudine Nord	kWh	70
Portata acqua circuito primario alla potenza massima	m^3/h	0,85
Perdita di carico circuito **sycon**	kPa	17,5
Pressione residua disponibile per l'impianto, con utilizzo di pompa di circolazione opzionale	kPa	45
Dimensioni dello scambiatore di calore LxHxP	mm	683 x 323 x 638
Dimensioni massime in posizione di lavoro LxHxP	mm	4.370 x 3.700 x 3.450
Dimensioni basamento portante LxHxP	mm	1.354 x 200 x 1.444
Spazio di manovra parabola	Ø mm	5.000
Spazio di manovra scambiatore	Ø mm	6.900
Massimo angolo di rotazione azimut	α°	270
Attacchi idraulici M-R	F"	3/4
Contenuto acqua	l	10
Peso	kg	742
Alimentazione elettrica	V/Hz	230/50
IN ABBINAMENTO AL MODULO ENERGETICO POSSIBLITÀ DI:		
Potenza modulante in Freddo	kW	17 ÷ 300
Potenza modulante in Caldo	kW	20 ÷ 400

ESEMPIO DI APPLICAZIONE CON SU UN IMPIANTO DI RISCALDAMENTO E CONDIZIONAMENTO

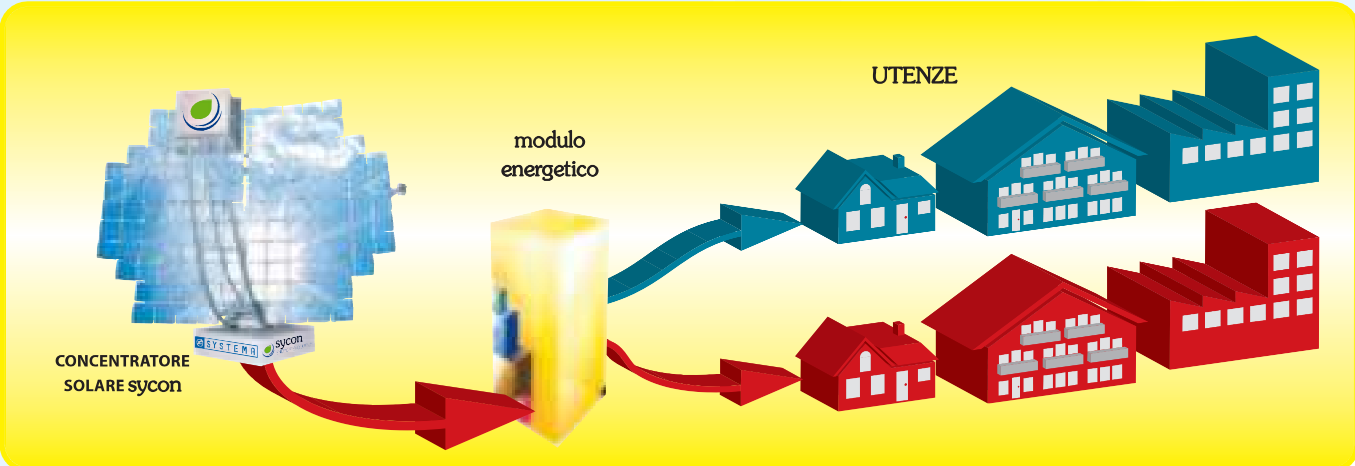
RISCALDAMENTO: Acqua calda prodotta dal concentratore solare SYCON e dalla caldaia a condensazione per l'eventuale integrazione di potenza.

CONDIZIONAMENTO: Acqua fredda prodotta dall'Assorbitore a bromuro di litio SYBCT il quale viene alimentato dell'acqua calda prodotta dal concentratore solare SYCON e dalla caldaia a condensazione per l'eventuale integrazione di potenza.



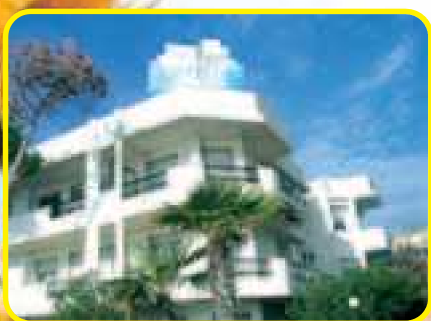
ATTENZIONE! Lo schema è da ritenersi puramente indicativo e non impegnativo.
Si riserva il diritto di modificarlo senza obbligo di preavviso.

Esempio di applicazione con sycon con modulo energetico



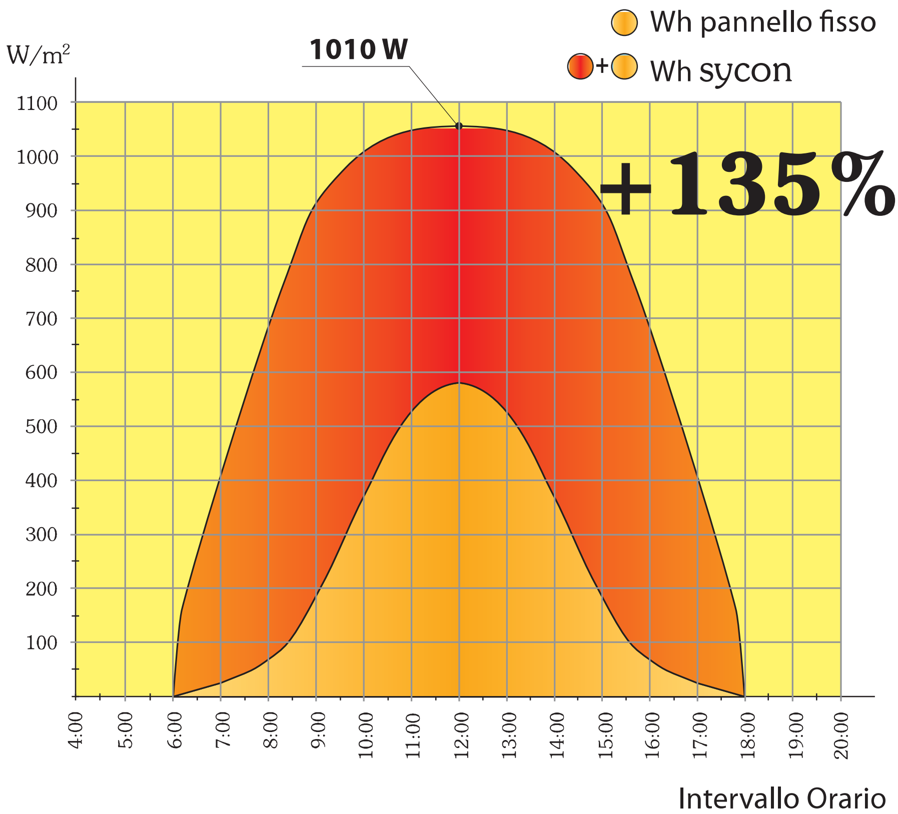
Abbinabile su impianti di:

- Riscaldamento
- Condizionamento
- Produzione di acqua calda sanitaria
- Riscaldamento piscine
- Cogenerazione
- Trigenerazione

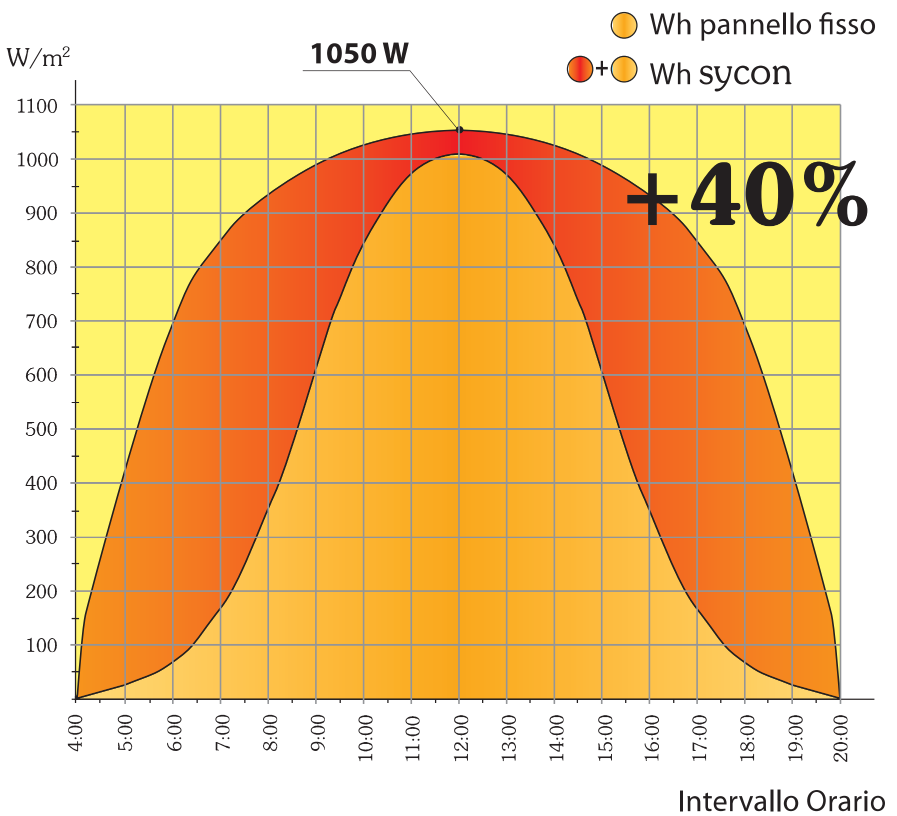


Confronto dell'irraggiamento giornaliero nel periodo invernale ed estivo tra sycon ed un collettore solare.

DICEMBRE

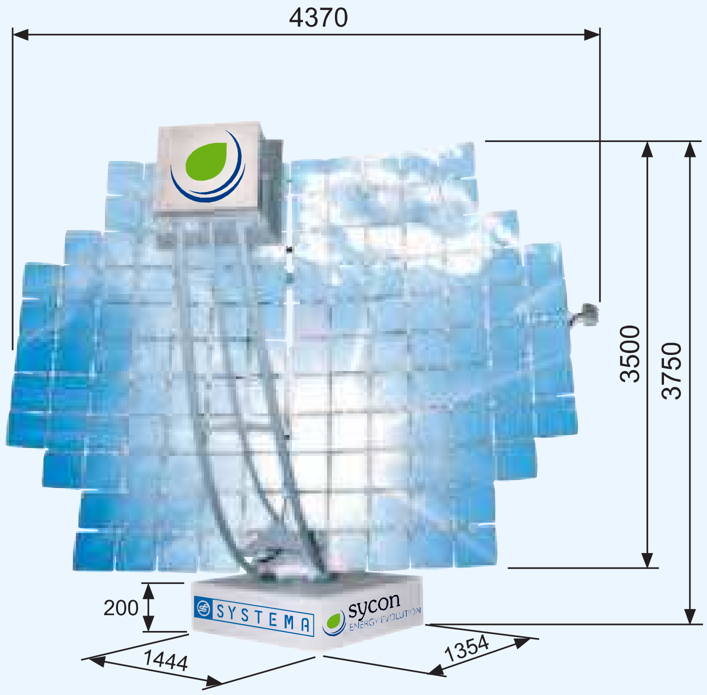


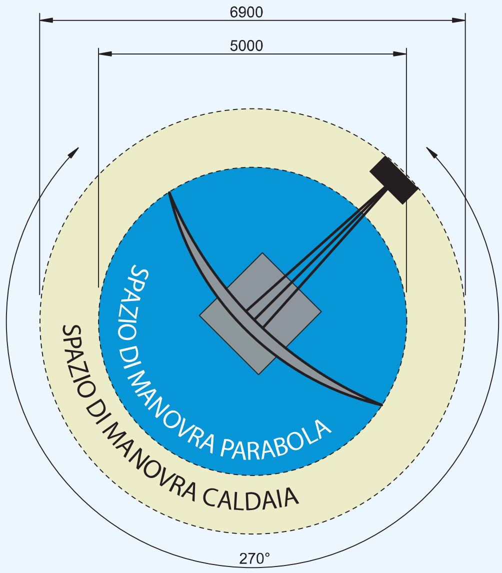
LUGLIO



Nota: Dati produttivi riferiti ad 1 m² di superficie captante

DIMENSIONI D'INGOMBRO PER L'INSTALLAZIONE

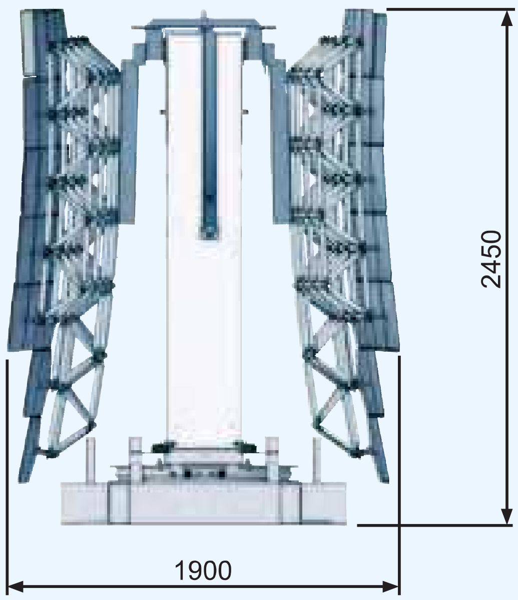




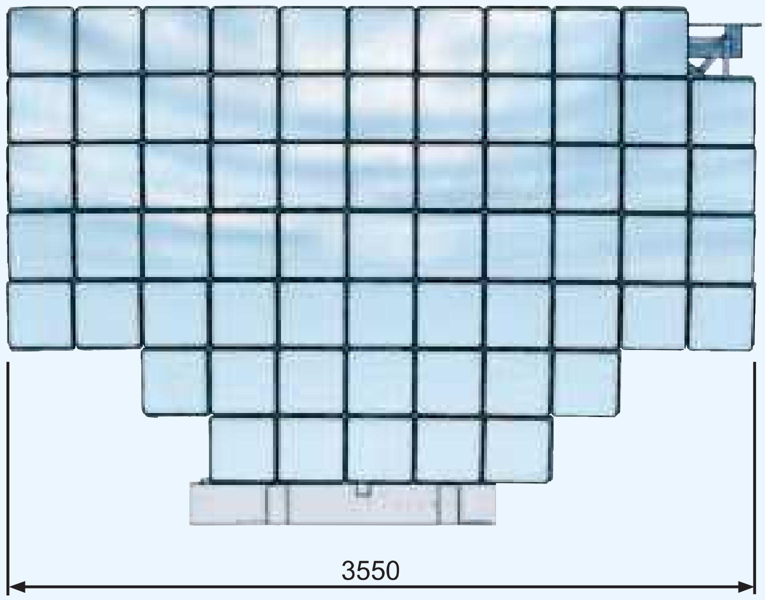
ALTEZZA MASSIMA RAGGIUNGIBILE DA
sycon

CONCENTRATORE SOLARE CHIUSO

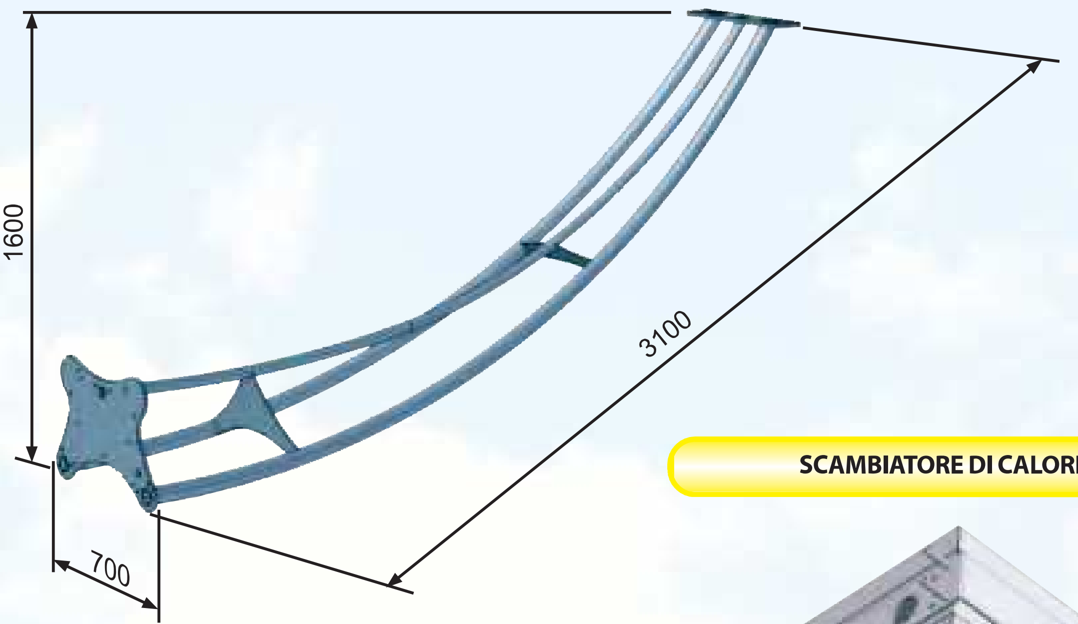
VISTA FRONTALE



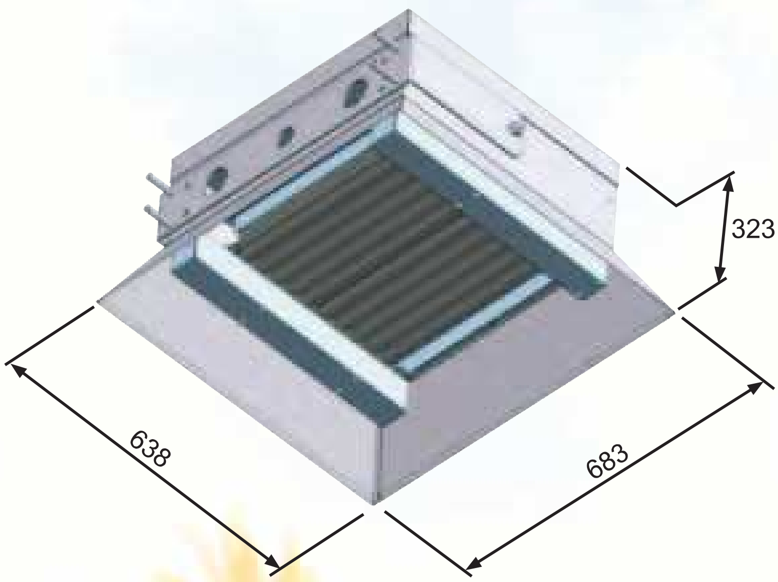
VISTA LATERALE



SUPPORTO SCAMBIATORE DI CALORE



SCAMBIATORE DI CALORE



SYSTEMA

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HCPV

Tecnología solar de alta concentración

Solar technology High-concentration

ISOFOTON +30 years

INTRODUCCIÓN A LA TECNOLOGÍA HCPV ISOFOTON

La tecnología HCPV de ISOFOTON obtiene energía eléctrica mediante la concentración de la luz del sol a través de un sistema óptico sobre células fotovoltaicas de alta eficiencia. El sistema obtiene una elevada producción de energía con una superficie de semiconductores muy inferior a otras tecnologías solares.

La tecnología HCPV de ISOFOTON utiliza células solares de alta eficiencia fabricadas con materiales semiconductores III-V. Se dispone un sistema óptico, compuesto por dos lentes, para concentrar varios cientos de veces la luz del sol sobre las células, que transforman la luz del sol en energía eléctrica con una eficiencia de aproximadamente el 39%.

GENERAL INTRODUCTION TO HCPV TECHNOLOGY

ISOFOTON's HCPV technology obtains power energy by concentrating sunlight through an optical system, onto high efficiency photovoltaic solar cells. The system enables a high electrical output from a semiconductor surface far smaller than other solar technologies.

ISOFOTON's HCPV technology uses high efficiency solar cells made of III-V semiconductor materials. To achieve these results, an optical system comprising two lenses is used. This concentrates sunlight by a factor of several hundred, onto the solar cells, that transform the concentrated sunlight into electrical energy at around 39% efficiency.

VENTAJAS DE LA TECNOLOGÍA HCPV ISOFOTON

Ventajas de la tecnología de alta concentración fotovoltaica sobre otras tecnologías fotovoltaicas convencionales:

- **Flexibilidad:** Apta para plantas desde 1 kWp hasta varios MWp.
- **Escalabilidad:** La potencia de una planta es fácilmente ampliable sin necesidad de desarrollar nuevos sistemas ni procedimientos.
- **Eficiencia:** Los coeficientes de temperatura de las células III-V utilizadas mejoran los resultados en campo.
- **Disponibilidad:** Plazos de construcción y puesta en marcha muy cortos, gracias a los sistemas "pre-montados".
- **Sostenibilidad medioambiental:** Se minimiza el impacto medioambiental, es posible un uso adicional del terreno y no se consume agua.
- **Economía del espacio:** Se requiere menor cantidad de terreno; ratio MW/m2 muy superior al de tecnologías como silicio mono y poli-cristalino (x-Si) o capa delgada (CdTe, a-Si ó CIGS)

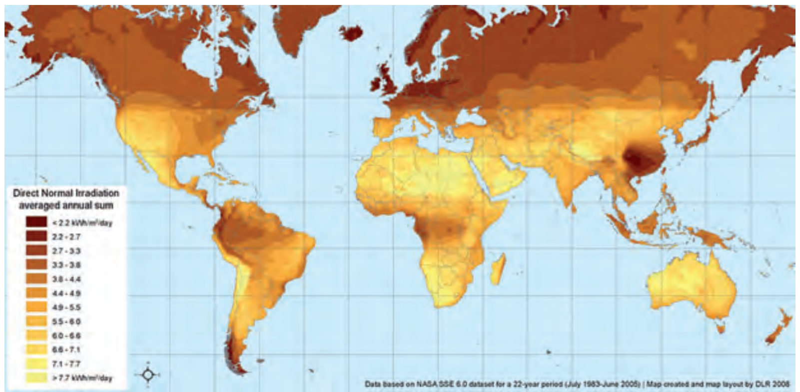
ISOFOTON HCPV TECHNOLOGY ADVANTAGES

High Concentration Photovoltaic technology offers important advantages over other established PV technologies:

- ***Flexibility:*** *Plants across a range of power capacities from 1 kWp systems up to several MWp.*
- ***Scalability:*** *Power plant can be scaled up very easily, without having to develop new systems or procedures.*
- ***Efficiency:*** *The temperature coefficients of the III-V cells used improve field HCPV outcomes.*
- ***Availability:*** *Construction and commissioning times are very short, thanks to "plug & play" HCPV systems.*
- ***Environmental sustainability:*** *It minimizes environmental impact, it allows a secondary use of land and it does not consume water.*
- ***Economy of space:*** *It requires less land. The MW/m2 ratio is far higher than more established technologies such as mono and polycrystalline silicon (x-Si) or thin-film (CdTe, a-Si and CIGS).*

UBICACIÓN ÓPTIMA

Esta tecnología obtiene resultados óptimos en condiciones específicas: zonas que reciben una alta irradiación solar directa y soportan elevadas temperaturas. Especialmente indicada para dosis muy elevadas del recurso solar, kWh/m2/día de energía luminosa proveniente del sol. Las ubicaciones más apropiadas para su implantación se localizan en: Australia, Norte y Sur de África, Suroeste de Estados Unidos, Sur de Europa, Oriente Medio, Mongolia y China.



OPTIMAL LOCATION

This technology gets its best results in specific conditions: high temperature areas that receive high levels of direct solar radiation. High Concentration Photovoltaic Technology is particularly suitable for very high levels of solar energy, kWh/m2/day of light energy from the sun. Best situated areas for its implementation are located in: Australia, Northern and Southern Africa, South Western United States, Southern Europe, the Middle East, Mongolia and China.

SISTEMAS HCPV ISOFOTON

Una instalación HCPV consta de varios seguidores solares de doble eje sobre los que son colocados los módulos de alta concentración, que compone de 6 células solares con sus respectivos sustratos y lentes de concentración. Los equipos ISOFOTON de alta concentración son capaces de resistir y de ser eficientes incluso en las condiciones medioambientales más extremas.

ISOFOTON comercializa dos sistemas totalmente integrados que permiten una rápida ingeniería y construcción de planta, en suelo o cubierta residencial o industrial.

Los inversores, las protecciones DC y AC y el Control y monitorización remotos vía web están ya integrados en el seguidor. El pre-montaje en fábrica minimiza el trabajo en campo. La independencia eléctrica y de control entre sistemas garantiza la modularidad y escalabilidad de la instalación.

ISOFOTON HCPV SYSTEMS

A HCPV installation consists of a several dual-axis solar trackers upon which the high-concentration modules are placed and comprises 6 solar cells with their respective substrates and concentration lenses. ISOFOTON high concentration equipment is capable of withstanding even the most extreme environmental conditions and remaining effective.

ISOFOTON commercializes two completely integrated systems that lets perform a quick engineering and installation works, on the ground or residential & industrial rooftops.

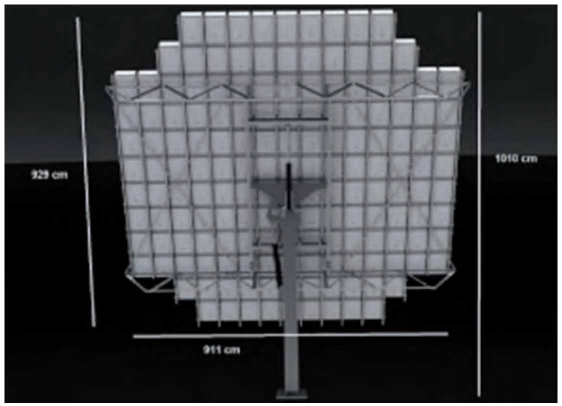
The inverters, CC and AC protections, remote control and the web monitoring are integrated in the tracker. The in-factory assembly tasks make easier the field works. The electrical and controlling independence between systems guarantees the modularity and scalability of the installations.

	EN SUELO	EN CUBIERTA		ON THE GROUND	ON ROOFTOPS
Potencia CC	15.200 W	1.140 W	***DC power rating***	*15.200 W*	*1.140 W*
Dimensiones (l x a x a)	9.1 x 8.7 x 6.5 m	3.35 x 2.5 x 0.35 m	***Dimensions (length x width x height)***	*9.1 x 8.7 x 6.5 m*	*3.35 x 2.5 x 0.35 m*
Estructura	Acero galvanizado	Acero galvanizado	***Structure***	*Galvanised steel*	*Galvanised steel*
Superficie total de módulos	62 m²	4.65 m²	***Total module surface area***	*62 m²*	*4.65 m²*
Número de módulos GEN 2	160	12	***No. of GEN 2 modules***	*160*	*12*
Rango de azimut	-130 º a +130 º	-130 º a +130 º (*)	***Azimuth range***	*-130 ° to +130 °*	*-130° to +130° (*)*
Rango de elevación	0 a 82º	0 a 82º (*)	***Elevation range***	*0 to 82°*	*0 to 82° (*)*
Movimiento del sistema	Sistema hidráulico con actuadores lineales electromecánicos	Motoreductores DC	***System movement***	*Hydraulic system with electromechanical linear actuators*	*Motoreductores DC*

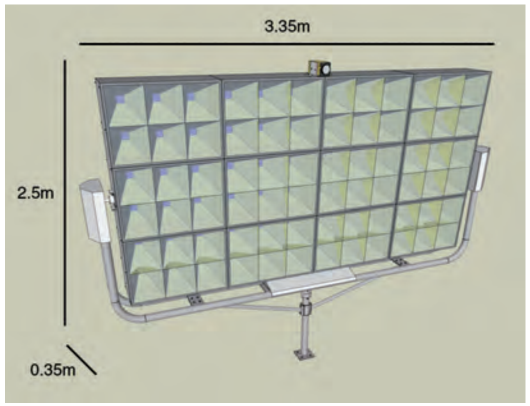
Resistencia al viento (posición de defensa)	145 km/h	145 km/h	***Wind resistance (defense position)***	*145 km/h*	*145 km/h (*)*
Máxima velocidad en operación	60 km/h	60 km/h	***Maximum operating speed***	*60 km/h*	*60 km/h (*)*
Máxima carga soportada	60 kg/m²	60 kg/m²	***Maximum load capacity***	*60 kg/m²*	*60 kg/m² (*)*

*Especificaciones preliminares

**Preliminary specifications*



TÜV NORD
TÜV NORD CERT GmbH
Type Tested
IEC 62108
Concentrator Photovoltaic Modules
Testing in cooperation with AT4 wireless
■ Design qualification and type approval



DATOS TÉCNICOS GEN-2

Célula:

Formada por una asociación monolítica en serie de tres sub-células de distintos materiales semiconductores (GaInP/GaInAs/Ge) optimizados para absorber regiones específicas del espectro solar, de forma que la conversión de la radiación solar en energía eléctrica es mucho más eficiente que en las células convencionales. Su eficiencia en laboratorio supera el 43%, y en producción se aproximan al 41%. Cuentan con un elevado potencial para aumentar su rendimiento y ser todavía más eficientes en un futuro próximo.

Módulo:

Certificado IEC 62108 que garantiza la superación de los más altos estándares de calidad y las pruebas más duras para asegurar su fiabilidad y robustez. Diseñado para resistir y ser eficiente incluso en las condiciones medioambientales más extremas.

Seguidor:

El seguidor solar sobre el que se colocan los módulos GEN 2, ha sido diseñado por la empresa española líder en tecnología, INDRA, siguiendo los estrictos requerimientos técnicos establecidos por ISOFOTON.

TECHNICAL DATA OF GEN-2

Cell:

Built as a monolithic association where each of the three sub-cells are series connected and compound by different semiconductor materials (GaInP/GaInAs/Ge) designed to absorb specific different ranges of the solar spectrum, so that the solar radiation conversion into electrical energy is much more efficient than in the traditional solar cells. The in-lab efficiency is higher than 43%, and production efficiencies are around 41%. This type of solar cell still has a vast room for improvement and it's expected to be much more efficient in the near future.

Module:

The IEC-62108 certificate guarantees the satisfaction of the hardest quality standards and the conformity with the most strict tests in terms of reliability and sturdiness. This module is designed to resist the external agents and to be efficient even under the worse ambient conditions.

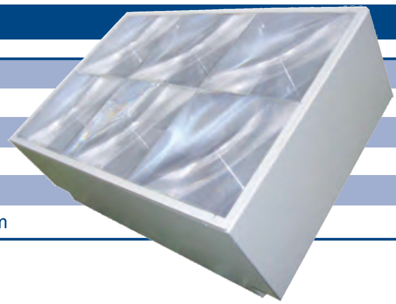
Tracker:

GEN 2 modules are fitted on solar trackers designed by INDRA, a Spanish technology leader, and conform to strict technical specifications set down by ISOFOTON.

STC 1000 W/m2, 25℃, AM1.5D

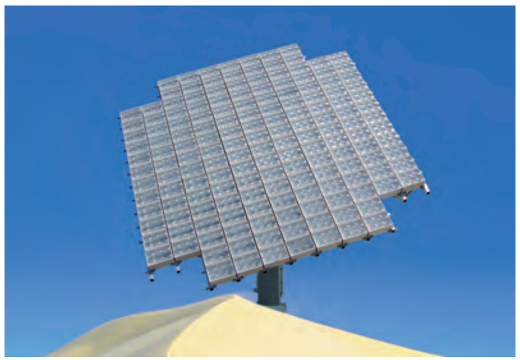
CARACTERÍSTICAS ELÉCTRICAS

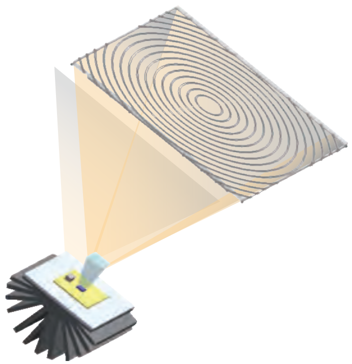
Corriente de cortocircuito	6.35 A
Tensión de circuito abierto	18.45 V
Potencia CC	95 W
Corriente punto máxima potencia	5.73 A
Tensión punto máxima potencia	16.62 V
Dimensiones (l x a x a)	754 x 514 x 303.2 mm



ELECTRICAL CHARACTERISTICS

Short-circuit current (Isc)	6.35 A
Open-circuit voltage (Voc)	18.45 V
DC power	95 W
Maximum power current (Imp)	5.73 A
Maximum power point voltage (Vmp)	16.62 V
Dimensions (L x W x H)	754 x 514 x 303.2 mm





CASOS DE ÉXITO / *SHOW CASES*

ISOFOTON ha realizado varias instalaciones de **HCPV**. Los proyectos más relevantes son:

***ISOFOTON** has completed several **HCPV** installations. Among the most important of these are:*

1 GOLMUD, CHINA / *CHINA*

Planta HCPV DE 100 kW equipada con módulos Gen 2.

100 kW HCPV plant featuring our Gen 2 modules.

2 PUERTOLLANO, ESPAÑA / *SPAIN*

Cuatro instalaciones de 100 kW HCPV con nuestros módulos de Gen 1 y desarrollado en colaboración con ISFOC (Instituto de Sistemas Fotovoltaicos de Concentración).

Four 100 kW HCPV facilities featuring our Gen 1 modules and developed in collaboration with ISFOC (Institute of Concentration Photovoltaic Systems).

3 IFRANE, MARRUECOS / *MOROCCO*

Planta de 30 kW HCPV, dentro del proyecto europeo Nacir, con nuestros módulos Gen 1.

30 kW HCPV plant, known as the european project Nacir, featuring our Gen 1 modules.

4 SANTA MARIA DE LICODIA, ITALIA / *ITALY*

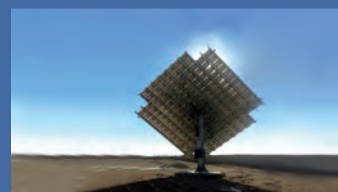
Planta comercial HCPV de 100 kW compuesta por módulos Gen2 y ejecutada bajo la regulación del 4º Conto de Energia.

100 kW HCPV commercial plant under 4th Conto Energia scheme, featuring our Gen 2 modules.

4 MA'AN JORDANIA / *JORDAN*

Sistema Gen2 de 15.2kWp instalado en Ma'an Jordania, uno de los lugares con más radiación en el mundo.

Gen2 System of 15.2kWp installed in Ma'an Jordan, one of the best radiation location in the world, to track down performance of HCPV ISOFOTON technology.



ISOFOTON +30 years

TEAM PARTNER OF MERCEDES AMG PETRONAS FORMULA ONE™ TEAM

DATOS DE CONTACTO

Si desea obtener más información sobre HCPV puede remitirnos un correo electrónico a la siguiente dirección: **hcpv-info@isofoton.com**
O visite nuestra web: **www.isofoton.com**

FÁBRICA

Parque Tecnológico de Andalucía (PTA)
C/ Severo Ochoa, 50
E-29590 Málaga
Tel: +34 95 1233500

OFICINA DE VENTAS

Torre de Cristal
Paseo de la Castellana, 259 C (Planta 18)
E-28046 Madrid
Tel: +34 91 414 7800

CONTACT DETAILS

If you would like more information about HCPV, please write to us at:
hcpv-info@isofoton.com
Or visit our website: **www.isofoton.com**

FACTORY

Parque Tecnológico de Andalucía (PTA)
C/ Severo Ochoa, 50
E-29590 Málaga
Tel: +34 95 1233500

SALES OFFICE

Torre de Cristal
Paseo de la Castellana, 259 C (Planta 18)
E-28046 Madrid
Tel: +34 91 414 7800

Seguidor solar monitorización de precisión

SOLYS 2

2-Axis Sun Tracker

Manual de Usuario

INFORMACIÓN IMPORTANTE PARA EL USUARIO

Es imprescindible leer este manual entero para entender completamente el uso adecuado y el funcionamiento seguro de este producto.

Si tiene algún comentario sobre este manual le agradecemos que los envíe a:

Kipp & Zonen B.V.
Delftechpark 36, 2628 XH , Delft, Holanda
Apartado de correos 507, 2600 AM, Delft, Holanda
Teléfono +31 (0)15 2755210
Fax +31 (0)15 2620351
Correo electrónico info@kippzonen.com
Web www.kippzonen.com

Kipp & Zonen se reserva el derecho de cambiar las especificaciones sin previo aviso.

GARANTÍA Y RESPONSABILIDAD

Kipp & Zonen garantiza que el producto entregado se ha probado a fondo para asegurar que cumple con las especificaciones publicadas. La garantía incluida en las condiciones de entrega es válida solo si se ha instalado y utilizado el producto de acuerdo con las instrucciones proporcionadas por Kipp & Zonen.

Kipp & Zonen no será responsable en ningún caso de daños fortuitos o consecuentes, incluyendo sin límite, pérdida de beneficios, pérdida de ingresos, pérdida de oportunidades de negocio, pérdida de uso y otros gastos relacionados, causados o surgidos por un defecto y uso incorrecto del producto.

Las modificaciones que haga el usuario pueden afectar a la validez de la declaración CE.

Versión del manual: 0811

En el manual y en el instrumento SOLYS 2 se usan símbolos para indicar al usuario información importante.
El significado de los símbolos es el siguiente:

 Cuidado (consultar los documentos adjuntos)

 Cuidado, riesgo de descarga eléctrica

 Terminal conductor de protección

 Corriente Continua (CC)

 Corriente Alterna (CA)

DECLARACIÓN DE CONFORMIDAD CE DE TIPO

Nosotros: **Kipp & Zonen B.V.**
Apartado de correos 507
2600AM Delft
Holanda

Declaramos bajo nuestra única responsabilidad que el producto:

Tipo: **SOLYS 2**
Nombre: **Seguidor solar**

Al que ser refiere esta declaración cumple con las Normas Armonizadas Europeas según se publicó en:
Diario Oficial de las CE: Número: C246 (05-10-2005)

La conformidad del producto se basa en:

EN 61326-1:2000 Emisiones e Inmunidad
EN 61010-1:2001 Seguridad

Siguiendo las provisiones de la directiva:

Directiva CEM:	2004/108/EC
Seguridad eléctrica:	65/2005/EC

Estas conclusiones se basan en los informes de prueba:

1678/EL SOLYS/EMC
1678/EL SOLYS/LVD
ce-test, ensayos cualificados por
Kiotoweg 363 3047BG Rotterdam

Delft,

8 de febrero de 2008

B.A.H. Dieterink
President
KIPP & ZONEN B.V.

ÍNDICE

1 INFORMACIÓN GENERAL

1.1 PRESENTACIÓN DEL SOLYS 2

El seguidor solar de dos ejes SOLYS 2 es una carga de posicionamiento que sirve para cualquier clima que se usa para apuntar instrumentos especializados al movimiento del sol a través del cielo. Es completamente automático y no necesita ordenador ni software de instalación.

El receptor de GPS integrado configura automáticamente la posición y los datos de hora. Los LED multicolores indican el estado de funcionamiento y un puerto Ethernet permite la actualización del software. El sistema de transmisión de correas de alto rendimiento no necesita mantenimiento.

La carcasa de aluminio de fundición resistente y característica tiene un trípode integrado con patas de nivelación. Se incluye como estándar un plato lateral con soporte de montaje para un pirheliómetro Kipp & Zonen y se puede poner un segundo plato lateral para un pirheliómetro adicional. El plato de montaje superior permite montar de forma adecuada hasta tres radiómetros Kipp & Zonen. La unidad de sombreado incluye un plato de montaje superior y permite configurar el seguidor como una estación completa de monitorización solar.

El reloj interno DEL SOLYS 2 no tiene deriva ya que la hora se actualiza con el receptor de GPS. Existe disponible un sensor de sol, para el seguimiento activo del sol, para su utilización en aquellas circunstancias donde no es posible garantizar la estabilidad de la plataforma de instalación.

El SOLYS 2, ha sido diseñado para realizar un seguimiento solar fiable y asequible para cargas de mediano y pequeño tamaño. La precisión es excelente para aplicaciones de monitorización solar.
La fuente de alimentación incorporada acepta tanto 24 V CC como 90 – 264 V CA y permite utilizar la alimentación CC, como respaldo.

El SOLYS 2 es un instrumento adecuado para todo tipo de climas, proporcionando un rendimiento óptimo incluso en las condiciones climáticas más rigurosas (de las regiones ecuatoriales a las polares). La calefacción incorporada, amplía la temperatura de funcionamiento hasta los – 40 ºC y únicamente funciona con alimentación de CA. El SOLYS 2 se caracteriza por su alta precisión, resolución y repetibilidad.

En la Figura 1.1 se muestra un SOLYS 2 estándar sin accesorios.

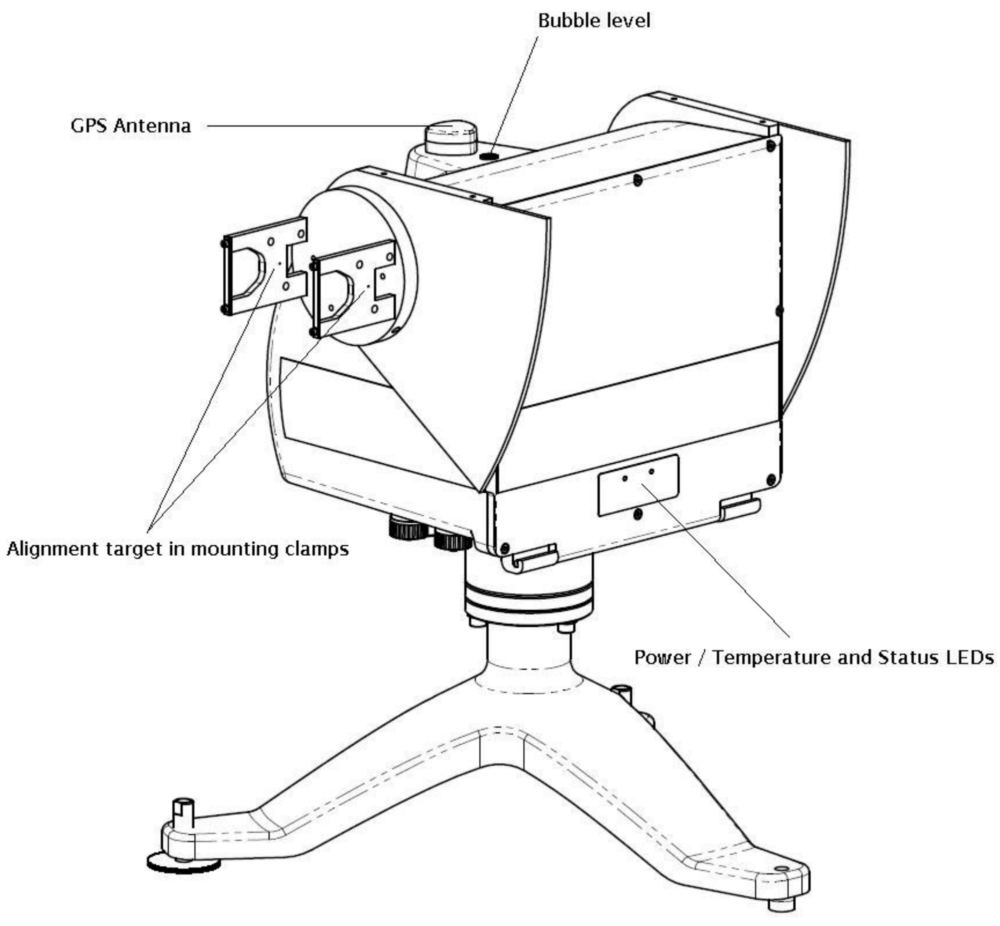


Figura 1.1: SOLYS 2 estándar

1.2 MANUAL

El *MANUAL DE INSTRUCCIONES DEL SOLYS 2* está pensado para usuarios que han comprado SOLYS 2 con alguno o todos los accesorios disponibles para mejorar o ampliar sus capacidades. Incluye toda la información necesaria para instalar y poner en funcionamiento el SOLYS 2 para funcionamiento automático y desatendido.

2 DATOS TÉCNICOS

2.1 ESPECIFICACIONES DEL SOLYS 2

	SOLYS 2	**Comentarios**
Rendimiento		
Precisión de apuntado	< 0,1 °	Cumple con los requisitos de BSRN
Par	20 Nm	
Carga	20 kg	Equilibrada
Velocidad angular	5 °/s	
Aceleración angular	3,6 °/s²	
Rotación	110 ° cenit	
	540 ° acimut	
Protección contra sobre rotación y daños	Topes limitadores físicos	
Condiciones de funcionamiento y dimensiones		
Tensión de suministro	18 a 30 VCC (nominal 24 CC)	Permite la recarga de batería o carga baja
	90 a 264 VCA 50 / 60 Hz	Para uso en todo el mundo
Potencia	25 W máximo	Alimentación CC
	125 W máximo	Alimentación CA con el calefactor funcionando
Temperatura de almacenamiento	- 40 a + 50 °C	
Intervalo de temperatura de funcionamiento	- 20 a + 50 °C	Alimentación en CC
	- 40 a + 50 °C	Alimentación en CA (calefactor estándar)
Peso	23 kg	Para sensor estándar
	5 kg	Trípode
Dimensiones (LxAxH)	50 x 34 x 38 cm (excluyendo el trípode)	Incluye el montaje del pirheliómetro estándar
Precisión del nivel de burbuja	< 0,1°	Relativo al eje cenital
Cumplimiento con normas internacionales		
Protección del medioambiente	IP 65	Adecuado para uso en exterior con todo tipo de clima
Cumplimiento CE	Sí	
Materiales	Adecuado para uso en áreas costeras y contaminadas	
Características		
Transmisión	Correa dentada	Pretensionada, no necesita ajuste
Conexiones	Enchufe y toma para Alimentación CC, Alimentación CA, Ethernet	
GPS para información de posición y fecha/hora (posición y hora / fecha)	Estándar	Antena en la parte superior de la carcasa
Montaje de pirheliómetro	Plato lateral y kit de montaje (como) estándar.	Para Kipp & Zonen CH 1 o CHP 1
Base de montaje	Trípode estándar	Incluye patas ajustables para nivelado

LED indicadores para	Alimentación , temperatura interna y estado	Multicolor para indicar varios modos
Actuaciones del cliente		
Instalación	Enchufar y listo, no necesita PC	El GPS adquiere la posición y fecha/hora
Autodiagnóstico funcional	Estándar	LED multicolor indicador de estado
Instalación de diagnóstico / prueba	Estándar	Via puerto Ethernet
Modo de seguimiento solar	Estándar	Algoritmo Michalsky (1988)
Posibilidad de actualización del firmware	Memoria flash	Via puerto (de) Ethernet
Mantenimiento	No es necesario ningún mantenimiento programado	Se recomienda inspección anual
Reinicio automático después de interrupción de alimentación	Sí	
Opciones		
Kit de sensor de sol	Para seguimiento solar activo	Enchufar la unidad con ajuste de alineación. Ángulo de visión 7°
Segundo plato de montaje lateral	Para fijación al eje cenital del lado opuesto del pirheliómetro estándar existente	No incluye platos de montaje del instrumento
Plato de montaje superior	3 posiciones para radiómetros Kipp & Zonen (con o sin unidades de ventilación CV 2) o Eppley PSP / PIR (con o sin unidades de ventilación VEN)	No necesita adaptadores
Montaje de la unidad de sombreado	Incluye el plato de montaje superior y un segundo plato de montaje lateral y 2barras con unidad de sombreado ajustables	Altura de la unidad de sombreado regulable para ajustarse a los radiómetros de arriba
Kits de montaje del radiómetro	Para pirheliómetro Kipp & Zonen CH 1 o CHP 1	Todos necesitan un plato de montaje lateral
	Para pirheliómetro de cavidad absoluta PMOD-WRC PMO 6	
	Para fotómetro solar Middleton SP02 o SP01-L	
	Para pirheliómetro de cavidad absoluta Eppley HF o AHF	

Tabla 1: Especificaciones de funcionamiento del SOLYS 2

3 CONEXIÓN ELÉCTRICA E INFORMACIÓN DE SEGURIDAD

3.1 FUENTE DE ALIMENTACIÓN Y CAPACIDAD DEL FUSIBLE

Importante: Fuente de alimentación

El SOLYS 2 puede funcionar a 115 / 230 VCA o 24 VCC. En el caso que exista tanto alimentación CC como CA, dentro del rango de funcionamiento (90 – 264 VCA), el SOLYS 2 usará la alimentación CA. En el caso de fallo de la alimentación CA y existir alimentación en CC, el SOLYS 2 seguirá funcionando sin interrupción con la alimentación CC. En el interior del SOLYS 2 se encuentra un fusible lento de 4 A, para el calefactor interno.

3.2 DATOS Y CONEXIONES DEL CABLE ELÉCTRICO

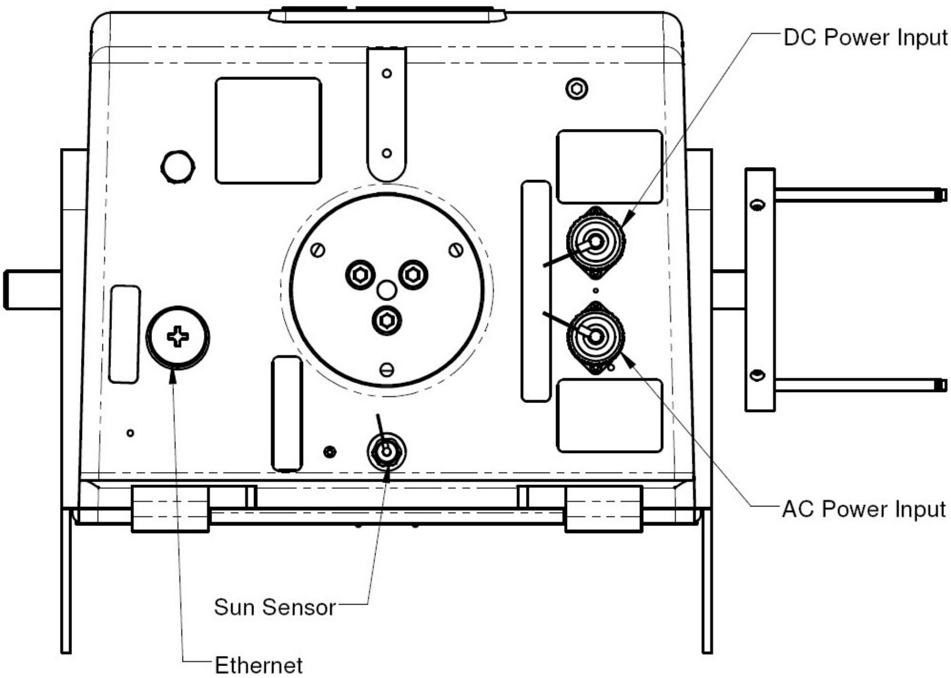


Figura 3.1: conectores de la parte inferior del SOLYS 2

Importante: Alimentación y cable de comunicación

EL SOLYS 2 se suministra con dos conectores de intemperie, tanto para CA como CC. Estos conectores cumplen las regulaciones de seguridad para uso en exteriores. Una caída de tensión en el cable no causará que el voltaje esté fuera de las especificaciones.

Tanto el conector de CA como el de CC, son adecuados para diámetros de cable entre 6 y 12 mm. Para 6 – 9 mm y 9 – 12 mm se usarán juntas distintas.

El conector de CA es un conector hembra tipo Hirschmann CA 3 LD.

El conector de CC es un conector macho tipo Hirschmann CA 3 LS.

En las fig 3.4 y fig. 3.5 se muestran los esquemas tanto de los conectores como de su número de pin .

En el interior del conector están visibles tanto el número de pin conexión de tierra. La conexión de tierra está ligeramente por encima de las otras conexiones.

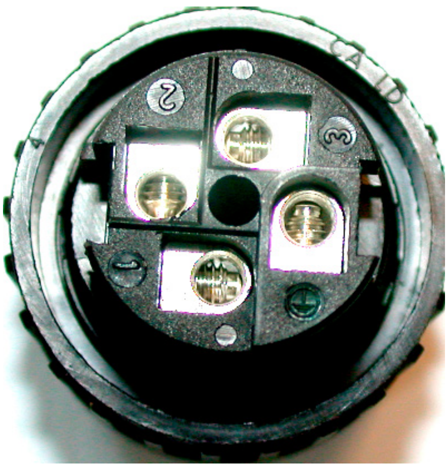


Figura 3.2: numeración de los pines de los conectores de alimentación macho y hembra

El conector de Ethernet se protege con una tapa roscada para hacerlo resistente al agua. Si se quita esta tapa, hay que conectar un conector RJ45. El cable tiene que ser del tipo Cat 5e cruzado y preferentemente protegido. Para hacer la conexión resistente a la intemperie, la pieza suministrada del conector para el cable tiene que ajustarse de forma que selle el conector para que no entre agua. Puede ser necesario quitar el recubrimiento aislante de algunos conectores RJ45. La parte del cable que cierra el conector Ethernet de intemperie debe estar firmemente cerrada para conseguir la estanqueidad adecuada.

Figura 3.3: Conector de Ethernet del SOLYS 2

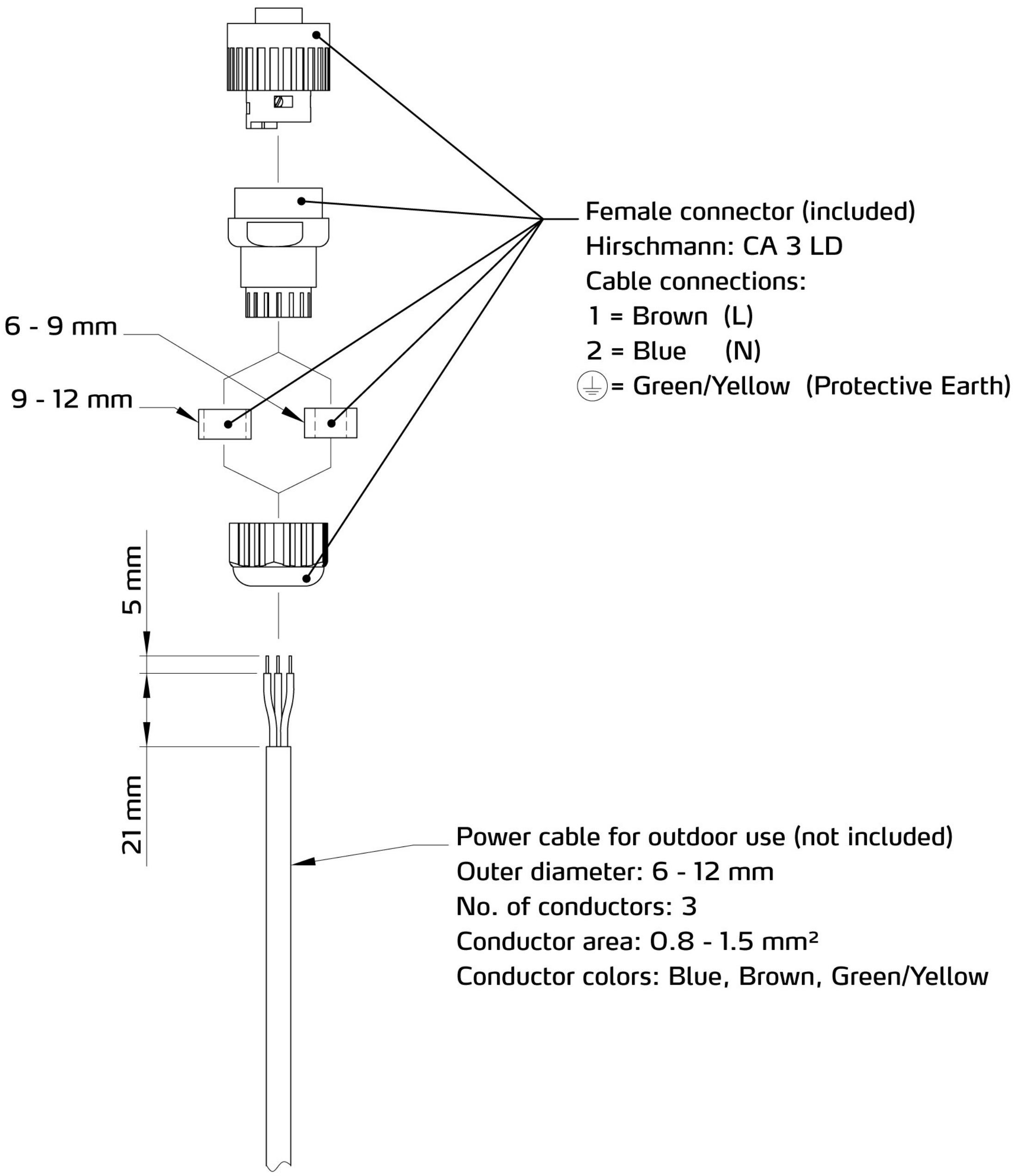


Figura 3.4: Conector del cable de alimentación para 90 – 264 VCA

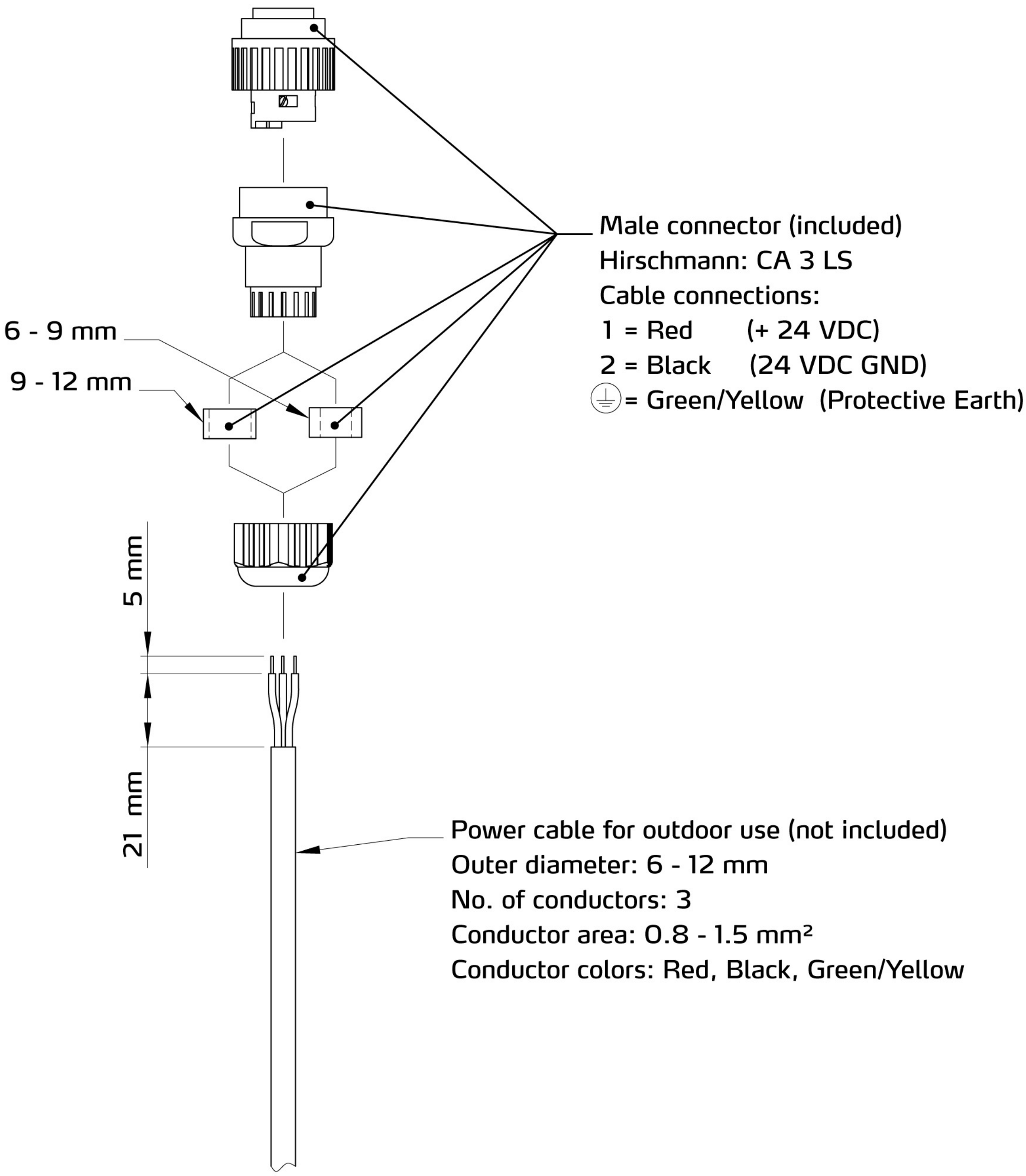


Figura 3.5: Conector del cable de alimentación para 24 VCC

Importante: Interruptor automático

El interruptor de encendido/apagado no se suministra con el SOLYS 2, los requisitos para los equipos eléctricos de exteriores deben cumplir:

- Se tiene que incluir un aislador eléctrico (interruptor o interruptor automático) en la instalación del cable.
- El aislador tiene que estar cerca del equipo y a mano del operario.
- El aislador tiene que estar marcado como el dispositivo de desconexión de alimentación para el equipo.

3.3 CONDICIONES MEDIOAMBIENTALES

Importante: Tapa trasera del SOLYS 2

EL SOLYS 2 no contiene ninguna pieza útil para el usuario en su interior. Por lo tanto, se aconseja no abrir la tapa trasera. Si se abre se pueden desactivar los sensores ópticos internos causando daños físicos al SOLYS 2 y/o cualquier equipo adjunto. La garantía no cubre este daño.

Importante: Temperatura de funcionamiento

EL SOLYS 2 tiene un rango de temperatura de funcionamiento de – 20 °C a + 50 °C cuando funciona a 24 VCC. Cuando se aplica alimentación de CA se usará el calefactor incorporado estándar. El uso del calefactor amplía la temperatura de funcionamiento hasta – 40 ºC. El calefactor interno se enciende automáticamente por debajo de 5 ºC. Si el SOLYS 2 se pone en funcionamiento por debajo de – 20 ºC puede tardar hasta 30 minutos antes de que en el interior se superen los – 20 ºC y arranque el SOLYS 2.

Tabla 4: Intervalo de temperatura de funcionamiento del SOLYS 2.

SOLYS 2 funcionando con alimentación CC (calefactor no funcional)	- 20 ºC a + 50 ºC
SOLYS 2 funcionando con alimentación CA (calefactor operativo)	- 40 ºC a + 50 ºC

Importante: Precipitación

Con la tapa trasera del SOLYS 2 instalada adecuadamente, de forma que los 8 tornillos estén apretados, el SOLYS 2 está protegido medioambientalmente para IP65, según EN 60529: 1991 + CI 1993. Esto cualifica al SOLYS 2 para que pueda ser utilizado en condiciones climatológicas bajo todo tipo de precipitación.

4 INSTALACIÓN Y MONTAJE

Las secciones siguientes proporcionan información sobre la instalación y el montaje del SOLYS 2.
La instalación es fácil y consta de los pasos siguientes:

- Crear una base firme para montar el trípode
- Montar el trípode con el logotipo K&Z hacia el este
- Montar el seguidor con la E en la pestaña de montaje orientada hacia el este
- Montar los accesorios
- Montar los instrumentos
- Nivelar el SOLYS 2 usando el nivel de burbuja integrado
- Conectar la alimentación CA y/o CC
- Ajustar bien la orientación al este girando el SOLYS 2 en el trípode
- Ajustar bien el sensor de sol, opcional, con los tornillos de montaje en intervalos de 10s

Aparte de la fabricaron de la base de plato del trípode y del montaje de los accesorios e instrumentos, **el nivelado y adecuado ajuste es solo cuestión de minutos. No obstante, se necesita de un día despejado para realizar esta operación.**

EL SOLYS 2 tiene varios accesorios para mejorar y ampliar su funcionamiento, incluyen:

- Plato de montaje superior
- Plato de montaje lateral extra
- Unidad de direccionamiento y sombreado:
  Incluye un Plato de montaje lateral extra y un Plato de montaje superior.
- Sensor de sol
- Kits de montaje para varios instrumentos, para la meda de la radiación solar directa.
- Unidades de ventilación para Piranómetros/Pirgeómetros

Las instalaciones de las distintas opciones e instrumentos se describen a partir del apartado 4.5.

4.1 HERRAMIENTAS NECESARIAS PARA EL MONTAJE DEL SOLYS 2

Para su instalación se entregan los siguientes materiales junto con el SOLYS 2
- Llave Allen No. 6 (para los tornillos M8 del trípode)
- Llave Allen No. 3
- Llave Allen No. 2.5
- Tornillos M8 x 20 con arandelas M8

Material necesario pero no suministrado:
- Destornillador para conexión del cable de alimentación al conector
- Cable para la conexión de alimentación del SOLYS 2
- Brújula para localizar el este geográfico.

4.2 HERRAMIENTAS PARA EL MONTAJE DE LA UNIDAD DE SOMBREADO

Las herramientas necesarias para el montaje de La unidad de sombreado son suministradas con este elemento opcional,:

- Regla para medir la posición del sensor de sol opcional. (ver fig. 4.21)

4.3 ÁREA DE FUNCIONAMIENTO MÍNIMA

El SOLYS 2, completo con todos sus accesorios montados, necesita una superficie libre de obstáculos para funcionar de forma adecuada. Hay que tenerlo en cuenta cuando decidamos dónde y cómo se va a montar la unidad. La figure 4.1 muestra el área de funcionamiento mínimo con respecto tanto al eje acimutal como cenital de un SOLYS 2 completo con todos sus accesorios, incluyendo Trípode y unidad de sombreado.

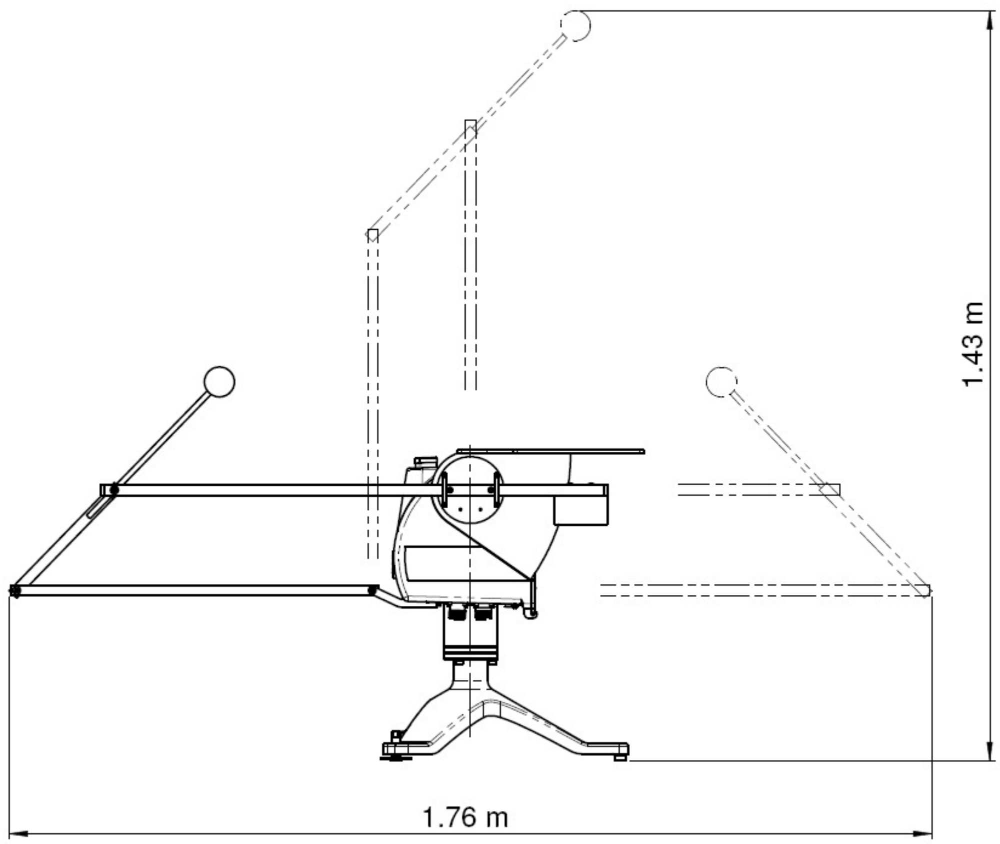


Figura 4.1: Área de funcionamiento mínima con Unidad de Sombreado

Importante:

Es importante considerar los puntos siguientes antes/durante el montaje de un SOLYS 2.

- Verificar que todos los cables están situados adecuadamente para evitar que los cables se enganchen con algún plato, cierres, el SOLYS 2 o instrumentos.
- Asegurarse de que la superficie sobre la que se montará el Seguidor solar esté razonablemente nivelada, pero sobre todo es muy importante crear una base muy firme para que se asienten las patas del trípode.
- Asegurarse de que no hay obstáculos dentro del círculo de funcionamiento y que hay una visión clara del horizonte en todas las direcciones.
- Asegurarse de que el SOLYS 2 y sus accesorios estarán accesibles para realizar el mantenimiento.
- Asegurarse que el SOLYS 2 está situado de forma que las sombras no se proyectarán sobre los radiómetros en ningún momento.
- Asegurarse que antes de operar el SOLYS 2 el cable del Sensor de sol y otros cables de los instrumentos montados, no se engancharán en ningún cierre o plato.

4.4 MONTAJE DEL SOLYS 2

Es importante elegir un emplazamiento cuando se instala el SOLYS 2, ya que necesita un espacio determinado para funcionar.

El SOLYS 2 se suministra con un reborde inferior de ∅ 102 mm, con un diseño de montaje con 3 agujeros de M8 para que ajuste el Trípode con sus patas de nivelación. El trípode tiene 3 ranuras para montar los 3 tornillos M8 en el reborde inferior. Tanto la marca E del cilindro o como el logotipo K&Z del trípode **se tienen que dirigir al este** cuando esté montado el SOLYS 2. Preferiblemente los tornillos tienen que estar en el medio de las ranuras cuando esté montado el trípode en el SOLYS 2. Esto permitirá realizar el ajuste fino de la posición final.

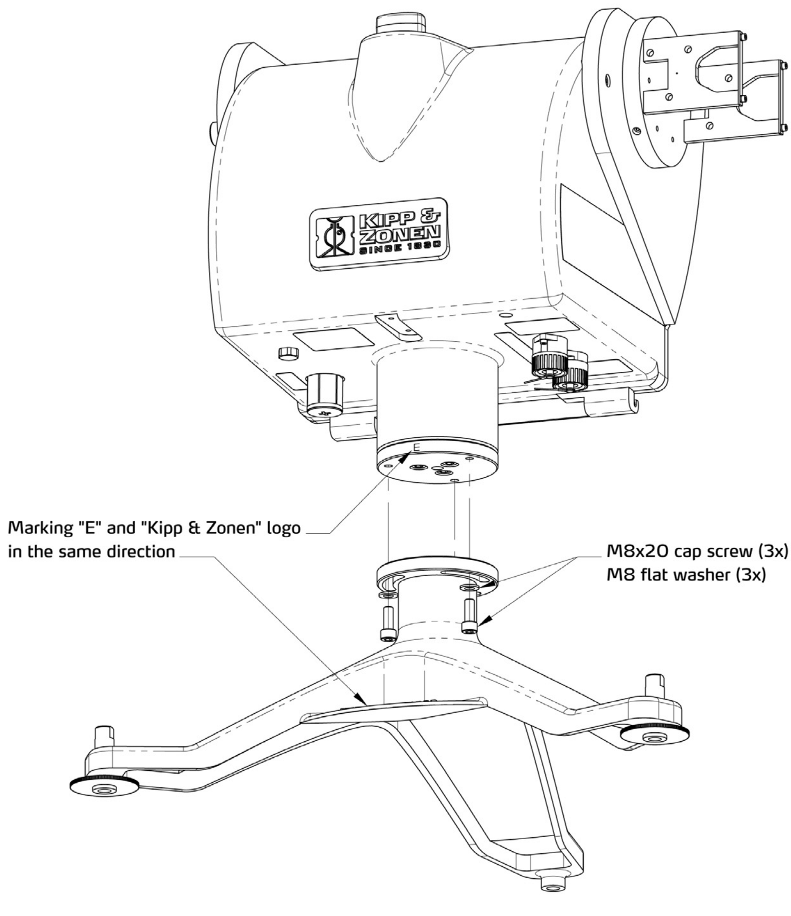


Figura 4.2: Montaje de SOLYS 2 en el Trípode

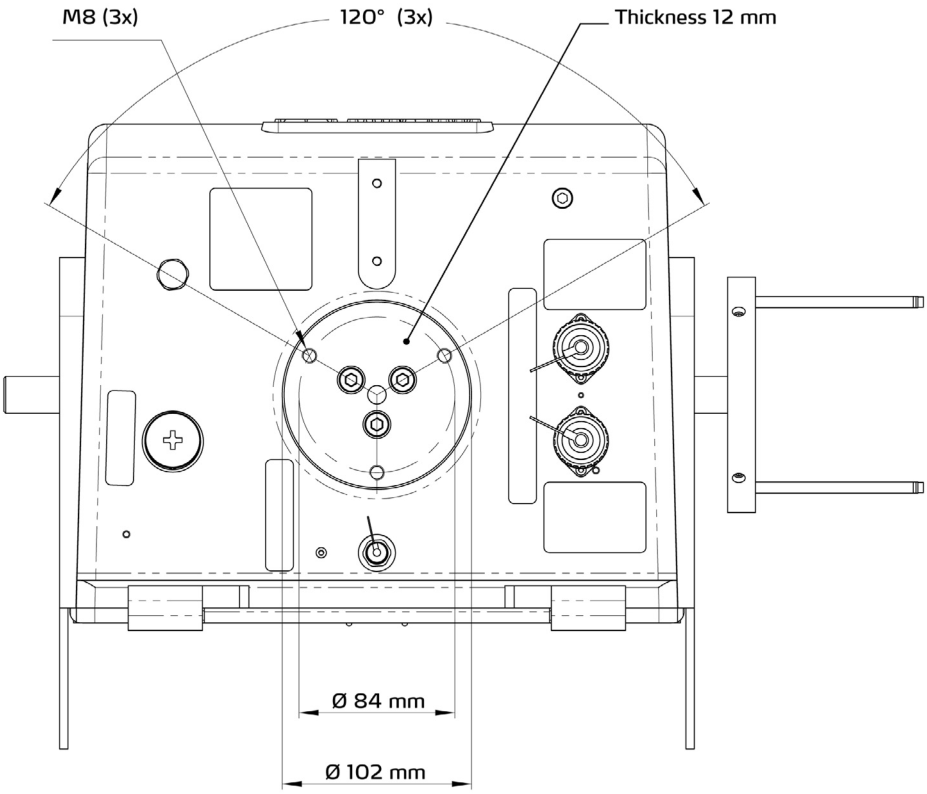


Figura 4.3: Dimensiones del reborde inferior de SOLYS 2

Nota: Cuando se usen distintos tornillos de montaje estos no deberán sobresalir del cilindro inferior.

Consejo: *Cuando se instale una orientación acimutal inicial, justo hacia el este se hará con la ayuda de una brújula. Cuando se ponga en funcionamiento el SOLYS 2, podrá ser ajustada la posición exacta, siempre cuando haya sol (disponible).*

4.5 NIVELACIÓN DEL SOLYS 2

Antes de poner en marcha el SOLYS 2, hay que nivelarlo sobre su superficie de montaje. Para ayudar a realizar esta tarea, el SOLYS 2 está equipado con una burbuja de alta precisión en la parte superior de la carcasa. Hay que ajustar las patas de nivelación del trípode para llevar la burbuja al centro del nivel. Las patas de nivelación se pueden ajustar con facilidad usando una llave de 13 mm. La precisión del SOLYS 2 estará entonces dentro de 0,1°

Las patas del trípode tienen unos agujeros de montaje de 11 mm para fijar el SOLYS 2 al suelo. Se aconseja volver a comprobar la nivelación después de instalar los accesorios y los instrumentos.

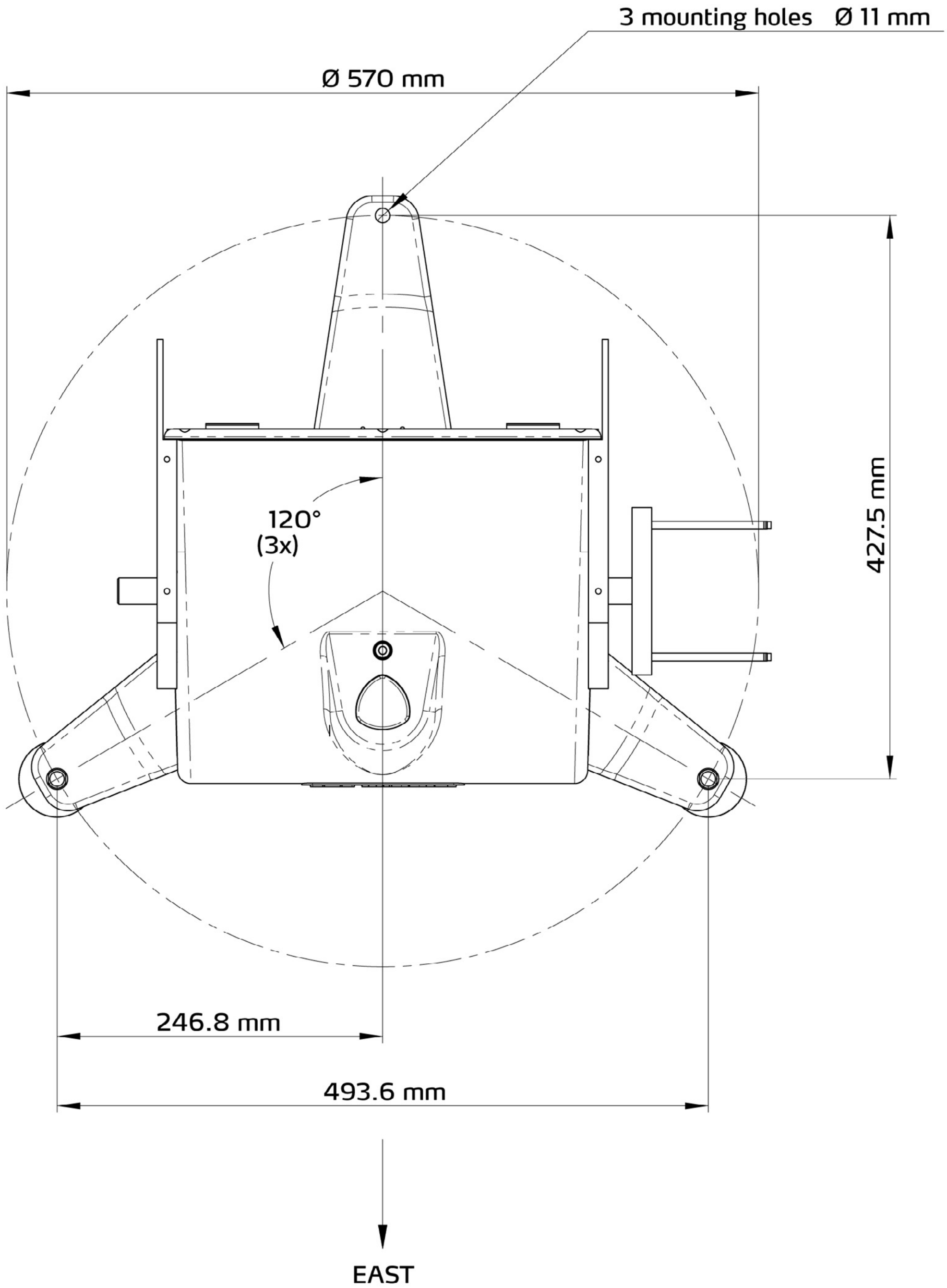


Figura 4.4: Huella del trípode

4.6 INSTALACIÓN DE ACCESORIOS

Este capítulo proporciona toda la información sobre la instalación de los accesorios en un SOLYS 2.

4.5.2 Plato de montaje lateral

El SOLYS 2 se suministra de manera estándar con un Plato de montaje lateral. Este plato viene instalado de fábrica en la posición correcta y no necesita ajustes.
Un segundo Plato de montaje lateral se utiliza junto con la unidad de sombreado. Los platos suministrados se pueden personalizar para que reúnan los requisitos de configuración específicos. Para alinear el segundo plato de montaje es necesario que haya un día despejado para poder ajustar su posición en el eje. Durante el funcionamiento normal (SOLYS 2 encendido) la posición del plato de montaje lateral se puede realizar con la mirilla de alineamiento de las monturas de montaje (o de los Pirheliómetro).
El esquema de mecanizaciones del Plato de montaje lateral se muestra en la figura 4.5.
Si se utiliza el segundo plato de montaje lateral para montar el brazo de la unidad de sombreado (sin monturas de montaje de instrumento) este brazo se tiene que alinear con el primero antes de fijar los tornillos en los ejes.

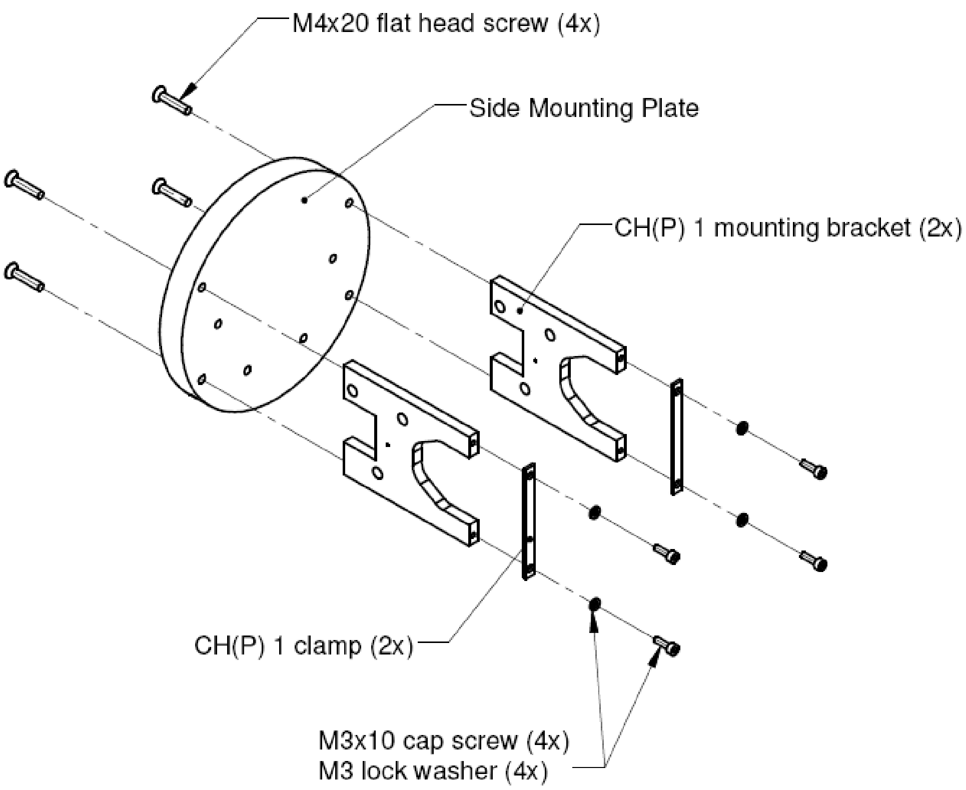


Figura 4.5: Ensamblaje del Plato de montaje lateral con el kit de montaje de pirheliómetro CH(P) 1

- Desconectar la alimentación del SOLYS 2
- Pre-montar el Plato de montaje lateral como se indica en la figura 4.5 y fijar el Palto de montaje lateral al eje cenital. Asegurarse de que el plato está presionando contra el extremo del eje cenital.
- Comprobar el nivel de la burbuja circular una vez más para verificar que el SOLYS 2 sigue nivelado adecuadamente.
- Usar el dispositivo de alineación (mirilla) para posicionar el plato de montaje lateral hacia el sol. Esto requiere que el SOLYS 2 esté funcionando y que haya un día despejado, o alinear el segundo brazo de sombra con el primero. (como se describe en la unidad de sombreado)
- Apretar los dos tornillos M6 interiores del plato de montaje lateral para sujetarla con la abrazadera de forma segura al eje. (usar una llave #3)

4.6.1 Montaje de la unidad de sombreado

La unidad de sombrado consta varios componentes que, cuando se montan en el SOLYS 2, proporcionan una unidad mecánica para asegurar el sombrado preciso durante las operaciones de seguimiento solar normales, ver la figura 4.11.

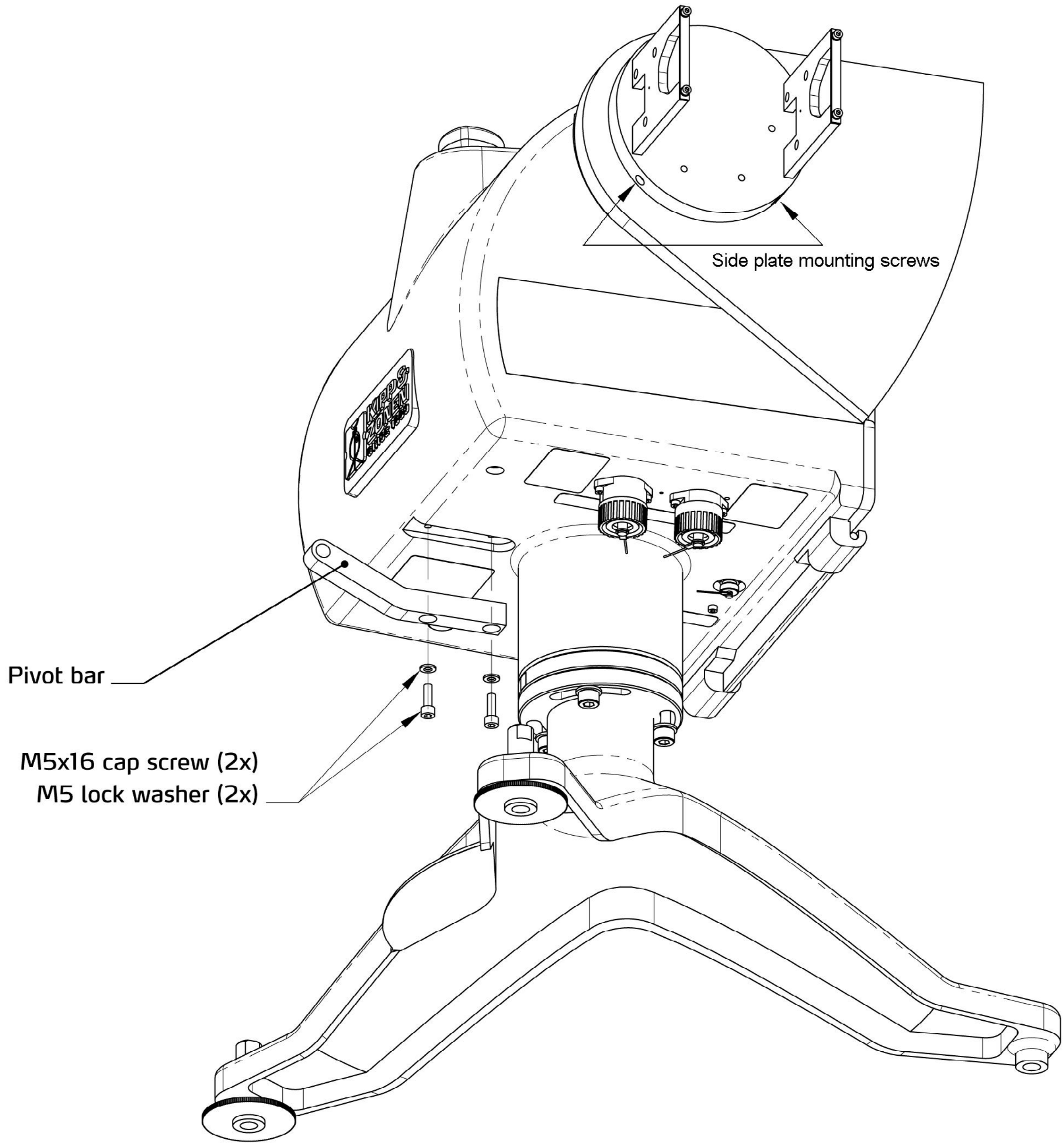


Figura 4.6: Montaje de la barra pivote

La sección 4.5.6 contiene más información sobre el Plato de montaje superior, recomendado para que los piranómetros funcionen conjuntamente con la unidad de sombreado.

Abajo se lista la secuencia de montaje recomendada:

- Instalar la Barra pivotante inferior en la parte inferior del SOLYS 2 con los tornillos designados, ver figura 4.6
- Fijar ambos Brazos de guiado de la unidad de sombreado con los tornillos designados. Asegurarse de que los contrapesos están boca abajo. No apretar completamente los tornillos todavía, puede ser necesario realizar algún movimiento para instalar la barra T, ver figura 4.7

- Instalar la barra T (sin las esferas de sombreado). Instalar las arandelas de plástico en los pivotes de la barra T. Insertar las arandelas de plástico en los agujeros del extremo del brazo lateral. Instalar las arandelas planas externas y las tuercas de bloqueo, asegurándose de que todos los casquillos están situados adecuadamente en los brazos laterales. Solo instalar sin apretar las tuercas de bloqueo en este punto.

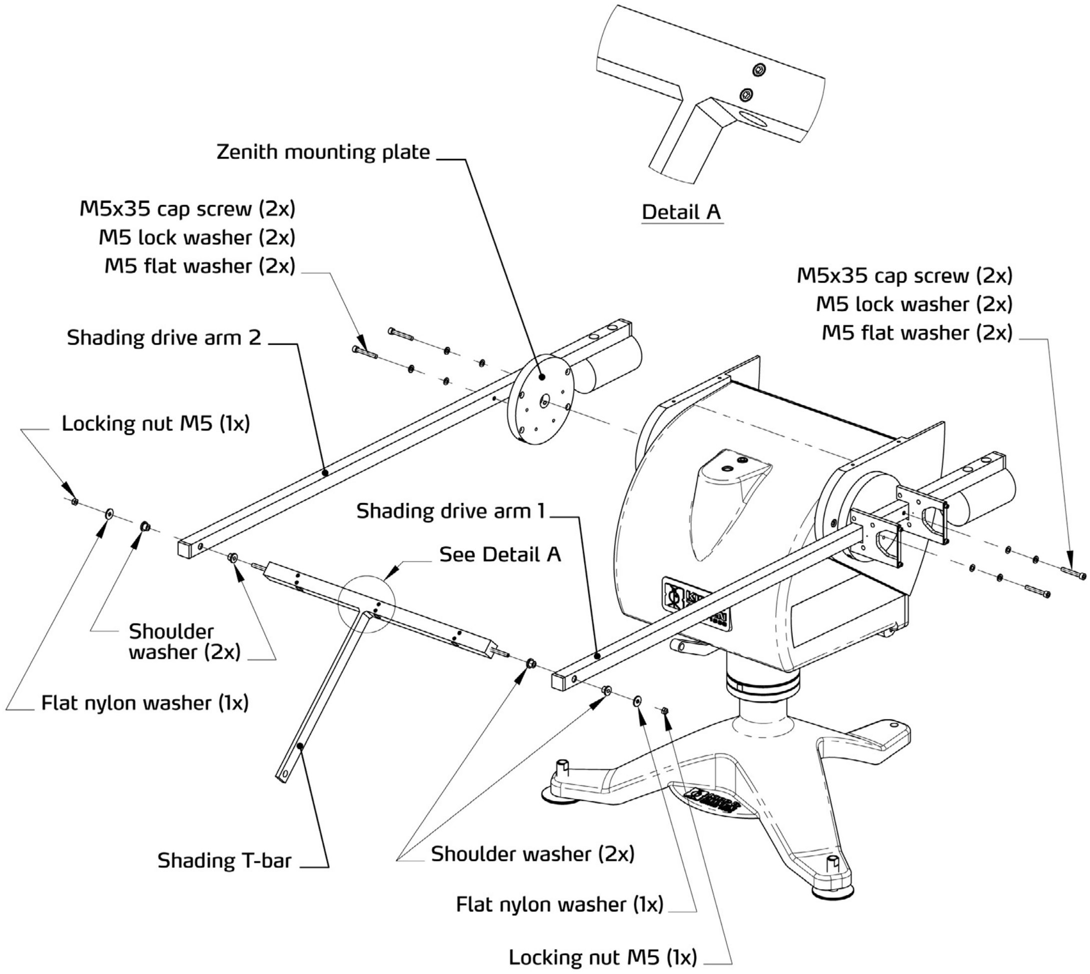


Figura 4.7: Montaje de los brazos de accionamiento de sombreado

- Apretar los tornillos del Brazo lateral y montar el segundo plato lateral en el eje con sus dos tornillos (ver figura 4.6) después de alinear los dos Brazos de accionamiento de sombra.
- Ahora apretar las tuercas de bloqueo de la barra T hasta que desaparezca la holgura entre los brazos y las arandelas de plástico. No apretar bien, asegurar que la barra T gira libremente pero tiene un movimiento lateral mínimo.
- Instalar el Brazo de accionamiento de sombra en la barra T. Instalar las arandelas de plástico en los agujeros como se muestra. Apretar solo la tuerca de bloqueo para que la holgura sea mínima, asegurar el movimiento de rotación libre.
- Instalar el otro extremo del Brazo de accionamiento de sombra en la Barra pivote de sombra con las arandelas de nylon y la tuerca de bloqueo que se muestra en la figura 4.7. Apretar solo la tuerca de bloqueo para que la holgura sea mínima, asegurar el movimiento de rotación libre.
- Instalar las Barras con unidad de sombreado deslizándolas en los agujeros designados. Ver la figura 4.11 para la colocación preliminar de las Barras con las esferas de sombreado en la barra T. El ajuste fino de las Barras de las esfera de sombreado, se tiene que hacer más adelante en el montaje, después del procedimiento de verificación del nivelado. NO SOBREAPRETAR los tornillos de bloqueo, dificultaría ajustes más adelante en el procedimiento.

Nota: *Para verificar que el Ensamblaje de sombra no interferirá con ningún obstáculo, mover la unidad de sombreado hacia abajo y girar el SOLYS 2 a mano por todo su rango mecánico. (apagado)*

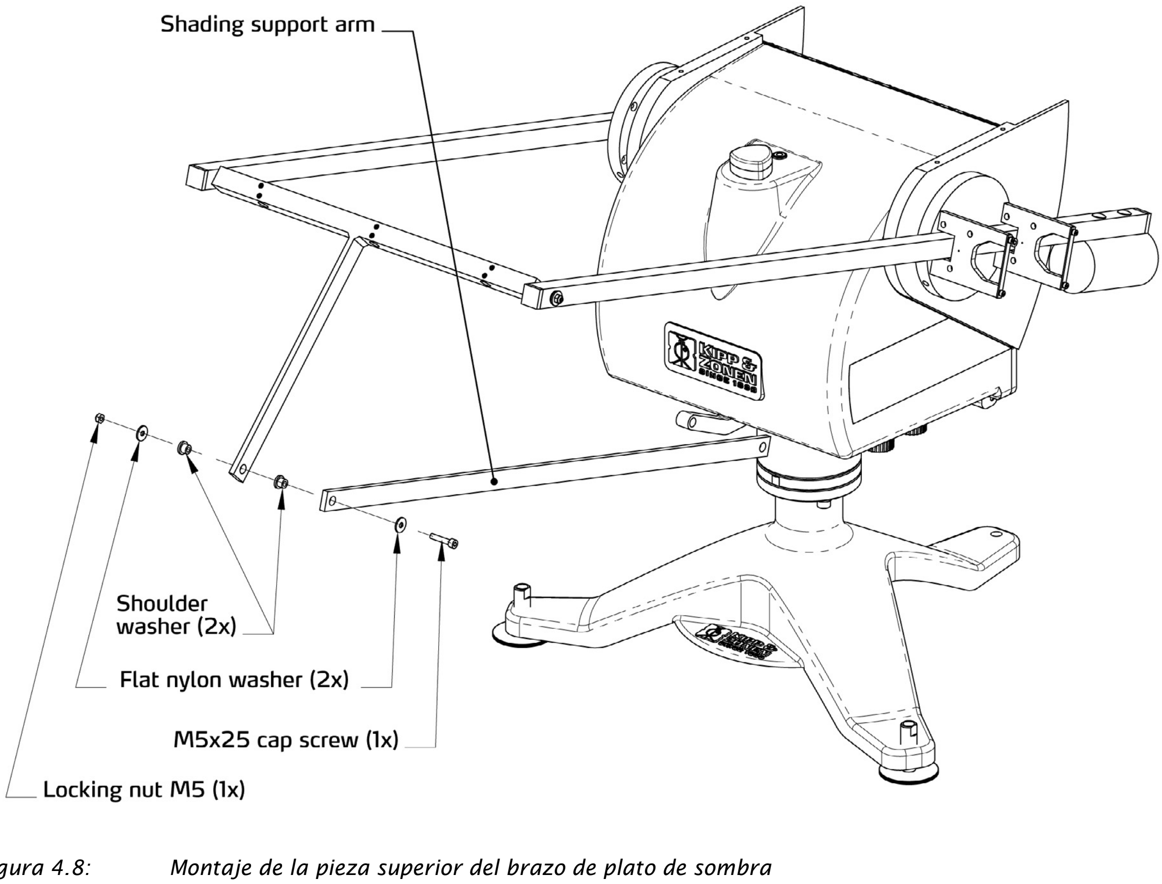


Figura 4.8: Montaje de la pieza superior del brazo de plato de sombra

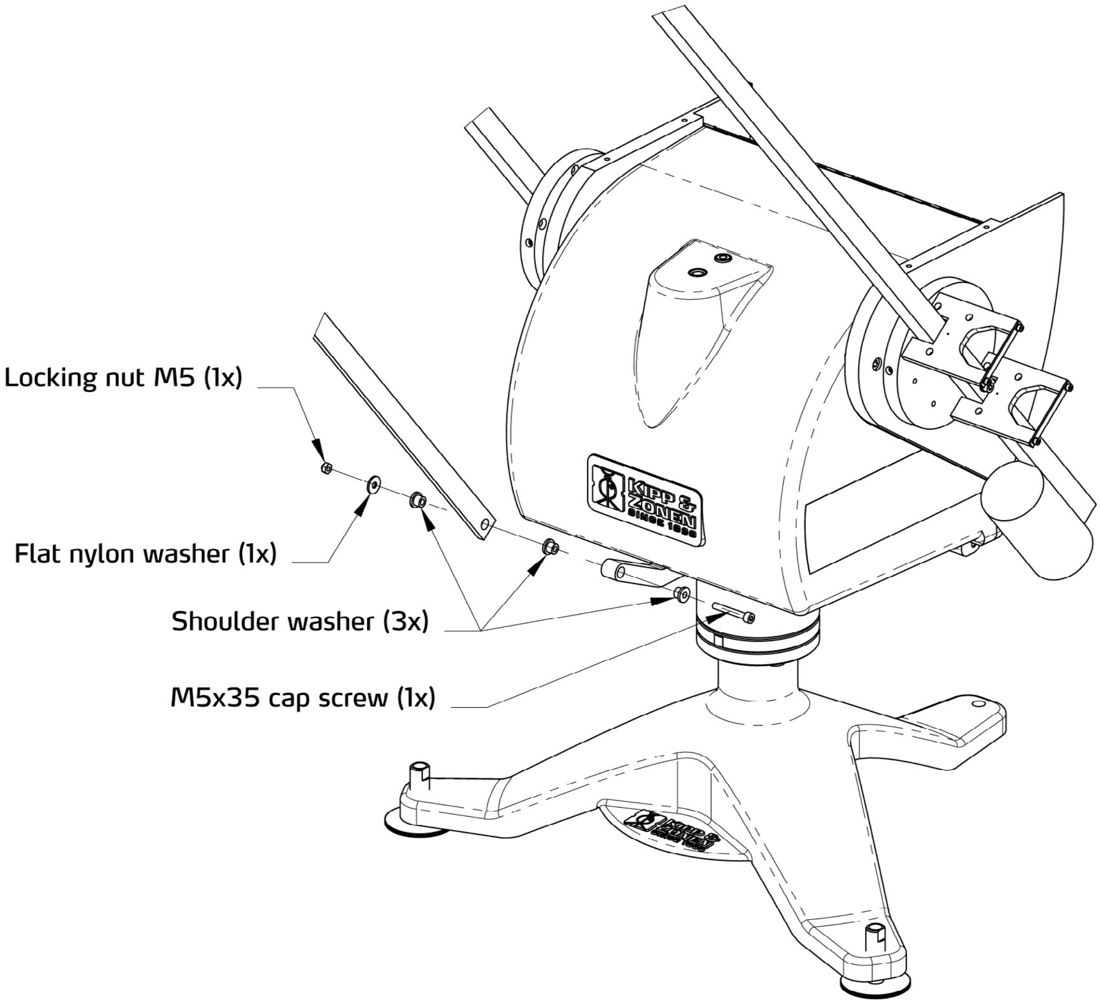


Figura 4.9: Montaje de la pieza inferior del brazo de plato de sombra

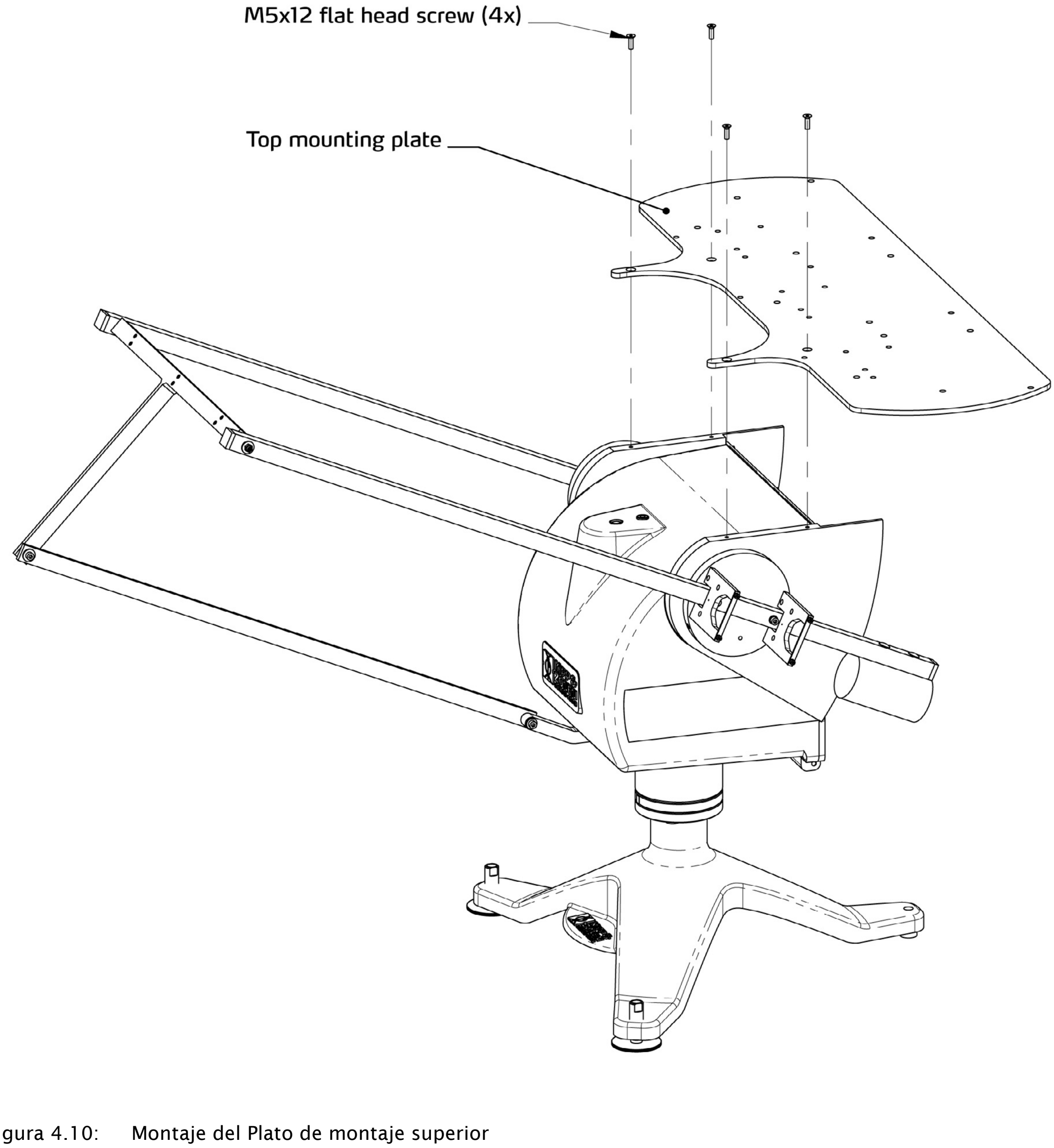


Figura 4.10: Montaje del Plato de montaje superior

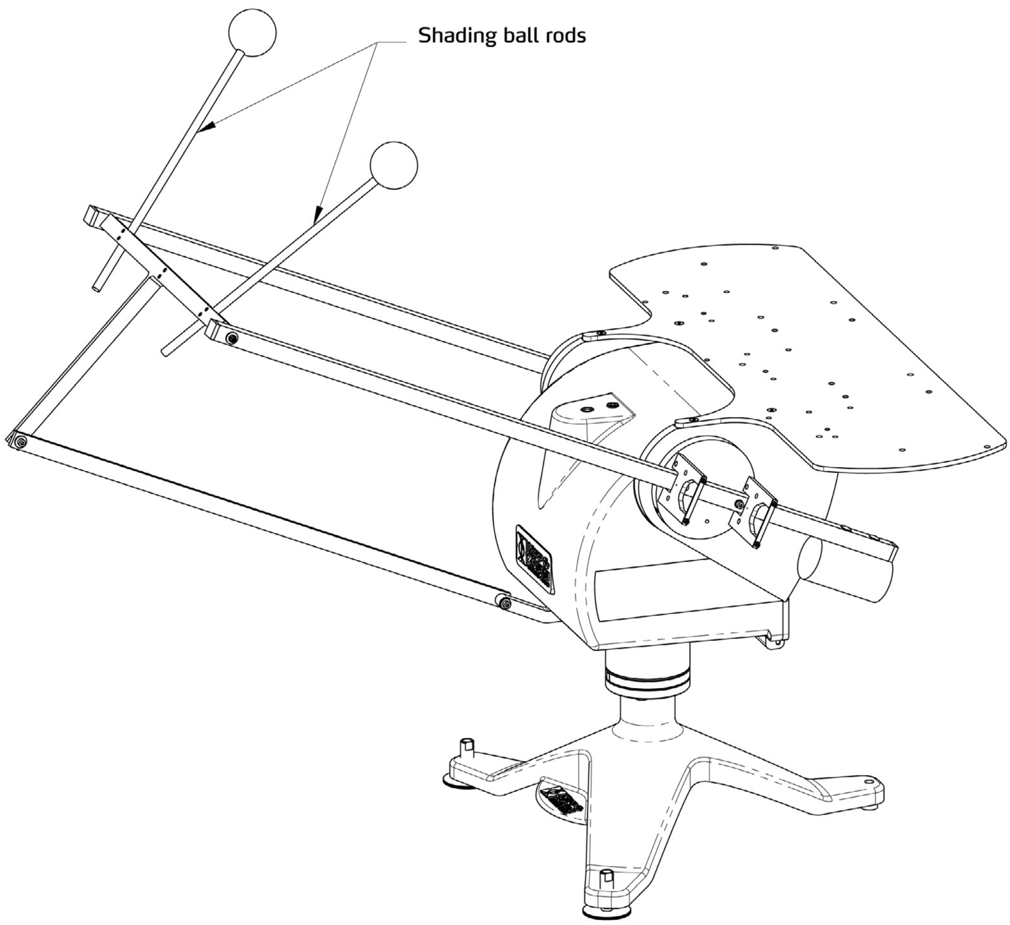


Figura 4.11: Montaje de las barras con unidad de sombreado

La posición de las unidades de sombreado depende del tipo (altura) de sensor.
Abajo, en las figuras 4.12 y 4.13, se describen dos posiciones distintas para los radiómetros CMP / CGR con y sin unidad de ventilación. Asegurarse de utilizar la posición correcta en su situación.

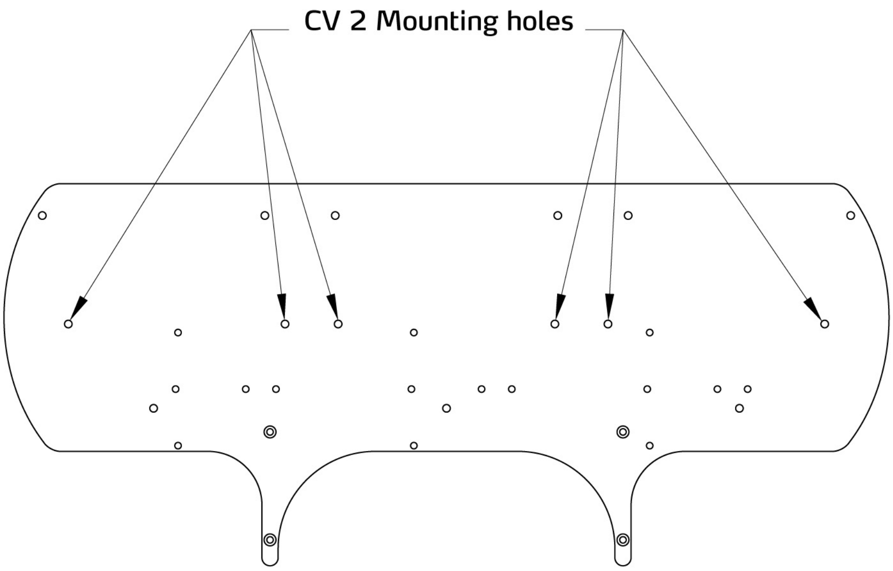


Figura 4.12A: Posiciones de montaje de radiómetros con unidad de ventilación CV 2

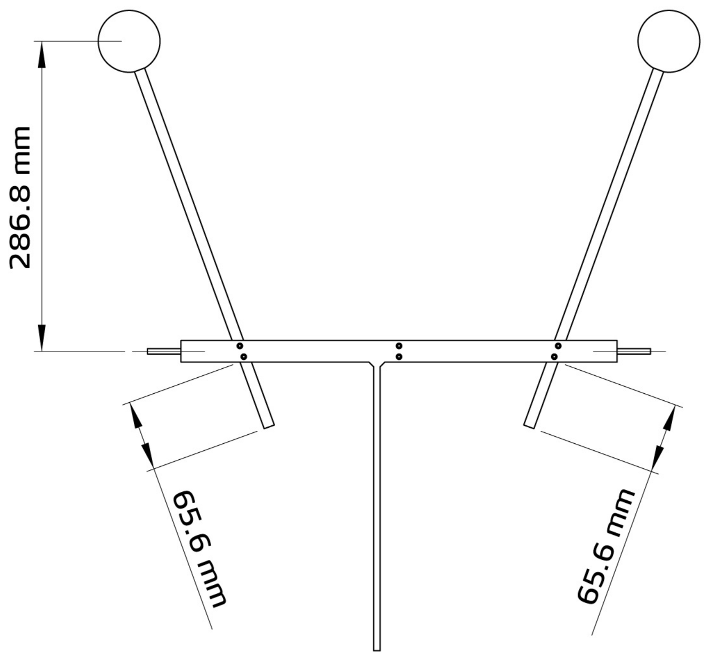


Figura 4.12B: Instalación de las Barras de unidad de sombreado para radiómetros Kipp & Zonen con CV 2

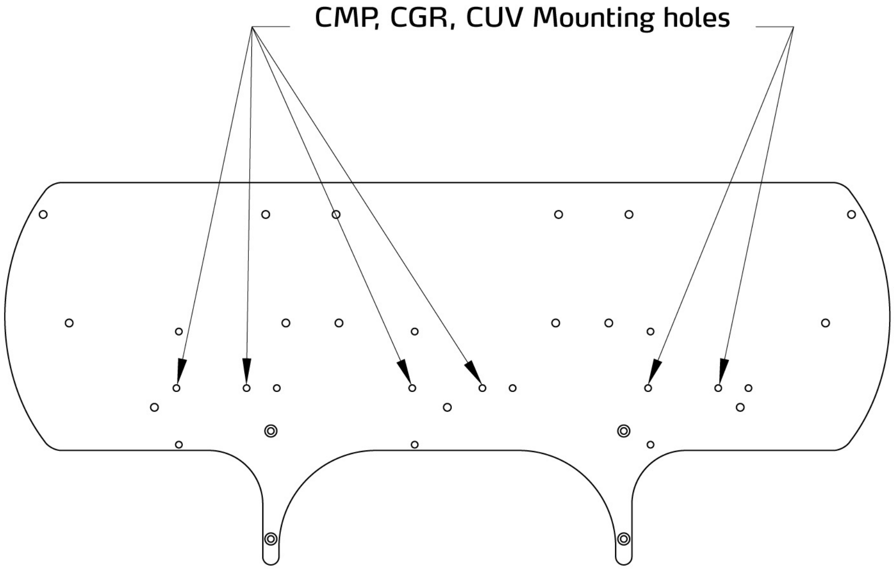


Figura 4.13A: Agujeros de montaje de radiómetros Kipp & Zonen (sin CV 2)

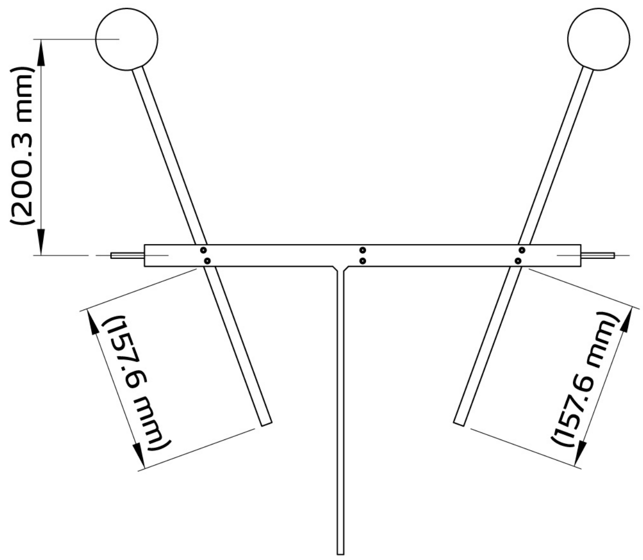


Figura 4.13B: Barras con unidad de sombreado para radiómetros Kipp & Zonen (sin CV 2)

4.6.2 Sujeción de instrumentos al SOLYS 2

Esta sección describe como se sujetan los radiómetros Kipp & Zonen para mediciones solares difusas y directas. La sección 4.5.6.3 proporciona información adicional sobre la instalación de otros instrumentos que no sean Kipp & Zonen.

El SOLYS 2 esta diseñado especialmente para aplicaciones de medición de luz solar directa y difusa. La unidad de sombreado de sombra proporciona el montaje para un piranómetro a la sombra (radiación difusa) y un pirogeómetro a la sombra (radiación de infrarrojo hacia abajo). Los dos Platos de montaje laterales sirven para el montaje para el pirheliómetro, y un pirheliómetro y otro sensor en el otro lado. El montaje del sensor de sol es independiente de los instrumentos de medida y se ajusta al mismo lado que el primer pirheliómetro.

4.6.6.1 Sujeción de radiómetros Kipp & Zonen al Plato de montaje lateral

La figura 4.14 muestra cómo se instala el pirheliómetro Kipp & Zonen en el Plato de montaje lateral. Ver el Pirheliómetro Kipp & Zonen CH(P) 1 para más información.

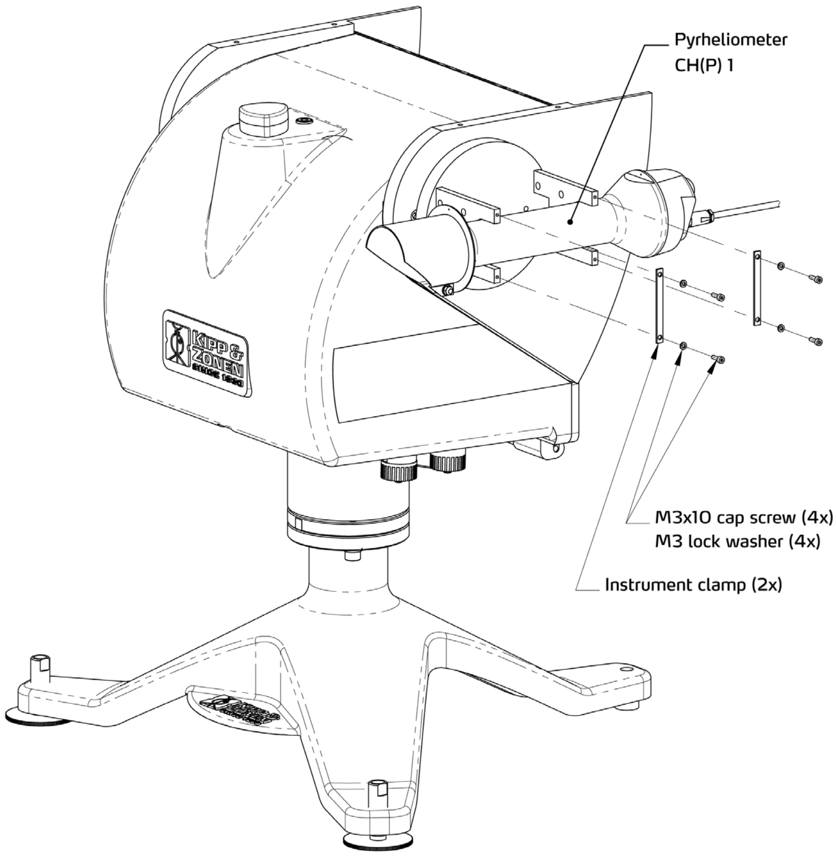


Figura 4.14: Diagrama de instalación del pirheliómetro

Sujeción de radiómetros Kipp & Zonen a el Plato de montaje superior

Un SOLYS 2 con la unidad de sombreado proporciona la capacidad de medir irradiancia de luz difusa con hasta tres piranómetros/pirogeómetros. El Ensamblaje de sombra del SOLYS 2 está diseñado para radiómetros Kipp & Zonen con o sin Sistema de ventilación CV2. No necesita adaptadores.
La Figura 2.15A/B muestra cómo se instala un piranómetro Kipp & Zonen con Unidad de ventilación CV 2 en la Plato de montaje superior. Asegurar que los radiómetros están sujetos con seguridad al Plato de montaje superior. Todo el material de montaje para los radiómetros se suministra con estos instrumentos. En una etapa posterior, después de verificar la nivelación del SOLYS 2, será necesario nivelar los radiómetros. Ver las hojas y manuales de instrucciones de los Piranómetros/Pirogeómetros Kipp & Zonen para más información.

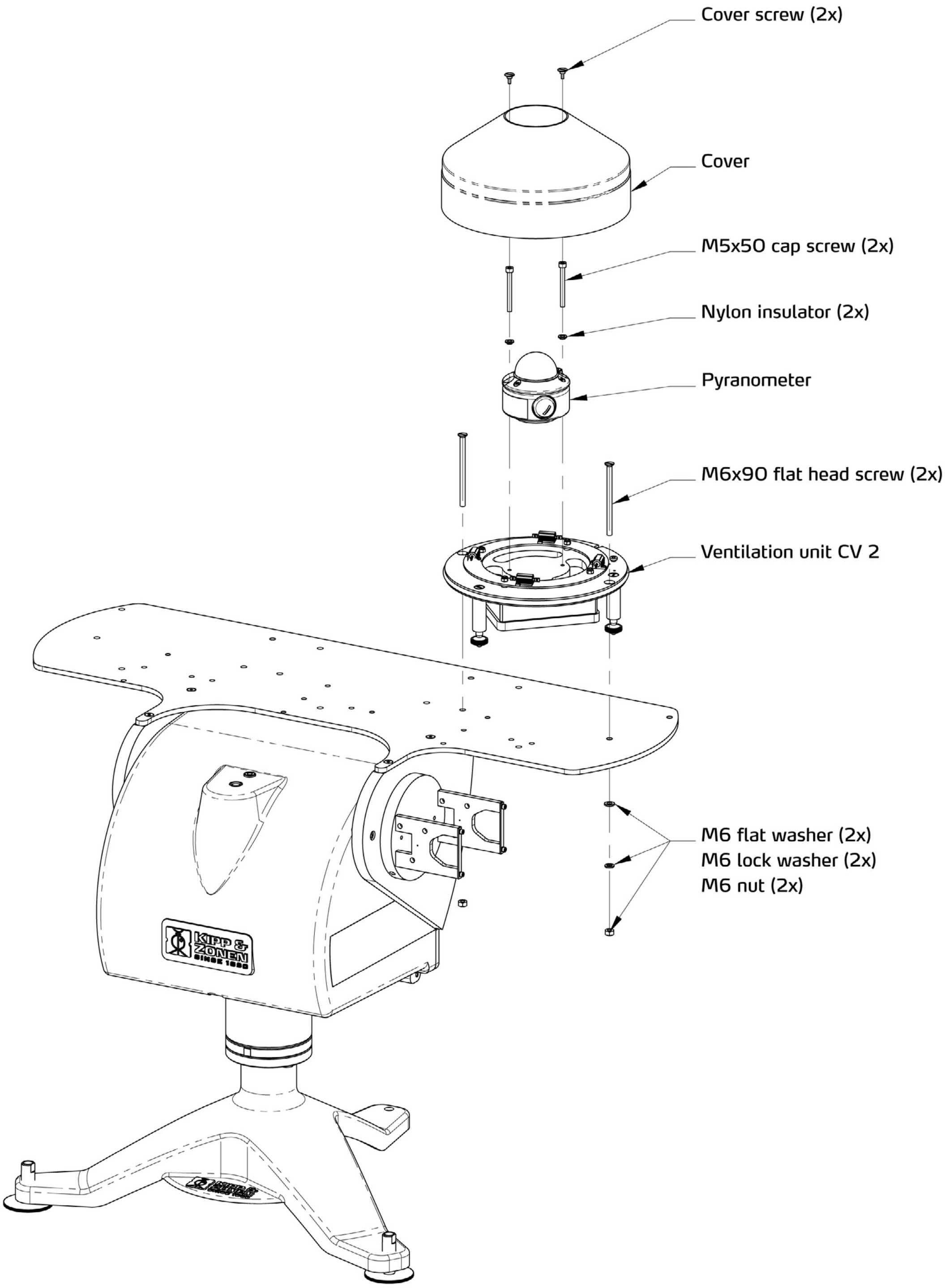


Figura 4.15A: Diagrama de instalación del Piranómetro Kipp & Zonen con CV 2

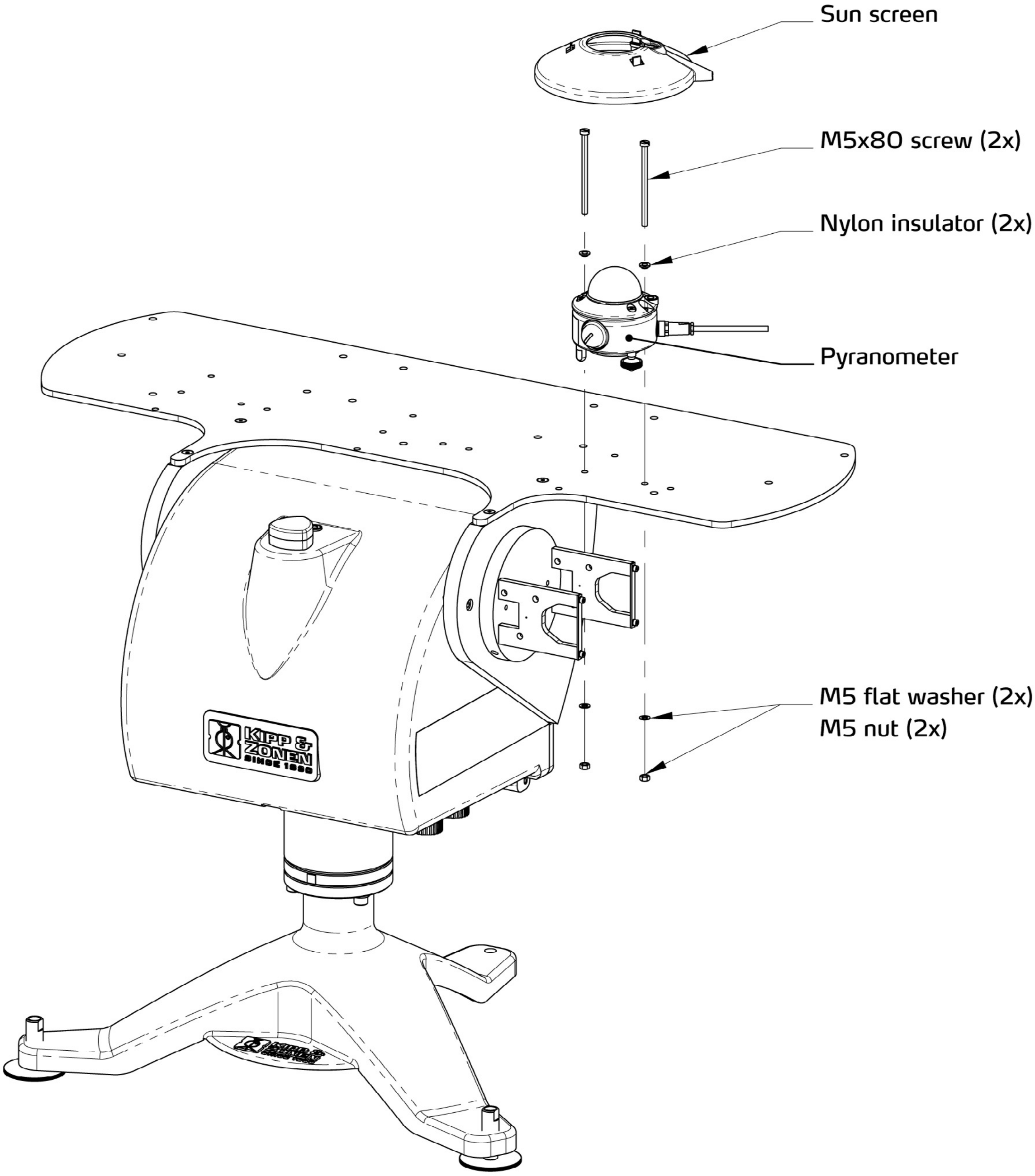


Figura 4.15B: Diagrama de instalación del Piranómetro Kipp & Zonen

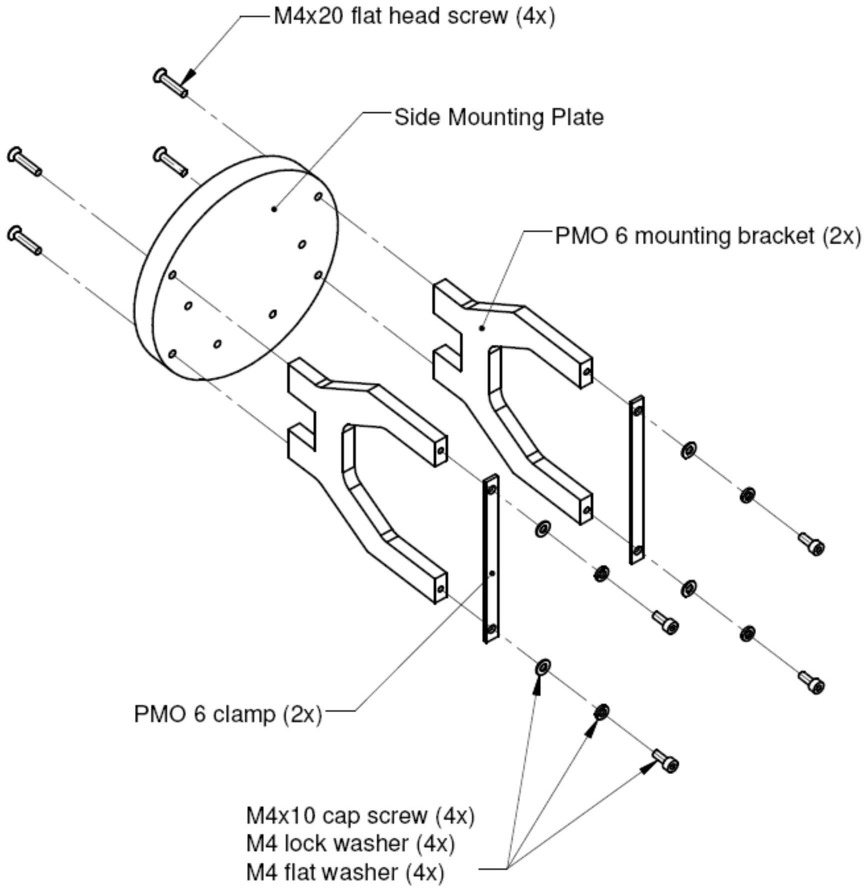


Figura 4.16: Instalación del Piranómetro de cavidad absoluta PMOD-WRC PMO6 en el plato de montaje lateral

Plato de montaje lateral:
SOLYS 2 puede manejar cargas de hasta 10 kg, contrapesos incluidos, en cada plato.

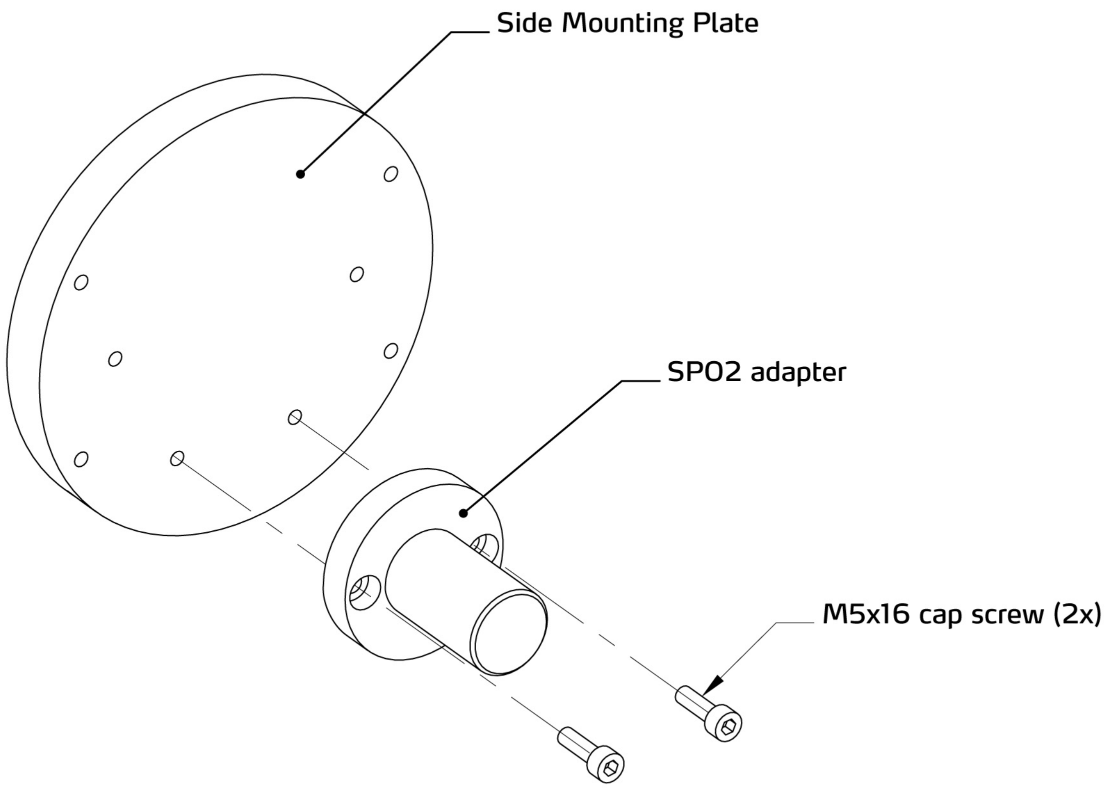


Figura 4.17: Instalación del adaptador del fotómetro solar Middleton SPO2 en el plato de montaje lateral

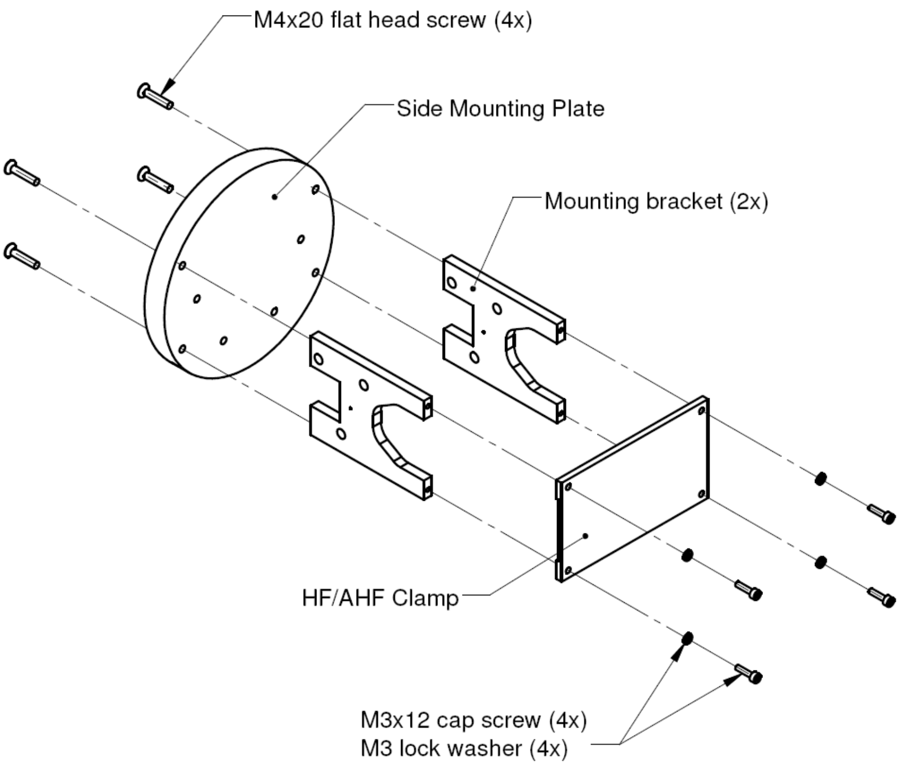


Figura 4.18: Instalación del Pirheliómetro de cavidad absoluta Eppley (A)HF en el plato de montaje lateral

4.6.3 Sensor de sol

El Sensor de Sol opcional consta de un sensor fotodiodo cuadrante que se ajusta dentro del recinto resistente al clima con el hardware de montaje del SOLYS 2.

La instalación del Sensor de Sol se realiza de la forma siguiente:

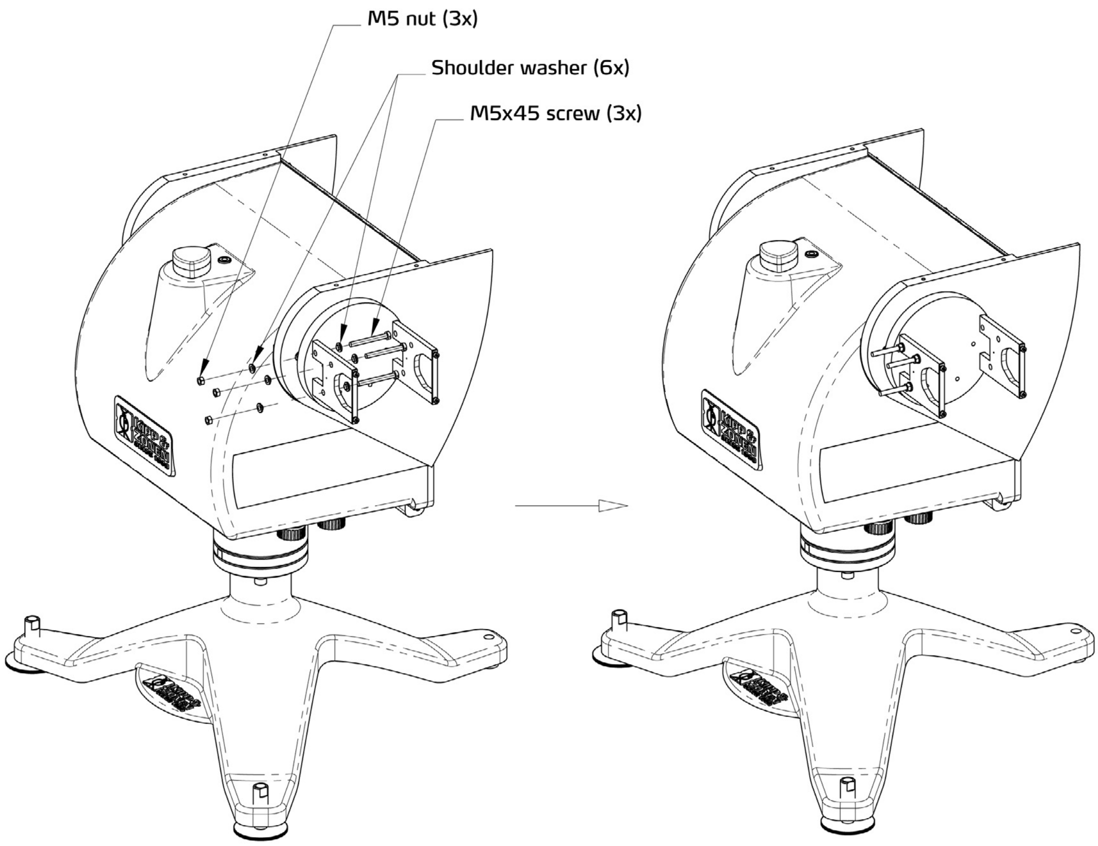


Figura 4.19: Preparación del plato para el montaje del Sensor de sol

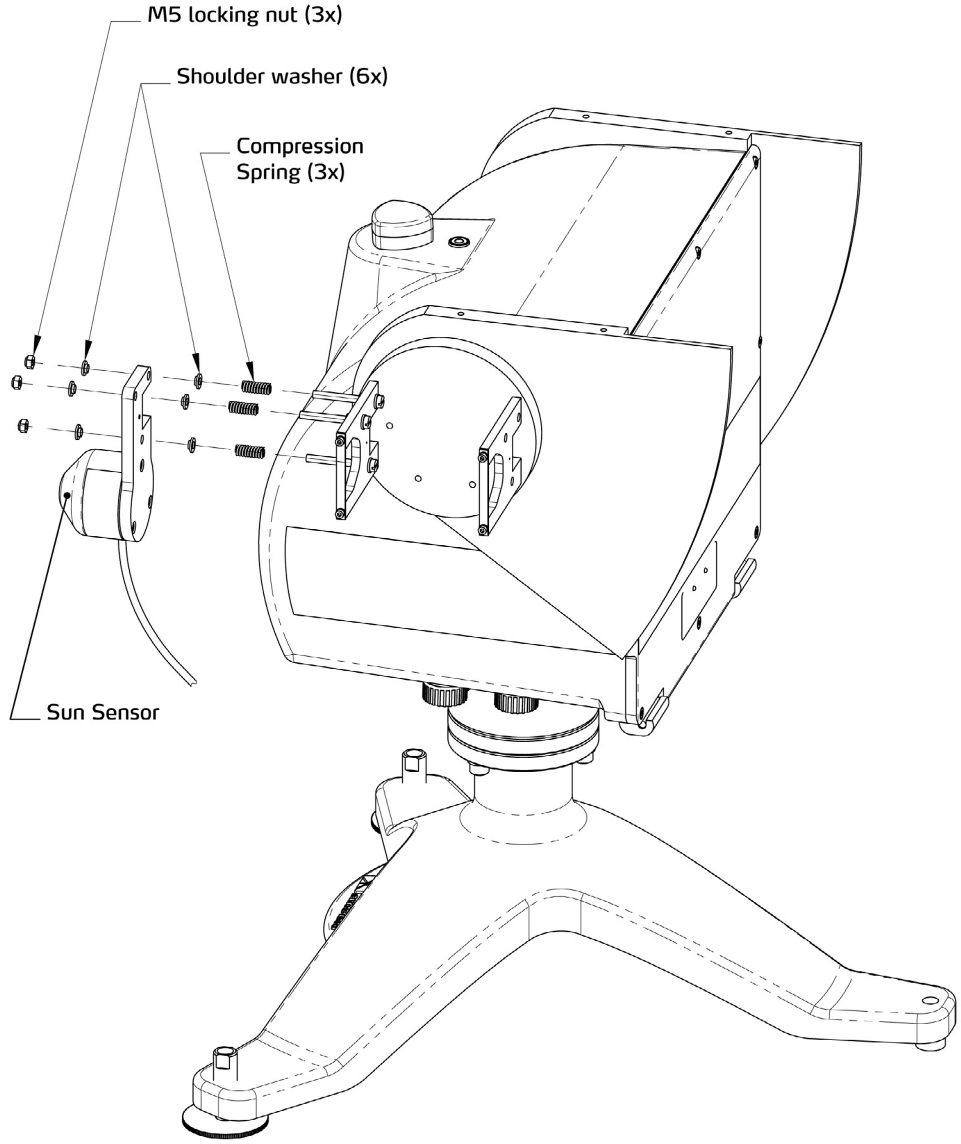


Figura 4.20: Montaje del Sensor de sol

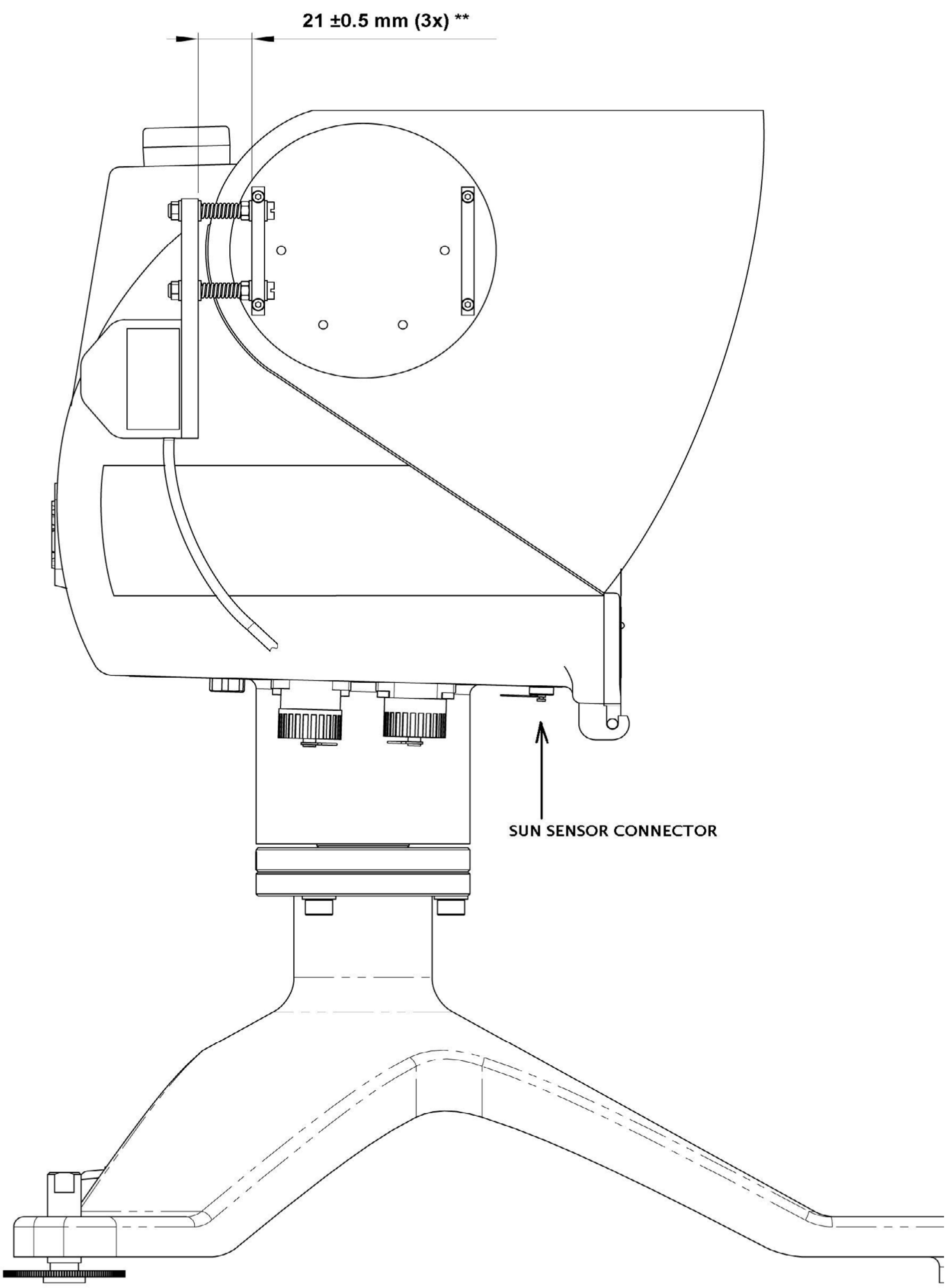


Figura 4.21: Ajuste del Sensor de sol

Destornillar la tapa de conector del sensor de sol de la parte de abajo del SOLYS 2 y conectar el conector del sensor.
** La distancia indicada de 21 mm entre los platos es para una longitud de resorte descomprimido de 19 mm
Para modelos antiguos esta distancia es 23 mm cuando la longitud de muelle descomprimido es 25 mm

Consejo: Cuando se montan todas las opciones e instrumentos se aconseja volver a comprobar la nivelación del SOLYS 2, volver a ajustar las patas de nivelación si es necesario antes de atornillar el trípode al suelo.

Consejo: Después de nivelar y asegurar de forma adecuada el SOLYS 2 volver a comprobar la alienación y nivelación adecuada de todos los radiómetros.

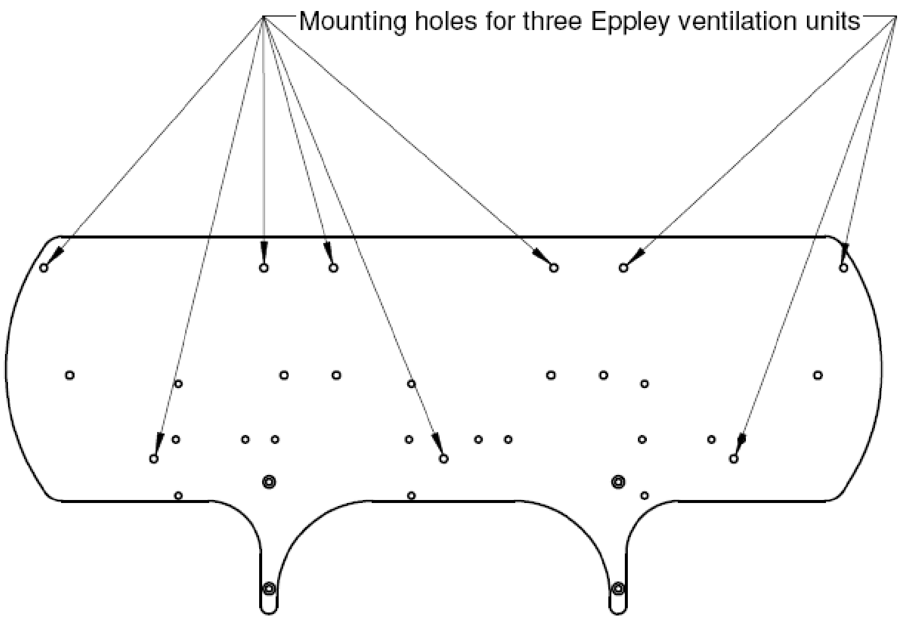


Figura 4.22A: Montaje de instrumentos Eppley ventilados en el Plato de montaje superior

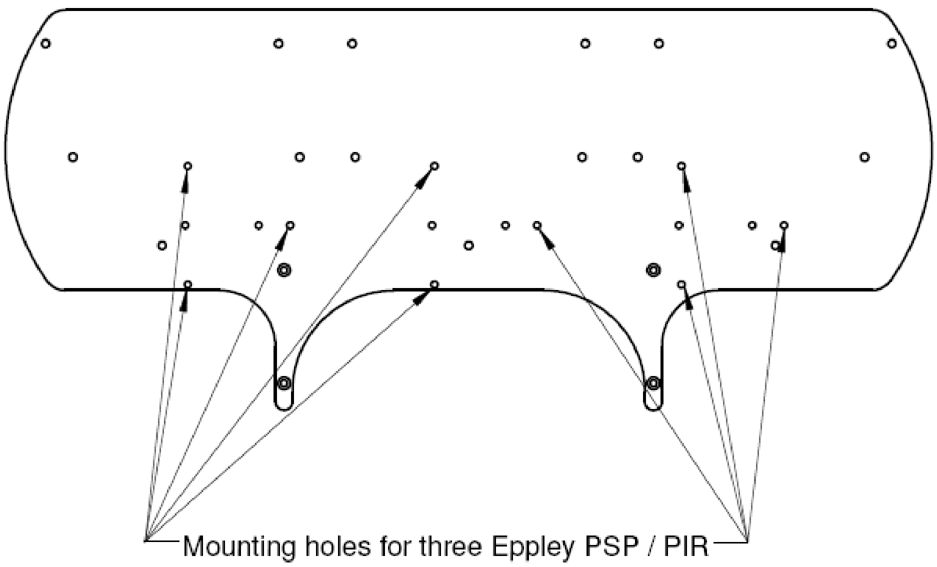


Figura 4.22B Montaje de radiómetros Eppley en el Plato de montaje superior

5 SEGUIMIENTO SOLAR

El SOLYS 2 está equipado con dos LED multifunción para informar al usuario sobre el estado operativo.

El LED de Alimentación / Temperatura muestra si hay corriente de entrada (AC o DC) y el color indica la temperatura interna del SOLYS 2. Verde está por encima de – 20 °C y ROJO está por debajo de – 20 °C. Si este LED parpadea indica un error en el ventilador del calefactor. El calefactor está incorporado pero solo funciona con alimentación CA.

El LED de estado da información sobre el funcionamiento del seguidor. ROJO indica errores de arranque o de hardware, Naranja muestra que no hay o se ha perdido la información del GPS. Verde es el modo de funcionamiento normal con situación de GPS. Las tablas de abajo muestran esta información que incluye combinaciones y parpadeo de los LED.

LED DE ESTADO DEL SOLYS 2						
Estado	ROJO	ROJO	NARANJA	NARANJA	VERDE	VERDE
	parpadea	encendido	parpadea	encendido	parpadea	encendido
Arranque	√					
Error(es) de hardware		√				
Inicialización completa	3X		3X		3X	
Seguimiento sin GPS				√		
Posición de GPS OK, esperando la hora			√		√	
Información de GPS completa						√
Radiación demasiado baja para usar el sensor de sol					√	

Tabla 5.1 LED de estado

Procedimiento de arranque normal después de encender:
- LED de estado parpadea rojo durante la inicialización (el tiempo depende de la posición del seguidor)
- El LED de estado cambia Rojo / Naranja / Verde, tres veces para indicar que ha terminado la inicialización
- LED de estado Naranja para indicar el seguimiento sin GPS (usando información de GPS previa)
- LED de estado Verde / Naranja para indicar la posición de GPS encontrada pero la hora no es (todavía) estable
- LED de estado Verde indica que la información de GPS está completa (posición, altura, hora y fecha)

LED DE ALIMENTACIÓN/TEMPERATURA DE SOLYS 2				
Estado	ROJO	ROJO	VERDE	VERDE
	parpadea	encendido	parpadea	encendido
Temperatura < -20 °C, ventilador OK, voltaje de entrada OK		√		
Temperatura > -20 °C, ventilador OK, voltaje de entrada OK				√
Temperatura < -20 °C, error de ventilador, voltaje de entrada OK	√			
Temperatura > -20 °C, error de ventilador, voltaje de entrada OK			√	

Tabla 5.2 LED de Alimentación / Temperatura

El voltaje de entrada puede ser 24 VCC o 90 – 264 VCA, si están presentes ambas se usará la alimentación CA. Cuando funciona con alimentación CA y la temperatura interna está por debajo de – 20 °C el seguidor no funciona hasta que se alcanza la temperatura de – 20 °C. (indicado por LED de Alimentación / Temp.). Cuando funciona con alimentación CC solo el seguidor intentará arrancar incluso por debajo de – 20 °C. Cuando funciona con alimentación CC (calefactor no activado) el indicador seguirá por debajo de – 20 °C durante mucho tiempo, incluso cuando baje la temperatura ambiente. La disipación interna amplía así el rango de temperatura por debajo de - 20 °C.

5.1 INICIO DEL SEGUIDOR SOLAR

Los parámetros de hora, posición y altitud son las variables necesarias para que el SOLYS 2 calcule la posición del sol en el cielo. Todas estas variables las obtiene el SOLYS 2 automáticamente. Al final, se puede hacer la corrección acimutal manual durante el procedimiento de ajuste de alineación.

Ahora que están instalados todos los accesorios y el SOLYS 2 está nivelado y colocado con precisión, se puede pasar al procedimiento de Ajuste de alineación.

5.2 AJUSTE DE ALINEACIÓN

Debido a que el plato de montaje lateral se ha colocado correctamente en la fábrica el único ajuste necesario es la orientación al este del EL SOLYS. Cuando haya sol suficiente y se encienda el SOLYS 2, éste puede rotar en el trípode aflojando los 3 tornillos M8 en el resorte inferior.
Alinear el SOLYS 2 hasta la alineación en el pirheliómetro apunte correctamente al sol. Si no hay pirheliómetro se puede utilizar la alineación de los dos platos de montaje. Ambos platos tienen un agujero y los rayos de luz que pasan por el primer agujero proyectarán un círculo de brillo alrededor del segundo agujero.

El procedimiento de ajuste de alineación compensa los errores de la posición inicial (este) del SOLYS 2.

Consejo: *Es el momento de ajustar las Barras de la unidad de sombreado (de la unidad de sombreado y direccionamiento) de forma que las esferas de sombreado proyecten sombras en los centros de los elementos de detección de los piranómetros en el Plato de montaje superior.*

5.3 ALINEACIÓN DEL SENSOR DE SOL

Esta sección se aplica solo si ha comprado un Sensor de sol opcional para que funcione junto con el SOLYS 2. Se aconseja que se haga que el EL SOLYS siga correctamente al sol antes de ajustar el sensor de sol.

El sensor de sol solo puede estar alineado cuando la dirección de la radiación está por encima de 300 W/m^2. Esto se puede comprobar por el LED de estado. Cuando el sensor de sol está conectado y el LED de estado está verde la radiación está por encima de 300 W/m^2, cuando parpadea, la radiación es demasiado baja para alinear el sensor de sol. Una vez que se ha conectado el sensor de sol y la radiación directa está por encima de 300 W/m^2 se corregirá la posición del seguidor. La posición inicial del sensor de sol como se indicó en la figura 4.21 debe ser de 23 mm desde la abrazadera de montaje del pirheliómetro. Es importante hacer este ajuste; de otra forma el sensor de sol está demasiado lejos para encontrar al sol.

Cuando hay suficiente sol se puede realizar un ajuste fino del sensor de sol. La posición correcta se puede obtener de la alineación objetivo del pirheliómetro. Si no hay pirheliómetro se puede utilizar la alineación objetivo de los dos platos de montaje. Ambos platos tienen un agujero y los rayos de luz que pasan por el primer agujero proyectarán un círculo alrededor del segundo agujero. La información del sensor de sol se **actualiza cada 10 segundos**, por lo tanto después de cambiar la alineación se debe esperar este intervalo antes de que tenga efecto la posición nueva. Por supuesto, cuando empieza a parpadear el LED de estado verde no se pueden hacer más ajustes porque la radiación directa es demasiado baja. Hay que ajustar la posición del sensor de sol usando los 3 tornillos que mantienen al sensor de sol en su sitio. Es mejor empezar ajustando uno de los tornillos media vuelta para ver el efecto. Si la mancha del sol se mueve más allá del objetivo, la dirección de rotación tiene que ser la contraria. Cada vez hay que esperar 10 segundos para que el SOLYS 2 actualice su posición según el ángulo del sensor de sol nuevo. Se ajustan los tres tornillos del sensor de sol hasta que la alineación objetivo está situada exactamente en el sol.
Cunado se desconecta el sensor de sol del SOLYS 2 hay que recalcular su posición y se moverá primero a la posición inicial antes de arrancar otra vez el seguidor. Cuando se vuelva a conectar se utilizará directamente (después de 10 segundos) la información del sensor de sol cuando el LED de estado esté verde fijo.
La información de posición del sensor de sol no se guarda porque la mala alineación puede ser diferente para distintas posiciones (distinta hora del día). El sensor de sol arrancará todos los días con un seguimiento activo cuando la radiación solar esté por encima de 300 W/m^2

Consejo: *Comprobar que todos los conectores del fondo del SOLYS 2 que no se utilizan tienen su tapa instalada durante el funcionamiento normal. La conexión de Ethernet tiene una tapa gris suelta. Tanto las conexiones de energía como las del sensor de sol tienen tapas que se tienen que cerrar cuando no se usen.*

6 MANTENIMIENTO

El mismo SOLYS 2 no necesita ningún mantenimiento. Los puntos siguientes se pueden revisar en los intervalos de visita:

- Comprobación periódica del estado de todos los cables y conectores.
- Comprobación de los cartuchos de secado para los radiómetros montados.
- Comprobación de si el nivel de la burbuja está todavía dentro del rango.
- Comprobación de la posición del sensor de sol.

7 RESOLUCIÓN DE PROBLEMAS

El SOLYS 2 está diseñado para periodos de funcionamiento largos sin mantenimiento por parte del operario. No obstante, si se produce un problema que no se puede resolver correctamente utilizando la información de funcionamiento estándar proporcionada en las secciones precedentes de este manual, se puede usar la información de este capítulo para identificar y resolver el problema.

Si no se puede corregir el problema después de ver la información de la sección siguiente, contactar con Kipp & Zonen. Cuando se contacte con Kipp & Zonen con preguntas de asistencia técnica, hay que asegurarse de que se tiene preparada la información siguiente para ayudar al técnico a resolver el problema:

- El número de serie del SOLYS 2. Esta información aparece en la etiqueta del número de serie, situada en la parte de abajo de la unidad.
- Opciones montadas
- Descripción del problema

Si no se puede resolver el problema con los consejos de las páginas siguientes, se puede enviar un correo electrónico o un fax con la descripción del problema al centro de Kipp & Zonen más cercano, que aparece en nuestro sitio web.

Kipp & Zonen B.V.
Apartado de correos 507,
2600 AM Delft,
Holanda

Tel: +31-15-2755210
Fax: +31-15-262 0351
Correo electrónico: info@kippzonen.com
Sitio web: http://www.kippzonen.com

7.1 LISTA DE COMPROBACIÓN DE PROBLEMAS

Compruebe los puntos de la lista siguiente. Si estos no le ayudan, vea la sección siguiente sobre localización de averías.

Compruebe que:

- Se suministra alimentación a la unidad. El LED de Alimentación / Temperatura tiene que estar encendido y verde.
  En caso de que el LED de alimentación esté rojo y funcione con alimentación CA, pueden pasar hasta 30 minutos antes de que el SOLYS 2 tenga una temperatura interior superior a – 20 ºC
- En caso de que el LED de alimentación esté rojo y funcionando con alimentación CC, el EL SOLYS solo arrancará cuando la temperatura ambiente supere los – 20 ºC.
- Es posible la recepción de GPS, la antena de GPS no debe tener obstáculos por instrumentos u objetos cercanos. (LED de estado verde)

El SOLYS 2 no sigue al sol de forma adecuada, ¿qué puede haber mal?
  ¿Está conectado el sensor de sol pero no está ajustado?
  Compruebe el nivel de la burbuja, si la burbuja está todavía en el círculo.
- ¿Está alineado (desde el pirheliómetro o las arandelas de montaje) correctamente señalando al sol?

8 VISIÓN GENERAL DEL SOFTWARE

El software que utiliza el SOLYS 2 contiene componentes de código abierto que se listan en la tabla de abajo.

Este software está disponible en nuestro sitio web: www.kippzonen.com/suntrackers/El SOLYS2/software/download

El software y las versiones listadas abajo se utilizaron durante la producción de este manual. Mire en el sitio web para ver la última revisión de esta lista.

Software	Versión	Licencia
Apache	httpd-2.2.8	Apache License 2.0
Avahi	avahi-0.6.17	LGPL 2.1
BusyBox	busybox-1.1.3	GPL 2
Expat XML parser	expat-2.0.0	EXPAT License
GNU C Library	glibc-2.3.3	LGPL 2.1 / Licenses for non-FSF code in GLIBC
GNU Project Debugger	gdb-6.5	GPL 2
GPS Daemon	gpsd-4093 (pre 2.34 + patches)	GPSD License
Grand Unified Bootloader	grub-0.97-33	GPL 2
Ifplugd	ifplugd-0.28	GPL 2
Libdaemon	libdaemon-0.10	LGPL 2.1
Linux Kernel	linux-2.4.31	GPL 2
LinuxThreads Library	glibc-linuxthreads-2.3.3	LGPL 2
Ncurses Library	ncurses-5.5	NCURSES License
Network Time Protocol Daemon	ntp-4.2.2p3-RC	NTP License
OpenSSL (solo para configuración de datos de integridad)	openssl-0.9.8c	OpenSSL License / SSLeay License
PHP	php-5.2.5	PHP 3.01 License
RT-Linux	rtlinux-3.1	OPEN RTLINUX PATENT LICENSE / GPL 2
El SOLYS2 Suntracking Tools	V1R1	Kipp & Zonen El SOLYS License
uClibc	uClibc-0.9.28.3	LGPL 2
Vortex86 watchdog driver	vx86wdt	GPL 2
Watchdog Daemon	watchdog-5.4	GPL 1

Our customer support remains at your disposal for any maintenance or repair, calibration, supplies and spares.

Für Servicearbeiten und Kalibrierung, Verbrauchsmaterial und Ersatzteile steht Ihnen unsere Customer Support Abteilung zur Verfügung.

Notre service 'Support Clientèle' reste à votre entière disposition pour tout problème de maintenance, réparation ou d'étalonnage ainsi que pour les accessoires et pièces de rechange.

Nuestro apoyo del cliente se queda a su disposición para cualquier mantenimiento o la reparación, la calibración, los suministros y reserva.

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Go to www.kippzonen.com for your local distributor or contact your local sales office

Passion for Precision

Instrumental medida y accesorios

2012

Product Catalogue

Instruments for measuring solar radiation and atmospheric properties

KIPP & ZONEN
SINCE 1830

The Kipp & Zonen Product Catalogue

2012

Welcome to our comprehensive catalogue of Solar Radiation and Atmospheric Science Instruments and Accessories. We hope that you will find it both interesting and informative.

The company began in 1830 when Dutch pharmacist Petrus Jacobus Kipp bought a pharmacy shop in the centre of Delft and gave it his name. Shortly afterwards he started an instrument business and became an important adviser to the Royal Academy, now the Delft University of Technology.

In 1844 he designed a constant-flow gas generator, which was used in chemical laboratories all over the world. This “Kipp Generator” remains part of our company logo today. In 1866 his two sons joined the business and the name changed to Kipp & Zonen (‘Sons’).

By 1927 the extensive catalogue of scientific instruments included laboratory glassware, galvanometers, electronic chart recorders, analytical instruments, telephones, and the first ‘Solarimeters’ for measuring solar radiation.

Today, Kipp & Zonen focuses on designing, manufacturing, and marketing, class-leading, high quality instruments for the measurement of solar radiation and atmospheric properties. To support our customers worldwide we have sales offices in France, Singapore and the USA, and a network of distributors in more than 40 countries.

Precise long-term measurements of the radiation budget and atmospheric properties are fundamental to understanding the Earth’s climate system and improving weather and climate forecast models.

Kipp & Zonen provides the widest range available of instruments to meet these needs in Meteorology, Climatology, Agriculture, Hydrology, and Industry.

Our products have guaranteed quality at levels of price and performance to suit all applications and are fully traceable to international standards.

The limited reserves, rising prices and concerns over the security of supply of traditional energy sources; together with the increasing awareness of climate change, have resulted in rapid development of alternative energy sources.

Recent years have seen rapid exponential growth in renewable energy markets. Kipp & Zonen provides solar radiation measurement solutions for both photovoltaic and thermal solar energy systems, and for other industrial applications such as material testing and building automation.

Our Capabilities

Kipp & Zonen is a leading authority in the measurement of solar radiation and atmospheric properties and is widely recognized for expertise, quality and service. We support significant research and development and maintain close links with the scientific community and international bodies such as the World Meteorological Organisation (WMO).

We take part in scientific comparisons and field campaigns, are involved with the creation of international standards and are a founder member of the Association of the Hydro-Meteorological Equipment Industry (HMEI). We have in-house facilities for research, development, software, manufacture and testing, and we can provide customer-specific solutions.

High quality customer support is essential to our business and includes provision of spare parts, repair, service and calibration. Our experts are available to give assistance and advice on the most appropriate equipment for an application. For our more complex products we offer on-site installation, commissioning and training.

Kipp & Zonen produces the widest range available of radiometers for the measurement of solar and sky radiation. The solar instruments portfolio covers the spectrum from the Ultraviolet (UV) to the Far Infrared (FIR) and includes integrated net radiometers. The instruments fully comply with World Meteorological Organisation (WMO) and ISO requirements, where applicable.

We make high precision sun trackers, a range of accessories, and provide interfacing and data logging solutions. There is also the Lite™ range of low-cost sensors, a sunshine duration sensor, and more.

Our expertise, close links with the scientific community, and strategic partnerships have led to high-end solutions for the measurement of atmospheric properties such as stratospheric Ozone, UV spectra, aerosols, heat fluxes, evapo-transpiration and the ground-truthing of satellite data. The Brewer Spectrophotometer, LAS MkII Large Aperture Scintillometer, Sky Radiometers and a spectral Sun Photometer all form part of our Atmospheric Science Instruments range.

About this Catalogue

The catalogue is arranged by types of product, for instance Pyranometers. For each type there is an introduction to the measurement made, the technology used, the typical applications and the range of models available.

Each model has a description, key specifications, part numbers and a list of available options and accessories. The catalogue gives a comprehensive overview of our product range at the time of publication but much additional product information, including improvements and new introductions, is available from our website at www.kippzonen.com

Additional Product Information

Our website contains a lot more information than it is possible to include in this catalogue. Brochures, Instruction Sheets and Manuals are free to download in pdf. These are always the latest versions and therefore may differ slightly from the information printed in this catalogue. Also available are application guides, technical documents, scientific papers, FAQ section, and more. Please go to www.kippzonen.com and have a browse.

Part Numbering

Many Kipp & Zonen instruments have a range of options available, such as temperature sensors and cable lengths. To minimise the possibility of errors we use a part number system whereby each option has a unique code attached to the basic instrument number. This system also allows us to introduce future options with the minimum of complication.

All items have a 7-digit part number. Where there are no options available this is the whole number. Where options are available the instrument has the basic number plus 3 extension codes, in the format 1234567-ABC. For each product the 'standard' version with part number and description is shown first.

Price and Delivery

Please contact your local Kipp & Zonen sales office or distributor for prices and delivery times. Their contact information can be found on our website at **www.kippzonen.com**

Quality

Kipp & Zonen B.V. is an ISO 9001:2008 certified company.

Warranty

The products in this catalogue have a world-wide 2 year warranty valid from the date of invoice, with the exception of a few items, such as consumables.

Spare Parts, Service, Calibration and Repairs

Contact your local Kipp & Zonen sales office or distributor for a quotation. Please give the instrument type, the serial number and a description of the problem or the work/parts required. Their contact information can be found on our website www.kippzonen.com

Disclaimer

Whilst every effort has been made to ensure that the information and specifications quoted in this catalogue are correct at the date of going to press, Kipp & Zonen reserves the right to alter specifications without notice due to product changes and improvements. For this reason there may sometimes be differences between this catalogue and the latest product brochures.

KIPP & ZONEN
SINCE 1830

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Using this table

Click on any item in the table of contents to be taken directly to the relevant page.
Click on the Kipp & Zonen logo at the bottom of any page to be taken back to the table of contents.

Solar Instruments

INTRODUCTION

Kipp & Zonen is the specialist in the measurement of solar and sky radiation, from the ultraviolet to the far infrared. Kipp & Zonen solar instruments are relied upon by meteorological networks all over the world and are widely used in climate research, hydrology, agriculture, water resource management, materials testing, renewable energy and public health applications.

On the following pages you will find a complete range of high quality instrumentation, from reliable cost-effective products to the best performance available. There is a wide range of accessories; including sun trackers, shading rings, ventilation units, signal amplifiers and data acquisition solutions.

For the latest product information, brochures, manuals and application information visit our website at www.kippzonen.com

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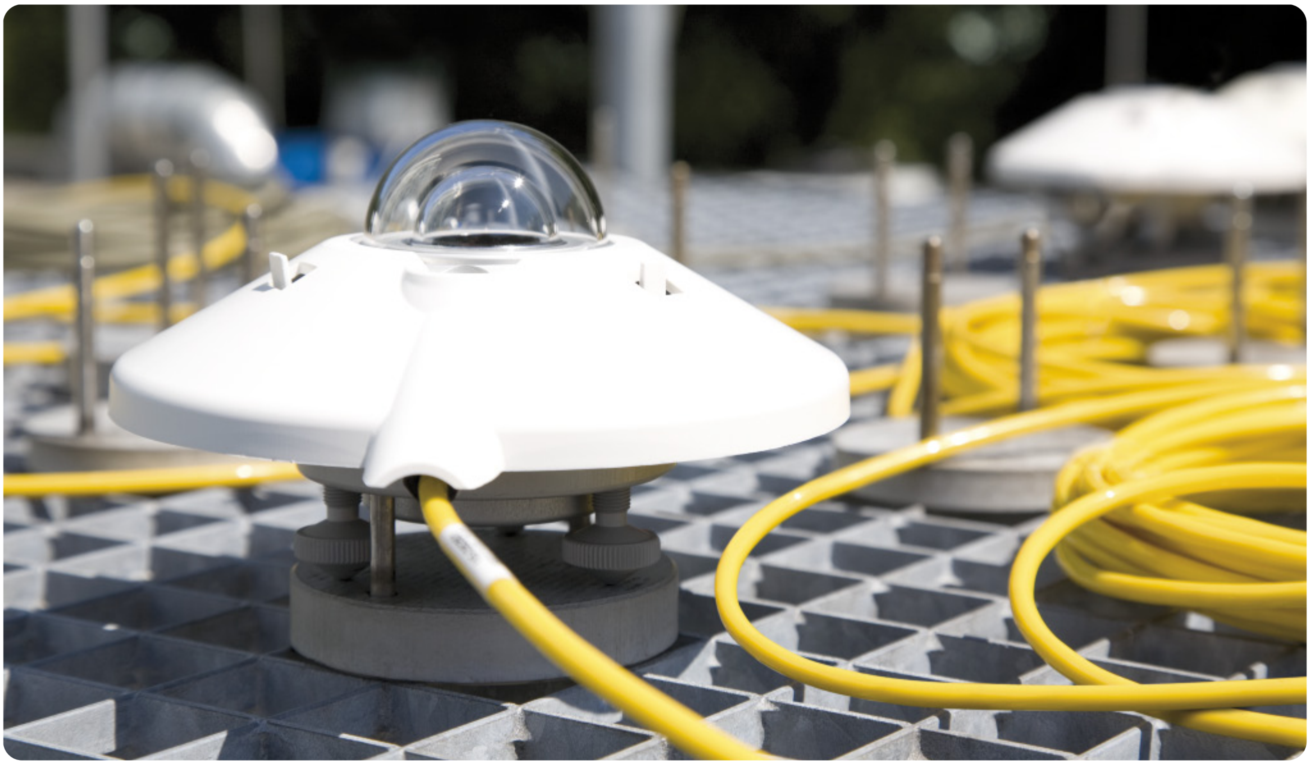


Pyranometers

FOR THE ACCURATE MEASUREMENT OF SOLAR IRRADIANCE

Scientists, researchers and commercial companies in renewable energy, climatology, weather, agriculture, water resources and environment all require accurate and reliable measurements of solar radiation. The measurement is made by pyranometers, which are radiometers designed for measuring the total (global) irradiance on a plane surface resulting from radiant fluxes in the wavelength range from 300 to 3000 nanometers (nm).

Kipp & Zonen has been manufacturing pyranometers for over 75 years. We produce models at all price and performance points, up to the very best available.

Our pyranometers are designed for a long operating life with simple maintenance. All models have built-in levelling facilities, except the CM 4, and a wide range of accessories is available.

The SP Lite2 silicon photo-diode pyranometer, is compact and low cost and is ideal for use in solar energy applications, plant growth, evapo-transpiration and building automation.

The CM 4 high temperature pyranometer has a thermopile detector and is specially designed for measuring solar or artificial light irradiance under the most extreme temperature conditions.

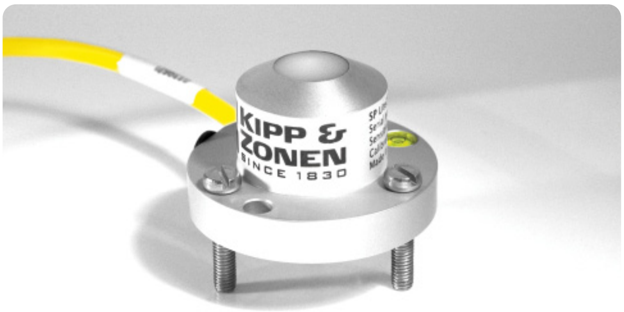
The CMP series of thermopile pyranometers are known for their ergonomic and user-friendly features to facilitate installation, maintenance, and exchange for recalibration.

The SMP series are the world's first smart pyranometers with built-in intelligence. Building on the proven CMP Series design and measurement technology they add digital signal processing to improve performance and interfaces optimised for industrial data acquisition and control systems.

The smart interface that features Modbus® data communication for connection to programmable logic controllers (PLC's), inverters, digital control equipment and the latest generation of data loggers. Amplified Voltage or Current outputs are also included.

All models, except the SP Lite2, comply with the requirements of ISO 9060:1990 and are fully traceable to the World Radiometric Reference (WRR) in Davos, Switzerland, where Kipp & Zonen instruments form part of the World Standard Group.

SP Lite2



SP Lite2 is designed for all-weather measurement of solar radiation. It has a specially shaped diffuser that gives very good directional response and is largely self-cleaning. The detector is a silicon photo-diode, so the spectral response is not as broad or flat as our CMP/SMP series pyranometers with thermopile detectors. The standard cable length is 5 m with an option of 15 m.

The mounting flange incorporates a bubble level and 3 adjustment screws for easy levelling. A threaded hole takes the accessory screw-in mounting rod for fitting to masts and poles.

Two SP Lite2 instruments can easily be bolted back-to-back and fitted with the mounting rod to make a simple albedometer.

Article	Part number
SP Lite2 Silicon Pyranometer • 5 m cable	**0339920-001**
Options for SP Lite2	
SP Lite2 Silicon Pyranometer • 15 m cable	0339920-003
SP Lite2 Silicon Pyranometer • 10 µV/W/m² • 5 m cable	0339920-021
SP Lite2 Silicon Pyranometer • 10 µV/W/m² • 15 m cable	0339920-023
SP Lite2 Silicon Pyranometer • METEON • 5 m cable	0339920-701
SP Lite2 Silicon Pyranometer • AMPBOX • 5 m cable	0339920-801
SP Lite2 Silicon Pyranometer • AMPBOX • 15 m cable	0339920-803
Note: AMPBOX is adjusted so that 4 - 20 mA output = 0 - 1600 W/m²	

SP Lite2 Albedometer

SP Lite2 Silicon Albedometer
A low-cost Silicon Albedometer can be self-assembled by ordering:
2x SP Lite2 Silicon Pyranometer + 1x Mounting Rod

Note: SP Lite2 Albedometer can be used with the AMPBOX but it has two individual outputs, so 2 x AMPBOX are required.

Specifications

Response time (95 %)	< 500 ns
Non-stability (change/year)	< 2 %
Non-linearity (0 to 1000 W/m²)	< 1 %
Directional error (up to 80 ° with 1000 W/m² beam)	< 10 W/m²
Temperature dependence (-30 °C to +70 °C)	- 0.15 %/°C
Other specifications	
Sensitivity	60 to 100 µV/W/m²
Impedance	50 Ω
Operating temperature	-30 °C to +70 °C
Spectral range	400 to 1100 nm
Typical signal output for atmospheric applications	0 to 100 mV
Maximum irradiance	2000 W/m²
Detector	Silicon photo-diode

Accessories for SP Lite2	Part number
Mounting Rod Screw-in 300 mm long x 12 mm Ø	**0338720**
CMB 1 Mounting Bracket In combination with mounting rod for easy attachment to a pole or a wall	**0369701**

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CM 4

CM 4 is a high temperature pyranometer for measuring solar or artificial light irradiance under the most extreme temperature conditions. With an operating temperature range from -40 °C to +150 °C and measurement up to 4000 W/m² it is a unique instrument. All the radiometer components are specially selected for their ability to withstand these extremely high temperature and irradiance levels.

CM 4 has internal first-order temperature compensation, but it is also supplied with a built in Pt-100 temperature sensor to provide additional information on the measurement conditions. To optimize the accuracy in different applications the CM 4 is supplied with calibration information split into temperature sections. Beside the standard calibration factor for +25 °C the following intervals are defined: -20 to +25, +25 to +75, +25 to +100, +75 to +100 and +100 to +150 °C. For each temperature range the sensitivity and the maximum temperature error (in %) are specified. CM 4 is supplied as standard with 10 m of special high temperature signal cable.

CM 4 is specifically designed for use in environmental chambers and solar simulators and materials testing.

Specifications	
ISO 9060:1990 CLASSIFICATION	Second Class
Response time (95 %)	< 8 s
Zero offsets (a) thermal radiation (200 W/m²) (b) temperature change (5 K/hr)	 < 15 W/m² < 4 W/m²
Non-stability (change/year)	< 1 %
Non-linearity (0 to 2500 W/m²)	< 3 %
Directional error (up to 80 ° with 1000 W/m² beam)	< 20 W/m²
Temperature dependence (Over any 50 °C interval in the range from -20 °C to +150 °C)	< 3 %
Tilt error (at 1000 W/m²)	< 1 %
Other specifications	
Sensitivity (nominal)	4 to 10 μV/W/m²
Impedance	200 to 2000 Ω
Operating temperature	-40 °C to +150 °C
Spectral range (50 % points)	300 to 2800 nm
Maximum irradiance	4000 W/m²
Cable length	10 m
Temperature sensor	Pt-100 4 wire

Article	Part number
CM 4 High Temperature Pyranometer • 10 m cable	**0356900-022**
Options for CM 4	
CM 4 High Temperature Pyranometer • METEON • 10 m cable	0356900-722
CM 4 High Temperature Pyranometer • AMPBOX • 10 m cable	0356900-822
Note: AMPBOX is adjusted so that 4 - 20 mA output = 0 - 4000 W/m²	
Note: AMPBOX and METEON are not suitable for use in extreme temperatures	

Accessories for CM 4	Part number
Desiccant Refill Pack • contains 10 sachets	**2643960**
CLF 4 Levelling Fixture High temperature design for CM 4 only	**0356700**

CMP 3

CMP 3 is an ISO Second Class pyranometer designed for shortwave global solar radiation measurements in the spectral range from 300 to 2800 nm. The thermopile detector measures irradiance up to 2000 W/m^2 with a response time less than 18 seconds and typical sensitivity of 10 μV/W/m^2, that varies less than 5 % from -10 °C to +40 °C.

CMP 3 is smaller and lighter than the other CMP Series pyranometers. It has a robust 4 mm thick glass dome to protect the thermopile detector from external influences. The small size and sealed construction make this instrument the ideal choice for horticulture, monitoring solar energy installations, industrial applications, and entry level weather stations.

Two CMP 3's can easily be mounted back-to-back and fitted with the accessory mounting rod to make a low-cost albedometer.

Specifications

ISO 9060:1990 CLASSIFICATION	Second Class
Response time (95 %)	< 18 s
Zero offsets (a) thermal radiation (200 W/m^2) (b) temperature change (5 K/hr)	 < 15 W/m^2 < 5 W/m^2
Non-stability (change/year)	< 1 %
Non-linearity (0 to 1000 W/m^2)	< 1 %
Directional error (up to 80 ° with 1000 W/m^2 beam)	< 20 W/m^2
Temperature dependence of sensitivity	< 5 % (-10 °C to +40 °C)
Tilt error (at 1000 W/m^2)	< 1 %

Other specifications

Sensitivity	5 to 20 μV/W/m^2
Impedance	20 to 200 Ω
Level accuracy	1 °
Operating temperature	-40 °C to +80 °C
Spectral range (50 % points)	300 to 2800 nm
Typical signal output for atmospheric applications	0 to 20 mV
Maximum irradiance	2000 W/m^2

Article	Part number
CMP 3 Pyranometer • 10 m cable	**0338920-002**
Options for CMP 3	
CMP 3 Pyranometer • 25 m cable	0338920-004
CMP 3 Pyranometer • 50 m cable	0338920-005
CMP 3 Pyranometer • plug only, no cable	0338920-008
CMP 3 Pyranometer • METEON • 10 m cable	0338920-702
CMP 3 Pyranometer • AMPBOX • 10 m cable	0338920-802
CMP 3 Pyranometer • AMPBOX • 25 m cable	0338920-804
CMP 3 Pyranometer • AMPBOX • 50 m cable	0338920-805
CMP 3 Pyranometer • AMPBOX • plug only, no cable	0338920-808
100 m cable	On request
Note: AMPBOX is adjusted so that 4 - 20 mA output = 0 - 1600 W/m^2	

Accessories for CMP 3	Part number
Mounting Rod Screw-in 300 mm long x 12 mm Ø	**0338720**
CMF 1 Mounting Fixture For 1 or 2 unventilated radiometers (1 upper / 1 lower) Diameter 88 mm. Mounting rod 350 mm long x 16 mm Ø	**0362700**
CMB 1 Mounting Bracket In combination with mounting rod for easy attachment to a pole or a wall	**0369701**
CM 121B Shadow Ring for unventilated radiometers Manually adjusted device provides diffuse sky irradiance measurement	**0346900**
Note: CMP 3 cannot be used with CVF 3 Ventilation Unit	
Note: CMP 3 cannot be used with Glare Screen Kit	

CMP 3 Albedometer

CMP 3 Second Class Albedometer
An ISO Second Class Albedometer can be self-assembled by ordering:
2x CMP 3 Pyranometer + 1x Mounting Rod

Note: CMP 3 Albedometer can be used with the AMPBOX but it has two individual outputs, so 2 x AMPBOX are required.

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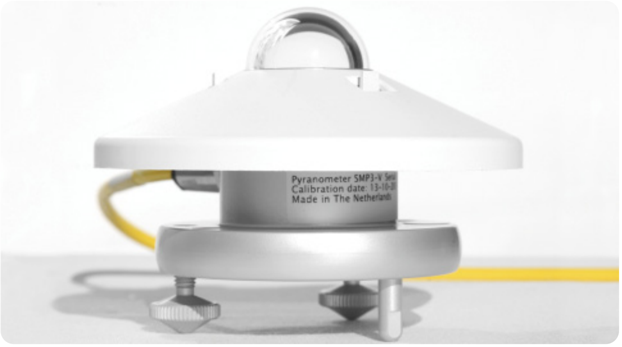
SMP3



SMP3 is our entry level smart pyranometer. It is ISO Second Class, with the same housing and detector design as the passive CMP 3 model. SMP3 is equipped with a smart interface. There are two versions, one has an analogue output of 0-1 V, the other has 4-20 mA. Both have a 2-wire RS-485 interface with Modbus® (RTU) protocol. All the outputs are protected against short-circuits.

SMP series pyranameters have analog outputs that allow easy connection to virtually any data logger without the need for sensitive mV inputs. Modbus® interfaces directly to RTU's, PLC's, SCADA syatems, industrial networks and controllers. An integrated temperature sensor and polynomial functions provide correction for the temperature sensitivity of the detector. The response time is improved and the output ranges are standardised.

Using Modbus® a range of instrument status and configuration information is available, with user-selectable options. SMP pyranometers have extremely low power consumption, so that internal heating does not affect the detector performance, and they operate from a wide range of supply voltages.

SMP3 is ideal for solar energy performance monitoring and for the new generation of all-digital automatic weather stations.

Article	Part number
SMP3-V Smart Pyranometer • 0-1 V version • 10 m cable	**0374900-102**
Options for SMP3-V	
SMP3-V Smart Pyranometer • 0-1 V version • 25 m cable	0374900-104
SMP3-V Smart Pyranometer • 0-1 V version • 50 m cable	0374900-105
SMP3-V Smart Pyranometer • 0-1 V version • plug only, no cable	0374900-108
100 m cable	On request

Article	Part number
SMP3-A Smart Pyranometer • 4-20 mA version • 10 m cable	**0374900-202**
Options for SMP3-A	
SMP3-A Smart Pyranometer • 4-20 mA version • 25 m cable	0374900-204
SMP3-A Smart Pyranometer • 4-20 mA version • 50 m cable	0374900-205
SMP3-A Smart Pyranometer • 4-20 mA version • plug only, no cable	0374900-208
100 m cable	On request

Specifications

ISO 9060:1990 CLASSIFICATION	Second Class
Response time (63 %)	< 1.5 s
Response time (95 %)	< 12 s
Zero offsets (a) thermal radiation (200 W/m²) (b) temperature change (5 K/hr)	 < 15 W/m² < 5 W/m²
Non-stability (change/year)	< 1 %
Non-linearity (0 to 1000 W/m²)	< 2.5 %
Directional error (up to 80° with 1000 W/m² beam)	< 20 W/m²
Temperature dependence of sensitivity	< 3 % (-20 °C to +50 °C)
Temperature dependence of sensitivity	< 5 % (-40 °C to +70 °C)
Tilt error (at 1000 W/m²)	< 1 %

Other specifications

Anologue output	-V version: 0 to 1 V -A version: 4 to 20 mA
Anologue output range	-V version: -200 to 2000 W/m² -A version: 0 to 1600 W/m²
Digital output	2-Wire RS-485
Digital output range	-400 to 2000 W/m²
Digital communication protocol	Modbus®
Supply voltage	5 to 30 VDC
Power consumption (at 12 VDC)	-V version: 55 mW -A version: 100 mW
Level accuracy	1 °
Operating temperature	-40 °C to +80 °C
Spectral range (50 % points)	300 to 2800 nm

Accessories for SMP3	Part number
Mounting Rod Screw-in 300 mm long x 12 mm Ø	**0338720**
CMF 1 Mounting Fixture For 1 or 2 unventilated radiometers (1 upper / 1 lower) Diameter 88 mm. Mounting rod 350 mm long x 16 mm Ø	**0362700**
CMB 1 Mounting Bracket In combination with mounting rod for easy attachment to a pole or a wall	**0369701**
CM 121B Shadow Ring for unventilated radiometers Manually adjusted device provides diffuse sky irradiance measurement	**0346900**
Note: SMP3 cannot be used with CVF 3 Ventilation Unit	
Note: SMP3 cannot be used with Glare Screen Kit	

SMP3 Albedometer

SMP3 Second Class Albedometer
An ISO Second Class Albedometer can be self-assembled by ordering:
2x SMP3 Pyranometer + 1x Mounting Rod

CMP 6

CMP 6 is an ISO First Class pyranometer. It has a similar detector to CMP 3, but has improved performance due to the increased thermal mass and the double glass dome construction. The tilt error and levelling accuracy are also improved. The bubble level is visible through the snap-on white sun shield. The drying cartridge keeps the instrument free of internal condensation and is easily removable.

CMP 6 is ideal for cost-effective, good quality, measurements in meteorological and hydrological networks and agriculture. Performance can be further improved by using the CVF 3 Ventilation Unit.

A range of mounting accessories is available.

Specifications

Specifications	
ISO 9060:1990 CLASSIFICATION	First Class
Response time (95 %)	< 18 s
Zero offsets (a) thermal radiation (200 W/m^2) (b) temperature change (5 K/hr)	 < 12 W/m^2 < 4 W/m^2
Non-stability (change/year)	< 1 %
Non-linearity (0 to 1000 W/m^2)	< 1 %
Directional error (up to 80° with 1000 W/m^2 beam)	< 20 W/m^2
Temperature dependence of sensitivity	< 4 % (-10 °C to +40 °C)
Tilt error (at 1000 W/m^2)	< 1 %

Other specifications

Other specifications	
Sensitivity	5 to 20 μV/W/m^2
Impedance	20 to 200 Ω
Level accuracy	0.1 °
Operating temperature	-40 °C to +80 °C
Spectral range (50 % points)	285 to 2800 nm
Typical signal output for atmospheric applications	0 to 20 mV
Maximum irradiance	2000 W/m^2

Article	Part number
CMP 6 Pyranometer • 10 m cable	**0362900-002**
Options for CMP 6	
CMP 6 Pyranometer • 25 m cable	0362900-004
CMP 6 Pyranometer • 50 m cable	0362900-005
CMP 6 Pyranometer • plug only, no cable	0362900-008
CMP 6 Pyranometer • METEON • 10 m cable	0362900-702
CMP 6 Pyranometer • AMPBOX • 10 m cable	0362900-802
CMP 6 Pyranometer • AMPBOX • 25 m cable	0362900-804
CMP 6 Pyranometer • AMPBOX • 50 m cable	0362900-805
CMP 6 Pyranometer • AMPBOX • plug only, no cable	0362900-808
100 m cable	On request
Note: AMPBOX is adjusted so that 4 - 20 mA output = 0 - 1600 W/m^2	

Accessories for CMP 6	Part number
Desiccant Refill Pack • contains 10 sachets	**2643960**
CVF 3 Ventilation Unit Recommended to reduce offsets and frequency of dome cleaning	**See accessories**
CMF 1 Mounting Fixture For 1 or 2 unventilated radiometers (1 upper / 1 lower) Diameter 88 mm. Mounting rod 350 mm long x 16 mm Ø	**0362700**
CMF 2 Mounting Fixture For 1 or 2 ventilated or unventilated radiometers (1 upper / 1 lower) Diameter 220 mm. Mounting rod 350 mm long x 16 mm Ø	**0362701**
CMB 1 Mounting Bracket In combination with mounting rod for easy attachment to a pole or a wall	**0369701**
CM 121B Shadow Ring for unventilated radiometers Manually adjusted device provides diffuse sky irradiance measurement *Note: CM 121B can not be used with CVF 3 ventilation unit*	**0346900**
CM 121C Shadow Ring for ventilated radiometers Manually adjusted device provides diffuse sky irradiance measurement Mounts the radiometer at the correct height when used with a CVF 3	**0346901**
Glare Screen Kit Sun protection screen for downward facing radiometers with fixings	**0305722**

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CMP 11

CMP 11 is an ISO Secondary Standard pyranometer. Compared to the CMP 6 it has better directional response. The detector design is different with faster response and has temperature compensation for greater accuracy with temperature changes. The tilt error and levelling accuracy are also improved.

CMP 11 is a step up in performance from CMP 6 and is particularly suitable for upgrading meteorological networks. The fast response time of 1.7 seconds (63 %) meets the requirements for solar energy research and development applications and materials testing.

CMP 11 is ideal for use in sun tracker based solar monitoring stations.

Specifications

ISO 9060:1990 CLASSIFICATION	Secondary Standard
Response time (95 %)	< 5 s
Zero offsets (a) thermal radiation (200 W/m²) (b) temperature change (5 K/hr)	 < 7 W/m² < 2 W/m²
Non-stability (change/year)	< 0.5 %
Non-linearity (0 to 1000 W/m²)	< 0.2 %
Directional error (up to 80° with 1000 W/m² beam)	< 10 W/m²
Temperature dependence of sensitivity	< 1 % (-10 °C to +40 °C)
Tilt error (at 1000 W/m²)	< 0.2 %

Other specifications

Sensitivity	7 to 14 μV/W/m²
Impedance	10 to 100 Ω
Level accuracy	0.1 °
Operating temperature	-40 °C to +80 °C
Spectral range (50 % points)	285 to 2800 nm
Typical signal output for atmospheric applications	0 to 15 mV
Maximum irradiance	4000 W/m²

Article	Part number
CMP 11 Pyranometer • 10 m cable	**0362910-002**
Options for CMP 11	
CMP 11 Pyranometer • 25 m cable	0362910-004
CMP 11 Pyranometer • 50 m cable	0362910-005
CMP 11 Pyranometer • plug only, no cable	0362910-008
CMP 11 Pyranometer • METEON • 10 m cable	0362910-702
CMP 11 Pyranometer • AMPBOX • 10 m cable	0362910-802
CMP 11 Pyranometer • AMPBOX • 25 m cable	0362910-804
CMP 11 Pyranometer • AMPBOX • 50 m cable	0362910-805
CMP 11 Pyranometer • AMPBOX • plug only, no cable	0362910-808
100 m cable	On request
Note: AMPBOX is adjusted so that 4 - 20 mA output = 0 - 1600 W/m²	

Accessories for CMP 11	Part number
Desiccant Refill Pack • contains 10 sachets	**2643960**
CVF 3 Ventilation Unit Recommended to reduce offsets and frequency of dome cleaning	**See accessories**
CMF 1 Mounting Fixture For 1 or 2 unventilated radiometers (1 upper / 1 lower) Diameter 88 mm. Mounting rod 350 mm long x 16 mm Ø	**0362700**
CMF 2 Mounting Fixture For 1 or 2 ventilated or unventilated radiometers (1 upper / 1 lower) Diameter 220 mm. Mounting rod 350 mm long x 16 mm Ø	**0362701**
CMB 1 Mounting Bracket In combination with mounting rod for easy attachment to a pole or a wall	**0369701**
CM 121B Shadow Ring for unventilated radiometers Manually adjusted device provides diffuse sky irradiance measurement *Note: CM 121B can not be used with CVF 3 ventilation unit*	**0346900**
CM 121C Shadow Ring for ventilated radiometers Manually adjusted device provides diffuse sky irradiance measurement Mounts the radiometer at the correct height when used with a CVF 3	**0346901**
Glare Screen Kit Sun protection screen for downward facing radiometers with fixings	**0305722**

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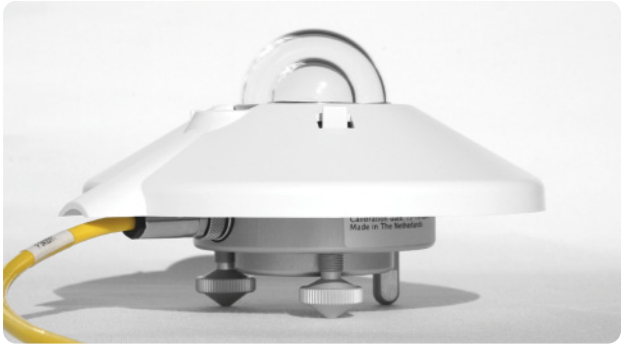
SMP11



SMP11 has the same housing and detector design as the passive CMP 11 model and is an ISO Secondary Standard pyranometer. Like SMP3, the SMP11 is equipped with a smart interface and there are two versions, One has an analogue output of 0-1 V, the other has 4-20 mA. Both have a 2-wire RS-485 interface with Modbus® (RTU) protocol.

SMP11 has all the smart interface advantages and features of the SMP3 but a significantly higher level of performance, and also has a faster response than the CMP 11. All instruments can have the same analog and digital measurement ranges, saving time on installation and when exchanging instruments for re-calibration. SMP series pyranometers can operate from a power supply in the range from 5 VDC to 30 VDC and have both reverse polarity and over-voltage protection.

Through the Modbus® interface the user can access the pyranometer type and serial number, instrument settings, calibration history, status information, and more. Pyranometers can be assigned individual addresses and 'daisy-chained' together for use in site networks.

SMP11 is the best choice for site prospecting, technology research and high quality solar radiation monitoring in renewable energy applications. It is also particularly suitable for upgrading meteorological networks and for use in sun tracker based solar monitoring stations.

Article	Part number
SMP11-V Smart Pyranometer • 0-1 V version • 10 m cable	**0374910-102**
Options for SMP11-V	
SMP11-V Smart Pyranometer • 0-1 V version • 25 m cable	0374910-104
SMP11-V Smart Pyranometer • 0-1 V version • 50 m cable	0374910-105
SMP11-V Smart Pyranometer • 0-1 V version • plug only, no cable	0374910-108
100 m cable	On request

Article	Part number
SMP11-A Smart Pyranometer • 4-20 mA version • 10 m cable	**0374910-202**
Options for SMP11-A	
SMP11-A Smart Pyranometer • 4-20 mA version • 25 m cable	0374910-204
SMP11-A Smart Pyranometer • 4-20 mA version • 50 m cable	0374910-205
SMP11-A Smart Pyranometer • 4-20 mA version • plug only, no cable	0374910-208
100 m cable	On request

Specifications

ISO 9060:1990 CLASSIFICATION	Secondary Standard
Response time (63 %)	< 0.7 s
Response time (95 %)	< 2 s
Zero offsets (a) thermal radiation (200 W/m²) (b) temperature change (5 K/hr)	 < 7 W/m² < 2 W/m²
Non-stability (change/year)	< 0.5 %
Non-linearity (0 to 1000 W/m²)	< 0.2 %
Directional error (up to 80° with 1000 W/m² beam)	< 10 W/m²
Temperature dependence of sensitivity	< 1 % (-20 °C to +50 °C)
Temperature dependence of sensitivity	< 2 % (-40 °C to +70 °C)
Tilt error (at 1000 W/m²)	< 0.2 %
Other specifications	
Anologue output	-V version: 0 to 1 V -A version: 4 to 20 mA
Anologue output range	-V version: -200 to 2000 W/m² -A version: 0 to 1600 W/m²
Digital output	2-Wire RS-485
Digital output range	-400 to 4000 W/m²
Digital communication protocol	Modbus®
Supply voltage	5 to 30 VDC
Power consumption (at 12 VDC)	-V version: 55 mW -A version: 100 mW
Level accuracy	0.1 °
Operating temperature	-40 °C to +80 °C
Spectral range (50 % points)	300 to 2800 nm

Accessories for SMP11	Part number
Desiccant Refill Pack • contains 10 sachets	**2643960**
CVF 3 Ventilation Unit Recommended to reduce offsets and frequency of dome cleaning	**See accessories**
CMF 1 Mounting Fixture For 1 or 2 unventilated radiometers (1 upper / 1 lower) Diameter 88 mm. Mounting rod 350 mm long x 16 mm Ø	**0362700**
CMF 2 Mounting Fixture For 1 or 2 ventilated or unventilated radiometers (1 upper / 1 lower) Diameter 220 mm. Mounting rod 350 mm long x 16 mm Ø	**0362701**
CMB 1 Mounting Bracket In combination with mounting rod for easy attachment to a pole or a wall	**0369701**
CM 121B Shadow Ring for unventilated radiometers Manually adjusted device provides diffuse sky irradiance measurement *Note: CM 121B can not be used with CVF 3 ventilation unit*	**0346900**
CM 121C Shadow Ring for ventilated radiometers Manually adjusted device provides diffuse sky irradiance measurement Mounts the radiometer at the correct height when used with a CVF 3	**0346901**
Glare Screen Kit Sun protection screen for downward facing radiometers with fixings	**0305722**

SMP11 Albedometer

SMP11 Secondary Standard Albedometer (unventilated version)
An ISO Secondary Standard Albedometer can be self-assembled by ordering:
2x SMP11 Smart Pyranometer + 1x **CMF 1** Mounting Fixture + 1x Glare Screen Kit

SMP11 Secondary Standard Albedometer (ventilated version)
An ISO Secondary Standard Albedometer can be self-assembled by ordering:
2x SMP11 Smart Pyranometer + 1x **CMF 2** Mounting Fixture + 2x CVF 3 Ventilation Unit

CMP 21

CMP 21 is a research grade instrument that exceeds the requirements for an ISO Secondary Standard pyranometer. It is similar to CMP 11 but has individually optimised temperature compensation. A standard 10 kΩ thermistor sensor is fitted to monitor the housing temperature; a Pt-100 thermocouple sensor is optional. Each instrument is supplied with its own temperature and directional (cosine) response data.

CMP 21 is the choice for scientific use and in top level solar radiation monitoring networks such as the Baseline Surface Radiation Network (BSRN) of the World Meteorological Organisation. The excellent temperature dependence makes CMP 21 particularly suitable for reference measurements in extreme climates, from deserts to the Antarctic.

Specifications

ISO 9060:1990 CLASSIFICATION	Secondary Standard
Response time (95 %)	< 5 s
Zero offsets (a) thermal radiation (200 W/m²) (b) temperature change (5 K/hr)	 < 7 W/m² < 2 W/m²
Non-stability (change/year)	< 0.5 %
Non-linearity (0 to 1000 W/m²)	< 0.2 %
Directional error (up to 80° with 1000 W/m² beam)	< 10 W/m²
Temperature dependence of sensitivity	< 1 % (-20 °C to +50 °C)
Tilt error (at 1000 W/m²)	< 0.2 %

Other specifications

Sensitivity	7 to 14 µV/W/m²
Impedance	10 to 100 Ω
Level accuracy	0.1 °
Operating temperature	-40 °C to +80 °C
Spectral range (50 % points)	285 to 2800 nm
Typical signal output for atmospheric applications	0 to 15 mV
Maximum irradiance	4000 W/m²
Temperature sensor	10 K Thermistor (optional Pt-100)

Article	Part number
CMP 21 Pyranometer • 10 K • 10 m cable	**0362920-012**
Options for CMP 21	
CMP 21 Pyranometer • 10 K • 25 m cable	0362920-014
CMP 21 Pyranometer • 10 K • 50 m cable	0362920-015
CMP 21 Pyranometer • 10 K • plug only, no cable	0362920-018
CMP 21 Pyranometer • Pt-100 • 10 m cable	0362920-022
CMP 21 Pyranometer • Pt-100 • 25 m cable	0362920-024
CMP 21 Pyranometer • Pt-100 • 50 m cable	0362920-025
CMP 21 Pyranometer • Pt-100 • plug only, no cable	0362920-028
CMP 21 Pyranometer • METEON • 10 m cable	0362920-712
CMP 21 Pyranometer • AMPBOX • 10 K • 10 m cable	0362920-812
CMP 21 Pyranometer • AMPBOX • 10 K • 25 m cable	0362920-814
CMP 21 Pyranometer • AMPBOX • 10 K • 50 m cable	0362920-815
CMP 21 Pyranometer • AMPBOX • 10 K • plug only, no cable	0362920-818
CMP 21 Pyranometer • AMPBOX • Pt-100 • 10 m cable	0362920-822
CMP 21 Pyranometer • AMPBOX • Pt-100 • 25 m cable	0362920-824
CMP 21 Pyranometer • AMPBOX • Pt-100 • 50 m cable	0362920-825
CMP 21 Pyranometer • AMPBOX • Pt-100 • plug only, no cable	0362920-828
100 m cable	On request
Note: AMPBOX is adjusted so that 4 - 20 mA output = 0 - 1600 W/m²	

CMP 21 Albedometer

CMP 21 Scientific Secondary Standard Albedometer (unventilated version)
An ISO Secondary Standard Albedometer can be self-assembled by ordering:
2x CMP 21 Pyranometer + 1x **CMF 1** Mounting Fixture + 1x Glare Screen Kit

CMP 21 Scientific Secondary Standard Albedometer (ventilated version)
An ISO Secondary Standard Albedometer can be self-assembled by ordering:
2x CMP 21 Pyranometer + 1x **CMF 2** Mounting Fixture + 2x CVF 3 Ventilation Unit

Accessories for CMP 21	Part number
Desiccant Refill Pack • contains 10 sachets	**2643960**
Extended Temperature Test for CMP 21 Temperature dependence from -40 °C to +50 °C in 10 steps of 10 °C	**0999920-3**
CVF 3 Ventilation Unit Recommended to reduce offsets and frequency of dome cleaning	**See accessories**
CMF 1 Mounting Fixture For 1 or 2 unventilated radiometers (1 upper / 1 lower) Diameter 88 mm. Mounting rod 350 mm long x 16 mm Ø	**0362700**
CMF 2 Mounting Fixture For 1 or 2 ventilated or unventilated radiometers (1 upper / 1 lower) Diameter 220 mm. Mounting rod 350 mm long x 16 mm Ø	**0362701**
CMB 1 Mounting Bracket In combination with mounting rod for easy attachment to a pole or a wall	**0369701**
CM 121B Shadow Ring for unventilated radiometers Manually adjusted device provides diffuse sky irradiance measurement *Note: CM 121B can not be used with CVF 3 ventilation unit*	**0346900**
CM 121C Shadow Ring for ventilated radiometers Manually adjusted device provides diffuse sky irradiance measurement Mounts the radiometer at the correct height when used with a CVF 3	**0346901**
Glare Screen Kit Sun protection screen for downward facing radiometers with fixings	**0305722**

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CMP 22

CMP 22 is our highest quality pyranometer and it easily exceeds the requirements for an ISO Secondary Standard instrument. It has all the features of CMP 21 but uses very high quality quartz domes for a wider spectral range, improved directional response, and reduced thermal offsets. Because of the high optical quality of these domes the directional error is reduced below 5 W/m² up to 80° solar zenith angle.

A standard 10 kΩ thermistor sensor is fitted to monitor the housing temperature; a Pt-100 thermocouple sensor is optional. Each instrument is supplied with its own temperature and directional (cosine) response data. Kipp & Zonen is confident that CMP 22 is the best pyranometer currently available.

Specifications

ISO 9060:1990 CLASSIFICATION	Secondary Standard
Response time (95 %)	< 5 s
Zero offsets (a) thermal radiation (200 W/m²) (b) temperature change (5 K/hr)	 < 3 W/m² < 1 W/m²
Non-stability (change/year)	< 0.5 %
Non-linearity (0 to 1000 W/m²)	< 0.2 %
Directional error (up to 80° with 1000 W/m² beam)	< 5 W/m²
Temperature dependence of sensitivity	< 0.5 % (-20 °C to +50 °C)
Tilt error (at 1000 W/m²)	< 0.2 %

Other specifications

Sensitivity	7 to 14 μV/W/m²
Impedance	10 to 100 Ω
Level accuracy	0.1 °
Operating temperature	-40 °C to +80 °C
Spectral range (50 % points)	200 to 3600 nm
Typical signal output for atmospheric applications	0 to 15 mV
Maximum irradiance	4000 W/m²
Temperature sensor	10 K Thermistor (optional Pt-100)

Article	Part number
CMP 22 Pyranometer • 10 K • 10 m cable	**0362930-012**
Options for CMP 22	
CMP 22 Pyranometer • 10 K • 25 m cable	0362930-014
CMP 22 Pyranometer • 10 K • 50 m cable	0362930-015
CMP 22 Pyranometer • 10 K • plug only, no cable	0362930-018
CMP 22 Pyranometer • Pt-100 • 10 m cable	0362930-022
CMP 22 Pyranometer • Pt-100 • 25 m cable	0362930-024
CMP 22 Pyranometer • Pt-100 • 50 m cable	0362930-025
CMP 22 Pyranometer • Pt-100 • plug only, no cable	0362930-028
CMP 22 Pyranometer • METEON • 10 m cable	0362930-712
CMP 22 Pyranometer • AMPBOX • 10 K • 10 m cable	0362930-812
CMP 22 Pyranometer • AMPBOX • 10 K • 25 m cable	0362930-814
CMP 22 Pyranometer • AMPBOX • 10 K • 50 m cable	0362930-815
CMP 22 Pyranometer • AMPBOX • 10 K • plug only, no cable	0362930-818
CMP 22 Pyranometer • AMPBOX • Pt-100 • 10 m cable	0362930-822
CMP 22 Pyranometer • AMPBOX • Pt-100 • 25 m cable	0362930-824
CMP 22 Pyranometer • AMPBOX • Pt-100 • 50 m cable	0362930-825
CMP 22 Pyranometer • AMPBOX • Pt-100 • plug only, no cable	0362930-828
100 m cable	On request
Note: AMPBOX is adjusted so that 4 - 20 mA output = 0 - 1600 W/m²	

CMP 22 Albedometer

CMP 22 Scientific Secondary Standard Albedometer (unventilated version)
An ISO Secondary Standard Albedometer can be self-assembled by ordering:
2x CMP 22 Pyranometer + 1x **CMF 1** Mounting Fixture + 1x Glare Screen Kit

CMP 22 Scientific Secondary Standard Albedometer (ventilated version)
An ISO Secondary Standard Albedometer can be self-assembled by ordering:
2x CMP 22 Pyranometer + 1x **CMF 2** Mounting Fixture + 2x CVF 3 Ventilation Unit

Accessories for CMP 22	Part number
Desiccant Refill Pack • contains 10 sachets	**2643960**
Extended Temperature Test for CMP 22 Temperature dependence from -40 °C to +50 °C in 10 steps of 10 °C	**0999920-3**
CVF 3 Ventilation Unit Recommended to reduce offsets and frequency of dome cleaning	**See accessories**
CMF 1 Mounting Fixture For 1 or 2 unventilated radiometers (1 upper / 1 lower) Diameter 88 mm. Mounting rod 350 mm long x 16 mm Ø	**0362700**
CMF 2 Mounting Fixture For 1 or 2 ventilated or unventilated radiometers (1 upper / 1 lower) Diameter 220 mm. Mounting rod 350 mm long x 16 mm Ø	**0362701**
CMB 1 Mounting Bracket In combination with mounting rod for easy attachment to a pole or a wall	**0369701**
CM 121B Shadow Ring for unventilated radiometers Manually adjusted device provides diffuse sky irradiance measurement *Note: CM 121B can not be used with CVF 3 ventilation unit*	**0346900**
CM 121C Shadow Ring for ventilated radiometers Manually adjusted device provides diffuse sky irradiance measurement Mounts the radiometer at the correct height when used with a CVF 3	**0346901**
Glare Screen Kit Sun protection screen for downward facing radiometers with fixings	**0305722**

Pyrgeometers

FOR THE PRECISE MEASUREMENT OF FAR INFRARED RADIATION

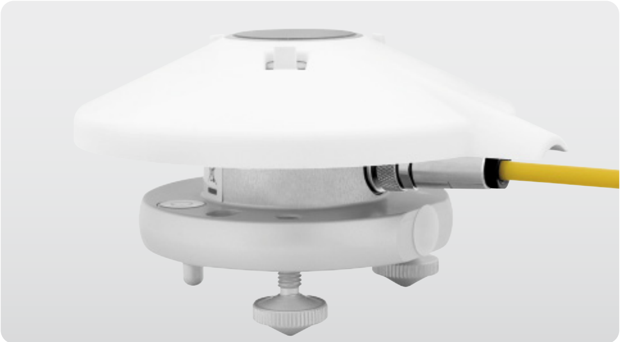
Radiation from the sun is mainly in the 'short-wave' range from 300 to 4000 nm (4 µm) that includes the visible and ultraviolet. A proportion of this radiation is absorbed by clouds, aerosols and molecules in the atmosphere which warm up and radiate 'long-wave' radiation. This is far infrared thermal energy (FIR) at wavelengths from 4.5 µm to beyond 40 µm.

Both the short-wave and long-wave radiation reach the Earth, where some is reflected and the remainder warms up the surface. The Earth radiates long-wave thermal energy back to the sky. Short-wave radiation is measured by a pyranometer and long-wave radiation by a pyrgeometer.

A pyrgeometer provides a voltage that is proportional to the radiation exchange between the instrument and the sky (or ground) in its field of view. The detector signal output can be positive or negative. In order to calculate the incoming or outgoing FIR it is necessary to know the temperature of the instrument housing close to the detector and the data must be recorded simultaneously with the detector signal.

Kipp & Zonen CGR pyrgeometers are installed around the world for meteorology, hydrology, climate research, and agriculture; wherever accurate measurements of the radiation energy balance are required. They comply with the requirements of the World Meteorological Organisation and are fully traceable to the World Infrared Standard Group (WISG) in Davos, Switzerland, where the CGR 4 forms part of the Group.

CGR 3



CGR 3 is the partner to the CMP 3 and CMP 6 pyranometers. The flat silicon window transmits infrared radiation and an internal thin film coating blocks short-wave solar radiation from reaching the broadband thermopile detector. The field of view is 150 °. The small size and sealed construction make this instrument the ideal choice for horticulture and agriculture. A screw-in mounting rod is available for easy installation.

The waterproof connector has gold-plated contacts and is fitted with 10 m of high quality signal cable as standard. A 10 K thermistor internal temperature sensor is fitted; a Pt-100 sensor is optional. There is an integrated bubble level and a white sun shield prevents the body heating up.

Two CGR 3's can easily be mounted back-to-back and fitted with the accessory screw-in mounting rod to make a low cost net pyrgeometer.

Specifications	
Response time (95 %)	< 18 s
Non-stability (change/year)	< 1 %
Non-linearity (-250 to 250 W/m²)	< 1 %
Window heating offset (with 1000 W/m² direct solar radiation)	< 15 W/m²
Temperature dependence of sensitivity	< 5 % (-10 °C to +40 °C)
Sensitivity	5 to 15 µV/W/m²
Operating temperature	-40 °C to +80 °C
Field of view	150 °
Spectral range (50 % points)	4.5 to 42 µm
Irradiance (net)	-250 to 250 W/m²
Temperature sensor	10 K Thermistor (optional Pt-100)

Article	Part number
CGR 3 Pyrgeometer • 10 K • 10 m cable	**0359920-012**
Options for CGR 3	
CGR 3 Pyrgeometer • 10 K • 25 m cable	0359920-014
CGR 3 Pyrgeometer • 10 K • 50 m cable	0359920-015
CGR 3 Pyrgeometer • 10 K • plug only, no cable	0359920-018
CGR 3 Pyrgeometer • Pt-100 • 10 m cable	0359920-022
CGR 3 Pyrgeometer • Pt-100 • 25 m cable	0359920-024
CGR 3 Pyrgeometer • Pt-100 • 50 m cable	0359920-025
CGR 3 Pyrgeometer • Pt-100 • plug only, no cable	0359920-028
CGR 3 Pyrgeometer • Ampbox • 10 K • 10 m cable	0359920-812
CGR 3 Pyrgeometer • Ampbox • 10 K • 25 m cable	0359920-814
CGR 3 Pyrgeometer • Ampbox • 10 K • 50 m cable	0359920-815
CGR 3 Pyrgeometer • Ampbox • 10 K • plug only, no cable	0359920-818
CGR 3 Pyrgeometer • Ampbox • Pt-100 • 10 m cable	0359920-822
CGR 3 Pyrgeometer • Ampbox • Pt-100 • 25 m cable	0359920-824
CGR 3 Pyrgeometer • Ampbox • Pt-100 • 50 m cable	0359920-825
CGR 3 Pyrgeometer • Ampbox • Pt-100 • plug only, no cable	0359920-828
100 m cable	On request
Note: AMPBOX is adjusted with offset zero for negative values; 4 mA = -600 W/m², 16 mA = 0 W/m², 20 mA = +200 W/m²	

Accessories for CGR 3	Part number
Outdoor Calibration under clear skies For increased accuracy, instead of standard laboratory calibration	**0999915-1**
Mounting Rod Screw-in 300 mm long x 12 mm Ø	**0338720**
CMF 1 Mounting Fixture For 1 or 2 unventilated radiometers (1 upper / 1 lower) Diameter 88 mm. Mounting rod 350 mm long x 16 mm Ø	**0362700**
CMB 1 Mounting Bracket In combination with mounting rod for easy attachment to a pole or a wall	**0369701**
CM 121B Shadow Ring for unventilated radiometers Manually adjusted device shades CGR 3 from direct solar radiation Correction factors for latitude of location supplied	**0346900**
Note: CGR 3 cannot be used with the CVF 3 ventilation unit	
Note: CGR 3 cannot be used with glare screen kit	

CGR 3 Net Pyrgeometer

CGR 3 Net Pyrgeometer
A Net Pyrgeometer can be self-assembled by ordering:
2x CGR 3 Pyrgeometer + 1x Mounting Rod

Note: CGR 3 Net Pyrgeometer can be used with the AMPBOX but it has two individual outputs, so 2 x AMPBOX are required

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CGR 4

CGR 4 is the best pyrgeometer currently available and is the choice for scientific use and in top level solar radiation monitoring networks such as the Baseline Surface Radiation Network (BSRN) of the World Meteorological Organisation. It is the partner for CMP 11, CMP 21 and CMP 22 pyranometers.

CGR 4 has a specially designed silicon meniscus dome that provides a 180 ° field of view and has a hard-carbon coating on the outside to smooth the spectral response and provide extra surface protection. CGR 4 is calibrated outdoors under clear skies for the best accuracy. Each instrument is supplied with its own temperature response data. All pyrgeometers use infrared window materials that absorb a large part of the short-wave solar radiation. The window heats up and creates an offset in the readings. It is normally necessary to shade pyrgeometers from direct solar radiation to minimise this effect. However, the unique design of CGR 4 reduces the dome heating offset to a negligible level (particularly when ventilated), eliminating the need for dome temperature measurements or dome shading.

Specifications

Response time (95 %)	< 18 s
Non-stability (change/year)	< 1 %
Non-linearity (-250 to 250 W/m²)	< 1 %
Window heating offset (with 1000 W/m² direct solar radiation)	< 4 W/m²
Temperature dependence of sensitivity	< 1 % (-20 °C to +50 °C)
Sensitivity	5 to 15 μV/W/m²
Operating temperature	-40 °C to +80 °C
Field of view	180 °
Spectral range (50 % points)	4.5 to 42 μm
Irradiance (net)	-250 to 250 W/m²
Temperature sensor	10 K Thermistor (optional Pt-100)

Article	Part number
CGR 4 Pyrgeometer • 10 K • 10 m cable	**0363900-012**
Options for CGR 4	
CGR 4 Pyrgeometer • 10 K • 25 m cable	0363900-014
CGR 4 Pyrgeometer • 10 K • 50 m cable	0363900-015
CGR 4 Pyrgeometer • 10 K • plug only, no cable	0363900-018
CGR 4 Pyrgeometer • Pt-100 • 10 m cable	0363900-022
CGR 4 Pyrgeometer • Pt-100 • 25 m cable	0363900-024
CGR 4 Pyrgeometer • Pt-100 • 50 m cable	0363900-025
CGR 4 Pyrgeometer • Pt-100 • plug only, no cable	0363900-028
CGR 4 Pyrgeometer • Ampbox • 10 K • 10 m cable	0363900-812
CGR 4 Pyrgeometer • Ampbox • 10 K • 25 m cable	0363900-814
CGR 4 Pyrgeometer • Ampbox • 10 K • 50 m cable	0363900-815
CGR 4 Pyrgeometer • Ampbox • 10 K • plug only, no cable	0363900-818
CGR 4 Pyrgeometer • Ampbox • Pt-100 • 10 m cable	0363900-822
CGR 4 Pyrgeometer • Ampbox • Pt-100 • 25 m cable	0363900-824
CGR 4 Pyrgeometer • Ampbox • Pt-100 • 50 m cable	0363900-825
CGR 4 Pyrgeometer • Ampbox • Pt-100 • plug only, no cable	0363900-828
100 m cable	On request

Note: AMPBOX is adjusted with offset zero for negative values; 4 mA = -600 W/m², 16 mA = 0 W/m², 20 mA = +200 W/m²

Accessories for CGR 4	Part number
Desiccant Refill Pack • contains 10 sachets	**2643960**
Extended Temperature Test for CGR 4 Temperature dependence from -40 °C to +50 °C in 10 steps of 10 °C	**0999920-3**
CVF 3 Ventilation Unit Recommended to reduce offsets and frequency of dome cleaning	**See accessories**
CMF 1 Mounting Fixture For 1 or 2 unventilated radiometers (1 upper / 1 lower) Diameter 88 mm. Mounting rod 350 mm long x 16 mm Ø	**0362700**
CMF 2 Mounting Fixture For 1 or 2 ventilated or unventilated radiometers (1 upper / 1 lower) Diameter 220 mm. Mounting rod 350 mm long x 16 mm Ø	**0362701**
CMB 1 Mounting Bracket In combination with mounting rod for easy attachment to a pole or a wall	**0369701**

Note: It is not necessary to use shading with the CGR 4. The effect of direct solar heating is very small and insignificant when the CVF 3 is used

CGR 4 Net Pyrgeometer

CGR 4 Net Pyrgeometer

A Net Pyrgeometer can be self-assembled by ordering:
2x CGR 4 Pyrgeometer + 1x CMF 1 or CMF 2 Mounting Fixture + 1x Glare Screen Kit

Note: CGR 4 Net Radiometer can be used with the AMPBOX but it has two individual outputs, so 2x AMPBOX are required

Note: Glare Screen Kit cannot be fitted when CVF 3 Ventilation Unit is used

Pyrheliometer

FOR UNATTENDED DIRECT NORMAL INCIDENCE SOLAR RADIATION MEASUREMENT

Solar rays travelling through our atmosphere are absorbed and scattered, resulting in different components of solar radiation reaching the Earth's surface. The direct component travels in a straight beam from the sun. Diffuse components come from all directions, due to atmospheric scattering processes.

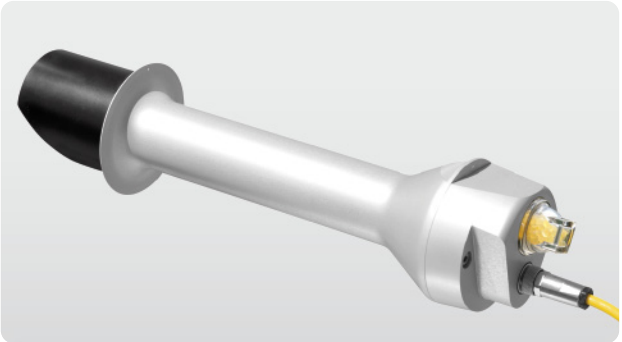
A pyrheliometer is an instrument designed specifically to measure the direct beam solar irradiance with a field of view limited to 5 °. This is achieved by the shape of the collimation tube, with precision apertures, and the detector design. The front aperture is fitted with a quartz window to protect the instrument and to act as a filter that passes solar radiation between 200 nm and 4000 nm in wavelength.

The Kipp & Zonen CHP 1 pyrheliometer is an all-weather instrument for the continuous measurement of direct solar radiation and exceeds the specifications for high end solar radiation networks, such as the Baseline Surface Radiation Network (BSRN). These networks need accurate and reliable long-term measurements for climate change investigations and validating satellite data (ground-truthing).

The SHP1 is the world's first smart pyrheliometer with built-in intelligence. Building on the proven CHP 1 design and measurement technology it adds digital signal processing to improve performance and interfaces optimised for industrial data acquisition and control systems. The fast response time and individual temperature correction make it the best pyrheliometer available.

Good quality Direct Normal Incidence (DNI) irradiance data is often needed in the renewable energy sector. For example, when 'prospecting' for sites to locate solar farms the incoming energy available throughout the year is a key part of the decision making process. Pyrheliometers must be pointed accurately at the sun at all times and Kipp & Zonen automatic sun trackers are specifically designed for this purpose.

CHP 1



CHP 1 exceeds ISO and WMO performance criteria for First Class Normal Incidence Pyrheliometers. Every CHP 1 is calibrated upon manufacture, and is supplied as standard with a WRR (World Radiometric Reference) traceable calibration certificate.

Thanks to the superior mechanical design, CHP 1 offers excellent performance under any atmospheric condition. The zero offsets have been reduced to a minimum and the temperature dependence is limited to just ± 0.5 % between -20 °C and +50 °C. The rain shield protects the window and there are integrated alignment aids.

Both Pt-100 and 10 K thermistor temperature sensors are fitted as standard, to allow use of the individual temperature response data supplied with each CHP 1, and for easy connection to any type of data logger. Thanks to the signal cable connector and screw-in desiccant cartridge the instrument is easy to install and maintain.

Specifications	
ISO 9060:1990 CLASSIFICATION	First Class
Response time (95 %)	< 5 s
Zero offset (b) temperature change (5 K/hr)	< 1 W/m²
Non-stability (change/year)	< 0.5 %
Non-linearity (0 to 1000 W/m²)	< 0.2 %
Temperature dependence of sensitivity	< 0.5 % (-20 °C to +50 °C)
Full viewing angle	5 ° ± 0.2 °
Other specifications	
Sensitivity	7 to 14 µV/W/m²
Impedance	10 to 100 Ω
Operating temperature range	-40 °C to +80 °C
Spectral range (50 % points)	200 to 4000 nm
Maximum irradiance	4000 W/m²
Required sun tracker pointing accuracy	< 0.5 ° from ideal
Temperature sensor	10 K thermistor and Pt-100

Article	Part number
CHP 1 Pyrheliometer • 10 K + Pt-100 • 10 m cable	**0368900-032**
Options for CHP 1	
CHP 1 Pyrheliometer • 10 K + Pt-100 • 25 m cable	0368900-034
CHP 1 Pyrheliometer • 10 K + Pt-100 • 50 m cable	0368900-035
CHP 1 Pyrheliometer • 10 K + Pt-100 • plug only, no cable	0368900-038
CHP 1 Pyrheliometer • AMPBOX • 10 K + Pt-100 • 10 m cable	0368900-832
CHP 1 Pyrheliometer • AMPBOX • 10 K + Pt-100 • 25 m cable	0368900-834
CHP 1 Pyrheliometer • AMPBOX • 10 K + Pt-100 • 50 m cable	0368900-835
CHP 1 Pyrheliometer • AMPBOX • 10 K + Pt-100 • plug only	0368900-838
100 m cable	On request
Note: AMPBOX is adjusted so that 4 - 20 mA output = 0 - 1600 W/m²	

Accessories for CHP 1	Part number
Desiccant Refill Pack • contains 10 sachets	**2643960**
Extended Temperature Test for CHP 1 Temperature dependence from -40 °C to +50 °C in 10 steps of 10 °C	**0999920-3**
Calcium Fluoride Window Kit Tube end-cap with Calcium Fluoride (CaF_2) window to replace standard end-cap with Quartz window. Spectral range 0.2 - 9.5 µm (50 % points)	**0368700**
Note: Calcium Fluoride is soft and slightly hygroscopic and is not suitable for continuous outdoor use	
Note: The CHP 1 must be mounted on an automatic sun tracker such as the Kipp & Zonen SOLYS 2 or 2AP	

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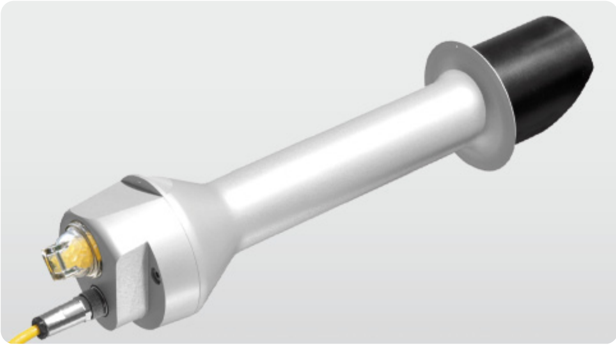
SHP1



SHP1 is a pyrheliometer for the measurement of direct solar radiation according to ISO standard 9060 first class.

The SHP1 combines the CHP 1 sensor technology with smart interface advantages, which makes the SHP1 the best commercially available pyrheliometer.

The smart interface provides both analogue and digital outputs and individual correction for the temperature sensitivity of the detector from -40 °C to + 70 °C.

The improved response time and the standardised output make it easy to interchange instruments for recalibration.

SHP1 pyrheliometers have extremely low power consumption and operate from a wide range of supply voltages, making them ideal for power-critical applications.

SHP1 pyrheliometer is available in two versions, one has an analogue output of 0 to 1 V, the other is 4 to 20 mA. Both have a 2-wire RS-485 interface with Modbus® (RTU) protocol.

Specifications	
ISO 9060:1990 CLASSIFICATION	First Class
Response time (63%)	< 0.7 s
Response time (95 %)	< 2 s
Zero offset (b) temperature change (5 K/hr)	< 1 W/m²
Non-stability (change/year)	< 0.5 %
Non-linearity (0 to 1000 W/m²)	< 0.2 %
Temperature dependence of sensitivity	< 0.5 % (-30 °C to +60 °C)
Full viewing angle	5 ° ± 0.2 °
Other specifications	
Anologue output	-V version: 0 to 1 V -A version: 4 to 20 mA
Anologue output range	-V version: -200 to 2000 W/m² -A version: 0 to 1600 W/m²
Digital output	2-Wire RS-485
Digital output range	-400 to 4000 W/m²
Digital communication protocol	Modbus®
Supply voltage	5 to 30 VDC
Power consumption (at 12 VDC)	-V version: 55 mW -A version: 100 mW
Operating temperature	-40 °C to +80 °C
Spectral range (50 % points)	200 to 4000 nm
Required sun tracker pointing accuracy	< 0.5 ° from ideal

Article	Part number
SHP1-V Smart Pyrheliometer • 0 to 1 V version • 10 m cable	**0375900-102**
Options for SHP1-V	
SHP1-V Smart Pyrheliometer • 0 to 1 V version • 25 m cable	0375900-104
SHP1-V Smart Pyrheliometer • 0 to 1 V version • 50 m cable	0375900-105
SHP1-V Smart Pyrheliometer • 0 to 1 V version • plug only	0375900-108
100 m cable	On request

Article	Part number
SHP1-A Smart Pyrheliometer • 0 to 1 V version • 10 m cable	**0375900-202**
Options for SHP1-A	
SHP1-A Smart Pyrheliometer • 4 to 20 mA version • 25 m cable	0375900-204
SHP1-A Smart Pyrheliometer • 4 to 20 mA version • 50 m cable	0375900-205
SHP1-A Smart Pyrheliometer • 4 to 20 mA version • plug only	0375900-208
100 m cable	On request

Accessories for SHP1	Part number
Desiccant Refill Pack • contains 10 sachets	**2643960**
Calcium Fluoride Window Kit Tube end-cap with Calcium Fluoride (CaF_2) window to replace standard end-cap with Quartz window. Spectral range 0.2 - 9.5 µm (50 % points)	**0368700**
Note: Calcium Fluoride is soft and slightly hygroscopic and is not suitable for continuous outdoor use	
Note: The SHP1 must be mounted on an automatic sun tracker such as the Kipp & Zonen SOLYS 2 or 2AP	

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Sun Trackers

FOR SOLAR TRACKING AND PC-BASED POSITIONING OPERATIONS

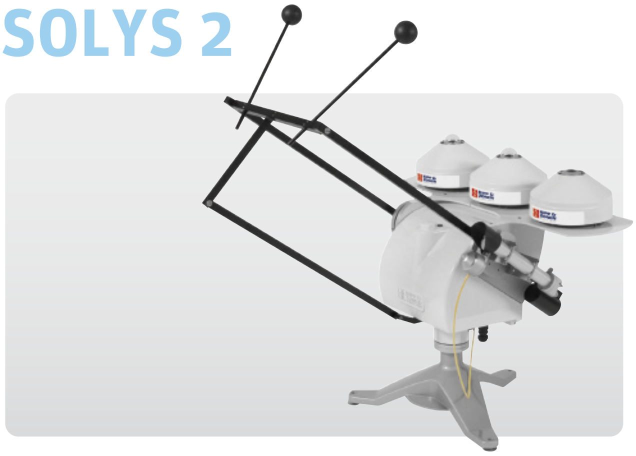
Solar radiation is normally measured using a pyranometer that sees the whole hemisphere above it and responds to radiation from both sun and sky, the 'global' solar radiation. However, it is often necessary to accurately measure the 'direct' radiation coming only from the sun, particularly in solar energy, meteorology and climatology applications.

A pyrheliometer has a view slightly larger than the sun and its aureole and does not see the rest of the sky. To make measurements it must point precisely at the sun and this is achieved using an automatic two-axis sun tracker. The sun tracker provides a stable mounting for the pyrheliometer and moves horizontally (azimuth) and vertically (zenith) to follow the solar arc.

Stepping motors controlled by a micro-processor drive through belts or gears to provide movement with the desired torque and accuracy. An on-board programme uses accurate longitude, latitude, altitude, date, and time information for the measurement site to calculate the sun's position. An optional shading assembly blocks the direct solar radiation from reaching a pyranometer mounted on the tracker so that the 'diffuse' solar radiation from the sky can be measured.

Kipp & Zonen's fully automatic sun trackers are widely used in high quality solar radiation networks, such as the Baseline Surface Radiation Network (BSRN) of the World Climate Research Programme.

SOLYS 2



SOLYS 2 is a cost-effective and simple sun tracking solution. It does not require a computer and software for installation because the integrated GPS automatically configures location and time data. Multi-colour LEDs indicate the operating status and an Ethernet port allows for communication via a web browser. The high-efficiency belt drive system requires no maintenance and the low consumption makes it ideal for use with solar and battery power systems. The 'sleep mode' reduces power by 50 % at night-time.

The tripod stand with levelling feet and the mountings for a pyrheliometer are included as standard. A second side plate can be fitted for an additional direct radiation instrument and top mounting plates are available for global radiometers. A shading assembly for diffuse radiation allows SOLYS 2 to be configured as a complete solar monitoring station and a sun sensor is available for active tracking.

Article	Part number
SOLYS 2 Sun Tracker Including tripod stand and mountings for CHP 1/SHP1 pyrheliometer	**0367900-001**

Specifications

Pointing accuracy	< 0.1 ° passive tracking < 0.02 ° active tracking (sun sensor)
Torque *	> 20 Nm (max. load & angular velocity) > 23 Nm (when sun tracking)
Payload (balanced)	20 kg
Supply voltage (50/60 Hz)	18 to 30 VDC and 90 to 264 VAC
Power *	21 W (reduces to 13 W at night) 100 W extra with heater on (AC only)
Operating temperature range	-20 °C to +50 °C (DC) -40 °C to +50 °C (AC)
Transmission	Inverted tooth belts
Location, time/date information and setup	Automatic by integrated GPS
Mounting base	Tripod stand included
Zenith axis fittings	One side plate and pyrheliometer mounting kit standard
Heater for low temperature operation	Standard (operates on AC power only)
Communication	Ethernet and web interface
Indicators	Power, internal temperature and status LEDs

* The standard torque setting is ideal for all normal measurement applications, but it is adjustable in firmware. Torque can be reduced to save power, or increased to a maximum of 30 Nm when sun tracking.

Accessories for SOLYS 2	Part number
Shading Ball and Rod Extra, for third position on shading assembly	**0353704**
Shading Ball Assembly Including 2 shading balls, large top plate and second side plate	**0367703**
PMO 6 Mounting Kit * To fit 1 x PMOD-WRC PMO 6 absolute cavity pyrheliometer	**0367704**
SPO2 Mounting Kit * To fit 1 x Middleton Solar SPO2 (-L) sun photometer	**0367705**
HF/AHF Mounting Kit * To fit 1 x Eppley HF or AHF absolute cavity pyrheliometer	**0367706**
Sun Sensor Kit for active tracking	**0367707**
Side Mounting Plate for second side of zenith shaft	**0367708**
Large Top Mounting Plate For up to 3 global radiometers (ventilated or un-ventilated)	**0367709**
Pyrheliometer Mounting Kit * To fit a second CHP 1/SHP1 pyrheliometer	**0367710**
Small Top Mounting Plate For 1 global radiometer (ventilated or un-ventilated)	**0367712**
Tilted CMP Pyranometer Mounting Kit * To mount a CMP/SMP series pyranometer to a side plate of the SOLYS 2	**0367713**
PGS-100 Mounting Kit * To fit 1 x Prede PGS-100 Spectral Sun Photometer	**0367714**
NIP Mounting Kit To fit 1 x Eppley NIP pyrheliometer, either as an extension to the standard CHP 1/SHP1 mountings, or directly to a side plate	**0367717**
Adjustable Tilt CMP Mounting Kit To mount a CMP/SMP series pyranometer to a top plate of the SOLYS 2 to measure tilted diffuse radiation. Zenith angle can be adjusted from 0° to 90° with graduated scale	**0367718**

*** *Note: These mounting kits also require a side mounting plate***

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2AP

2AP is the high-end market leader for all conditions. It has proven performance in the harshest climates. High power motors and precision gear drives have the torque to break ice and to operate in high winds. Options enable operation down to -50 °C. After setup using Win2AP software and a PC, operation is stand-alone. The accessory heavy duty tripod stand provides a very stable mounting for the tracker.

No instrument mountings are included as standard, but a wide range of mounting kits is available for pyrheliometers and other radiometers. A shading assembly is available for measuring diffuse radiation and an optional active-tracking sun sensor corrects for internal clock drift or movement of the support platform. 2AP has the power to carry large numbers of instruments and loads up to 65 kg.

Specifications	
Pointing accuracy	< 0.1 ° passive tracking < 0.02 ° active tracking (sun sensor)
Torque	> 40 Nm (max. load & angular velocity) > 40 Nm (when sun tracking)
Payload (balanced)	65 kg
Supply voltage	24 VDC only or 115/230 VAC, 50/60 Hz only
Power	50 W 150 W with optional heater operating
Operating temperature range	0 °C to +50 °C -20 °C to +50 °C with optional cold cover -50 °C to +50 °C with optional heater and cold cover
Transmission	Worm and bevel gear
Location, time/date information and setup	Manual, by Win2AP software and PC (PC not included)
Mounting base	Flat base plate (optional heavy duty tripod stand)
Zenith axis fittings	Two small side plates standard, no mounting kit
Heater for low temperature operation	Optional
Communication	RS 232 and Win2AP software for PC (PC not included)

Article	Part number
2AP Sun Tracker 115/230 VAC With 2 x small side mounting plates, no mountings	**0353900-000**
2AP Sun Tracker 24 VDC With 2 x small side mounting plates, no mountings	**0353902-000**
Options for 2AP	
2AP Sun Tracker 115/230 VAC • Sun Sensor	**0353900-001**
2AP Sun Tracker 115/230 VAC • Heater	**0353900-002**
2AP Sun Tracker 115/230 VAC • Sun Sensor • Heater	**0353900-003**
2AP Sun Tracker 24 VDC • Sun Sensor	**0353902-001**
2AP Sun Tracker 24 VDC • Heater	**0353902-002**
2AP Sun Tracker 24 VDC • Sun Sensor • Heater	**0353902-003**

Accessories for 2AP	Part number
Large Side Mounting Plate With fittings for 2 x CHP 1/SHP1 or 1 x CHP 1/SHP1 and sun sensor	**0353700**
Shading Ball Assembly Including 3 shading balls, rear plate and 2 x large side plates	**0353705**
Adapter Kit To fit one radiometer on rear plate without CVF 3 ventilation unit	**0353706**
Tripod Floor Stand heavy duty, height 0.45 m	**0353710**
Sun Sensor Kit for active tracking	**0353720**
Heater Kit 115/230 VAC for operation to -50 °C (cold cover needed)	**0353741**
Heater Kit 24 VDC for operation to -50 °C (cold cover needed)	**0353743**
Height Extension Tube For tripod stand, extends height by 0.60 m	**0353750**
SPO2 Mounting Kit To fit 1 x Middleton Solar SPO2 (-L) sun photometer	**0353763**
PFR Mounting Kit To fit 2 x PMOD-WRC Precision Filter Radiometers (PFR)	**0353795**
NIP Mounting Kit to fit 4 x Eppley NIP pyrheliometers	**0353796**
PMO 6 Mounting Kit To fit 1 x PMOD-WRC PMO 6 absolute cavity pyrheliometer	**0367704**
HF/AHF Mounting Kit To fit 1 x Eppley HF or AHF absolute cavity pyrheliometer	**0367706**
Pyrheliometer Mounting Kit To fit 1 x CHP 1/SHP1 pyrheliometer to standard small side plate	**0367710**
Tilted CMP Pyranometer Mounting Kit To mount a CMP/SMP series pyranometer to the side plate of the 2AP	**0367713**
PGS-100 Mounting Kit To fit 1 x Prede PGS-100 Spectral Sun Photometer	**0367714**
Adjustable Tilt CMP Mounting Kit To mount a CMP/SMP series pyranometer to the rear plate of the 2AP to measure tilted diffuse radiation. Zenith angle can be adjusted from 0° to 90° with graduated scale	**0367718**
Cold Weather Cover extends operating temperature to -20 °C	**12103152**

Albedometers

FOR GLOBAL AND REFLECTED RADIATION MEASUREMENT

The albedo of a surface is the extent to which it diffusely reflects short-wave radiation from the sun in the wavelength range from 300 nanometers (nm), or less, to 3000 nm. It is the ratio of the reflected radiation to the incoming radiation and varies from 0 (dark) to 1 (bright). As an indication, albedo is about 0.15 for grass, 0.5 for dry sand and 0.8 for fresh snow.

An Albedometer consists of two identical pyranometers that measure the incoming global solar radiation and the radiation reflected from the surface below. The two signal outputs are used to calculate the albedo and the net short-wave radiation.

Kipp & Zonen albedometers are installed around the world for meteorology, hydrology, climate research, and agriculture. A particular use is for measuring the albedo of glaciers, snow and ice fields in climate change research.

Our CMA series are convenient all-in-one instruments designed for a long operating life with simple maintenance. They have a mounting rod for easy attachment to a mast and a white sun shield to prevent the body heating up. An integrated lower glare screen prevents direct illumination of the lower domes at sunrise and sunset. The waterproof connector has gold-plated contacts and is fitted with 10 m of high quality signal cable as standard and the instruments do not require power.

Entry-level albedometers can be configured by using two SP Lite2 or CMP 3 pyranometers with the accessory mounting rod.

Kipp & Zonen has been manufacturing pyranometers for over 75 years and our CMA albedometers share this experience and technology. They comply with the requirements of ISO 9060 and are fully traceable to the World Radiometric Reference (WRR) in Davos, Switzerland, where Kipp & Zonen instruments form part of the World Standard Group.

CMA 6

CMA 6 is an ISO First Class albedometer that uses two CMP 6 pyranometer detector assemblies built into a single housing. An integrated glare screen prevents direct illumination of the lower domes at sunrise and sunset, and a screw-in drying cartridge keeps the interior free from humidity. A mounting rod is fitted to provide easy attachment to a mast in combination with the CMB 1 mounting bracket.

Its good quality and cost-effectiveness make CMA 6 ideal for meteorology, hydrology and agriculture. The light weight is ideal for portable applications.

Specifications

ISO 9060:1990 CLASSIFICATION	First Class
Response time (95 %)	< 18 s
Zero offsets (a) thermal radiation (200 W/m²) (b) temperature change (5 K/hr)	 < 12 W/m² < 4 W/m²
Non-stability (change/year)	< 1 %
Non-linearity (0 to 1000 W/m²)	< 1 %
Directional error (up to 80 ° with 1000 W/m² beam)	< 20 W/m²
Temperature dependence of sensitivity	< 4 % (-10 °C to +40 °C)
Tilt error (at 1000 W/m²)	< 1 %

Other specifications

Sensitivity	7 to 20 μV/W/m²
Impedance	20 to 200 Ω
Level accuracy	0.1 °
Operating temperature	-40 °C to +80 °C
Field of view	180 ° (upper) 170 ° (lower)
Spectral range (50 % points)	285 to 2800 nm
Typical signal output for atmospheric applications	0 to 20 mV (upper) 0 to 15 mV (lower)
Maximum irradiance	2000 W/m²
Mounting rod (fixed)	350 mm long x 16 mm Ø

Article	Part number
CMA 6 Albedometer • 10 m cable	**0362950-002**
Options for CMA 6	
CMA 6 Albedometer • 25 m cable	0362950-004
CMA 6 Albedometer • 50 m cable	0362950-005
CMA 6 Albedometer • plug only, no cable	0362950-008
100 m cable	On request
Note: CMA 6 can be used with the AMPBOX but it has two individual outputs, so 2 x AMPBOX are required. Each AMPBOX is adjusted so that 4-20 mA output = 0-1600 W/m²	

Accessories for CMA 6	Part number
Desiccant Refill Pack • contains 10 sachets	**2643960**
CMB 1 Mounting Bracket To enable easy attachment of the mounting rod to a pole or a wall	**0369701**
Note: CMA 6 cannot be used with CVF 3 Ventilation Unit	

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CMA 11

CMA 11 is a double CMP 11 pyranometer that complies with the highest level of ISO classification, Secondary Standard. It has all the features of the CMA 6 but uses a faster response detector design with temperature compensation. The tilt error and levelling accuracy are also improved.

CMA 11 is a step up in performance from CMA 6 and is recommended for scientific applications, for which accuracy needs to be according to the highest standards.

Specifications	
ISO 9060:1990 CLASSIFICATION	Secondary Standard
Response time (95 %)	< 5 s
Zero offsets (a) thermal radiation (200 W/m²) (b) temperature change (5 K/hr)	 < 7 W/m² < 2 W/m²
Non-stability (change/year)	< 0.5 %
Non-linearity (0 to 1000 W/m²)	< 0.2 %
Directional error (up to 80 ° with 1000 W/m² beam)	< 10 W/m²
Temperature dependence of sensitivity	< 1 % (-10 °C to +40 °C)
Tilt error (at 1000 W/m²)	< 0.2 %
Other specifications	
Sensitivity	7 to 14 μV/W/m²
Impedance	10 to 100 Ω
Level accuracy	0.1 °
Operating temperature	-40 °C to +80 °C
Field of view	180 ° (upper) 170 ° (lower)
Spectral range (50 % points)	285 to 2800 nm
Typical signal output for atmospheric applications	0 to 15 mV (upper) 0 to 10 mV (lower)
Maximum irradiance	4000 W/m²
Mounting rod (fixed)	350 mm long x 16 mm Ø

Article	Part number
CMA 11 Albedometer • 10 m cable	**0362960-002**
Options for CMA 11	
CMA 11 Albedometer • 25 m cable	0362960-004
CMA 11 Albedometer • 50 m cable	0362960-005
CMA 11 Albedometer • plug only, no cable	0362960-008
100 m cable	On request
Note: CMA 11 can be used with the AMPBOX but it has two individual outputs, so 2 x AMPBOX are required. Each AMPBOX is adjusted so that 4-20 mA output = 0-1600 W/m²	

Accessories for CMA 11	Part number
Desiccant Refill Pack • contains 10 sachets	**2643960**
CMB 1 Mounting Bracket To enable easy attachment of the mounting rod to a pole or a wall	**0369701**
Note: CMA 11 cannot be used with CVF 3 Ventilation Unit	

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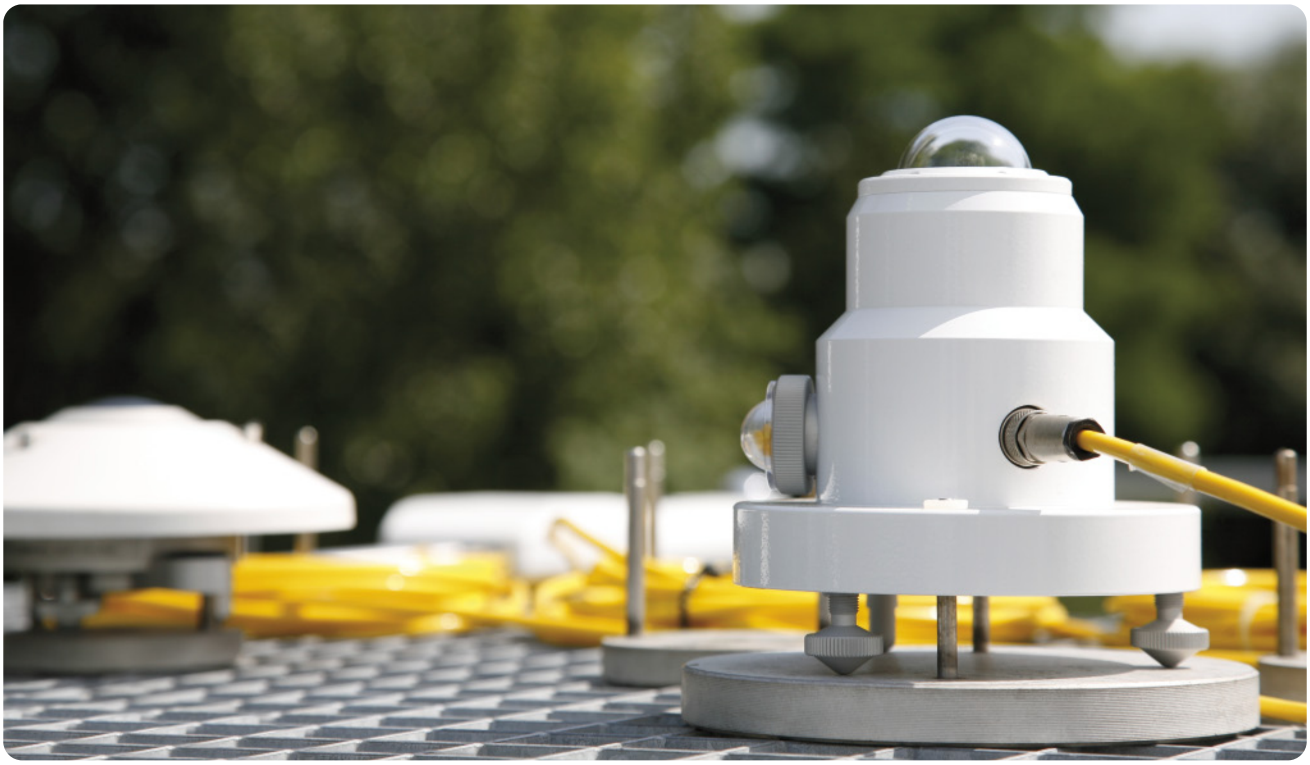

UV Radiometers

FOR SOLAR ULTRAVIOLET RADIATION MEASUREMENT

The Ultraviolet (UV) part of the solar spectrum has several beneficial effects for human biology, but too much can be very harmful. The UV region covers the wavelength ranges 100-280 nm (UVC), 280-315 nm (UVB) and 315-400 nm (UVA). Almost all UVC, and approximately 90% of UVB, from the sun is absorbed by the Earth's atmosphere. UVA radiation at the Earth's surface is normally 15-20 times greater than UVB.

UV radiation helps to produce Vitamin D, but it can also burn the skin and cause cancers, melanoma and cataracts. UV radiation measured with a similar response to the human skin is termed Erythemally Active UV irradiance (UVE) and must be used to calculate the Global Solar UV Index (UVI) for public health information. Our UVS range measures solar ultraviolet radiation with specific models for UVA, UVB and UVE. Dual-band models are available to measure two components in one convenient instrument. The unique Kipp & Zonen UVIATOR software for the UVS further improves the accuracy of the measurements by correcting for the amount of Ozone in the atmosphere and the solar elevation.

For many applications it is only necessary to monitor the 'total UV' irradiance, which represents the combined UVA and UVB components and for this we have the CUV 5. For the ultimate in UV measurements there is the Kipp & Zonen Brewer Mk III Spectrophotometer.

UVIATOR

People are very sensitive to small changes in the amount of UVB/UVE radiation and this depends upon altitude, the height of the sun in the sky, the amount of Ozone in the atmosphere and cloud cover. UVS radiometers are calibrated for a typical air-mass (solar zenith angle) and Ozone column concentration.

Kipp & Zonen UVIATOR is a Windows™ software programme that imports the calibration and data files for UVS radiometers. It works out the solar zenith angle from the date, time and location information and goes online to find the relevant Ozone Monitoring Instrument (OMI) satellite data. The corrected output file has the best accuracy available for a broadband UV radiometer.

CUV 5

CUV 5 shares features with the CMP range of pyranometers and can be used with the same accessories. It measures the total UV irradiance of the UVA and UVB components.

It is suitable for use in all environments. Adjustable feet and a bubble level are used to ensure that the radiometer is horizontal and a snap-on sun shield provides protection. The instrument is kept dry internally by an easily removable desiccant cartridge.

CUV 5 has a glass dome with very good UV transmission and a specially shaped diffuser to provide excellent directional response. The waterproof connector has gold-plated contacts and is fitted with 10 m of high quality signal cable as standard. The detection system includes optical filters and a photo-diode and CUV 5 does not require power to operate.

Specifications

Specifications	
Response time (95 %)	< 1 s
Non-linearity (0 to 200 W/m²)	< 1 %
Temperature dependence of sensitivity	- 0.1 %/°C
Sensitivity	300 to 500 μV/W/m²
Operating temperature range	-40 °C to +80 °C
Spectral range (overall)	280 to 400 nm
Spectral range (50 % points)	290 to 385 nm
Output range	0 to 200 W/m²
Maximum UVA/UVB irradiance	400 W/m²

Article	Part number
CUV 5 Broadband UV Radiometer • 10 m cable	**0364910-002**
Options for CUV 5	
CUV 5 Broadband UV Radiometer • 25 m cable	0364910-004
CUV 5 Broadband UV Radiometer • 50 m cable	0364910-005
CUV 5 Broadband UV Radiometer • plug only, no cable	0364910-008
CUV 5 Broadband UV Radiometer • METEON • 10 m cable	0364910-702
CUV 5 Broadband UV Radiometer • AMPBOX • 10 m cable	0364910-802
CUV 5 Broadband UV Radiometer • AMPBOX • 25 m cable	0364910-804
CUV 5 Broadband UV Radiometer • AMPBOX • 50 m cable	0364910-805
CUV 5 Broadband UV Radiometer • AMPBOX • plug only, no cable	0364910-808
100 m cable	On request
Note: AMPBOX is adjusted so that 4 - 20 mA output = 0 - 100 W/m² *For measurements in test chambers, 0 - 240 W/m² can be specified*	

Accessories for CUV 5	Part number
Desiccant Refill Pack • contains 10 sachets	**2643960**
CVF 3 Ventilation Unit Recommended to reduce frequency of dome cleaning	**See accessories**
CMF 1 Mounting Fixture For 1 or 2 unventilated radiometers (1 upper / 1 lower) Diameter 88 mm. Mounting rod 350 mm long x 16 mm Ø	**0362700**
CMF 2 Mounting Fixture For 1 or 2 ventilated or unventilated radiometers (1 upper / 1 lower) Diameter 220 mm. Mounting rod 350 mm long x 16 mm Ø	**0362701**
CMB 1 Mounting Bracket In combination with CMF mounting fixture for easy attachment to a pole or a wall	**0369701**
CM 121B Shadow Ring for unventilated radiometers Manually adjusted device provides diffuse sky irradiance measurement *Note: CM 121B can not be used with or CVF 3 ventilation unit*	**0346900**
CM 121C Shadow Ring for ventilated radiometers Manually adjusted device provides diffuse sky irradiance measurement Mounts the radiometer at the correct height when used with a or CVF 3	**0346901**

UVS-A-T

UVS instruments have a precision quartz dome and specially shaped diffuser to provide class-leading directional response. The detection system includes optical filters a very sensitive phosphor and a photo-diode. The system is temperature stabilised at +25 °C to prevent changes in spectral response and sensitivity with variations in the ambient conditions. The signal output is amplified and the internal stabilisation temperature can be monitored.

Power and signal connections are via a waterproof plug with high quality UV resistant cable and the instrument is kept dry internally by an easily removable desiccant cartridge. UVS radiometers are supplied with comprehensive calibration files and the unique Kipp & Zonen UVIATOR software. UVIATOR increases the accuracy of UV measurements by correcting error sources. When the calibration file for a particular UVS is imported, along with correctly formatted measurement data, UVIATOR automatically makes corrections for total column Ozone concentration (using online satellite data) and for air-mass.

UVS-A-T Radiometer

UVS-A-T has a spectral response optimised for precise measurements of atmospheric UVA irradiance.

Article	Part number
UVS-A-T UV Radiometer • 10 m cable	**0354920-002**
Options for UVS-A-T	
UVS-A-T UV Radiometer • 25 m cable	0354920-004
UVS-A-T UV Radiometer • plug only, no cable	0354920-008

Specifications	
Spectral range	315 to 400 nm
Typical sensitivity	30 $W/m^2/V$
Response time (95 %)	< 1.5 s
Non-stability (change/year)	< 5 %
Non-linearity (over full range)	< 1 %
Directional error (up to 70 ° solar zenith angle)	< 2.5 %
Temperature dependence	Temperature stabilized at +25 °C, ± 2 °C
Operating temperature	-40 °C to +50 °C
Internal temperature output	~2.5 V @ +25 °C
Output range	0 to 3 V
Power supply	7 to 18 VDC / 8 W
UVIATOR software	Included, corrects for solar zenith angle and Ozone

Accessories for UVS-A-T	Part number
Desiccant Refill Pack • contains 10 sachets	**2643960**
CVP 2 Power Supply 115 / 230V AC Power adaptor with 12 VDC output	**0349401**
Note: CVP 2 is not suitable for unprotected outdoor use	
CMF 2 Mounting Fixture For 1 or 2 UVS radiometers (1 upper / 1 lower) Diameter 220 mm. Mounting rod 350 mm long x 16 mm Ø	**0362701**
CMB 1 Mounting Bracket In combination with CMF mounting fixture for easy attachment to a pole or a wall	**0369701**

Software for UVS-A-T	Part number
UVIATOR software package on CD-ROM For older UVS radiometers	**0354120**
Note: UVIATOR is supplied included with all new UVS radiometers	

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UVS-B-T

UVS-B-T Radiometer

UVS-B-T has a spectral response optimised for precise measurements of atmospheric UVB irradiance.

Specifications

Spectral range	280 to 315 nm
Typical sensitivity	2 W/m²/V
Response time (95 %)	< 1.5 s
Non-stability (change/year)	< 5 %
Non-linearity (over full range)	< 1 %
Directional error (up to 70 ° solar zenith angle)	< 2.5 %
Temperature dependence	Temperature stabilized at +25 °C, ± 2 °C
Operating temperature	-40 °C to +50 °C
Internal temperature output	~2.5 V @ +25 °C
Output range	0 to 3 V
Power supply	7 to 18 VDC / 8 W
UVIATOR software	Included, corrects for solar zenith angle and Ozone

Article	Part number
UVS-B-T UV Radiometer • 10 m cable	**0354925-002**
Options for UVS-B-T	
UVS-B-T UV Radiometer • 25 m cable	0354925-004
UVS-B-T UV Radiometer • plug only, no cable	0354925-008

Accessories for UVS-B-T	Part number
Desiccant Refill Pack • contains 10 sachets	**2643960**
CVP 2 Power Supply 115 / 230V AC Power adaptor with 12 VDC output	**0349401**
Note: CVP 2 is not suitable for unprotected outdoor use	
CMF 2 Mounting Fixture For 1 or 2 UVS radiometers (1 upper / 1 lower) Diameter 220 mm. Mounting rod 350 mm long x 16 mm Ø	**0362701**
CMB 1 Mounting Bracket In combination with CMF mounting fixture for easy attachment to a pole or a wall	**0369701**

Software for UVS-B-T	Part number
UVIATOR software package on CD-ROM For older UVS radiometers	**0354120**
Note: UVIATOR is supplied included with all new UVS radiometers	

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UVS-E-T

UVS-E-T Radiometer

UVS-E-T has a spectral response function close to the Erythemal (sunburn) action spectrum of the human skin (ISO: 17166:1999 / CIE S 007/E-1998). UVE includes some UVA radiation and a response into the UVC band. For this reason a UVB radiometer should not be used to measure UVE and to calculate the Global Solar UV Index.

Specifications	
Spectral range	ISO 17166:1999 CIE S007/E-1998
Typical sensitivity	0.2 W/m²/V
Response time (95 %)	< 1.5 s
Non-stability (change/year)	< 5 %
Non-linearity (over full range)	< 1 %
Directional error (up to 70 ° solar zenith angle)	< 2.5 %
Temperature dependence	Temperature stabilized at +25 °C, ± 2 °C
Operating temperature (full accuracy)	-40 °C to +50 °C
Internal temperature output	~2.5 V @ +25 °C
Output range	0 to 3 V
Power supply	7 to 18 VDC / 8 W
UVIATOR software	Included, corrects for solar zenith angle and Ozone

Article	Part number
UVS-E-T UV Radiometer • 10 m cable	**0354930-002**
Options for UVS-E-T	
UVS-E-T UV Radiometer • 25 m cable	0354930-004
UVS-E-T UV Radiometer • plug only, no cable	0354930-008

Accessories for UVS-E-T	Part number
Desiccant Refill Pack • contains 10 sachets	**2643960**
CVP 2 Power Supply 115 / 230V AC Power adaptor with 12 VDC output	**0349401**
Note: CVP 2 is not suitable for unprotected outdoor use	
CMF 2 Mounting Fixture For 1 or 2 UVS radiometers (1 upper / 1 lower) Diameter 220 mm. Mounting rod 350 mm long x 16 mm Ø	**0362701**
CMB 1 Mounting Bracket In combination with CMF mounting fixture for easy attachment to a pole or a wall	**0369701**

Software for UVS-E-T	Part number
UVIATOR software package on CD-ROM For older UVS radiometers	**0354120**
Note: UVIATOR is supplied included with all new UVS radiometers	

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UVS-AB-T / UVS-AE-T

UVS-AB-T and UVS-AE-T Dual-Band Radiometers

These dual-band models are very cost-effective by combining two independent measurements in a single instrument. The performance of each band is the same as for the single-band radiometers.

Specifications

Specifications for each band are the same as for the single-band UVS-A-T, -B-T and -E-T models

Article	Part number
UVS-AB-T UV Dual-Band Radiometer • 10 m cable	**0354940-002**
Options for UVS-AB-T	
UVS-AB-T UV Dual-Band Radiometer • 25 m cable	0354940-004
UVS-AB-T UV Dual-Band Radiometer • plug only, no cable	0354940-008

Article	Part number
UVS-AE-T UV Dual-Band Radiometer • 10 m cable	**0354945-002**
Options for UVS-AE-T	
UVS-AE-T UV Dual-Band Radiometer • 25 m cable	0354945-004
UVS-AE-T UV Dual-Band Radiometer • plug only, no cable	0354945-008

Accessories for UVS-AB-T and UVS-AE-T	Part number
Desiccant Refill Pack • contains 10 sachets	**2643960**
CVP 2 Power Supply 115 / 230V AC Power adaptor with 12 VDC output	**0349401**
Note: CVP 2 is not suitable for unprotected outdoor use	
CMF 2 Mounting Fixture For 1 or 2 UVS radiometers (1 upper / 1 lower) Diameter 220 mm. Mounting rod 350 mm long x 16 mm Ø	**0362701**
CMB 1 Mounting Bracket In combination with CMF mounting fixture for easy attachment to a pole or a wall	**0369701**

Software for UVS-AB-T and UVS-AE-T	Part number
UVIATOR software package on CD-ROM For older UVS radiometers	**0354120**
Note: UVIATOR is supplied included with all new UVS radiometers	

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Net Radiometers

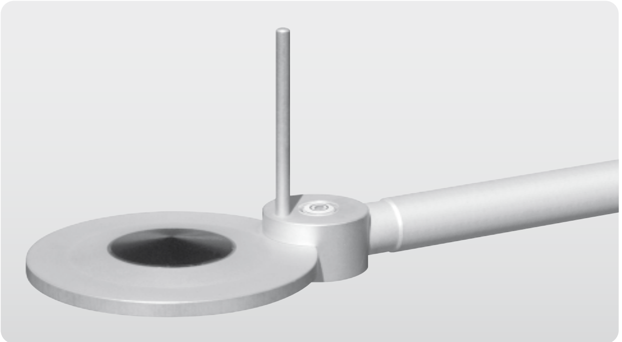
FOR THE MEASUREMENT OF THE BALANCE OF INCOMING AND OUTGOING RADIATION

The combination of short-wave radiation from the sun and long-wave (infrared) radiation from the atmosphere and ground are the driving forces for many of the dynamic atmospheric processes at the Earth's surface. In the short term they directly influence weather systems and in the long term they are key parameters driving the climate systems around the world.

Commonly four separate components are monitored; incoming and reflected short-wave solar radiation, plus down-welling and up-welling long-wave radiation. The sum of the incoming and outgoing components is called the net radiation balance (sometimes termed the 'radiation budget'). This balance is used as a parameter in meteorological, climatological and hydrological research.

Kipp & Zonen offers a complete range of robust, lightweight, net radiometers that do not require power to operate. Thanks to this, using our net radiometer will save time spent on maintenance and accurate data.

NR Lite2



NR Lite2 is a single-component net radiometer widely used in agriculture and hydrology. The thermopile detector is fitted with black PTFE coated conical absorbers on both sides that have a very wide spectral response from the Ultraviolet (UV) to the far infrared (FIR). The signal output is the difference between the sun and sky radiation and the ground radiation and can be positive or negative, depending upon the conditions.

There is an integral mounting rod for fitting to masts and poles, a bubble level, 15 m long signal cable, and a stick to prevent birds settling on the instrument. The single output provides a direct measurement of the total net radiation balance.

In case separate measurement for the short-wave and long-wave components and the upwards and downwards components are required, please use our two-component or four-component net radiometers.

Specifications

Number of signal outputs	1 - net total radiation
Response time (63 %)	< 20 s
Directional error (up to 60 ° solar zenith angle)	< 3 %
Temperature dependence of sensitivity	- 0.1 % / °C (typical)
Sensitivity (nominal)	10 μV/W/m²
Operating temperature	-30 °C to +70 °C
Spectral range	200 nm to 100 μm
Irradiance (net)	-2000 to +2000 W/m²
Sensor asymmetry (upper / lower)	< 15 %
Field of view	180 °
Mounting rod (fixed)	800 mm long x 20 mm Ø

Article	Part number
NR Lite2 Net Radiometer • single-component • 15 m cable	**0344920-003**
Options for NR Lite2	
NR Lite2 Net Radiometer • METEON • 15 m cable	0344920-703
NR Lite2 Net Radiometer • AMPBOX • 15 m cable	0344920-803
Note: NR Lite2 will not fit in the METEON carrying case	
Note: AMPBOX is adjusted so that 4 mA output = -400 W/m², 8 mA = 0 W/m² and 20 mA = +1200 W/m²	

Accessories for NR Lite2	Part number
CMB 1 Mounting Bracket To enable easy attachment of the mounting rod to a pole or a wall	**0369701**

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CNR 4

CNR 4 is a four-component net radiometer for accurate and reliable measurements and can be used as the reference instrument for a network of lower performance net radiometers.

There are four separate signal outputs and the integrated temperature sensors can be used to calculate the FIR radiation. The screw-in mounting rod, bubble level, and cables with waterproof connectors, make installation easy and minimize installation time. CNR 4 combines two pyranometers for solar radiation with two pyrgeometers for infrared measurements, all integrated into the instrument body.

The upper pyrgeometer has a silicon meniscus dome so that water rolls off and the field of view is 180 °. A heated ventilation unit, the CNF 4, is available to minimize offsets, maximize stability, remove precipitation and clear hoar frost.

Specifications

Number of signal outputs	4 - incoming and reflected short-wave radiation downward and upward long-wave radiation
Pyrgeometer temperature sensors	10 K thermistor and Pt-100
Response time (95 %)	< 18 s
Non-linearity (over full range)	< 1 %
Temperature dependence of sensitivity	< 5 % from -10 °C to +40 °C
Sensitivity	7 to 20 μV/W/m² short-wave 5 to 15 μV/W/m² long-wave
Operating temperature	-40 °C to +80 °C
Spectral range (50 % points)	300 to 2800 nm short-wave 4.5 to 42 μm long-wave
Field of view	180 ° short-wave 150 ° long-wave lower 180 ° long-wave upper
Mounting rod (screw-in)	350 mm long x 16 mm Ø

Article	Part number
CNR 4 Net Radiometer • four-component • 10 m cable	**0369900-032**
Options for CNR 4	
CNR 4 Net Radiometer • 25 m cable	0369900-034
CNR 4 Net Radiometer • 50 m cable	0369900-035
CNR 4 Net Radiometer • plug only, no cable	0369900-038
100 m cable	On request

Accessories for CNR 4	Part number
Drying Cartridge (minimum order 5 cartridges)	**4250024**
CNF 4 Ventilation Unit	**0369700**
CMB 1 Mounting Bracket To enable easy attachment of the mounting rod to a pole or a wall	**0369701**

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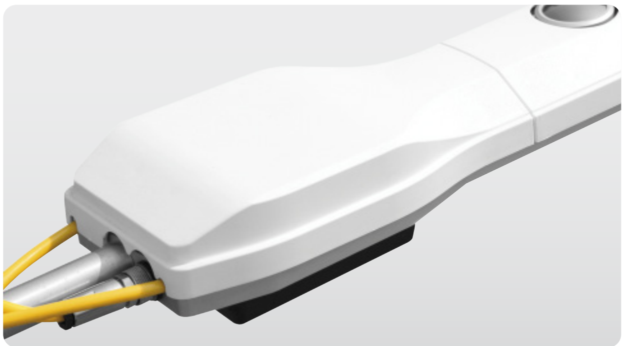
CNF 4



CNF 4 is the ventilation and heating unit for the Kipp & Zonen CNR 4 net radiometer. The CNF 4 minimizes the effects of precipitation, condensation and frost on the accuracy of your radiometers measurement data. It improves the CNR 4 accuracy and reliability even further as well as minimizing the need for cleaning and maintenance.

CNF 4 provides a clean air flow over all four of the CNR 4 radiometer domes and windows and is designed to operate under all weather conditions. The only part that needs maintenance is the air inlet filter, which should be checked at regular intervals and cleaned or replaced when necessary.

The integrated 10 W heating can be switched on by the operator when required. This raises the temperature of the domes and windows slightly above ambient to prevent the formation of dew and frost and to disperse precipitation. The ventilation fan and heater run from 12 VDC and can be operated by the accessory CVP 2 universal AC-DC power adaptor.

CNF 4 can be integrated at production. But it can also be bought as an accessory kit for retro-fitting to a CNR 4 that was purchased without it.

Specifications

Ventilator fan power	5 W continuously
Heater power	10 W
Operating temperature	-40 °C to +70 °C
Cable voltage drop	0.07 V/m (with heater)
Power required	12 Volt DC, 1.3 A (with heater)

Article	Part number
CNF 4 Ventilation Unit • 10 m cable	**0369700-002**
Options for CNF 4	
CNF 4 Ventilation Unit • 25 m cable	0369700-004
CNF 4 Ventilation Unit • 50 m cable	0369700-005
CNF 4 Ventilation Unit • plug only, no cable	0369700-008
Note: The cable for the CNF 4 ventilation unit is limited to 50 m because of voltage drop	

Article	Part number
CNR 4 Net Radiometer + CNF 4 Ventilation Unit • 10 m cable	**0369900-132**
Options for CNR 4 Net Radiometer + CNF 4 Ventilation Unit	
CNR 4 Net Radiometer + CNF 4 Ventilation Unit • 25 m cable	0369900-134
CNR 4 Net Radiometer + CNF 4 Ventilation Unit • 50 m cable	0369900-135
CNR 4 Net Radiometer + CNF 4 Ventilation Unit • plug only, no cable	0369900-138

Accessories for CNF 4	Part number
Spare Filters pack of 5 fan inlet filters	**2682047**
CVP 2 Power Supply 115 / 230V AC Power adaptor with 12 VDC output	**0349401**
Note: CVP 2 is not suitable for unprotected outdoor use	

KIPP & ZONEN SINCE 1830

Horticultural Sensors

FOR THE MEASUREMENT OF PHOTOSYNTHETICALLY ACTIVE RADIATION

Exposure to light is essential for the growth of a plant. Under the influence of light from the sun, or from artificial sources, plants convert carbon dioxide and water into glucose and oxygen. This process is called Photosynthesis and occurs mainly under the influence of light in a number of discrete wavebands within the range between 400 nm (blue) and 700 nm (red). Light within this spectral region is referred to as Photosynthetically Active Radiation (PAR).

To monitor and optimize the development of plants, accurate determination of the amount of PAR radiation received is essential. In addition to high quality PAR radiation measurement durability is an important factor.

Especially in greenhouses conditions can be very harsh due to high temperature and humidity, artificial lighting, and possibly spraying with pesticides. For sensors to operate reliably they must be designed to resist the influences of these conditions.

Kipp & Zonen offers the PQS 1 sensor that is sensitive to light in the PAR region with an excellent price-performance ratio and superior durability for virtually any environment. PQS 1 is the ideal choice for greenhouse automation applications as well as for use outdoors in crop research and monitoring.

PQS 1

PQS 1 Photosynthetically Active Radiation (PAR) from the sun or artificial light sources produces chlorophyll and promotes growth in plants, and is a key input for agriculture, horticulture and greenhouse automation. PQS 1 features a much improved responsivity, providing an excellent match with the ideal PAR spectrum. This significantly increases the measurement accuracy over its predecessor the PAR Lite and rivals the best comparable instruments.

The PQS 1 PAR Quantum Sensor is designed to provide accurate, continuous measurement of PAR outdoors or indoors. The rugged construction makes it well protected from harsh weather conditions around the world and from exposure to pesticides.

No power is required; the detector generates a small voltage output proportional to the PAR received. Two PQS 1 instruments can easily be bolted back-to-back to make a simple net PAR sensor. The standard cable length is 5m with an option of 15 m.

Specifications

Spectral range	(400 to 700) ± 4 nm
Sensitivity	4 to 10 μV/μmol/m²·s
Response time	< 1 μs
Non-linearity	< 1 %
Temperature dependence	< -0.1 %/ °C
Sensitivity change per year	< 2 %
Directional error (up to 80 °)	< 3 %
Impedance	240 Ω
Field of view	180 °
Operating temperature	-30 °C to +70 °C

Article	Part number
PQS 1 PAR Quantum Sensor • 5 m cable	**0373900-001**
Options for PQS 1	
PQS 1 PAR Quantum Sensor • 15 m cable	**0373900-003**
PQS 1 PAR Quantum Sensor • METEON • 5 m cable	**0373900-701**
PQS 1 PAR Quantum Sensor • AMPBOX • 5 m cable	**0373900-801**
PQS 1 PAR Quantum Sensor • AMPBOX • 15 m cable	**0373900-803**

Note: AMPBOX is adjusted so that 4-20 mA output = 0-3200 μmol/s.m²

Accessories for PQS 1	Part number
Mounting Rod Screw-in 300 mm long x 12 mm Ø	**0338720**
CMB 1 Mounting Bracket In combination with mounting rod for easy attachment to a pole or a wall	**0369701**

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Sunshine Duration Sensors

FOR THE MEASUREMENT OF HOURS OF SUNSHINE

For weather reports (rather than weather forecasts) it is often interesting to know the actual duration of sunshine in a period of time. The World Meteorological Organisation (WMO) defines 'sunny' as when the direct solar irradiance exceeds the level of 120 W/m² and sunshine duration as the number of sunny hours per day.

This information is useful for holiday resort daily reports, tourism marketing, health spas and clinics. In agronomy the amount of sunshine received by crops can be used to help forecast yields.

Traditionally, sunshine duration is monitored using a Campbell-Stokes recorder, where a glass sphere focuses the sun onto a marked card and burns it when it is sunny. However, the burn marks vary depending upon the paper of the card, dampness of the card (high humidity or after rain), and the card must be changed every day. The marks must be analysed manually, and the results are highly subjective.

Meteorological agencies want to automate this process and to reduce the variability of results. A very accurate solution is to use a sun tracker and a pyrheliometer, but this is relatively expensive. Therefore, Kipp & Zonen developed the CSD 3 Sunshine Duration Sensor. It is designed for continuous outdoor use and is easy to install and maintain. It is used by major national weather networks across Europe, and elsewhere.

CSD 3

CSD 3 measures sunshine duration through a high quality glass tube. It has no moving parts and uses 3 photo-diodes with specially designed diffusers to make an analogue calculation of when it is sunny. The output is switched high or low to indicate sunny or not sunny conditions. The calculated direct irradiance value is also available.

The waterproof plug-and-socket cable connection enables easy installation and servicing. The standard cable is 15 m long, 25 m is an option. The large drying cartridge with screw-on cap gives extended change intervals, and a humidity indicator shows clearly when this is necessary.

CSD 3 operates from 12 VDC power and has two levels of built-in heating to dissipate rain, snow and frost. These are normally switched externally, but an optional internal thermostat control is available. A robust mounting arm is fitted to the base of the instrument.

Article	Part number
CSD 3 Sunshine Duration Sensor • 15 m cable	**0342901-003**
Options for CSD 3	
CSD 3 Sunshine Duration Sensor • 25 m cable	0342901-004
CSD 3 Sunshine Duration Sensor • plug only, no cable	0342901-008
CSD 3 Sunshine Duration Sensor • thermostat • 15 m cable	0342901-033
CSD 3 Sunshine Duration Sensor • thermostat • 25 m cable	0342901-034
CSD 3 Sunshine Duration Sensor • thermostat • plug only, no cable	0342901-038
Note: Cable length is limited to 25 m because of voltage drop on the heater power supply wires	
Note: Optional internal thermostat switches on the 10 W heater at housing temperature < 6 °C ± 3 °C and off at temperature > 14 °C ± 3 °C	

Specifications

Spectral range	400 to 1100 nm
Operating temperature range	-40 °C to +70 °C
Sunshine signal (direct radiation > 120 W/m²)	1 ±0.1
Response time	< 1 ms
Accuracy (monthly sunshine hours)	> 90%
Accuracy (direct signal for clear sky)	> 90%
Temperature dependence	< 0.1 %/°C
Analogue output signal	1 mV/W/m²
Non-stability	< 2 % change per year
Heaters	1 W and 10 W
Power supply	12 VDC

Accessories for CSD 3	Part number
Drying Cartridge (minimum order 5 cartridges)	**4250024**
CMB 1 Mounting Bracket For easy attachment to a pole or a wall	**0369701**

Laboratory Thermopile

FOR THE MEASUREMENT OF RADIANT FLUXES IN LABORATORY ENVIRONMENTS

There are many cases in laboratory environments, both in education and research where it is necessary to measure radiant fluxes with high accuracy. Typically this is an optical laboratory or a physics department where the equipment is mounted onto optical benches or tables.

For this application a thermopile is the ideal type of detector because of its wide spectral response and good linearity. Because the laboratory environment is stable and clean, it does not need temperature correction or weather protection and can be used without a window for the widest measurement range.

The radiometer should have a restricted field of view so that it only sees the radiation required to be measured and not the other sources of radiation in the environment around it. The thermopile detector generates a small voltage proportional to the radiation received.

The Kipp & Zonen model CA 2 radiometer is widely used in optical and physics laboratories around the world and is supplied with a mounting rod suitable for use with standard optical bench mountings. The signal voltage is usually displayed using a high accuracy digital voltmeter and can be converted into irradiance values in W/m^2, using the sensitivity supplied on the calibration certificate.

CA 2

CA 2 is based on the same type of thermopile detector as our CMP 3 and CMP 6 pyranometers. Because it has a limited field of view it can be used to measure the amount of radiant fluxes coming from a specific location or a specific source.

CA 2 is sensitive to radiation from 0.2 to 50 µm, and has a field of view of 20 ° for 90 % of the received radiation. This is determined by cylindrical brass housing that contains a conical reflector. The removable glass window reduces convection effects and radiation losses but restricts the spectral range to 0.3 to 3 µm.

The thermopile is ideal for control (ovens), demonstration purposes in schools and technical institutes or to be used for reference measurements. The mounting rod allows easy fixing to standard optical bench mountings. The terminals allow simple connection of bare wires or banana plugs.

Article	Part number
CA 2 Laboratory Thermopile	**1311907**

Specifications

Spectral range	
- Without window	0.2 to 50 µm
- With window	0.3 to 3 µm
Sensitivity (Parallel beam on front window)	7 to 20 µV/W/m²
Response time (95%)	18 s
Field of view	20 ° (90%)
Non-linearity	< 3 %
Impedance	20 - 200 Ω
Maximum irradiance	2000 W/m²
Mounting rod	170 mm long x 10 mm Ø

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Data Loggers

TO RECORD AND DISPLAY DATA FROM INSTRUMENTS

Finding the right data acquisition system for your valuable measurement data can be very time consuming. The system needs to be able to accurately read the output signals from our instruments, apply calibration factors, convert measurements to 'engineering units' store the results and offer protection from varying environmental conditions.

Kipp & Zonen has made this task easy for you by offering a wide range of data acquisition solutions. They are designed to work with our instruments and offer the functionality you need for virtually any type of installation.

Kipp & Zonen data loggers and display units have very sensitive inputs with high resolution and use the instrument calibration factor (sensitivity) to convert the input voltage into radiation values in W/m², or other units appropriate to the type of radiometer. They all have software for configuring the logging functions and for download and storage of the data on a Windows™ computer. The data files are in ASCII and can be easily exported to spreadsheets.

METEON is a single-channel hand-held data logger with built in display. It is supplied in a rugged carry case with all accessories and space for a pyranometer, making it ideal for use as field test equipment.

LOGBOX SD is a rugged multi-channel, weatherproof data logger for outdoor use that can also handle temperature sensors and other signal types. It can run for several months on its internal batteries.

COMBILOG is very flexible multi-channel data logger system for applications requiring high accuracy data collection. The data logger system comes in a weatherproof stainless steel enclosure with many options for communication, data processing and backup power.

METEON

METEON is an accurate hand-held display unit and data logger for the measurement of solar irradiance. Its small size, long battery life and universal input make it an ideal tool for many test and field applications.

METEON is delivered in a tough carrying case together with:
- USB interface cable
- Software and manual on CD-ROM
- 2 x AA alkaline batteries

The carrying case also has space for a pyranometer.

METEON can be used with all our single output pyranometers plus the CHP 1, CUV 5, NR Lite2, PQS 1 and CA 2. It is primarily intended to display real-time radiation values in Watt per square meter or PAR in micro-mol per square meter per second.

Configuration with a computer is simple, using the supplied software and USB interface cable. Just select the radiometer type from a list, enter its sensitivity, and the correct measuring range is automatically selected. Once METEON is configured, connect the radiometer, switch on, and the large 4-digit display directly shows the correct values. This makes it a perfect tool for convenient use in the field.

The great advantage of the METEON is the integrated data logging function that can store data for up to 3500 samples. It stores minimum, maximum and average values per logging interval. The low power consumption allows the METEON to record at least 50 days of data on 2x AA type batteries.

Article	Part number
METEON Irradiance Meter and Data Logger	**0365910**
Options for METEON	
METEON Adjusted • configured to suit an existing radiometer	**0365911**
Note: Specify type and serial number of radiometer for use with METEON	

Specifications

Analogue inputs	1
AD conversion resolution	16 bits
Temperature coefficient	< 0.5 % over range
Accuracy	< 0.1 %
Input ranges	± 6.25 to ± 200 mV
Operating temperature range	-10 °C to +40 °C
Display	4 digits with polarity
Power requirements	2 x AA battery included
Communication interface	USB 1.1/2.0 cable included
Data logger memory	3518 samples
Logging interval	2 to 65535 seconds
Logged information	min., max., average
Software, Windows™	Configuraton, data download, graphical display

Accessories for METEON	Part number
METEON Irradiance Measurement Kits METEON is also available ready to go as a kit supplied with a radiometer and is pre-programmed to show the measured radiation value when the instrument is connected and the METEON switched on	
METEON + SP Lite2 Silicon Pyranometer • 5 m cable	**0339920-701**
METEON + CMP 3 Pyranometer • 10 m cable	**0338920-702**
METEON + CMP 6 Pyranometer • 10 m cable	**0362900-702**
METEON + CMP 11 Pyranometer • 10 m cable	**0362910-702**
METEON + CMP 21 Pyranometer • 10 m cable	**0362920-712**
METEON + CMP 22 Pyranometer • 10 m cable	**0362930-712**
METEON + CM 4 High Temperature Pyranometer • 10 m cable	**0356900-722**
METEON + CUV 5 Broadband UV Radiometer • 10 m cable	**0364910-702**
METEON + PQS 1 PAR Quantum Sensor • 5 m cable	**0373900-701**
METEON + NR Lite2 Net Radiometer • 15 m cable	**0344920-703**
Note: NR Lite2 will not fit in the METEON carrying case	

SOLRAD

SOLRAD radiation indicator is a hand-held read-out/integrator for the majority of Kipp & Zonen radiometers. The calibration factor of the sensor is entered and the radiation indicator displays in real-time the measured value in the correct units for the type of sensor that is used. It can accept a single analogue voltage input up to 10 V.

SOLRAD can also integrate the measured values over a time period. Both manual reset and automatic reset of the integrator can be selected. The automatic reset occurs at midnight (according to the internal clock). Up to 31 integrated values can be stored in the internal memory. This allows for a month of daily values. It can operate for over 24 hours using the internal PP3 battery; an AC power adapter is included.

The measured values and the integration totals can be transmitted to a personal computer through the SOLRAD's RS 232 serial port. The supplied software enables you to display real-time values; log measured and integrated values to disk, and graphically displays data. The data that is stored on the computer disk can be processed with popular spreadsheets such as Excel.

Article	Part number
SOLRAD Irradiance Meter and Integrator	**3303008**
Note: SOLRAD is not a data logger, it only records integrated values	

Specifications

Analogue inputs	1
AD conversion resolution	Resolution 1:10.000 bits Temperature coefficient <0.01 %/°C Conversion rate: > 10 samples per second
Accuracy	< 0.1 %
Input ranges	1 mV to 10 V
Operating temperature range	-10 °C to +40 °C
Display	2 x 16 characters
Power requirements	9 Volt PP3 battery (included) Mains adapter (included)
Communication interface	RS 232, cable included
Functions	Real-time or integrated value read-out Integrator reset-method: manual or automatic Internal clock Internal storage of last 31-measured integration values
Integrator	Update of integrated value every two seconds
Battery life-time	25 hours at least
Software, Windows™	Data download, real-time display, graphical display

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LOGBOX SD

LOGBOX SD is an 8 channel data logger that allows connection to multiple instruments at the same time. Each input can convert measured values into the correct engineering units. The data is stored on the internal 128 kB memory or the 512 MB SD memory card that is included as standard.

The 24 bits, high resolution, differential analogue inputs can be easily configured for all our instruments, including the Pt-100 and 10K thermistor temperature sensors fitted to many of our models. Four digital inputs are available for measuring time or frequency, or as counter inputs.

LOGBOX SD has an IP 65 weatherproof enclosure and wide operating temperature range from -40 °C to +60 °C. The state of the art design consumes so little power that it will run for months on the four internal AA type batteries. The wide power supply operating range makes it possible to use solar panels or other external DC power sources.

The included user-friendly computer software makes configuration and data download fast and simple, using RS 232 serial communication. All Kipp & Zonen radiometer settings are pre-defined and can be selected from a pull-down list. LOGBOX SD is supplied with a mounting bracket for easy fixing to masts up to 50 mm diameter.

Article	Part number
LOGBOX SD Data Logger	**3303090**

Specifications

Analogue inputs	8 single-ended, or 3 differential + 2 single-ended, or combinations
Accuracy	0.05 % for 24 bits resolution
Input ranges	± 20 mV to ± 2.5 V (24 bits) 0 to 3 V (12 bits)
Digital inputs	4, maximum input 15 Volt
Operating temperature range	-40 °C to +60 °C
Power supply	4 x AA type bateries (included) or 4 to 20 V DC/7 mA
Power consumption	1.7 mA typical during measurement
Communication interface	RS 232 RS 232 cable included
Internal memory	128 kB
Memory card	SD, 512 MB (included)
Environmental protection	IP 65
Software, Windows™	Configuration and data download
Mounting bracket	Included, for masts up to 50 mm Ø

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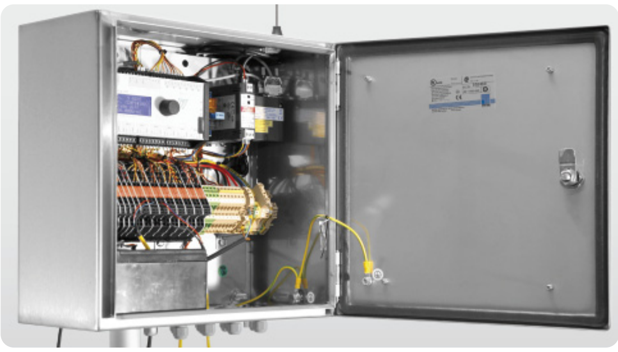
COMBILOG



COMBILOG data logger systems are recommended for higher quality solar radiation monitoring stations, in particular those complying with the requirements of the Baseline Surface Radiation Network (BSRN).

COMBILOG is compatible with the full range of Kipp & Zonen solar radiometers and industry standard meteorological instruments for wind, temperature, pressure, rainfall, etc. For ease of use, it comes with configuration examples for our instruments.

The COMBILOG offers 16 bit resolution, excellent linearity, and temperature compensation to ensure optimal data collection accuracy. The COMBILOG is very flexible. Up to 8 analog and 6 digital channels are available to connect all Kipp & Zonen instruments and many other sensors.

Kipp & Zonen has selected a range of complete configurations for the COMBILOG data logger to meet specific operational requirements. Whether you require a data logger in a compact enclosure to protect the system from harsh weather conditions, or a complete solution for autonomous operation, our data acquisition systems offer the appropriate solution. Each configuration has been designed with easy setup and installation in mind and is optimized for Kipp & Zonen solar instrumentation.

Specifications	
Analogue inputs	8 with 16 bits resolution, single-ended, differential, voltage, current or resistance; 2, 3 or 4-wire temperature sensors
Input ranges	Voltage from ± 6.25 mV to ± 10 V, full-scale
Resolution	From 0.003 % to 0.03% (depending on the range)
Digital inputs	6 I/O ports
Virtual inputs	Additional internal arithmetic channels
Supply voltage DC	10 to 30 V
Power consumption	265 mW Typical @12V
Internal memory size	7 MB for data
Memory card type	SD memory card (purchase locally)
Communication interfaces	USB, Ethernet, RS 232 or RS 485 serial
Environmental protection	IP 65 stainless steel enclosure
Software, Windows™	Configuration, data download, real-time monitoring
Mounting bracket	Included, for masts up to 60 mm Ø

Article	Part number
COMBILOG data logger with communication cable Data logger including weatherproof enclosure comes as standard with: • Over voltage protection modules for signals and power inputs • Mast mounting clamps (60 mm) • Lockable • Cable glands	**0372900-000**
Options for COMBILOG	
COMBILOG in small IP65 enclosure (38 x 38 cm)	0372900-100
COMBILOG in small IP65 enclosure • 12V Power Supply	0372900-101
COMBILOG in small IP65 enclosure 12 V Power Supply • Backup Battery	0372900-102
COMBILOG in small IP65 enclosure Solar Controller • Backup Battery	0372900-103
COMBILOG in small IP65 enclosure Solar Controller • Backup Battery • 10 W Solar Panel	0372900-104
The above options but with 2 data loggers in a large enclosure (50 x 50 cm) add a two as the first digit	0372900-2xx
Remote communication options for COMBILOG	
The above options including GSM modem add a one as the second digit	0372900-x1x

Accessories for COMBILOG	Part number
RS 232 / RS 485 Converter Kit Isolated connection of the COMBILOG RS 485 communication to a PC. Including RS 232 to RS 485 converter, 230 VAC power adaptor, 9-pin RS 232 cable for PC serial port, 9-pin to 25-pin adapter for the converter.	**0361700**
COMGRAPH Software Enables scheduled downloads of COMBILOG data, directly or by modem. Provides graphical display and evaluation of stored data.	**3303055**

Note: The Converter Kit is not suitable for unprotected outdoor use

KIPP & ZONEN SINCE 1830

Solar Accessories

SPECIALLY DESIGNED FOR OUR SOLAR INSTRUMENTS

To help with the installation and use of our solar radiometers we produce a wide range of accessories.

SMP Starter Sets
The SMP3 Starter Set includes a SMP3 smart pyranometer and everything you need to connect it to a computer in a convenient carrying case. The SMP Software provides numerical and graphical display and logging of measurement data. The Starter Set is also available without a pyranometer.

Ventilation Units
Ventilation of radiometers improves the stability and quality of measurements and decreases the frequency of cleaning the domes. Our ventilation units also include heaters that can be externally switched on to clear frost and snow.

Power Supplies
Some of our instruments and accessories operate from 12 VDC power and for these we have power supply units available.

Amplifier
For customers who require an industry standard output, or to use long cables, we have the AMPBOX signal amplifier which converts the low level instrument output to a 4-20 mA current loop signal.

Mountings
Several of our instruments are supplied with a mounting rod and others have a rod available as an accessory. For instruments without these features we have mounting fixtures available which incorporate a rod and a plate to mount a radiometer on one side only, or on both sides (facing upwards and downwards). We also have a bracket available to enable easy attachment of a mounting rod to a pole or a wall and a kit to mount pyranometers at an adjustable angle.

Shadow Rings
To make measurements of diffuse solar radiation a pyranometer has its dome shaded from the direct solar irradiance. Typically this is done using an automatic sun tracker fitted with a shading assembly. An alternative that does not need any power is to use a shadow ring, although this requires regular manual adjustment to keep the dome correctly shaded.

Glare Screen
For some types of radiometers, when used facing downwards, it is advisable to fit a glare screen to prevent the instrument seeing radiation from close to the horizon.

SMP Starter Set

SMP Starter Set contains everything you need to connect a smart pyranometer to your computer and start exploring it. The SMP software provides numerical and graphical display and logging of measurement data. MODBUS® addresses of the connected SMP(s) can be changed. It is possible to connect and display up to 10 SMP pyranometers in parallel.

The set includes a CVP 2 universal AC power supply with 12 VDC output and an isolated USB to RS-485 convertor. The CVP 2 and RS-485 convertor are pre-wired and come with a clear wiring diagram. The SMP Starter Set is packed in a convenient carrying case and contains the following items:

- RS-485/USB isolated interface
- CD with USB driver and installation instructions
- USB cable
- CVP 2 universal 12 VDC power supply
- Connection strip SMP/CVP/Interface
- Connection diagram
- Carrying case

SMP3 Starter Set also includes a SMP3-V smart pyranometer with 10 m cable and the standard SMP3 accessories and documentation.

Article	Part number
SMP3 Starter Set • including a SMP3-V • 10 m cable	**0374901**
SMP Starter Set • no SMP pyranometer included	**0374902**

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CVF 3 Ventilation Unit

CVF 3 Ventilation Unit is designed to be used with the Kipp & Zonen CMP, SMP, CGR and CUV series of instruments (except the CMP 3, SMP3 and CGR 3). It stabilises the temperature of the radiometer near to that of the ambient air and suppresses the thermal offsets which are produced by cooling down of the domes under calm clear sky conditions or by dome heating due to the absorption of solar radiation.

CVF 3 is designed to operate under all weather conditions and the only part that needs maintenance is the air inlet filter, which should be checked at regular intervals and cleaned or replaced when necessary. A pulse output allows the fan speed to be monitored and there is a waterproof connector for the cable.

Two levels of integrated heating are built-in that can be switched on by the operator when required. 5 Watt heating is used under normal conditions to raise the temperature of the dome slightly above ambient to prevent the formation of dew and frost. 10 Watt heating for more extreme climates melts snow and ice. The ventilation fan and heaters run from 12 VDC.

The accessory CVP 2 universal AC-DC power adaptor can operate up to two CVF 3 ventilation units with the heaters on.

Specifications

Ventilator fan power	5 W continuously
Heater power (selectable)	5 W and 10 W
Operating temperature	-40 °C to +70 °C
Air temperature rise caused by CVF 3	< 0.25 K with ventilator fan only < 0.5 K with 5 W heater < 1 K with 10 W heater
Offset caused by 10 W heater	< 1 W/m² for CMP 11 Pyranometer
Tacho output	5 V, 2 pulses per revolution
Cable voltage drop	0.07 V/m (with 10 W heater)
Power required	12 VDC, 1.3 A (with 10 W heater)

Article	Part number
CVF 3 Ventilation Unit • 10 m cable	**0370900-002**
Options for CVF 3	
CVF 3 Ventilation Unit • 25 m cable	0370900-004
CVF 3 Ventilation Unit • 50 m cable	0370900-005
CVF 3 Ventilation Unit • plug only, no cable	0370900-008
Note: The cable for the CVF 3 is limited to 50 m because of voltage drop	
Spare Filters pack of 5 fan inlet filters	**2682916**

Accessories for CVF 3	Part number
CVP 2 Power Supply 115 / 230V AC Power adaptor with 12 VDC output	**0349401**
Note: CVP 2 is not suitable for unprotected outdoor use	

Adjustable Tilt CMP Mounting Kit

Adjustable Tilt CMP Mounting Kit

In solar energy applications it is often desirable to measure the 'tilted' global solar radiation at the angle of non-tracking (fixed) photovoltaic panels, in addition to the horizontal global radiation.

Adjustable Tilt CMP Mounting Kit is designed to be installed on a horizontal surface and allows a CMP, SMP, CGR or CUV series instrument to be mounted at zenith angles from 0° to 90°, using a graduated scale.

The kit can also be installed using a CMF 2 Mounting Fixture and CMB 1 Mounting Bracket.

It is not possible to use a ventilation unit with the kit.

Article	Part number
Adjustable Tilt CMP Mounting Kit	**0367718**
To mount a tilted global radiometer at a zenith angle from 0° to 90°	

Mounting Accessories

A range of mounting accessories enables the attachment of Kipp & Zonen radiometers to poles, masts or walls.

Mounting Rod

For the SP Lite2, PQS 1, CMP 3, SMP3 and CGR 3 a mounting rod is available, which screws into the instrument housing. Rod diameter 12 mm, length 300 mm.

CMF 1 Mounting Fixture

For the CMP, SMP, CGR and CUV series of instruments without ventilation units. It can take one upwards and/or one downwards facing radiometers.
Plate diameter 88 mm. Rod diameter 16 mm, length 350 mm.

CMF 2 Mounting Fixture

For the CMP, SMP, CGR and CUV series of instruments with or without ventilation units. CMF 2 can also be used to mount the UVS ultraviolet radiometer series. It can take one upwards and/or one downwards facing radiometer.
Plate diameter 220 mm. Rod diameter 16 mm, length 350 mm

CMB 1 Mounting Bracket

For attaching mounting rods of 12-20 mm diameter, or the CSD 3 to poles, masts or walls. The radiometer can be levelled by rotating and tilting the rod. The bracket includes u-bolts for fixing to poles and masts from 22 to 60 mm diameter.

CLF 4 Levelling Fixture

For the CM 4 high temperature pyranometer. Baseplate for CM 4 with three adjustable height screws and removable cap with bubble level.

Article	Part number
Mounting Rod for SP Lite2, PQS 1 , CMP 3, SMP3 and CGR 3	**0338720**
CMF 1 Mounting Fixture for 1 or 2 unventilated radiometers	**0362700**
CMF 2 Mounting Fixture For 1 or 2 ventilated or unventilated radiometers and UVS	**0362701**
CMB 1 Mounting Bracket To enable easy attachment of all mounting rods to a pole or a wall	**0369701**
CLF 4 Levelling Fixture for CM 4 high temperature pyranometer	**0356700**

CVP 1 and CVP 2

CVP 1 is a weatherproof heavy duty power supply with wide-range AC input and a fully protected 12 VDC output at up to 3.5 A. It is suitable for powering ventilation units and other equipment, such as data loggers, and is supplied pre-wired with 5 m AC cable.

CVP 1 LAS MkII is a special version for use with Kipp & Zonen Large Aperture Scintillometer (LAS). It is pre-wired with 10 m cable fitted with the waterproof connector for the LAS MkII transmitter or receiver. It supplies power to the LAS MkII and has a pass-through facility for the LAS MkII signal connections.

CVP 2 is a universal AC power adaptor with 12 VDC output. It operates from 115 or 230 VAC and can power one or two CVF 3 ventilation units, with or without heating. It can also be used to power the UVS series of UV radiometers.

Please note that CVP 2 is not suitable for unprotected outdoor use.

Specifications CVP 1

Power input	100 - 240 VAC / 1.2 - 0.7 A, 50 - 60 Hz
Power output	12 VDC / 3.5 A
Line regulation	± 0.2 % maximum
Load regulation	± 1 % maximum
Operating temperature range	- 20 °C to + 50 °C
Ingress protection	IP 65

Specifications CVP 2

Power input	100 - 240 VAC, 50 - 60 Hz
Power output	12 VDC / 2.5 A
Operating temperature range	0 °C to + 40 °C
Ingress protection	For indoor use only
Plug type	European, UK, USA and Australian plug adapters

Article	Part number
CVP 1 Power supply 12 VDC output	**0357700**
CVP 1 LAS MkII Power supply for LAS MkII transmitter or receiver	**0371701**

Article	Part number
CVP 2 Power supply 12 VDC output	**0349401**

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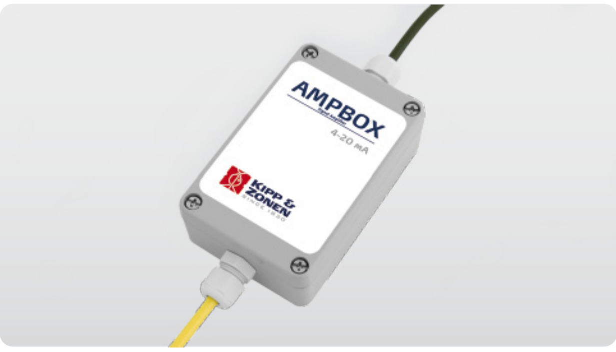
AMPBOX



AMPBOX is a digital amplifier perfectly suited to combine with our instruments. Most Kipp & Zonen solar radiation radiometers are passive instruments that do not require any power to operate. The output signal is generated by the thermopile or photo-diode detector. However, the output is a very low voltage, typically in the region of 10 mV on a bright sunny day.

AMPBOX can be used to provide a 4-20 mA current loop signal for applications where longer cables are required, or the low signal outputs cannot be handled. AMBOX is fully waterproof and can be installed outdoors close to the radiometer and connected by several hundred metres of cable to the data acquisition system. The amplifier is ‘current-sink’ (powered by the current loop). The power for the loop must be supplied from the data acquisition system.

AMPBOX is a programmable digital amplifier and the input and output are isolated to minimize feedback and to protect the data collection equipment. As standard the amplifier is delivered with an input signal of 2 mV producing an output of 1 mA, so that 4-20 mA represents 0-32 mV.

AMPBOX can be adjusted to suit the sensitivity of a particular radiometer to provide a defined radiation output range, for instance 4-20 mA represents 0-1600 W/m² of radiation. For radiometers that can produce a negative output the zero point is offset.

Article	Part number
AMPBOX Signal Amplifier standard gain setting	**0365900**
Options for AMPBOX	
AMPBOX Signal Amplifier gain adjusted To suit a specific radiometer	0365901
AMPBOX Signal Amplifier for pyrgeometers	0365903

Note: For a new radiometer supplied with an AMPBOX the adjustment is included in the radiometer part number, and price.

For an existing radiometer please specify the model, serial number and sensitivity when ordering.

Specifications

Output range	4 to 20 mA
Input range	-12 to +150 mV
Standard gain	2 mV / mA
Gain range	0.1 to 4 mA / mV
Zero adjustment	Up to 12 mA
Input impedance	10 MΩ
Operating temperature range	-40 °C to +85 °C
Voltage drop to power amplifier	7.2 VDC
Maximum supply voltage	35 VDC
Ingress protection	IP 66

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CM 121B/C Shadow Ring

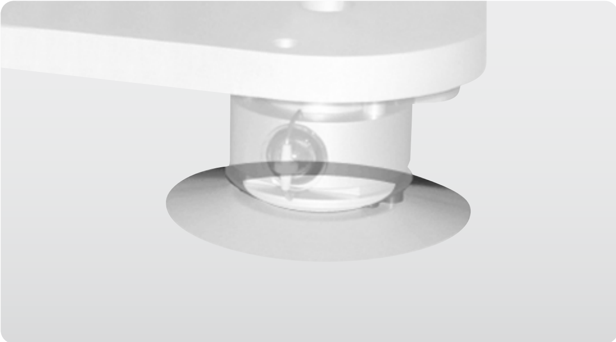
CM 121 is a shadow ring that does not require power and can be used with all the Kipp & Zonen CMP, SMP, CGR and CUV series of instruments. It is used for measurements of the diffuse sky radiation or to shade a pyrgeometer from the direct solar radiation. CM 121B is for unventilated radiometers and CM 121C is for ventilated instruments.

The radiometer is installed on the mounting pedestal and after correct adjustment for the location and the sun declination the ring makes a shadow on the radiometer dome throughout the day. To maintain the shading accuracy it is necessary to adjust the position of the ring every few days to compensate for changes in the solar arc.

The ring has a width / diameter ratio of 0.185 and has a view of 10.6 ° seen from the radiometer.

Article	Part number
CM 121B Shadow Ring for unventilated radiometers	**0346900**
CM 121C Shadow Ring for ventilated radiometers	**0346901**

Glare Screen Kit



Glare Screen Kit

A downward facing radiometer should not see any radiation coming from the hemisphere above or from the first 5 ° below the horizon. Our albedometers and net radiometers have this feature integrated into the design.

An accessory glare screen kit is available for use with the CMP, SMP, CGR and CUV series of instruments (except the CMP 3, SMP3 and CGR 3).

Please note that the CVF 3 ventilation unit cannot be fitted if the glare screen kit is used.

Article	Part number
Glare Screen Kit for downwards facing radiometers	**0305722**

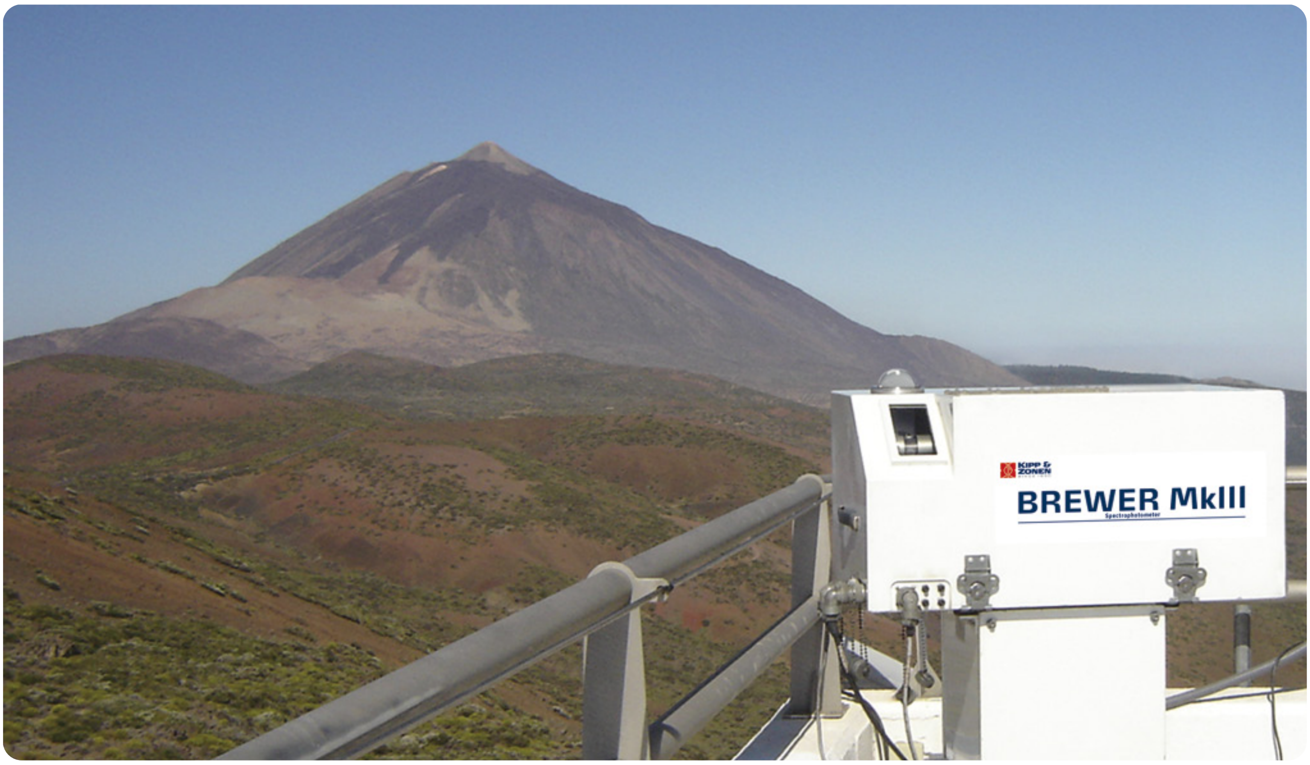
Atmospheric Science Instruments

INTRODUCTION

Our atmospheric science range of instruments includes both products manufactured by Kipp & Zonen and others that have been developed by specialist companies and are exclusively distributed by Kipp & Zonen worldwide. In general these are more complex instruments for scientific research and network use and are computer controlled with sophisticated data processing software.

Atmospheric science instruments include the Brewer spectrophotometer for stratospheric Ozone and high accuracy UV measurements, scintillometers, sky radiometers, and sun photometers. All can be found on the following pages.

For the latest product information, brochures, manuals and application information visit our website at www.kippzonen.com



Brewer Spectrophotometer

FOR THE HIGHEST ACCURACY OBSERVATIONS OF UV AND OZONE

A major health concern in many parts of the world is the amount of harmful ultraviolet radiation from the sun and sky that people are exposed to. ‘Holes in the Ozone layer’ are areas of stratospheric Ozone depletion and are not confined to the North and South Poles. They are indicators of the general health of the atmosphere, and a reduction in Ozone means that more harmful UV reaches the ground.

To accurately measure stratospheric Ozone, and solar UV radiation, requires a sophisticated instrument that can also act as a reference for networks of lower performance instruments. The Kipp & Zonen ‘Brewer’ spectrophotometer is the only instrument in current production sanctioned by the World Meteorological Organisation (WMO) for making total column Ozone measurements and provides much of the data for the World Ozone and UV Data Centre (WOUDC).

The Brewer is unique, designed by Environment Canada specifically for operating automatically with high accuracy over long periods of time, in all climates and environments from the tropics to Antarctica. There have been several versions of the Brewer over the years, but the only model now in production is the MkIII ‘double’ Brewer because of its superior UV measurement capability.

The Brewer MkIII is manufactured exclusively by Kipp & Zonen under licence of Environment Canada. We provide a full range of calibration, spares, repairs and support services for the MkIII and for older models.

Brewer MkIII

Brewer MkIII has a unique design of spectrometer that is self-compensating for the expansion and contraction of components caused by changes in temperature. This means that it can be used around the world outdoors without the need for complex temperature stabilisation. There are built-in wavelength and sensitivity check lamps.

The MkIII ‘double’ Brewer uses two of these spectrometers in series for improved ultraviolet measurement accuracy, into the UVC band. This gives the MkIII a significant advantage over the single spectrometer MkII and MkIV Brewers, which are no longer manufactured.

The Brewer is mounted on a dedicated azimuth tracker and makes measurements of the direct solar radiation at specific wavelengths to determine the total column Ozone and Sulphur Dioxide in the atmosphere. It also has the capability to make high resolution UV spectral scans of both the direct and global solar radiation. The software can accurately calculate UVA, UVB, UVE (Erythemal) and UVI (Index). The Brewer must be connected to a PC running the operating software in order to make measurements and store data.

Article	Part number
Brewer MkIII 230 VAC for UV, Ozone and SO_2	**0361900**
Brewer MkIII 115 VAC for UV, Ozone and SO_2	**0361901**

Specifications

Measurement principle	Unique self-compensating dual Ebert spectrometers
Detector	UV-enhanced photo-multiplier tube (PMT)
Sun Tracker	Integrated, includes heavy duty tripod stand
Supply voltage	115 or 230 VAC, 50 - 60 Hz
Operating temperature range	-20 °C to +40 °C -50 °C to +40 °C (with optional insulated cold cover)
Wavelength range	286.5 nm to 363 nm
Resolution / stability	0.6 nm / ± 0.01 nm
Ozone and SO_2 measurement wavelengths	303.2 nm • 306.3 nm • 310.1 nm 313.5 nm • 316.8 • nm • 320.1 nm
Column Ozone measurement accuracy	± 1%
UV measurement	Direct sun or global radiation, UVA, UVB, UVE and UVI
Communication	RS 422, supplied with isolated RS 422 to RS 232 converter for PC running operating software (PC not included)
Software, GW-BASIC	Operation of Brewer, data storage and analysis

Accessories for Brewer MkIII	Part number
UV-B Stability Kit external UV calibration lamp kit	**BA-C 126**
Insulated Cold Cover extends operation to -50 °C	**BA-C 210**
Aluminium Transit Case foam lined	**BM-C 206**

Scintillometers

FOR THE MEASUREMENT OF HEAT FLUXES AND EVAPORATION AT LARGE SCALES

Heat fluxes and evaporation at the Earth's surface are of great importance to the fields of meteorology and hydrology. Accurate continuous measurement of these parameters is often required for research projects and monitoring applications. Where the measurements need to be done on a field or landscape scale, or for validating satellite data, the traditional in-situ point measurement techniques are not sufficient.

The Kipp & Zonen LAS MkII is a large aperture scintillometer (LAS) designed to provide continuous measurements of heat flux and turbulence statistics over long distances, for energy balance studies and evaporation monitoring. Thanks to the extended range, from 100 m up to 4.5 km, LAS measurements can be compared to the typical pixel sizes of satellite-based instruments, for ground validation.

The measurement technique is based on the scintillation phenomenon. Heat fluxes between the ground and the atmosphere cause variations in the refractive index of the air. The LAS detects these variations using a pulsed beam of infrared light which is emitted by the transmitter and detected by the receiver. From the measurements the LAS MkII can calculate the path-averaged structure parameter of the refractive index of air (C_n^2).

When the accessory meteorological sensor kit is connected to the receiver it automatically recognizes the sensors and can calculate surface sensible heat flux (H). The LAS MkII can store more than a month of data. The raw data can also be exported to a PC where the supplied EVATION® software package can calculate (C_n^2), (H) and other parameters and display them graphically in real time or historically.

For more advanced applications Kipp & Zonen offers the LAS MkII ET system to measure latent heat flux (L_vE) and Evapotranspiration (ET). This is a turn-key system which provides all the instrumentation and software necessary to monitor C_n^2, H, L_vE and ET. Kipp & Zonen's ET system is specifically designed for Earth energy balance studies, water and crop management and for the ground-truth validation of satellite remote sensing measurements.

LAS MkII Scintillometer

LAS MkII provides measurements of the path-averaged structure parameter of the refractive index of air C_n^2 over path lengths from 250 m to 4.5 km, using the scintillometry technique. A pair of aperture restrictors is supplied to allow measurements down to 100 m. The durable design enables operation under almost any atmospheric condition and with very low maintenance.

The internal digital processing unit automatically computes C_n^2 and other relevant parameters. Results are stored in the internal non-volatile data memory. Using the built-in display and control keys, real time measurement data and installation parameters can be read directly from the display receiver.

The digital output of the receiver can be connected to a PC for remote real time display of data and instrument control. Our EVATION® software suite is included as standard to view real-time data numerically and graphically as well as to post-process advanced data. In addition analogue voltage outputs of C_n^2 and signal strength are available for connection to data loggers.

The accessory meteorological sensor kit allows the LAS MkII to calculate the surface sensible heat flux (*H*). Other accessories include stands, rugged transit cases and power supplies.

Article	Part number
LAS MkII Large Aperture Scintillometer	**0371900**

Specifications LAS MkII

Path length / aperture diameter	100 m to 1 km / 100 mm (restrictors included) 250 m to 4.5 km / 150 mm
Dimensions (LxWxH)	40 x 23 x 30 cm
Weight (per transmitter/receiver)	8.5 kg
Wavelength	850 nm
Scintillation bandwidth	0.2 to 400 Hz
C_n^2 range	10^{-17} to 10^{-12} $m^{-2/3}$
Power requirements	12 VDC nominal 6 W (heater off) / 54 W (maximum when heater on)
Pan and tilt adjustment	Built-in
Alignment telescopes	Included
Data processing	Internal processing of C_n^2, H_{free} (with meteorological sensor kit) and other parameters
Data logging	Integrated, minimum one month
Instrument control and data display	Built-in display and key-pad, or remotely via digital interface
Interfaces	Digital: RS-232 / RS-422 Analogue: 0 to 2 V (C_n^2 and signal strength)
External sensor connection	Wind speed, temperature and pressure kit
Software	EVATION® instrument control and data analysis suite for Windows™ (PC not included)

Accessories for LAS MkII	Part number
Meteorological sensor kit Wind speed, temperature and pressure sensors - pre-wired with cable and connector for LAS MkII receiver 2 m high mast for fixing in ground, with mountings for meteorological sensors	**0371704**
CVP1 LAS MkII Weatherproof heavy-duty AC-DC power supply unit for outdoor use For transmitter and receiver (one required for each) Wide AC input range, fully protected output 12 VDC at 3.5 A Operating temperature range -20 °C to +50 °C Pre-wired with 10 m ouput cable and connector for LAS MkII, 5 m AC power input cable with IEC female plug	**0371701**
Transit Case Foam-lined rugged transit case, for safe transport of LAS MkII For transmitter and receiver (one required for each)	**4483411**
Adjustable Heavy-Duty Tripod Package Aluminium folding tripod, adjusts up to 3 m height, includes base-frame for hard surfaces and fixing bolts for LAS MkII. Two supplied, one each for transmitter and receiver, in a wood carrying case	**0357703**
Tripod Floor Stand For easy mounting and levelling of the LAS MkII, height 0.45 m Very stable and rugged. As used with Kipp & Zonen Brewer and 2AP Tracker For transmitter and receiver (one required for each)	**0353710**
Height Extension Tube Extends the tripod mounting height by 0.60 m to a total of 1.05 m	**0353750**
Re-calibration Service and factory test, excluding any replacement parts needed	**0357720**

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LAS MkII ET System

LAS MkII ET System is a complete solution for monitoring the energy balance within the boundary layer, including latent heat flux (L_vE) and Evapotranspiration (ET). It is specifically designed for field scale observations of the path averaged energy fluxes using the scintillometry technique.

All the equipment of the ET system is selected and designed to offer easy installation and low maintenance operation. Our EVATION® software suite is included as standard to view real-time data numerically and graphically and to post-process advanced data. EVATION® reads the ET system measurement data but can also use files from other types of data acquisition systems.

The system features a LAS MKII scintillometer. The analogue outputs are connected to a COMBILOG data logger in a stainless steel weatherproof enclosure, which also houses the ambient pressure sensor. The data logger inputs have over voltage protection and there are mast mounting clamps for the enclosure. The COMBILOG requires 12 VDC power. A NR Lite2 net radiometer is also connected to the data logger.

Sensors for wind speed, wind direction, temperature at two heights and soil heat flux at two depths are also connected to the COMBILOG. A 4 m height telescopic mast has all the necessary mountings for the meteorological and net radiation sensors and includes guy wires and a lightning rod.

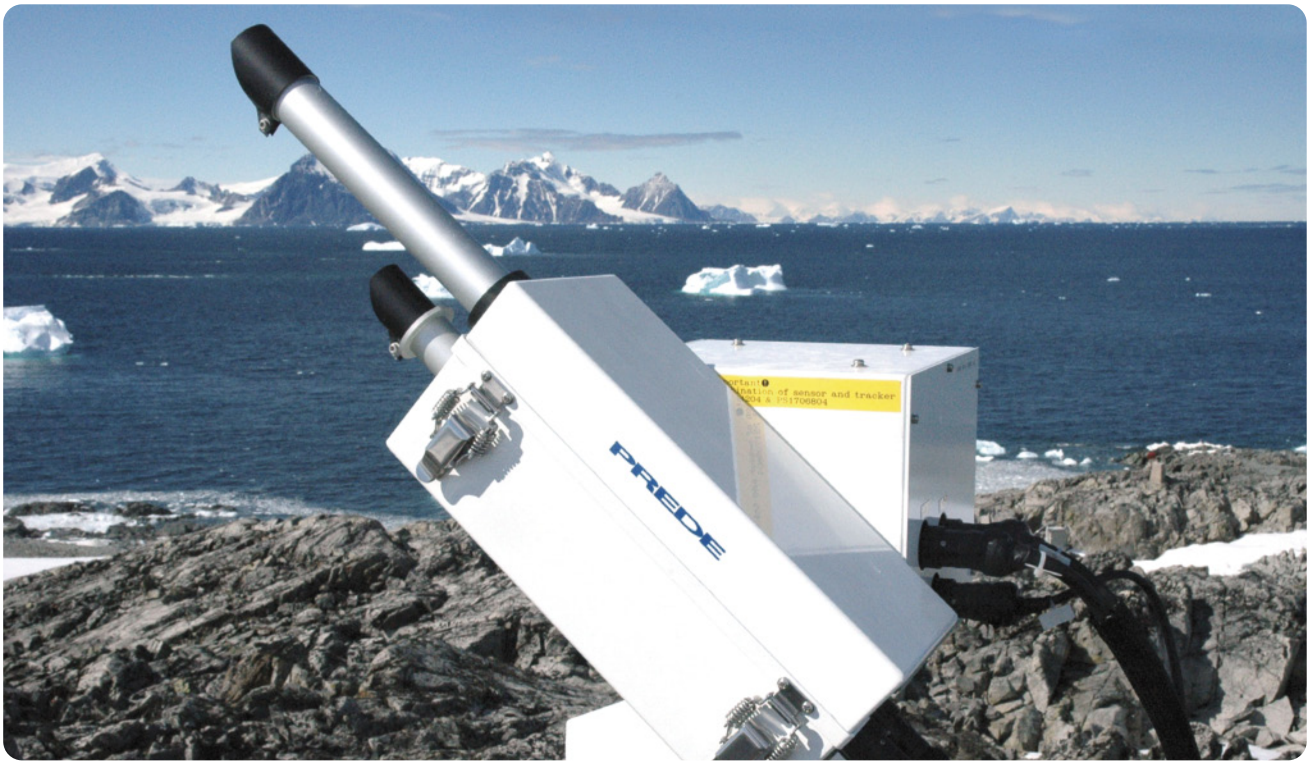
The COMBILOG can be ordered with an AC to 12 VDC power supply and backup battery fitted in the enclosure. A further option is a GSM modem for remote communication (a suitable SIM card and network access must be provided by the user). Software to configure the COMBILOG, manually download data and display it in real-time is included.

Article	Part number
LAS MkII Evapo-Transpiration system The standard system consists of the items below, which must all be specified on the order	
LAS MkII Large Aperture Scintillometer	0371900
Meteorological Sensors and Mast	3303094
NR Lite2 Net Radiometer	0344920-003
COMBILOG in Small IP65 Enclosure	0372900-100
Options for LAS MkII ET system	
COMBILOG in Small IP65 Enclosure with 12 V power supply & backup battery	0372900-102
COMBILOG in Small IP65 Enclosure with 12 V power supply & backup battery & GSM Modem	0372900-112

Specifications LAS MkII ET System

Scintillometer	LAS MkII
Meteorological sensors and mast	Wind speed Wind direction Atmospheric pressure Ambient temperature at two heights Soil heat flux at two depths 4 m high telescopic mast with mountings for meteorological and net radiation sensors, lightning rod, guys and baseplate
Net radiation sensor	NR Lite2
Data acquisition	COMBILOG data logger system in weather-proof stainless steel enclosure with over-voltage protection, requires 12 VDC power
Software	EVATION® instrument control and data analysis suite for Windows™ (PC not included)

Accessories for LAS MkII ET System	Part number
CVP 1 LAS MkII Weatherproof heavy-duty AC-DC power supply unit for outdoor use For transmitter and receiver (one required for each) Wide AC input range, fully protected output 12 VDC at 3.5 A Operating temperature range -20 °C to +50 °C Pre-wired with 10 m ouput cable and connector for LAS MkII, 5 m AC power input cable with IEC female plug	0371701
Transit Case Foam-lined rugged transit case, for safe transport of LAS MkII For transmitter and receiver (one required for each)	4483411
Adjustable Heavy-Duty Tripod Package Aluminium folding tripod, adjusts up to 3 m height, includes base-frame for hard surfaces and fixing bolts for LAS MkII. Two supplied, one each for transmitter and receiver, in a wood carrying case	0357703
Tripod Floor Stand For easy mounting and levelling of the LAS MkII, height 0.45 m Very stable and rugged. As used with Kipp & Zonen Brewer and 2AP Tracker For transmitter and receiver (one required for each)	0353710
Height Extension Tube Extends the tripod mounting height by 0.60 m to a total of 1.05 m	0353750
Re-calibration Service and factory test, excluding any replacement parts needed	0357720



Sky Radiometers

FOR STUDYING THE EFFECTS OF STRATOSPHERIC AEROSOLS

With the increasing interest in climate change and global warming research, the effects of stratospheric aerosols are being studied in greater detail. Primarily, this refers to water vapour and suspended particles such as smoke, dust, sand and ash. These absorb and scatter solar radiation, act as nuclei for the formation of clouds and promote atmospheric chemical reactions.

Understanding atmospheric aerosols is one of the most important ways that scientists can improve models for weather and air quality forecasting and for climate change prediction. In order to gather information on the size and shape of particles it is necessary to measure the characteristics of light directly from the sun and also light scattered and absorbed by the aerosols, at angles up to 90 ° away from the sun.

A radiometer with a narrow field of view makes measurements in several narrow wavebands in the ultraviolet, visible and near-infrared parts of the spectrum. It is mounted on a dedicated sun tracker that can follow the sun and also make scans across the sky at defined angles away from the sun.

One of the most widely used instruments for this purpose is the POM Sky Radiometer, manufactured by Prede Co. Ltd. in Tokyo and distributed by Kipp & Zonen. POM is used in the Asia-Pacific SKYNET network, the European SkyRad users network (ESR) and for aerosol monitoring and satellite ground-truthing around the world.

POM-01

POM-01 is a sky radiometer mounted on a dedicated sun tracker. It uses a single detector and rotating filter wheel to measure radiation in seven narrow wavebands, either directly from the sun or at user-defined angles away from the sun. The instrument has a base with levelling feet and a sun sensor for active tracking. Installation is quick and simple and a precipitation sensor is included so that the radiometer is pointed downwards during rain to keep the optics clean.

POM-01 must be connected to a PC running the operating software in order to make measurements and store data. The supplied software allows comprehensive user selection of the scanning modes. The data can be post-processed to provide parameters including aerosol optical depth, scattering coefficients, aerosol distribution and energy distribution.

Article	Part number
POM-01 Sky Radiometer • 115/230 VAC 7 wavelengths with sun & rain sensors	**3307001**
POM-01 Sky Radiometer • 24 VDC 7 wavelengths with sun & rain sensors	**3307002**
Options for POM-01	
POM-01 Low Temperature Option for operation up to -30 °C (insulating covers)	**3307011**
POM-01 High Temperature Option for operation up to +60 °C (cooling system - AC power only)	**3307012**
POM-01 Dust Protection System for optical windows (filtered air blower - AC power only)	**3307013**

Distribution

POM is designed and produced by **Prede Co. Ltd** of Tokyo and is distributed exclusively by Kipp & Zonen worldwide (with the exception of Japan, Korea and India)

Specifications

Measurement principle	Multiple band filter spectrometer
Detector	Silicon photo-diode
Sun tracker	Integrated, with sun and rain sensors
Supply voltage	115/230 VAC, 50/60 Hz (standard), 24 VDC (option)
Operating temperature range	-10 °C to +45 °C -30 °C to +45 °C with low temperature option -10 °C to +60 °C with high temperature option
Wavelengths	315, 400, 500, 675, 870, 940 and 1020 nm
Wavelength accuracy	2 nm
Half-power bandwidth	3 nm for 315 nm filter, 10 nm for other filters
Full opening view angle	1 °
Communication	RS 232 to PC (not included) running operating software
Software, Windows™	Configuration, operation, data storage

POM-02

POM-02 has all the features of the POM-01, but with extended waveband ranges. There is growing interest in monitoring aerosols of larger size and this requires measurement at longer wavelengths. In addition to the optical system with silicon photo-diode detector of the POM-01, the POM-02 has a second optical system with an Indium Gallium Arsenide infrared detector.

The filter wheel has 11 wavebands, providing measurements to 2200 nm, and also has additional UV channels. POM-02 must be connected to a PC running the operating software in order to make measurements and store data. Like the POM-01, maintenance is minimal; consisting of regular cleaning of the optical windows and checking the desiccant in the radiometer.

Article	Part number
POM-02 Sky Radiometer • 115/230 VAC 11 wavelengths with sun & rain sensors	**3307010**
POM-02 Sky Radiometer • 24 VDC 11 wavelengths with sun & rain sensors	**3307020**
Options for POM-02	
POM-02 Low Temperature Option for operation up to -50 °C (insulating covers)	**3307018**
POM-02 High Temperature Option for operation up to + 50 °C (cooling system - AC power only)	**3307012**
POM-02 Dust Protection System for optical windows (filtered air blower - AC power only)	**3307013**

Distribution

POM is designed and produced by **Prede Co. Ltd** of Tokyo and is distributed exclusively by Kipp & Zonen worldwide (with the exception of Japan, Korea and India)

Specifications

Measurement principle	Multiple band filter spectrometer
Detector	Silicon photo-diode and InGaAs photo-diode
Sun tracker	Integrated, with sun and rain sensors
Supply voltage	115/230 VAC, 50/60 Hz (standard), 24 VDC (option)
Operating temperature range	-30 °C to +35 °C -50 °C to +35 °C with low temperature option -35 °C to +50 °C with high temperature option
Wavelengths	315, 340, 380, 400, 500, 675, 870, 940, 1020, 1627 and 2200 nm
Wavelength accuracy	2 nm
Half-power bandwidth	3 nm for 315 nm filter, 10 nm for other filters
Full opening view angle	1 °
Communication	RS 232 to PC (not included) running operating software
Software, Windows™	Configuration, operation, data storage

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Sun Photometers

FOR THE SPECTRAL MEASUREMENT OF SOLAR RADIATION

The majority of measurements of the direct irradiance from the sun are made using broad-band radiometers, such as pyrheliometers. These are mounted on automatic sun trackers and measure the total irradiance in the ultraviolet, visible and near infrared with high accuracy. This is very useful for meteorology and climatology applications, but there are a number of areas of research where it is interesting to know information about the energy reaching the ground in different wavebands.

Traditional sun photometers measure the radiation in four or more narrow wavebands and are typically used to derive the optical depth of the atmosphere. For example, the POM sky radiometer from Kipp & Zonen can measure up to 11 wavebands of both direct and scattered light. However, the most flexible solution is to record the complete spectrum of the light so that the user can analyse the data for the specific parameters of interest.

The PGS-100 Sun Photometer manufactured by Prede Co. Ltd. in Tokyo and distributed by Kipp & Zonen can measure the direct solar radiation reaching the ground in the wavelength range from 350 nm to 1050 nm. It uses a spectrometer with no moving parts, for reliability and low maintenance, and has a weather-proof housing. In order to make measurements the sun photometer must be fitted to an automatic sun tracker. A dedicated mounting kit is available to fit the PGS-100 to Kipp & Zonen sun trackers.

PGS-100

PGS-100 is a sun photometer for mounting on an automatic sun tracker. It uses a solid state spectrometer with a CCD detector array to measure the direct solar radiation in the wavelength range 350 nm to 1050 nm. The only maintenance is to periodically clean the optical windows and check the desiccant in the radiometer. Installation is quick and simple on a Kipp & Zonen SOLYS 2 or 2AP sun tracker, using the accessory mounting kit.

PGS-100 must be connected to a PC running the operating software in order to make measurements and store data. The software allows selection of the spectrum acquisition modes and graphically displays the stored results. The data can be post-processed by the user (software not provided) to derive atmospheric parameters such as energy distribution, optical depth, aerosol properties and gas absorption.

Specifications

Measurement principle	Solid state grating spectrometer
Detector	Silicon CCD array
Supply voltage	115/230 VAC, 50/60 Hz
Operating temperature range	-10 °C to +45 °C -30 °C to +45 °C with low temperature option -10 °C to +60 °C with high temperature option
Wavelength range	350 nm to 1050 nm
Wavelength accuracy	0.5 nm
Half-power bandwidth	3.6 nm
Full opening view angle	2 °
Communication	RS 232 to PC (not included) running operating software
Software, Windows™	Configuration, operation, data storage, graphical display

Article	Part number
PGS-100 Sun Photometer full spectrum, 350 - 1050 nm	**3307015**
Options for PGS-100	
PGS-100 Sun Photometer Low Temperature Option for operation up to -30 °C (insulating cover)	**3307016**
PGS-100 Sun Photometer High Temperature Option for operation up to +60 °C (cooling system)	**3307017**

Accessories for PGS-100	Part number
PGS-100 Mounting Kit To fit 1 x Prede PGS-100 Sun Photometer to a SOLYS 2 or 2AP sun tracker	**0367714**
Note: This mounting kit also requires a side mounting plate	

Distribution

PGS-100 is designed and produced by **Prede Co. Ltd** of Tokyo and is distributed exclusively by Kipp & Zonen worldwide (with the exception of Japan, Korea and India)

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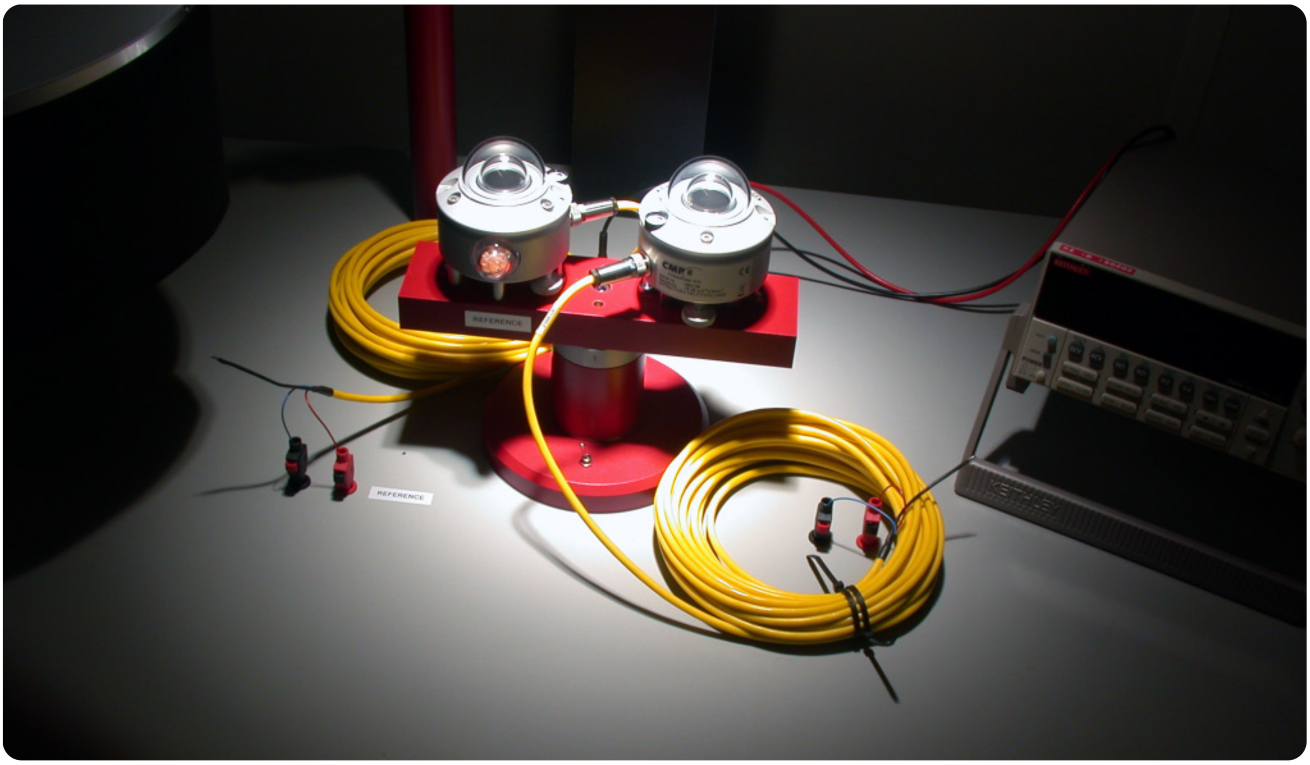

Calibration Facility

FOR THE CALIBRATION OF FIELD PYRANOMETERS, ALBEDOMETERS AND PYRGEOMETERS

A radiometer gives a voltage output that is proportional to the absolute irradiance level. This relationship can be expressed as a ratio called 'sensitivity'. The sensitivity of a particular radiometer is unique. It is determined by comparison against a reference radiometer of similar type under controlled standard test conditions.

Kipp & Zonen supplies all new radiometers with a high quality factory calibration carried out by trained operatives. Calibrations are to World Meteorological Organisation (WMO) and International Standards Organisation (ISO) requirements and are traceable to the World Radiometric Reference.

We maintain two reference radiometers of each type. These are calibrated at the World Radiation Centre in Davos, Switzerland, and are fully characterized for linearity, temperature dependence and directional response.

The spectral content of the calibration lamp differs slightly from the outdoor solar spectrum at the World Radiation Centre, but this has no consequences for the transfer of calibration, provided that the reference and test radiometers have the same characteristics. A precisely controlled infrared heat source is used for laboratory pyrgeometer calibrations.

We advise recalibration of radiometers every two years. Over a two year period in the field the sensitivity of an instrument changes slightly. Normally, instruments are returned to the factory in Delft or sent to an organistion that is authorised by Kipp & Zonen to carry out calibrations to factory standards of quality, traceability and documentation - such as Kipp & Zonen USA.

For customers who have a large number of radiometers, or who maintain a network of instruments, Kipp & Zonen offers the CFR and CFI Calibration Facilities so that they can perform their own calibrations saving time and money.

To ensure that customers carry out calibrations to Kipp & Zonen, WMO and ISO standards of quality calibration facilities are only supplied complete with installation and training at the customer site by a Kipp & Zonen specialist. Appropriate new reference radiometers must be purchased, or existing customer instruments must be recalibrated at the factory before delivery.

For the above reasons specific terms and conditions apply to the purchase of calibration facilities, such as regular recalibration of the reference instruments and the precision voltmeter.

CFR

CFR Calibration Facility Radiometers is designed for the calibration of field pyranometers and albedometers by comparison to a reference instrument of similar type.

CFR offers a solution for quality control of the stability of the pyranometers that are used in a network. The procedure used complies with Annex A.3 of international standard ISO 9847 “Calibration of Field Pyranometers by Comparison to a Reference Pyranometer”. Annex A.3 refers to “Calibration Devices Using Artificial Sources”. Our equipment and method is specifically referred to in ISO 9847 as the “Kipp & Zonen Device and Procedure”

The facility is manually operated and the time needed for each calibration is approximately 10 minutes. Preparation for a measurement session including warm-up and stabilisation of the calibration lamp will take about 30 minutes. The calibration transfer uncertaintyy between reference and test pyranometers of high quality, such as the CMP 11, is estimated to be ± 1%.

The turntable supplied with the CFR is suitable for calibration of CM 6, 11, 21, 22, 31 and CMP 3, 6, 11, 21, 22 pyranometers. Adaptors and alternative turntables are available to suit other pyranometers and albedometers. CFR is supplied without reference pyranometers. These must be of similar characteristics to the field radiometers under test and must be either purchased with the CFR, or existing customer instruments must be recalibrated at the factory before delivery.

Calibration facilities are only supplied on the basis that they are installed by a Kipp & Zonen specialist, who will check the suitability of the laboratory and provide training to the customer staff. The laboratory must meet requirements for light shielding, temperature control and, in the case of the SMP series smart pyranometers, ESD precautions.

The CFI Calibration Faciity Infared can be mounted on the CFR for the calibration of pyrgeometers. It cannot be used separately, without the CFR.

Specifications

Calibration procedure	ISO 9847, Annex A 3.1, the ‘Kipp & Zonen Device and Procedure’
Calibration table	Rugged workbench with ESD protection
Light source	Metal-Halide, low infrared output, precision stabilised, adjustable height
Measurement system	High accuracy, calibrated, 6½ digit programmeable voltmeter switchable to reference or test radiometer
Turntable	To interchange reference and test radiometer positions
Shading mechanism	Mounted on table to determine zero offsets
Power requirements	115 or 230 V, 500 W
Calibration labels	Weatherproof, UV resistant, labels and Windows™ compatible printer
Calibration certificates	Windows™ software to calculate sensitivity and uncertainty and to print certificates

Article	Part number
CFR Calibration Facility Radiometers 230 VAC for pyranometers and albedometers	**0341900**
CFR Calibration Facility Radiometers 115 VAC for pyranometers and albedometers	**0341901**

Accessories for CFR	Part number
Test Box SMP for SMP pyranometer calibration on CFR USB interface, power supply and PC software	**0374900**
Adaptor for CM 5 for test CM 5 + spacer for reference CMP 6	**0341701**
Adaptor for CM 3, SP Lite2	**0341702**
Note: When used for SP Lite2 two adaptors are required, for test and reference	
Turntables	
Turntable for Albedometers for CM 7B, 14, 14B / CMA 6, 11	**0341704**
Turntable for Eppley for PSP and 8-48 pyranometers	**0341700**
Reference pyranometers	
CMP 22 for calibrating CM 22, 31 / CMP 22	**0362930-012**
CMP 21 for calibrating CM 21 / CMP 21 / Eppley PSP, 8-48	**0362920-012**
CMP 11 for calibrating CM 11, 11B, 14, 14B / CMP 11 / SMP11 / CMA 11	**0362910-002**
CMP 6 for calibrating CM 5, 6B, 7B / CMP 6 / CMA 6	**0362900-002**
CMP 3 for calibrating CM 3 / CMP 3 / SMP3	**0338920-002**
SP Lite2 for calibrating SP Lite2	**0339920-001**
Note: The reference must be of similar type to the radiometer under test	

CFI

CFI Calibration Facility Infrared is an accessory for the CFR that is designed for the indoor calibration of field pyrgeometers by comparison to a reference instrument of similar type.

Please note that there are currently no internationally agreed standards for the indoor calibration of pyrgeometers. The method used for Kipp & Zonen factory calibrations is replicated by the CFI. The procedure is similar to that used to calibrate pyranometers and albedometers with the CFR. The calibration transfer uncertainty between reference and test pyrgeometers is estimated to be ± 3-4 %.

The CFI comprises an infrared hot-plate with a bracket for fitting to the CFR lamp mounting pillar, below the CFR calibration lamp. The hot-plate has a precise and stable temperature control unit, which is normally set at +60 °C. A heat shield is fitted to the top of the CFR shading mechanism to prevent heat transfer in the 'dark' measurement mode.

The turntable supplied as standard with the CFR is suitable for calibration of CG 1, CG 4, CGR 3 and CGR 4 pyrgeometers. CFI is supplied without reference pyrgeometers. These must be of similar characteristics to the field radiometers under test and must be either purchased with the CFI, or existing customer instruments must be recalibrated at the factory before delivery.

Article	Part number
CFI Calibration Facility Infrared 230 VAC for pyrgeometers	**0341705-2**
CFI Calibration Facility Infrared 115 VAC for pyrgeometers	**0341705-1**

Specifications

Mounting	Fits to CFR lamp pillar below calibration lamp
Heat shield	For CFR shading mechanism
Infrared source	Silicone rubber heater mat, 400 W
Source area	457 x 457 mm
Maximum temperature	232 °C
Calibration temperature	60 °C
Temperature control	115 or 230 VAC, stabilised with thermocouple feedback
Temperature accuracy	± 0.25 %

Passion for Precision

Kipp & Zonen is the leading company in measuring solar radiation and atmospheric properties. Our passion for precision has led to the development of a large range of high quality instruments: from all weather radiometers to complete measurement systems.

We promise our customers guaranteed performance and quality in various markets: Meteorology, Climatology, Hydrology, Industry, Renewable Energy, Agriculture and Public Health. We hope you will join our passion for precision.

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Sistemas fijos e integración arquitectónica

SOLARWORLD QUALITY

2012 product overview for installers, planners and wholesalers

We turn sunlight into power.

www.solarworld.com

With SolarWorld, you'll be ready for the solar future today

The solar future is already underway. As a solar pioneer, we are always ahead of every new development so that our customers can easily keep up with the industry's rapid technological advancements. Our products are your best option for embracing the solar future. We are the only German manufacturer already offering standardized mounting kits and solar system solutions that are perfectly tailored to the current market conditions.

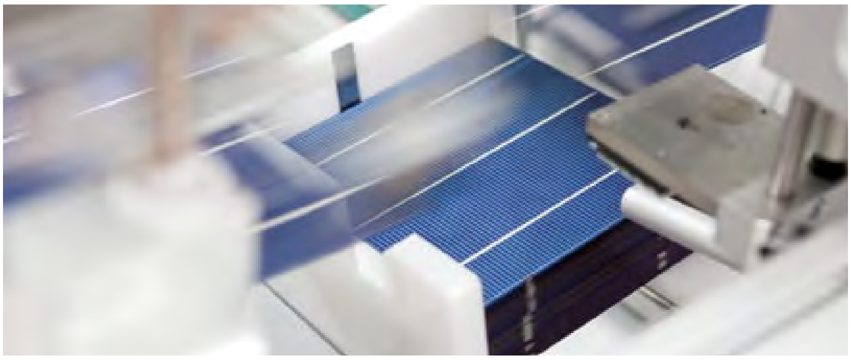
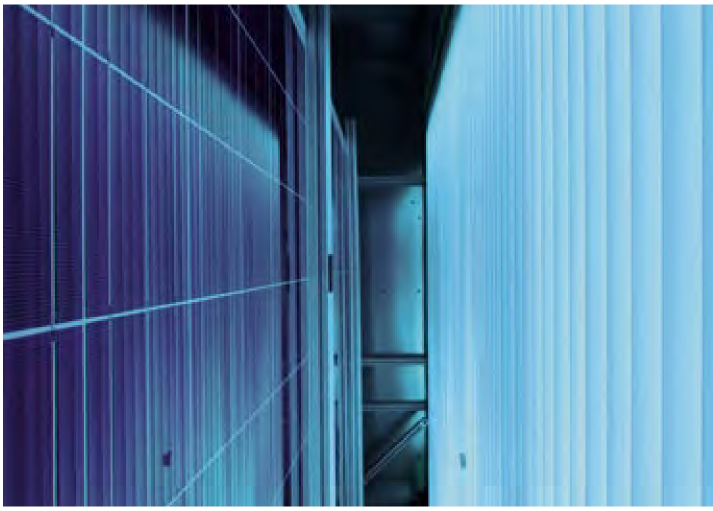
With our high-quality products, we provide system operators with the necessary instruments for monitoring and controlling their energy consumption, as well as increasing the amount of self-generated energy that they consume themselves. After all, direct consumption is becoming increasingly important.

In light of steadily increasing electricity prices, the demand for independence from power companies and for fixed electricity prices is on the rise. If you consume a great deal of electricity directly, you increase your system's profitability, since the energy you produce yourself is almost the most affordable power available today. This is exactly where SolarWorld products – such as the SunPac storage battery system – come into play. With our products, you'll be ready for the future.

We offer top-quality and powerful "made in Germany" technology at fair prices. Our quality standards drive our entire philosophy. We have all stages of the solar production cycle covered: From acquiring the raw material silicon through to manufacturing solar wafers, solar cells and solar modules, and even recycling, we provide everything from a single source. This allows us to deliver outstanding quality as well as ensure that our products are produced in a sustainable and environmentally-friendly way.

Let us do the hard work for you:
Invest with us in your solar future.



SOLARWORLD PRODUCTS – QUALITY FROM A SINGLE SOURCE

- **QUALITY "MADE IN GERMANY":** The standardized SolarWorld module concept stands for excellent products. SolarWorld ensures constantly high profitability thanks to first-class quality.
- **GROUP-WIDE QUALITY MANAGEMENT:** Fully-automated production lines and seamless process and material monitoring ensure the high level of quality that the company sets as its benchmark for its subsidiaries worldwide.
- **COMPREHENSIVE WARRANTIES:** SolarWorld quality modules come with a linear 25-year performance guarantee as well as a 10-year extended workmanship warranty*.
- **NUMEROUS CERTIFICATIONS:** The quality of SolarWorld products is certified by external and independent testing institutions.
- **SERVICE THAT GOES FURTHER:** Customized system solutions by professionals for professionals with a whole host of extras, ranging from storage systems to system monitoring and free insurance.

* in accordance with the applicable SolarWorld service certificate upon purchase | www.solarworld.de/module/service-certificate


SolarWorld
Quality modules
made in Germany
www.tuv.com
TÜVRheinland
ID: 0000022848
Power
controlled
ÖKO-TEST
LIFE WORTH LIVING
SolarWorld
Sunmodule Plus
SW 225 poly
excellent
issue 05/2010

Sunmodule Plus – Quality and performance

With over 30 years of production experience, SolarWorld has been one of the global market leaders for many years and played a key role in the development of solar power technology from the very beginning. All the stages of production, from the acquisition of silicon to module production, were established at the German production site in Freiberg. This is precisely how SolarWorld ensures the best quality throughout the entire production process. After all, only the best solar system also offers a secure investment. And if you invest in the most efficient product, you can look forward to long-term yields. SolarWorld makes the decision for your customers easy and ensures the best quality – starting with the module.

MADE IN GERMANY – SolarWorld AG relies on Germany as its technology location, thereby ensuring sustainable product quality.

-0/+5 Wp – The positive power tolerance guarantees utmost system efficiency. Only modules achieving or exceeding the designated nominal power in performance tests are dispatched. The power tolerance ranges between -0 Wp and +5 Wp.

TUV POWER CONTROLLED – The TUV Rheinland Power controlled inspection mark guarantees that the nominal power indicated for a Sunmodule Plus is inspected at regular intervals and thus ensured. The deviation to TUV is maximum 2 percent.

WARRANTY – With its linear performance warranty covering a period of 25 years, SolarWorld guarantees a maximum performance degression of 0.7 % p.a., a significant added value compared to the two-phase warranties common in the industry. Therefore, the service certificate offers comprehensive protection for your investment in the long term.



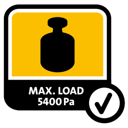
In addition to the product benefits listed on the previous page, the SolarWorld Sunmodule Plus also includes the following high-quality features.

ADDITIONAL PRODUCT BENEFITS

Fully automated production at highest quality level

SolarWorld solar modules are resistant to frost and hail and can therefore withstand any winter conditions

DLG and TUV-tested resistance against ammonia



Maximum pressure load up to 5.4 kN/m² for high snow loads

Tested resistance to salt mist for use in coastal areas

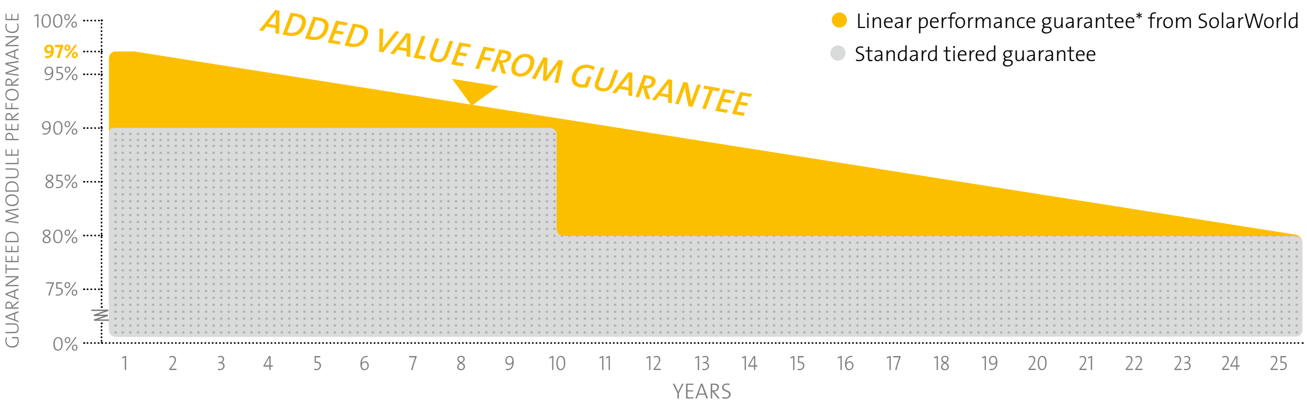
Sunmodule Plus SW 240–250 poly

Sunmodule Plus SW 240–250 mono black

Sunmodule® on-grid *technical data*

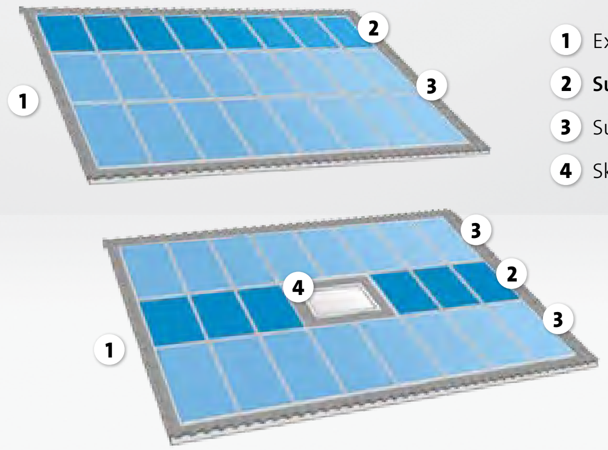
	SW 240–250 POLY	SW 240–250 MONO BLACK
Length x width x height	1675 x 1001 x 31 mm	1675 x 1001 x 31 mm
Frame	Silver anodized aluminum	Black anodized aluminum
Weight	21.2 kg	21.2 kg
Cells per module	60	60
Cell dimensions	156 x 156 mm	156 x 156 mm
Performance tolerance	-0/+5 Wp	-0/+5 Wp

*Linear performance guarantee**



* in accordance with the applicable SolarWorld service certificate upon purchase | www.solarworld.de/module/service-certificate

Sunmodule Plus SW 196 Vario poly



Application examples

1. Existing roof surface
2. **Sunmodule Plus SW 196 Vario poly**
3. Sunmodule Plus SW 245 poly
4. Skylight

New module size offers greater flexibility for solar systems

This SolarWorld innovation makes it possible to combine two module classes within one roof-mounted system for the very first time. The combined installation can also be planned using Suntool 2. The Sunmodule Plus SW 196 Vario poly has the same width as standard SolarWorld modules, yet is two cell rows shorter – plus it's perfectly matched to the Sunmodule Plus SW 245 poly. By combining these two quality modules and the Sunfix plus mounting frame, you make optimum use of your roof surface.

PRODUCT BENEFITS

- Compact dimensions increase flexibility for fully exploiting the roof surface
- Includes the option of combining two power classes within one solar system for the very first time
- Can be planned with Suntool 2
- Perfectly matched to the Sunmodule Plus SW 245 poly
- Homogenous module installation for an elegant appearance and impressive efficiency
- Compatible with mounting kits for self-consumption

COMPATIBLE
ATTRACTIVE
-0/+4 Wp

Sunmodule® on-grid *technical data*

	SW 196 VARIO POLY		
Length x width x height	1357 x 1001 x 31 mm	*Cells per module*	48
Frame	Silver anodized aluminum	*Cell dimensions*	156 x 156 mm
Weight	17.4 kg	*Performance tolerance*	-0/+4 Wp

Sunmodule SW 50 poly RMA

Sunmodule SW 80 poly RNA

Sunmodule SW 135 poly R6A

Sunmodule – For off-grid solar systems

SolarWorld also produces solar modules for powering small decentralized applications at its fully automated production facility in Freiberg. These off-grid modules meet the same durability, quality and performance requirements as the standard SolarWorld sets for the Sunmodule Plus series. In close collaboration with battery and charge controller manufacturers, SolarWorld also offers additional services for the design of off-grid systems.

PRODUCT BENEFITS

- The diodes of the Sunmodule off-grid modules can be replaced without special tools
- The module's permanent and laminated type plate ensures that the nominal power can no longer be falsified

MADE IN GERMANY | TUV POWER CONTROLLED | RELIABLE | FROST RESISTANT | AMMONIA RESISTANT | MAX. LOAD 5400 Pa

DIODE

TAMPER-PROOF

Sunmodule® off-grid *technical data*

	SW 50 POLY RMA	**SW 80 POLY RNA**	**SW 135 POLY R6A**
Length x width x height	680 x 680 x 34 mm	958 x 680 x 34 mm	1508 x 680 x 34 mm
Frame	Aluminum	Aluminum	Aluminum
Weight	5.6 kg	7.6 kg	11.8 kg
Cells per module	36	36	36
Cell dimensions	62 x 156 mm	94 x 156 mm	156 x 156 mm
Performance tolerance	+/-10 %	-5/+10 %	+/-5 %

Sunkits – "All-inclusive package" by professionals for professionals

Enjoy sales success with your customers: With the SolarWorld Sunkits, you'll receive special all-inclusive service. The kits contain all components required for constructing and operating a solar system: SolarWorld quality modules, inverters, data loggers with power management, mounting systems, cables and accessories. SolarWorld takes into consideration your customers' individual requirements as well as the specific building and on-site conditions to assemble a customized system solution. Sunkits are perfectly planned in advance, assembled according to the latest standards and norms and then delivered directly to the customer's construction site – for a fixed price depending on the system size. This saves time during the preparation and installation. Service that goes further: To round off the package, Sunkits are insured for two years at no extra cost. This Sunkits offer will not only safeguard your customers' investments but also give them real peace of mind. And to provide you and your customers with an overview of the system details at all times, SolarWorld also gives you a Sunpass – a comprehensive collection of quality and performance documents that is exclusive to SolarWorld.

PRODUCT BENEFITS

- Planning, design and perfectly matched components from a single source
- Tailor-made, pre-assembled kits with fixed prices for each system size that can be quickly and safely mounted
- Always in compliance with the latest standards and norms
- Upon request, the kits can be delivered directly to the construction site
- Lots of optional extras, from system monitoring to system insurance
- Certified mounting system statics according to Eurocode 1 / DIN 1055

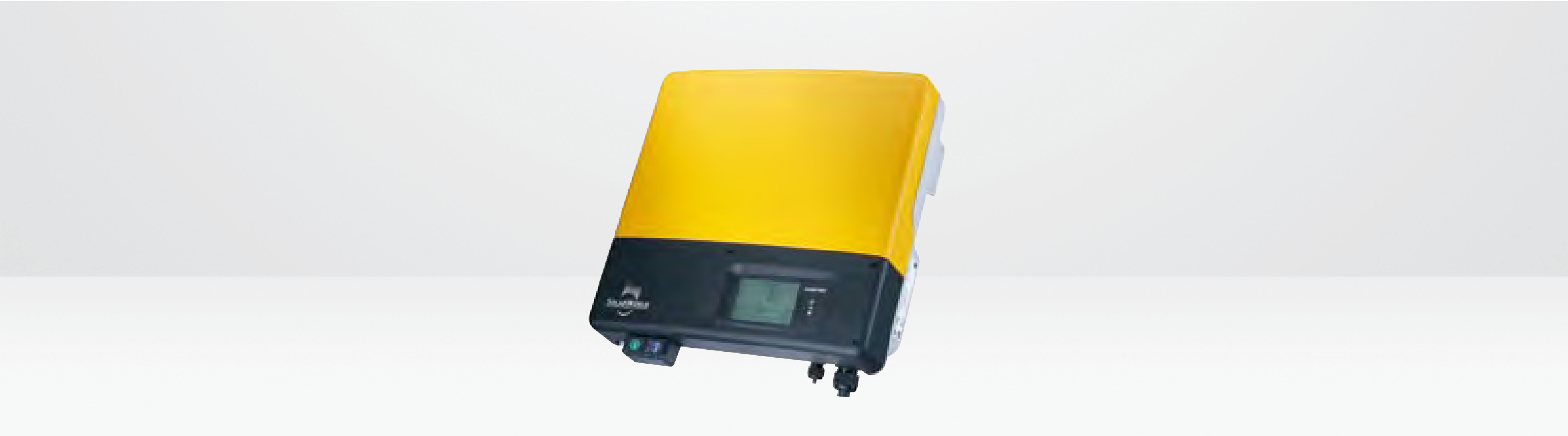
MADE IN GERMANY
WARRANTY
RELIABLE
INSURANCE
DIN COMPLIANT

Sunkits
PERFECTLY MATCHED COMPONENTS, EXCELLENT SOLARWORLD QUALITY

Sunkits *technical data*

EACH SUNKITS INCLUDES THE FOLLOWING COMPONENTS:

- Solar modules: Sunmodule Plus or Sunmodule Plus black
- Inverters according to SolarWorld's standard configuration: Kostal or SMA
- SolarWorld mounting system: Sundeck, Sunfix plus, Sunfix aero, Suntub
- DC cable set: Suncable 1 x 4 mm² / 1 x 6 mm²
- System monitoring and visualization: Suntrol
- System documentation: Sunpass PDF and high-quality print version
- Special insurance: Two or optional five-year term
- Optional: Suntrol LED / LCD display
- Optional: Battery storage system and consumption control



SMA – Versatile and user-friendly

SolarWorld offers a wide product portfolio that includes SMA inverters. Inverters come with communication interfaces as standard and feature a well thought-out installation concept, which makes them especially user-friendly. All models provide a wide input voltage range, offering maximum flexibility for system planning. Devices with or without transformers are available for every grid type.

SMA inverters – technical data (SB 4000 TL-20)

Rated AC output power	4000 W
3-phase grid feed-in	no
MPP voltage range	175–500 V
Max. input voltage	750 V
Euro efficiency	96.4 %
Number of MPP trackers	2
Integrated data logger	no
Standard communication interface	RS-485, Bluetooth
Weight	26 kg
Certification	CE, VDE0126-1-1, DK 5940 ED2.2, G83/1-1, G59/2, RD 1663/2000, RD 661/2007, PPC, AS4777, EN 50438, PPDS, KEMCO, C10/11, AEEG 084-12, UTE C15-712-1

SMA PRODUCT BENEFITS

- Integrated power management functions and graphical display
- Standard wireless and wired communication (wireless only with new generation devices)
- Innovative installation concept, including Sunclix plug connectors

INFO AT A GLANCE

KOSTAL – Standard communication

SolarWorld inverters from Kostal offer standard communication and feature comprehensive communication interfaces. They can be directly integrated into the Suntrol portal to visualize your system's yields so that an additional data logger is not required. The devices offer transformerless topology and feed power into the public grid through three phases. Highly efficient and equipped with at least 2 MPP trackers, they ensure maximum yields and flexibility for system planning.

KOSTAL inverters *– technical data (PIKO 8.3)*

Rated AC output power	8300 W
3-phase grid feed-in	yes
MPP voltage range	180 – 850 V
Max. input voltage	950 V
Euro efficiency	95.1 %
Number of MPP trackers	2
Integrated data logger	yes
Standard communication interface	RS-485, S0-Port, Ethernet
Weight	33 kg
Certification	CE, C10/C11, EN 50438, Enel-Guida, RD1663/2000, UTE C15/712-1, VDE 0126-1-1, VDE-AR-N 4105

KOSTAL PRODUCT BENEFITS

- Three phase feed-in, starting at 4 kW (AC)
- Integrated data logger saves additional costs
- Free yield monitoring via the Suntrol portal

INFO AT A GLANCE

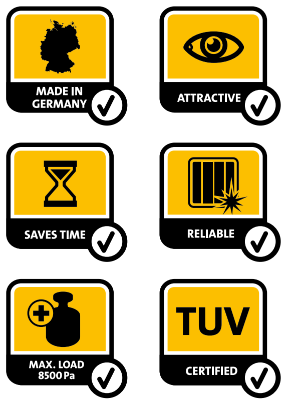
Sundeck – The perfect combination of aesthetics and efficiency

The roof-integrated system for customers with high standards: Sundeck enables SolarWorld high-performance solar modules to be elegantly positioned at the same level as the rest of the roof. Suitable for tiled roofs and slate roofs alike, it also sets new standards in terms of aesthetics as a complete roof solution. The Sundeck can be used for pitched roofs with an inclination of 15 to 60 degrees. This system will also save your customers the costs of a conventional rooftop covering. The Sundeck is technologically impressive and economical, with its small number of perfectly matched system elements. The cleverly designed rain-proof substructure is attached directly to the roof battens, making it easier to install solar systems and simultaneously saving you time. During the planning phase, the kit is adjusted to ideally suit the building's individual requirements. So your customers can look forward to a truly stylish addition to their home, as well as maximum yields.

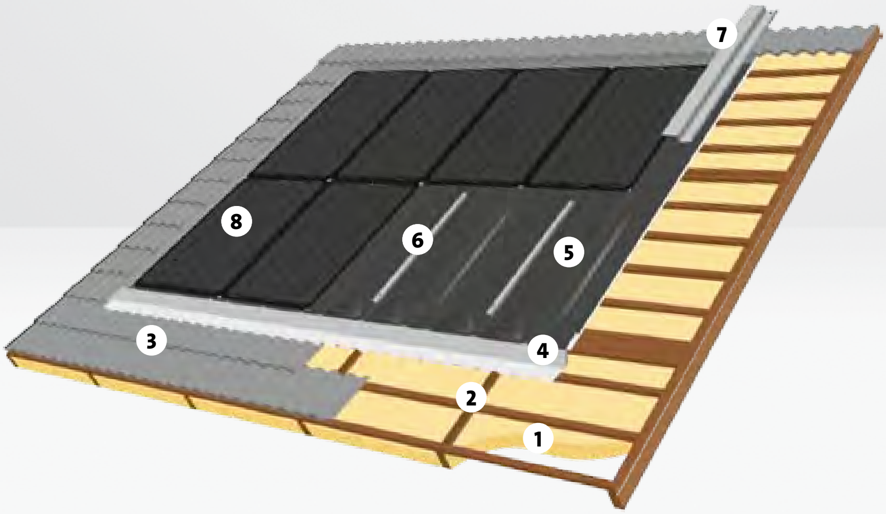
New: The Sundeck 8500 withstands extreme snow loads and is suitable for combined loads of up to 8.5 kN/m² thanks to its specially developed support profiles.

PRODUCT BENEFITS

- Unique selling point for your business success – the system is only available from SolarWorld
- Cost advantage through elimination of the rooftop cover
- High yields thanks to the special construction and optimum rear ventilation
- The sophisticated system elements do not require roof hooks, ensuring fast installation
- Perfectly suited for areas with high snow and wind loads
- TUV certification for maximum safety
- Meets the guidelines for rain safety stipulated by the Central Association of the German Roofing Industry



Sunkits
PERFECTLY MATCHED COMPONENTS, EXCELLENT SOLARWORLD QUALITY



1 Existing roof insulation
2 Existing rafters
3 Existing roof covering
4 Sundeck connection plates
5 Sundeck drainage plates
6 Sundeck support profiles (only with Sundeck 8500 model)
7 Sundeck verge cover (optional)
8 Sunmodule Plus solar modules

Sundeck roof-integrated system

Sundeck *technical data*

DETAILS

- Delivery as a complete Sunkits, including:
  - Drainage plate as a substructure (incl. fastening screws, sealing calottes, module clamp specially matched to the system, cable clips and other clips with pre-assembled nails, equipotential bonding screws)
  - Modules: Sunmodule Plus
  - Inverters
  - Pre-assembled cables
- Certified statics according to Eurocode 1 / DIN 1055 in the Sunkits
- Sundeck 8500: capable of bearing loads up to 8.5 kN/m² thanks to special support profiles
- Hard roof covering in conjunction with Sunmodule Plus according to DIN EN 13 501-5 and in conjunction with DIN V 4102-3
- TUV-certified safety with regard to the roof membrane thickness requirements
- Low load on roof construction compared to conventional roof coverings

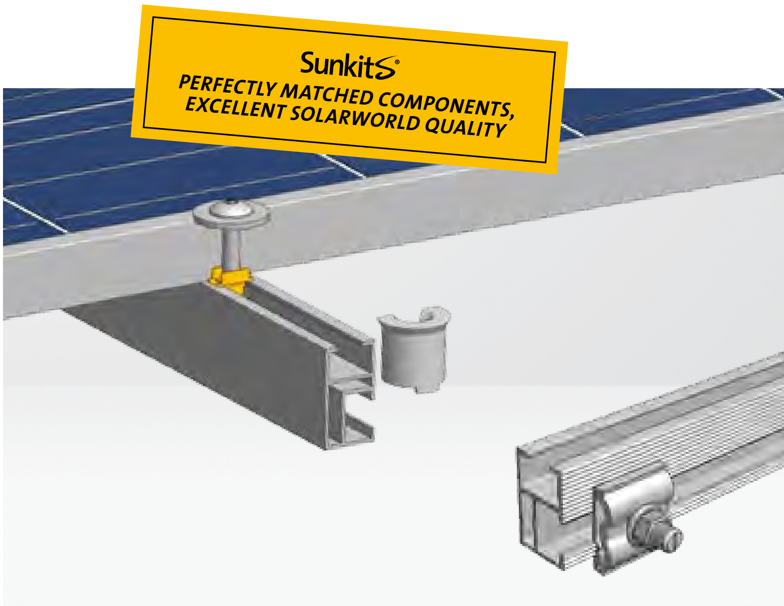
Sunfix plus – The talented all-rounder for pitched roofs

The Sunfix plus mounting system for pitched roofs is the multifunctional master of the SolarWorld framing systems. Its versatile supporting structure makes it possible to install SolarWorld quality modules parallel with the roof surface on all kinds of pitched roofs. The solar system subtly and elegantly blends into the roof's overall appearance thanks to the frame's sophisticated design. An all-inclusive package: Sunfix plus mounting kits feature high-quality, versatile components that are assembled to perfectly suit your customers' needs. It was designed by SolarWorld specialists to deliver optimum stability and a long system service life. Perfectly planned and matched to the requirements of your customers, the system can be quickly and easily installed on-site. With Sunfix plus, modules can be safely installed without causing any damage to the rooftop cover and roof membrane and the system consists of top-grade components made of aluminum and stainless steel to ensure a long service life. The potential equalization between the module and the mounting system in the overall system using the module and potential equalization clamps is VDE tested. Poor weather conditions are no match for the Sunfix plus: The mounting system for pitched roofs can withstand heavy loads in areas subject to heavy snowfall and strong winds.

PRODUCT BENEFITS

- Suitable for all pitched roofs
- Optimum rear ventilation for maximum yields
- The overall system's potential equalization is VDE-tested
- Components are perfectly and individually matched
- Pre-assembled components ensure straightforward and fast installation
- No damage to the rooftop cover and roof membrane
- Only high-quality materials are used ensuring stability and durability

Fast installation thanks to the easily accessible screw fittings



Overall system's potential equalization between the module and the mounting system using the module and potential equalization clamps is VDE-tested

Sunfix plus *technical data*

DETAILS

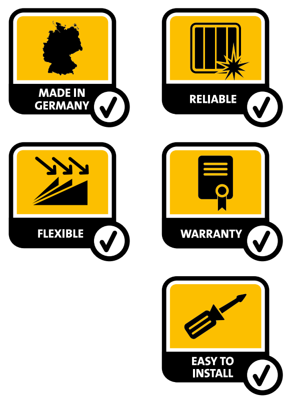
- Can be used as a single or double-layered system
- Suitable for vertical and horizontal solar module installation
- Low frame weight starting from 2 kg/m²
- Certified statics according to Eurocode 1 / DIN 1055 in the Sunkits
- Can be mounted against or with the roof pitch
- Roof hook types available for a wide range of applications
- Optionally available with theft protection

Sunfix plus – The ideal mounting system for flat roofs

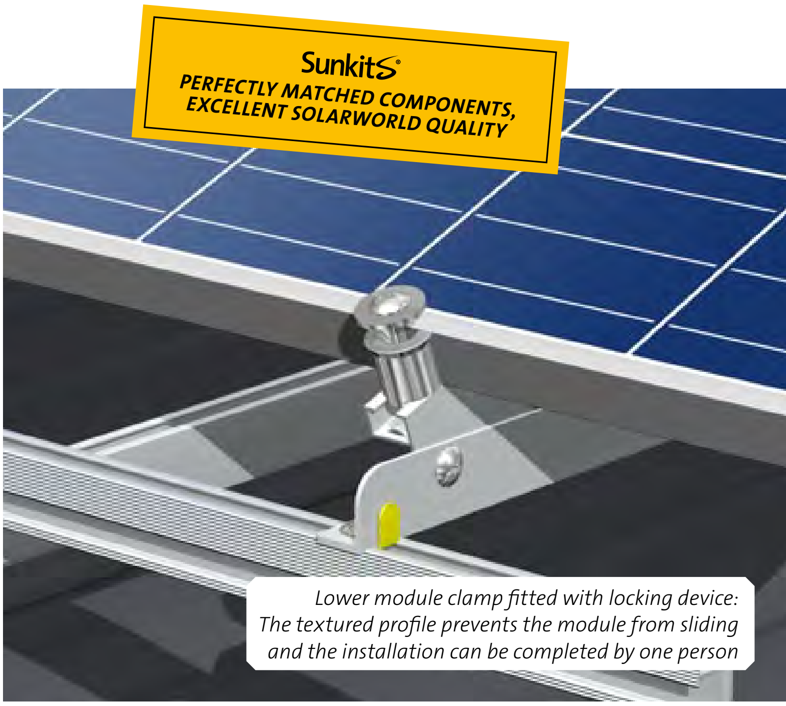
The Sunfix plus mounting system for flat roofs is suitable for all standard roof structures and turns any flat or slightly pitched roof into an effective high-yield surface for your customers. The supporting structure allows for the free-standing installation of SolarWorld quality modules both with and against the roof pitch. Module pitches of 15, 20 or 30 degrees ensure flexible installation on any roof, allowing you to optimize the efficiency of the solar modules. They can also be installed up to 5 degrees different to the roof pitch and easily individually aligned. Perfect pre-assembly: The pre-assembled SolarWorld Sunfix plus frames are made of three lightweight aluminum angle profiles that simply need to be bolted into place. SolarWorld quality right down to the smallest detail: All fixing and connecting elements are made of high-quality stainless steel or aluminum. The mounting profiles are installed in a single or double layer under the flat roof frame and the roof structure. This ensures the stability of the flat roof system.

PRODUCT BENEFITS

- Suitable for all standard roof structures
- Light aluminum frame ensures low roof load
- Optimum use of space thanks to the wide range of installation options
- Cost-efficient installation thanks to pre-assembled system
- Few tools required due to standardized components
- Flexible tilt angle for optimized module efficiency
- Only high-quality components are used ensuring stability and durability



Detailed view of angle profiles



Lower module clamp fitted with locking device: The textured profile prevents the module from sliding and the installation can be completed by one person

Sunfix® plus *technical data*

DETAILS

- Low frame weight starting from 6 kg/m²
- Suitable for vertical and horizontal solar module installation
- Can be used as a single or double-layered system
- Certified statics according to Eurocode 1 / DIN 1055 in the Sunkits
- Optionally available with theft protection

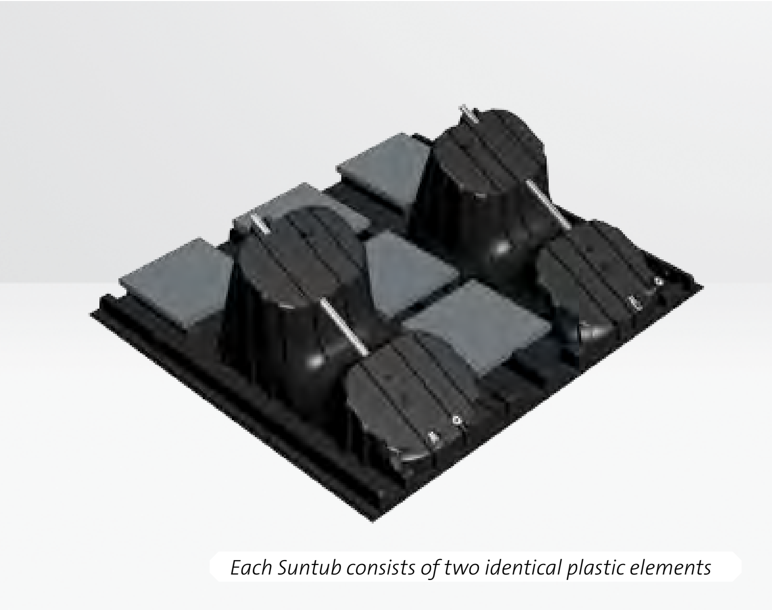
Suntub – Powerful flat roof system

The SolarWorld Suntub flat roof system is extremely versatile and easy to install. It is perfectly suited for roofs with a pitch of up to 6 degrees, for example, on company buildings or bungalows. Suntubs can be fitted with different module types. Each Suntub consists of two identical plastic elements that are easily slotted together and can be weighted down with the required ballast. The best part: You do not need a frame for the installation. As with all Sunkits, the perfectly matched components make it especially quick and easy to install. The optimized shape of the mounting system provides excellent rear ventilation and ensures that the solar modules deliver outstanding efficiency. Thanks to their special shape, Suntubs generate about 3 percent more energy than conventional flat-roof tub installation systems. Another advantage of the Suntubs is their aerodynamic design, which reduces wind resistance and keeps the roof load to a minimum.

PRODUCT BENEFITS

- Small number of individual components for very fast installation
- Reduced ballast load through minimized roof loads
- No penetration of the existing roof membrane or floor covering
- Extremely stable thanks to a special profile that withstands wind and snow loads
- Great module yield thanks to optimum shape and excellent rear ventilation
- Easy to transport and install: Low dead weight, the plastic elements can be easily stacked and the aluminum profiles feature a proven clamping technique

MADE IN GERMANY
SAVES TIME
RELIABLE
WARRANTY



Each Suntub consists of two identical plastic elements

The solar module is inserted from above and fastened using clamp connectors

Suntub® *technical data*

DETAILS

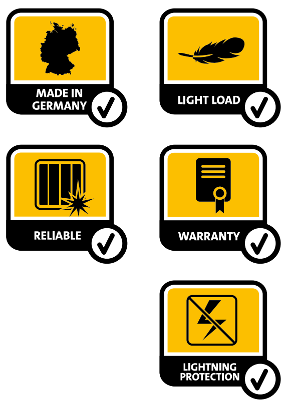
- Basic material: 100 % recyclable UV-resistant HDPE
- Modules: Sunmodule Plus
- Optimum module tilt: 28°
- Permitted roof pitch: 0° to 6°
- Required ballast: Gravel, concrete slabs (recommended slab dimension 40 x 40 cm)
- Can be used in temperatures ranging from: -40 °C to +85 °C

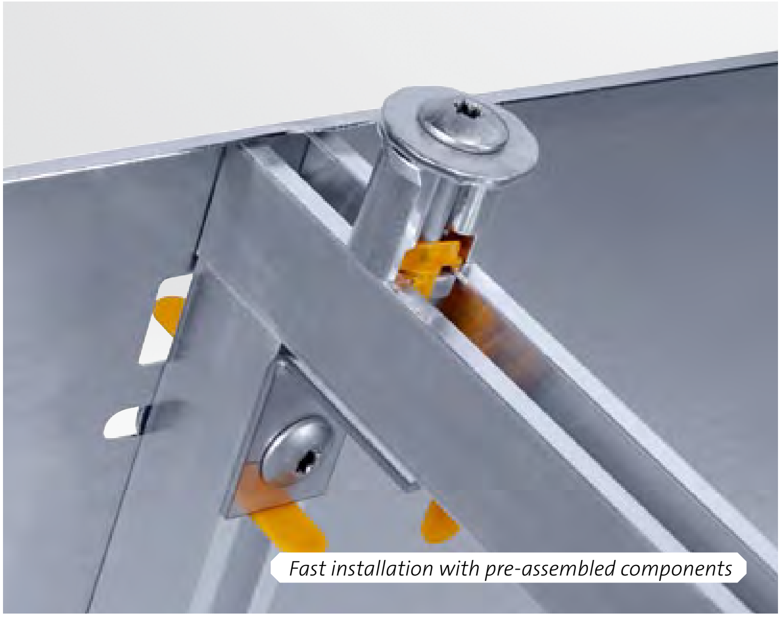
Sunfix aero – Low-ballast flat roof system

The name says it all: The Sunfix aero system is ideally suited for flat roofs with low load reserves that would typically not be able to support a solar system. The various models with a pitch of 10, 15 or 25 degrees can be optimized according to their specific yield and system capacity. The Sunfix aero can be installed on roofs with a pitch of up to 5 degrees without penetrating the roof at all. Maximum performance and minimum weight: The stainless steel and aluminum mounting system was developed according to aerodynamic principles and ensures minimum point loads and surface loads. Adjustable screw fittings and clamps on the long sides of the modules ensure increased stability and make it possible to match the system to the building. The base and ridge gap provides the SolarWorld quality modules with optimum rear ventilation for increased performance. With Sunfix aero, you'll also benefit from the all-inclusive package from SolarWorld, which is available with the Sunkits.

PRODUCT BENEFITS

- The aerodynamic design means less ballast is required, so the system can be installed on roofs with low load reserves
- No penetration of the sensitive roof membrane
- Quick and easy installation thanks to the pre-assembled, easily transportable system elements
- Optional lightning protection available
- Optimum rear ventilation through the base and ridge gap increases the solar module performance





Fast installation with pre-assembled components

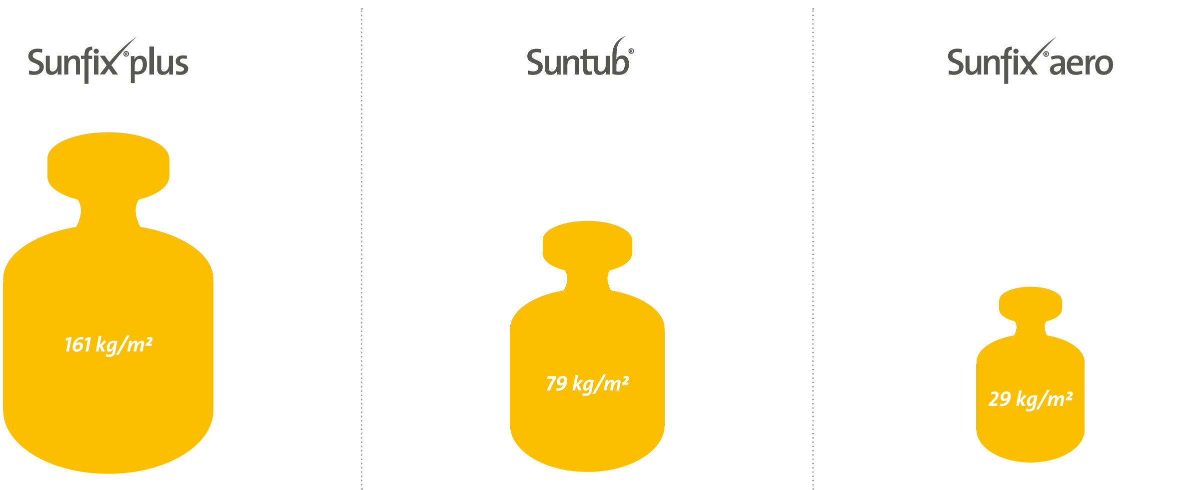
Ridge gap guarantees optimum rear ventilation

Sunfix aero *technical data*

DETAILS

- Tilt angle 10°, 15° or 25°
- Suitable for flat roofs with a pitch of up to 5°
- System weight approx. 10 kg/m² (standardized with 25° version)
- Frame / base static friction μ = 0.60 required
- Suitable for Sunmodule Plus
- Minimum system size: 3 x 3 modules
- High-quality components made of galvanized steel, stainless steel and aluminum

Comparison of the ballast load for a building height of 8–10 m

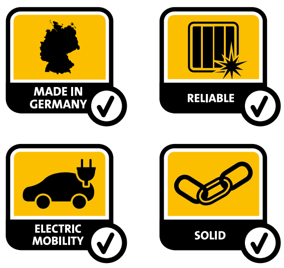


SunCarport – Power generation and weather protection

Truly multitalented: The SolarWorld SunCarport not only protects your car in any wind or weather, but it also creates an additional surface area for producing clean solar energy. Intelligent mobility: Electric cars will soon become commonplace on our streets and the SunCarport represents a vital contribution to this new kind of mobility. It acts like a solar service station where electric and hybrid vehicles can recharge their batteries. Individuality and outstanding quality: Just like every Sunkits, the SunCarport features SolarWorld quality modules, a matching inverter and a durable mounting frame. Anodized aluminum and powder-coated stainless steel components make it durable and virtually indestructible. In addition to the standard versions, SolarWorld also offers carports with reinforced components for particularly heavy snow and wind loads. SunShed is a smaller model providing a waterproof roof for e-bikes, scooters or garden equipment. SunShed can be flexibly installed directly at your house, in your garden or in open outdoor space.

PRODUCT BENEFITS

- Carport and solar charging station in one
- Includes a Sunkits, the high-quality all-in-one solution
- Can be used to charge electric cars and e-bikes with solar power
- High-quality materials
- SunShed: Smallest complete solar mounting kit on the market



Sunkits®
PERFECTLY MATCHED COMPONENTS, EXCELLENT SOLARWORLD QUALITY

SunCarport blue installed lengthwise

SunCarport black installed crosswise

SunCarport blue as a dual carport

SunCarport® *technical data* *(SolarWorld SunCarports with an inclination of 10°)*

	LENGTHWAYS AS A SINGLE CARPORT	**CROSSWISE AS A SINGLE CARPORT**	**LENGTHWAYS AS A DUAL CARPORT**
Generator	9 modules SW 240 (3 x 3)	10 modules SW 240 (5 x 2)	15 modules SW 240 (5 x 3)
Overall output	2.16 kWp	2.4 kWp	3.6 kWp
Inverters	SMA	SMA	SMA
Standard / heavy duty weight	535 / 562 kg	717 / 748 kg	1100 kg
Width	3220 mm	5241 mm	5241 mm
Length	5098 mm	3412 mm	5098 mm
Front height	2011 mm	2011 mm	2015 mm
Rear height	3024 mm	2829 mm	3005 mm

Available as a

SUNCARPORT BLUE
The standard solution: SunCarport with blue polycrystalline modules (SW 240 poly)

SUNCARPORT BLACK
The designer solution: SunCarport with black monocrystalline modules (SW 240 mono black)

SunShed® *technical data* *(SolarWorld SunShed with an inclination of 10°, installed crosswise)*

Generator	5 modules SW 240
Overall output	1.2 kWp
Standard / heavy duty weight	430 / 450 kg
Total area	7.9 m²


Suntrol portal

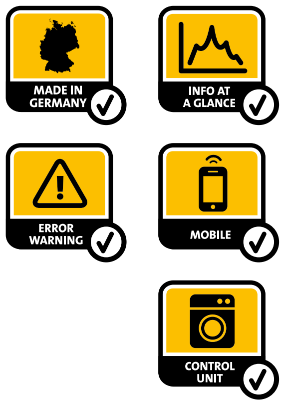

Suntrol live

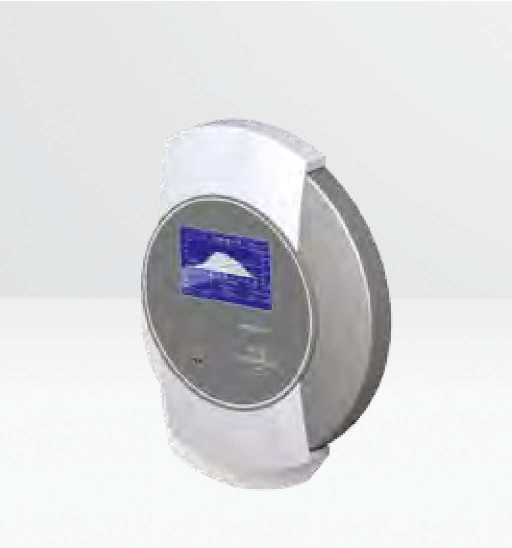
Suntrol – Keeping performance data in view

With Suntrol products from SolarWorld, you can display the yield of your solar system clearly and monitor all the system data conveniently online. The Suntrol Internet portal provides system operators with an overview of all their performance data on a PC or smartphone at all times. The Suntrol data logger is connected to the inverter and displays the daily yield minute by minute. Moreover, the monthly and annual yields are recorded and graphically evaluated. And if you use an electronic domestic supply meter, there is an added option for displaying your own energy consumption. This provides a precise overview of how much of your own electricity you have consumed and when, as well as tips on how to increase this amount. Efficient yield monitoring helps to quickly detect possible deviations and remedy their causes. This enables your customers to recognize any system errors before they receive their invoice. ↗ ***WWW.SUNTROL-PORTAL.COM***

PRODUCT BENEFITS

- Free portal for monitoring yields and the amount of electricity you produce
- Fault warning system saves your customers money
- Mobile system monitoring with Suntrol mobile for all smartphones and tablet PCs
- Option for presenting your own reference systems with the Suntrol portal and Suntrol mobile
- The amount of self-generated electricity consumed can be controlled via the Suntrol live in combination with the SunPac battery system





Suntrol data logger

Suntrol display

Suntrol mobile

Suntrol® *product family*

SUNTROL PORTAL / KOSTAL INVERTERS

Kostal brand inverters feature an integrated data logger that records the yields of the solar system. This data is then transmitted to the Suntrol portal, where it is evaluated and visualized.

SUNTROL LIVE

Suntrol live is the latest member of the Suntrol product family. It enables you to monitor and control your electricity production via a smartphone or tablet PC. But what makes Suntrol live really stand out is its real-time display of performance data and the control of loads via WLAN. This function enables you to further increase consumption of your own electricity and it also stores past statistics in the Suntrol portal at the same time. The application is directly connected to the Sunny WebBox, the communication interface between the inverter and router, via WLAN.

SUNTROL DATA LOGGER

The Suntrol data logger enables comprehensive monitoring of the solar system. It is connected to the inverter via a RS485 interface or, optionally, via Bluetooth. It comes in three versions to suit systems of different size and scope.

SUNTROL DISPLAY

With the Suntrol display, you can conveniently display and check the performance, yields and CO_2 savings. The display visualizes the current performance data inside and outside a building.

SUNTROL MOBILE

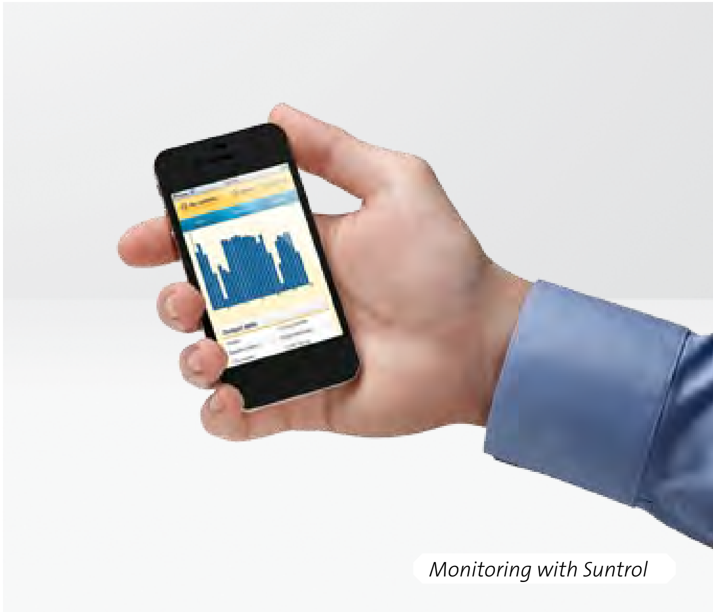
Suntrol mobile gives you an overview of your solar system's performance data and current yield situation 24/7, no matter where you are. There's a Suntrol mobile app for all Apple smartphones and tablet PCs and Android operating systems, and now there's even a web view for all smartphones.

SunPac – Innovative solar power storage system

Consume, store or feed electricity into the grid: With the SunPac battery system from SolarWorld, you can decide how you want to use the solar power you produce. Increasing the amount of power you consume directly makes you more independent from energy providers and future electricity prices. An electricity meter measures the energy flow between the grid and your home. If more power is generated than you need, the storage system will charge the battery. Conversely, if you're not generating enough power, the battery will feed additional energy into your home. In poor weather conditions, at night or in the event of a power outage, the battery system together with the special Sunny Backup charge controller switches to battery operation. In this way, the supply won't be interrupted. The Suntrol visualization software allows you to monitor the amount of solar power you generate and your consumption on a PC or smartphone. SunPac can be added to both new and existing solar systems.

PRODUCT BENEFITS

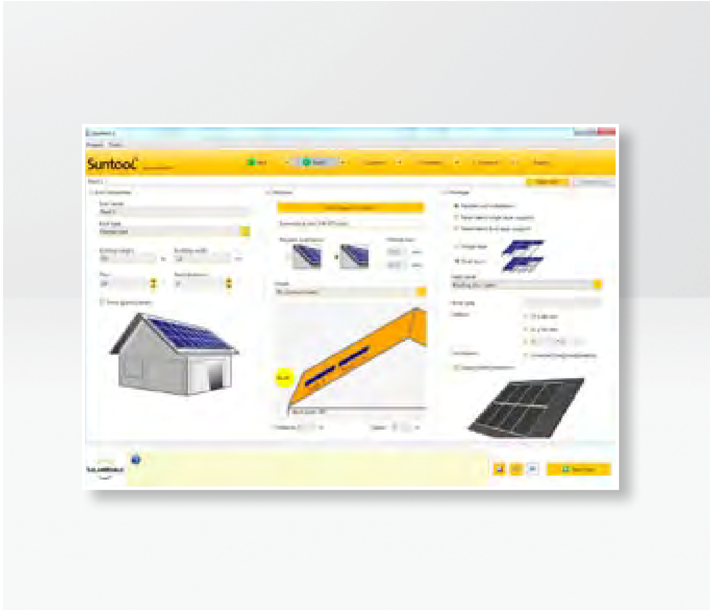
- Innovative technology that meets the highest standards
- Supplied as a complete system kit for various system sizes
- Suitable for new and existing solar systems
- Option for increasing the amount of electricity you consume directly
- Fixed electricity prices for greater independence from energy providers
- Secure power supply, thanks to coverage during power outages
- Environmentally-friendly recycling in cooperation with the battery manufacturer



Monitoring with Suntrol

SunPac® *technical data*

GENERAL SPECIFICATIONS	**SUNPAC S 6.9**	**SUNPAC S 13.8**
Rated power in grid operation	5.7 kW / 25 A	5.7 kW / 25 A
Phase number	1-phase	1-phase
Phases for backup operation	1	1
Backup power (duration / 30 min / 1 min)	2.2 kW / 2.9 kW / 3.8 kW	2.2 kW / 2.9 kW / 3.8 kW
Rated voltage	230 V / 50 Hz	230 V / 50 Hz
Rated input for AC PV power	4.6 kW / 20 A	4.6 kW / 20 A
Protection class (SBU / AS Box / battery)	IP54 / IP65 / IP25	IP54 / IP65 / IP25
Permitted grid type	TN	TN
Number of Sunny Backups	1 x SBU 2200	1 x SBU 2200
DIMENSIONS		
Dimensions SBU (W / H / D in mm)	470 / 445 / 180	470 / 445 / 180
Dimensions AS Box (W / H / D in mm)	200 / 300 / 120	200 / 300 / 120
Dimensions per battery bank (W / H / D in mm)	930 / 860 / 250	930 / 860 / 250
Number of battery banks	1	2
BATTERY		
Cycle life	approx. 2700 cycles with 50 % DoD	approx. 2700 cycles with 50 % DoD
Battery service life	approx. 13.5 years (200 cycles/yr.)	approx. 18 years (150 cycles/yr.)
Battery voltage	24 V	24 V
Energy / capacity (C10)	6.9 kWh / 289 Ah	13.8 kWh / 578 Ah
Weight (SBU / AS Box / battery)	19 kg / 4.5 kg / 292 (4 x 73 kg)	19 kg / 4.5 kg / 584 (8 x 73 kg)



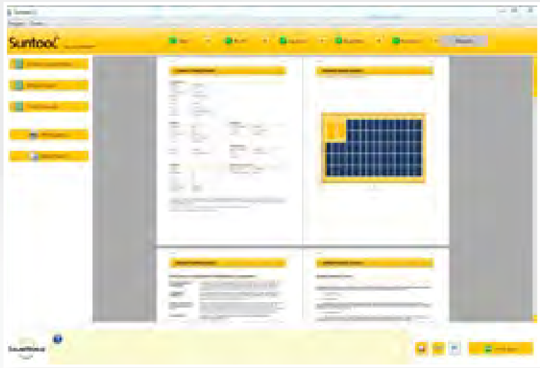
Suntool 2 – Professional design software

The Suntool software was especially developed by SolarWorld for installers, planners, wholesalers and architects. With Suntool, you can plan solar systems for virtually every roof surface in just a few minutes. Simply enter the desired system type, select the relevant mounting system and use the software to trace the available roof area for the solar system. In just a few seconds, the program calculates the maximum possible number of solar modules as well as the amount of inverters required. The software also features detailed yield forecasts, result reports and a data sheet for kit planning. Regional irradiation data, cost and yield estimates and financing possibilities are all included in the calculations. Regular updates can be accessed via the Internet and ensure that the program is always up-to-date.

New: Suntool now allows you to plan for two different performance classes (SW 196 poly and SW 245 poly) within one single solar system.

PRODUCT BENEFITS

- Uncomplicated system planning and yield calculation with professional planning software
- Especially developed for installers, planners, wholesalers and architects
- Quick and easy to use thanks to the user-friendly interface
- Straightforward document generation and management for preparing quotes
- Always up-to-date thanks to free Internet updates
- *New:* Optional planning of two different performance classes within one single solar system



Suntool® 2 *technical data*

SYSTEM REQUIREMENTS

- Windows XP or higher (Windows 7; Windows Server 2003 Service Pack 2; Windows Server 2008; Windows Server 2008 R2; Windows Vista Service Pack 1; Windows XP Service Pack 3)
- Net Framework 4.0
- Windows Installer 3.1 or higher
- Internet Explorer 6.0 or higher
- Processor: 1 GHz or higher
- RAM: at least 1 GB
- Hard drive: at least 100 MB free storage space
- Screen resolution: at least 1024 x 786
- Internet connection for updates

LICENSE TERMS

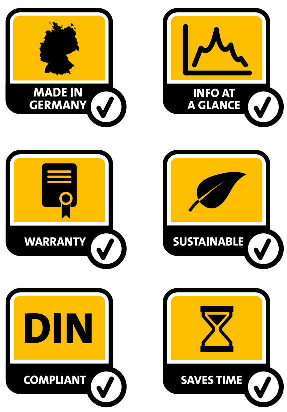
You must accept the license terms prior to using the Suntool software. They are displayed automatically when the CD starts. If you reject the contract, you can return the product and get your money back within two weeks after receiving the software. In such instances, you may not install or use the software.

Sunpass – Individualized quality and performance documentation

SolarWorld quality is not only evident in their high-quality products, but also in the way entire projects are managed, from the planning and professional installation to the comprehensive documentation of all important system data. With SolarWorld, everything's available from a single source. For example, with the Sunpass folder in German, English or French, you can provide your customers with comprehensive, individual system documentation. And when they buy a Sunkits, they'll receive all the necessary background information on the SolarWorld solar system for free – everything from the individual components and detailed construction plans, data sheets and warranty agreements. The added value for your customers: With the Sunpass folder, your customers will always have access to their solar system's performance data, also for potential requests from the sector or for maintenance. The Sunpass reflects your high-quality work – even after the system is installed.

PRODUCT BENEFITS

- Individualized SolarWorld system documentation for your customers
- All important documents are clearly organized according to DIN IEC 62446
- System data compiled in advance to save time
- Available as a practical folder or PDF document
- Comprehensive documentation illustrating the quality of the work
- Sustainably produced
- Free delivery with each Sunkits



SunpasS *technical data*

EACH SUNPASS INCLUDES THE FOLLOWING:

- Concise documentation of the solar system
- Warranty agreements
- Certification
- Data sheets
- Individualized quality and performance documentation
- Certificate from a specialist installer verifying the correct installation
- Sunkits special insurance certificate (free for two years, can be extended to five years upon request)
- Additional record for all correspondence regarding the solar system

Sunkits – Free special insurance for solar systems

Service from a single source: SolarWorld offers a customized insurance concept for all newly installed Sunkits. The free special insurance is included with the kit at the system operator's request. In cooperation with the ERGO Insurance Group, SolarWorld has developed a safety concept that covers property damage to the solar system as well as the associated risk of operational interruptions. Yield losses resulting from reduced performance are also covered. System operators can select between a two or five-year term and the insurance is free for the first two years. If it is extended to a five-year term, a reasonably priced one-off premium is charged for the additional three years. There is no minimum premium. SolarWorld is the policy holder; the system operator is also insured by a framework agreement and is the beneficiary in case of damage. This is how we save your customers the inconvenience of conducting complicated research and negotiations in advance. After the selected term has expired, the insurance expires without requiring termination.

PRODUCT BENEFITS

- Available upon request for all newly installed Sunkits
- Individual insurance for solar systems
- Maximum security for your solar investment
- Free two-year insurance coverage for the two or five-year term
- No minimum premium
- Quick and simple application process
- Insurance expires automatically after the term expires


Sunkits® *special insurance: targeted cover*

A) THE ALL-RISKS INSURANCE

Covers unforeseeable property damage and insured objects lost through theft, burglary or looting. In particular, the insurance covers damage caused by:

- Operating errors, ineptitude or willful intent by third parties
- Short-circuit, overcurrent and overvoltage
- Failure of measuring, control or safety equipment
- Fire, lightning strike, explosion
- Water or moisture
- Storms, hail, frost, ice drift, flooding or snow load
- Animal bite

B) OPERATIONAL INTERRUPTION INSURANCE

Compensation for any lost electricity feed-in revenue if the functioning of the solar system is interrupted or adversely affected by property damage or loss. The maximum compensatory payment is available as of the first day the system fails for maximum one year.

C) REDUCED YIELD INSURANCE

The reduced yield insurance offers unique extended coverage. A claim can be made if the level of the predicted annual energy yield is not reached by more than 10 percent due to insufficient solar irradiation.

D) CONSTRUCTION COVERAGE

This type of insurance is valid from the start of the installation phase, for maximum of 3 months. The construction coverage provides compensation for property damage caused by:

A. Fire, lightning strike, explosion, impact or if an airplane crashes into the construction, or an airplane's parts or cargo fall from the sky.

B. Storm or hail and loss due to theft of insured components securely connected to the building and burglary of securely stored, insured items.

Requirements for the insurance:

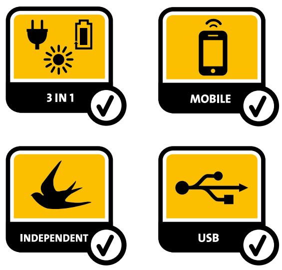
- All details regarding the installer and system operator must be included in the documentation at the time the order is placed.
- Purchase of a complete Sunkits or a SunCarport

SunCharger – Solar system for your pocket

The SolarWorld SunCharger is the world's first mobile device to combine a power supply, battery and solar generator in one. Cell phones, cameras and MP3 players obviously require power when you take them with you on vacation or business trips. SunCharger supplies power at all times, eliminates the need to carry around many different chargers and extends the operating time of your smartphone. Its integrated solar cell generates climate-friendly power, which allows you to power mobile devices using a USB cable. The high-performance silicon cells fitted on top of the device charge the SunCharger battery on demand and at any time. You can increase the solar cell area by opening the sliding device. SunCharger is your high-quality companion for a green lifestyle. Its modern design has even been honored with a red dot design award. Generate your own climate-friendly solar power and never go without a power supply – those are the benefits of the SolarWorld SunCharger.

PRODUCT BENEFITS

- 3 in 1 – SunCharger is a power supply, additional battery and solar charger
- Practical size when you're on the go – you can use it anywhere, any time
- Independence from the public grid
- USB connection ensures compatibility with a wide range of devices
- Green lifestyle product



SUNCHARGER® *technical data*

DETAILS

Dimensions (W x H x D)	78 x 115 x 23.8 mm
Weight	200 g
Solar cell area	10.470 mm²
Input voltage	100–240 V~/ 50–60 Hz / 130 mA
Output voltage	5 V
Output current	500 mA to 600 mA according to USB specifications
Internal battery capacity	≥ 1200 mAh
Rated battery voltage	3.7 V
Operating temperature	0°C to +40°C
Certification	VDE-tested, IEC 60950-1

reddot design award
winner 2012

Find out more

Do you have any questions about SolarWorld's quality standards or individual products? Then don't hesitate to contact us. We will gladly provide you with additional information and show you exactly how SolarWorld can prepare you for the solar future today.

SIMPLY CALL US OR SEND US AN EMAIL:

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SOLARWORLD

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