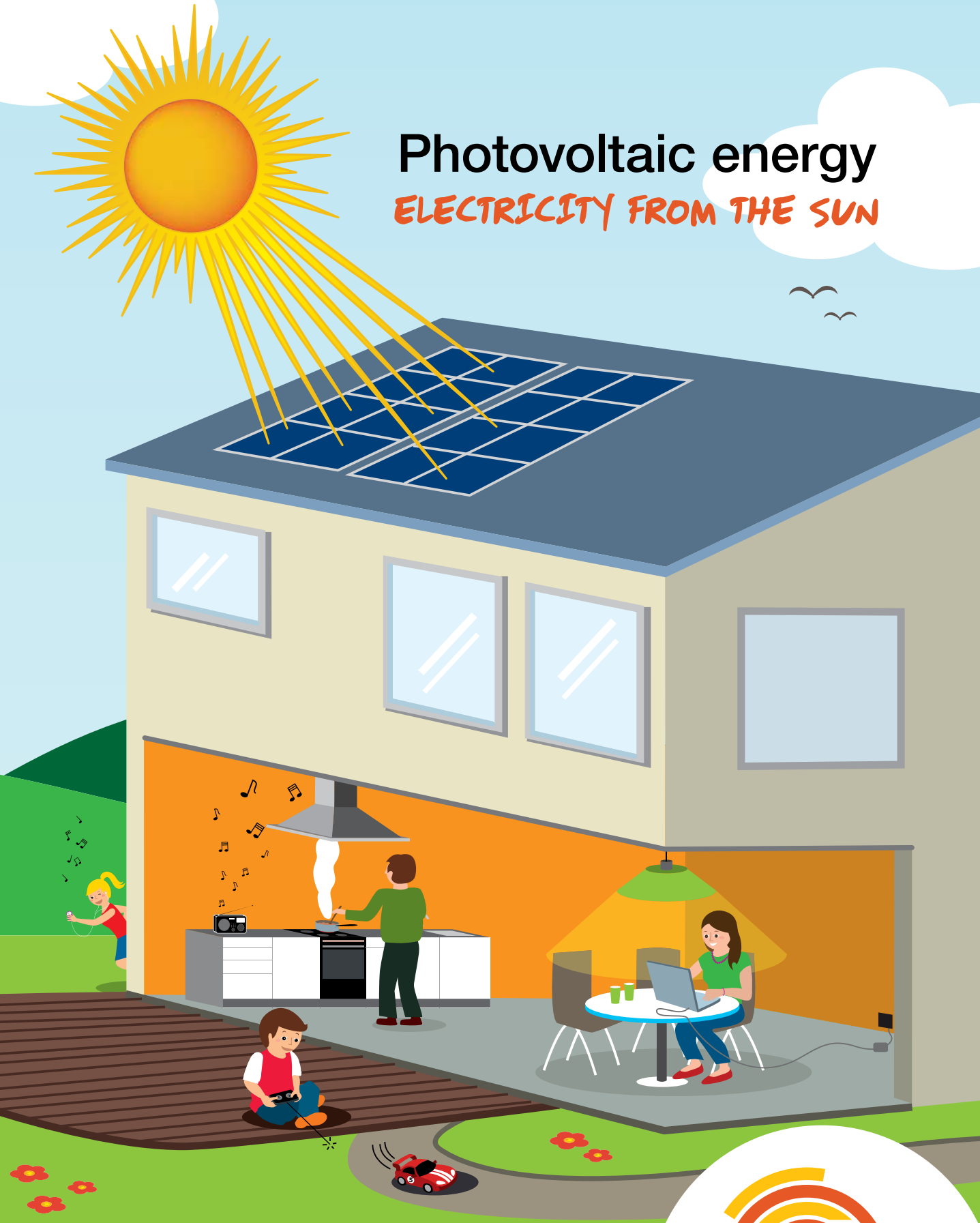
Photovoltaic energy

ELECTRICITY FROM THE SUN

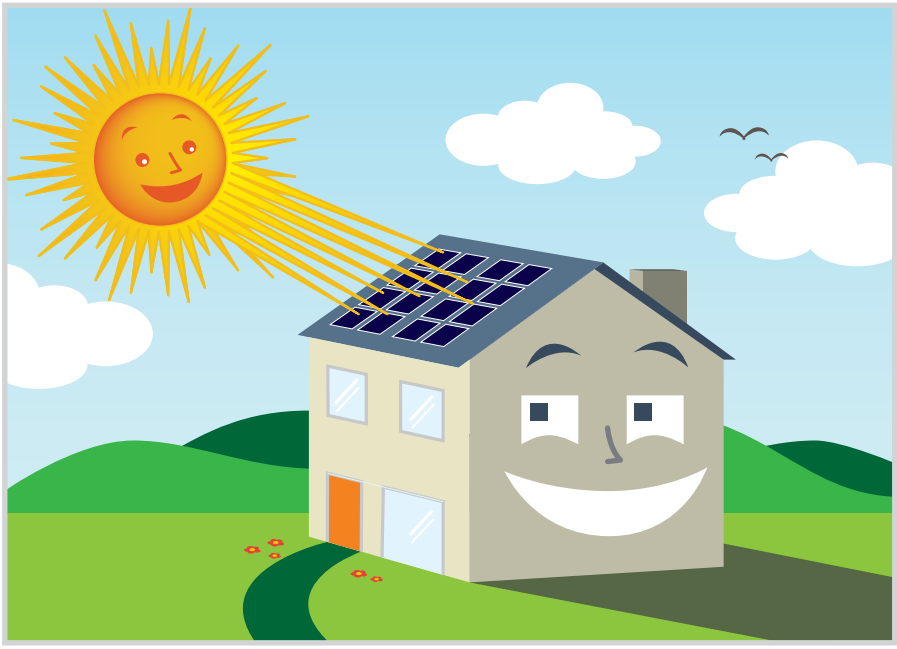


EPIA

European Photovoltaic Industry Association

The sun,

an energy available for free which can be used in many ways



Energy from the sun
can be used in three main ways, and when talking about solar energy it is important to distinguish between these three types:

Photovoltaic energy (PV)

Uses energy from the sun to create electricity to run appliances and lighting. A photovoltaic system requires only daylight - not direct sunlight - to generate electricity.

Passive heat

This is heat that we receive from the sun naturally. This can be taken into account in the design of buildings so that less additional heating is required.

Solar thermal

Where we use the sun's heat to provide hot water for homes or swimming pools (also heating systems).

The process

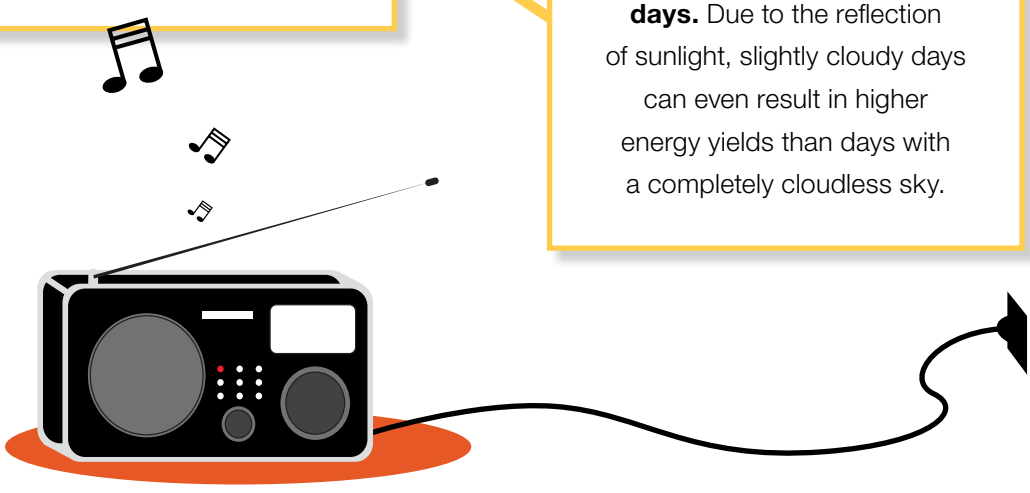
of turning sunlight into electricity

'Photovoltaic' is a marriage of two words: **'photo'**, from Greek roots, meaning **light**, and **'voltaic'**, from **'volt'**, which is the unit used to **measure electric potential** at a given point.

Photovoltaic systems use cells to convert solar radiation into electricity. The cell consists of one or two layers of a semi-conducting material. When light shines on the cell it creates an electric field across the layers, causing electricity to flow. **The greater the intensity of the light, the greater the flow of electricity is.**

The most common semi conductor material used in photovoltaic cells is **silicon**, an element most commonly found in sand. There is **no limitation** to its availability as a raw material; **silicon is the second most abundant material in the earth's mass.**

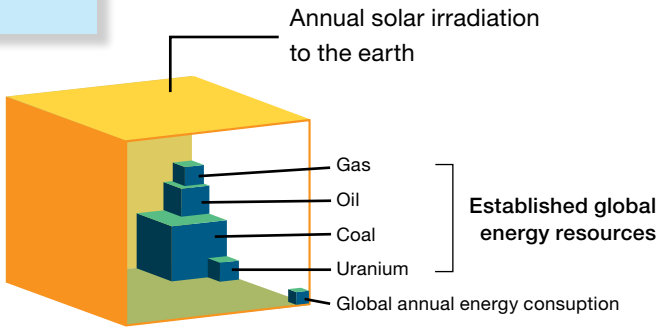
A photovoltaic system therefore does not need bright sunlight in order to operate. **It can also generate electricity on cloudy days.** Due to the reflection of sunlight, slightly cloudy days can even result in higher energy yields than days with a completely cloudless sky.



10 Good Reasons

to switch to solar photovoltaic electricity

Photovoltaic is emerging
as a major power source due to its numerous environmental and economic benefits and proven reliability.



Source: Eco Solar Equipment Ltd.

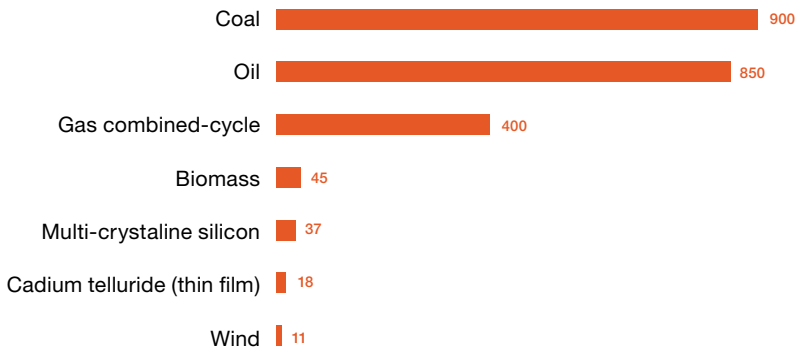
1

The fuel is free.
The sun is the only resource needed to power solar panels. And the sun will keep shining until the world's end. Also, most photovoltaic cells are made from silicon, and silicon is an abundant and non-toxic element (the second most abundant material in the earth's mass).

2

It produces no noise, harmful emissions or polluting gases. The burning of natural resources for energy can create smoke, cause acid rain, pollute water and pollute the air. Carbon dioxide CO_2, a leading greenhouse gas, is also produced. Solar power uses only the power of the sun as its fuel. It creates no harmful by-product and contributes actively to reduce the global warming.

Greenshouse gases (grams per kilowatt-hour of CO_2 equivalent)



From: Externe project, 2003; Kim and Dale, 2005; Fthenakis and Kim, 2006; Fthenakis and Kim, 2007; Fthenakis and Alsema, 2006

3

PV systems are very safe and highly reliable.
The estimated lifetime of a PV module is 30 years. Furthermore, the modules' performance is very high providing over 80% of the initial power after 25 years which makes photovoltaics a very reliable technology in the long term. In addition, very high quality standards are set at a European level which guarantees that consumers buy reliable products.

4

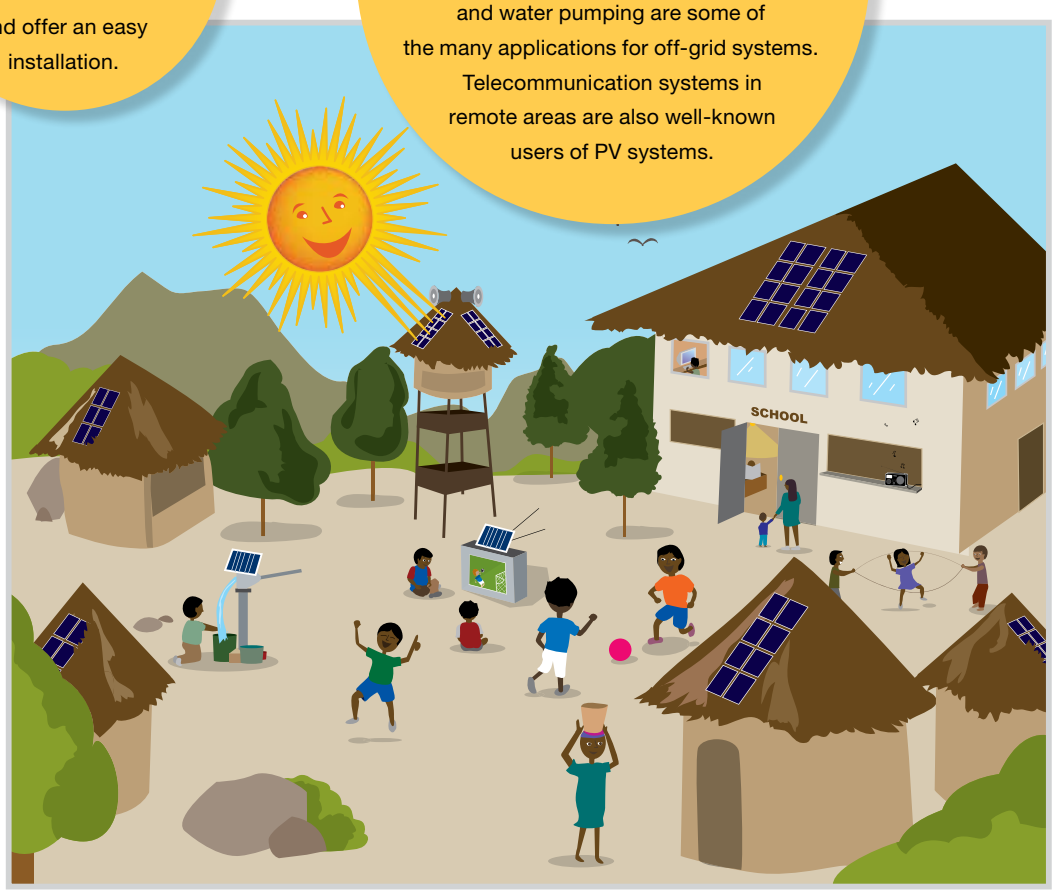
PV Modules can be recycled and therefore the materials used in the production process (silicon, glass, aluminium, etc.) can be reused. Recycling is not only beneficial for the environment but also for helping to reduce the energy needed to produce those materials and therefore the cost of fabrication. More information is available on the following website: **www.pvcyle.org**

5

It requires low maintenance.
Solar modules are almost maintenance-free and offer an easy installation.

6

It brings electricity to remote rural areas.
Solar systems give an added value to rural areas (especially in developing countries where electricity is not available). House lighting, hospital refrigeration systems and water pumping are some of the many applications for off-grid systems. Telecommunication systems in remote areas are also well-known users of PV systems.



7

It can be aesthetically integrated in buildings (BIPV). Systems can cover roofs and facades contributing to reduce the energy buildings consume. They don't produce noise and can be integrated in very aesthetic ways. European building legislations have been and are being reviewed to make renewable energies as a required energy source in public and residential buildings. This fact is accelerating the development of ecobuildings and positive energy buildings (E+ Buildings) which opens up many opportunities for a better integration of PV systems in the built environment. More information is available on **www.pvsunrise.eu**

PV cells used as sunshade in an office building, UK

Semi-transparent facade

PV system integrated in a facade

PV system integrated in a facade

9

It creates thousands of jobs. The PV sector, with an average annual growth of 40% during the past years is increasingly contributing to the creation of thousand of jobs in Europe and worldwide.

8

The energy pay-back time of a module is constantly decreasing. This means that the time required for a PV module to produce as much energy as it needs to be manufactured is very short, it varies between 1,5 years to 3 years. A module therefore produces 6 to 18 times more energy than is needed to manufacture it.

10

It contributes to improving the security of Europe's energy supply. In order to cover 100% of the electricity demand in Europe, only the 0.7% of the total land of Europe would be needed to be converted by PV modules. Therefore Photovoltaics can play an important role in improving the security of Europe's energy supply.

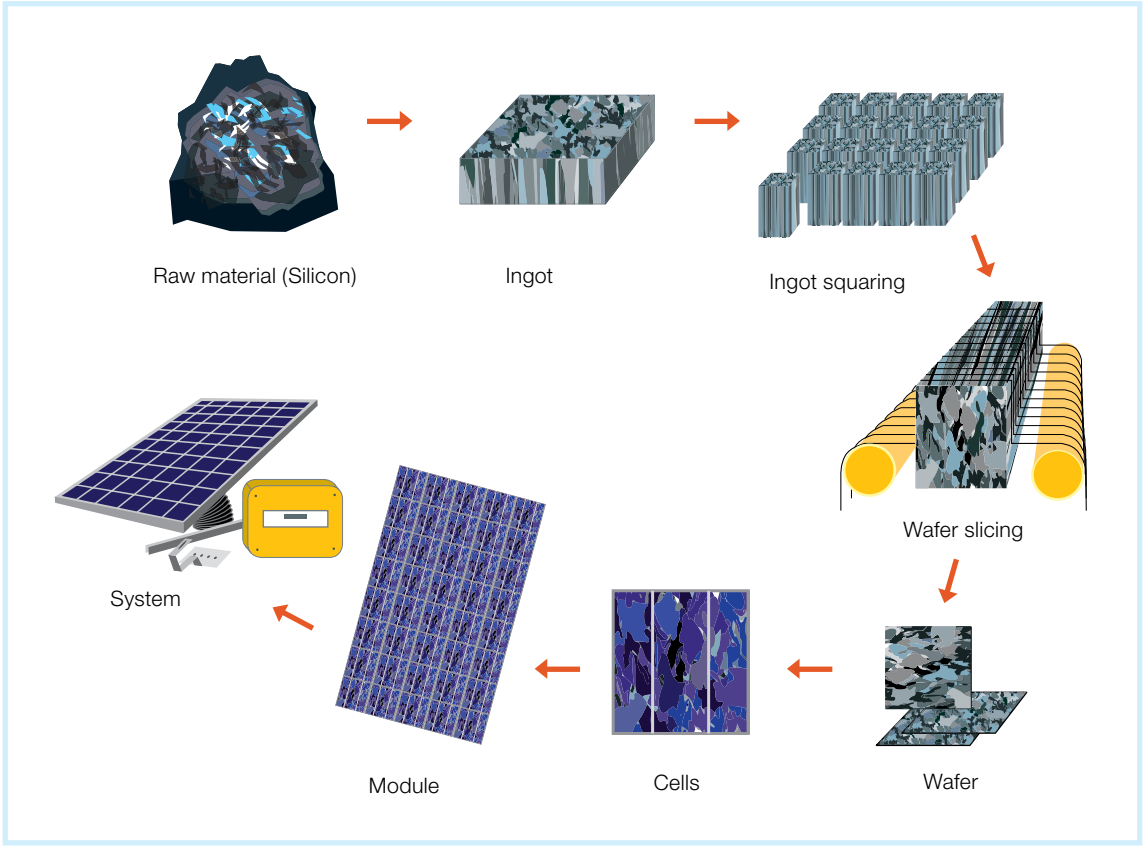
The Photovoltaic Technology

how does it work in practice?

The most important parts of a PV system are the cells which form the basic building blocks of the unit, collecting the sun's light, the modules which bring together large numbers of cells into a unit, and, in some situations, the inverters used to convert the electricity generated into a form suitable for everyday use.

. Production process: the Photovoltaic Value Chain

The following chart flow shows the different steps of production of a photovoltaic system (crystalline based technology)



. PV CELLS AND MODULES

PV cells are generally made either from crystalline silicon, sliced from ingots or castings, from grown ribbons or thin film, deposited in thin layers on a low-cost backing.

The performance of a solar cell is measured in terms of its efficiency at turning sunlight into electricity. A typical commercial solar cell has an efficiency of 15% - about one-sixth of the sunlight striking the cell generates electricity. Improving solar cell efficiencies while holding down the cost per cell is an important goal of the PV industry.

Overview of available photovoltaic technologies

Crystalline silicon technology

Crystalline silicon cells are made from thin slices cut from a single crystal of silicon (monocrystalline) or from a block of silicon crystals (polycrystalline), their efficiency ranges between 12% and 17%. **This is the most common technology representing about 90% of the market today.**

Three main types of crystalline cells can be distinguished:

- Monocrystalline (Mono c-Si)
- Polycrystalline (or Multicrystalline) (multi c-Si)
- Ribbon sheets (ribbon-sheet c-Si)

Thin Film technology

Thin film modules are constructed by depositing extremely thin layers of photosensitive materials onto a low-cost backing such as **glass, stainless steel or plastic.**
Thin film manufacturing processes result in **lower production costs** compared to the more material-intensive crystalline technology, a price advantage which is currently counterbalanced by substantially lower efficiency rates (from 5% to 13%).

Four types of thin film modules (depending on the active material used) are commercially available at the moment:

- Amorphous silicon (a-Si)
- Cadmium telluride (CdTe).
- Copper Indium/gallium Diselenide/ disulphide (CIS, CIGS)
- Multi junction cells (a-Si/m-Si)

Photovoltaic sound barrier along a motorway

Other cell types

There are several other types of photovoltaic technologies developed today starting to be commercialised or still at the research level, the main ones are:

Concentrated photovoltaic

Some solar cells are designed to operate with concentrated sunlight. These cells are built into concentrating collectors that use a lens to focus the sunlight onto the cells.
The main idea is to **use very little of the expensive semiconducting PV material while collecting as much sunlight as possible. Efficiencies are in the range of 20 to 30%.**

Concentrated photovoltaic module

Flexible solar cells, these can be easily integrated

Flexible cells

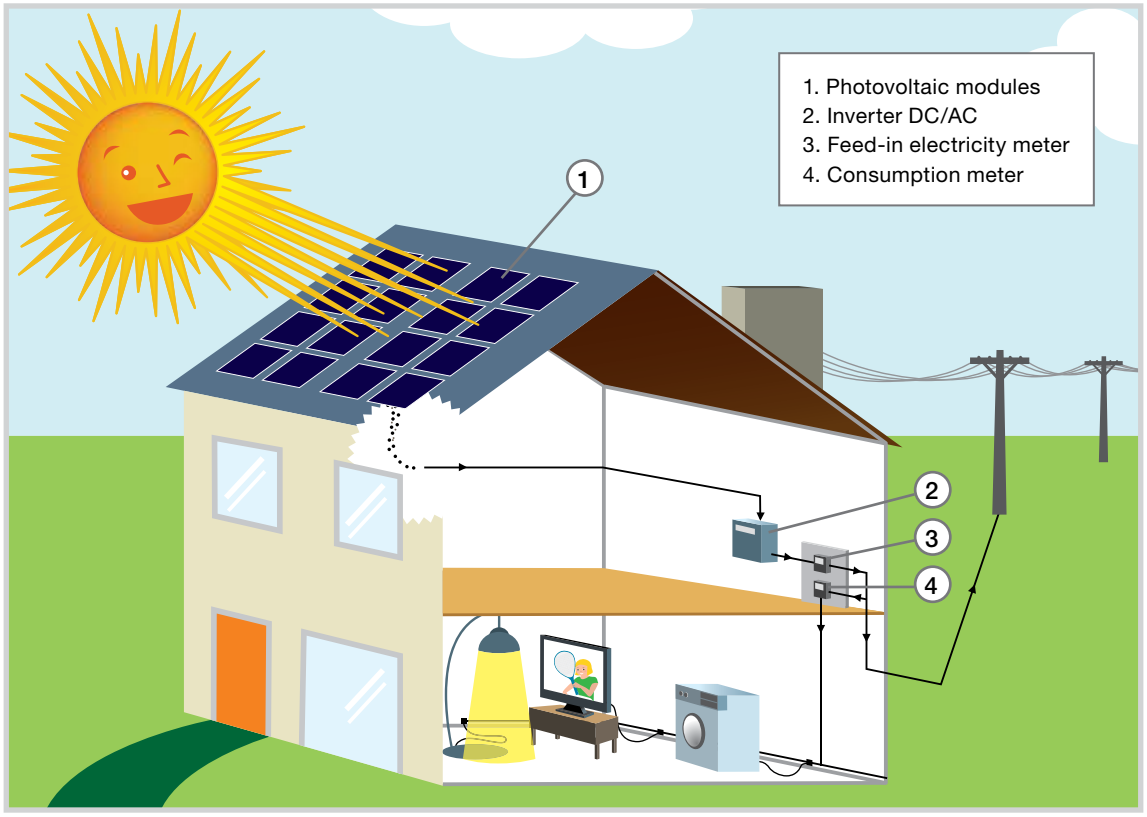
Based on a similar production process to thin film cells, when the active material is deposited in a thin plastic, the cell can be flexible.
This opens the range of applications, especially for building integration (roofs-tiles) and end-consumer applications.

. Photovoltaic applications

The Photovoltaic technology can be used in several types of applications:

Grid-connected domestic systems

This is the most popular type of solar PV system for homes and businesses in developed areas. Connection to the local electricity network allows any excess power produced to feed the electricity grid and to sell it to the utility. Electricity is then imported from the network when there is no sun. An inverter is used to convert the direct current (DC) power produced by the system to alternative current (AC) power for running normal electrical equipments.



Grid-connected power plants

These systems, also grid-connected, produce a large quantity of photovoltaic electricity in a single point. The size of these plants range from several hundred kilowatts to several megawatts. Some of these applications are located on large industrial buildings such as airport terminals or railway stations. This type of large application makes use of already available space and compensates a part of the electricity produced by these energy-intensive consumers.

Large photovoltaic power plant in Bavaria

Off-grid systems for rural electrification

Where no mains electricity is available, the system is connected to a battery via a charge controller. An inverter can be used to provide AC power, enabling the use of normal electrical appliances. Typical off-grid applications are used to bring access to electricity to remote areas (mountain huts, developing countries). **Rural electrification** means either small solar home system covering basic electricity needs in a single household, or larger solar mini-grids, which provide enough power for several homes.
More information is available on **www.ruralelec.org**.

Off-grid application in South America

Hybrid systems

A solar system can be combined with another source of power - a biomass generator, a wind turbine or diesel generator - to ensure a consistent supply of electricity. A hybrid system can be grid-connected, stand-alone or grid-support. More information is available on **www.ruralelec.org**.

PV-wind hybrid system

Sun roof system used to cool down the car

Consumer goods

Photovoltaic cells are used in many daily electrical appliances, including watches, calculators, toys, battery chargers, professional sun roofs for automobiles. Other applications include power for services such as water sprinklers, road signs, lighting and phone boxes.

Off-grid industrial applications

Uses for solar electricity for remote applications are very frequent in the telecommunications field, especially to link remote rural areas to the rest of the country. Repeater stations for mobile telephones powered by PV or hybrid systems also have a large potential. Other applications include traffic signals, marine navigation aids, security phones, remote lighting, highway signs and waste water treatment plants. **These applications are cost competitive today as they enable to bring power in areas far away from electric mains, avoiding the high cost of installing cabled networks.**

PV used for a remote telecommunication station

I am interested in this technology

and I would like to take the next step…

How can I proceed? Who should I contact?

You are convinced that solar photovoltaic energy is an increasingly important source of energy and you would like to contribute to its development by installing a photovoltaic system at home.

Good news!

In an increasing number of countries, adapted support mechanisms are helping citizens to take the next step by providing a financial support. This is, in particular the case in Germany, Spain, Italy, France, Greece or Slovenia where feed-in tariff schemes have been adopted.

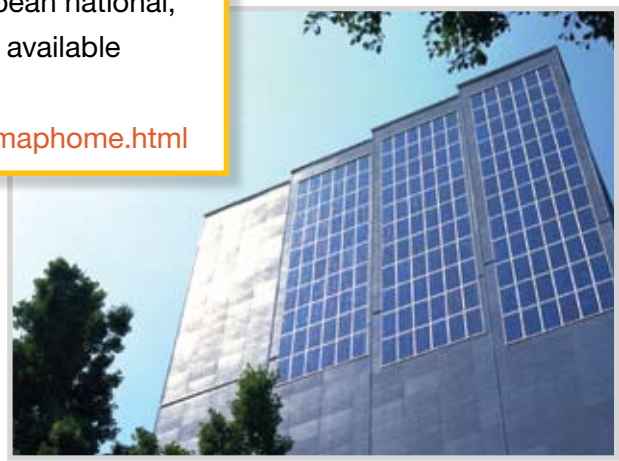
How do feed-in tariff mechanisms work in practice?

If you install a **PV system at home**, all electricity generated can be injected and sold to the electricity provider at higher price than the price paid in your monthly electricity bill. This mechanism enables you to pay-back your investment in a short time. The country which has best succeeded to develop photovoltaic energy today is Germany. Spain, Italy, France and Greece have also developed this system and step by step electricity consumers, aware of the importance of renewable energies, are switching to solar electricity receiving a compensation for their effort. Some other systems exist to develop renewables (green certificates, tendering, tax credit) but they have not proved to be as efficient in particular when they depend from State budgets. More information is available on **www.epia.org**.

In the long run no more support will be required to help the development of photovoltaic electricity. With increasing sales leading to scale economies and efforts realised by producers to reduce the cost of photovoltaic products, it is expected that photovoltaic will be competitive with electricity prices in the South of Europe by 2015 and in most of Europe by 2020.

Photovoltaic system integrated on the roof of a house, Germany

You are interested to know more about the situation in your country, the existing support to switch to green energy? You will find the most up-dated information about your country situation through energy agencies. A directory of European national, regional and local energy agencies is available on the following website:
http://www.managenergy.net/emap/maphome.html



PV system integrated in the facade of a social housing, France

The Photovoltaic Sector

is becoming a decisive employer in Europe and worldwide

The photovoltaic sector is particularly promising in terms of job and local wealth creation. The sector invests heavily in research and technological innovation and generates employment, which to a very high degree means skilled, high quality jobs. Moreover, the PV sector and the renewable energies in general have a decentralized structure, which leads to employment in the less industrialised areas.

The PV industry has created more than 75.000 jobs in Europe in the last few years, the following countries have been leading this trend:

- In Germany (the largest PV market worldwide), employment in the PV sector rose from 1.500 (1999) to over 40.000 (2007).
- In Spain, until 2007, more than 23.000 jobs were created.
- In Italy, until 2007, 1.700 jobs were created.
- In France over 2.100 persons are today directly employed by the photovoltaic sector.

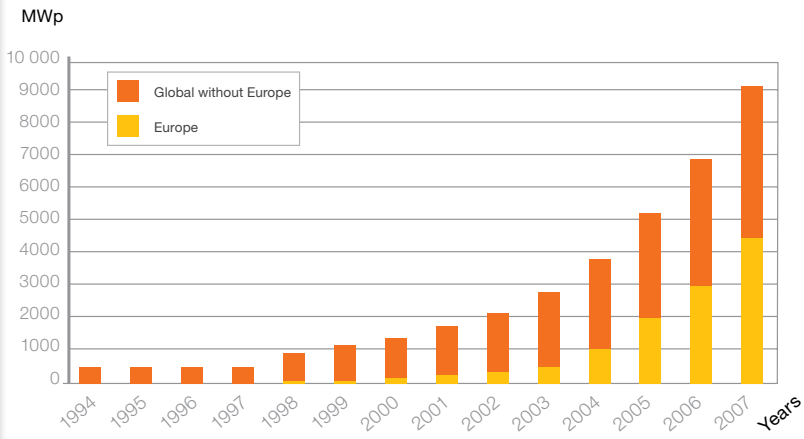
The European Photovoltaic Technology Platform estimates that the PV industry has the potential to create more than 200.000 jobs in the European Union by 2020 and ten times this number worldwide.

Solar Photovoltaic Electricity

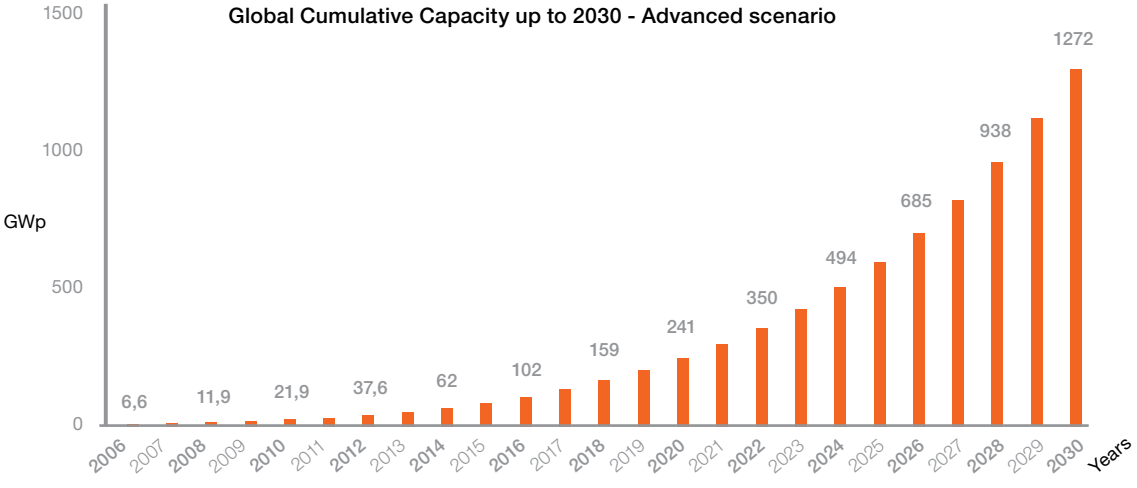
Sunny Future Ahead!

. Historical development of cumulative installed global and EU PV capacity

The solar PV market has been booming over the last years and is forecasted to confirm this trend in the coming years.
By the end of 2007 the global cumulative capacity exceeded 9 GWp. The European Union contributes to around 50 % of the global cumulative capacity. We estimate that today, approximately 1,5 million households in Europe get electricity produced from solar photovoltaic electricity.



. Long term potential of solar power



In the long term it is estimated that solar power could contribute to an increasing part of the total energy consumption. With appropriate policies both in developed and developing countries, EPIA and Greenpeace have devised in a joint scenario, that in 2030, photovoltaic could produce enough energy to supply electricity to 3,7 million people globally.
The majority of them will be located in remote areas where there is no access to the electricity grid.
However efforts to achieve this potential have to start now. By switching to green energy today, you can contribute to this change.

Credits

Photos

BP Solar (page 6)
First Solar (page 8)
Isofoton (pages 8 & 9)
Phoenix Solar (page 10)
Q-Cells (page 7)
Schott Solar (pages 6 & 11)
Sharp (page 15)
SMA (pages 6 & 11)
SolarWorld (page 12)
Tenesol (page 13)
TramaTecnoambiental (page 11)
United Solar Ovonic (page 9)

Text

Daniel Fraile
Marie Latour
Adel El Gammal
Michael Annett

Frisian Solar Challenge,
solar boat competition, The Netherlands

EPIA - European Photovoltaic Industry Association

The European Photovoltaic Industry Association is the world's largest industry association devoted to the solar electricity market. The association aims to promote photovoltaics at the national, European and worldwide levels and to assist its members in the development of their businesses in both the European Union and in export markets.

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