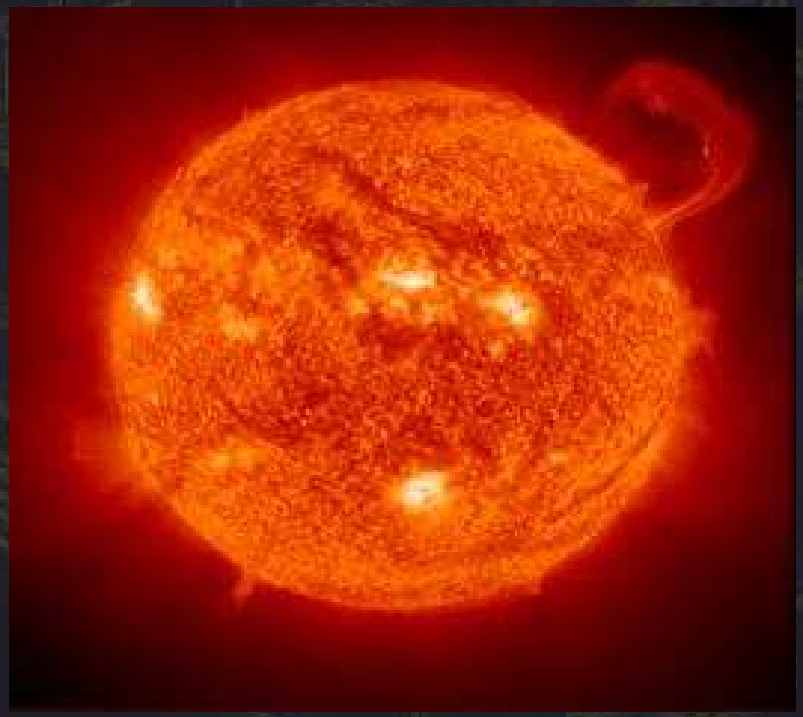
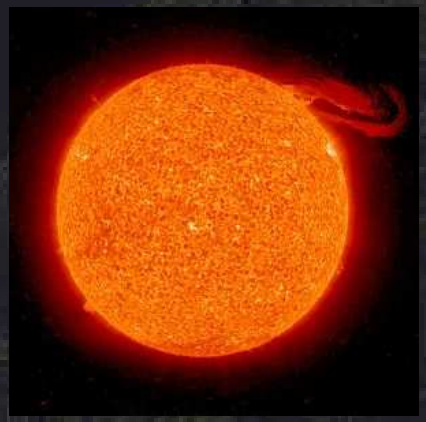
LESSON 3:
SOLAR RADIATION



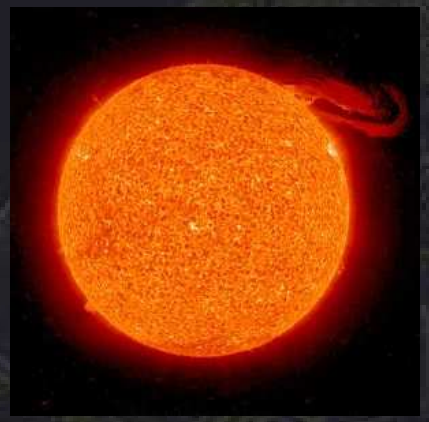
SOLAR THERMAL ENERGY



P = 1.72 x 10e17 W

P = 100 W

SOLAR THERMAL ENERGY



Incoming solar radiation energy in a year:

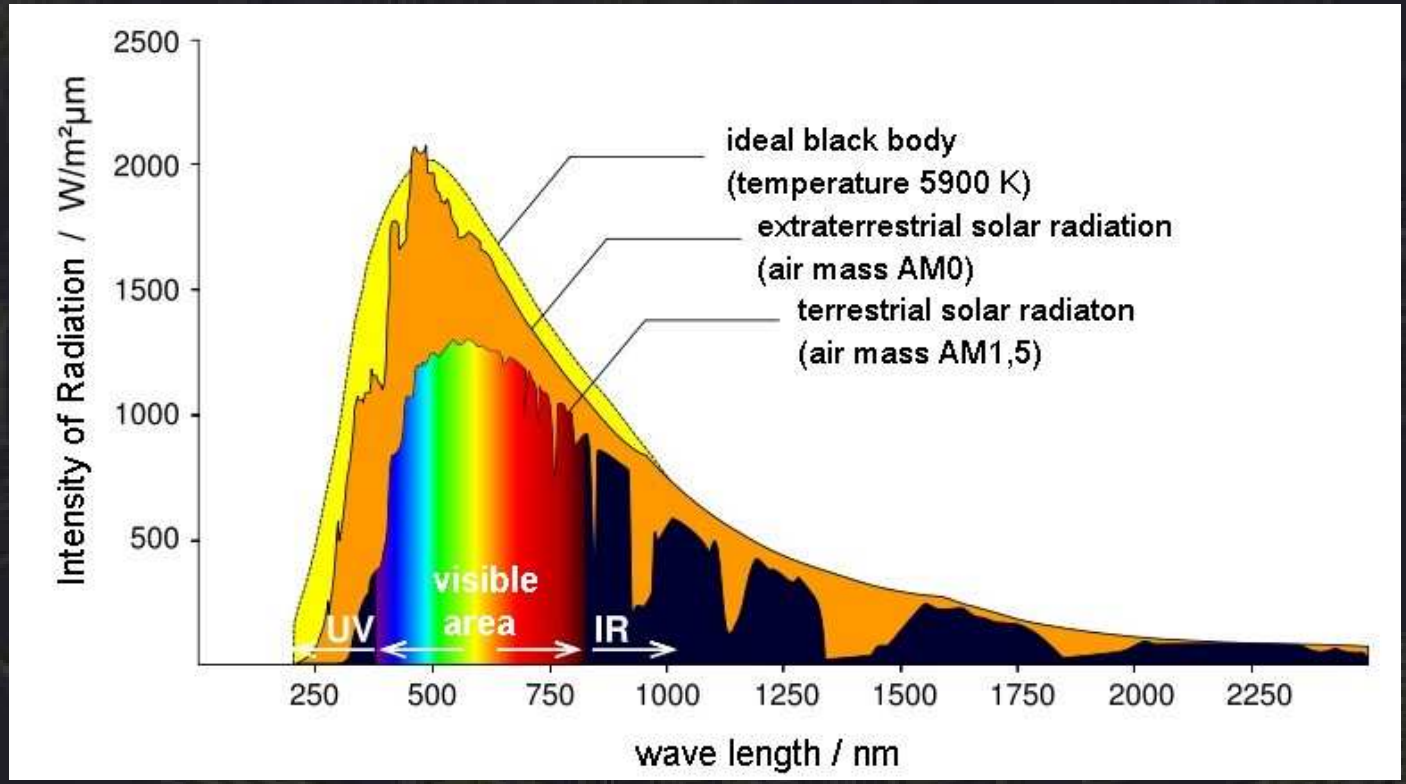
5.42×10^{24} J

yearly energy need of the whole world:

5×10^{20} J

More than 10 000 times

SOLAR THERMAL ENERGY



SOLAR CONSTANT = 1,353 W/m^2

SOLAR THERMAL ENERGY

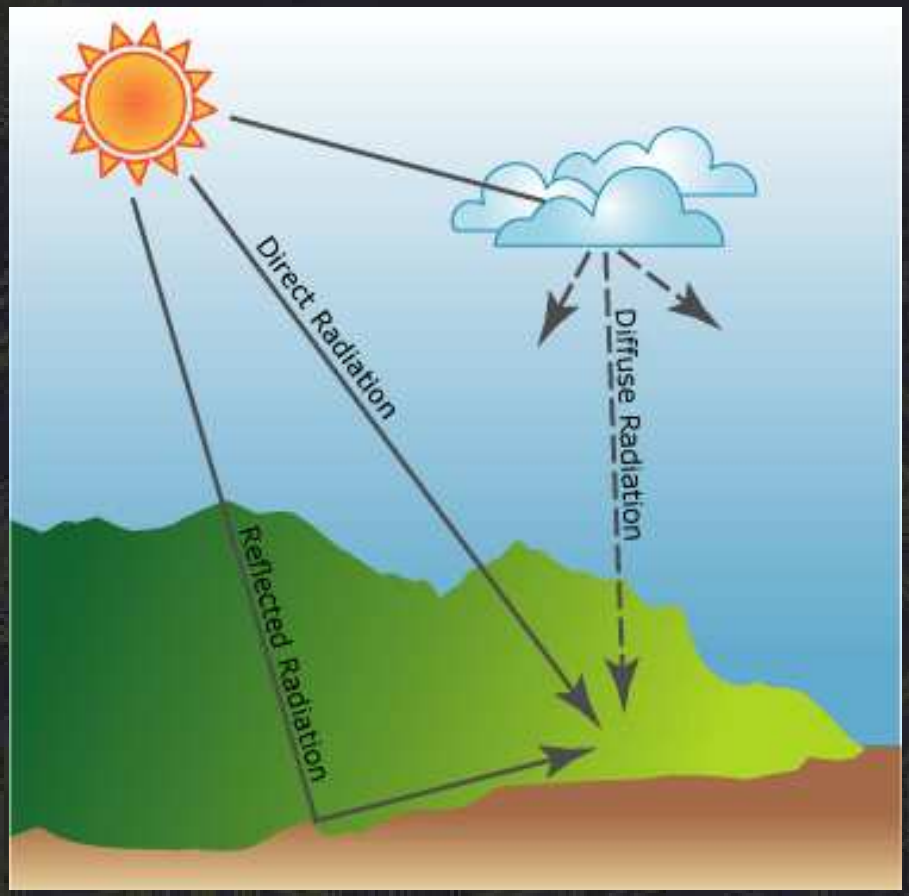
SOLAR CONSTANT

1360 W/m²

GLOBAL IRRADIATION

800 – 1000 W/m²

SOLAR THERMAL ENERGY



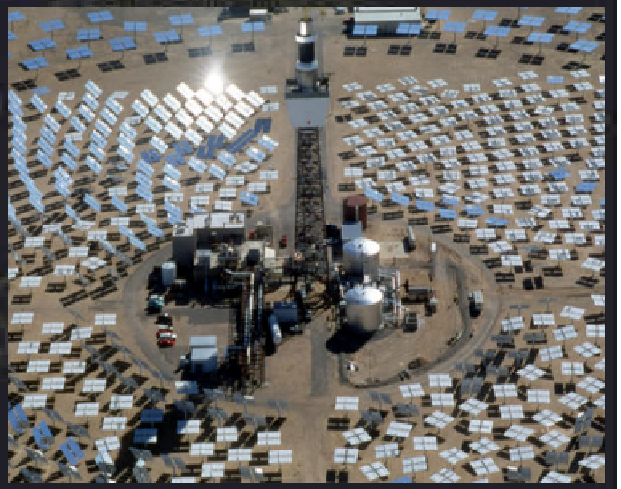
Direct, or also called "beam radiation" is the solar radiation received from the sun without having been scattered by the atmosphere.

SOLAR THERMAL ENERGY

< 90°C - low temperature

< 300°C - medium temperature

< 800°C - high temperature

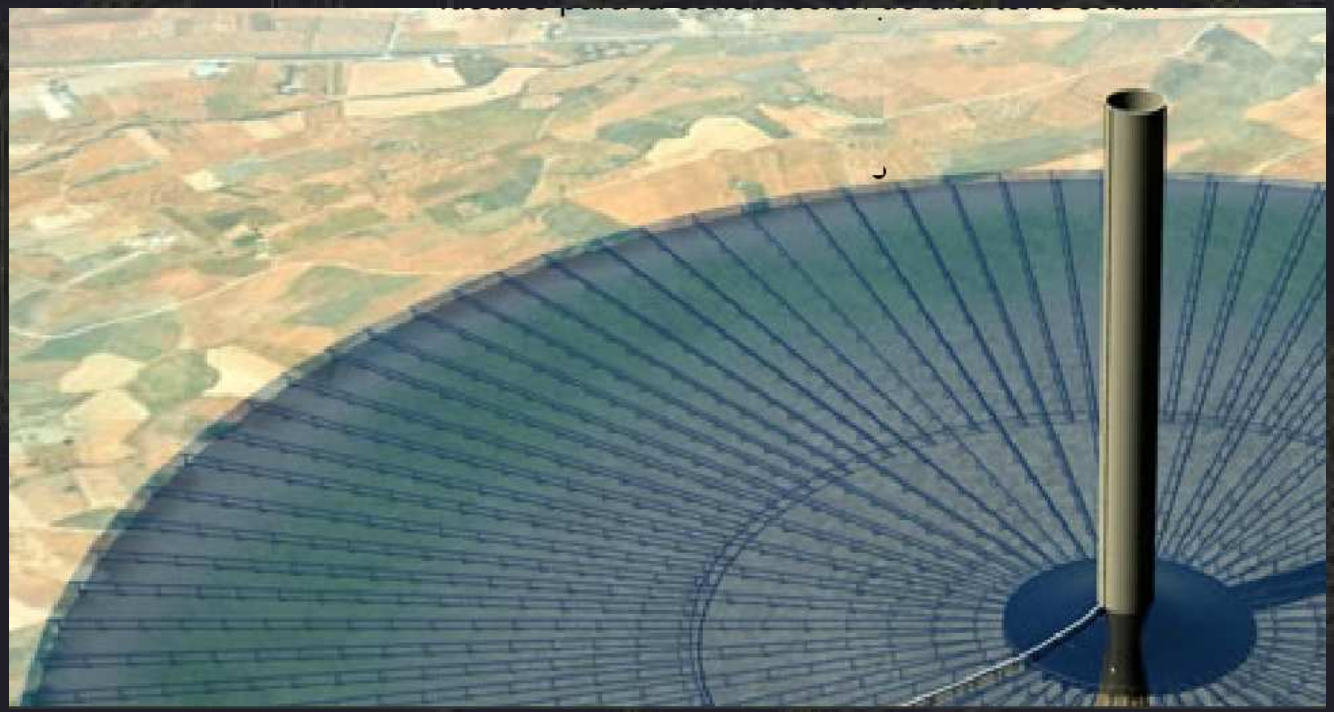


Parabolic and solar tower

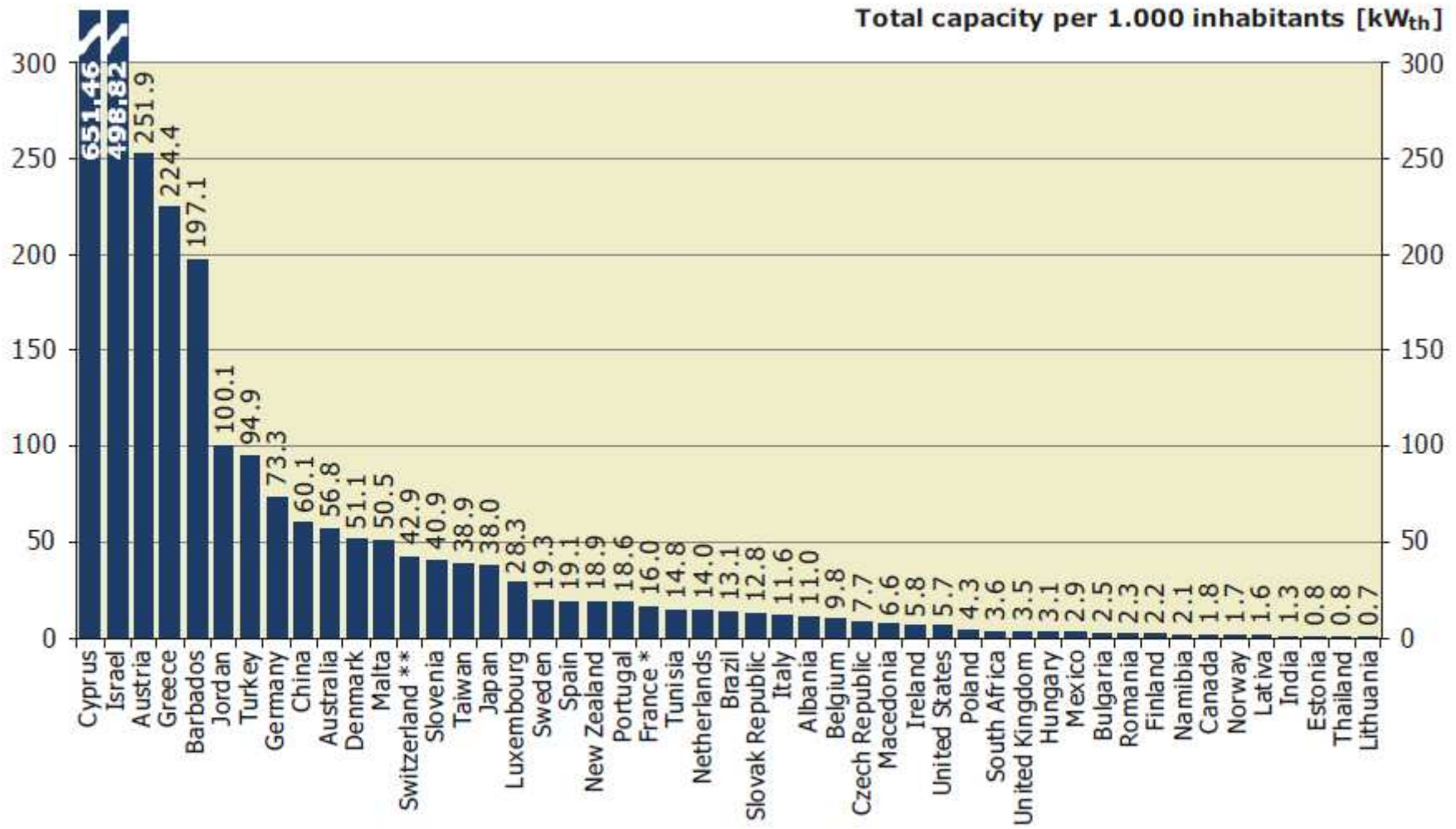
Solar updraft tower

The first prototype of this technology was tested in Manzanares (Ciudad Real), with a collector area of 240 meters in diameter and a tower of 195 meters. It was in operation for seven years (1982-1989). The plant supplied 50 kW peak.

Solar updraft tower



SOLAR THERMAL ENERGY



Total capacity of glazed flat-plate and evacuated tube collectors in operation at the end of 2007 in kWth per 1 000 inhabitants

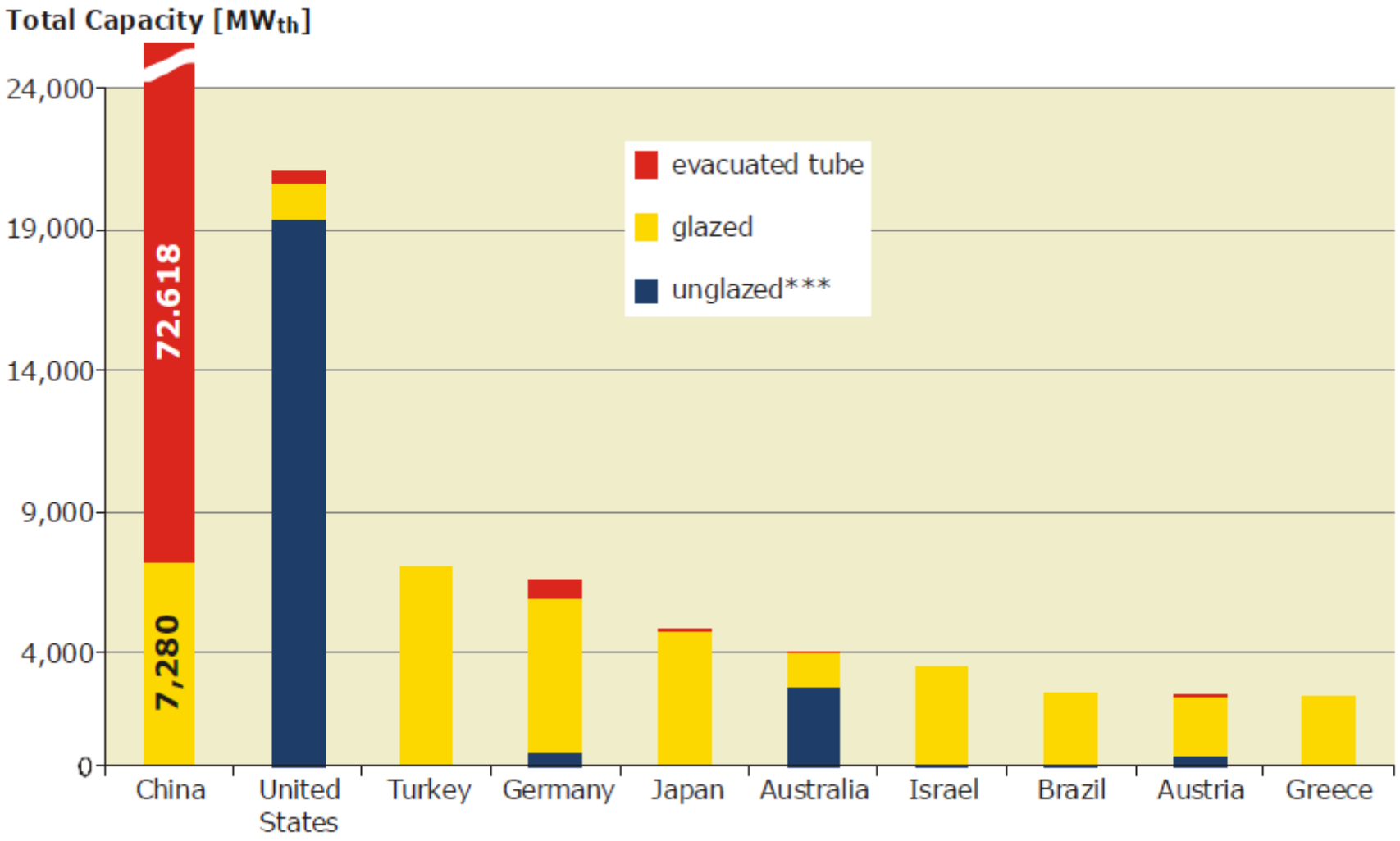
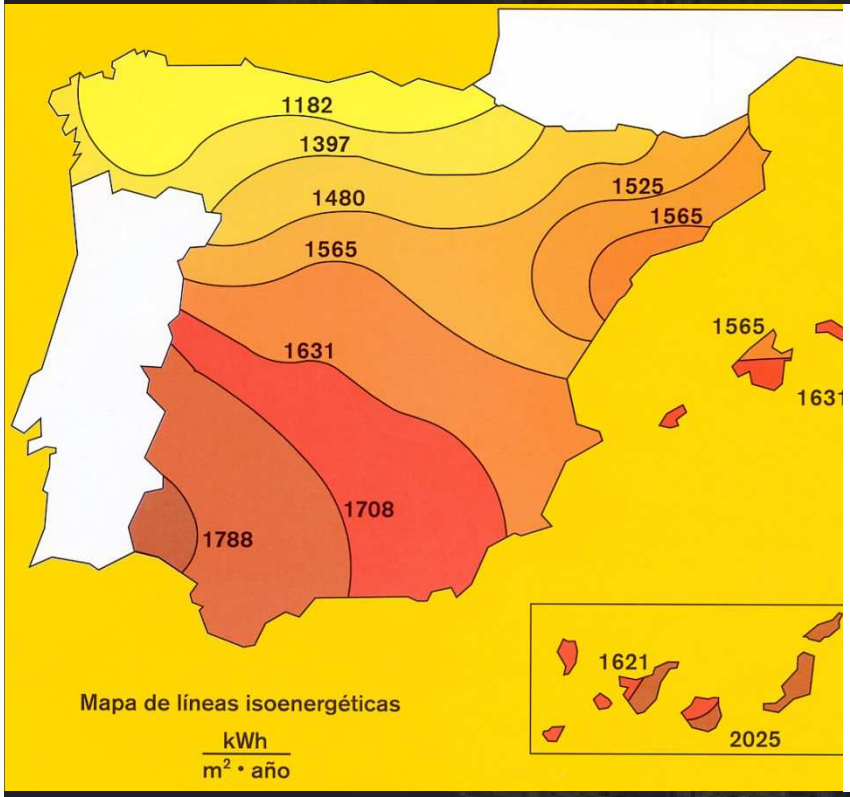
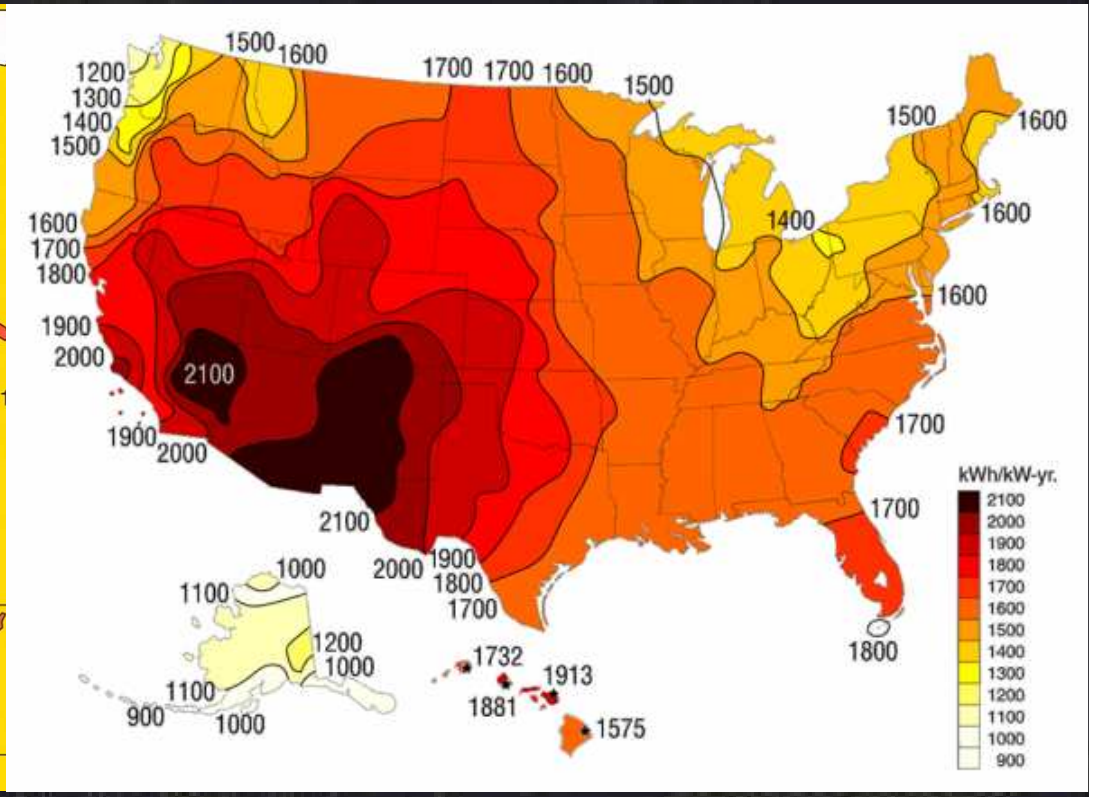


Figure 4: Total installed capacity of water collectors of the 10 leading countries at the end of 2007

SOLAR THERMAL ENERGY

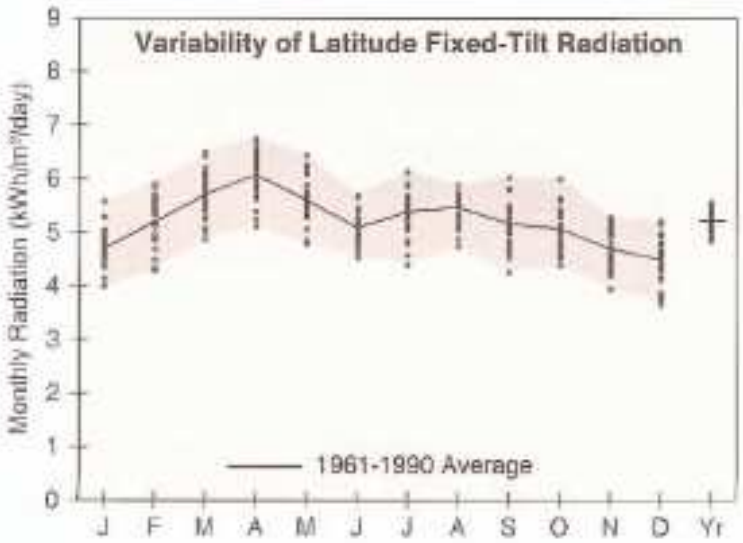




FACTORS AFFECTING THE INCIDENT RADIATION

- GEOGRAPHIC LOCATION
- GUIDANCE
- TILT
- TIME OF YEAR
- LOCAL WEATHER CONDITIONS

SOLAR THERMAL ENERGY



Miami, FL

WBAN NO. 12839

LATITUDE: 25.80° N
LONGITUDE: 80.27° W
ELEVATION: 2 meters
MEAN PRESSURE: 1017 millibars

STATION TYPE: Primary

Solar Radiation for Flat-Plate Collectors Facing South at a Fixed Tilt (kWh/m²/day), Uncertainty ±9%

Tilt (°)		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
0	Average	3.5	4.2	5.2	6.0	6.0	5.6	5.8	5.6	4.9	4.4	3.7	3.3	4.8
	Min/Max	3.1/4.0	3.6/4.7	4.5/5.8	5.1/6.7	5.1/6.9	4.9/6.3	4.7/6.7	4.9/6.0	4.1/5.7	3.9/4.9	3.2/4.0	2.8/3.7	4.5/5.1
Latitude -15	Average	4.1	4.7	5.5	6.2	5.9	5.5	5.7	5.6	5.1	4.7	4.2	3.9	5.1
	Min/Max	3.5/4.8	4.0/5.3	4.7/6.2	5.2/6.8	5.0/6.8	4.8/6.1	4.7/6.5	4.9/6.1	4.2/5.9	4.2/5.5	3.6/4.6	3.2/4.4	4.8/5.4
Latitude	Average	4.7	5.2	5.7	6.1	5.6	5.1	5.4	5.5	5.1	5.1	4.7	4.5	5.2
	Min/Max	4.0/5.6	4.3/5.9	4.9/6.5	5.1/6.7	4.8/6.4	4.5/5.7	4.4/6.1	4.7/5.9	4.2/6.0	4.4/6.0	3.9/5.3	3.7/5.2	4.8/5.5
Latitude +15	Average	5.0	5.4	5.6	5.7	5.0	4.5	4.8	5.0	4.9	5.1	4.9	4.9	5.1
	Min/Max	4.2/6.0	4.4/6.2	4.8/6.4	4.8/6.3	4.3/5.7	4.0/5.0	3.9/5.4	4.3/5.4	4.1/5.8	4.4/6.1	4.1/5.6	3.9/5.7	4.7/5.4
90	Average	4.1	3.9	3.4	2.6	1.9	1.6	1.7	2.1	2.7	3.5	3.9	4.1	3.0
	Min/Max	3.4/5.1	3.1/4.6	2.9/3.9	2.3/2.8	1.6/2.0	1.5/1.8	1.6/2.0	2.0/2.2	2.3/3.1	3.0/4.2	3.2/4.5	3.2/4.9	2.7/3.1

SOLAR THERMAL ENERGY

RADIACION SOLAR MEDIA DIARIA SOBRE SUPERFICIES INCLINADAS (kWh/m^2·día) PAIS VASCO ZONA COSTERA (DATOS EVE)														
ORIENT.	Inclin.	ENE	FEB	MAR	ABR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DIC	TOTAL
		31	28	31	30	31	30	31	31	30	31	30	31	kWh/m^2
S	0	1,333	1,985	2,848	3,876	4,711	5,099	5,093	4,589	3,592	2,503	1,622	1,107	**1.169**
S	10	1,571	2,229	3,058	4,027	**4,794**	**5,136**	**5,160**	4,740	3,832	2,796	1,907	1,306	**1.236**
S	20	1,773	2,422	3,199	**4,090**	4,770	5,059	5,111	**4,789**	3,985	3,024	2,148	1,475	**1.275**
S	30	1,933	2,560	**3,270**	4,064	4,653	4,880	4,961	4,737	**4,047**	3,182	2,337	1,610	**1.286**
S	40	2,048	**2,641**	3,270	3,952	4,442	4,614	4,715	4,584	4,020	3,267	2,471	1,708	**1.271**
S	50	2,115	2,662	3,201	3,759	4,144	4,256	4,376	4,337	3,906	**3,276**	2,547	1,766	**1.228**
S	60	**2,134**	2,625	3,067	3,495	3,770	3,823	3,956	4,007	3,711	3,213	**2,564**	**1,784**	**1.161**
S	70	2,105	2,532	2,873	3,170	3,347	3,359	3,494	3,605	3,441	3,079	2,521	1,762	**1.074**
S	80	2,028	2,387	2,627	2,795	2,888	2,852	2,989	3,160	3,107	2,879	2,421	1,701	**969**
S	90	1,907	2,193	2,338	2,394	2,399	2,342	2,462	2,677	2,720	2,621	2,267	1,603	**849**

FIRST APPROACH FOR CALCULATION:

1. How much energy is required to heat 150 liters of water from 10 ° C to 45 ° C? In Joules and KWh

Water density: 1000 Kg/m3

Specific heat: 4180 J/KgºC

1 Wh = 3600 J

2. How many square meters of panel do we need with the best inclination in January assuming that all radiation is useful?

Water consumption

The table below can be used as an indication of hot water consumption per occupant or person in common types of buildings:

Type of building	Consumption per occupant		Peak demand per occupant		Storage per occupant	
	liter/day	*gal/day*	*liter/hr*	*gal/hr*	*liter*	*gal*
Factories (no process)	22 - 45	5 - 10	9	2	5	1
Hospitals, general	160	35	30	7	27	6
Hospitals, mental	110	25	22	5	27	6
Hostels	90	20	45	10	30	7
Hotels	90 - 160	20 - 35	45	10	30	7
Houses and flats	90 - 160	20 - 35	45	10	30	7
Offices	22	5	9	2	5	1
Schools, boarding	115	25	20	4	25	5
Schools, day	15	3	9	2	5	1

SOLAR THERMAL ENERGY

Calculate the square footage of panel to be installed to meet the 70% of DHW needs of a hostel with 20 rooms. We assume that the system is capable of extracting 40% of the annual radiation.

Calculate the amount of CO2 avoided if each kWh of natural gas consumed involves the emission of 204 g of CO2.