SOLAR ENERGY

PHOTOVOLTAICS & SOLAR THERMAL

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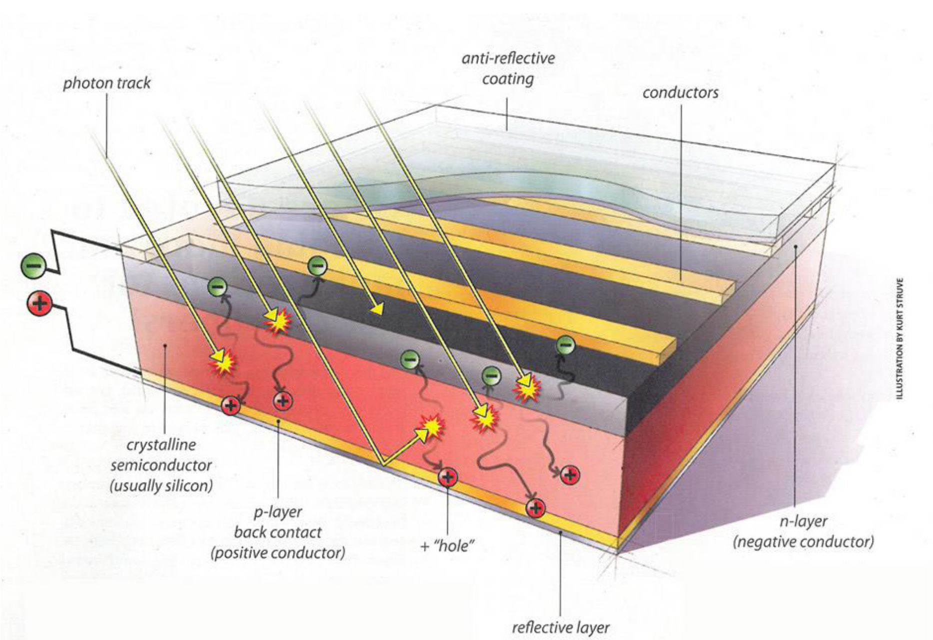


PHOTOVOLTAICS

Photovoltaic (PV) devices generate electricity directly from sunlight via an electronic process that occurs naturally in certain types of material, called semiconductors.

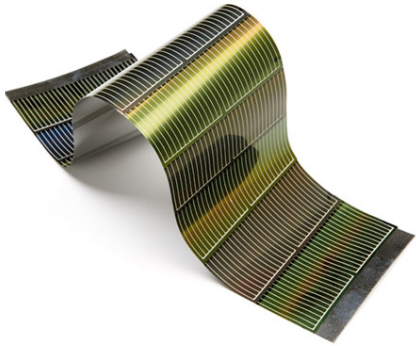
Electrons in these materials are freed by solar energy and can be induced to travel through an electrical circuit, powering electrical devices or sending electricity to the grid.

Photons strike and ionize semiconductor material on the solar panel, causing outer electrons to break free of their atomic bonds.

Due to the semiconductor structure, the **electrons** are forced in one direction creating a flow of electrical current.

Solar cells are not 100% efficient in part because some of the light spectrum is reflected, some is too weak to create electricity (infrared) and some (ultraviolet) creates heat energy instead of electricity.



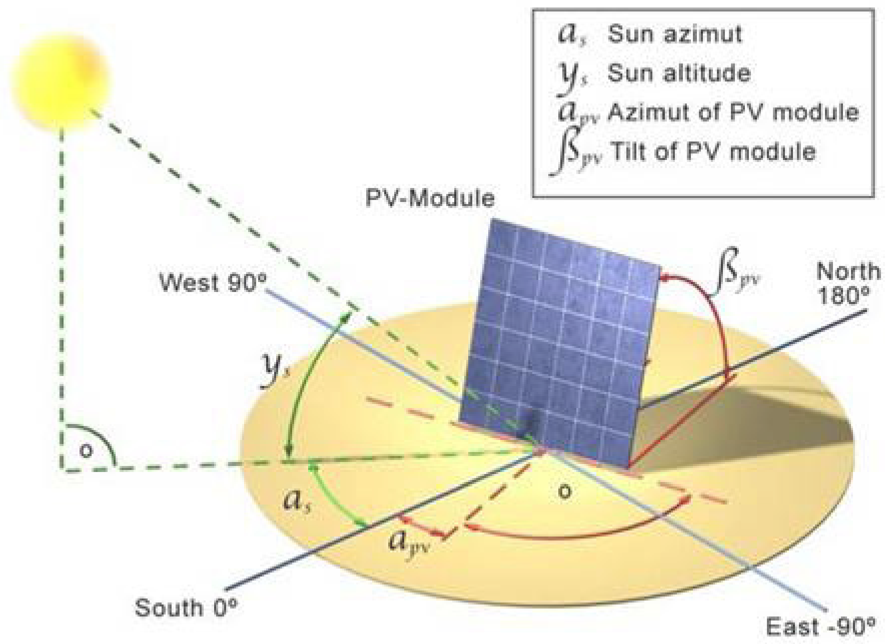


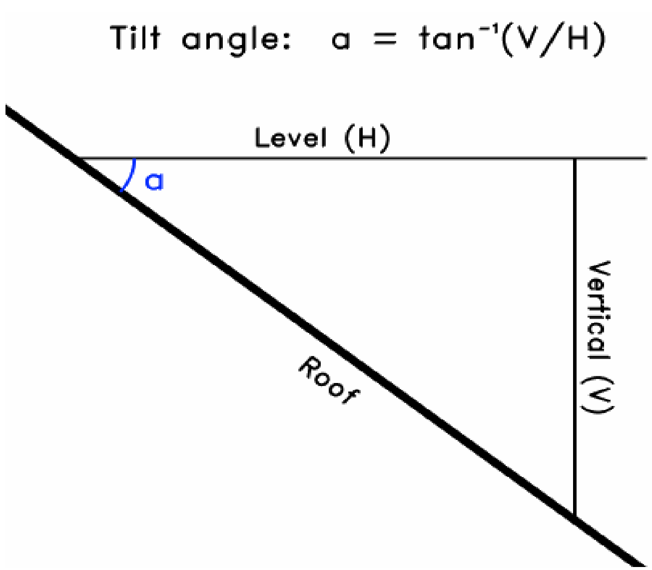

Materials presently used for photovoltaics include monocrystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium gallium selenide/sulfide.

Traditional solar cells are made from silicon, are usually flat-plate, and generally are the most efficient.

Second-generation solar cells are called thin-film solar cells because they are made from amorphous silicon or nonsilicon materials such as cadmium telluride. **Thin film solar cells** use layers of semiconductor materials only a few micrometers thick. Because of their flexibility, thin film solar cells can double as rooftop shingles and tiles, building facades, or the glazing for skylights.

Third-generation solar cells are being made from a variety of new materials besides silicon, including solar inks using conventional printing press technologies, solar dyes, and conductive plastics.





Solar orientation

In order to produce the most electricity, the Solar PV array should be orientated between **south-east** and **south-west**. It is not absolutely necessary for the array to face due south. There will be only a small percentage power loss, as a result of moving a few degrees east or west of south.

In trials, high annual yield values have been recorded for systems up to 30 degrees off south. It is much more important to keep all system losses low than to optimise the orientation. More substantial output reductions are recorded where the orientation is more than 40 degrees off south.

The vertical orientation of the pannel is the **tilt angle**.

Energy Production

Considering a solar pannel of **1KW of power**, perfect positioned in the northern Italy, we can say that it could produce around **1.000-1100 kWh/year**

The **avarage energy consumption** of an italian family is 3.000-4.000 kWh.

Orientation and Tilt Chart shows that maximum efficiencies are achieved at a tilt of about 35 degrees with an orientation due south.

Orientation Chart showing yearly output for different orientation and tilt angles (%of maximum).

Tilt (°) from horizontial	Orientation - Compass bearing (°) measures from North													
	Horizontal	West			S.W.			South			S.E.			East
		270 °	255 °	240 °	225 °	210 °	195 °	180 °	165 °	150 °	135 °	120 °	105 °	90 °
	0 °	90	90	90	90	90	90	90	90	90	90	90	90	90
	10 °	89	91	92	94	95	95	96	95	95	94	93	91	90
	20 °	87	90	93	96	97	98	98	98	97	96	94	91	88
	30 °	86	89	93	96	98	99	100	100	98	96	94	90	86
	40 °	82	86	90	95	97	99	100	99	98	96	92	88	84
	50 °	78	84	88	92	95	96	97	97	96	93	89	85	80
	60 °	74	79	84	87	90	91	93	93	92	89	86	81	76
	70 °	69	74	78	82	85	86	87	87	86	84	80	76	70
	80 °	63	68	72	75	77	79	80	80	79	77	74	69	65
	90 °	56	60	64	67	69	71	71	71	71	69	65	62	58
	Vertical	Near horizontal 0 ° inclinations are not recommended as the self-cleaning cannot be relied on at less than about 10 °												

European Photo Voltaic Energy production

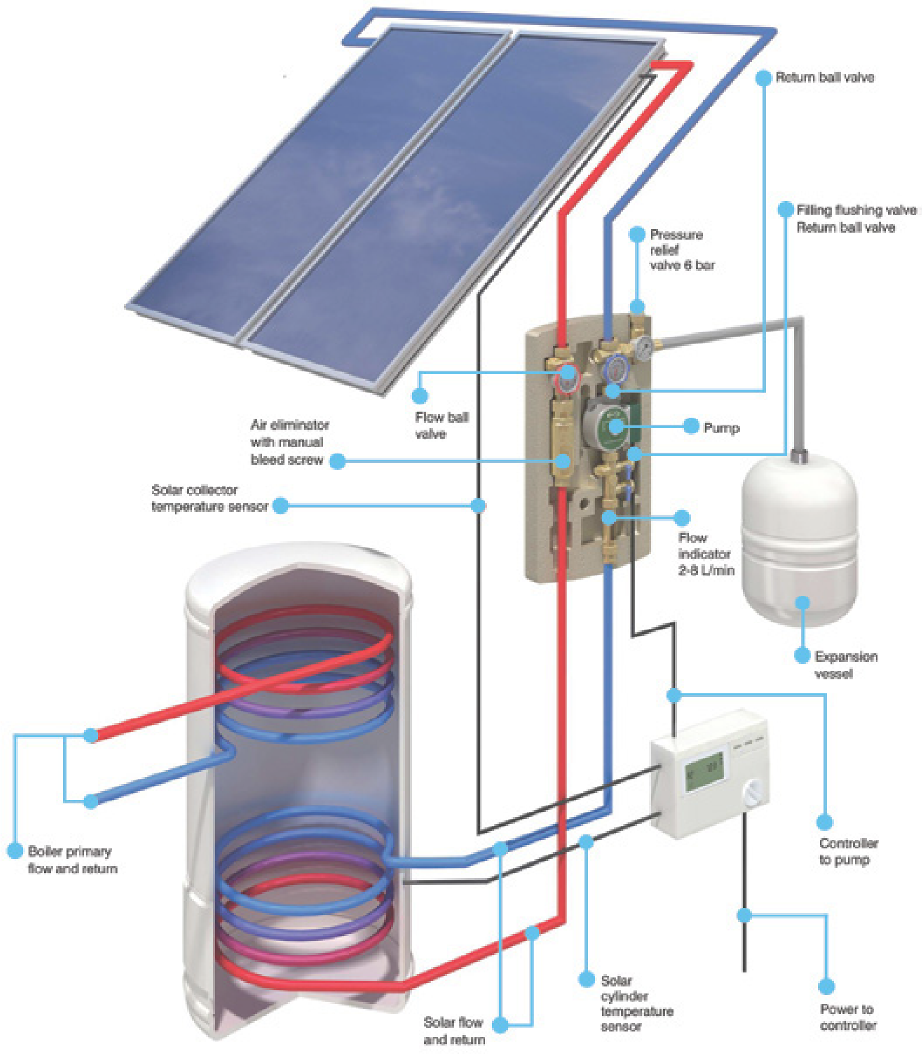
PV in the European Union (MW_{peak})[7][8][9][10][10][11][12][13]											
#	Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1	Germany	1,910	3,063	3,846	6,019	9,959	17,370	24,875	32,698	36,402	38,301
2	Italy	46	58	120	458	1,157	3,478	12,764	16,361	18,065	18,450
3	France	26	33	47	104	335	1,054	2,831	4,027	4,625	5,600
4	United Kingdom	11	14	19	23	30	75	1,014	1,657	2,782	5,230
5	Spain	58	118	733	3,421	3,438	3,808	4,214	4,516	4,766	4,787
6	Belgium	2	4	22	71	574	787	1,812	2,649	3,040	3,105
7	Greece	5	7	9	19	55	205	631	1,543	2,585	2,603
8	Czech	0	1	4	55	463	1,953	1,959	2,022	2,064	2,061
9	Romania	0	0.2	0.3	0.5	0.6	2	2.9	49	1,022	1,292.6
10	Netherlands	51	51	53	57	68	97	118	321	739	1,100
11	Bulgaria	0	0	0.8	1	6	17	132	933	1,019	1,020
12	Austria	24	29	27	32	53	103	173	421	631	771
13	Denmark	3	3	3	3	5	7	16	391	572	602
14	Slovakia	0	0	0	<0.1	0.2	144	488	517	588	590
15	Portugal	3	4	18	68	102	131	143	228	303	419

SOLAR THERMAL

Solar thermal technology uses the sun's energy, rather than fossil fuels, to generate low-cost, environmentally friendly **thermal energy**.

This energy is used to **heat water** or other fluids, and can also power solar cooling systems.

Solar thermal systems differ from solar photovoltaic (PV) systems, which generate electricity rather than heat.



How a Solar-Water-Heating system works

1. Solar thermal collectors (panels) on a roof, shade structure or other location **absorb solar energy**.

2. **Solar fluid circulated** through the collectors by a low-energy pump delivers heat to a water storage tank.

3. When users need hot water, the solar-heated water in the **storage tank** pre-feeds the primary water-heating system.

4. When pre-fed with the solar hot water, the **boiler** or water heater is either not activated, or activated for less time than if there were no solar hot water system.

5. Each month, building owners pay a **lower bill** for energy to heat water.

Typologies of Solar Collectors

- Low Temperature Unglazed Collectors

- Flat Plate Collectors

- Evacuated Tube Collectors

- Concentrating Collectors

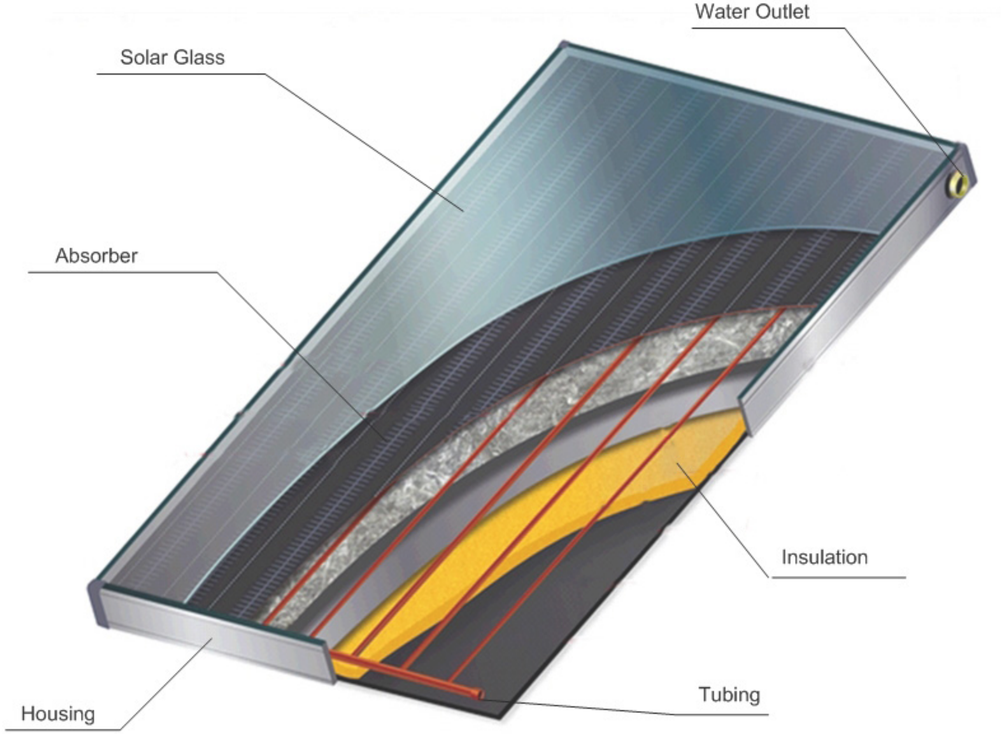
Low Temperature Unglazed Collectors

This type of collector is mainly used for **swimming pool heating** and consists of black coloured matting or tubes made from rubber or plastic based materials through which the pool water is circulated.

Such panels are effective at heating large volumes of water by a **small temperature rise** (perfects for pool) during warm sunny conditions. In hot sunny regions such panels have also been used for domestic hot water supply.

As this type of collector is **not insulated** it can't efficiently operate in cooler conditions or when hotter water (showering temperature) is required.

Such collectors are often referred to as "**unglazed**" as they don't have a glass cover like flat plate or evacuated tube collectors. This name, however, can cause confusion with the next type of collector "concentrating" outlined below which also are "unglazed", but very different in structure and operation.



Flat Plate Collectors

A flat-plate collector consists of an **absorber**, a **transparent cover**, a **frame**, and **insulation.**

Usually an iron-poor solar safety glass is used as a transparent cover, as it transmits a great amount of the short-wave light spectrum.

In addition, the transparent cover prevents **wind and breezes** from carrying the collected heat away (convection). Together with the frame, the **cover protects** the absorber from adverse weather conditions.

Flat collectors demonstrate a good price-performance ratio, as well as a broad range of mounting possibilities (on the roof, in the roof itself, or unattached).

Evacuated Tube Collectors

In this type of vacuum collector, the **absorber strip** is located in an evacuated and **pressure proof glass tube**.

The heat transfer fluid flows through the absorber directly in a U-tube or in countercurrent in a tube-in-tube system. Several single tubes, serially interconnected, or tubes connected to each other via manifold, make up the **solar collector**.

A **heat pipe collector** incorporates a special fluid which begins to **vaporize** even at low temperatures. The steam rises in the individual heat pipes and warms up the carrier fluid in the main pipe by means of a heat exchanger.

The **condensed liquid** then flows back into the base of the heat pipe.

Evacuted tubes offer the advantage that they work efficiently with **high absorber temperatures** and with **low radiation.**

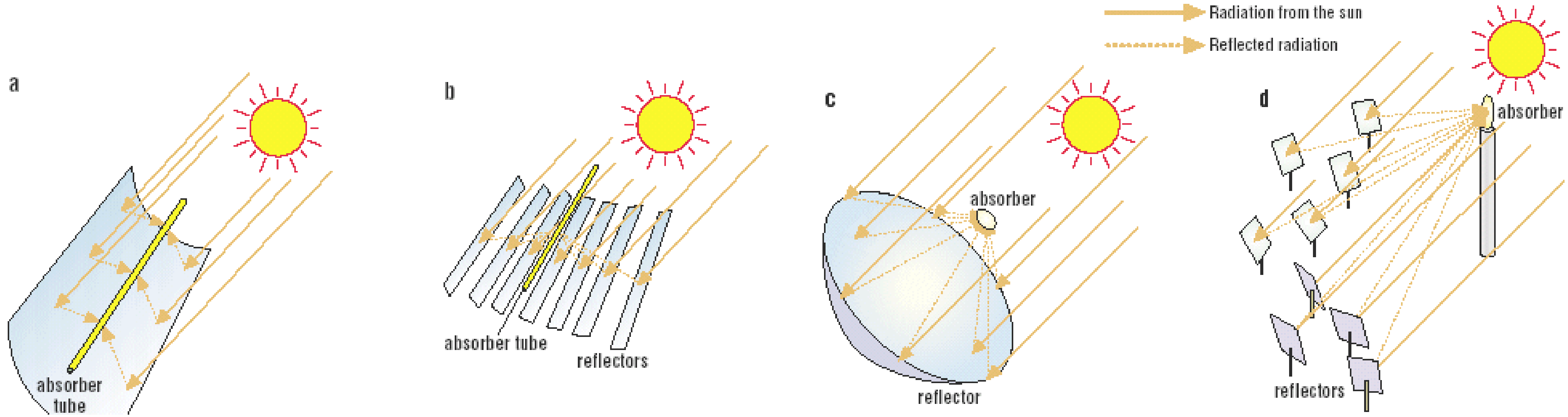
Concentrating Collectors

When high temperatures (>120˚C / 250˚F) are required, such as for steam production, concentrating collectors are often used.

A concentrating collector uses **mirrors** to concentrate the sunlight onto an **absorber tube** or panel, allowing much **higher temperatures** to be reached.

Such collectors normally require 1 or 2 **axis tracking** to follow the sun and ensure optimal reflection angle.

Due to the size and complexity of these systems they are primarily used for **large scale projects.**



Sizing The Collectors

In order to reach a **correct size** of the collectors , it is crucial to estimate the **amount of hot water** that we need daily . The **minimum daily** needs for hot water, for the residential sector, is estimated at about **50-75 liters** per person.

This demand can be satisfied by a **surface area** of about **1.00 m²** of average efficiency glazed flat collectors .

A similar collector surface is sufficient for heating **10 sqm of a building** equipped with heating systems at low temperatures, typically in the **radiant panels** .

Flat Plate Collectors		
GEOGRAPHIC AREA	production of 50 liters of water at 45° per day	production of warm water for heating a surface of 10sqm
Northern Italy	1,2 sqm	1-1,2 sqm
Central Italy	1 sqm	0,8-1,0 sqm
Southern Italy	0,8 sqm	0,6-0,8 sqm

Evacuated Tube Collectors		
GEOGRAPHIC AREA	production of 50 liters of water at 45° per day	production of warm water for heating a surface of 10sqm
Northern Italy	0,9 sqm	0,9 sqm
Central Italy	0,7 sqm	0,7 sqm
Southern Italy	0,5 sqm	0,5 sqm

European Solar Thermal Energy production

Solar heating in the European Union ($MW_{thermal}$)							
#	Country	2008	2009	2010	2011	2012	2013
1	Germany	7,766	9,036	9,831	10,496	11,416	12,055
2	Austria	2,268	3,031	3,227	2,792	3,448	3,538
3	Greece	2,708	2,853	2,855	2,861	2,885	2,915
4	Italy	1,124	1,410	1,753	2,152	2,380	2,590
5	Spain	988	1,306	1,543	1,659	2,075	2,238
6	France	1,137	1,287	1,470	1,277	1,691	1,802
7	Poland	254	357	459	637	848	1,040
8	Portugal	223	395	526	547	677	717
9	Czech Republic	116	148	216	265	625	681
10	Netherlands	254	285	313	332	605	616
11	Denmark	293	339	379	409	499	550
12	Cyprus	485	490	491	499	486	476
13	United Kingdom	270	333	374	460	455	475
14	Sweden	202	217	227	236	337	342
15	Belgium	188	204	230	226	334	374