Renewable Energy

Photovoltaics, wind, geothermal, solar thermal

Renewables:

Renewable energy sources, such as solar to generate electricity and hot water, as well as wind to generate electricity, geothermal to create heating, are increasingly being looked to as a means of reducing reliance on NON-renewable energy sources such as fossil fuels of all types.

Renewables have the advantage of being in infinite supply, as well as being FREE (ie. Sun and wind). What is difficult at present is the cost of the means required to convert both solar and wind to something "more useful" to the built environment.

As a result, these systems are only implemented where conditions are IDEAL, as a way to increase efficiency and reduce costs.

Systems to be considered:

Photovoltaic Systems: standard and BIPV (building integrated photovoltaics)

Solar thermal: concentrating units that use the sun

Wind energy: single turbines or wind farms

Geothermal: using the temperature of the ground beneath the building to preheat or precool

PV systems

Photovoltaic Systems:

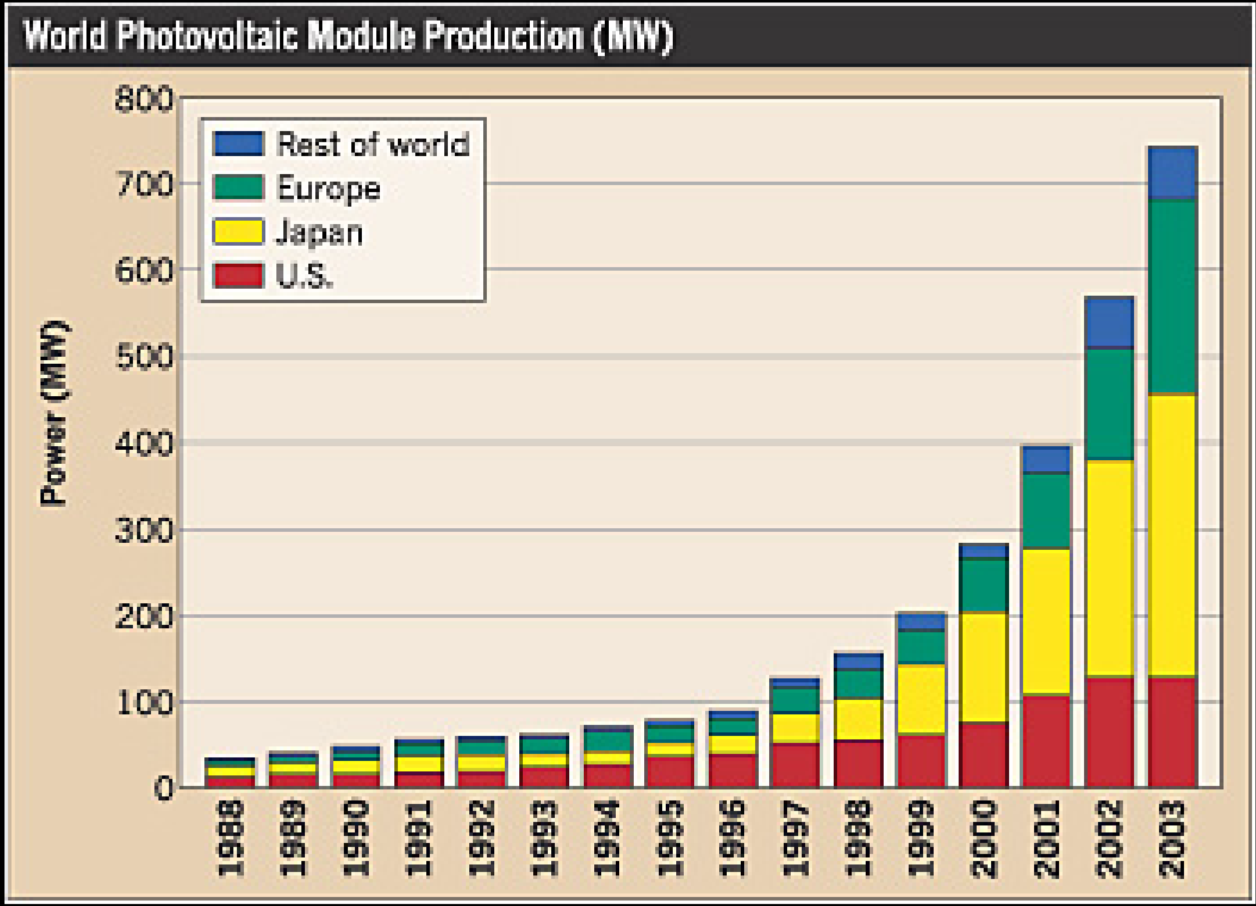
The Science of Photovoltaics

Photovoltaic science is the science of turning energy produced from the sun into electricity. Edmond Becquerel discovered the concept known as the photovoltaic effect in 1839. However, the first positive/negative (p/n) junction solar cell was not created until 1954 at Bell Labs.

Photovoltaics are semiconductor devices that convert light directly into electricity. They are usually made of silicon and are first cousins to transistors, LEDs and other electronic devices.

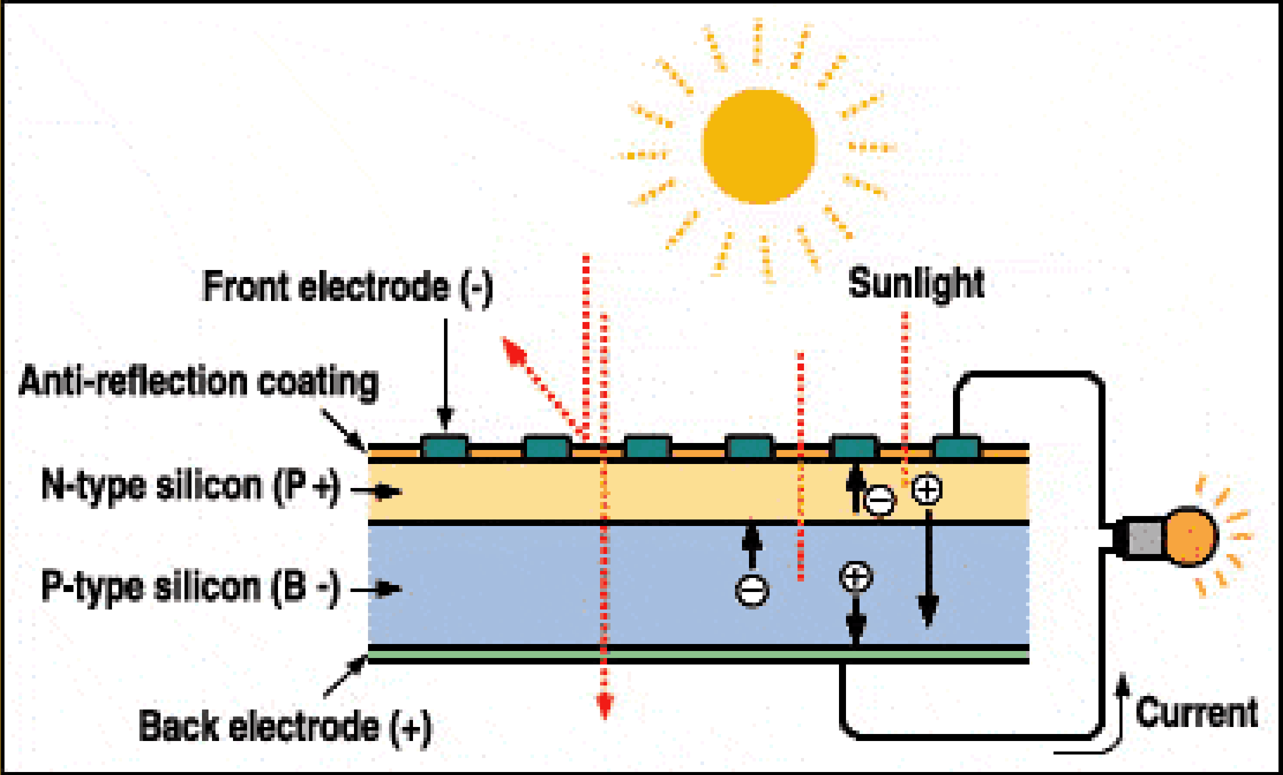
World pv production

Production of PV has increased dramatically since the initial sustainable design conference in 1987. The efficiency has increased and the costs have decreased.



Solar basics:

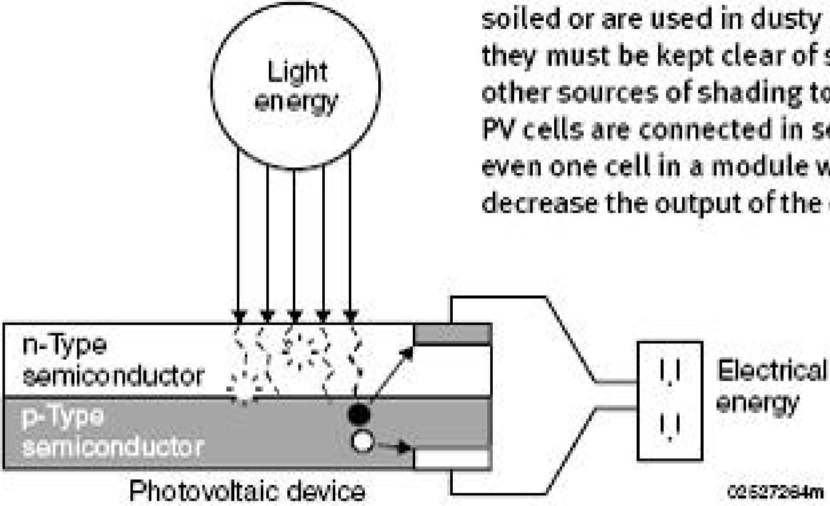
Solar cells are converters. They take the energy from sunlight and convert that energy into another form of energy, electricity. Solar cells convert sunlight to electricity without any moving parts, noise, pollution, radiation, or maintenance. The conversion of sunlight into electricity is made possible with the special properties of semi-conducting materials.



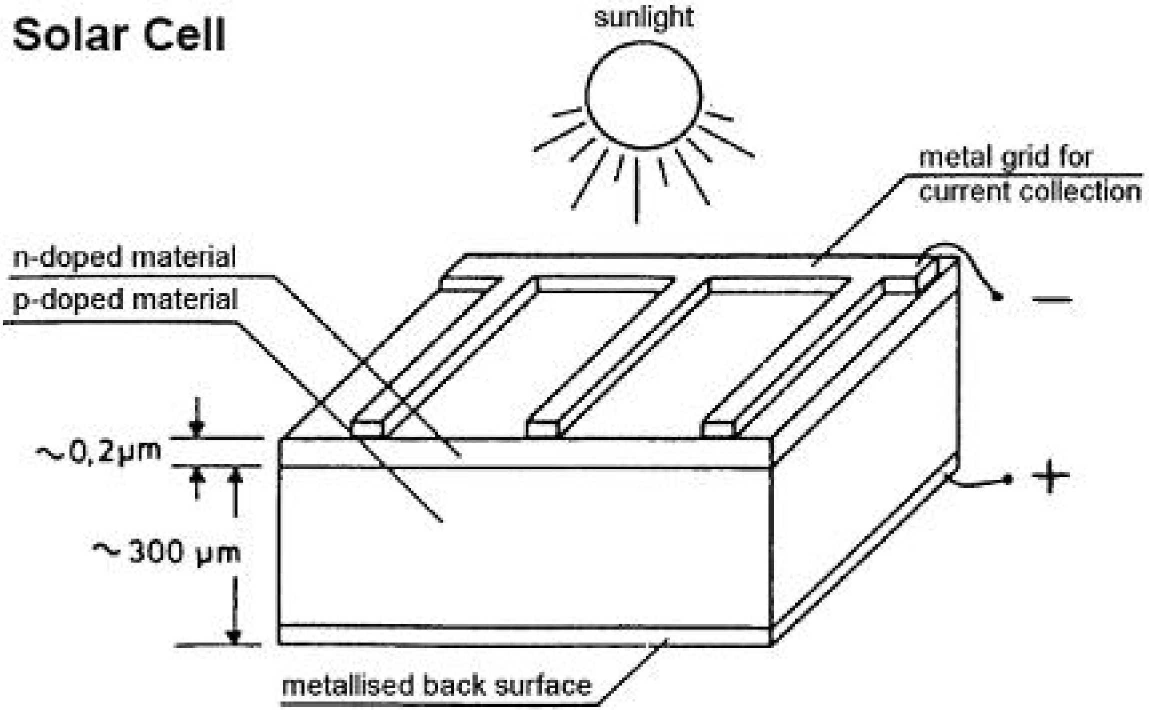
The Photovoltaic Effect

Sunlight is composed of photons—discrete units of light energy. When photons strike a PV cell, some are absorbed by the semiconductor material and the energy is transferred to electrons. With their new-found energy, the electrons can escape from their associated atoms and flow as current in an electrical circuit.

PV arrays require no care other than occasional cleaning of the surfaces if they become soiled or are used in dusty locations. However, they must be kept clear of snow, weeds, and other sources of shading to operate properly. PV cells are connected in series, so shading even one cell in a module will appreciably decrease the output of the entire module.

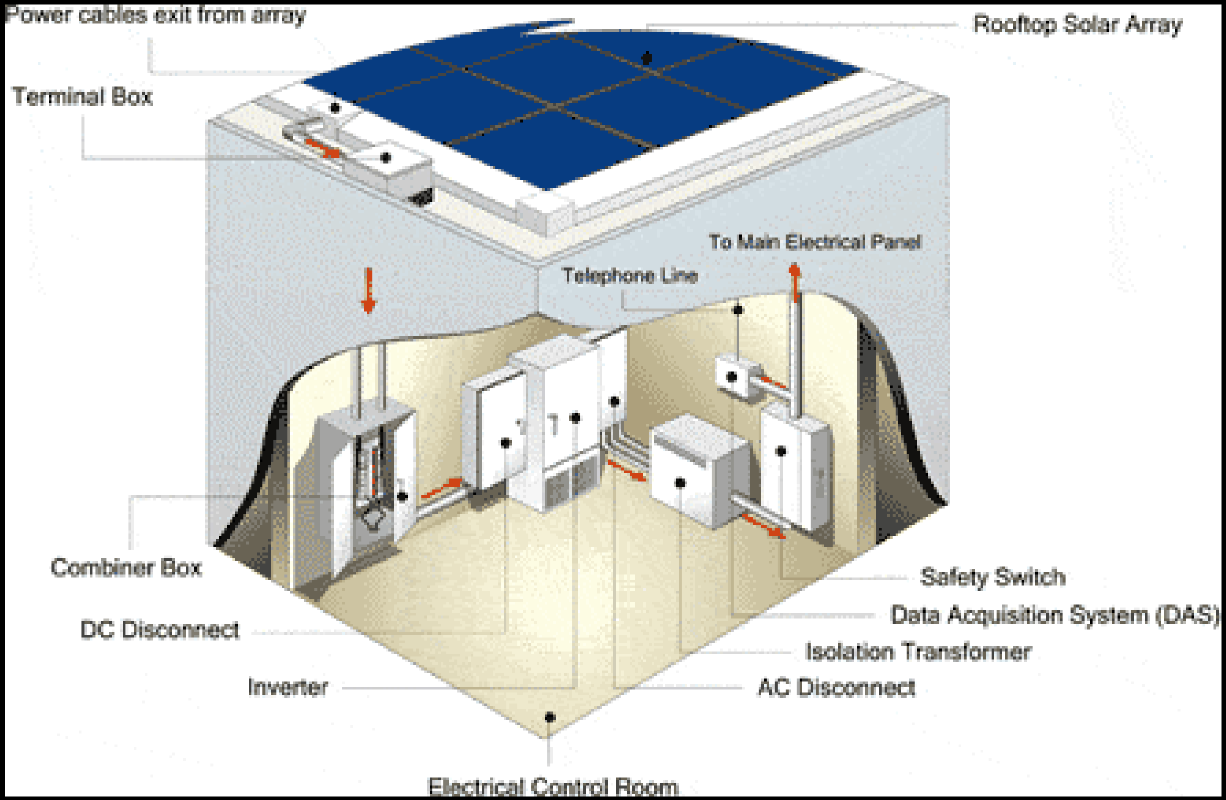


Principle Function of a crystalline Si Solar Cell

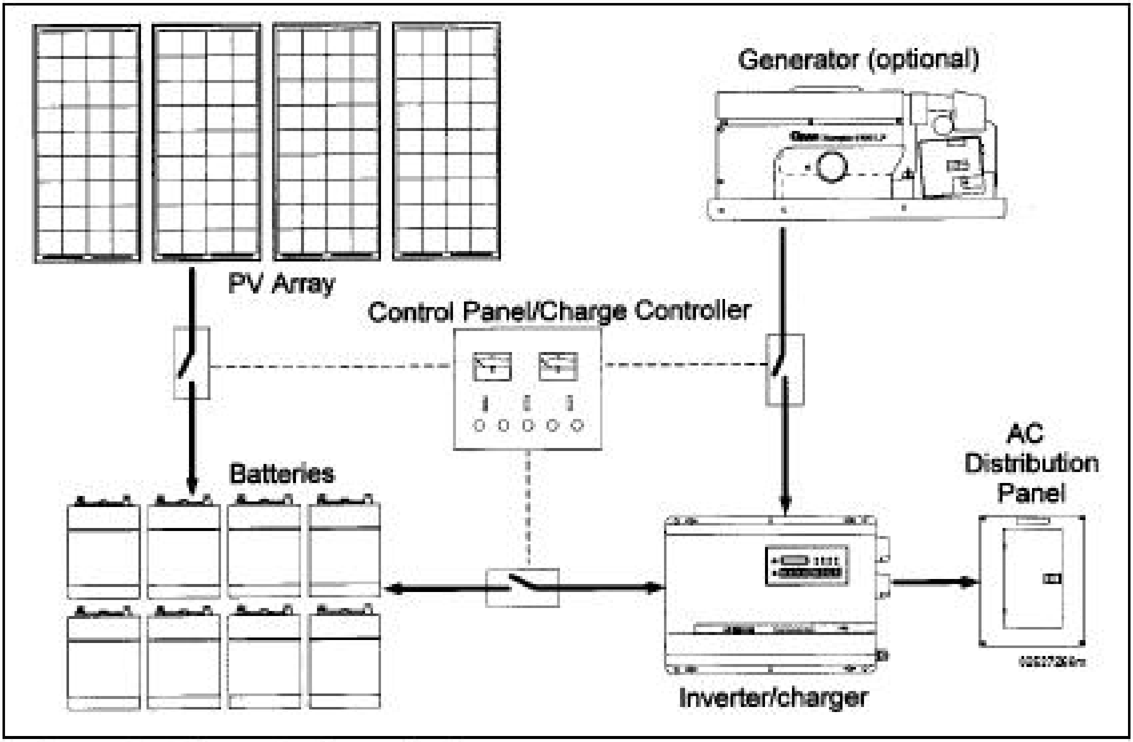


Solar cells alone cannot produce usable power. They need to be interconnected with other system components that ultimately serve a specific electrical demand, or 'load'. PV systems can either be stand-alone, or grid-connected. The main difference between these two basic types of systems is that in the latter case, the PV system produces power in parallel with the electrical utility, and can feed power back into the utility grid if the onsite load does not use all of the PV system's output.

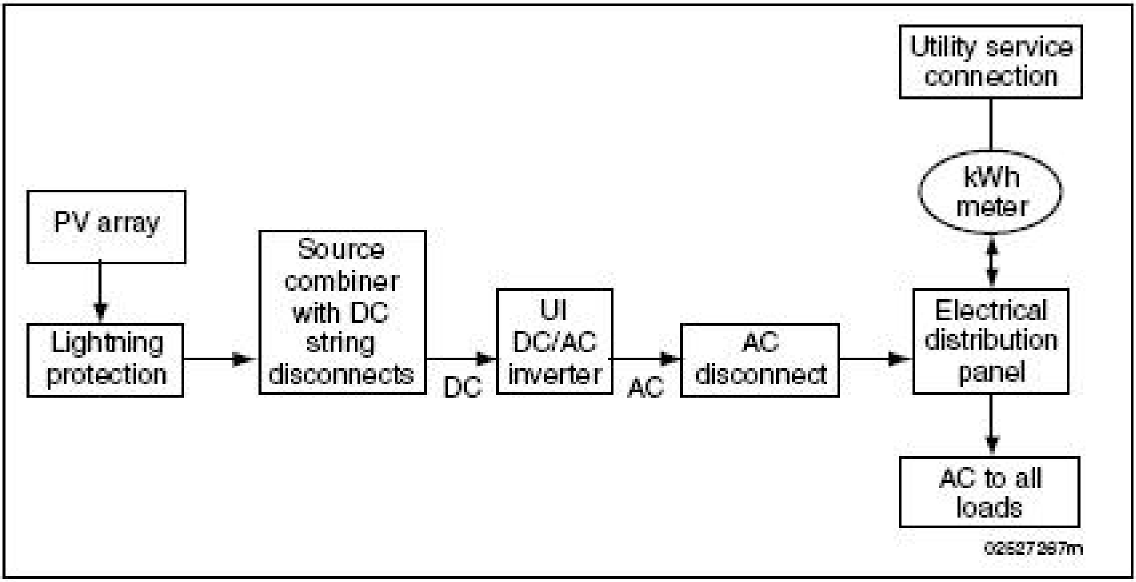
When the sun is shining, the direct current electricity (DC) from the PV modules is converted to alternating current (AC) by the power of an electronic inverter, and then fed directly into the building power distribution system where it supplies electric power.



Beyond the array itself…



Schematic of a typical stand-alone PV system

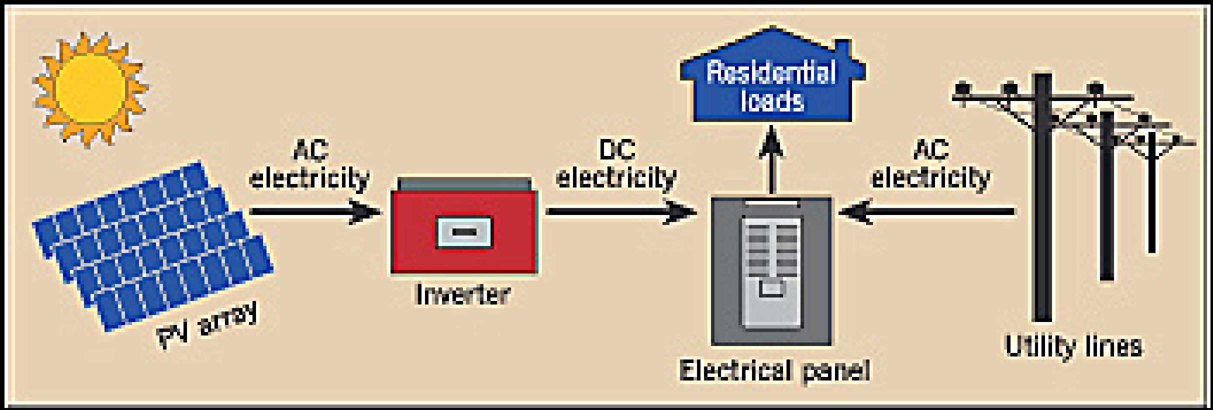


Block diagram of a utility-interactive PV system

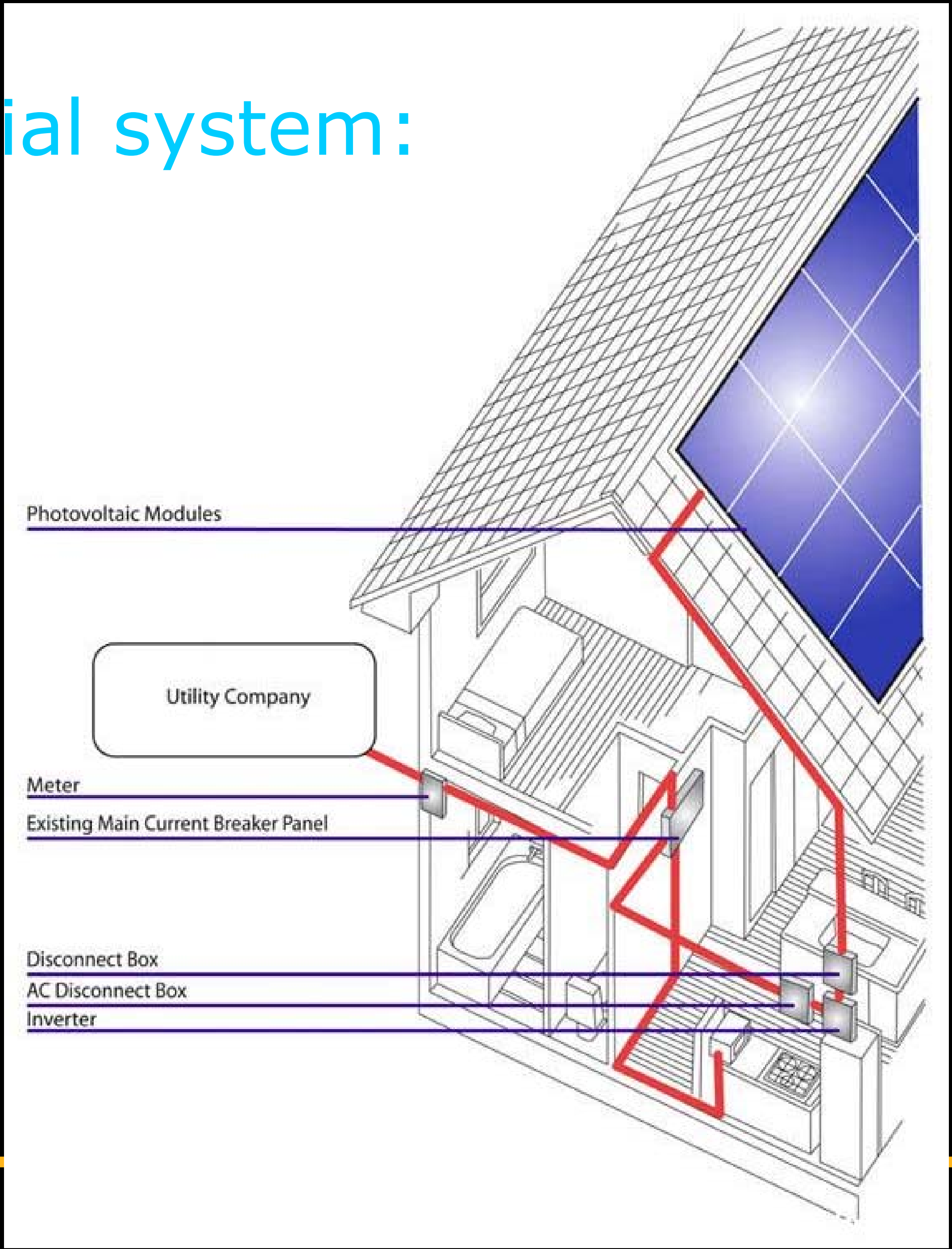
Inverters

Each of the modules must be wired and connected to the next, to eventually transfer the electrical charge to the inverter. In most cases this is done via thin, flat wires that run through the cells.

Inverters come in various sizes/types and result in some power loss via the process.



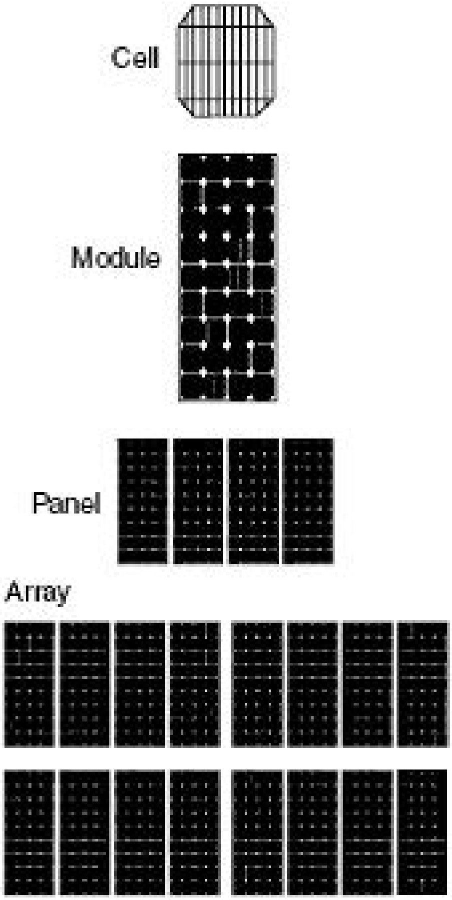
Typical residential system:



Types of silicon cells:

An individual solar cell can vary in size from 1cm to 15cm and produce between 1 and 2 watts. Main types on the market are crystalline and thin film.

Cells are combined into modules, modules into panels, and panels into arrays. Arrays are ganged on a surface to provide the amount of power required.


Cell
Module
Panel
Array

Crystalline silicon:

Mono crystalline cells: are made from very pure mono-crystalline silicon. This type of silicon has a single and continuous crystal lattice structure with almost no defects. High efficiency (15%). Energy intensive manufacturing process. Expensive.

Poly- or multi-crystalline cells: are produced using numerous grains of mono-crystalline silicon and have a more irregular surface. In the manufacturing process the silicon is cast into ingots which are rectangular/square in shape. These are cut into very thin wafers and assembled into complete cells. They can also grow this on a substrate. Less efficient (12%). Less expensive.

Mono-crystalline cells tend to be flat black or deep blue in color. Polycrystalline cells have a mottled (like galvanized steel), cobalt blue appearance.

mono

mono

poly

Photovoltaic modules of varying sizes.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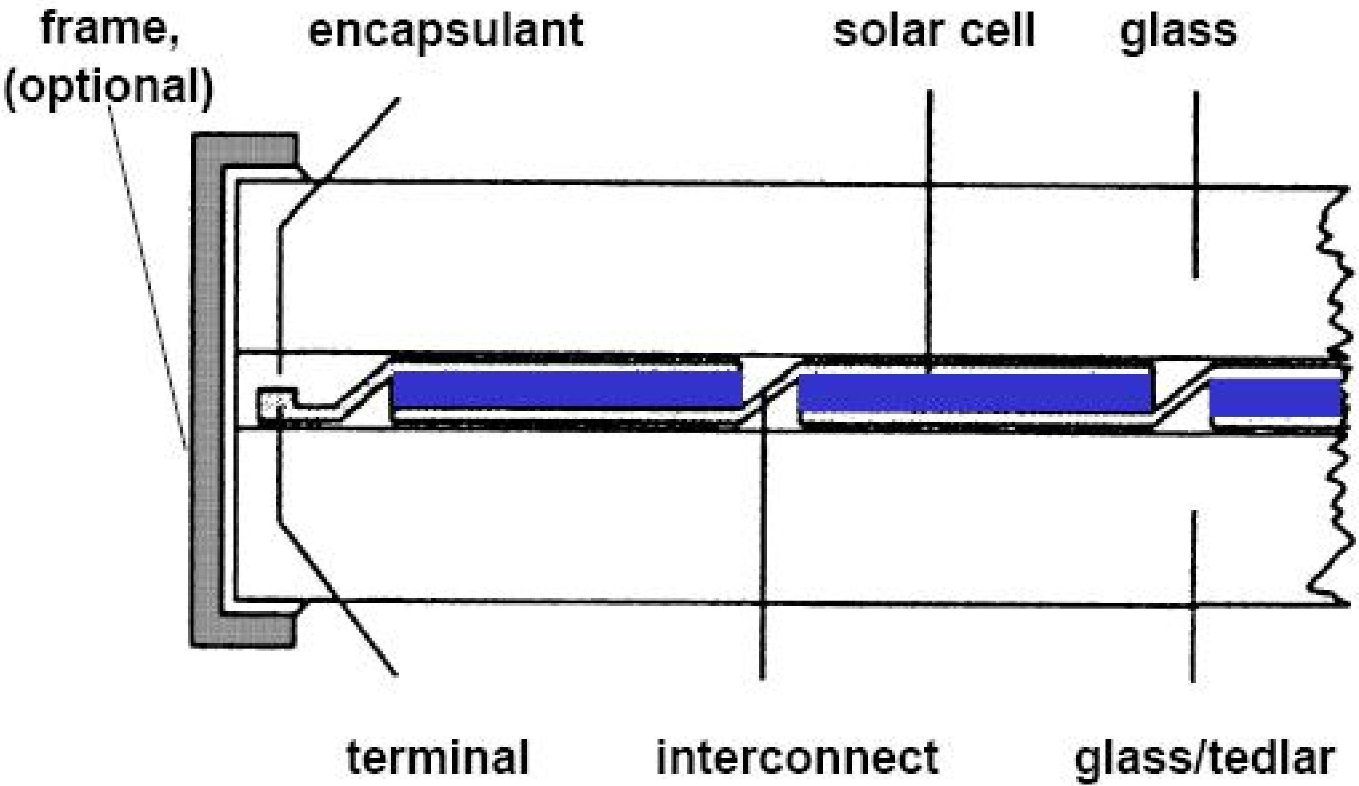
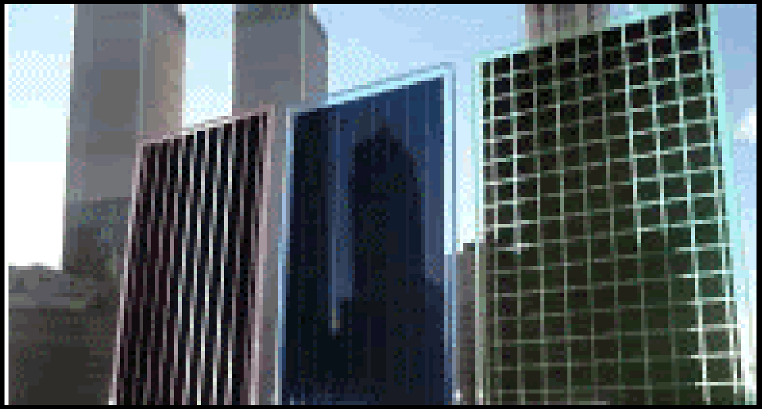

frame,
(optional)
encapsulant
solar cell
glass
terminal
interconnect
glass/tedlar

Thin film silicon:

Thin film cells can be amorphous silicon, copper-indium-diselenide (CIS) and cadmium-telluride (CdTe) cells.

Composed of silicon atoms arranged in a thin amorphous matrix rather than a crystalline structure. Amorphous silicon absorbs light more effectively than crystalline and the product is much thinner. Cheaper to produce, but with efficiencies around 6%. These modules have a charcoal grey or bronze color and look like low-E coating or fretting when used on vision glass. Other colors are available but, the cost will be higher.



Temperature:

Photovoltaics produce heat as a by-product of the process by which sunlight is changed to electricity. They must be installed so that they are vented, as overheating will decrease their efficiency.

Photovoltaics actually work better in cold weather situations. This makes Korea a relatively good climate for their use.

Contrary to most peoples' intuition, photovoltaics actually generate more power at lower temperatures with other factors being equal. This is because photovoltaics are electronic devices and generate electricity from light, not heat. Like most electronic devices, photovoltaics operate more efficiently at cooler temperature. In temperate climates, photovoltaics will generate less energy in the winter than in the summer, but this is due to the shorter days, lower sun angles and greater cloud cover, not the cooler temperatures.

Rain and snow:

Rain will not adversely affect a pv array system since during periods of rainfall the solar irradiance is already low.

Roof mounted pv arrays can be covered with snow in the winter. If the array is covered, it will not work. In snowy climates, sloped arrays are preferred to flat installations as theoretically the sun will penetrate the snow, heat the dark pv layer, melt the base of the snow and it will slide off of the panel. It is important to prevent such snow from piling up at the base of the array, or sliding uncontrolled onto passers by below the installation.

Sometimes it is necessary to shovel the array. Care must be taken not to damage it.

Dirt and pollution:

Any factor that reduces light transmittance to the pv surface will reduce the output of the system. If dirt is allowed to accumulate (more likely in urban areas), the output can be reduced by 2% to 6%. The higher value occurs if the slope of the array is less than 30 degrees.

The occasional heavy rainstorm is usually sufficient to clean the array.

If pv is installed on a wall surface, rain can keep it clean if the array is exposed to such. Otherwise, the surface can be cleaned in the same way as window systems would be.

Shading:

AVOID SHADING THE PANEL. The shaded area will not reduce the output proportionally to the area shaded -- loss is much higher. Within a chain of modules the output will be close to that of the weakest (shaded) module. If shade cannot be avoided at certain times, be sure to gang the affected modules together on the same circuit, leaving the sunny modules to fully function.

This goes for seasonal shading due to trees or vines, and even the shade from deciduous trees in the winter when they are bare. Watch for plant growth over time that can shade the panels.

Orientation:

It is essential to provide unobstructed access to sunlight to optimize efficiency.

Due south is ideal but deviations up to 45 degrees only result in a 10% loss of power. As a rule, BIPV installations are best when oriented south and tilted at an angle of 15 degrees higher than the site latitude; ie. The further north you go, the more vertical the panel as the sun angles are low in the sky and the system performs better when the rays strike at a right angle (less reflectance).

If using the system for AC rather than heating electrical supply, vary the installation for the time of year.

Variation of solar irradiance (%):

tilt	west	75	60	45	30	15	south	15	30	45	60	75	east
10°	83	85	86	87	88	89	90	89	88	87	86	85	83
20°	82	84	87	88	91	92	93	92	91	88	87	84	82
30°	79	83	87	91	95	96	96	96	95	91	87	83	79
40°	73	81	86	90	92	98	100	98	92	90	86	81	73
50°		78	83	87	91	95	96	95	91	87	83	78	
60°			80	82	84	90	91	90	84	82	80		
70°				78	81	84	85	84	81	78			
80°						75	77	75					
90°							72						

**this must be measured for the precise latitude in question.

PV versus BIPV??

BIPV stands for “building integrated photovoltaic” systems.

These use PV as architectural design components by the means of “architectural integration” of the PV into the roof, wall, glazing and

shading systems.

Integration aims to reverse the trend to think of PV as an “add-on” (and usually pretty ugly) system, and ensure that it works as part of the building envelope system.

This works with sustainable notions of having building elements “do” more than one thing. Roofs can easily accommodate another use -- by adding electrical production. The same with curtain walls, skylights, etc.

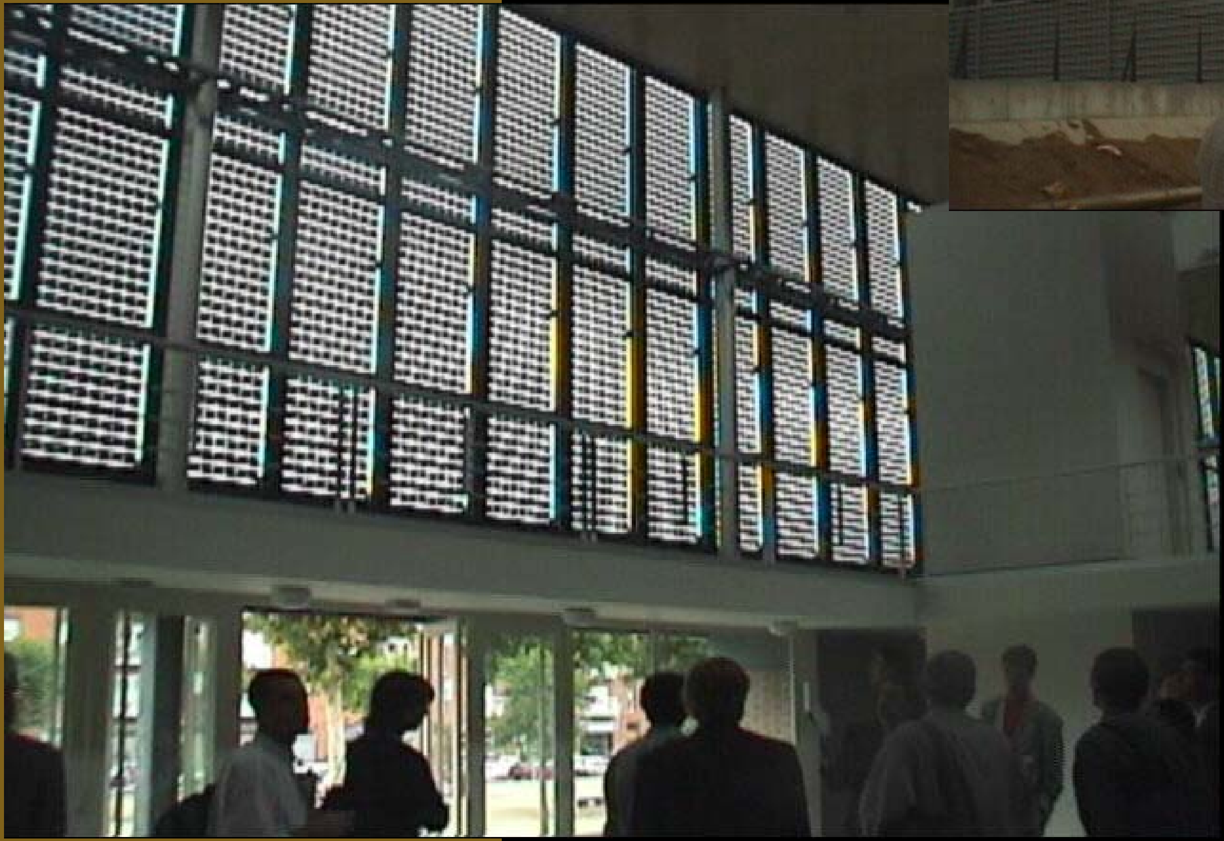
This is NOT Building INTEGRATED Photovoltaics!

This is not totally, but better, integrated.

This roofing IS being integrated into the flat roof system:

BIPV: wall systems

Glazing systems:



Vertical glazing applications

When thin films are incorporated into curtain wall glazing, they can act as a shading device as well.

Curtain wall glazing:

Integrated sloped roofs:

Balcony railings:

Balcony -- walls

Skylights:

When using thin film in the glazed panels of skylights, the growing practice is to use pitched skylights, have daylight enter from the north side and use the south facing slope for PV. This also cuts down on excess heat gain into the space, while allowing some south light to enter.

Skylight installations

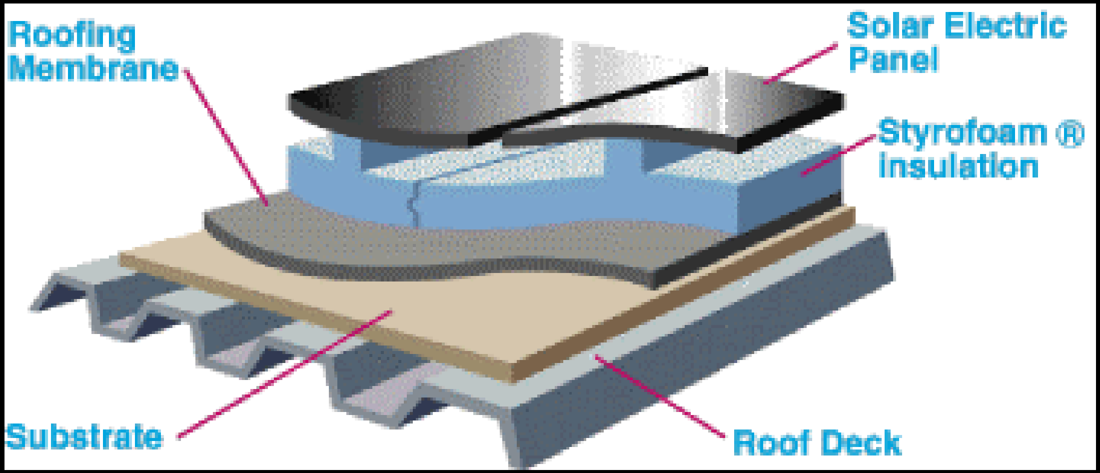
PV roof shingles:

Thin crystalline products have been made into shingles that are run in series and can be installed in lieu of standard shingles.

PV Flat roof systems:

PV modules are currently being manufactured as the "top layer" of roofing membranes. The membranes are installed as "normal" (adhered, mechanically fastened, etc.). These applications are more common in snow free climates where snow build-up will not eliminate solar rays for many months of the year.

standard



integrated

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Solar integrated sheet roofing

How much PV do I need for my house?

- Check electrical bills to find out your normal use amount
- Determine the space available for PV
- are you using roof or walls?
- You need about 90 sq.ft.(about 0.8 sq.m) of space for each kilowatt of power you want to produce. If needed, the system can be split to accommodate obstacles on your roof. Thin film modules take about 150 sq. ft. per kilowatt.
- Verify output of type of PV chosen
- verify amount of sunlight and light conditions for your area
- most buildings will NOT install adequate PV for complete standalone, off grid system
- usually need batteries to store for later retrieval