Frequently Asked Questions:

European photovoltaic Technology Platform

A. GENERAL

PHOTOVOLTAIC ENERGY, WHY, HOW?

PhotoVoltaic TECHNOLOGY PLATFORM

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Frequently Asked Questions:

European photovoltaic Technology Platform

B. SPECIFIED FAQ OF CONSUMERS, INSTALLERS, ARCHITECTS AND DEVELOPERS

B.1. CONSUMERS:

1. Can I produce my own electricity?
2. In the choice to produce green electricity, why should I use a photovoltaic system?
3. Does the manufacturing process of a photovoltaic system not need more energy than it itself produces during its lifetime?
4. Do I have to change my boiler if I install a photovoltaic system?
5. What happens if the sun doesn't shine?
6. Can I sell excess solar electricity back to my utility?
7. Does my grid-connected photovoltaic system have to include batteries?
8. How do I know what size photovoltaic system I need?
9. Do I need to contact my electricity supplier when installing a photovoltaic system?
10. Can I expect a positive return on investment from my photovoltaic system?
11. Do photovoltaic systems need to be cleaned?
12. Can I walk on photovoltaic modules on my roof?
13. If I install a photovoltaic system on my roof, will it attract wasp nests?
14. What if a photovoltaic roof/facade develops a leak or is damaged by hail?

B.2. INSTALLER

1. What do I need to take into account to properly size a photovoltaic system?
2. What knowledge do I need to install and maintain photovoltaic modules?
3. How do I calculate the kWh from the watt peak?
4. What kind of loads does a photovoltaic installation involve on a building?
5. How can I predict the CO_2 reductions for every watt peak?

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Frequently Asked Questions:

European photovoltaic Technology Platform

B. SPECIFIED FAQ OF CONSUMERS, INSTALLERS, ARCHITECTS AND DEVELOPERS

B.3. ARCHITECTS and DEVELOPERS

1. Why should I use photovoltaic systems as an energy efficient building solution?
2. What is the energy return of a photovoltaic system?
3. Can I combine a building element with energy production?
4. What are Building Integrated Photovoltaic Systems (BIPV)?
5. How can I enhance the design creation with photovoltaic systems?
6. How can photovoltaic systems be used as a multifunctional building element?
7. Can I install a photovoltaic system elsewhere than on a roof?
8. Is it possible to install photovoltaic modules using different directions and angles than tilted and facing south without major reductions in energy yield?
9. How heavy are photovoltaic modules? Does the support structure need to be reinforced?
10. How much light does a transparent photovoltaic roof element let through?

PhotoVoltaic TECHNOLOGY PLATFORM

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Frequently Asked Questions:

European photovoltaic Technology Platform

A. ANSWERS TO THE GENERAL FAQ: photovoltaic energy, why, how?

1. What is photovoltaic solar energy?

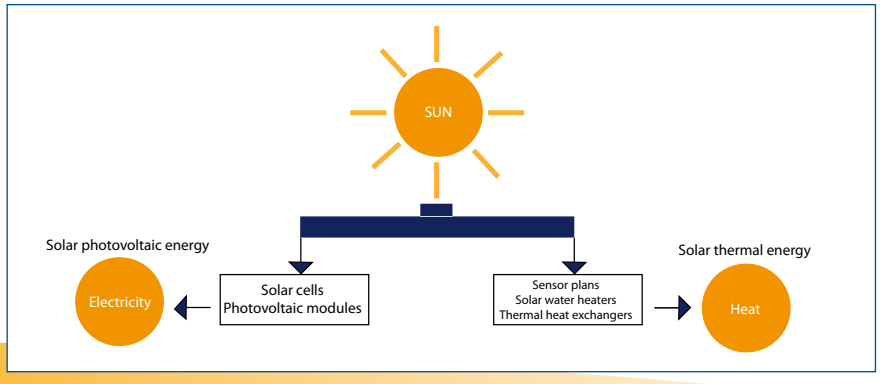
The word photovoltaic (PV) is composed of two terms: Photo - Photon which means "light" and Voltaic from 'Volt' which is the unit used to measure electric potential at a given point.

Photovoltaic systems use cells to convert sunlight into electricity. PV cells can be made from different so-called semiconductor materials. Today, silicon is the most widely used material, but other, usually compound (made from two or more elements) semiconductors are also used. They are silent and non-polluting, utilise a source of energy that renews itself, and require no special training.

2. What difference is there between thermal solar energy and photovoltaic solar energy?

The photovoltaic solar energy system converts sunlight directly into electric power to run lighting or electric appliances. A photovoltaic system requires only daylight (indirect sunlight) to generate electricity.

The solar thermal energy system generates and produces heat. This energy can be used to heat water or air in buildings or in many other applications.
Both use the irradiance of the sun even if the technology is quite different.



PhotoVoltaic TECHNOLOGY PLATFORM

A. ANSWERS TO THE GENERAL FAQ: photovoltaic energy, why, how?

3. What is a photovoltaic system?

A photovoltaic (PV) system is a system which uses solar cells to convert light into electricity.

A PV system consists of multiple components, including cells, mechanical and electrical connections and mountings and means of regulating and/or modifying the electrical output. Due to the low voltage of an individual solar cell (typically ca. 0.5V), several cells are combined into photovoltaic modules which are, in turn, connected together into an array.

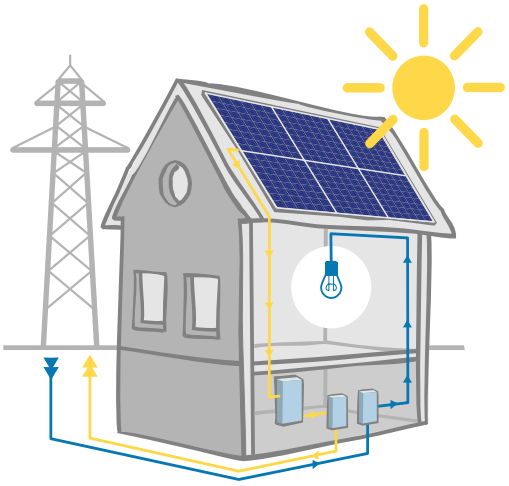
PV systems can be used for homes, offices, public buildings or remote sites where grid connection is either unavailable or too expensive. PV systems can be mounted on roofs or on building facades or operate as a stand-alone system. The innovative PV array technology and mounting systems mean that PV can be retrofitted on existing roofs or easily incorporated as part of the building envelope at construction stage. Modern PV technology has advanced rapidly and PV is no longer restricted to square and flat panel arrays but can be curved, flexible and shaped to the building design.

"Grid connected" means that the system is connected to the electricity grid. Connection to the local electricity network allows any excess power produced to feed the electricity grid and to sell it to the utility.
Such a PV system is designed to meet all or a portion of the daily energy needs. Typical on-grid applications are roof top systems on private houses

Frequently Asked Questions:

European photovoltaic Technology Platform

A. ANSWERS TO THE GENERAL FAQ: photovoltaic energy, why, how?



The diagram shows how electricity generated by solar cells in roof-mounted PV modules is transformed by an inverter into AC power suitable for export to the grid network. The householder/generator then has two choices: either to sell all the output to the local power utility (if a feed-in tariff is available) or to use the solar electricity to meet demand in the house itself, and then sell any surplus to the utility.

"Off-grid systems" have no connection to an electricity grid. Off-grid systems are contributing to rural electrification in many developing countries. PV is also used for many industrial applications where grid connection is not possible e.g. telecommunications, especially to link remote rural areas to the rest of the country.

Photovoltaic cells are equally 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, traffic signals, remote lighting and security phones.

PhotoVoltaic TECHNOLOGY PLATFORM

A. ANSWERS TO THE GENERAL FAQ: photovoltaic energy, why, how?

4. What is a photovoltaic system composed of?

Elements of a grid-connected PV system are: PV modules - converting sunlight into electric power, an inverter to convert direct current into alternating current, sub-construction consisting of the mounting system, cabling and components used for electrical protection, and a meter to record the quantity of electric power fed into the grid.

Off-grid (stand-alone) systems use charge controllers instead of inverters and have a storage battery for supplying the electric energy when there is no sunlight e.g. during night hours.

5. What is an inverter?

When sunlight strikes a photovoltaic cell, direct current (DC) is generated. By putting an electric load across the cell, this current can be utilised. An inverter is an electrical device which converts direct current [DC] to alternating current [AC].

Solar cells produce direct current. However, most of the electrical devices we commonly use expect a standard AC power supply. An inverter takes the DC from the solar cells and creates a useable form of AC.

An inverter is moreover necessary to connect a PV system to the grid.

A. ANSWERS TO THE GENERAL FAQ: photovoltaic energy, why, how?

6. What is net metering?

Solar electric systems use PV technology to convert sunlight into electricity during daylight hours. In a grid-connected PV system, PV modules pass DC electricity through an inverter to convert it into AC power. If the PV system's AC power is greater than the owner's needs, the inverter sends the surplus to the utility grid for use by others. It enables excess solar electricity to be sent back to the utility company.

If a home or office requires more electricity than can be provided by the PV system, the balance is provided through the grid connection. The utility provides AC power to the owner at night and during times when the owner's requirements exceed the capability of the PV system.

In many countries the utility company purchases all PV electricity generated at a higher rate (feed-in tariff) than the tariff applied for consumed electricity. In this case, a dedicated metering exists for 'PV generation' and a second metering for 'power taken from the grid', applying to each different tariff.

7. What is the feed-in tariff (FIT) and how does it work?

A legal obligation is put on utility companies to buy electricity from renewable energy producers at a premium rate, usually over a guaranteed period, making the installation of renewable energy systems a worthwhile and secure investment for the producer. The extra cost is shared among all energy users, thereby reducing it to a barely noticeable level.

FITs have been empirically proven to generate the fastest, lowest-cost deployment of renewable energy, and with this as a priority for climate protection and security of energy supply, not to mention job creation and competitiveness, FITs are the best vehicle for delivering these benefits.

The FIT system means that the pay-back time for PV is no longer several decades but several years instead. In countries such as Germany and Spain the demand for renewable energy systems has risen dramatically and the installation costs are coming down fast. This financing model has now been taken up widely around the world, as the table below shows:

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A. ANSWERS TO THE GENERAL FAQ: photovoltaic energy, why, how?

Countries, states and provinces that have adopted FITs

Year	Cumulative number	Countries/states/provinces added that year
1978	1	United States
1990	2	Germany
1991	3	Switzerland
1992	4	Italy
1993	6	Denmark, India
1994	8	Spain, Greece
1997	9	Sri Lanka
1998	10	Sweden
1999	13	Portugal, Norway, Slovenia
2000	14	Thailand
2001	16	France, Latvia
2002	20	Austria, Brazil, Czech Republic, Indonesia, Lithuania
2003	27	Cyprus, Estonia, Hungary, Korea, Slovak Republic, Maharashtra, (India)
2004	33	Italy, Israel, Nicaragua, Prince Edward Island (Canada), Andhra, Pradesh and Madhya Pradesh (India)
2005	40	Turkey, Washington (US), Ireland, China, India, (Karnataka, Uttaranchal, Uttar Pradesh)
2006	41	Ontario (Canada)

Source: REN21, 2006

FITs can be shaped according to a country's RE resources, its electricity distribution system and its RE targets. There are many design options to help take account of these variables, including some which make the system more compatible with liberalised energy markets (but carry higher investment risk). The important thing is that each technology is supported if viable.
Source: World Future Council

PhotoVoltaic TECHNOLOGY PLATFORM

A. ANSWERS TO THE GENERAL FAQ: photovoltaic energy, why, how?

8. Does photovoltaic technology need bright sunshine to work properly?

A PV system needs daylight to work but not direct sunlight. Indeed, if a PV module is exposed to an artificial light, it will also produce electricity.

The light of the sun consists both of direct light and indirect or diffuse light (which is the light that has been scattered by dust and water particles in the atmosphere). Photovoltaic cells not only use the direct component of the light, but also produce electricity when the sky is overcast. It is a common misconception that PV only operates in direct sunshine and is therefore not suitable for use in temperate climates. This is not correct: photovoltaics make use of diffuse solar radiation as well as direct sunlight.

When sunlight strikes a photovoltaic cell, direct current (DC) is generated. By putting an electric load across the cell, this current can be utilised. The amount of useful electricity generated by a PV module is proportional to the intensity of light energy which falls onto the conversion area. The greater the available solar resource the higher the electricity generation potential.

However, as the electrical output of a PV module is dependent on the intensity of the light to which it is exposed, it is certain that a PV module exposed to the sun in a clear sky at midday will produce a maximum of its output electricity. It can thus be said that PV modules will tend to generate more electricity on bright days than when skies are overcast. Nevertheless, photovoltaic systems do not need to be in direct sunlight to work, so even on overcast days a PV module will be generating some electricity.

Frequently Asked Questions:

European photovoltaic Technology Platform

A. ANSWERS TO THE GENERAL FAQ: photovoltaic energy, why, how?

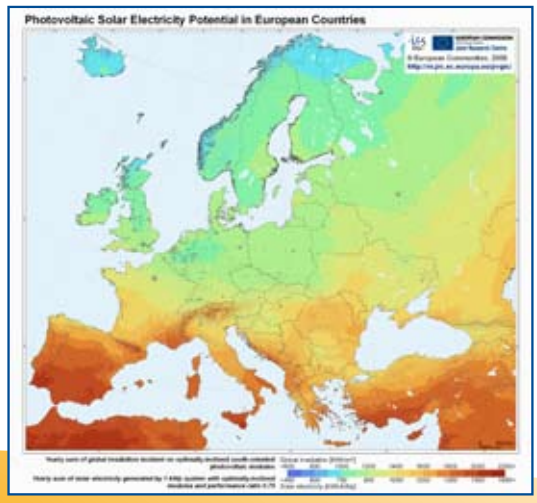
9. How much electricity does a photovoltaic system produce?

The electricity production of a PV system depends on external (environmental conditions) and internal (technology, layout of the system) parameters.

The efficiency of the PV module depends on:

- The size of the PV system and its technology
- The direction of the PV module towards the sun. The optimal direction for locations above the equator is the south
- The tilt angle or inclination of the roof. For European countries,
- the average optimal inclination is 30°-35°
- The irradiance value on site
- The climate zone

Shadows on the modules (also if they appear only at certain times of day) reduce significantly the gain of the whole system and should be avoided.
The map below represents the yearly sum of global irradiation on a horizontal (inclined) surface. Alternatively, the maps represent solar electricity [kWh] generated by a 1kWp system per year with horizontal (or inclined) modules.



Source: http://re.jrc.ec.europa.eu/pvgis/countries/europe.htm
To determine the PV electricity generation potential for a particular site, it is important to assess the average total solar energy received over the year.

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A. ANSWERS TO THE GENERAL FAQ: photovoltaic energy, why, how?

10. What does grid parity mean?

Grid parity means that, for consumers, photovoltaic electricity will be cheaper than the retail electricity price.

In light of decreasing solar electricity generation costs and increasing price for conventional electricity, solar power systems will equally become increasingly economic during the next few years. During the next 5-10 years solar electricity will become cheaper (depending on location and peak hours) for private households than retail electricity.

A considerable advantage of solar electricity is that it is mainly produced around midday when conventional electricity is particularly expensive. Solar electricity largely replaces expensive peak-load electricity at preferential customer prices, which is why it would be wrong to compare it with cheap base-load electricity.

Grid parity (competitiveness with retail electricity prices) will be reached progressively from 2010 onwards in several European markets. Countries with the highest solar irradiation and higher electricity prices, such as Italy and Spain, have the potential to reach grid parity starting in 2010 and 2012 respectively. Grid parity will be reached in Germany in 2015 and cover progressively most other EU countries up until 2020.

11. Do photovoltaic modules lose efficiency each year?

The degeneration of PV modules varies according to the type of PV modules installed. The loss of power production during a life cycle of 20 to 25 years is estimated to be 10 to 20% for crystalline PV modules.

Frequently Asked Questions:

European photovoltaic Technology Platform

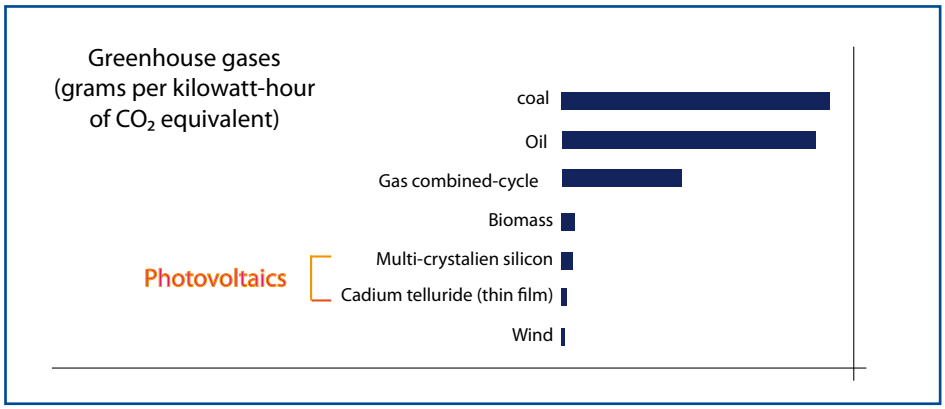
A. ANSWERS TO THE GENERAL FAQ: photovoltaic energy, why, how?

12. How much CO_2 will a solar roof save?

The CO_2 savings of a solar roof will depend on many factors, including:

- The energy source the solar production is replacing (coal, gas, hydro-electric, nuclear...)
- The quantity of energy produced by the solar roof (depending on the roof's location, direction towards the sun, inclination and shading)
- The quantity of electricity needed to manufacture the photovoltaic system (modules, inverter, cables, etc.)
- The "energy habits" of the solar roof owner.

If, for instance, electricity comes from a coal-fired power station, each kWh used will release around 1,000g of equivalent carbon (various greenhouse gases converted into 'equivalent carbon units' for comparison). However, if the original electricity comes from a hydro-electric power station, it is producing much less carbon equivalent emissions (less than 10g).
A very important factor is the design of the system. If a system is designed wrongly (e.g. modules facing north and 90° inclination) the electricity output will be very low and, therefore, the system will not replace much conventional electricity.
The amount of CO_2 saved is very much dependent on the source of the energy replaced. Next to CO_2 savings, each m^2 of solar module installed will produce clean and sustainable home-made electricity.



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A. ANSWERS TO THE GENERAL FAQ: photovoltaic energy, why, how?

13. Is it worthwhile using solar energy in Europe?

Definitely! In Germany, for example, the average annual solar irradiance is 1000 kWh per square metre. With efficient solar power systems, this is sufficient to generate a considerable volume of electricity and heat from solar power.
Obviously southern regions will reach grid parity and profitability more quickly.

Hence it is worthwhile producing solar energy in Europe, not least because this makes Europe less dependent on energy imports but also because:

- The fuel is free
- It produces no noise, harmful emissions or polluting gases
- PV systems are very safe and highly reliable
- It brings electricity to remote rural areas
- The energy pay-back time of a module is constantly decreasing
- It creates thousands of jobs
- It contributes to improving the security of Europe's energy supply

14. Can renewable energy sources guarantee a secure energy supply despite their dependence on the weather?

The best way forward to ensure a secure energy supply for the future is an energy mix of renewable energy sources, intelligent load management in combination with energy storage. This will enable renewable energy sources to ensure a secure, climate-friendly and sustainable energy supply.

Solar power is particularly available during periods of peak load demand (midday and in summer) and is excellently complemented by wind power, where peak values are principally reached in winter. Biomass, hydropower and geothermal energy are continually available and counterbalance any deficits.

A. ANSWERS TO THE GENERAL FAQ: photovoltaic energy, why, how?

15. What is the life cycle of a photovoltaic system?

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 photovoltaic a very reliable technology in the long term.

Most manufacturers in general propose performance guarantees on the modules after 20 years of 80% of the initial output power. As regards the electronic components and accessories (inverters), the guarantee usually does not exceed 10 years.
But this doesn't mean that PV systems do not produce energy after 20 – 25 years.
Most PV systems installed more than 25 years ago still produce energy today!

16. What if there is a problem with the photovoltaic system?

If a PV module has a defect or no longer produces electricity or, under identical conditions, produces much less electricity than before, it is generally covered by the manufacturer's performance guarantee against a drop in efficiency of more than 20%.

Most manufacturers indeed propose performance guarantees on modules of 20 and 25 years for 80% of the initial output power. On the electronic components and accessories (inverters), the guarantee usually does not exceed 10 years, although longer inverter insurances can be arranged.

A. ANSWERS TO THE GENERAL FAQ: photovoltaic energy, why, how?

17. Is solar energy more expensive than conventional energy?

In light of decreasing solar power generation costs and increasing costs for conventional electricity (due to oil and gas prices), solar power systems will equally become increasingly economic during the next few years.

A considerable advantage of solar power is that it is mainly produced during the day when the demand is high and therefore electricity is particularly expensive. Another important feature is that PV is normally produced at the same site than demand; therefore, a high investment on extending the electricity infrastructure is not required.
In the long term solar energy will be much cheaper than conventional energy. However, solar energy, like all energy production technologies (coal, gas, nuclear etc.) in the past and present, need financial support from the government to further develop the technology and thus reduce prices to become competitive.

However, solar energy is already well on the way: whereas the costs for conventionally generated energy have constantly increased in recent years and – faced with finite resources – will continue to increase by a considerable extent, increasing mass production has enabled the cost of solar energy to drop by an average of 10% per year.

A. ANSWERS TO THE GENERAL FAQ: photovoltaic energy, why, how?

18. What contribution can solar electricity play world-wide as regards total energy consumption?

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. In the long term it is estimated that solar power could contribute to an increasing share of total energy consumption. With appropriate policies both in developed and developing countries, EPIA and Greenpeace have devised in a joint scenario photovoltaic systems could produce enough energy to supply electricity to 3.7 million people globally by 2030.

The Solar Generation report published by Greenpeace and the European Photovoltaic Industry Association (EPIA) in September 2008 concludes that solar electricity can contribute largely to the energy needs of two-thirds of the world's population - including those in remote areas - by 2030.

The report confirms the impressive growth of the solar energy sector and demonstrates its potential of becoming a global energy contributor. It estimates that over 1800 GW of photovoltaic systems will have been installed worldwide by 2030, which represents over 2600 TWh of electricity produced per year or 14% of global electricity demand.

This is enough power to supply over 1.3 billion people in developed areas and over 3 billion people in remote rural areas who currently have no access to mains electricity.

A. ANSWERS TO THE GENERAL FAQ: photovoltaic energy, why, how?

19. Can the solar industry also grow without government subsidies?

In the long run public support will no longer be required to help the development of energy produced by photovoltaic means.
The solar industry will be capable of generating a high degree of growth without government subsidies in the foreseeable future. Given the increasing costs of conventional energy sources, the decreasing costs of renewable energy sources, as well as a growing export market, solar thermal energy could achieve this within the next five years and PV sector in 10-15 years.
With increasing sales leading to economies of scale and efforts realised by producers to reduce the cost of photovoltaic products, it is expected that costs for photovoltaic energy will be competitive with electricity prices in southern Europe by 2012 and in most of Europe by 2020.

Until then, the market introduction of solar energy is dependent on statutory frameworks if it is to become competitive and survive in the global market. The industry will require investment security for developing solar power manufacturing plants and for their high development input, and, until then, consumers will require legally secure incentives to invest in installing solar systems. The cost reduction can be achieved through research development and large-scale implementation with cost-effective financing instruments, such as the advanced feed-in tariff.

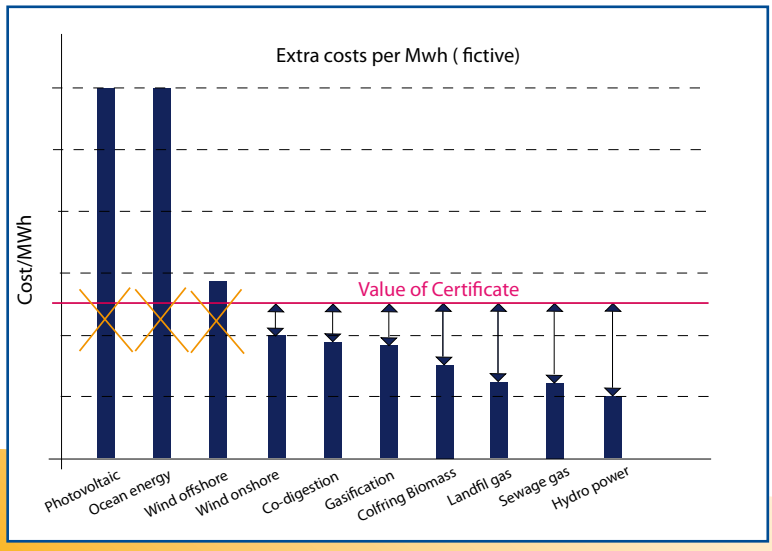
Frequently Asked Questions:

European photovoltaic Technology Platform

A. ANSWERS TO THE GENERAL FAQ: photovoltaic energy, why, how?

20. What are green certificates?

Green Certificate, also known as Renewable Energy Certificate (RECs), is a tradable commodity proving that a certain amount of electricity (normally sold to the customer) is generated using renewable energy sources. Typically, one certificate represents the generation of 1 MWh of electric power. Usually, the following sources are considered as renewable: wind, solar, wave, tidal, geothermal, hydro and biomass.
Green certificates represent the environmental value of renewable energy generated. The certificates can be traded separately from the energy produced. Several countries use green certificates as a means to make the support of green electricity generation closer to market economy instead of more bureaucratic investment support and feed-in tariffs. Such national trading schemes are in use in e.g. Poland, Sweden, UK, Italy, Belgium (Wallonia and Flanders), and some US states (Wikipedia).
In practice, producers, wholesalers, retailers or consumers (depending on who is obliged) are obliged to supply or consume a certain percentage from renewable electricity sources. For each unit of renewable electricity (e.g. MWh), a certificate is generated and issued to the producer. This certificate serves as proof that renewable electricity was delivered into the grid.
The graph below shows the costs per MWh versus the certificate value. Some technologies will be excluded from a Green Certificate market, while mature technologies are stimulated (only fictitious values are used to show the impact).



Unlike the feed-in tariff, specific for each technology, a green certificate has no technology-specific price. Instead of compensating specific generation costs of the technology, a number of technologies will generate windfall profits, meaning that the compensation is higher than their actual generation costs.

Technologies like PV are currently not competitive with other renewable technologies. However, their long-term potential in cost reduction is immense and their potential of contribution to future production is greater than for other energy sources.

PhotoVoltaic TECHNOLOGY PLATFORM

A. ANSWERS TO THE GENERAL FAQ: photovoltaic energy, why, how?

21. How long will the development of photovoltaics depend on feed-in tariffs?

The major challenge for the renewable energy industry in general has been to make the cost of clean energy competitive with heavily subsidised conventional energy. Householders or energy companies who wanted to install wind turbines or solar panels have been faced with lengthy pay-back times. Without increased consumer demand and political measures to facilitate access to the market, manufacturers of solar photovoltaic (PV) panels cannot produce the unit volumes needed to bring prices down and drive technological innovation.

The Feed-In Tariff (FIT) has proven to be the most effective policy instrument in overcoming these barriers. The feed-in tariff allows the pay-back time for PV to be only several years instead of decades (see also Q.7).

In 2008, the majority of installed PV systems benefit from well-designed grant support, in particular the feed-in tariff mechanism. This provides fair remuneration to the investor and rewards the effort made in investing in a clean energy source. Solar energy is becoming more economically viable and should become cost-competitive with conventional energy by 2015 in southern European countries and by 2020 across most of Europe.

Increasing customer's demand, decreasing installation costs and increasing costs for conventional electricity will make solar power systems become increasingly economic during the next few years. During the next 5-10 years solar power will become cheaper (depending on location and peak hours) for private households than conventional electricity. Thus solar power will become independent of subsidies much earlier than might be deemed at first glance.

With stand-alone systems remote from the electricity grid, it is already worthwhile using solar technology today.

The Renewable Energy Sources Directive at EU level reinforces the current legal framework and could facilitate the implementation of the feed-in tariff scheme throughout Europe.

Frequently Asked Questions:

European photovoltaic Technology Platform

B.1. SPECIFIED FAQ OF CONSUMERS

1. Can I produce my own electricity?

If your home has a roof with some shadow-free space, a PV system can generate electricity for your consumption. With a roof area of 30m2 and using standard modules (15% efficiency), you can produce about 3000kWh every year.

2. In the choice to produce green electricity, why should I use a photovoltaic system?

PV is a renewable energy source that produces electricity. Electricity can be used for all home appliances and lighting. Moreover, PV produces energy during periods of peak consumption. This reduces the load on conventional power stations, effectively reducing the price of electricity for all consumers.

Besides, the following arguments apply:

- The fuel is free: the sun is the only resource needed to power solar panels.
- It produces no noise, harmful emissions or polluting gases. PV systems are far better for the environment than power from conventional power plants.
- PV systems are very safe and highly reliable.
- PV modules require low maintenance and can be recycled.
- It brings electricity to remote rural areas. PV energy is produced locally, close to consumption.
- It can be aesthetically integrated into buildings, covering roofs or facades.
- The energy pay-back time of a module is constantly decreasing.
- It creates thousands of jobs. The PV sector has an annual growth of 40%, thereby playing a major contribution in job creation.
- It contributes to improving the security of Europe's energy supply. PV systems offer greater self-sufficiency, reducing dependence on imported oil.
- As PV energy is produced locally, close to consumption, the electricity usually does not need to travel long distances to be used, reducing losses and infrastructure costs and efforts.

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B.1. SPECIFIED FAQ OF CONSUMERS

3. Does the manufacturing process of a photovoltaic system not need more energy than it itself produces during its lifetime?

PV systems, like every other product, do require energy during the manufacturing process. However, PV systems pay back this energy input within 1 to 4 years, depending on cell type and location. This is called the energy payback time. The energy pay-back time is defined as the time in years needed for a PV system to "reimburse" its initial energy content.

The energy payback time will depend on irradiance and weather conditions, on the design of the systems (direction towards the sun, angle, shadows, etc.) and thus its output performance. It also depends on the technology used.

The energy payback time on a country-by-country basis is available at:
http://www.eupvplatform.org/fileadmin/Documents/Brochure-indicateurs_26_pays.pdf

During its expected life cycle a PV module will therefore produce 6 to 18 times more energy than is needed to manufacture it.

4. Do I have to change my boiler if I install a photovoltaic system?

PV is a technology that generates electricity, not heat. Therefore, the existing heating system remains unchanged. As a measure to reduce emissions, consideration may be given to improving the home insulation and heating/refrigeration systems or installing solar thermal modules to provide hot water, which is independent of the photovoltaic system.

B.1. SPECIFIED FAQ OF CONSUMERS

5. What happens if the sun doesn't shine?

A PV system needs daylight to work but not direct sunlight. Indeed, if a PV module is exposed to an artificial light, it will also produce electricity.

Sunlight consists both of direct light and indirect or diffuse light (which is the light that has been scattered by dust and water particles in the atmosphere). Photovoltaic cells not only use the direct components of light, but also produce electricity when the sky is overcast. It is a common misconception that PV only operates in direct sunshine and is therefore not suitable for use in temperate climates. This is not correct: photovoltaic cells make use of diffuse solar radiation as well as direct sunlight.

However, as the electrical output of a PV module is dependent on the intensity of the light to which it is exposed, it is certain that a PV module exposed to the sun in a clear sky at midday will produce a maximum of its output electricity. It can thus be said that PV modules will tend to generate more electricity on bright days than when skies are overcast. Nevertheless, photovoltaic systems do not need to be in direct sunlight to work, so even on overcast days a PV module will be generating some electricity.

Normally, the PV system is connected to the electricity grid. Therefore, when more electricity is produced that is consumed this surplus is fed into the grid so it can be used by other consumers. When the weather conditions don't allow the system to produce as much electricity as is required, or just during the nights, the electricity will come from the grid.

B.1. SPECIFIED FAQ OF CONSUMERS

6. Can I sell excess solar electricity back to my utility?

The householder of a PV system has two choices: either to sell all the output to the local power utility (if a feed-in tariff is available) or to use the solar electricity to meet demand in the house itself, and then sell any surplus to the utility.

Solar power systems use PV technology to convert sunlight into electricity during daylight hours.
If the PV system's AC power is greater than the owner's needs, the inverter sends the surplus to the utility grid for use by others.
If a home or office requires more electricity than can be provided by the PV system, the balance is provided through the grid connection. The utility provides AC power to the owner at night and during times when the owner's requirements exceed the capability of the PV system.

In many countries the utility company purchases all PV electricity generated by consumers at a rate higher (feed-in tariff) than the tariff applied to consumed electricity. In this case a dedicated metering exists for 'PV generation' and a second metering for 'power taken from the grid'.
Each meter has a different tariff.

7. Does my grid-connected photovoltaic system have to include batteries?

Batteries are only essential if power needs to be 'stored' in case of a utility outage. However, most grid-connected PV systems will send any excess generated electricity back to the utility using the utility grid (rather than batteries).

B.1. SPECIFIED FAQ OF CONSUMERS

8. How do I know what size photovoltaic system I need?

The best indicator for sizing a PV system is your historical electrical usage, or the number of kilowatt hours (kWh) you consume each year. It is especially important to determine an annual average for your kWh usage, because many families experience seasonal spikes in usage. This average gives you a starting point for comparing the energy output of various systems.

Depending on the technology a PV system of between 7m²-15m² (1KWp installed) can produce for instance about 1000kWh every year in Munich and 1400KWh in Malaga for instance. The calculation for a system size can easily be made if you know your electricity consumption per year.

9. Do I need to contact my electricity supplier when installing a photovoltaic system?

This depends on the country legislation in question. For example, in Germany the supplier neds to be asked concerning the system's connection point. It will usually be the same as the point where electricity is purchased, but if the system is bigger than the capacity of the grid at that point there may be complications. In Spain the process is similar on paper but requires a long time. In Portugal, there is a simple online application to be done for small systems.

Contact the photovoltaic association in the country concerned for specific details about the process.

B.1. SPECIFIED FAQ OF CONSUMERS

10. Can I expect a positive return on investment from my photovoltaic system?

The cost of PV technology has dropped dramatically in the past ten years and, thanks to government incentives or subsidies in some countries, a PV system may be the most cost-effective power solution. Photovoltaic systems allow electricity rates to be locked at current prices. With fossil fuels likely to become more expensive in the future, purchasing a PV system today is a smart economic move.

In some countries there is the possibility of enjoying feed-in tariffs or investment incentives. When installing a PV system at home, all electricity generated can be injected and sold to the electricity provider at a higher price than the price paid in one's monthly bill. This mechanism enables the investment made to be paid back 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 electricity consumers, aware of the importance of renewable energies, are gradually switching to solar power, receiving a compensation for their effort.

Moreover, in light of decreasing solar electricity costs and increasing costs for conventional electricity, solar power systems will equally become increasingly economically viable. During the next 5-10 years solar electricity will become cheaper (depending on location and peak hours) for private households than conventional electricity.

11. Do photovoltaic systems need to be cleaned?

Most PV modules don't need to be cleaned and are easy to maintain. When installed on roofs, the PV modules are installed with a tilt angle and the rain (in the areas where it falls) cleans the panels. For modules integrated in facades, no cleaning is necessary.

PhotoVoltaic TECHNOLOGY PLATFORM

B.1. SPECIFIED FAQ OF CONSUMERS

12. Can I walk on photovoltaic modules on my roof?

PV modules are most often encapsulated in two layers of tempered low iron glass or between glass and tedlar (a polymer) so they are stronger and less rigid than glass, in order to withstand, for instance, the most severe hail impacts.
There are many public projects where PV has been integrated on the floor and therefore walking on the modules doesn't present a problem. However, PV modules are normally not designed to be walked upon. It is recommended protecting the modules with lengths of wood before walking on them, as you would protect a skylight or other glass roofing material.

13. If I install a photovoltaic system on my roof, will it attract wasp nests?

PV modules are generally very dark in colour (blue or black, depending on the technology) and can become quite hot. A PV module with an efficiency of 12% converts 12% of the incident energy into electricity and most of the rest of the energy is converted into heat!
Wasps like warm but not hot environments. The most common wasps in western Europe ventilate their nests once they reach 35°C, and die at 40°C. Whilst wasps may be attracted to build their nest under roof-mounted PV modules or sunshades (or shutters and roof eaves), the wasps probably won't survive the mid-summer temperatures under the PV modules.

14. What if a photovoltaic roof/facade develops a leak or is damaged by hail?

This should be covered by your home or building insurance. Some insurers will automatically cover the system as it is considered to be just another part of the house and its contents, and no modifications are required to the contract. But check with your insurer if they can cover your system or whether a new clause is required in your contract.
Other elements of the system may require attention; inverters generally come with a one-year factory warranty, although some manufacturers have developed fee-paying extended warranties.
The electrical connections should be covered by your installer's professional insurance - ask your installer what guarantee he offers. For larger systems, specific contracts may be negotiated.

PhotoVoltaic TECHNOLOGY PLATFORM

B.2. SPECIFIED FAQ OF INSTALLERS

1. What do I need to take into account to properly size a photovoltaic system?

The first step is to find out the customer's wishes. This has to match the existing space - shadow-free roof. The roof must be analysed (there are tools for this) to find out how much area is not shadowed and can be used for a photovoltaic system. Some solutions can be found for shadowing during winter time or during early morning or late afternoon, but shadowing always reduces the system's performance.

Once the area is clear, one needs to know the type of modules that are to be installed. Obviously the dimensions of the modules and the electrical characteristics will be taken into account. The module layout has to match the working point of an inverter.

The best indicator for sizing a PV system is the historical electrical usage or the number of kilowatt hours (kWh) consumed each year. It is especially important to determine an annual average for the kWh usage, because many families experience seasonal spikes in usage. This average gives a starting point for comparing the energy output of various systems.

A PV system of between 7m^2-15m^2 (1KWp installed), depending on the technology, can produce about 1000kWh every year in Munich and 1400KWh in Malaga, for instance. If the electricity consumption per year is known, the calculation for a system size can easily be made.

2. What knowledge do I need to install and maintain photovoltaic modules?

In order to install Photovoltaic systems, knowledge about electricity is required, especially about dimensioning and protection. It is also necessary to assess the static requirements of the roof and the mounting systems. In some countries, in order to connect to the grid, the electrical contractor or installer needs to be certified.

The future Directive on the promotion of electricity produced from renewable energy sources might request member states to ensure a qualification for installing PV systems.

B.2. SPECIFIED FAQ OF INSTALLERS

3. How do I calculate the kWh from the watt peak?

The yearly value of kWh that a system will produce depends on the system size (in kWp), design, the irradiation and weather conditions and the system components.

Many tools already exist in the market in order to calculate the estimated energy production of the system during its whole life cycle. These programs normally calculate the electricity (KWh) produced based on the nominal power of the system (kWp) and takes into consideration irradiance, weather conditions and type of system (technology, direction towards the sun, angle, possible shadows, losses, etc.).
Photovoltaic Geographical Information System (PVGIS) is a free and online existing tool from the Joint Research Center, EC. It is available at:

http://re.jrc.ec.europa.eu/pvgis/index.htm
http://re.jrc.ec.europa.eu/pvgis/apps3/pvest.php

4. What kind of loads does a photovoltaic installation involve on a building?

Standard mono-crystalline modules are relatively light, around 10 to 15 kg per square metre. This load must be carried by the roof structure to which the system is attached but in most circumstances there is no need to reinforce existing structures.
Made-to-order modules may be heavier - insulated double and triple-glazed modules, often used in sunroofs and atriums, will be 2 to 3 times heavier. Other factors that may affect the weight of a photovoltaic system are the type of module frame and the selected connection method.
However, most existing (old) buildings were not designed to support the additional load of the photovoltaic systems on the structure. Some problems could therefore appear due to wind load, water tightness, snow and ice etc. Therefore the structure of the roof needs to be checked with the architect or structural engineer so as to ensure a successful and safely installed photovoltaic system. This is of vital importance for installers of photovoltaic systems. On existing buildings it is equally important to ensure that future buildings, close to a building with a photovoltaic system, will not cause any shadows and that the structure can support the over-loads of the photovoltaic system put on the roof without any problem. For new buildings, it is recommended to adapt the new roof to the pitch and direction requirements for photovoltaic systems. It is essential that photovoltaic installations comply with local building regulations and safety codes.

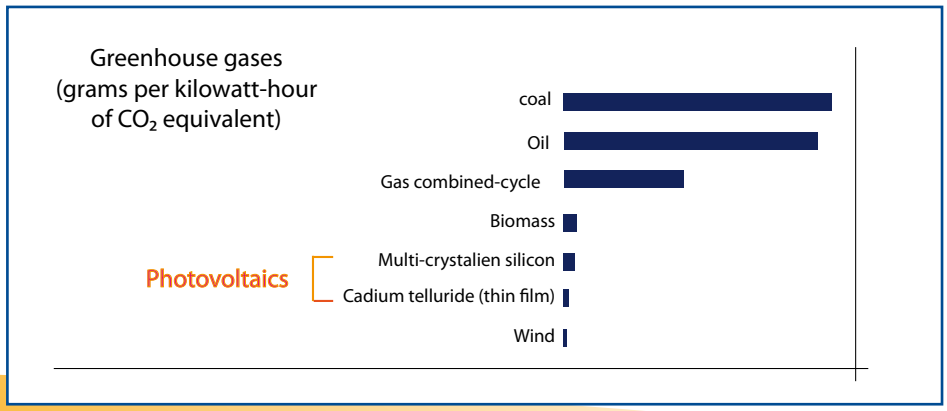
B.2. SPECIFIED FAQ OF INSTALLERS

5. How can I predict the CO_2 reductions for every watt peak?

The CO_2 savings of a solar roof will depend on many factors, including:

- The energy source the solar production is replacing (coal, gas, hydro-electric, nuclear...)
- The quantity of energy produced by the solar roof (depending on the roof's location, direction towards the sun, angle and shading)
- The quantity of electricity needed to manufacture the photovoltaic system (modules, inverter, cables, etc.)
- The "energy habits" of the solar roof owner

If electricity comes from a coal-fired power station, each kWh used will release around 1,000g of equivalent carbon (various greenhouse gases converted into 'equivalent carbon units' for comparison). However, if the original electricity comes from a hydro-electric power station, it produces much less carbon equivalent emissions (less than 10g).
A very important factor is the design of the system. If a system is wrongly designed (e.g. modules facing the north and 90° inclination), the electricity output will be very low and therefore the system will not replace much conventional electricity.
So clearly the amount of CO_2 saved is very much dependent on the source of the energy replaced. Next to CO_2 savings, each m^2 of solar module installed will produce clean and sustainable home-made electricity.



PhotoVoltaic TECHNOLOGY PLATFORM

B.3. SPECIFIED FAQ OF ARCHITECTS AND DEVELOPERS

1. Why should I use photovoltaic systems as an energy efficient building solution?

PV modules are multifunctional building components which, besides generating electricity, can fulfil many other functions such as shading systems, weather protection, heat insulation and sunlight modification, creating excellent lighting effects.

Furthermore, the integration of renewable energy sources in a building will provide the building designer/owner a "green image", developing positive relations with "green investors" and achieving better ranking in "green investment funds".

Today's PV systems can be easily integrated into the home's existing electrical system. They produce clean energy - no air pollution, no greenhouse gas emissions. And they can greatly reduce, or even eliminate, one's electricity bills. Photovoltaic power systems can now be integrated into the design of a building, combining energy production with other functionalities of a building's external structure. Roof tiles, windows, facades, canopies and skylights can all be incorporated with PV technology, and this combining of functionalities can lead to substantial cost savings.
A well designed and installed PV system is often considered a beneficial feature on a house and can even increase the value of the property.

B.3. SPECIFIED FAQ OF ARCHITECTS AND DEVELOPERS

2. What is the energy return of a photovoltaic system?

PV systems, like every other product, does require energy for the manufacturing process. However, PV systems pay back this energy input within 1 to 4 years, depending on cell type and location. This is called the energy pay-back time. The energy pay-back time is defined as the time in years needed for a PV system to "reimburse" its initial energy content.

The energy payback time will depend on irradiance and weather conditions, on the design of the systems (direction towards the sun, angle, shadows, etc.) and thus its output performance. It also depends on the technology used.

The energy payback time on a country-by-country basis is available at:
http://www.eupvplatform.org/fileadmin/Documents/Brochure-indicateurs_26_pays.pdf

During its expected life cycle a PV module will therefore produce 6 to 18 times more energy than is needed to manufacture it.

3. Can I combine a building element with energy production?

PV systems constitute a reasonable alternative for construction materials to be considered by architects. Besides replacing an existing building component, PV systems also produce energy making it a multi functional building component.

The possibility of using solar panels as a new building component such as for roofs, façades or blinds, offers a wide new spectrum and very important new design lines and challenges for both architects and module manufacturers.

PhotoVoltaic TECHNOLOGY PLATFORM

B.3. SPECIFIED FAQ OF ARCHITECTS AND DEVELOPERS

4. What are Building Integrated Photovoltaic Systems (BIPV)?

When speaking about BIPV, the PV modules are fully integrated into the building, since they form an integral part of the buildings into which they are integrated. Therefore, PV modules are part of the whole building design, replacing traditional construction materials.

BIPV or Building Integrated Photovoltaics' is an industry buzz phrase, which indicates photovoltaic modules integrated into various construction materials. Solar roof tiles are an example. Similar combination materials can be used on any other well illuminated surface.

5. How can I enhance the design creation with photovoltaic systems?

PV systems constitute a reasonable alternative for construction materials to be considered by architects. Besides replacing an existing building component, PV systems also produce energy making it a multi functional building component. Architects should consider the use of renewable energy sources from the design phase.

The possibility of using solar panels as a new building component such as for roofs, façades or blinds, offers a wide new spectrum and very important new design lines and challenges for both architects and panel manufacturers.

Active involvement by building developers, engineers, architects, module manufacturers and installers is therefore of the utmost importance from the project design phase to help in resolving the total integration of the panel on the roof in order to avoid potential problems with leaks, dampness and insulation that may occur.

PV systems have to be seen not only as energy generators, but also as multi-functional elements contributing to improving the look of the environment where they have to be placed.
The versatility of the PV component, obtained by means of design tools, ensures the possibility to enlarge its utilisation to many contexts, like urban and natural environments, archaeological areas, etc. in a creative way.

B.3. SPECIFIED FAQ OF ARCHITECTS AND DEVELOPERS

6. How can photovoltaic systems be used as a multifunctional building element?

Generally, a Building Integrated PV (BIPV) System is designed to serve more than one function. Hence, it is defined as a multi-functional building element. It can be used as an exterior shading device or insulating roofing material or it can directly displace the exterior facade of the building: BIPV façade systems include laminated and patterned glass, spandrel glass panels, curtain wall glazing systems, cladding systems and awning systems. Roofing systems include BIPV shingles, tiles, metal roofing, exterior insulation roof systems and atrium or laminated roof systems.

7. Can I install a photovoltaic system elsewhere than on a roof?

There are no limits for installing PV systems when a good exposure is achievable.
Beyond roofs, some of the most common places used to implement PV systems are, for example: facades which offer huge possibilities for architectural integration and visibility;

- sunshades
- canopies
- greenhouses
- noise mitigation barriers
- of course, the ground, especially for large-scale applications

B.3. SPECIFIED FAQ OF ARCHITECTS AND DEVELOPERS

8. Is it possible to install PV modules using different directions and angles than tilted and facing south without major reductions in energy yield?

There are no mandatory installation requirements. Certain shifts with respect to the optimum installation requirements for photovoltaics are allowed without incurring substantial power loss. For instance, considering the mean latitude value for Central Europe, a +/- 15° tilt shift can involve a slight 2% loss, while the same shift from the southern direction is merely capable of reducing a system's performance by 3%.

9. How heavy are photovoltaic modules? Does the support structure need to be reinforced?

Standard photovoltaic modules are relatively light, around 10 to 15 kg per square metre. This means that in most circumstances there is no need to reinforce existing structures. Made-to-order modules may be heavier - insulated double and tripled glazed modules, often used in sunroofs and atriums, will be 2 to 3 times heavier. Other factors that may affect the weight of a photovoltaic system are the type of module frame and the selected connection method.
However, most existing (old) buildings were not designed to support the additional load of the photovoltaic systems on the structure. Some problems could therefore appear due to wind load, water tightness, snow and ice etc. Therefore the structure of the roof needs to be checked with the architect or structural engineer so as to ensure a successful and safely installed photovoltaic system. This is of vital importance for installers of photovoltaic systems.
On existing buildings it is equally important to ensure that future buildings, close to a building with a photovoltaic system, will not cause any shadows and that the structure can support the overloads of the photovoltaic system put on the roof without any problem.
For new buildings, it is recommended to adapt the new roof to the pitch and orientation requirements for photovoltaic systems.

It is essential that photovoltaic installations comply with local building regulations and safety codes.

B.3. SPECIFIED FAQ OF ARCHITECTS AND DEVELOPERS

10. How much light does a transparent photovoltaic roof element let through?

Transparent PV modules are generally one of two principal types:

- normal cells in a double glass frame, the gaps between the cells are transparent
- thin films deposed on a glass surface; the PV layer is thin enough to let a certain amount of light through

However, this remains quite rare and it would be more usual to laser drill micro holes or have other gaps to have some white light coming through.
The gaps between normal PV cells in a double-glass module can be increased or decreased to change the transparency level of the module. Generally, the gaps between cells are such that the transparency is between 5% and 30%. A classic double-glass module will have a transparency of roughly 5%.
The transparency of thin-film modules depends on the transparency of the support and the thickness and type of cell used.
Nearly any degree of transparency desired can be achieved (subject to potential extra costs) made to order, but it is common to balance the natural light gains against potential overheating due to increased thermal gains.

GLOSSARY

Balance-of-System: The BoS mainly comprises electronic components, cabling, support structures and, if applicable, electricity storage or optics and sun trackers. BoS costs also include the labour costs of installation.
Charge controller: Charge controllers are typically used in off-grid photovoltaic power systems. The primary function of a charge controller (or regulator) is to maintain the battery at the highest possible State Of Charge (SOC) and provide the user with the required quantity of electricity, while protecting the battery from deep discharge (by the loads) or extended overcharge (by the PV array). Additional features, such as battery temperature or wire compensation, meters and alarms, can enhance the ability of the charge controller to meet the load demand and extend battery lifetime.
Electric Energy: The amount of work accomplished by electrical power, usually measured in kilowatt-hours (kWh). One kWh is 1,000 Watts and is equal to 3,413 Btu.
Feed-in Law: A legal obligation on utilities to purchase electricity from renewable sources.
Feed-in Tariff: The price per unit of electricity that a utility or supplier has to pay for renewable electricity from private generators. The government regulates the tariff rate.
Grid-Connected PV system: A PV system in which the PV array acts as a central generating plant, supplying power to the grid.
Ingot: A mass of metal or semi-conducting material, heated past the melting point, and then recast, typically into the form of a bar or block.
Inverter: Device that converts direct current (DC) into alternating current (AC) either for stand-alone systems or to supply power to an electricity grid.
Off-grid PV System: System installed in households and villages that is not connected to the utility grid. Usually, a means to store electricity is used (most commonly lead-acid battery). It is also known as "stand-alone photovoltaic power system".
On-grid PV System: Systems connected to the utility grid.
Payback Time: The length of time it takes for the savings received to cover the cost of implementing the technology.

PhotoVoltaic TECHNOLOGY PLATFORM

GLOSSARY

Photovoltaic (PV) Module or Panel: A solar photovoltaic product that generally consists of groups of PV cells electrically connected together to produce a specified power output under standard test conditions, mounted on a substrate, sealed with an encapsulate and covered by protective glazing. Available as mounted on an aluminium frame. A junction box, on the back or underside of the module, is used to allow for connecting the module circuit conductors to external conductors.
Photovoltaic (PV) Peak Power (Wp): PV modules are rated by their total power output. The peak power is the amount of power output a PV module produces at standard test conditions (STC) of a module operating temperature of 25 degrees Celsius in full sunshine (irradiance) of 1 000 watts per square metre. This is a clear summer day with sun approximately overhead and the cells faced directly towards the sun.
Photovoltaic (PV) System: A complete set of components for converting sunlight into electricity by the photovoltaic process, including the array and balance of system components.
Silicon (Si): A chemical element, atomic number 14, semi-metallic in nature, dark grey, an excellent semiconductor material. It is a common constituent of sand and quartz (as the oxide). It crystallizes in face-centred cubic lattice like a diamond. It's the most common semiconductor material used in making photovoltaic devices.
Solar Cell: A basic photovoltaic device, which generates electricity when exposed to a light source such as solar radiation. All photovoltaic cells produce direct current (DC).
Solar Wafer: A thin sheet of semiconductor material made by mechanically sawing it from a single-crystal or multi-crystal ingot or casting.

PhotoVoltaic TECHNOLOGY PLATFORM