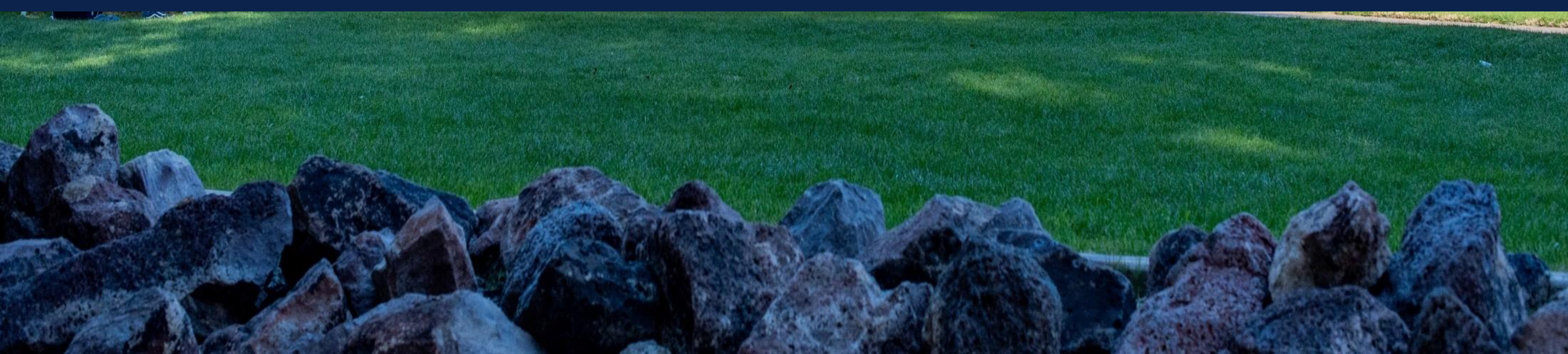
NSF NRT-InFEWS: Indigenous Food, Energy, and Water Security and Sovereignty Presents:

Food, Energy and Water (FEWS) Learning Modules

June 2021



Power from the Sun

Presenters:

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Learning Objectives

* Students will be able to explain how sunlight is converted into electricity
* Students will be able to explain the production and usage of electricity on the Navajo Nation
* Students will be able to describe current, voltage and resistance, and the relationship between them
* Students will be able to explain the difference between photovoltaic modules in series and parallel
* Students will be able to explain how solar irradiance, energy and power are quantified
* Students will be able to describe the difference between AC and DC power
* Students will be able to understand the variables impacting the size and generation capacity of a photovoltaic system
* Students will be able to identify current and potential sources of energy in their community

Agenda

* Module 1: Power from the Sun
  * Breakout #1
  * Sharing Session
  * Break (5-10 minutes)
* Module 2: Electrical Basics
  * Breakout #2
  * Sharing Session
  * Break (5-10 minutes)
* Module 3: Electrical Systems and System Sizing
  * Breakout #3
  * Sharing Session
  * Break (5-10 minutes)
* Module 4: Energy Storage, Environmental Impact, and Review
  * Group Discussion

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Navajo Nation

Electricity on the Navajo Nation

- 1/3 of the population, 34,000, without electricity
- 14.2% of the total Native American population lacks access to electricity (Energy Information Administration).
- 75% of those live in the Navajo Nation

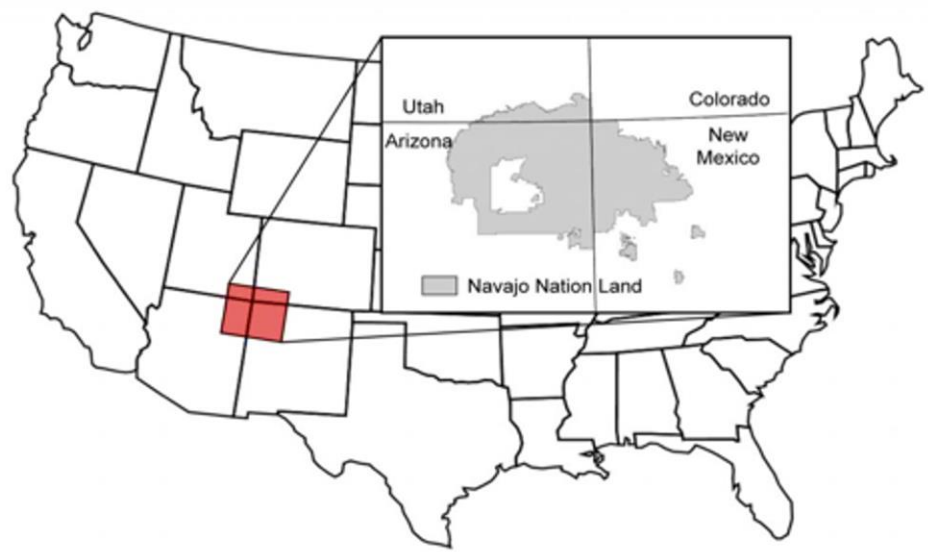


Fig 1: Source: IEEE Ocean Engineering Society. Credit: Cheryl Cary [2]

Navajo Tribal Utility Authority (NTUA)

Navajo Tribal Utility Authority

* Not-for-profit utility provider in Navajo Nation
* Established in 1959
* Provides electricity, water, wastewater, natural gas, solar energy, wireless, and internet

Navajo Tribal Utility Authority (NTUA)

Kayenta Solar Project

Provides total of 55 MW – enough to power 36,000 Diné homes – grid connected

Kayenta I (2017)

* Produces total of 27 MW power
* 119,301 sun-tracking panels (single-axis)

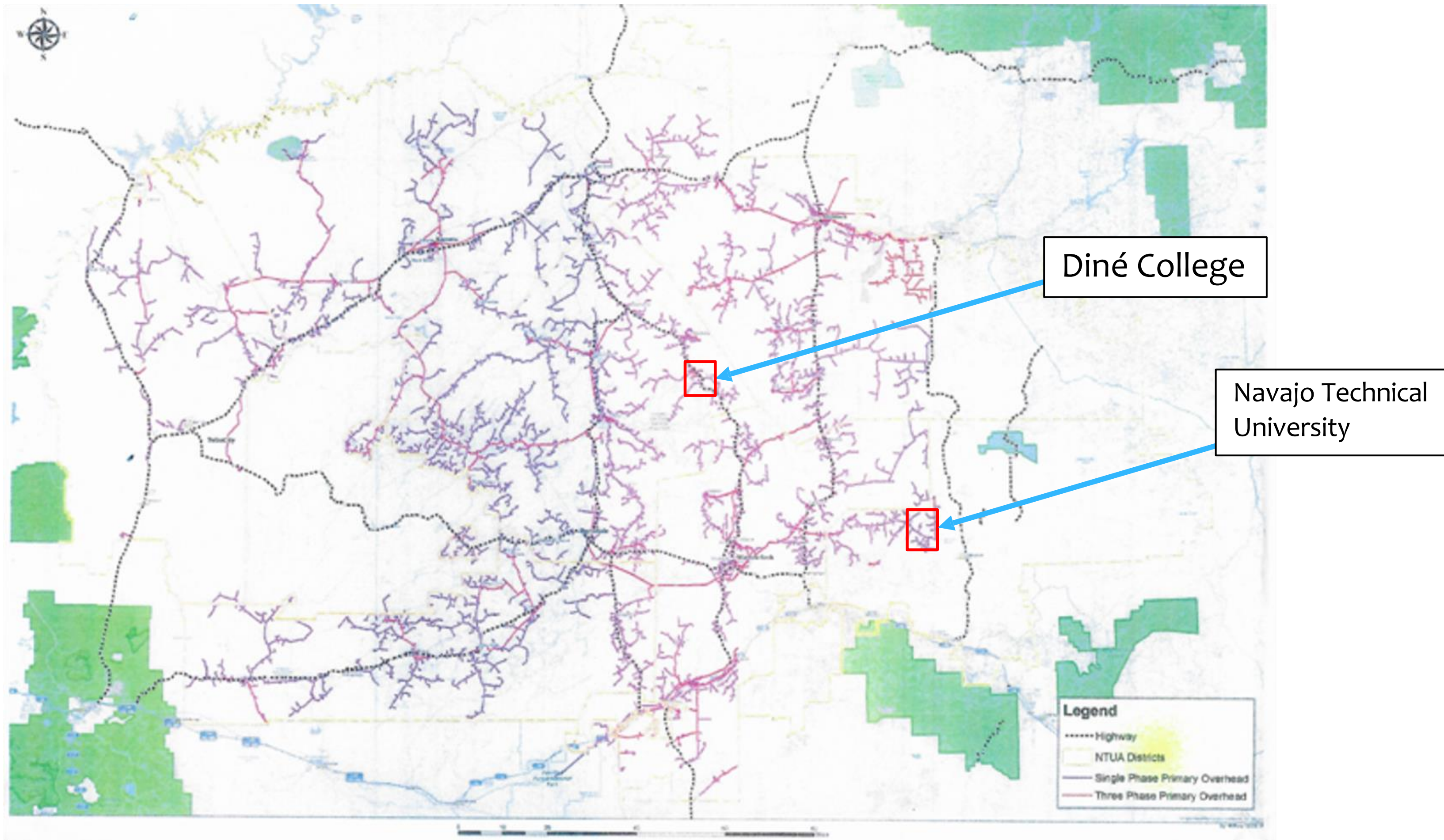
Kayenta II (2019)

* Added additional 28 MW Power

Red Mesa Tapaha Solar Project

* Utah Red Mesa Chapter
* 66 MW solar energy to sixteen Utah communities
* 4 MW solar energy to three Utah Navajo Chapters located in San Juan County
* Construction set to begin Summer 2021

NTUA Electric Route



CARES Act

CARES Act: NTUA's Off-Grid Solar Program –

* 300 Navajo families received an off-grid residential solar unit.
* Available only to homes not grid connected.

CARES Act: NTUA Electricity Connection to Homes Program –

As of March 9, 2021:

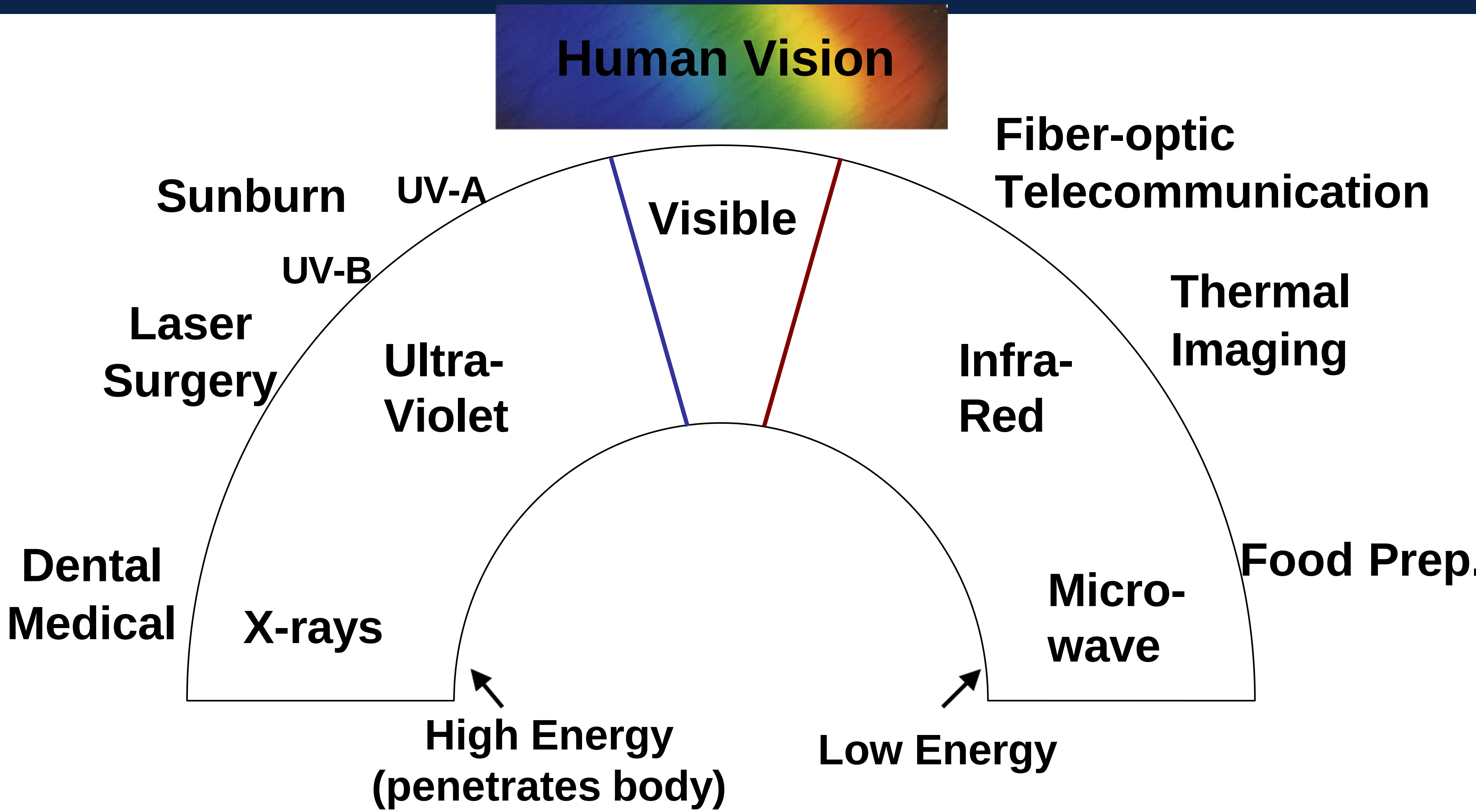
* 737 families have been connected to the electric grid
* 3,100 Navajo homes have been connected to the internet
* 105 families received a cistern and septic system
* 30 Navajo families received a waterline and septic system connection to their homes

Sunlight and Solar Energy

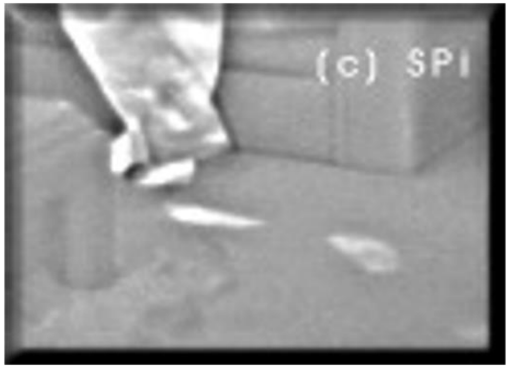
We will talk about:

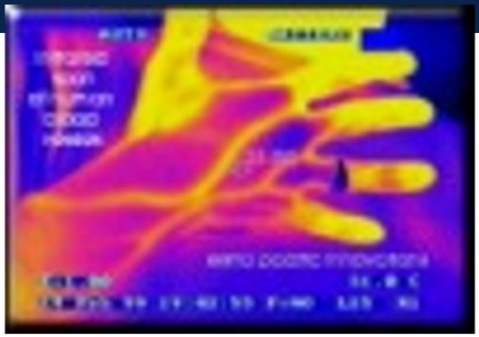
* Solar spectrum
* Sun Position
* Photovoltaics

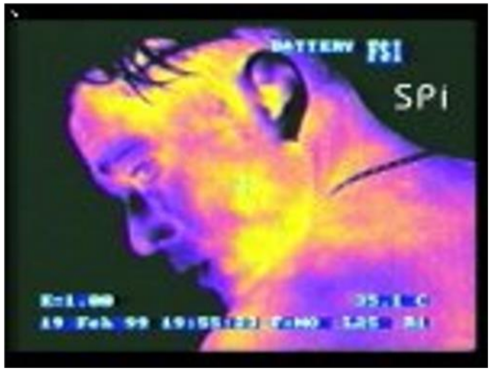
Solar Spectrum



Infrared (IR) Light

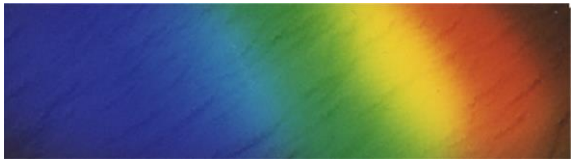






- Humans sense infrared light as <u>heat</u>.
- Some animals, such as pit vipers and sharks, can "see" infrared light with special heat sensors.
- IR cameras take pictures in total darkness. With no light visible to the human eye, the camera sees heat signatures from people, houses, vehicles…

Visible Light



Colors:

(low E)	**R - red**
	O - orange
	Y - yellow
	G - green
	B - blue
	I - indigo
(high E)	**V - violet**

"white light" is the combination of all of the visible colors

Ultraviolet Light

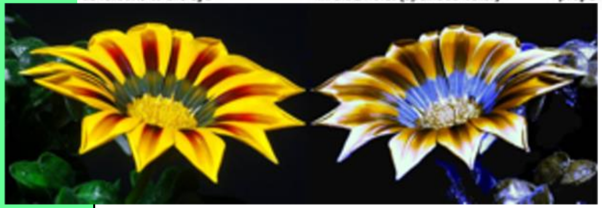
<u>Insect Vision</u> -

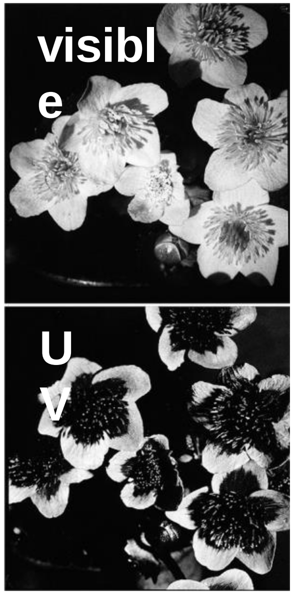
Bees and other insects can see UV light. The bright UV pattern at the center of flowers leads bees to the flower nectar.

<u>Sunburns</u> -

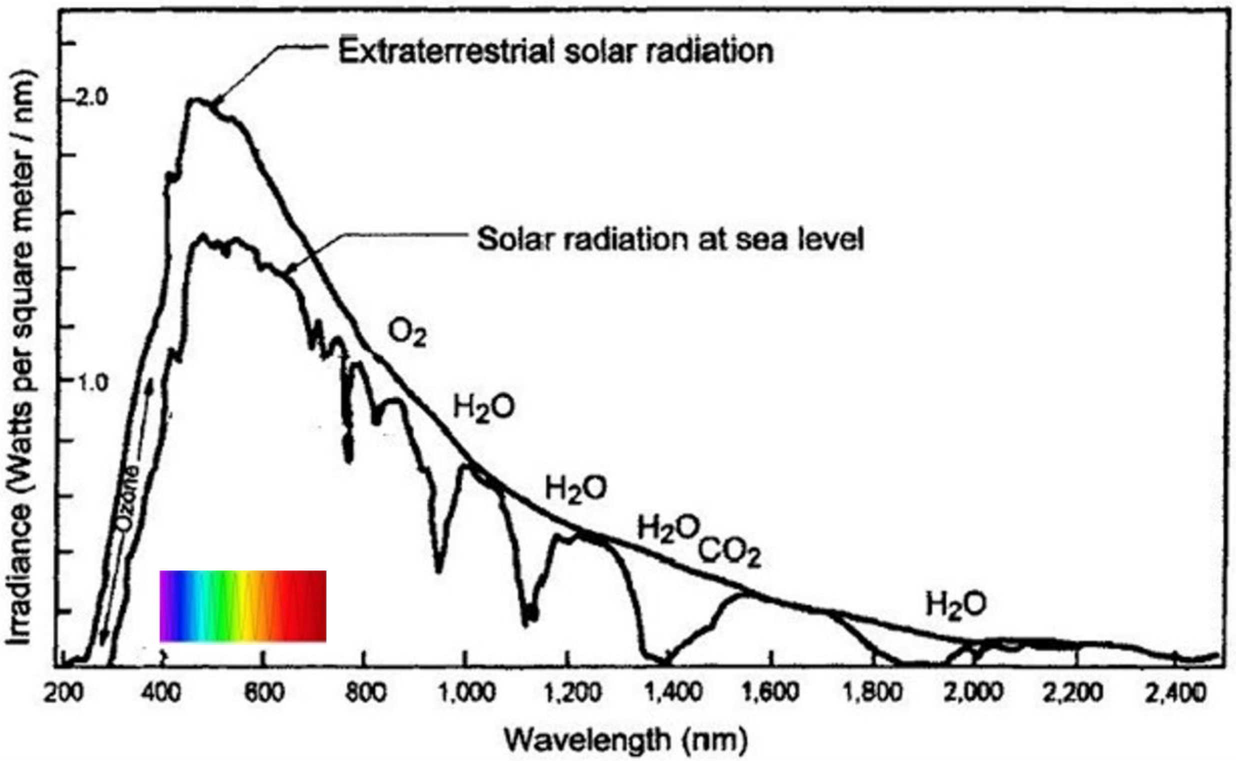
UV-A exposure leads to sunburns and cataracts of the eyes.

UV-B exposure causes accelerated skin aging and eventual skin cancer.



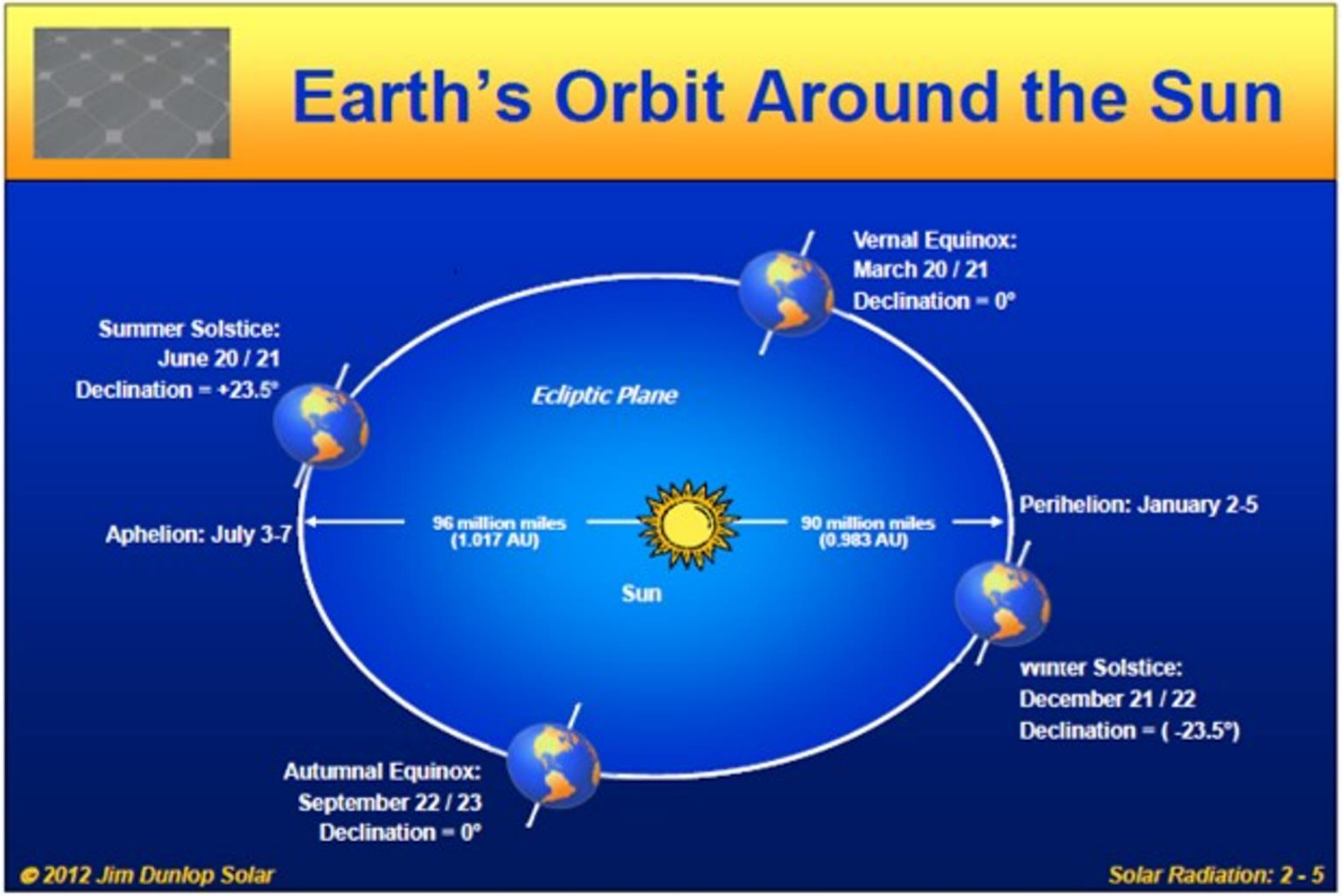


Solar Spectrum

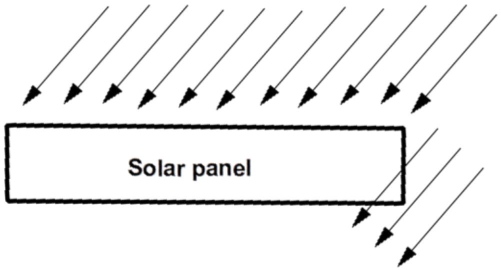


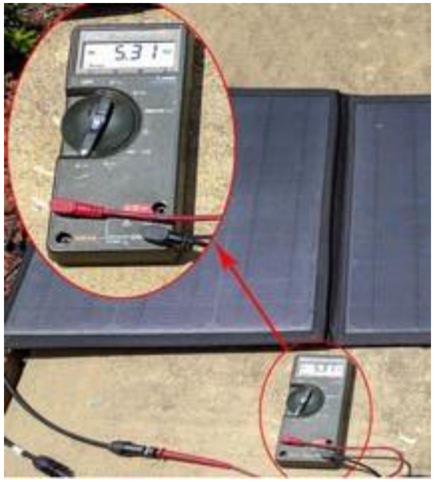
- Solar spectrum in space (extraterrestrial) and at sea level on Earth after it passes through the atmosphere.
- Notice H_2O, O_2, CO_2 absorption bands.

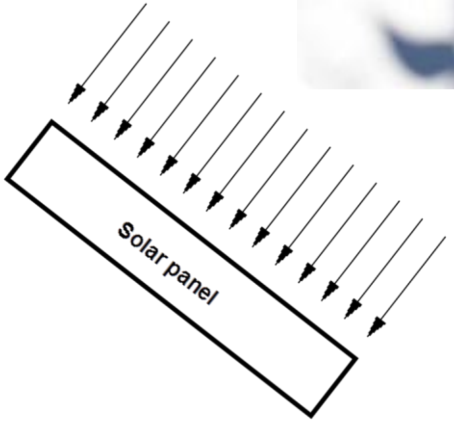
Solar Position



Impact of Angle on PV Power







* The Sun traverses the sky from east to west.
* However, the sun is always positioned south of our latitude (further south in the winter).
* A PV panel that is angled towards the sun will collect more light than one that is horizontal.

PV Module Orientation

In the northern hemisphere, PV modules always face South (towards the sun).

- For fixed arrays used for year-round loads:

  optimum tilt angle = site latitude

- For fixed array used primarily in the winter:

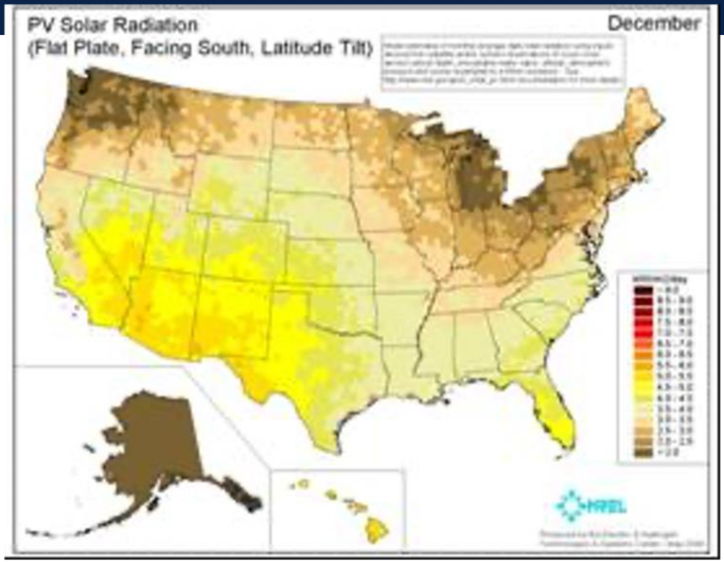
  optimum tilt angle = site latitude + 15^0

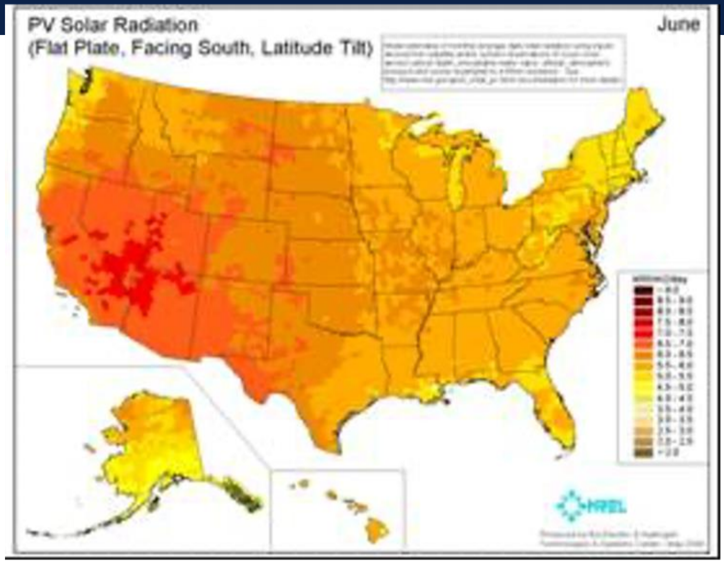
  (This increases the angle of the PV so that it faces more toward the south which enables you to get more sunlight in the winter when days are short and when cloudy weather is common.)

- For fixed arrays used primarily in the summer:

  optimum tilt angle = site latitude - 15°.

Solar Window and Irradiance Maps



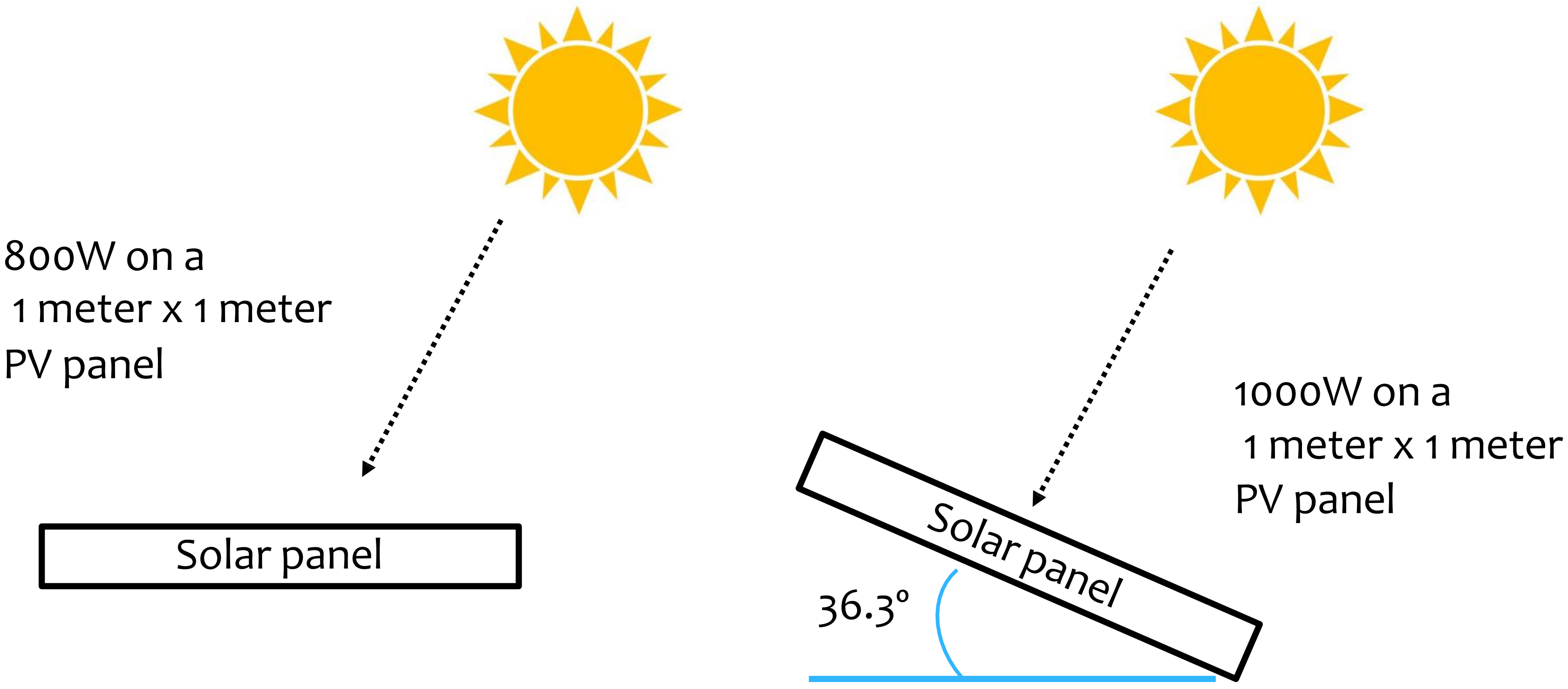


http://www.nrel.gov/gis/solar.html#maps

* Solar array positioning is critical to optimize system design.
* System must provide adequate power during period of least sun exposure.
* System provides excess power generation during high solar insolation months.

Tucson Latitude = 32.25⁰ **Phoenix Latitude = 33.45⁰** **Tsaile Latitude = 36.30⁰**

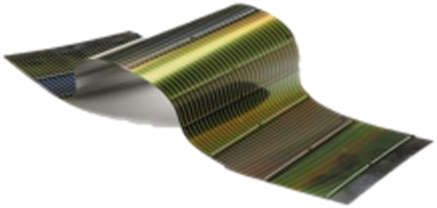
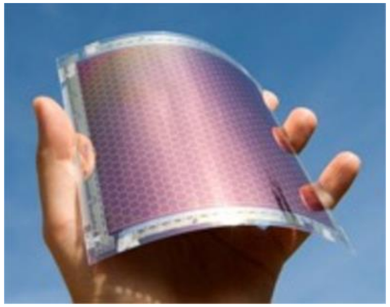
Effect of Tilt – Tsalie, AZ



Photovoltaics

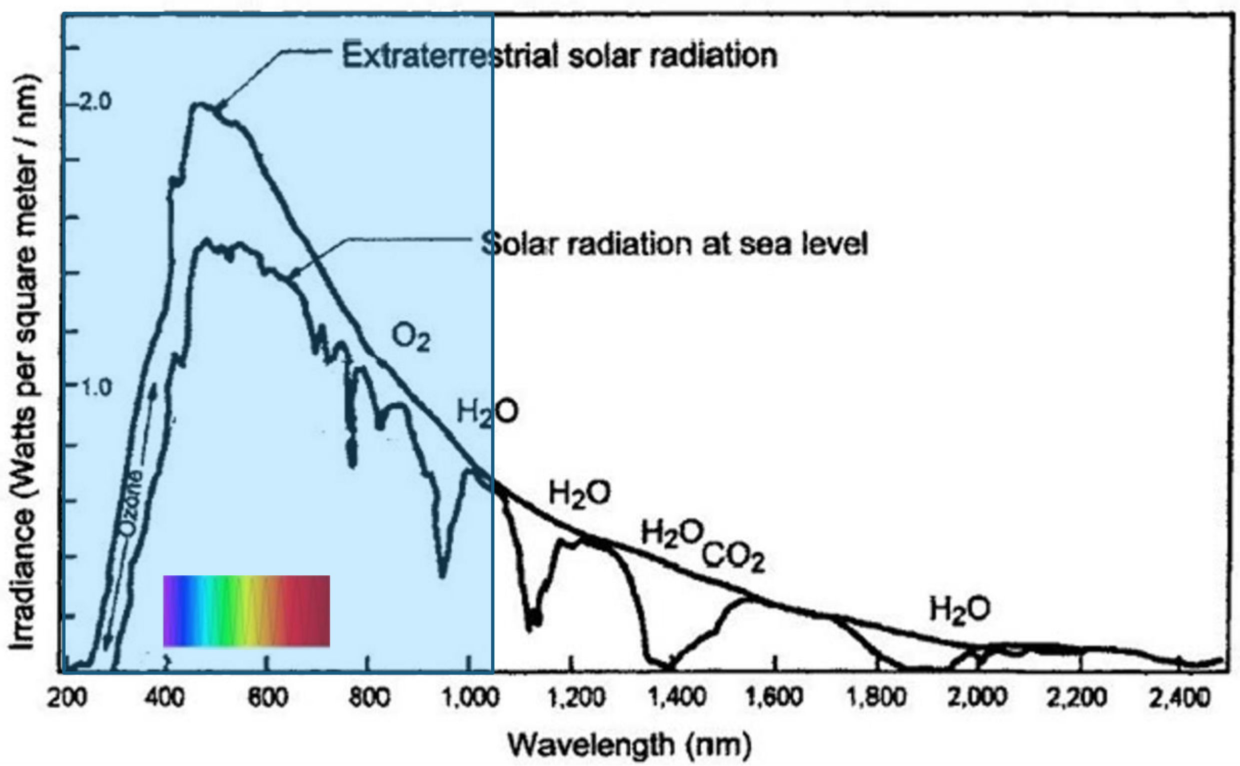


* Photovoltaics are devices that convert energy - A'tsinishklish - from the sun into electrical current.
* There are many types of materials that can be used to produce photovoltaic devices, including:
  - **Single-crystal silicon (Si)**
  - **Poly-crystalline silicon**
  - **Thin film semiconductors**
  - **Organic materials (OPV)**

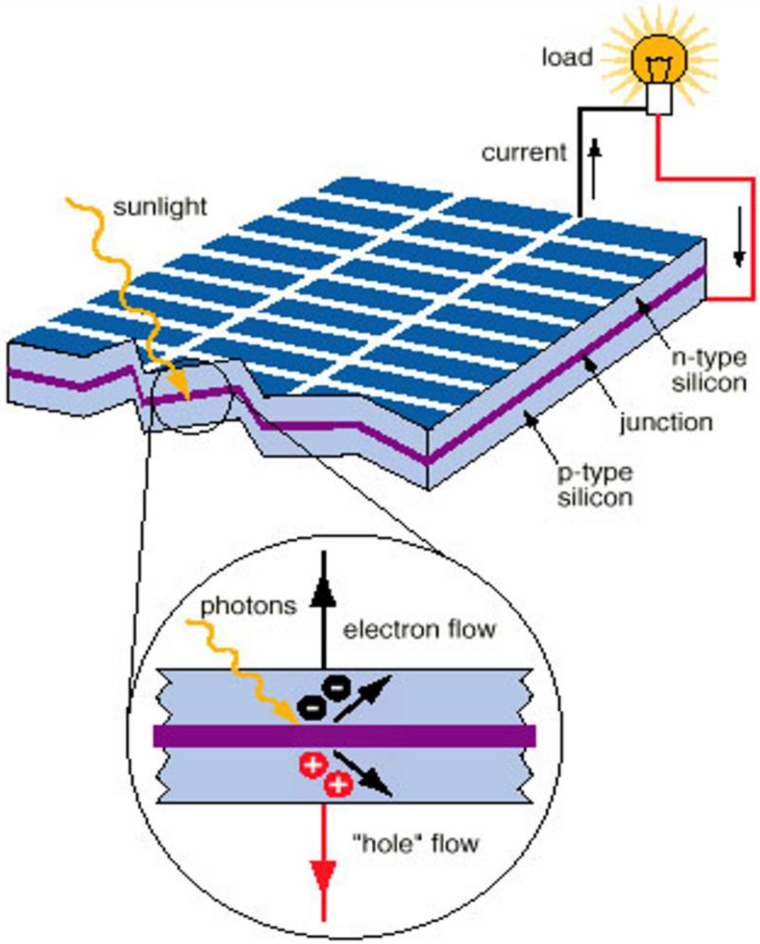
Solar Spectrum

Blue shaded region shows sunlight that is absorbed by photovoltaic cells to produce electricity.



- Solar spectrum in space (extraterrestrial) and at sea level on Earth after it passes through the atmosphere.

Photovoltaic Device



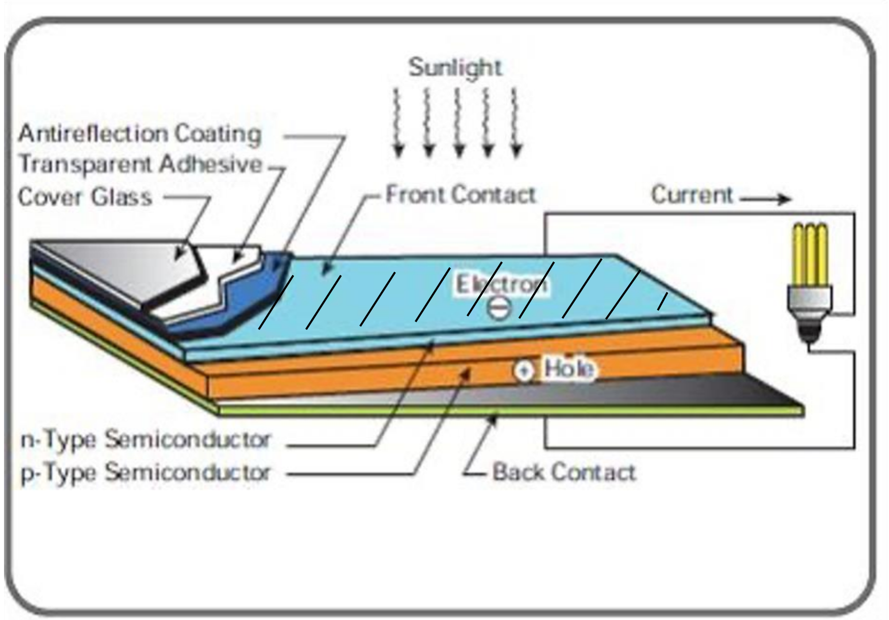
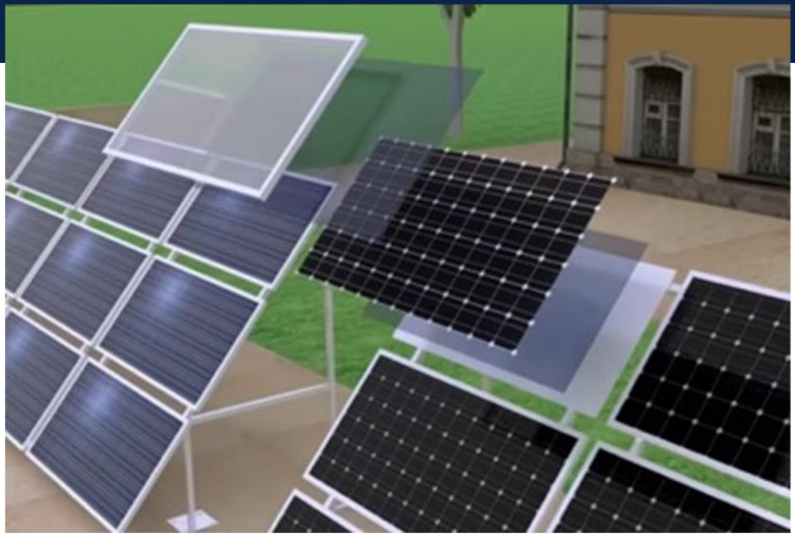
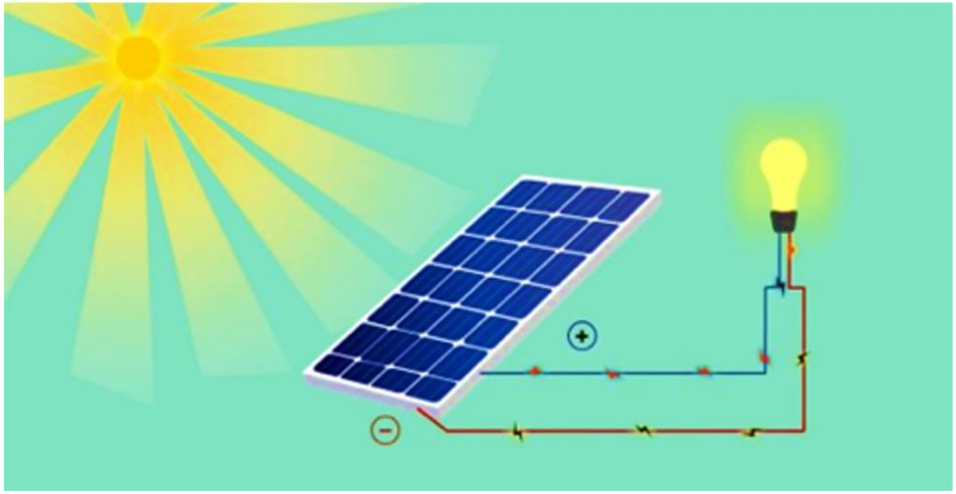
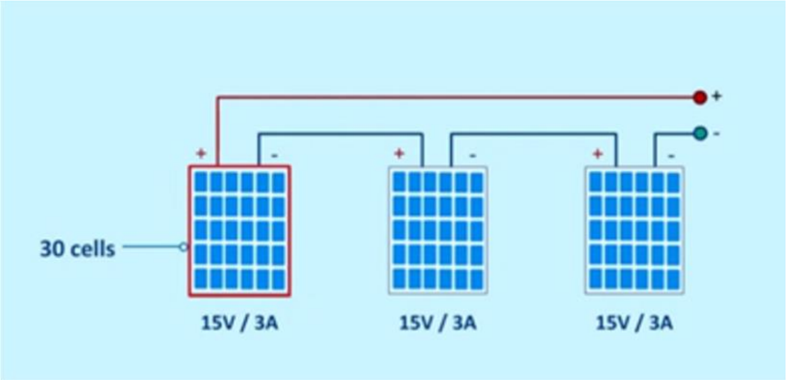


Photo-current in a PV device (left) and layer structure in a typical PV module (right).

Photovoltaic Devices







References

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