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The following is a short description on the various types of panels available and some of their characteristics.

Crystalline Silicon (c-Si)

Almost 90% of the World's photovoltaics today are based on some variation of silicon.

In 2011, about 95% of all shipments by U.S. manufacturers to the residential sector were crystalline silicon solar panels.
The silicon used in PV takes many forms.
The main difference is the purity of the silicon.
But what does silicon purity really mean? The more perfectly aligned the silicon molecules are, the better the solar cell will be at converting solar energy (sunlight) into electricity (the photovoltaic effect).

The efficiency of solar panels goes hand in hand with purity, but the processes used to enhance the purity of silicon are expensive.
Efficiency should not be your primary concern.

As you will later discover, cost-and space-efficiency are the determining factors for most people.
Crystalline silicon forms the basis of mono- and polycrystalline silicon solar cells:

Monocrystalline Silicon Solar Cells

Solar cells made of monocrystalline silicon (mono-Si), also called single-crystalline silicon (single-crystal-Si), are quite easily recognizable by an external even colouring and uniform look, indicating high-purity silicon, as you can see on the picture below:

Monocrystalline solar cells are made out of silicon ingots, which are cylindrical in shape.

To optimize performance and lower costs of a single monocrystalline solar cell, four sides are cut out of the cylindrical ingots to make silicon wafers, which is what gives Monocrystalline solar panels their characteristic look.

A good way to separate mono- and polycrystalline solar panels is that polycrystalline Solar cells look perfectly rectangular with no rounded edges.

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Advantages

- **Monocrystalline solar panels have the highest efficiency rates** since they are made out of the highest-grade silicon. The efficiency rates of monocrystalline solar panels are typically 15-20%. SunPower produces the highest efficiency solar panels on the market today. Their E20 series provide panel conversion efficiencies of up to 20.1%.[3]
- **Monocrystalline silicon solar panels are space-efficient**. Since these solar panels yield the highest power outputs, they also require the least amount of compared to any other types. Monocrystalline solar panels produce up to four times the amount of electricity as thin-film solar panels.
- **Monocrystalline solar panels live the longest**. Most solar panel manufacturers put a 25-year warranty on their monocrystalline solar panels.
- **Tend to perform better than similarly rated polycrystalline solar panels** at low-light and low-temperature conditions.

Disadvantages

- **Monocrystalline solar panels are the most expensive**. From a financial standpoint, a solar panel that is made of polycrystalline silicon (and in some cases thin-film) can be a better choice for homeowners.
- If the solar panel is partially covered with shade, dirt or snow, the entire circuit can break down. Consider getting micro-inverters instead of central string inverters if you think coverage will be a problem. Micro-inverters will make sure that not the entire solar array is affected by shading issues with only one of the solar panels.
- The Czochralski process is used to produce monocrystalline silicon. It results in large cylindrical ingots. Four sides are cut out of the ingots to make silicon wafers. A significant amount of the original silicon ends up as waste.
- Monocrystalline solar panels tend to be more efficient in cold weather. Performance may suffer as temperature goes up. For most homeowners temperature is not a concern.

Polycrystalline Silicon Solar Cells

The first solar panels based on polycrystalline silicon, which also is known as polysilicon (p-Si) and multi-crystalline silicon (mc-Si), were introduced to the market in 1981.
Unlike monocrystalline-based solar panels, polycrystalline solar panels do not require the Czochralski process.
Raw silicon is melted and poured into a square mould, which is cooled and cut into perfectly square wafers.

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Advantages

- The process used to make polycrystalline silicon is simpler and cost less. This reduces the amount of waste silicon.
- Polycrystalline solar panels tend to have higher heat tolerance and therefore perform better than monocrystalline at high temperatures. Heat can affect the performance of solar panels and shorten their lifespans. However, this effect is minor, and the majority of homeowners do not need to take it into account.

Disadvantages

- **The efficiency of polycrystalline-based solar panels is typically 13-16%.** Because of lower silicon purity, polycrystalline solar panels are not quite as efficient as monocrystalline solar panels.
- You need to cover a larger surface to output the same electrical power as you would with a solar panel made of monocrystalline silicon.
- Monocrystalline and thin-film solar panels tend to be more aesthetically pleasing since they have a more uniform look compared to the speckled blue colour of polycrystalline silicon.

String Ribbon Solar Cells

String Ribbon solar panels are also made out of polycrystalline silicon. String Ribbon is the name of a manufacturing technology that produces a form of polycrystalline silicon. Temperature-resistant wires are pulled through molten silicon, which results in very thin silicon ribbon.
Solar panels made with this technology looks similar to traditional polycrystalline solar panels.
Evergreen Solar was the main manufacturer of solar panels using the String Ribbon technology. The company is now bankrupt, rendering the future for String Ribbon solar panels unclear.

Advantages

- The manufacturing of String Ribbon solar panels only uses half the amount silicon as monocrystalline manufacturing. This significantly contributes to lower costs.

Disadvantages

- String Ribbon manufacturing is also significantly more energy extensive, which unfortunately increase costs.
- Efficiency is at best on par with the low-end polycrystalline solar panels at around 13-14%. In research laboratories, the efficiency of String Ribbon solar cells have reached as high as 18.3%
- String Ribbon solar panels have the lowest space-efficiency of any of the solar panels based on crystalline silicon.

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Thin-film Solar Cells (TFSC)

Depositing one or several thin layers of photovoltaic material onto a substrate is what makes thin-film solar cells (also known as thin-film photovoltaic cells (TFPV)).
The different types of thin-film solar cells can be categorized by which photovoltaic material is deposited onto the substrate:

- Amorphous silicon (a-Si)
- Cadmium telluride (CdTe)
- Copper indium gallium selenide (CIS/CIGS)
- Organic photovoltaic cells (OPC)

Depending on the technology, thin-film module prototypes have reached efficiencies between 7–13% and production modules operate at about 9%. Future module efficiencies are expected to climb close to the about 10–16%.
The market for thin-film PV grew at a 60% annual rate from 2002 to 2007.
In 2011, close to 5% of U.S. photovoltaic module shipments to the residential sector were based on thin-film.

Advantages

- Easier to mass-produce and potentially cheaper to manufacture than crystalline based solar cells.
- Their homogenous appearance makes them look more appealing.
- Can be made flexible, which opens up many new potential applications.
- High temperatures and shading have less of an impact on solar panel performance.
- **In situations where space is not an issue, thin-film solar panels can make sense.**

Disadvantages

- **Thin-film solar panels are in general not very useful for in most residential situations.** They are cheap, but they also require a lot of space. Sunpower's monocrystalline solar panels produce up to four times the amount of electricity as thin-film solar panels for the same amount of space.
- Poor space-efficiency also means that costs of support structures, cables and other PV equipment increase.

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- Thin-film solar panels tend to degrade faster than mono- and polycrystalline solar panels, which is why they usually come with a shorter warranty.

Solar panels based on amorphous silicon, cadmium telluride and copper indium gallium selenide are currently the only thin-film technologies that are commercially available on the market:

Amorphous Silicon (a-Si) Solar Cells

Because the output of electrical power is low, solar cells based on amorphous silicon have traditionally only been used for small-scale applications such as in pocket calculators.
However, recent innovations have made them more attractive for some large-scale applications too.
With a manufacturing technique called “stacking”, several layers of amorphous silicon solar cells can be combined, which results in higher efficiency rates (typically around 6-8%).
Only 1% of the silicon used in crystalline silicon solar cells is required in amorphous silicon solar cells. On the other side, stacking is expensive.

Cadmium Telluride (CdTe) Solar Cells

Cadmium telluride is the only thin-film solar panel technology that has surpassed the cost-efficiency of crystalline silicon solar panels in a significant portion of the market (multi-kilowatt systems).
The efficiency of solar panels based on cadmium telluride usually operates in the range 9-11%.
First Solar has installed over 5 gigawatts (GW) of cadmium telluride thin-film solar panels worldwide. The same company holds the world record for CdTe PV module efficiency of 14.4%.

Copper Indium Gallium Selenide (CIS/CIGS) Solar Cells

Compared to the other thin-film technologies above, CIGS solar cells have showed the most potential in terms of efficiency. These solar cells contain less amounts of the toxic material cadmium that is found in CdTe solar cells. Commercial production of flexible CIGS solar panels were started in Germany in 2011.

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The efficiency rates for CIGS solar panels typically operate in the range 10-12 %.
Many thin-film solar cell types are still early in the research and testing stages. Some of them have enormous potential, and we will likely see more of them in the future.

Building-Integrated Photovoltaics (BIPV)

Lastly, we`ll briefly touch on the subject of building integrated photovoltaics.
Rather than an individual type of solar cell technology, building integrated photovoltaics have several subtypes, or rather different methods of integration, which can be based on both crystalline and thin-film solar cells.

Building integrated photovoltaics can be used to replace facades, roofs, windows, walls and many other things with photovoltaic material. If you have the extra money and want seemingly integrate photovoltaics with the rest of your house, you should look up building-integrated photovoltaics.
For most homeowners it`s simply way too expensive.

Best Solar Panel Type for Home Use

Having your particular situation evaluated by an expert would be the best way to find out what solar panel type would be best for your household. Here are some typical scenarios we see:

Limited Space
For those who don’t have a lot space for thin-film solar panels (or want to limit the amount of space their PV-system takes up), or if they are simply not offered in your area, crystalline-based solar panels is usually your best choice (and they likely would be the your best choice even if you had the extra space).
The manufacturer usually offers a set of different solar panel sizes. The 180, 200 and 220-watt rated solar panels are usually physically the same size. They are manufactured exactly the same way, but under- or over perform when tested, hence ending up in different categories for power output. If size is important, you should go for the highest rated power output for a particular physical size.
Both mono- and polycrystalline solar panels are good choices and offer similar advantages. Even though polycrystalline solar panels tend to be less space-efficient and monocrystalline solar panels tend to produce more electrical power, this is not always the case.
It would be nearly impossible to recommend one or the other by not examining your situation closer.

Monocrystalline solar panels are slightly more expensive, but also slightly more space efficient.
If you had one polycrystalline and one monocrystalline solar panel, both rated 220-watt, they would generate the same amount of electricity, but the one made of monocrystalline silicon would take up less space.

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Lastly there is a new type of solar panel which is relatively new technology.

PET Polymer Laminated Solar Panels.

A polymer solar cell is a type of flexible solar cell made with polymers, large molecules with repeating structural units that produce electricity from sunlight by the photovoltaic effect. Polymer solar cells include organic solar cells (also called "plastic solar cells"). They are one type of thin film solar cell; others include the currently more stable amorphous silicon solar cell. Polymer solar cell technology is relatively new and is currently being very actively researched by universities, national laboratories, and companies around the world.

Currently, most commercial solar cells are made from a refined, highly purified silicon crystal, similar to the material used in the manufacture of integrated circuits and computer chips (wafer silicon). The high cost of these silicon solar cells and their complex production process has generated interest in developing alternative photovoltaic technologies.

Compared to silicon-based devices, polymer solar cells are lightweight (which is important for small autonomous sensors), potentially disposable and inexpensive to fabricate (sometimes using printed electronics), flexible, and customizable on the molecular level, and they have lower potential for negative environmental impact. An example device is shown in Fig. 1. The disadvantages of polymer solar cells are also serious: they offer about 1/3 of the efficiency of hard materials, and they are relatively unstable toward photochemical degradation. For these reasons, despite continuing advances in semiconducting polymers, the vast majority of solar cells rely on inorganic materials.

Polymer solar cells currently suffer from a lack of enough efficiency for large scale applications and stability problems but their promise of extremely cheap production and eventually high efficiency values has led them to be one of the most popular fields in solar cell research. It is worth mentioning that state-of-the-art devices produced in academic labs – with the record currently held by Yang Yang’s group in UCLA – have reached certified efficiencies above 8% while devices produced which have remained unpublished – probably to maintain secrecy for industrial applications – are known to have already gone above 10%

Acknowledgments: Source – Wikipedia & Sunpower.

Members: Steve Davies.
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