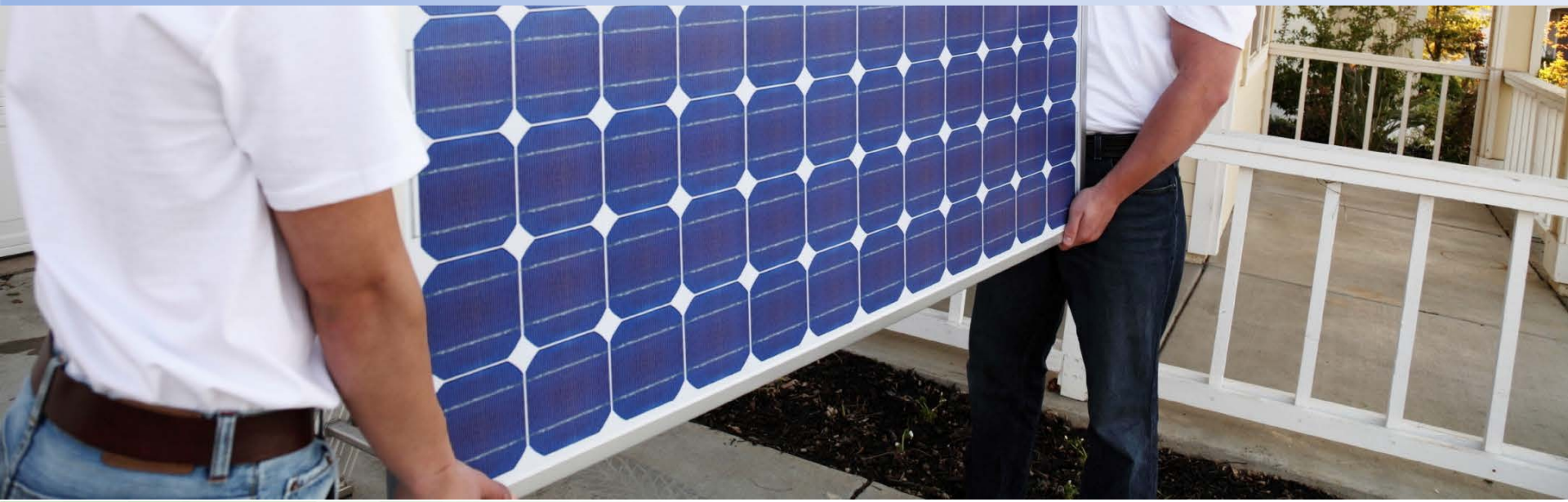
Basic technical information on solar PV



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Agenda

1. How does solar PV work?
2. Main components of a PV system
3. Solar PV mounting options
4. Solar thermal systems
5. Emerging technologies

How does solar PV work?

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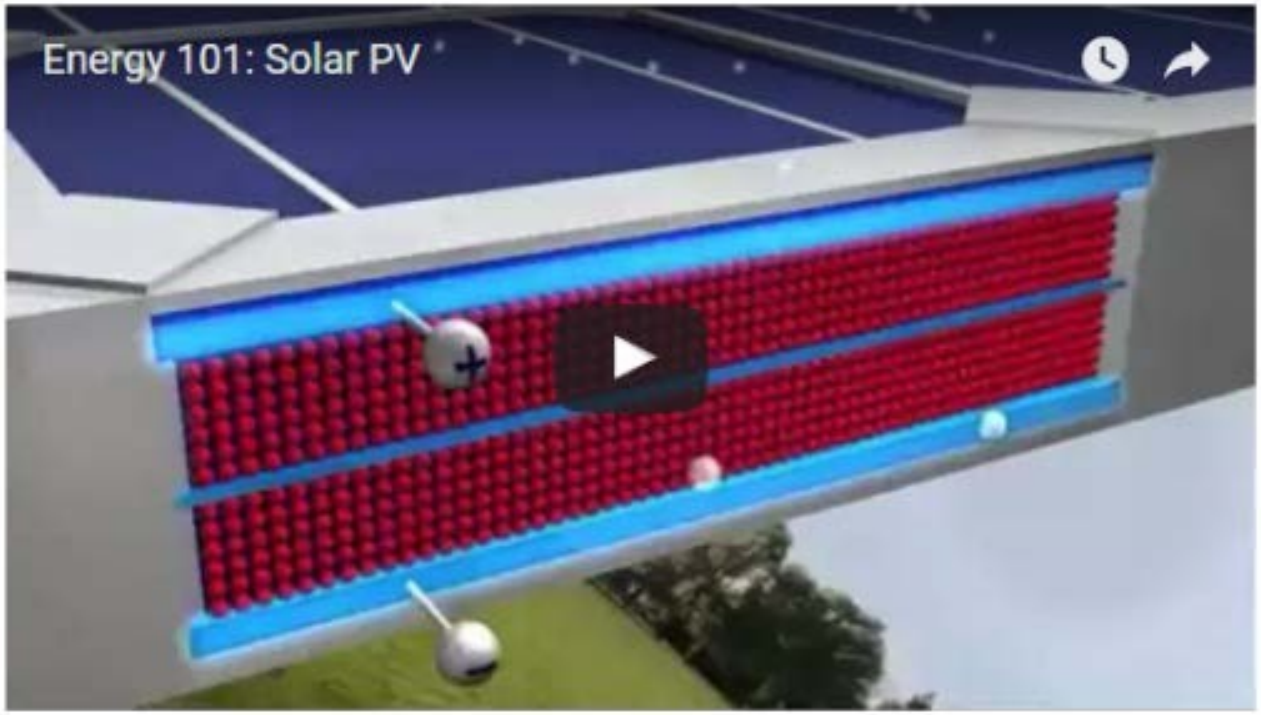
Video: Basics of solar PV technology



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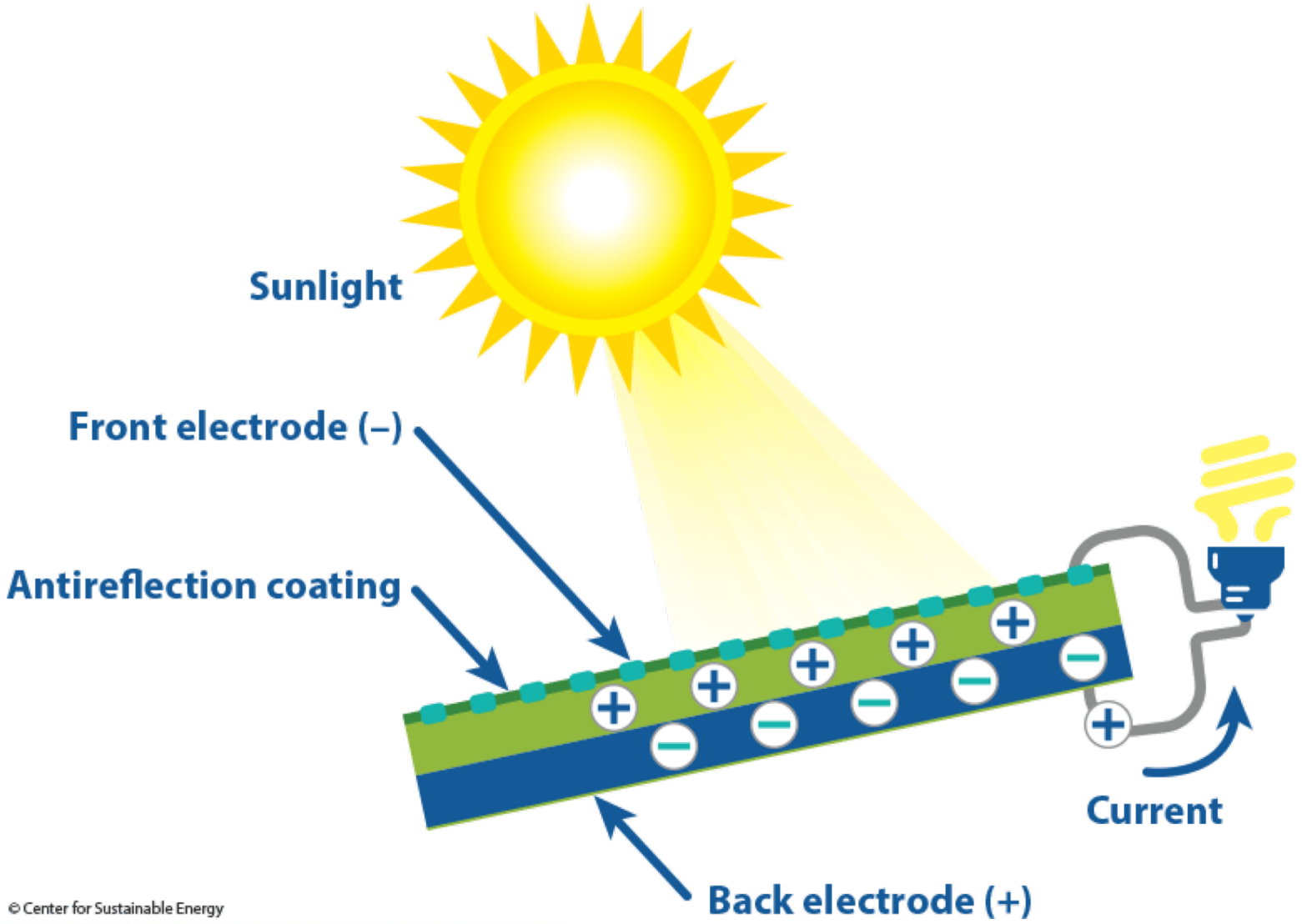
How does solar PV work?



What's a watt?

1 Light Bulb

= **100 Watts (W)**

10 Light Bulbs

= **1,000 Watts (W)**

or

1Kilowatt (kW)

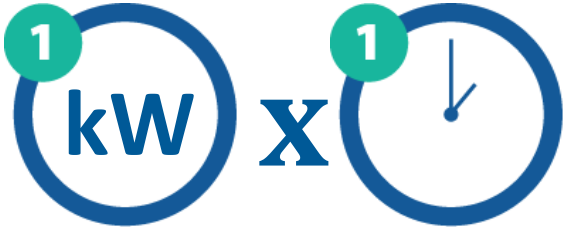
What's a kilowatt hour?

1 Kilowatt-hour (kWh)

Energy vs. power

= ***Power***

Kilowatt (kW)



= ***Energy***

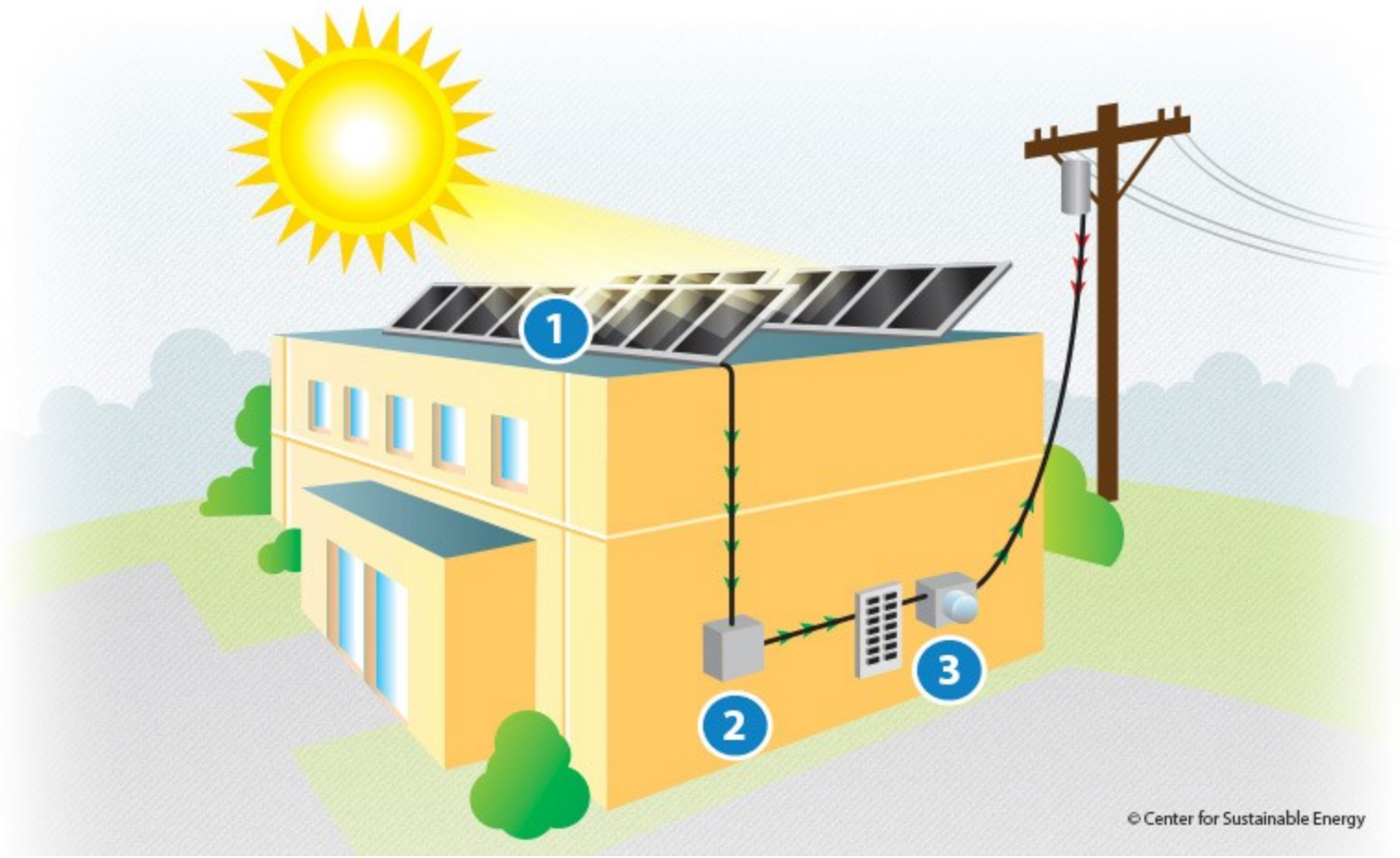
Kilowatt-hour (kWh)

Direct Current vs. Alternating Current

Direct Current (DC) = ***Produced by solar panels***

Alternating Current (AC) = ***'usable' energy in your home or business***

What are the main components of a PV system?



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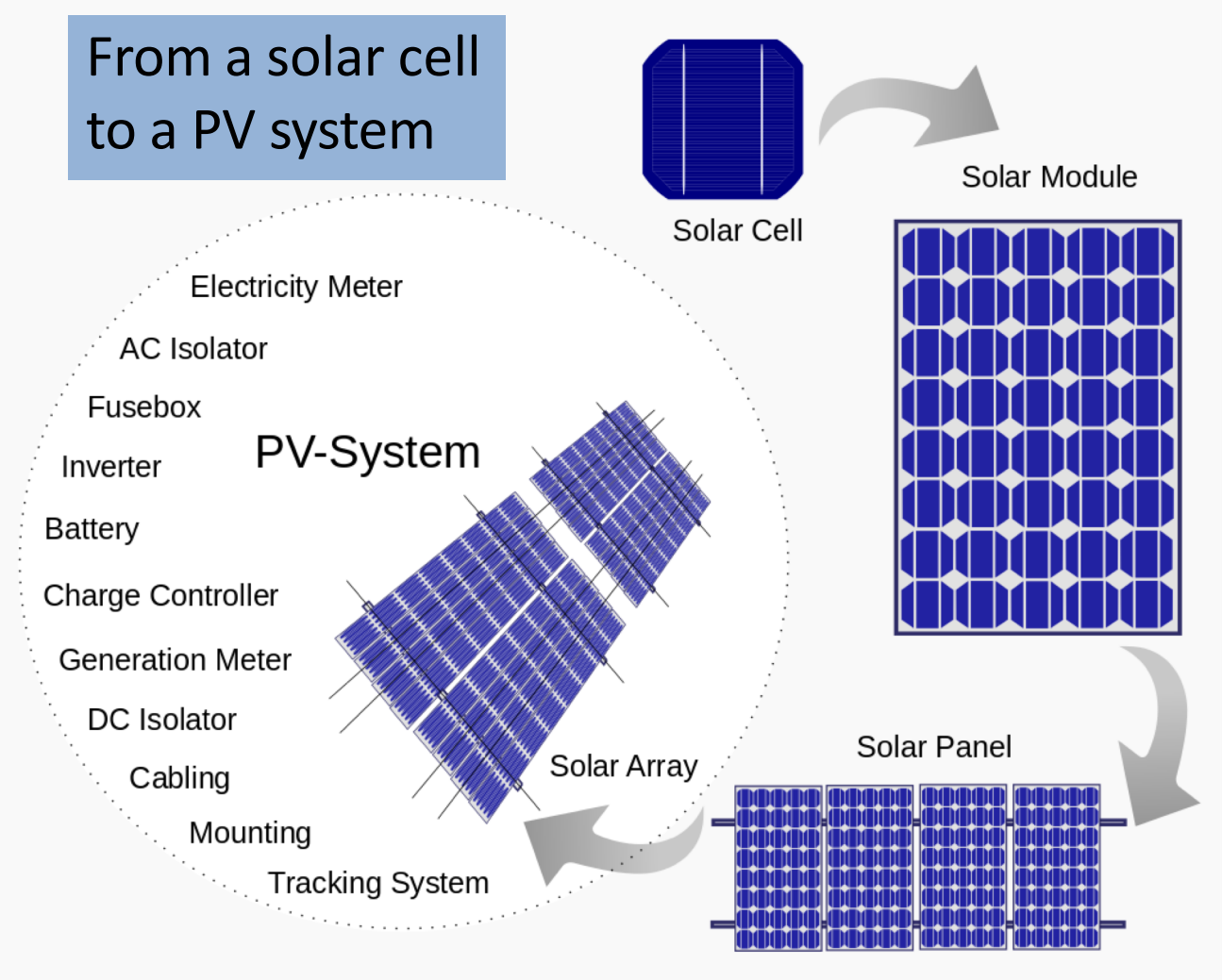
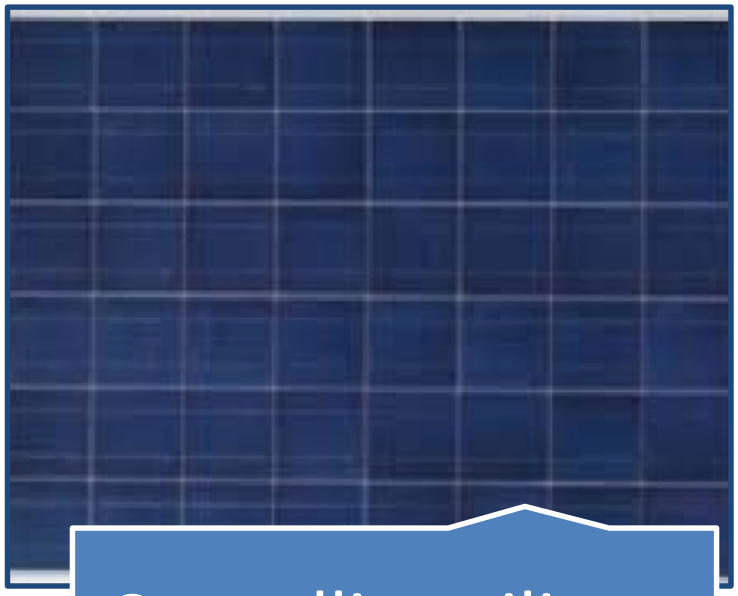
Main components of solar PV



PV cell technology



Crystalline silicon

Thin film

Main components of solar PV: cell

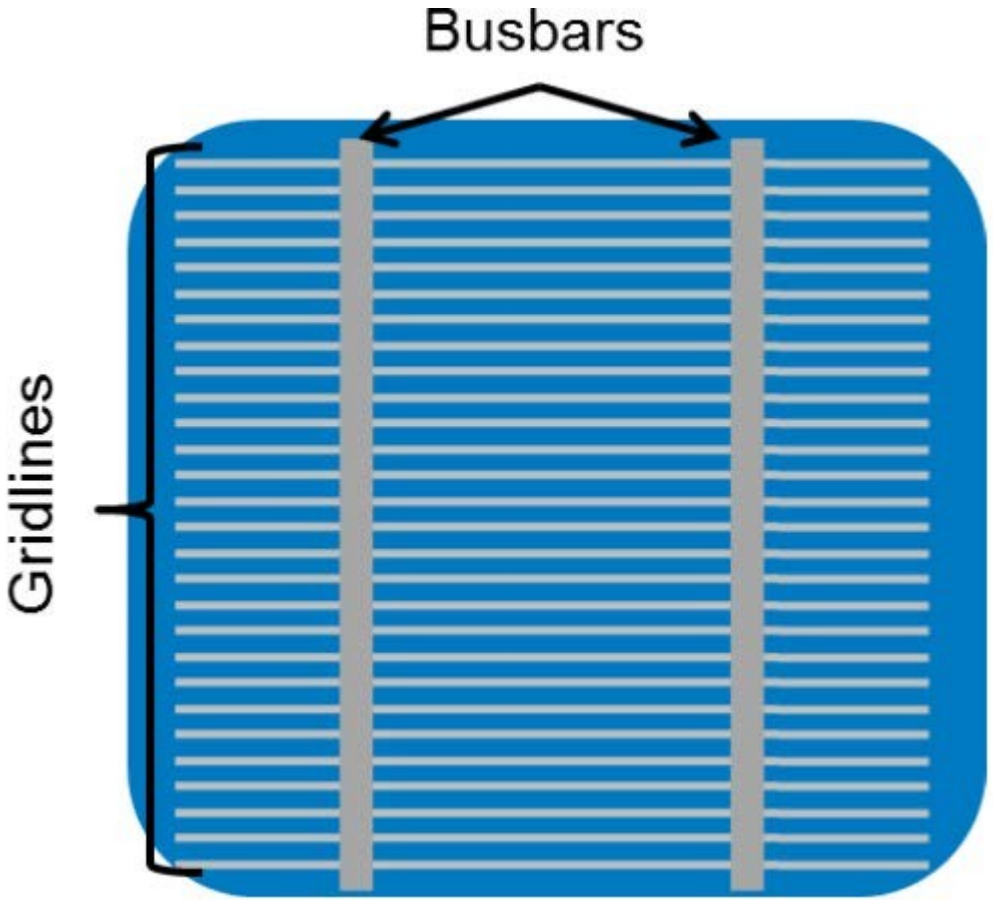


Photo credit : International Energy Agency

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Main components of solar PV: cell

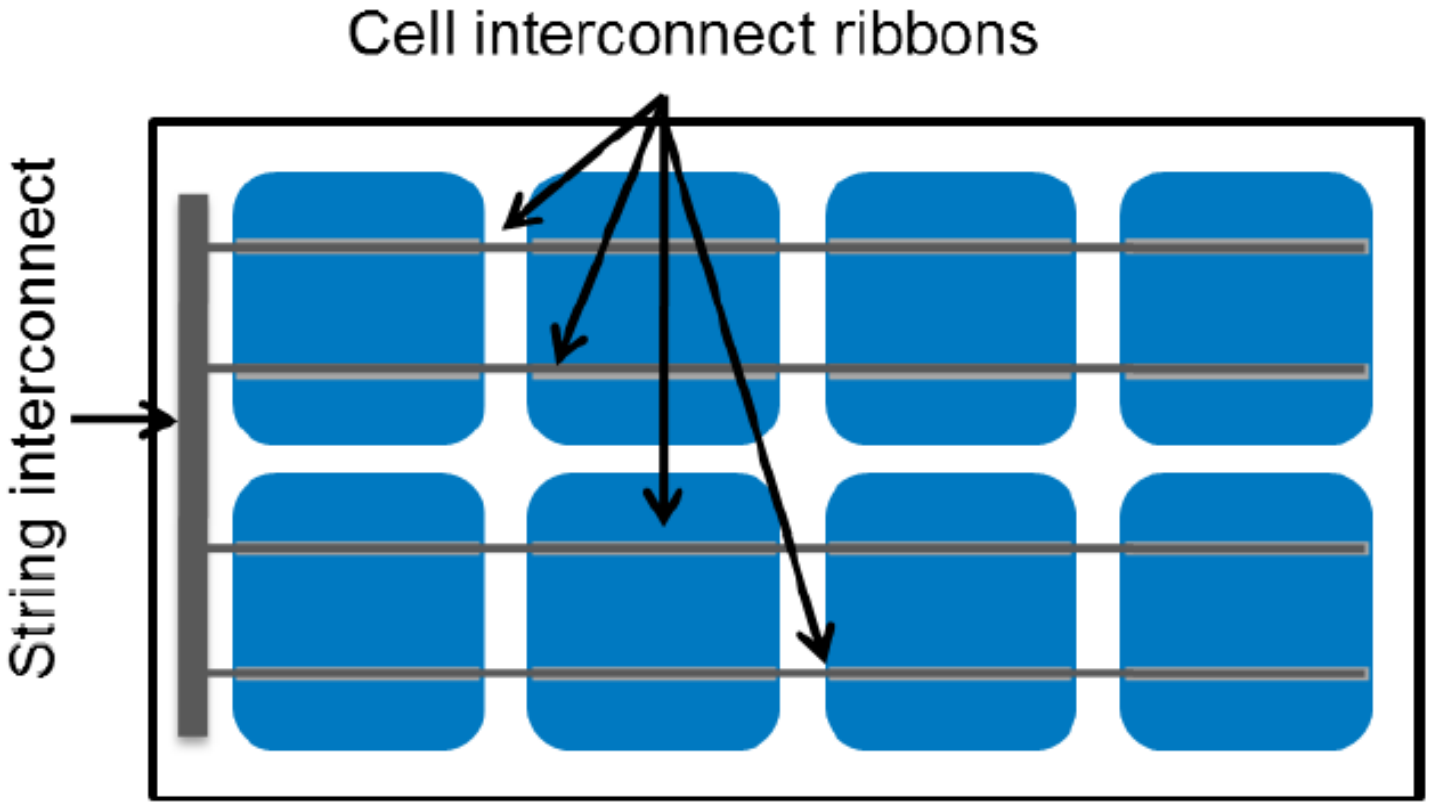


Photo credit: International Energy Agency

Main components of solar PV: module/panel

Multiple PV cells make up a PV **module**

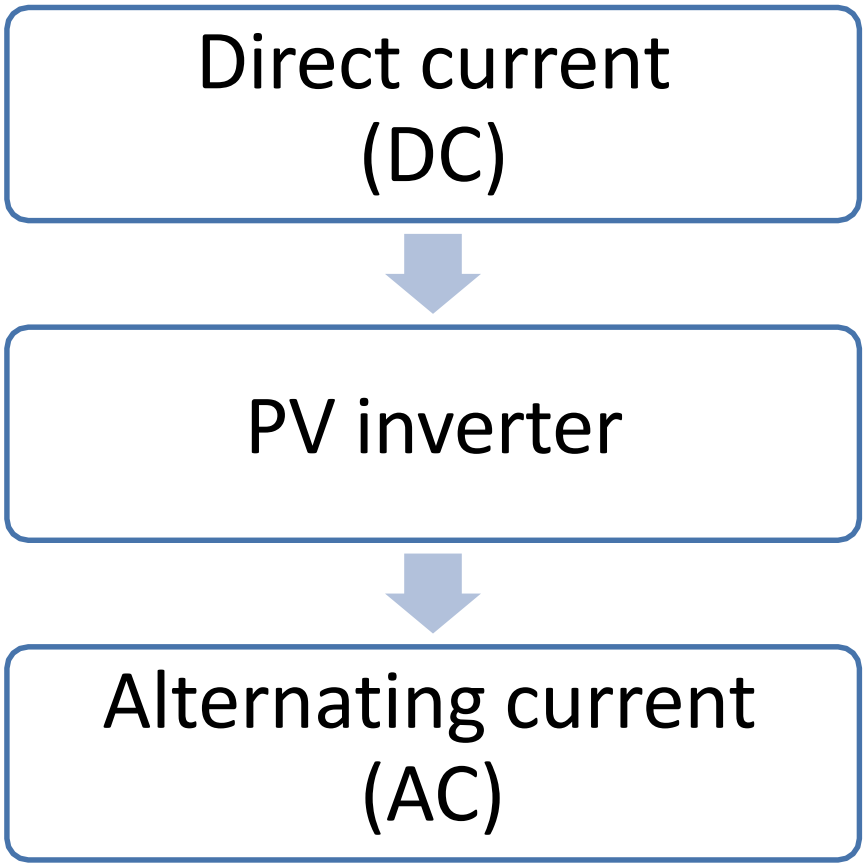
Photo credit : CSE

Main components of solar PV: array

The visible assembly of multiple modules and support structure is the **array**

Photo credit : CSE

Main components of solar PV: inverter



Two types of inverters:

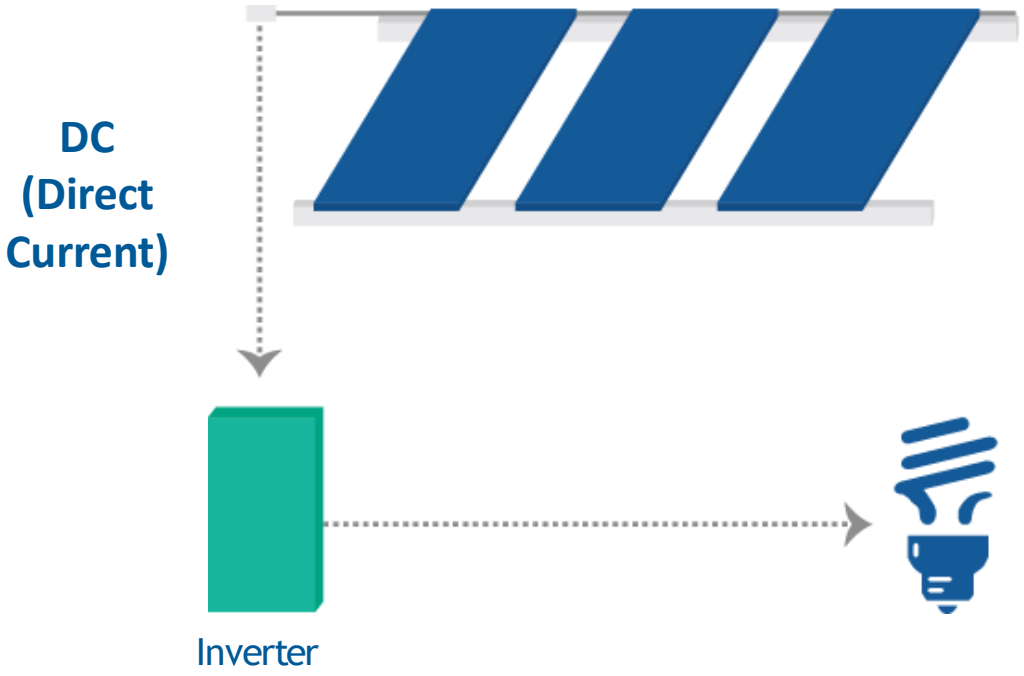
- String Inverters
- Micro Inverters

Inverters

Inverters change **DC** electricity from panels to **AC** electricity for use in your building.

There are basically two types of inverters:

- **String inverters**
- **Micro-inverters**



String inverters

One individual inverter per array

String inverters

One individual inverter **per array**

Benefits

- Longer track record
- Established reliability
- High efficiency
- Lower cost*

Disadvantages

- Shading can affect power output dramatically
- Does not allow for easy system size increases

Micro inverters

One individual inverter **per module**

Micro inverters

One individual inverter **per module**

Benefits

- Makes the array more tolerant to shading
- Allows flexibility in design and for future additions
- Built-in rapid shut-down compliance

Disadvantages

- Shorter track record

DC Power Optimizers

Attaches to or is integrated in the junction box of a PV module

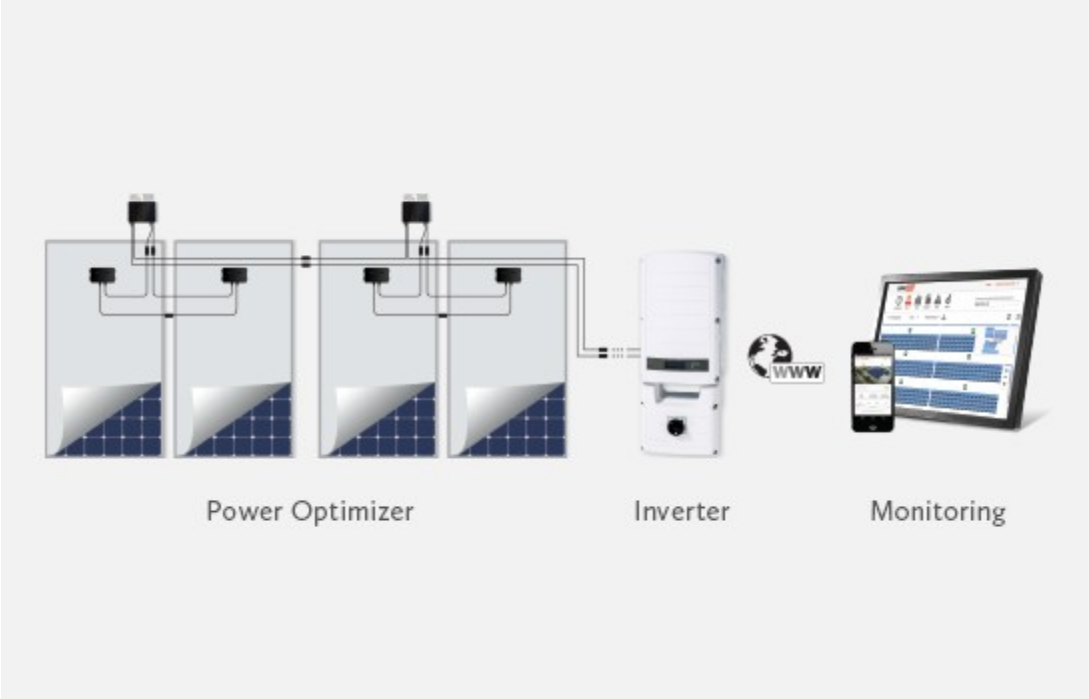
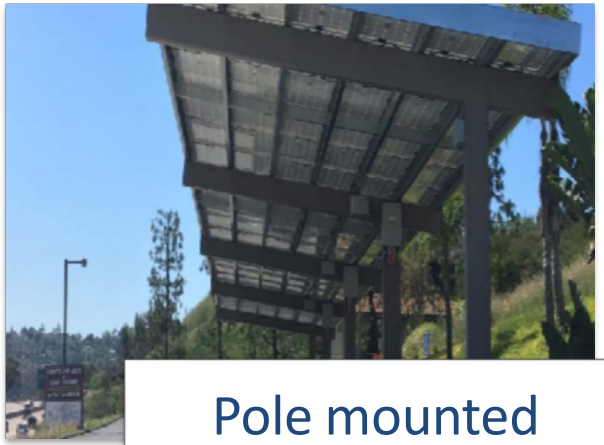


Photo credit : SolarEdge

What are the available solar PV mounting options?

Flush mounted

Tilted rack mounted



Pole mounted

Ballasted

Photo credit: NREL

Flush mounted

Photo credit: EERE

Tilted rack mounted

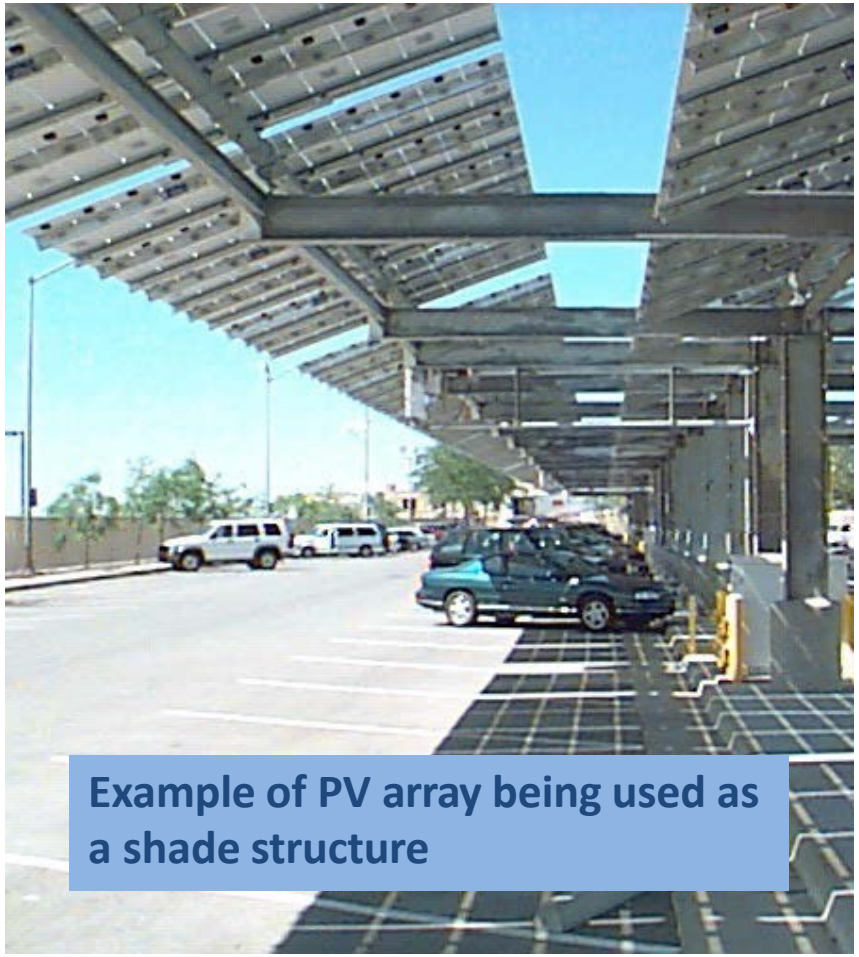
- Solar cells perform best when their surface is perpendicular to the sun's rays
- Many PV systems are installed on tilted rack mounted systems, which can help to optimize PV module output

Photo credit: EERE

Ballasted

Photo credit: EERE

Ground and pole mounted



Example of PV array being used as a shade structure

Photo credit: NREL

Solar thermal systems

Solar thermal systems are a different type of system used to collect and utilize the suns energy.

How is solar thermal different from solar PV?

- **Solar PV** converts photons to electricity.
- **Solar thermal systems** use solar thermal energy to heat water or to heat another medium to store the energy.

Solar thermal systems

Two categories that solar thermal systems fall into:

- Glazed
- Unglazed

Unglazed solar thermal

Unglazed collectors are flat plates generally used to heat swimming pools

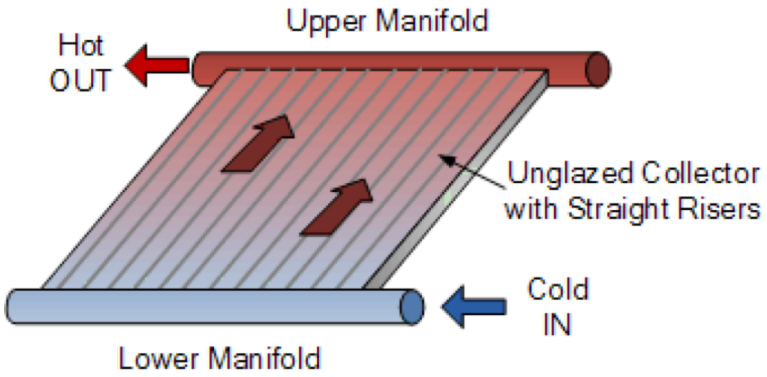


Photo credit: Alternative Energy Tutorials

Unglazed solar thermal

Unglazed solar thermal systems are fairly easily discernable from solar photovoltaic systems because of the observable piping systems which carry the heated water.

Photo credit: NREL

Solar thermal system types

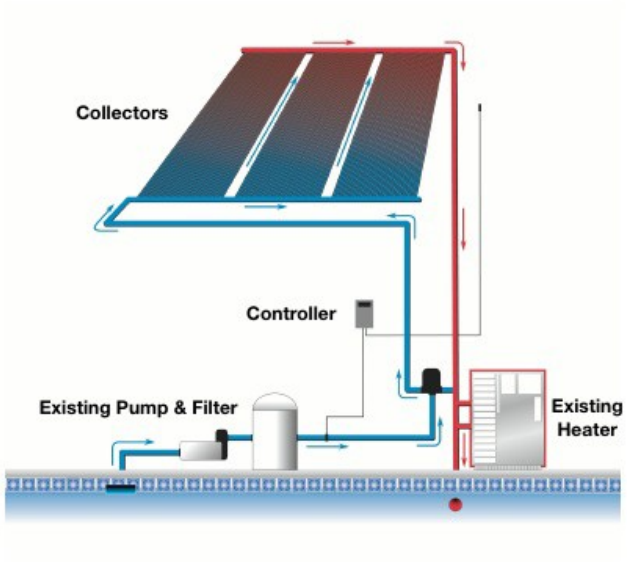
System Types

aquatherm INDUSTRIES, INC. LIVE GREEN. SWIM WARM.

SOLAR ENERGY FOCUS 2011

Open Loop:

Direct heating with Low-Temperature Unglazed Polymer Collectors



Closed Loop:

Indirect heating with a heat exchanger using Medium-Temperature or Evacuated-Tube Collectors

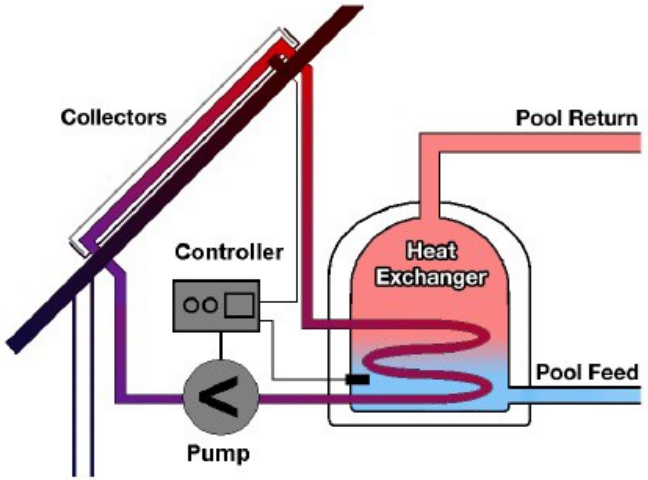


Photo credit: Aquatherm/Slideshare

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Glazed solar thermal collectors

Glazed collectors are also usually flat plates but are used for heating water or air

Photo credit: NREL

Glazed solar thermal collectors

Flat plate collectors

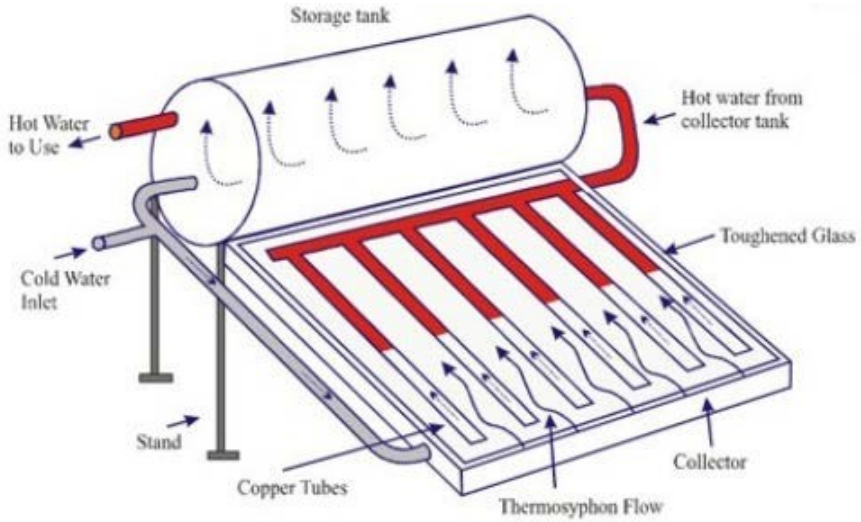

Photo credit: NREL

Emerging technologies

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World Economic Forum report

The list of top 10 emerging technologies of 2016 includes two solar technologies:

- Next generation batteries
- Perovskite solar cells

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These are the top 10 emerging technologies of 2016

Written by

Oliver Cann
Head of Media Content, World Economic Forum Geneva

Published

A diverse range of breakthrough technologies, including batteries capable of providing power to whole villages, "socially aware" artificial intelligence and new generation solar panels, could soon be playing a role in tackling the world's most pressing challenges, according to a list published today by the World Economic Forum.

"Technology has a critical role to play in addressing each of the major challenges

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Emerging Technology: Alternative Energy Storage (AES)

Photo credit: CSE

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Emerging Technology: Ready-to-install storage systems

Photo credit: SolarCity

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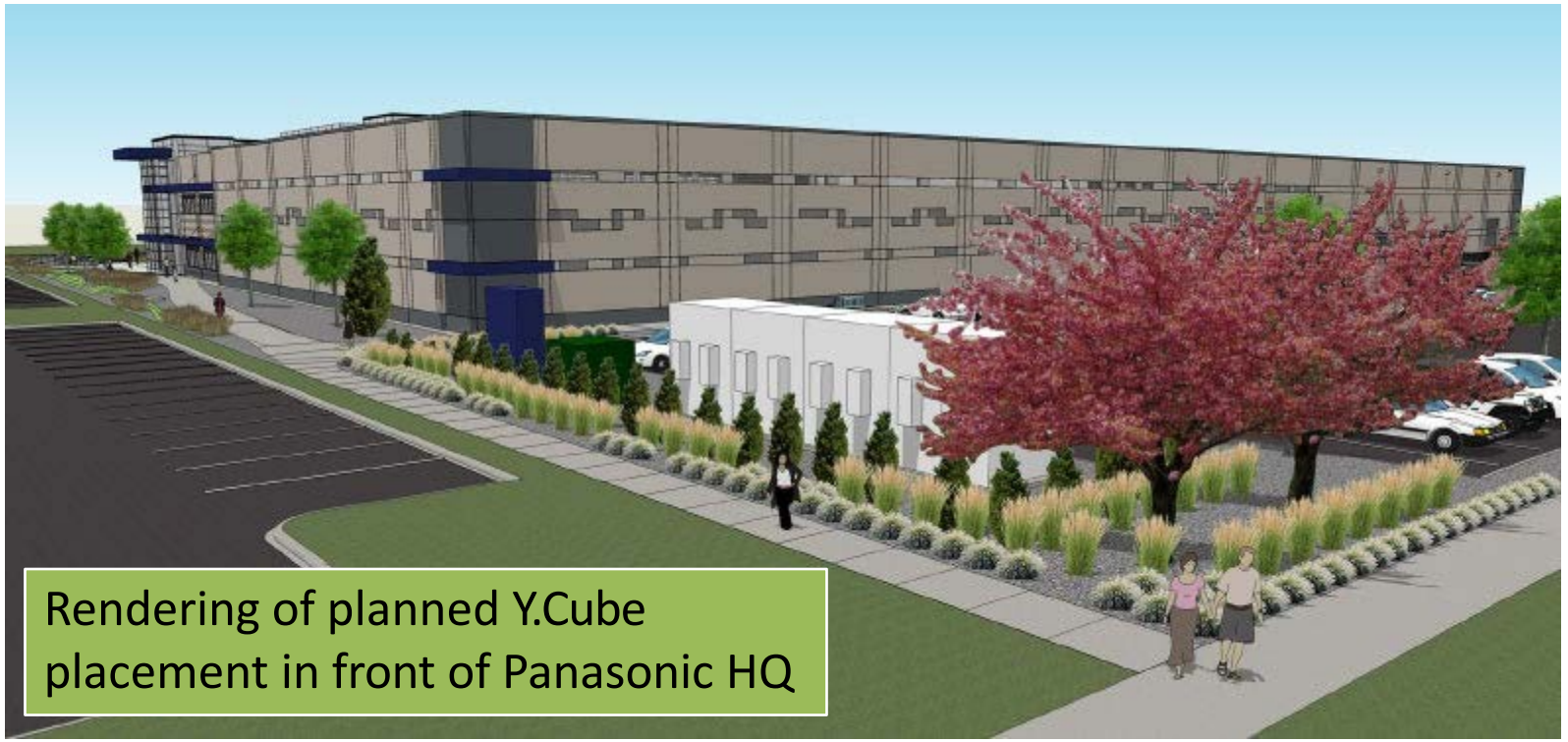
Emerging Technology: Ready-to-install storage systems

Example: Y.Cubes

Panasonic and Denver International Airport plan to install 1.86 MW solar system and Y.Cubes



Rendering of planned Y.Cube placement in front of Panasonic HQ

Photo credit: Younicos

Emerging Technology: Colored Solar PV

Photo credit: CSEM

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Emerging Technology: White PV Modules

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Emerging Technology: Tesla Roof Tiles

Photo credit: Tesla

Emerging Technology: Tesla Roof Tiles

Photo credit: Tesla

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Emerging Technology: Spray on / Paint-on PV

Perovskite cells

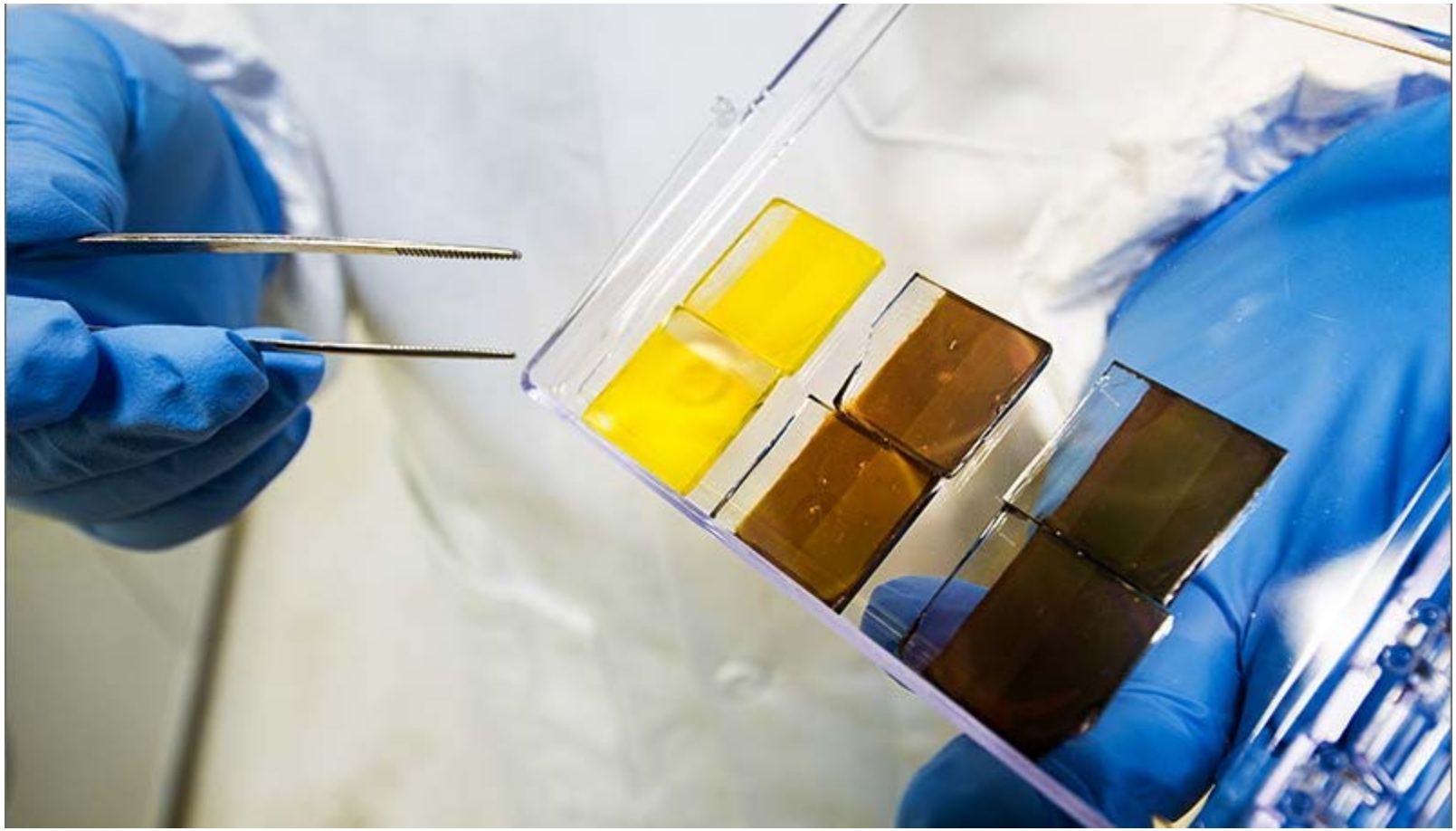

Photo credit: NREL

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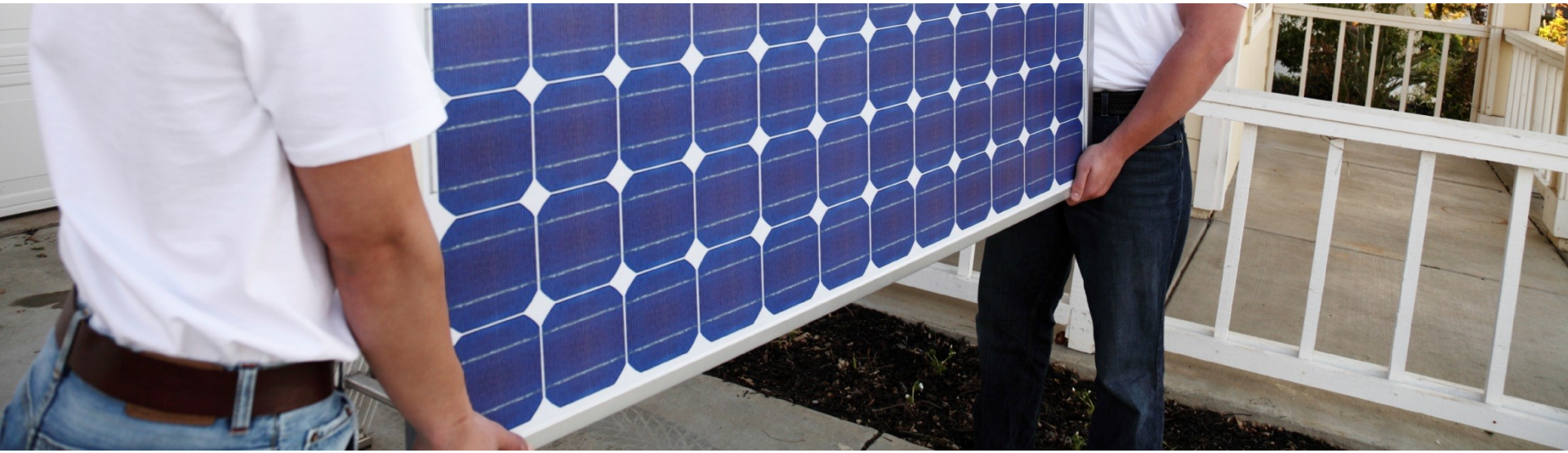
Emerging Technology: Peel-and-stick modules

Photo credit: Miasole

Quiz and discussion



Question 1

Which of the following PV systems is considered building integrated?

a) Flush mounted PV system

b) Tilted rack roof mounted PV system

c) Photovoltaics shingles

d) Ballasted PV system

Question 2

Which of the following PV systems is not a roof mounted PV system?

a) Titled rack mounted PV system

b) Ballasted PV system

c) Integrated PV system

d) Pole mounted PV system

e) None of the above

Question 3

Which of the following roof mounted systems does not penetrate the roofing material?

a) Flush mounted PV system

b) Building integrated PV system

c) Ballasted PV system

d) Class A PV system

e) Class C PV system