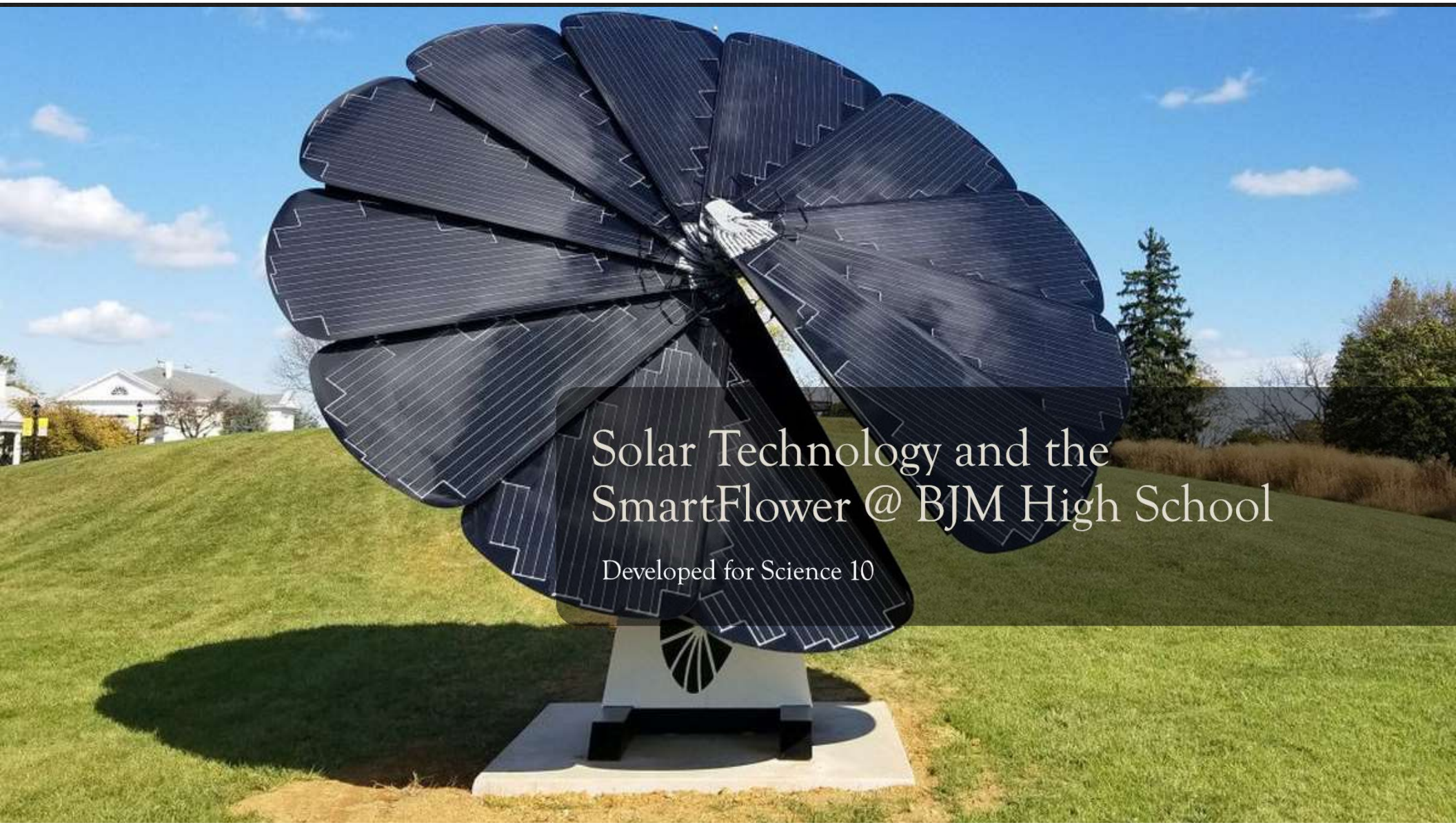
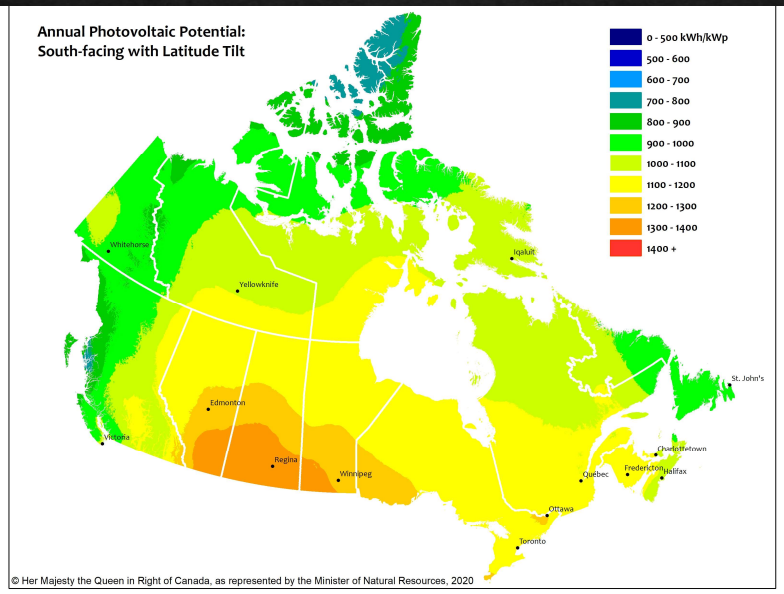


Solar Technology and the SmartFlower @ BJM High School

Developed for Science 10

What is Solar Power?

- Solar power involves the capture and conversion of energy within sunlight to electricity
- The amount of sunlight that hits the Earth's surface in 90 minutes is enough to cover all the energy demands of humanity for an entire year.



To create solar power you need sunlight...

- Southern Saskatchewan gets more hours of cloud free sunlight than anywhere in Canada
  - *Saskatoon Shines*
  - *Sunny Saskatchewan*
- Humanity is choosing to set up utility solar power plants in locations that have much more continuous solar exposure.
- Large solar installations tend to be in deserts or grasslands, not on arable land
  - Also not common to have large installations in locations that receive continuous rain and cloud cover (ex. Prince Rupert, BC; St. John's, Newfoundland)

Do we get the same amount of sunlight all year round?

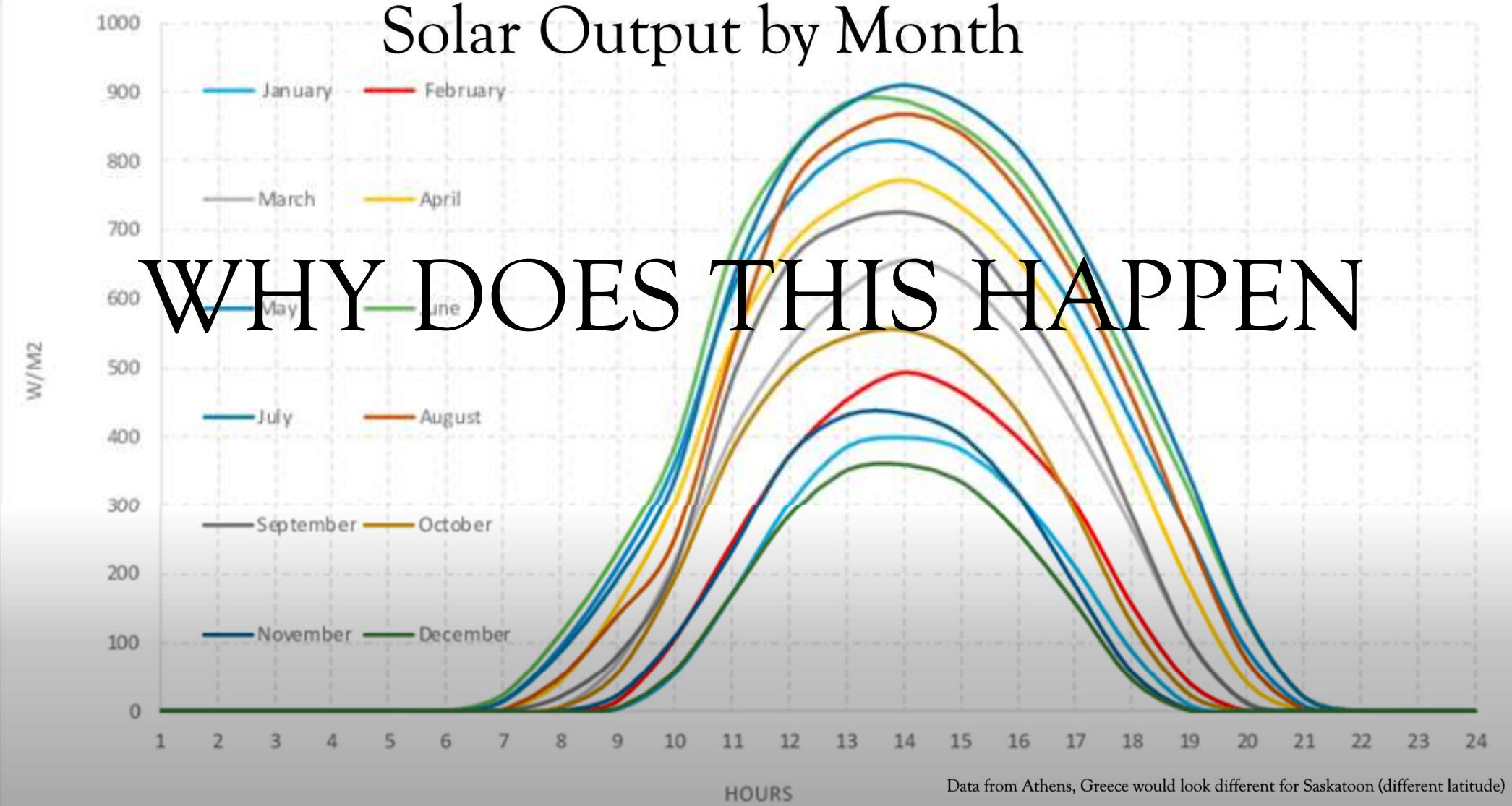
- No!
- In Saskatoon (much further away from the equator) there can be 16 or more hours of sunlight in the summer and 8 or less hours of sunlight in the winter
  - Solar output is inconsistent
- Close to the equator there is close to 12 hours of sunlight and 12 hours of darkness all year long
  - Solar output would be quite consistent

Hours of Sunlight Available to Produce Solar Energy in Saskatoon

Date	Sunrise	Sunset	Hours of Sunlight	Hours of Darkness
January 21, 2022	9:01	5:34	8:33	15:27
February 21, 2022	8:09	6:31	10:23	13:37
March 21, 2022**	**7:06**	**7:21**	**12:15**	**11:45**
April 21, 2022	5:56	8:15	14:19	9:41
May 21, 2022	5:03	9:03	16:00	8:00
June 21, 2022*	**4:45**	**9:31**	**16:45**	**7:15**
July 21, 2022	5:12	9:13	16:01	7:59
August 21, 2022	6:00	8:17	14:17	9:43
Sept. 21, 2022**	**6:51**	**7:06**	**12:16**	**11:44**
October 21, 2022	7:42	5:59	10:17	13:43
November 21, 2022	8:37	5:07	8:29	15:31
December 21, 2022*	**9:12**	**4:55**	**7:43**	**16:17**

https://www.timeanddate.com/sun/canada/saskatoon?month=6&year=2022

Solar Output by Month

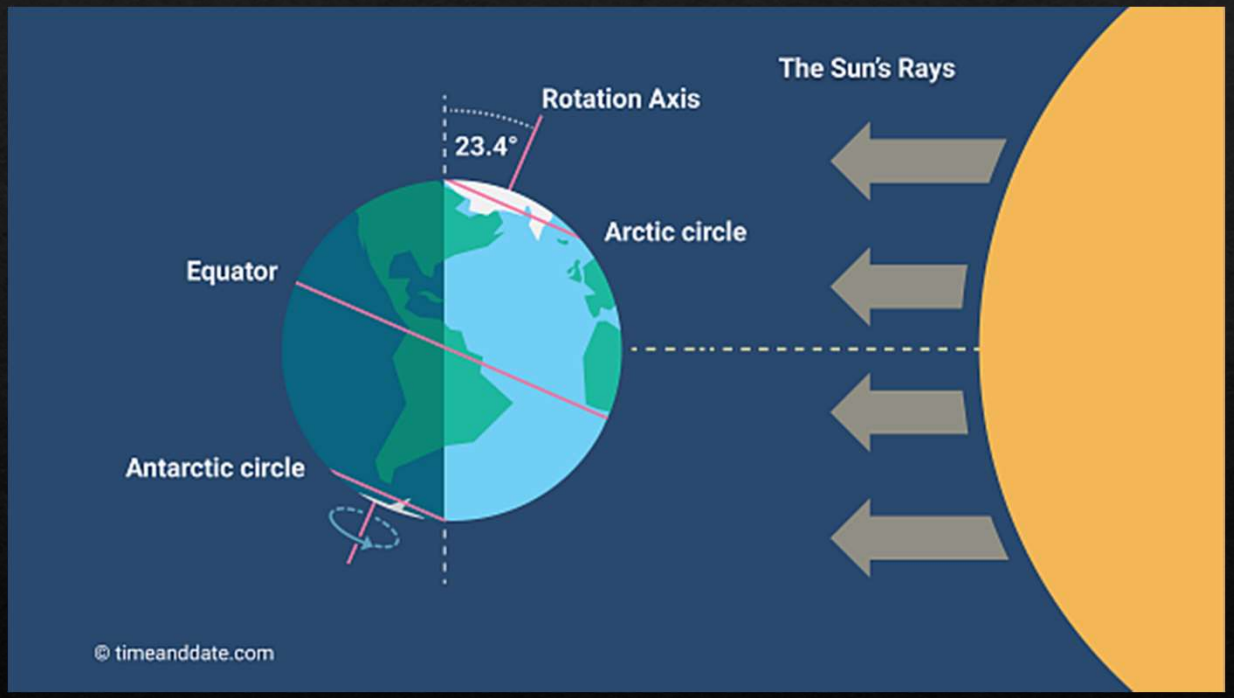


WHY DOES THIS HAPPEN

Data from Athens, Greece would look different for Saskatoon (different latitude)

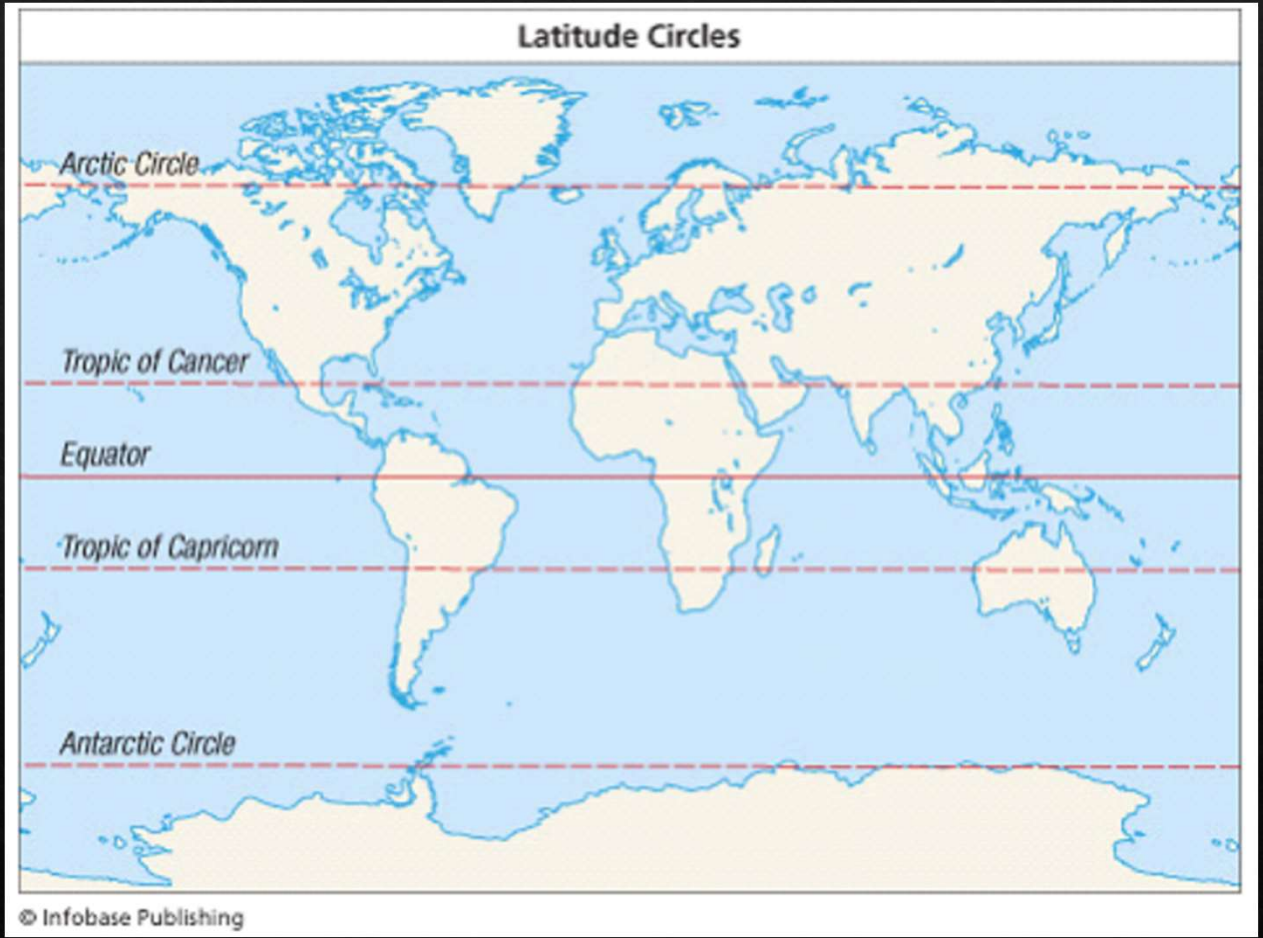
Tilt of the Earth

- Every 24 hours it spins on its rotation axis
- Every 365.26 days the Earth revolves around the sun
- The Earth does not sit straight up and down on its axis.
  - It is tilted 23.4 degrees



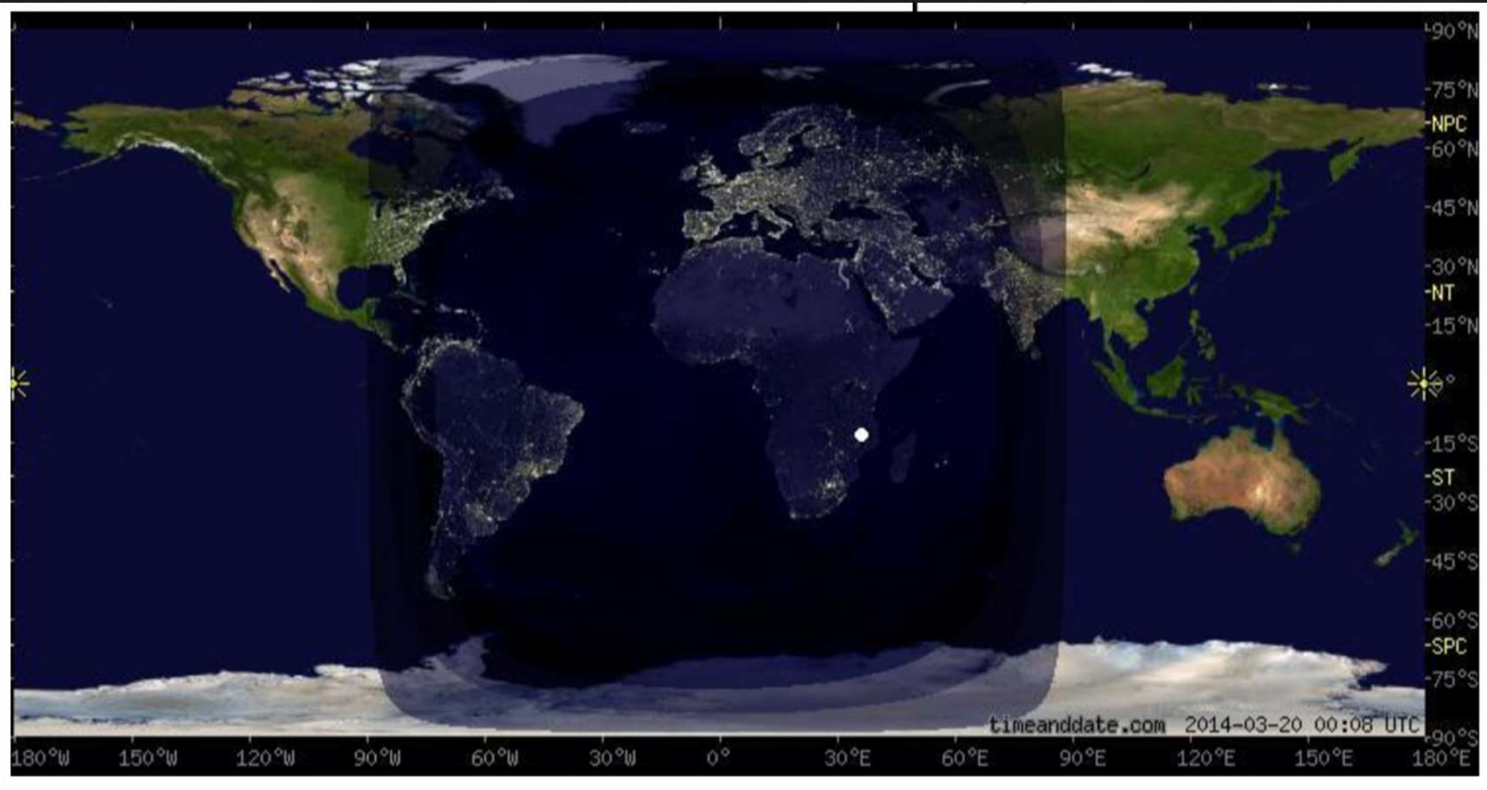
Tilt of the Earth

- On any map / globe of the Earth there are five major lines of latitude that are marked:
  - Equator (zero degrees)
  - Tropic of Cancer (23.4 degrees North),
  - Tropic of Capricorn (23.4 degrees South)
  - Arctic Circle (66.6 degrees North)
  - Antarctic Circle (66.6 degrees South)
- These specific latitudes are marked because of the tilt of the Earth (23.4 degree)



Equinox – September 21st and March 21st

- Image on the right illustrates that there is direct sunlight at the equator.
- There are 12 hours of sunlight and 12 hours of darkness everywhere on Earth.



What is direct sunlight?

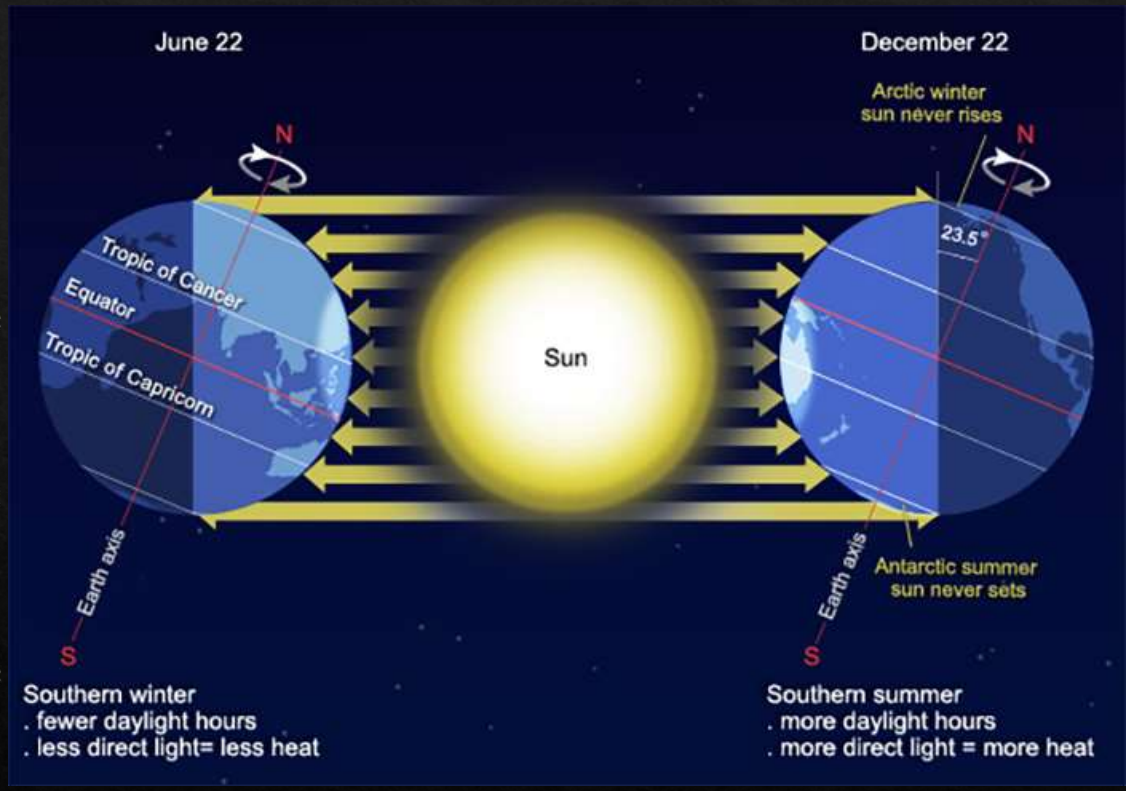
- Sunlight that comes in perpendicular the surface of the Earth. (90 degrees)
  - Some objects cast no shadow!
- This happens everywhere on Earth between the Tropic of Cancer and Tropic of Capricorn
  - It is impossible outside of the tropics

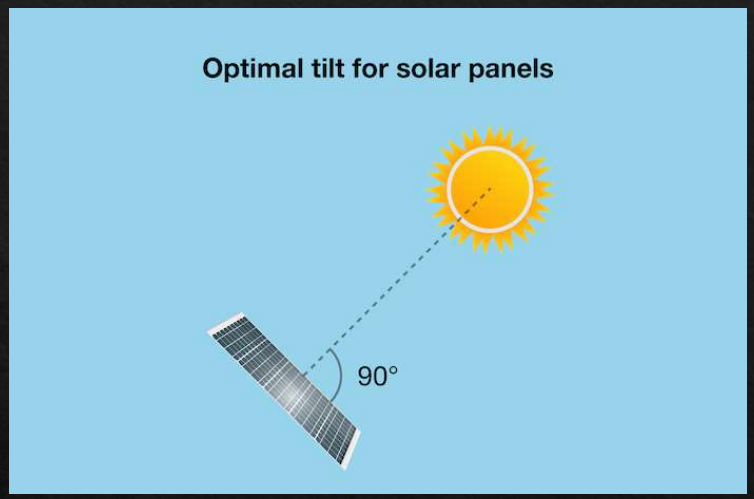
What is perpetual darkness and perpetual sunlight?

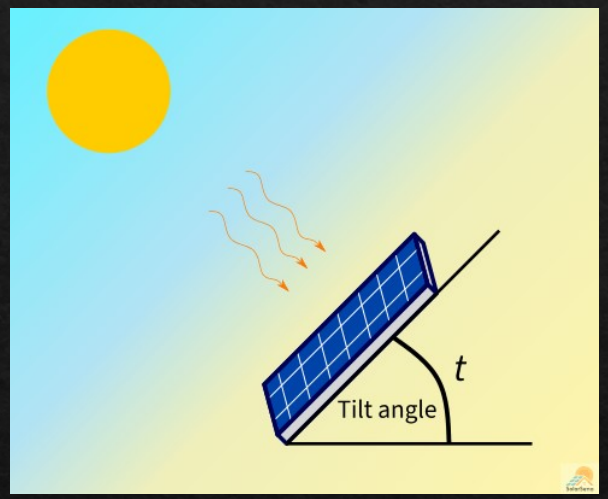
- Outside of the Arctic and Antarctic Circle it is possible for the sun to never rise or never set.
- First Photo – Summer Solstice
  - Perpetual Sun North of the Arctic Circle
  - Perpetual Darkness South of the Antarctic Circle
- Second Photo – Winter Solstice
  - Perpetual Darkness North of the Arctic Circle
  - Perpetual Sun South of the Antarctic Circle

Why Do We Have Seasons? Summer vs. Winter

- Arctic Summer
  - On its path around the sun the Northern Hemisphere is tilted toward the sun during summer.
  - More hours of sunlight in Northern Hemisphere
  - Direct solar radiation at Tropic of Cancer on June 21st
- Arctic Winter
  - On its path around the sun the Northern Hemisphere is tilted away from the sun in the winter.
  - Less hours of sunlight
  - Direct solar radiation at Tropic of Capricorn on December 21st

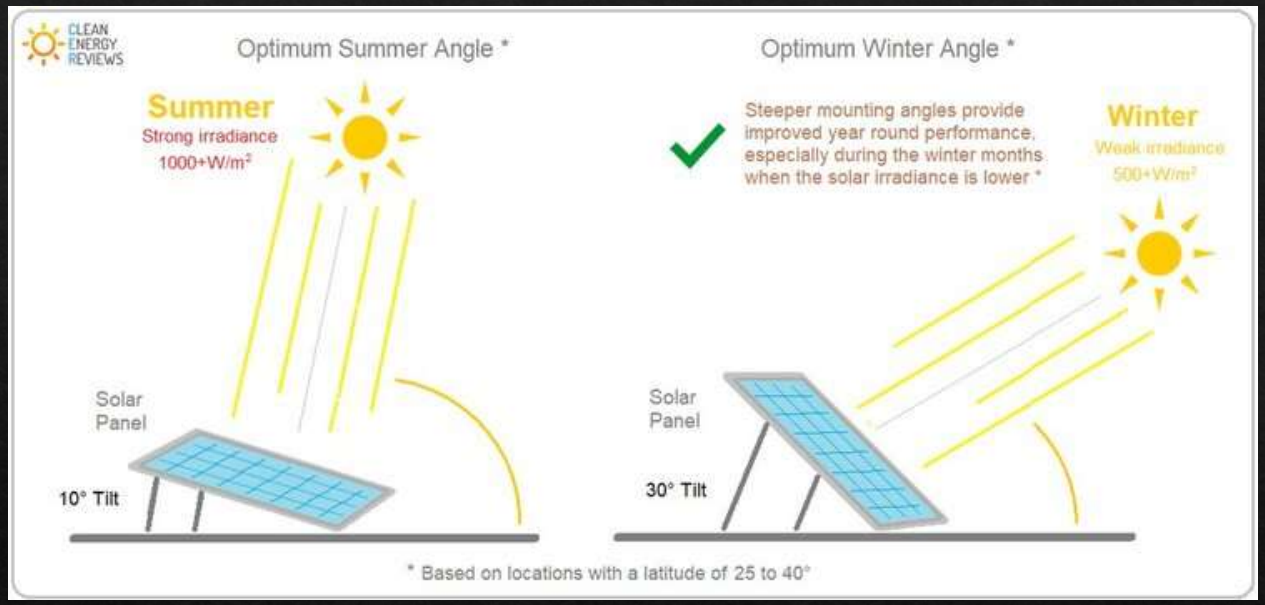


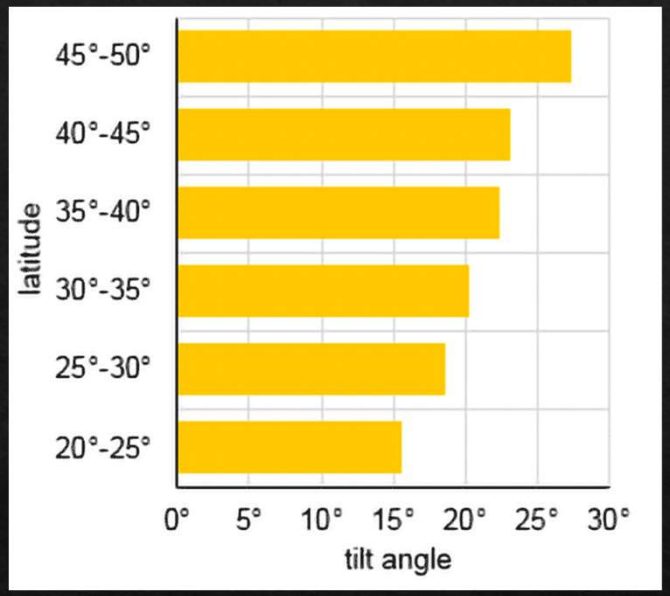




Why Do We Tilt The Panels?

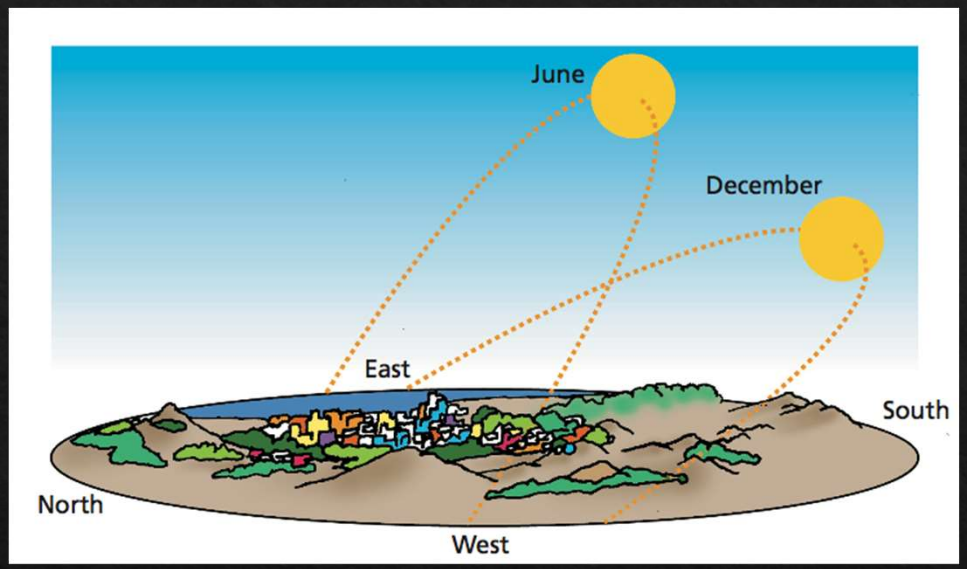
- To capture the maximum amount of energy, solar panels can be tilted so that incoming light is perpendicular to the panel.
- The best angle for panels to be at depends on
  - how far you are from the equator (latitude)
  - the time of year
  - the time of day





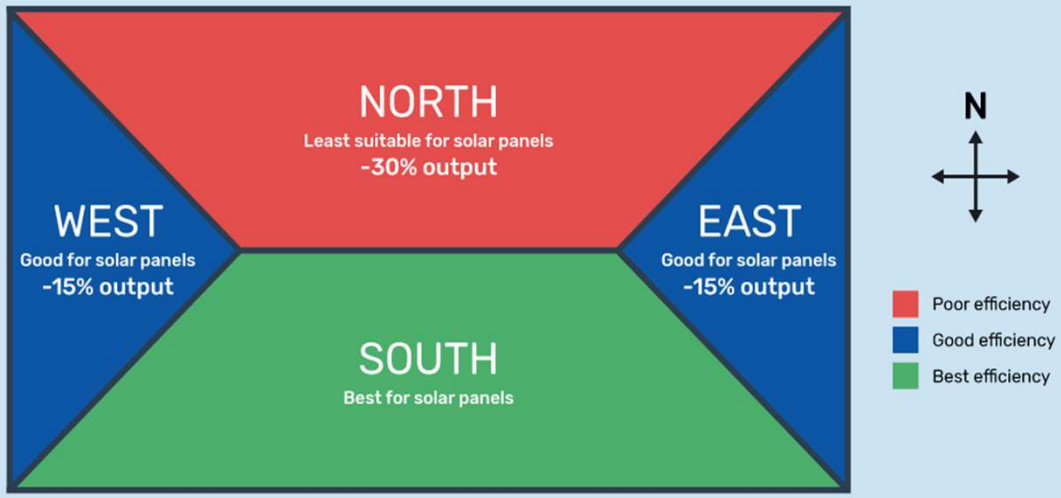
What Angle Should The Panels Be At?

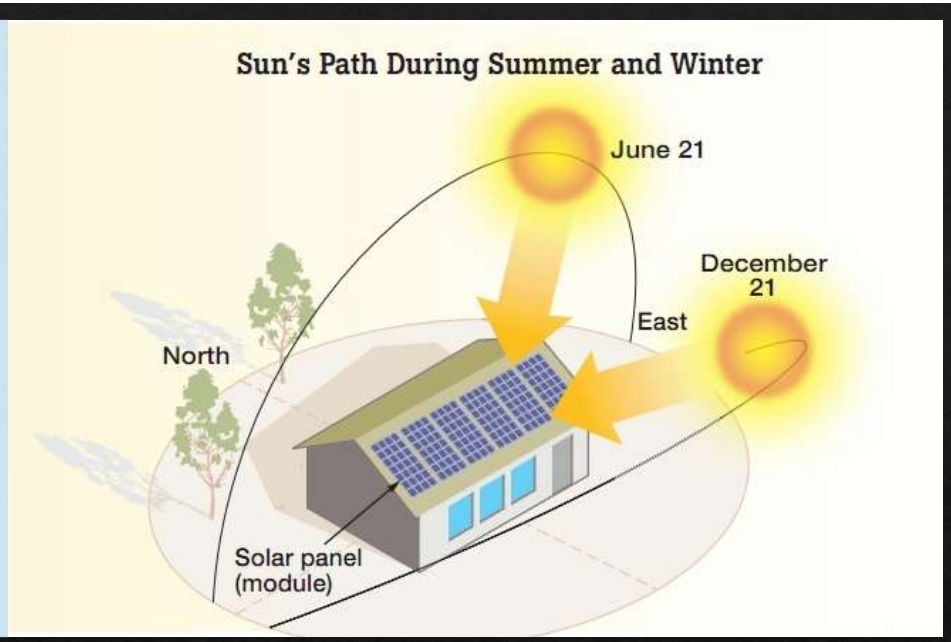
- The optimal angle in the summer is not the same as the optimal angle in the winter.
- The optimal angle will be different at different latitudes



Tilt of the Earth – Effect on Solar Power

- No one tilt setting is perfect
- Every day the sun rises in the East and sets in the West.
  - The ideal tilt angle changes throughout the day
- In the summer months there is not only more hours of sunlight, the sun rises higher in the sky.
  - The ideal tilt angle changes throughout the year

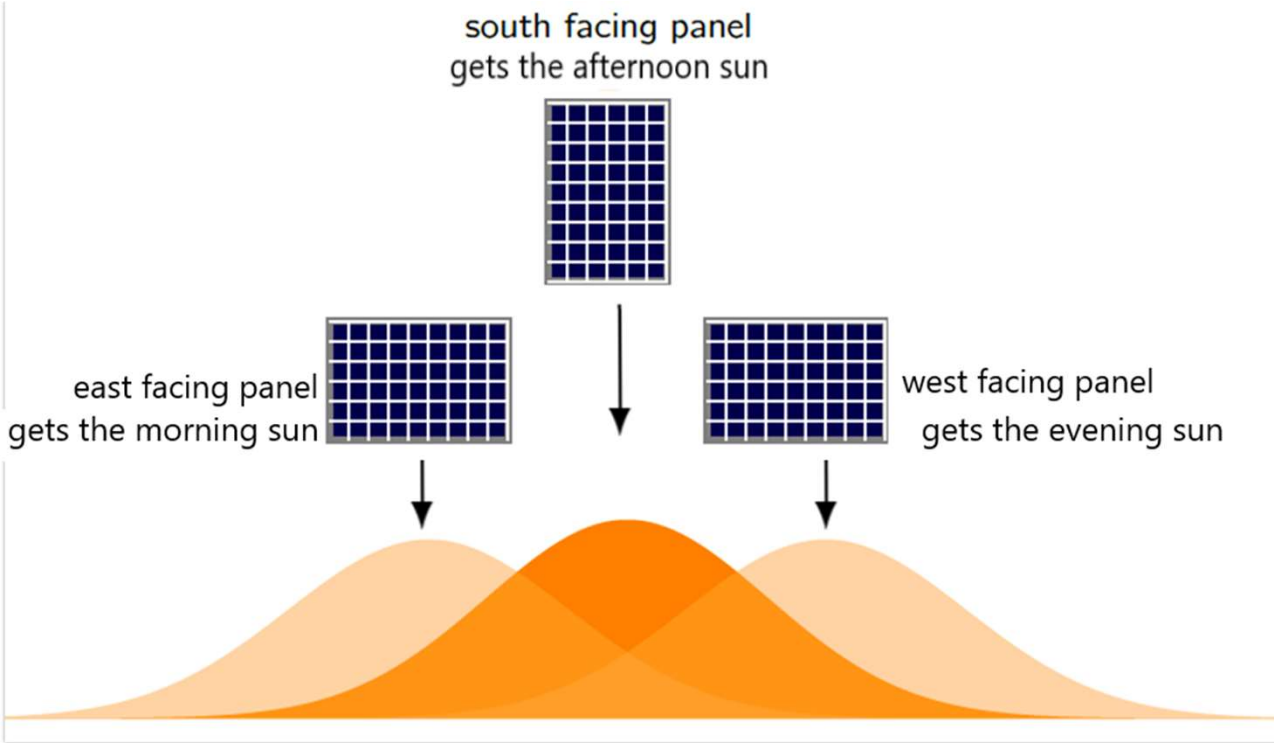


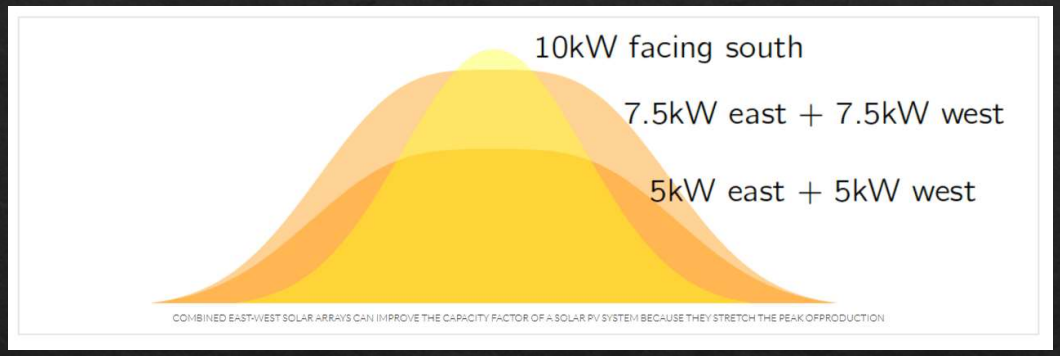


Do solar panels need to face south to work?

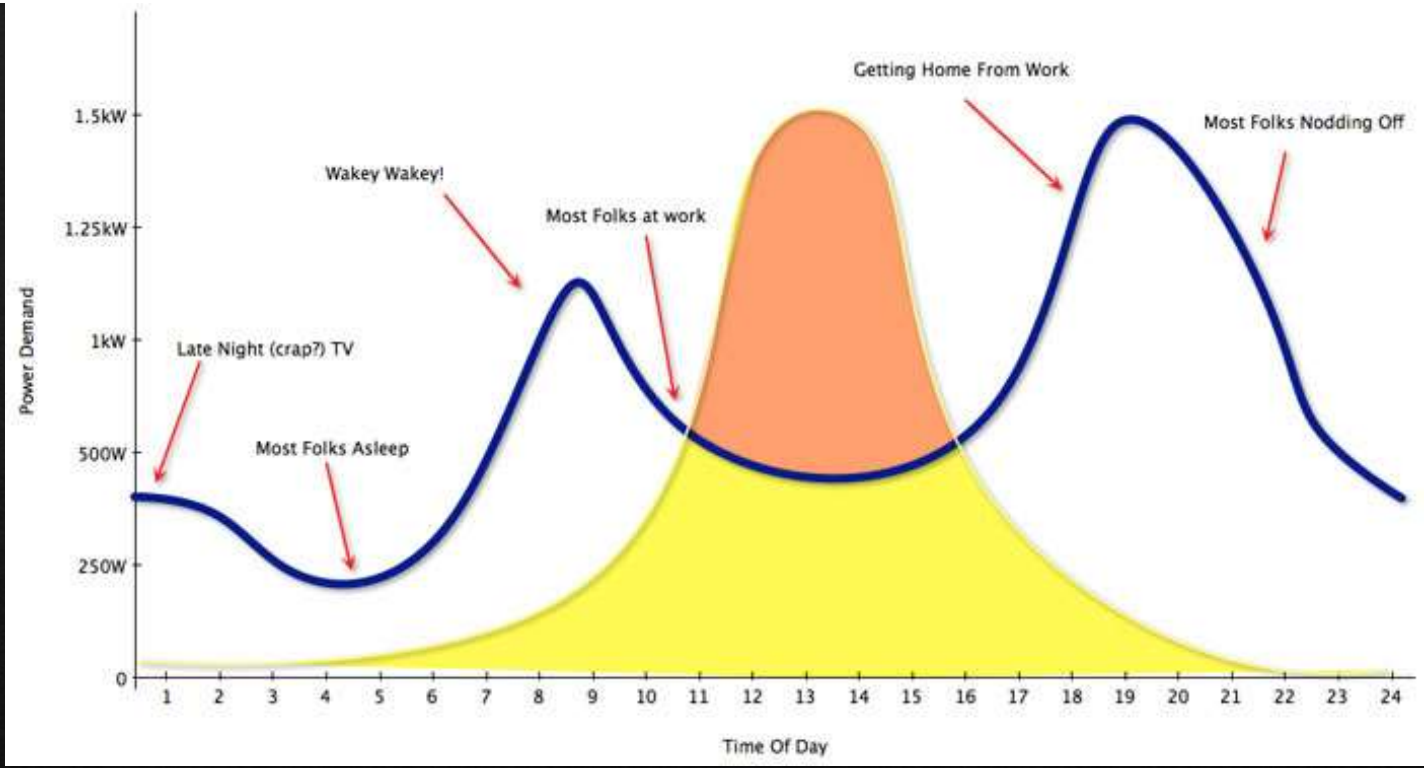
- No.
- A system set up on an east or west roof will produce only 15% less power on average
- A north roof, 30% less (but not zero)

- The figure on the right shows how little difference is seen when comparing the power produced from East, South, and West facing Solar Panels.
- A system with both east/west panels performs as well as a south facing system of the same size.

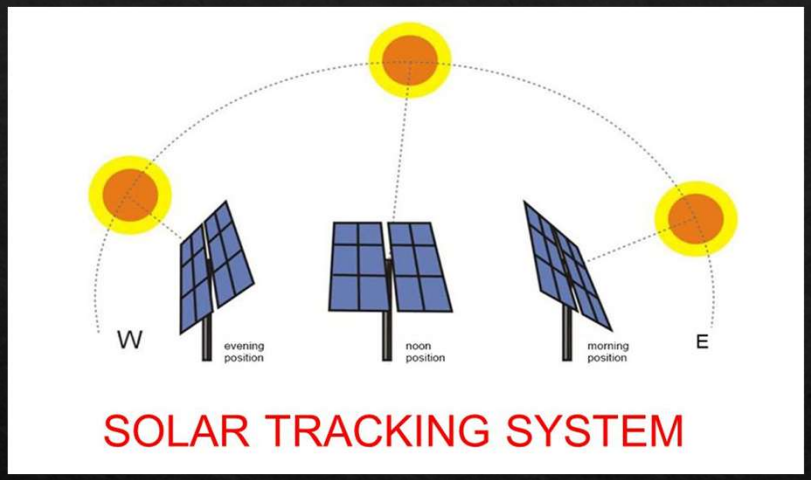


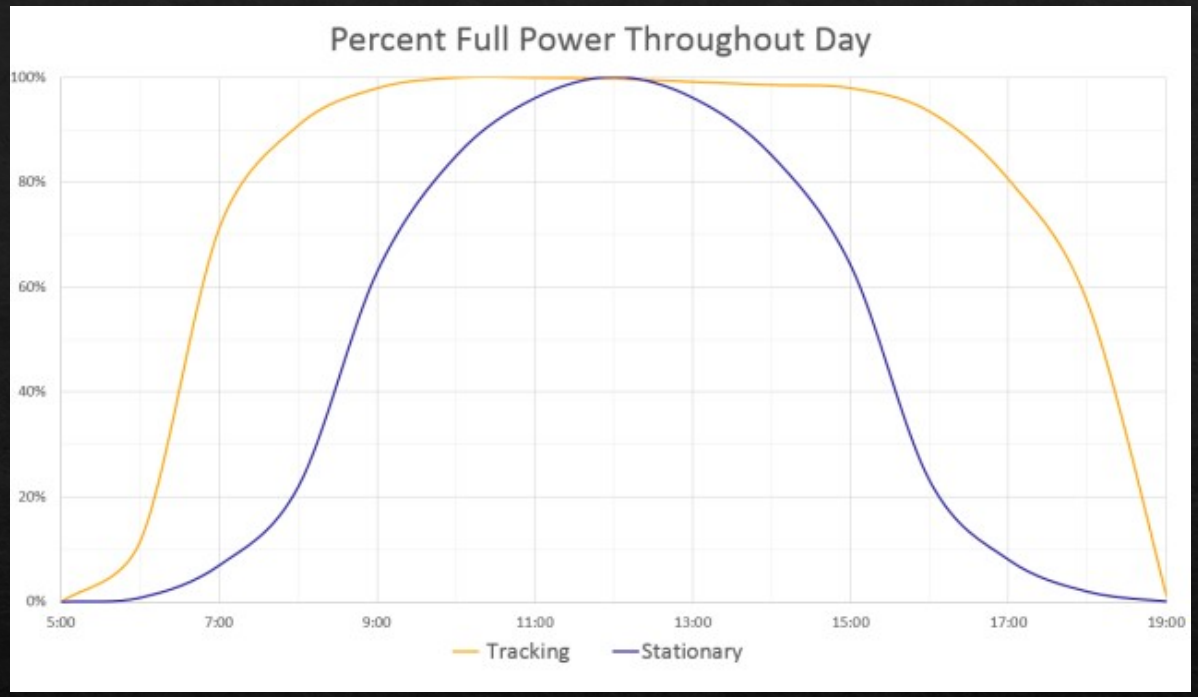


- Field or Flat Rooftop Installs all over the world are being put up with East/West pattern
- This setup produces a similar amount of power spread over the length of the whole day, somewhat reducing the power usage vs solar power production issue.



- Solar Output is the highest between 11AM and 3PM. Energy Demand is the highest at between 7AM and 10AM and then again between 6PM and 9PM.This does not align! We can't go 100% solar!





Solar Tracker Technology

- Solar Panels installed on a solar tracker system follow the sun as it rises and sets.
- The system spins once on its axis every 24 hours, just like the Earth.
- Combines the East/West/South Pattern to generate as much as 32% more power.

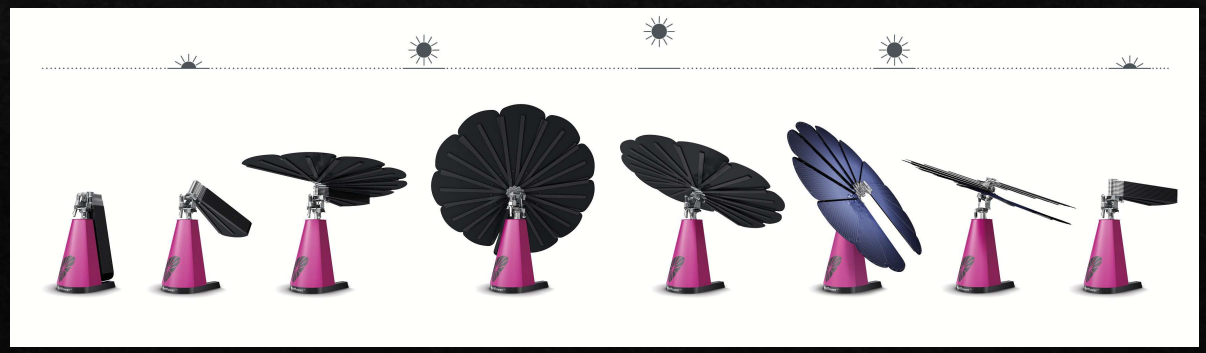
Saskatoon Landfill Solar Demonstration and Research Site

- 3 Sets of fixed panels at different tilt angles
  - Goal is to have data to understand the best tilt angle for future installation in Saskatoon
- 2 single axis solar trackers
  - Goal is to understand if tracker technology produces the additional energy it claims to

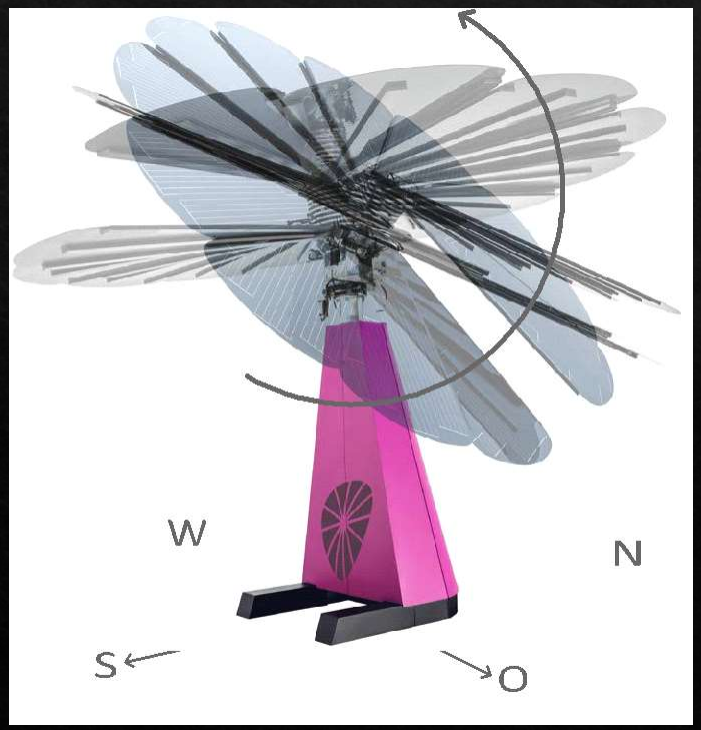
Why is the SmartFlower so Special?

SMARTFLOWER – DUAL AXIS TRACKER @ BJM

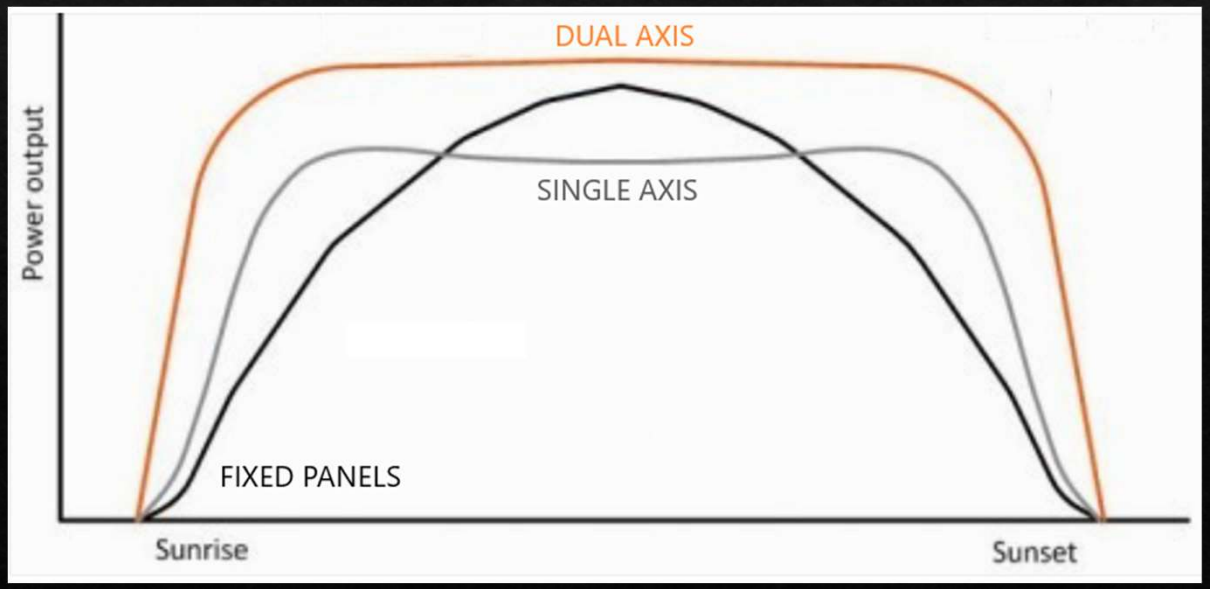
- Much like a real flower, the system unfolds its petal-panels when the sun rises.
- The SmartFlower then directs its petals toward the sun at a 90-degree angle and almost immediately begins to produce renewable energy at maximum capacity.
- At sunset, the petals automatically retract until the next morning.



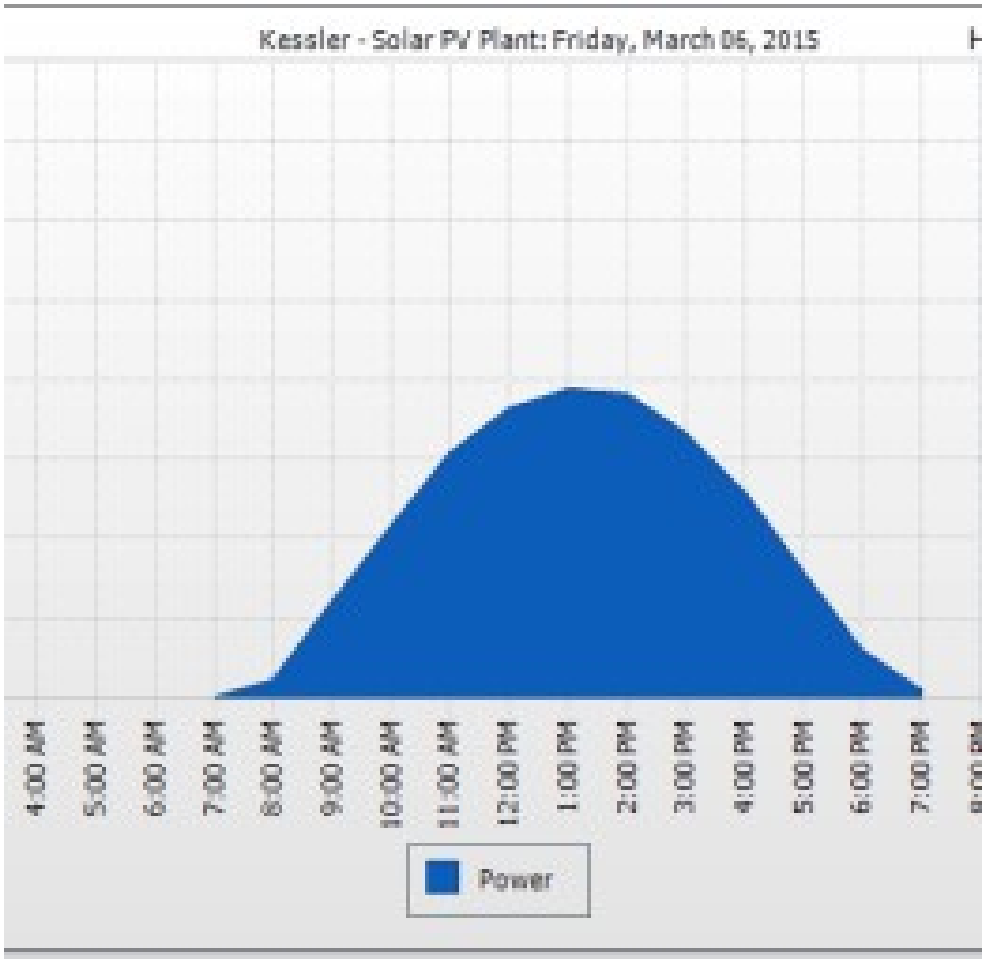
SmartFlower – Dual Axis Tracker

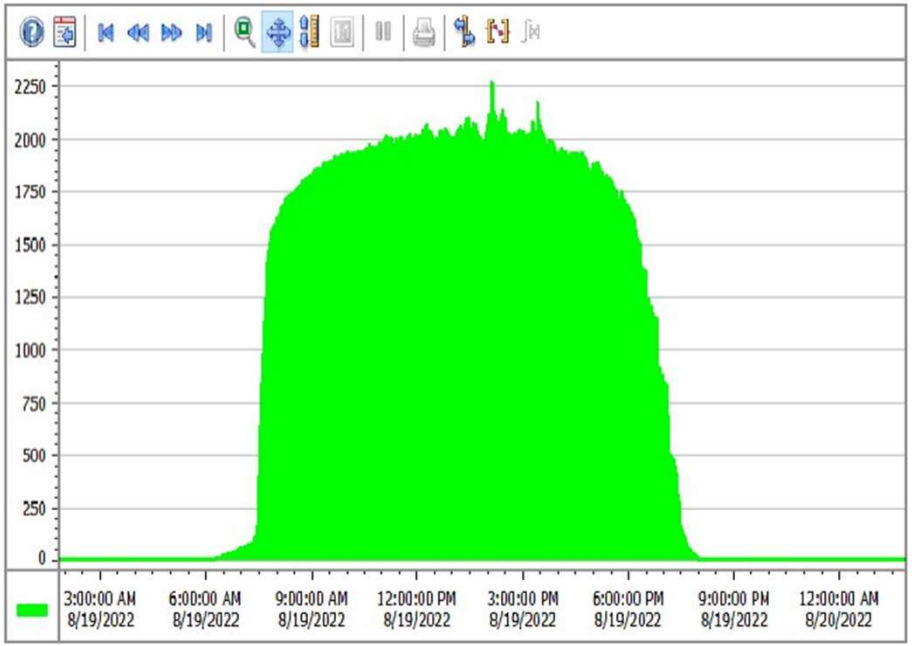


- All-in-one solution
  - Accounts for both changes in the rotation of the Earth and the ideal tilt angle throughout both the day and year
  - Contains solar tracker technology on one axis
  - Also has a second axis that tilts the panels to reliably allow for direct radiation at all times of the day.
  - Produces upwards of 40% more clean energy than a traditional fixed solar panel system.



Standard Output from a Solar Panel

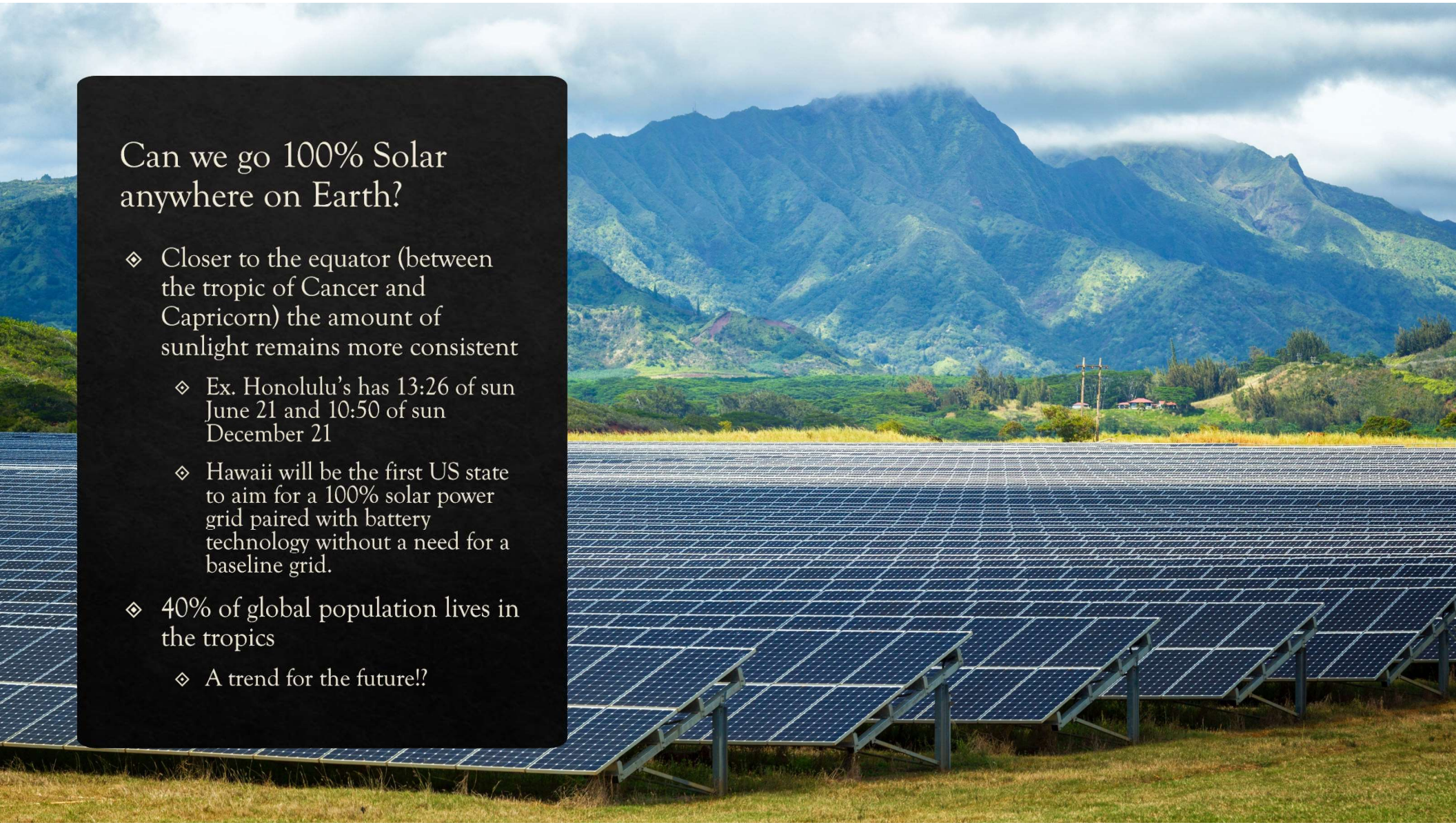




40% more power produced than compared to a standard, stationary, solar panel tilted properly

Shape of the curve is no longer bell shaped.

Biome Connections of Solar Angle – Qu'Appelle Valley



Can we go 100% Solar anywhere on Earth?

- Closer to the equator (between the tropic of Cancer and Capricorn) the amount of sunlight remains more consistent
  - Ex. Honolulu's has 13:26 of sun June 21 and 10:50 of sun December 21
  - Hawaii will be the first US state to aim for a 100% solar power grid paired with battery technology without a need for a baseline grid.
- 40% of global population lives in the tropics
  - A trend for the future!?