SOLAR ENERGY

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ISCAT
Innovative Science
Application and Technology

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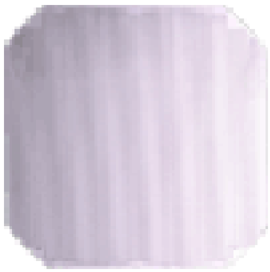
Novembre 2006, Gianfranco Sorasio :: Energia solare parte II

THE PV CELL

PV CELLS

Photovoltaic system are designed around PV cells.

Front Side



Back Side

The I-V characterstics of an ideal PV cell are:

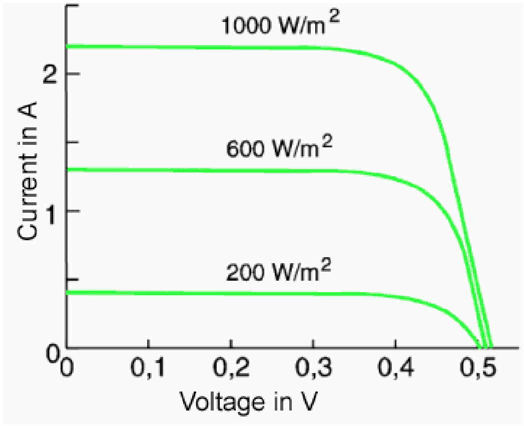
$$I = I_\ell - I_0 \left(e^{\frac{qV}{kT}} - 1 \right)$$

Where I_ℓ is proportional to the irradiance and, when V = 0, is equal to I_{OC}.

To a very good approximation, the cell current is proportional to the cell irradiance

The voltage, varies slightly with irradiance and can be written as:

$$V_{OC} = \frac{kT}{q} \ln \frac{I_\ell}{I_0}$$



FILL FACTOR

The maximum power of a PV cell can now be written as:

$$P_{max} = I_{max}V_{max} = I_{SC}I_{OC} \times FF$$

The FF is the fill factor. It is very important to understand how the cell characteristics are close to the ideal bahaviour.
The fill factor is the measure of the quality of the cell. We can extend this logic to the PV Modules.

The cells are very Temperature dependence. The reverse saturation current is proportional to the temperature --> the Voc decreeases of about 0,5%/ºC, the current remanis constant ... if the temperature is about +30 over the STD we have 15% decrease in maximum power

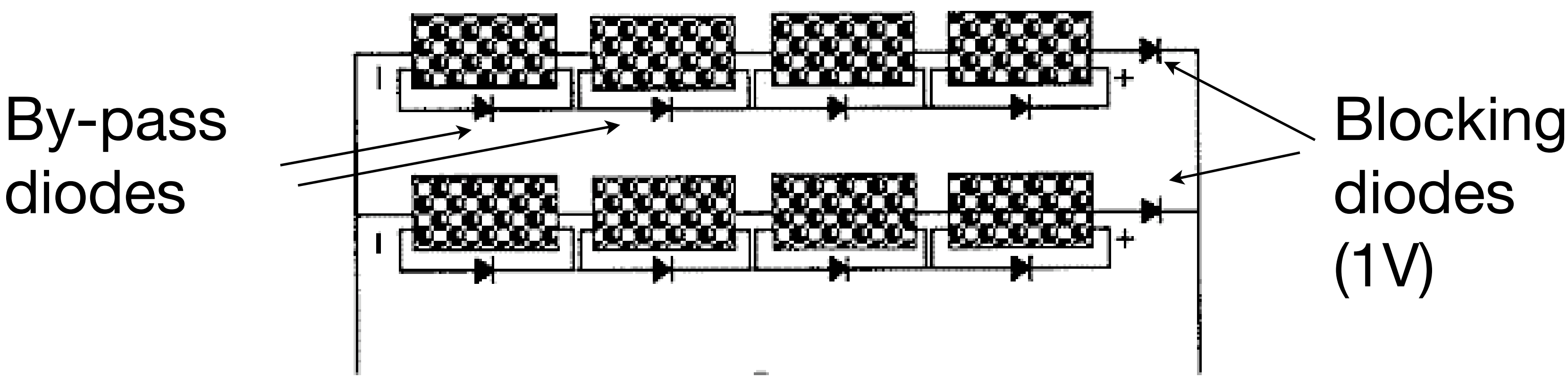
PV MODULES

PV PANELS :: I

The cells work at low voltages (0,5 V) and low power (2 W). In order to increase both the cells are connected in series to create a PV panel.

Clearly the PV modules must be optimized to guarantee maximum performance:

- what happens when there is no sun, night or clouds
- what happens when a portion is shaded



PV PANELS :: II

PV Modules characteristics ... I_{SC}, P_{max}, V_{OC} , tolerances to maximum power, temperature coefficient...

NOCT is nominal operating cell temperature

Is the temperature the cells will reach when operated at open circuit in an ambient temperature at 20ºC at AM 1.5, irradiance I = 0.8 kW/m^2 and wind speed less than 1 m/s
The working temperature can be extimated to be:

$$T_C = T_A + \left(\frac{NOCT - 20}{0.8}\right) I$$

When I = 1 kW/m^2 in summer (T_A ~ 35ºC) the NOCT is 44.2ºC for the Sanyo and 48.5ºC for SunPower. T_C ~ 65 ºC for the Sanyo and 70ºC for SunPower. If the temperature coefficient is about 0.3% / ºC (Sanyo) or 0,38% /ºC (sunpower) then the lost is about ~ 12% .. if we use Sunpower 0,38%/ºC then the lost is about 17%. Using SE220 we have NOCT = 43ºC, Tc=64ºC, 0.43% / ºC and the lost is about 19%. For Evergreen is NOCT = 47ºC, Tc=68ºC and the lost is about 22%.

EU installed power

T1 **PUISSANCE PHOTOVOLTAÏQUE INSTALLÉE DANS L'UNION EUROPÉENNE DURANT L'ANNÉE 2004-2005 (EN MWC)**
PHOTOVOLTAIC POWER INSTALLED IN EUROPEAN UNION DURING THE YEAR 2004-2005 (IN MWP)

Pays/*Countries*	Marché/*market* 2004			Marché/*market* 2005*		
	réseau/ *on grid*	hors réseau/ *off grid*	Total	réseau/ *on grid*	hors réseau/ *off grid*	Total
Allemagne/*Germany*	500,000	3,000	503,000	600,000	3,000	603,000
Espagne/*Spain*	9,241	1,348	10,589	18,700	1,500	20,200
France/*France*	4,180	1,050	5,230	5,800	0,567	6,367
Italie/*Italy*	4,200	0,800	5,000	4,500	0,500	5,000
Royaume-Uni/*United Kingdom*	2,197	0,064	2,261	2,400	0,100	2,500
Autriche/*Austria*	1,833	0,514	2,347	1,730	0,520	2,250
Pays-Bas/*Netherlands*	5,540	0,120	5,660	2,000	0,100	2,100
Grèce/*Greece*	0,150	1,151	1,300	0,156	0,745	0,900
Portugal/*Portugal*	0,103	0,528	0,631	0,100	0,500	0,600
Total U.E.	536,431	9,443	545,873	636,857	8,430	645,287

The expected production in 2010 of 10,4 gigawatt (530% growth versus 2005) at a turnover of 57,6 billion euro and a pre-tax profit of 21,6 billion euro.

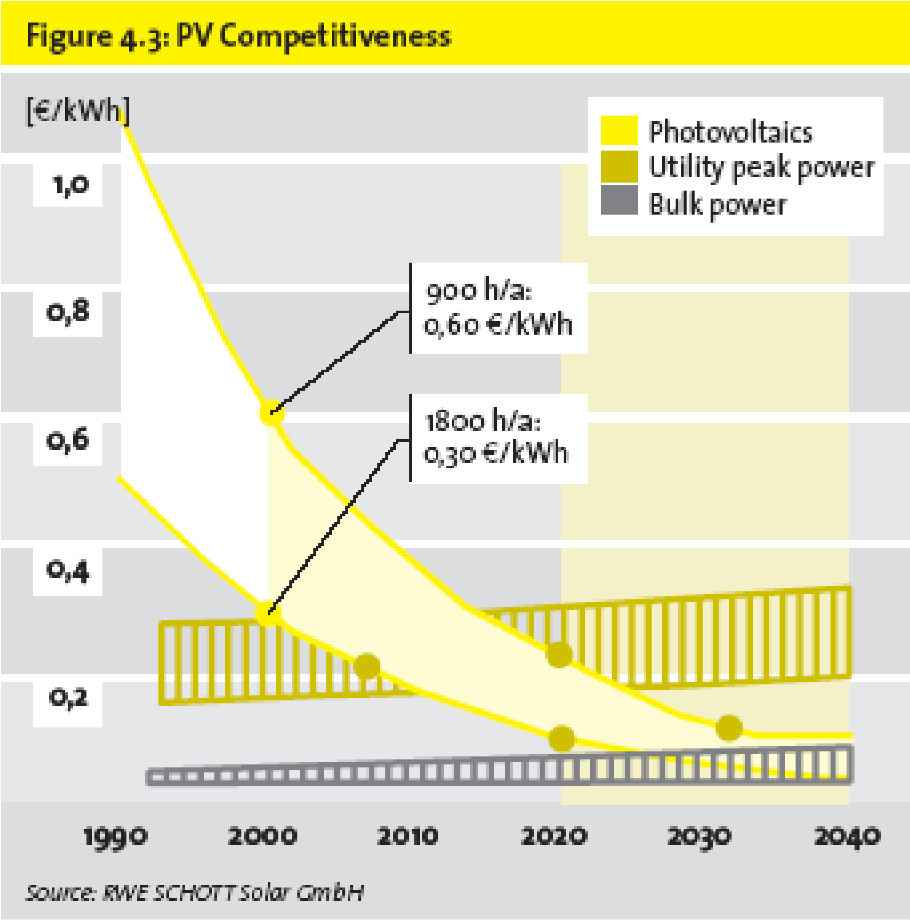
THE COST

How much costs a solar kWh

About 30 jobs are created to produce and install 1 MW of solar modules.

The maintenance creates about 2 to 3 jobs per MW.

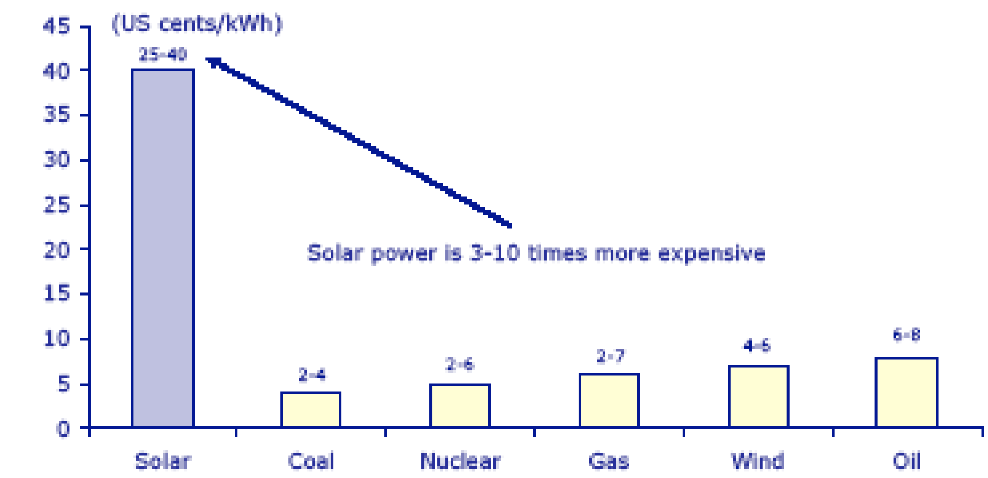
Very much higher than all the other energy sources.



Cost Data

Figure 1

Typical range of fully-loaded generating cost



Note: rough range of typical costs. Source: CLSA Asia-Pacific Markets

Figure 3

Outlook for solar power sector[1]

	2003	2004	2005	2006	2007	2008	2009	2010
Demand (gigawatt)	0.7	1.0	1.4	1.9	2.4	3.2	4.1	5.3
Demand growth (% increase in MW)	0	40	38	35	30	30	30	30
Average installed price (US$/watt)	7.0	7.1	7.0	6.8	6.5	6.2	5.8	5.5
Revenue pool (US$bn)	5	7	10	13	16	19	24	30
Industry avg. operating margin (%)	8	11	13	14	14	13	12	11
Operating profit pool (US$bn)	0.4	0.8	1.2	1.8	2.3	2.6	3.0	3.3

[1] Estimates based on >60 interviews with solar industry executives, government officials, and customers. Average prices are higher than typical prices due to higher-price small wattage modules, higher price installations (often in more remote areas), customer design services, processing fees in some markets, use of additional components (e.g. batteries) in small percentage of installations. Source: CLSA Asia-Pacific Markets

More data

Figure 16

Rough estimate of 2004 global solar power revenue pool[1]

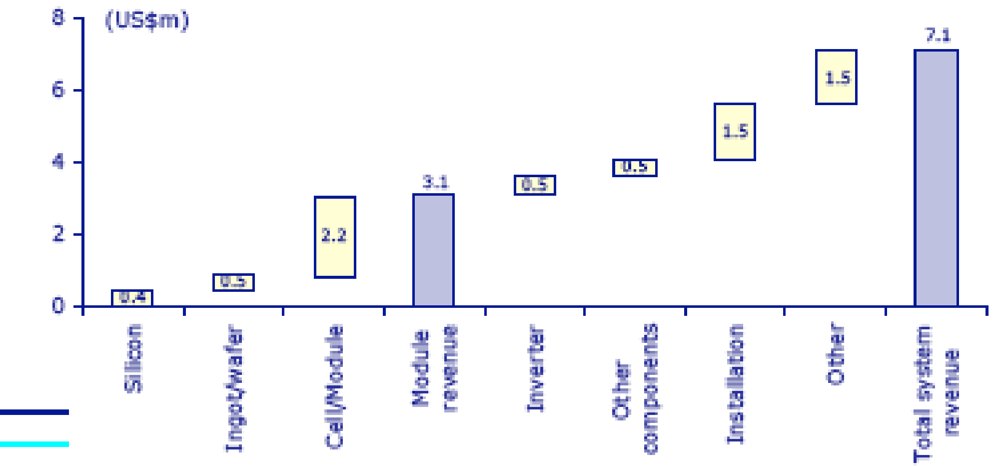
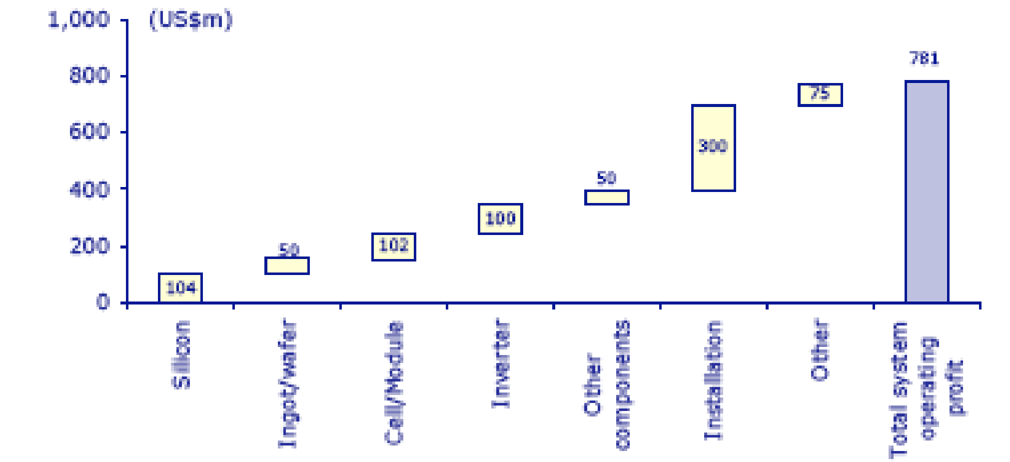


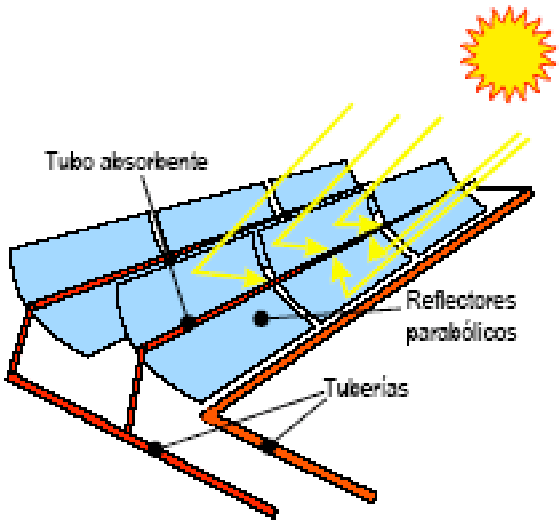
Figure 18

Estimate of 2004 solar power profit pool[1]



RESEARCH

Solar Concentration :: Thermal



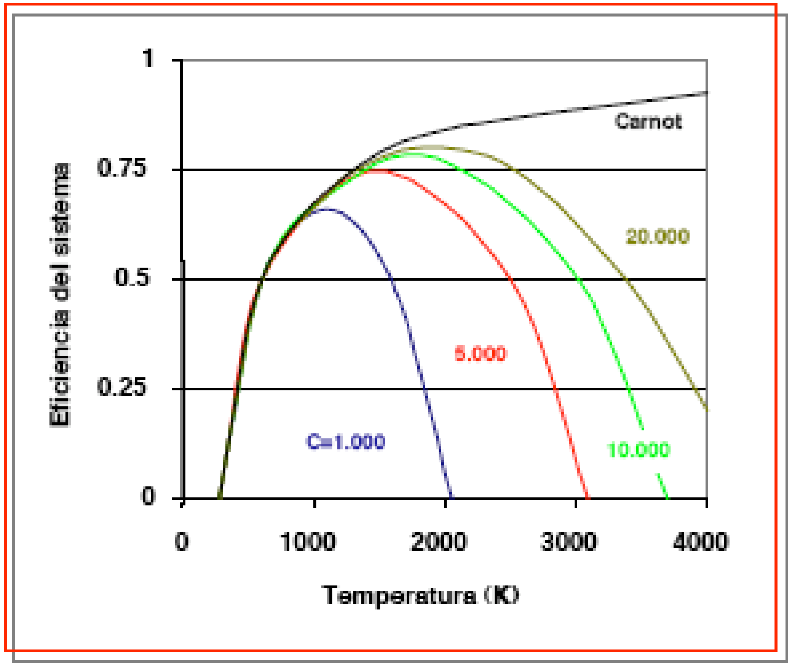
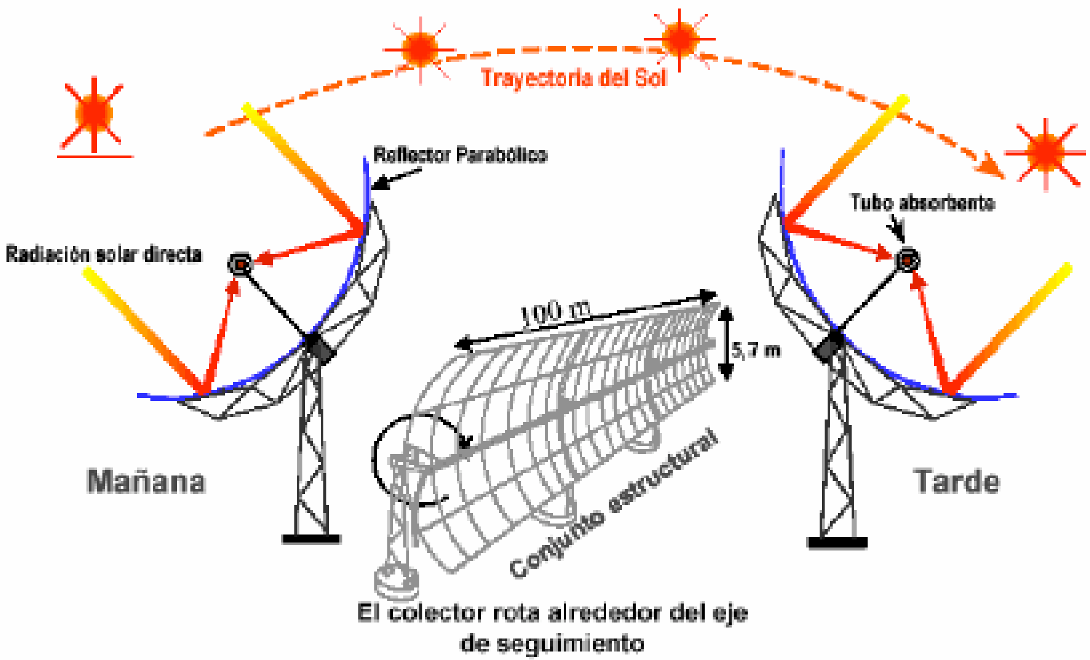


Figura 2. Rendimiento energético de un sistema termosolar en función de la temperatura de operación, tomando como parámetro la razón de concentración

Solar concentration :: thermal



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COMPACT LINEAR FRESNEL REFLECTOR SOLAR THERMAL POWERPLANTS

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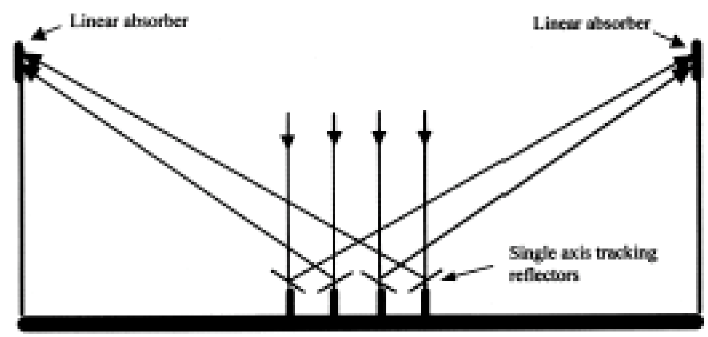
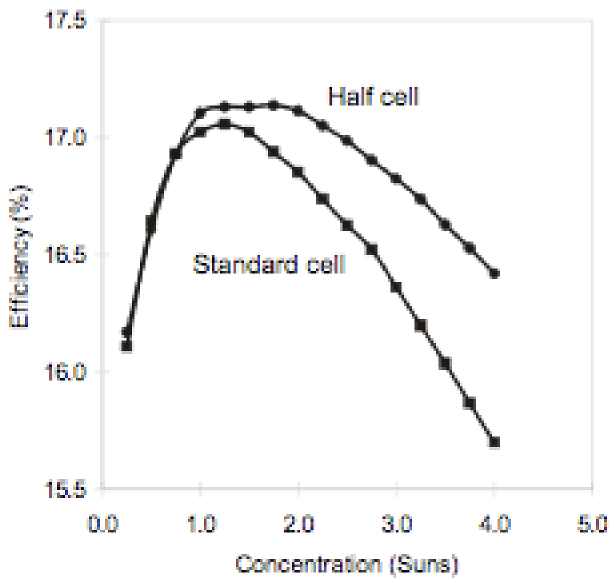


Fig. 1. Schematic diagram showing interleaving of mirrors without shading between mirrors.

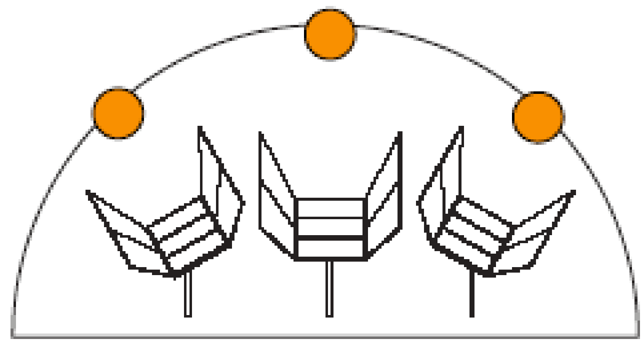
PV CONCENTRATION

Research in Portugal

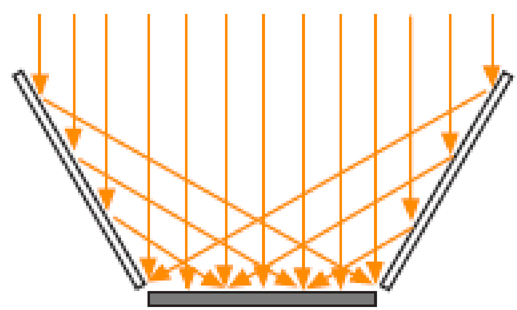


Como funciona?

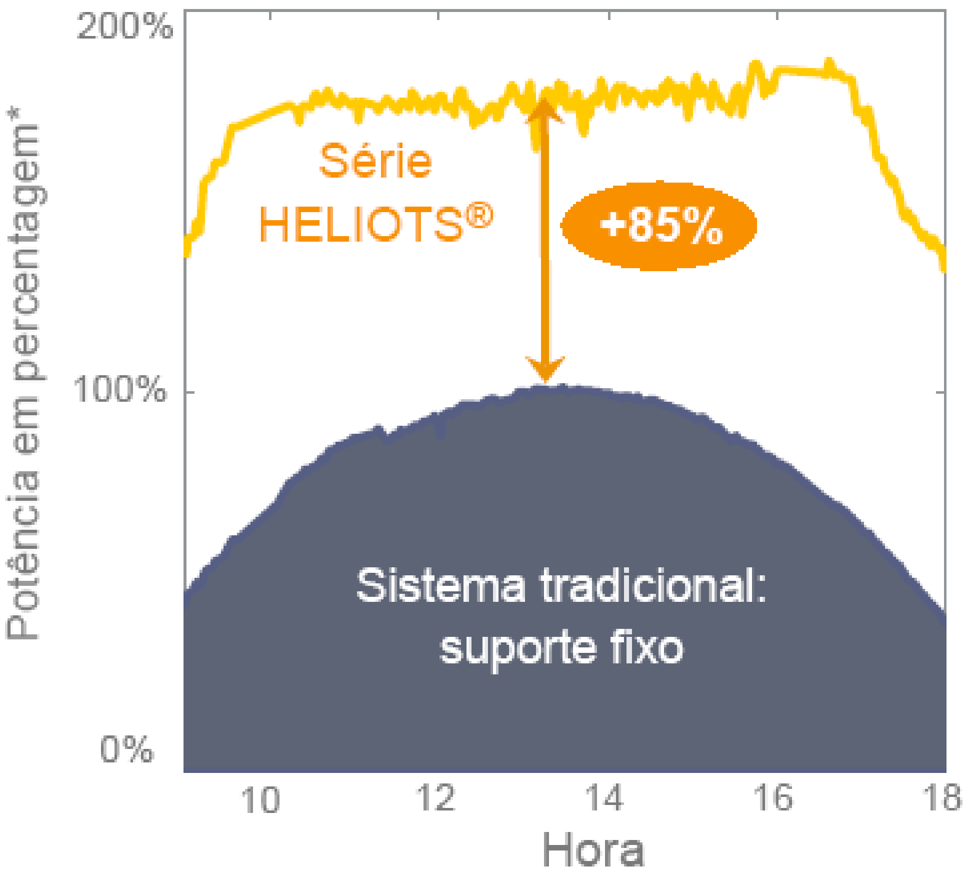
Sistema de seguimento do Sol

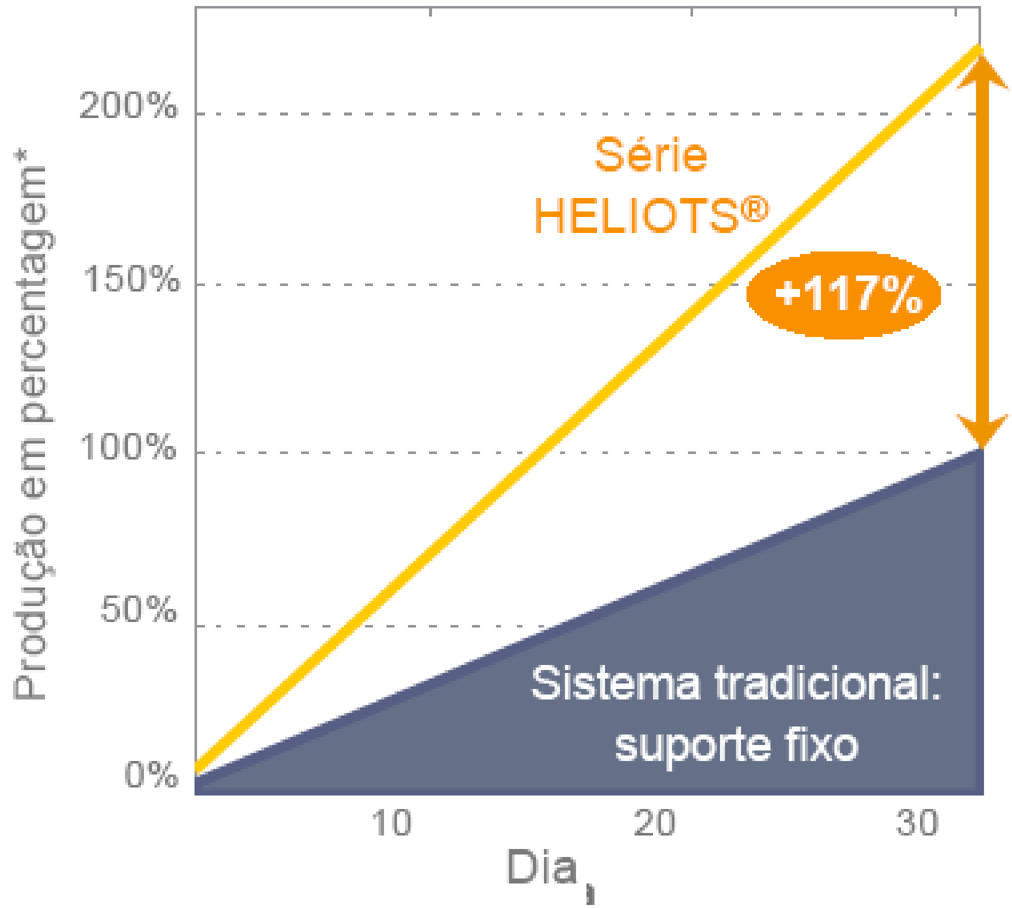


Sistema de concentração da radiação solar



Serie HELIOTS





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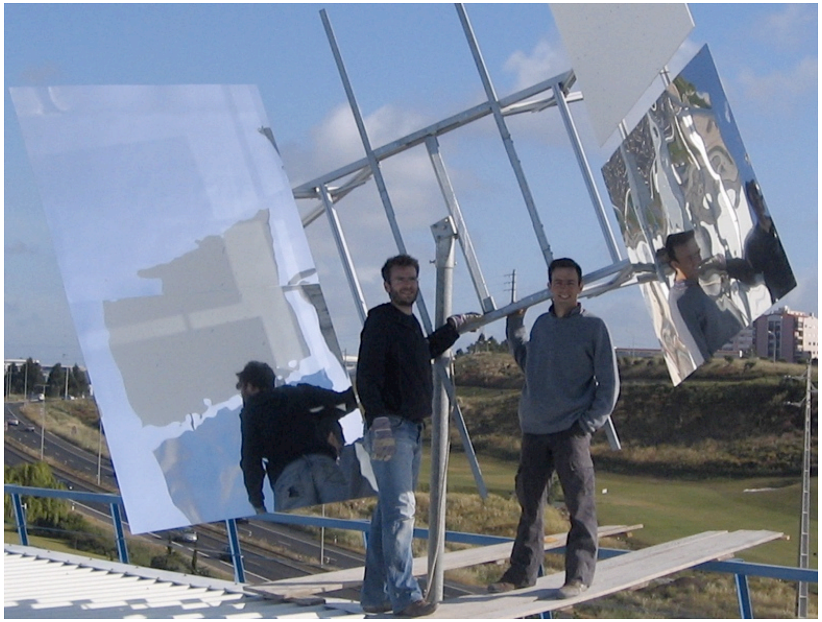

MIRRORS

WORK FOR YOU

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