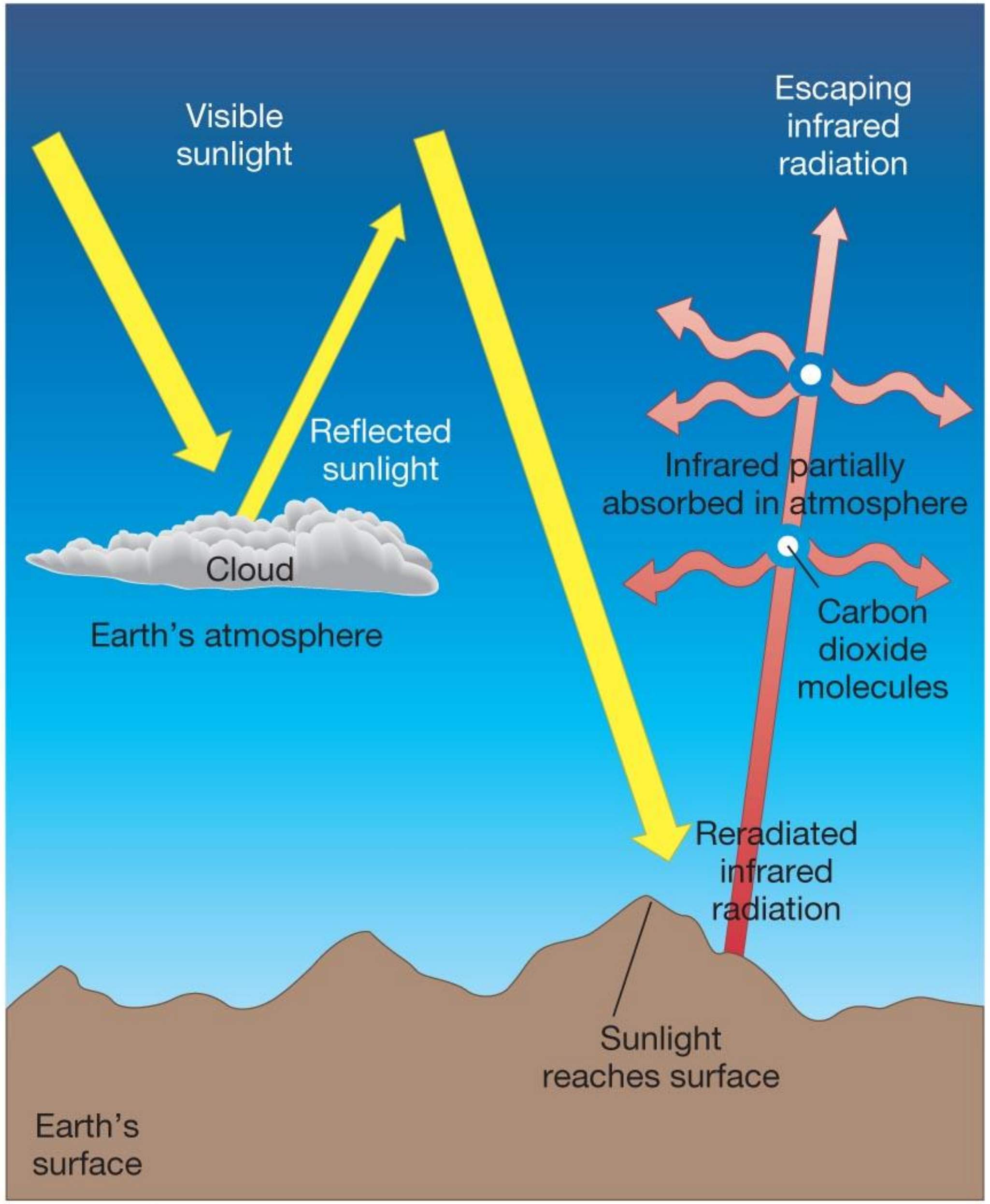
Climate Change and Sun Power

Svetlana Barkanova, Physics
School of Science and Environment
Grenfell, MUNL

NSERC CRSNG PromoScience | Canada | Qalipu First Nation | Grenfell Campus Memorial University | newfoundland labrador hydro a nalcor energy company

Greenhouse Effect

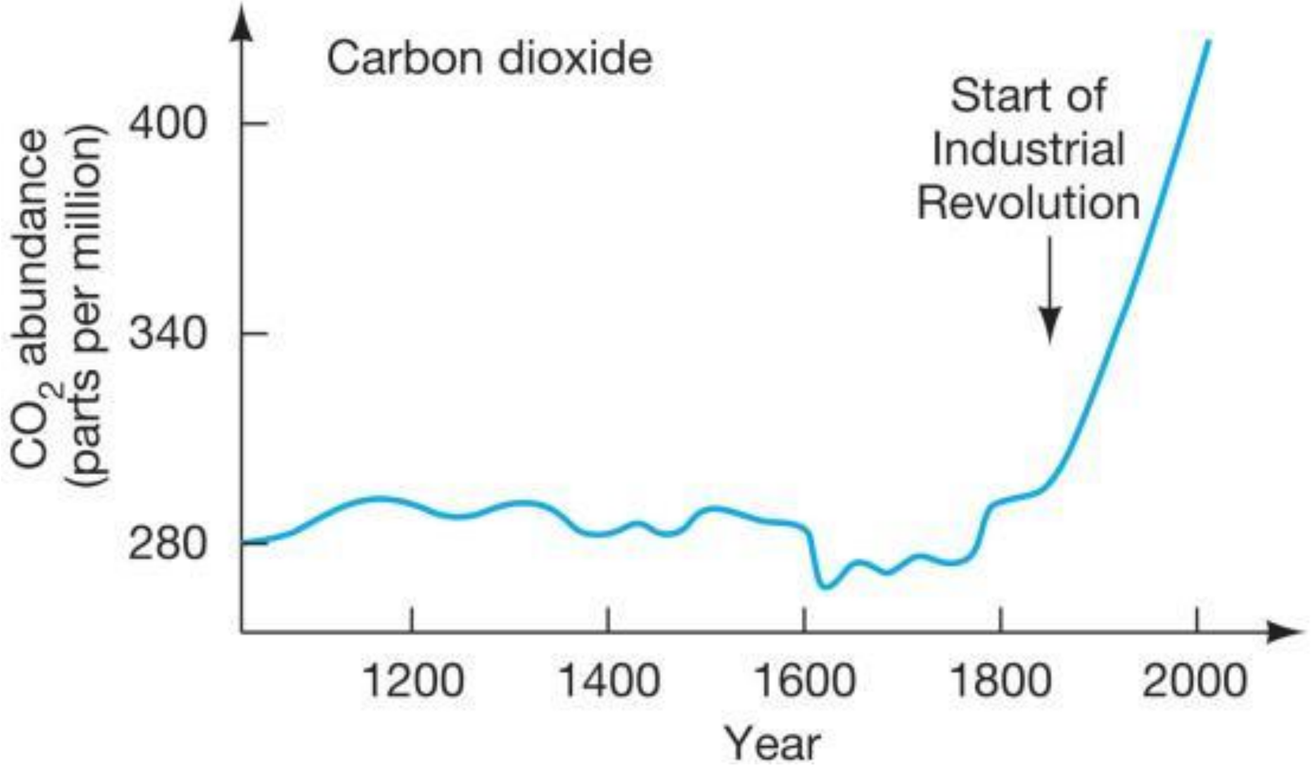
Infrared radiation reradiated from the surface is partially absorbed by the carbon dioxide and water vapor in the atmosphere, causing the overall surface temperature to rise.



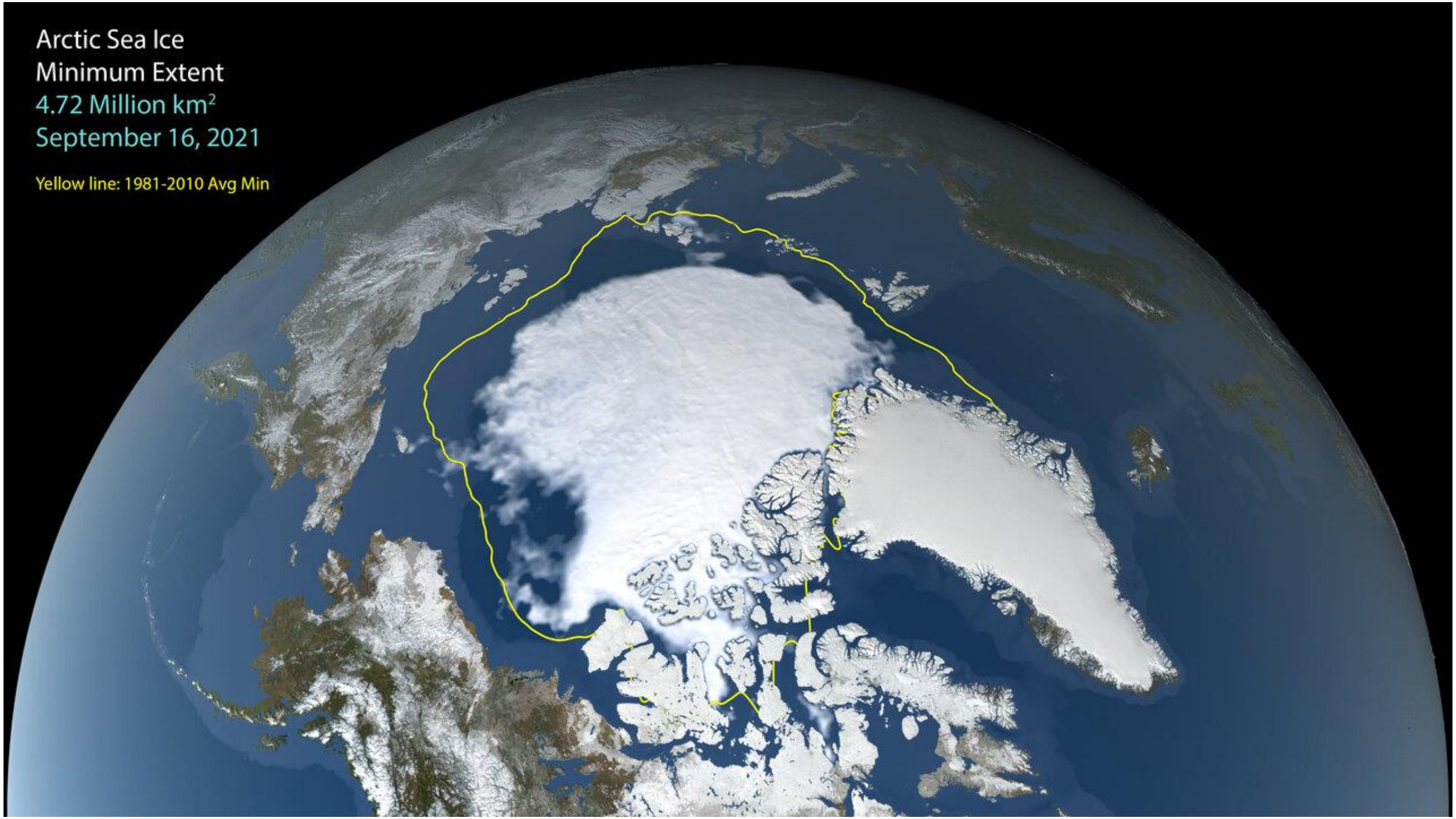
Modern society has greatly increased CO_2 levels in the atmosphere, increasing global average temperature.

Some consequences of global warming:

- Rise in sea level
- More severe weather
- Crop failures (as climate zones change)
- Expansion of deserts
- Spread of tropical diseases
- Shrinking sea ice



The Arctic is warming at a rate of almost twice the global average.



Credit: NASA's Scientific Visualization Studio

We can confront the climate change by decreasing emissions by transitioning to "clean" or "renewable" sources of energy.

Renewable energy is derived from sources that can naturally replenish themselves, while clean energy encompasses all zero-carbon energy sources.

Examples:

Renewable – sun, wind, hydropower, biomass, geothermal, tidal

Clean – nuclear

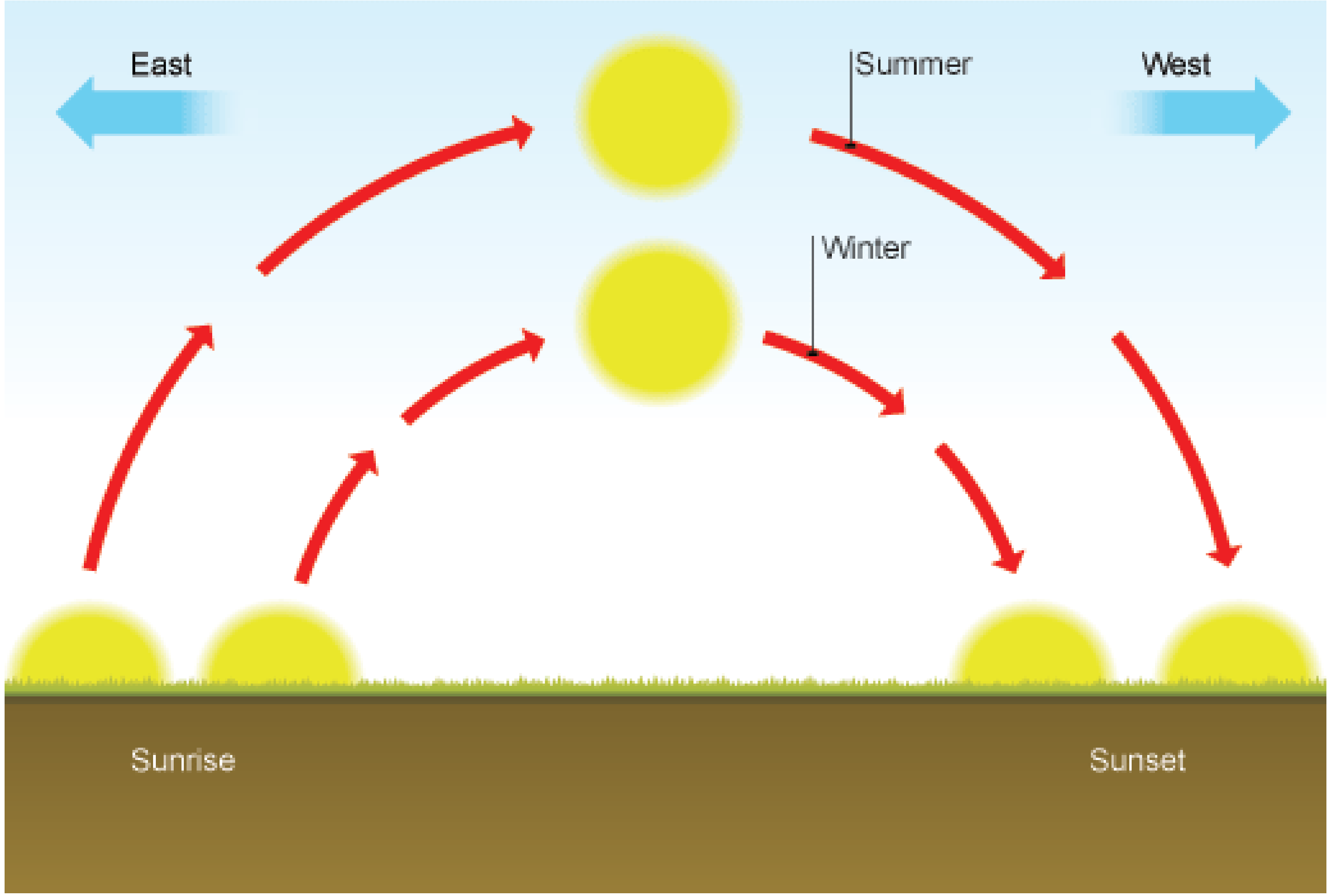
Naku'set (nah-goo-set) Mi’kmaq

Naku'set is the sun which travels in a circle and owes its existence to Creator.

Naku'set is the giver of life.

It is also a giver of light and heat.

http://www.muiniskw.org/pgCulture3a.htm



Julie Lawrence and Hillary Blanchard, WISE NL

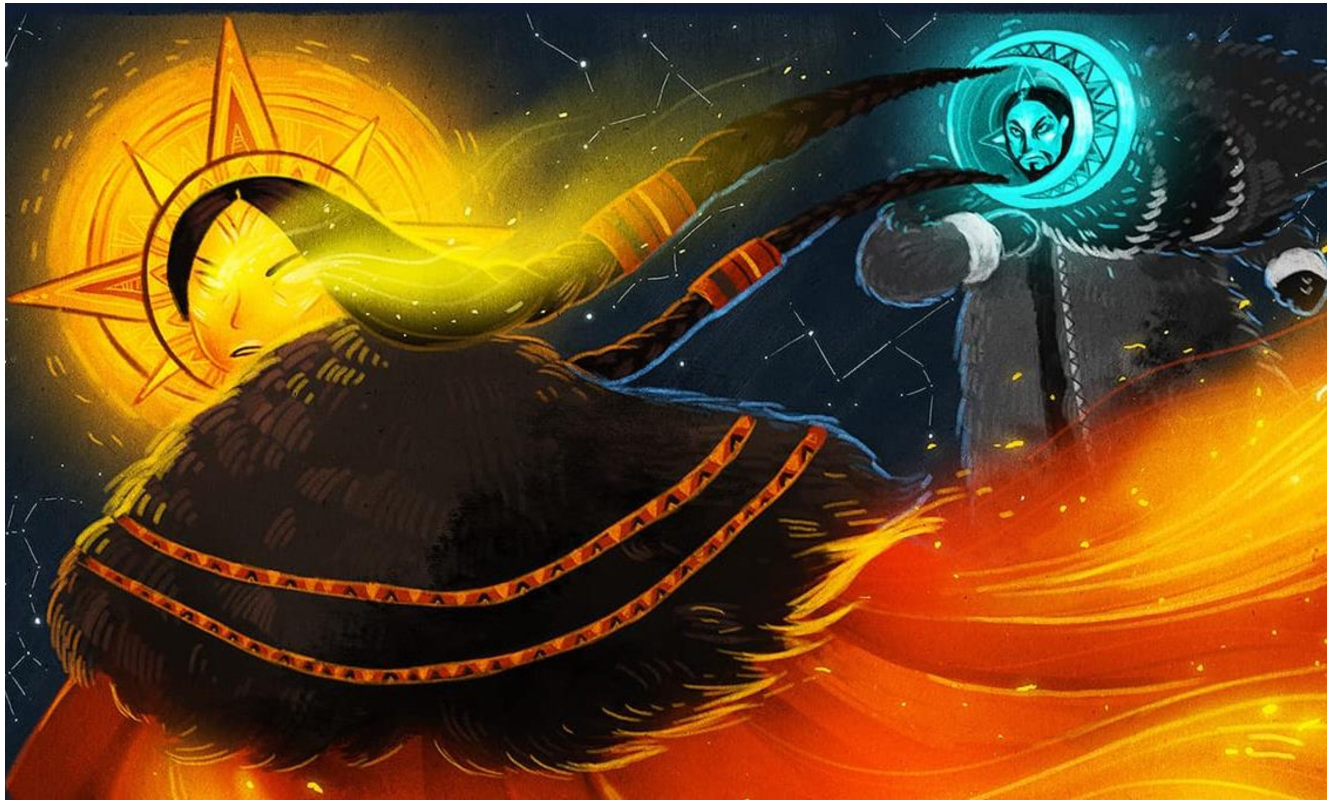
Malina - the Inuit Sun goddess

In the Inuit story, Malina is the sun and her brother Annigan is the moon.

The two had a dispute and Malina fled into the sky. Anningan followed her. Because he is in a constant pursuit of his sister, he does not eat, and he gets thinner and thinner, which explains the waning phase of the moon.

When the moon disappears, the Inuit say that Anningan has gone away to eat.

When he catches up to Malina, it causes an eclipse.



https://www.expedia.ca/travelblog/the-legends-behind-the-sun/

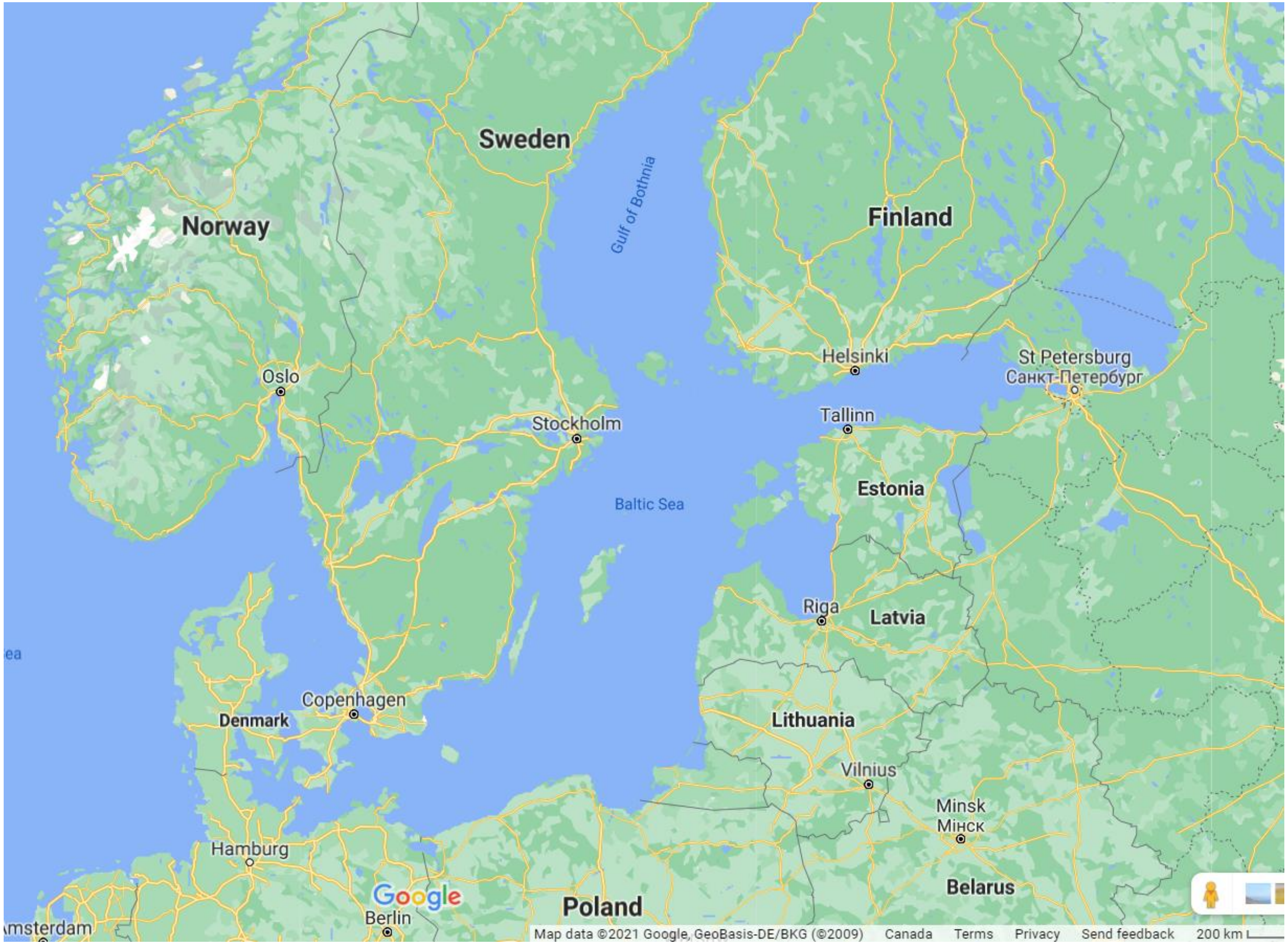
Julie Lawrence and Hillary Blanchard, WISE NL

Riga, Latvia:
56.95° N, 24.11° E

Nain, Labrador:
56.54° N, 61.70° W

Corner Brook, Newfoundland:
48.95° N, 57.95° W

St. John’s, Newfoundland:
47.56° N, 52.72° W



Quiz #1

Which of these locations has the longest summer days?

1. Riga, Latvia, 56.95° N

2. Nain, Labrador, 56.54° N

3. Corner Brook, Newfoundland, 48.95° N

4. St. John’s, Newfoundland, 47.56° N

Quiz #1 Answer

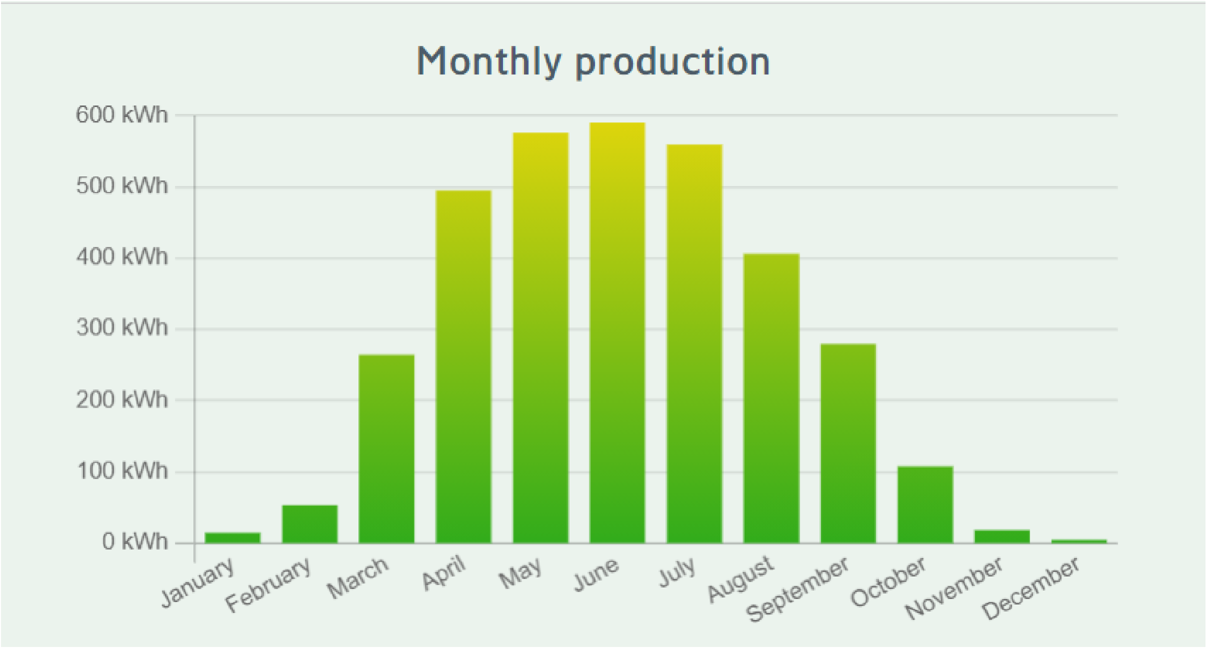
Which of these locations has the longest summer days?

1. Riga, Latvia, 56.95° N

2. Nain, Labrador, 56.54° N

3. Corner Brook, Newfoundland, 48.95° N

4. St. John's, Newfoundland, 47.56° N



Answer: Riga, Latvia (18 hours on June 21)

1000 kW solar power plant in Da

https://transventa-solar.lt/en/project/1000-kw-solar-...

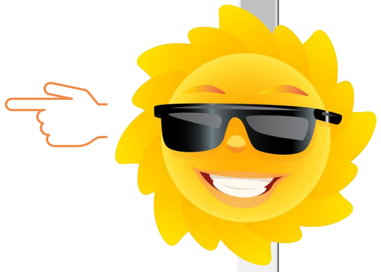
Sign in

About us Our works Contacts

1000 kW solar power plant in Daugpils, Latvia 2018

Produktų kategorijos

- Inverteriai
  - Huawei SUN2000
  - Fronius Symo Inverteriai
  - Sungrow
- Saulės moduliai
  - Seraphim
  - Canadian Solar
- Kabeliai ir jungtys



Solar Power near the Arctic Circle? In Nordic climes, it is becoming the norm!
An apartment complex in Turku, Finland (60.45° N), sports 516 rooftop solar panels.

[Inside Climate News](#) Credit: Turku Student Village Foundation (TYS)

Quiz #2

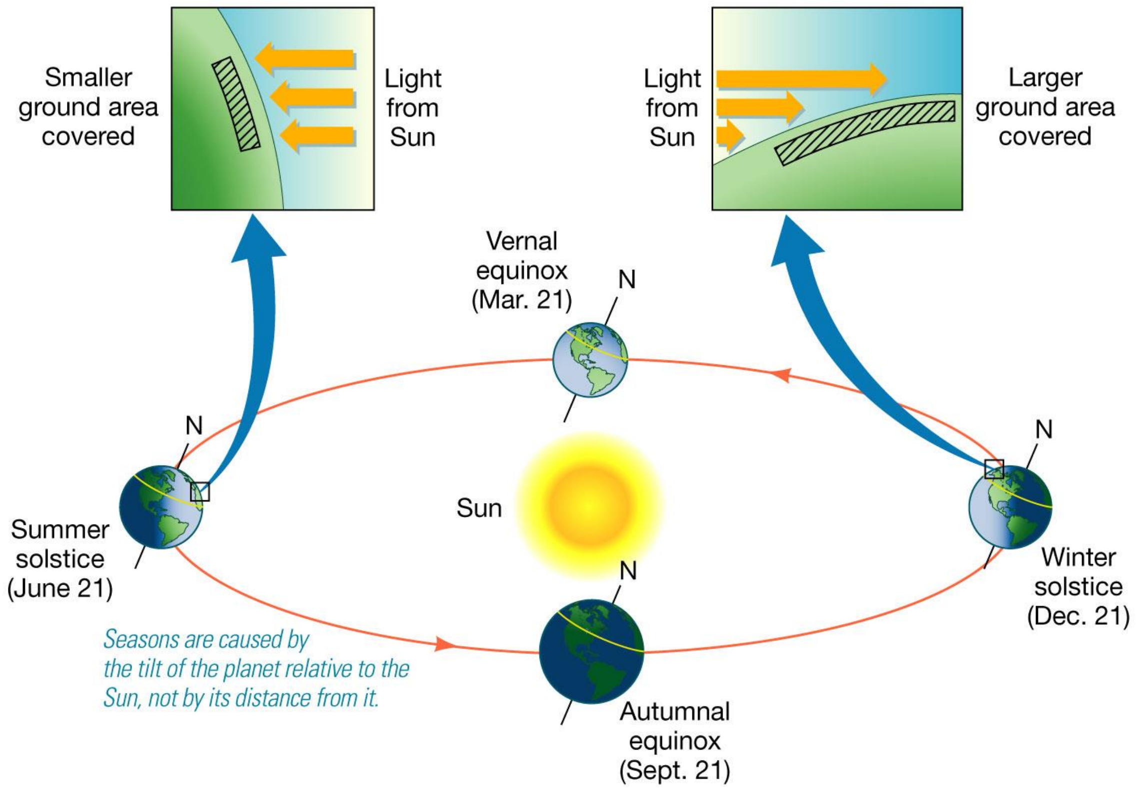
All of these solar panels face the same way. Which way do they face?

1. North
2. South
3. East
4. West
5. Depends on the season

Quiz #2 Answer

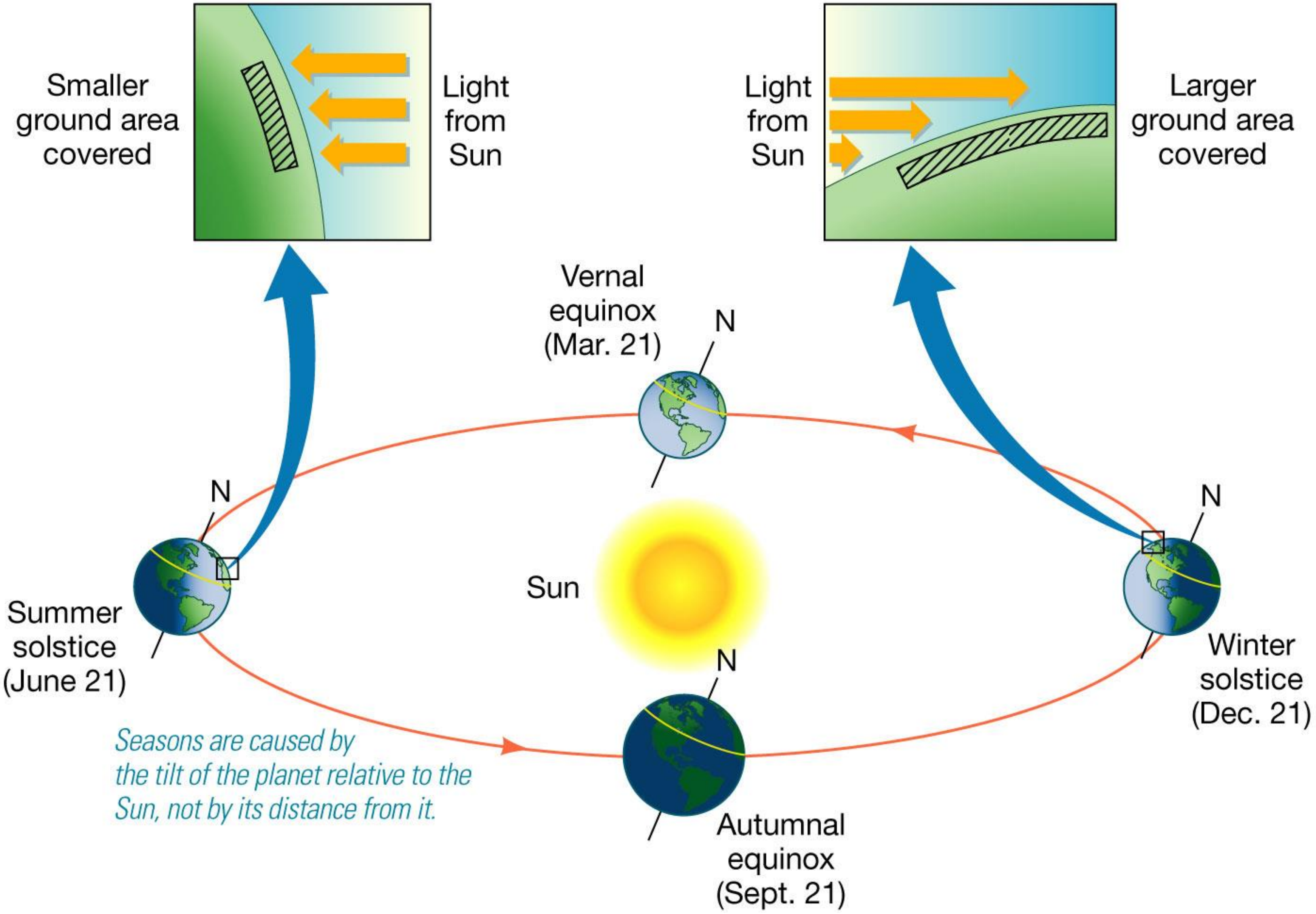
All of these solar panels face the same way. Which way do they face?

1. North
2. South
3. East
4. West
5. Depends on the season



Answer: South

As Earth orbits around the Sun, combination of day length and sunlight angle gives seasons:

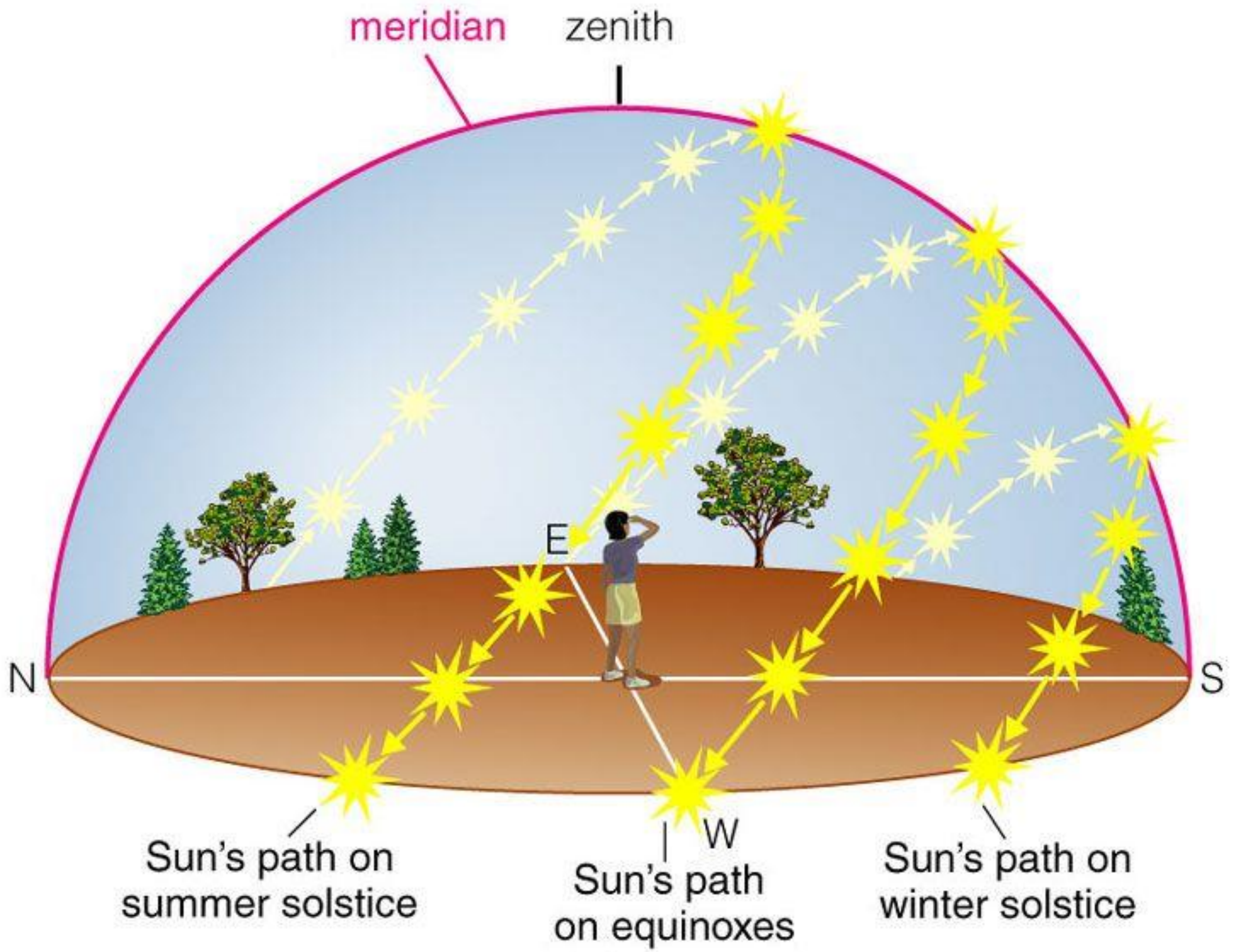


OK, solar panels should be facing South. But at what tilt angle?

The goal is to have your solar panels exactly perpendicular to the incoming rays of the sun, as that is when they produce the most electricity.

The sun moves throughout the day, generally East to West, and gets higher around noon.

Its position and angle also changes with the seasons.



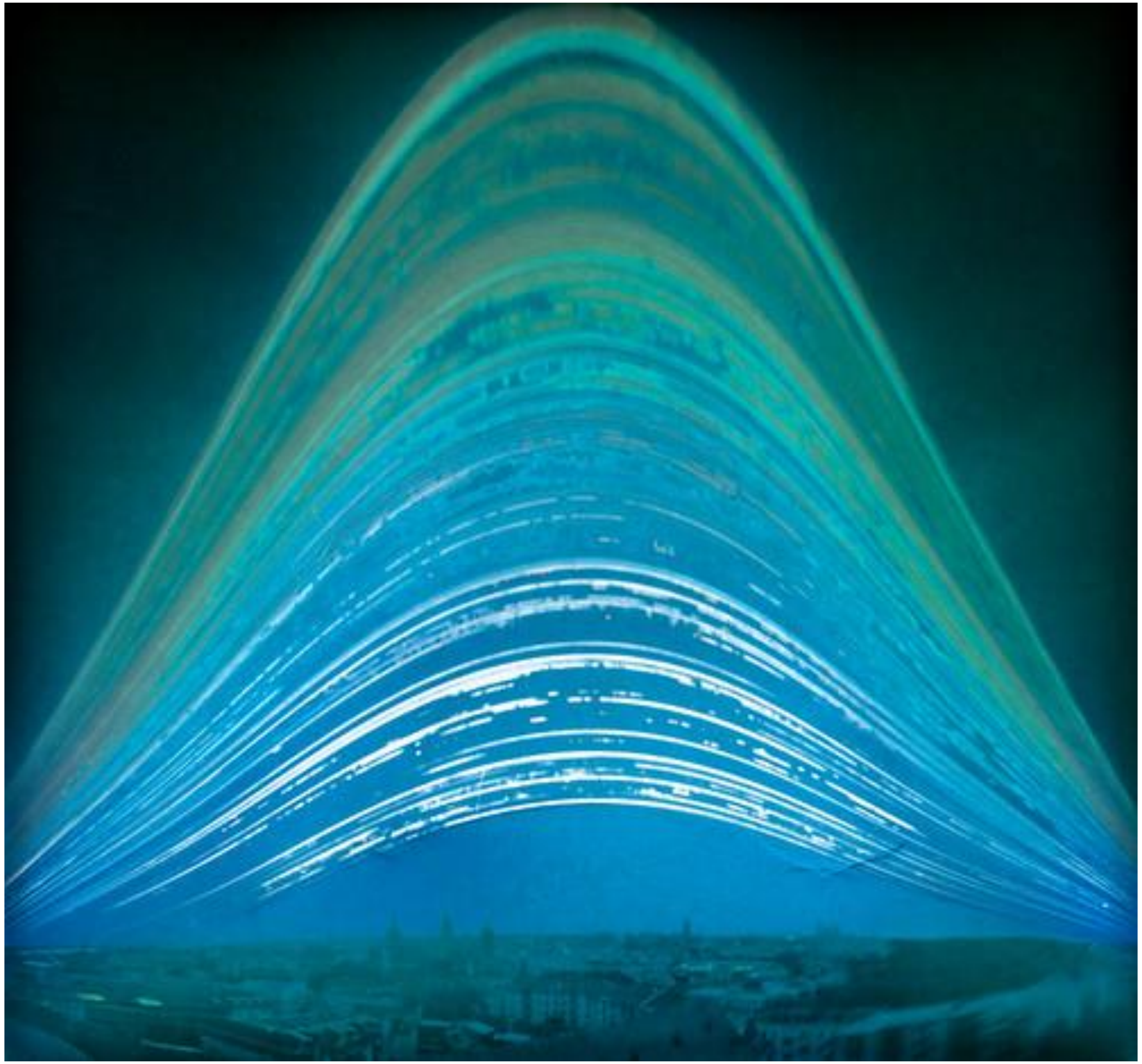
The goal is to have your solar panels ~~exactly~~ perpendicular to the incoming rays of the sun.

Generally, the sun is at a higher position during summers and a lower position during winters.

However, there is an average position between the two, which is optimal for the photovoltaic panels.

This corresponds to **the latitude of the place** where you are housing the panels. Tilting it at that average angle would produce the highest output.

The solar panel tilt also depends on when you want the panels to produce the most energy.



Willi Winzig, Mainz, Germany




The total energy radiated by the Sun is about 4×10^{26} W.

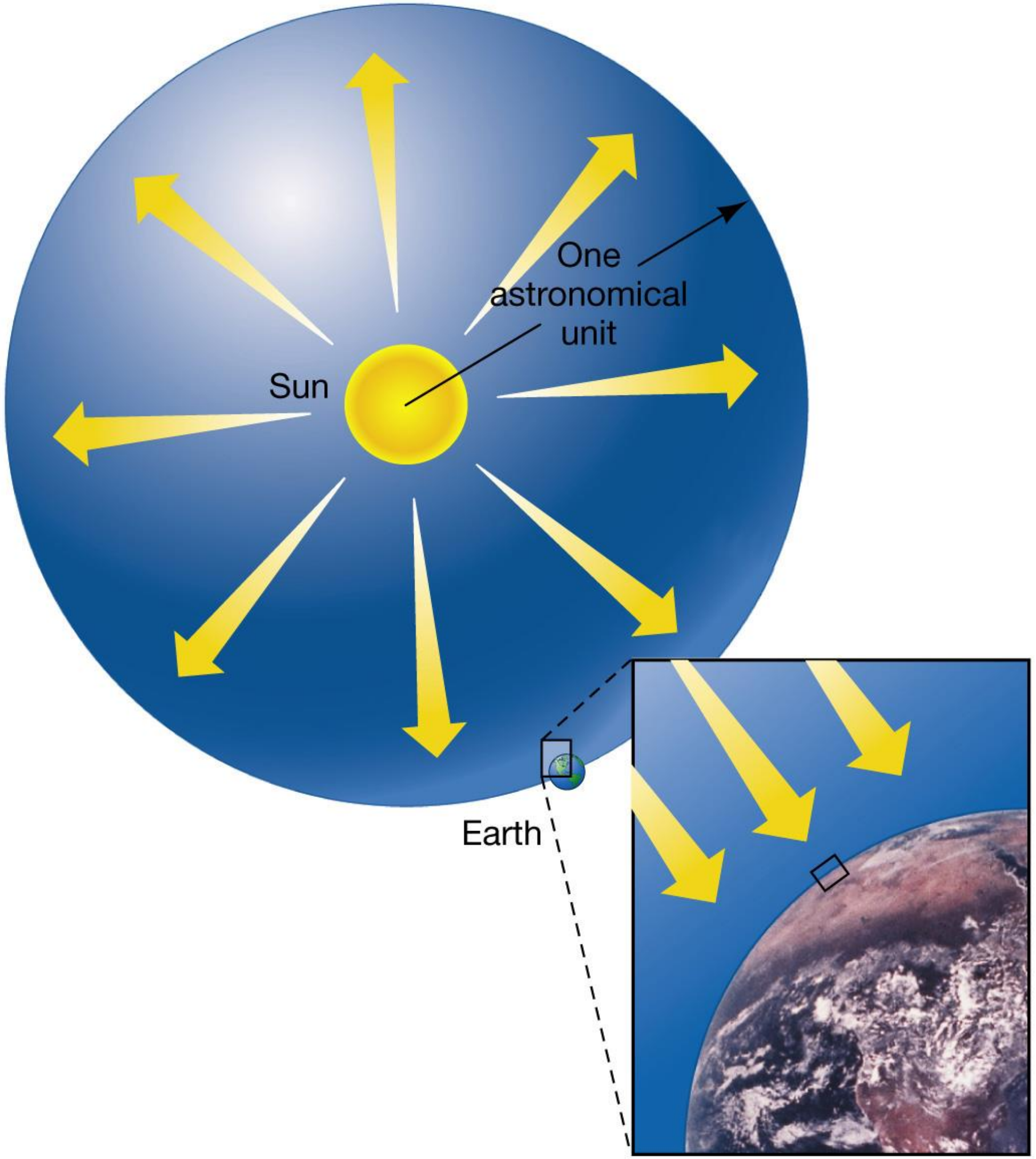
This is the equivalent of 10 billion 1-megaton nuclear bombs per second.

Six seconds worth of solar energy output, suitably focused, would evaporate all of Earth's oceans.

Three minutes would melt our planet's crust.

The amount of Sun's energy reaching the top of Earth's atmosphere 150 million kilometers away is 1400 W/m^2.

Most solar panels used today have efficiencies between 15% and 20%.



Quiz #3

The total energy radiated by the Sun is about 4×10^{26} W.
Our largest power plants produce around 5×10^{9} W.
How many of these power plants would you need to reproduce Sun's power?

1. 8×10^{16}
2. 4×10^{17}
3. 9×10^{16}
4. 2×10^{36}

Quiz #3 Answer

The total energy radiated by the Sun is about 4×10^{26} W.
Our largest power plants produce around 5×10^{9} W.
How many of these power plants would you need to reproduce Sun's power?

1. 8×10^{16}
2. 4×10^{17}
3. 9×10^{16}
4. 2×10^{36}

Answer: Sun is equivalent to 8×10^{16} of these power plants.
(4×10^{26} W / 5×10^{9} W = 8×10^{16})

So far, solar power is underutilized in Newfoundland and Labrador.

However, solar power is gaining popularity, especially since the launch of a new federal program that offers grants for energy-saving home upgrades which includes solar panels.

[Canada Greener Homes Grant (nrcan.gc.ca)]

Quiz #4

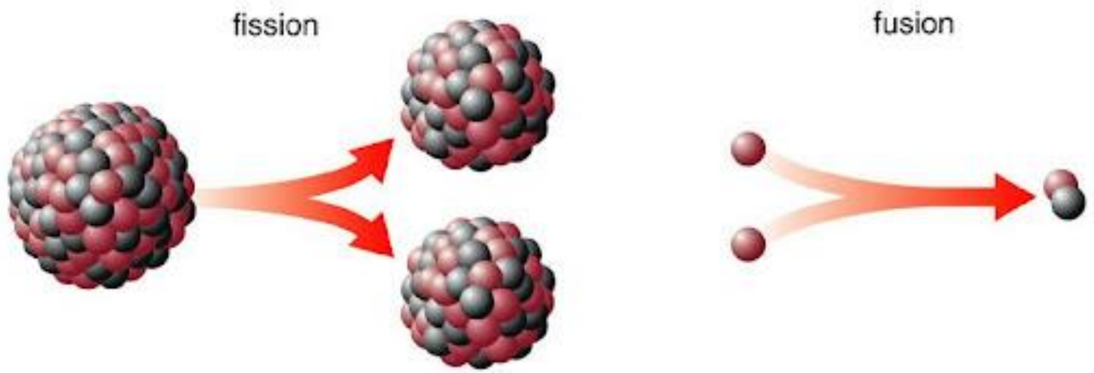
What powers the Sun?

1. Nuclear fusion
2. Nuclear fission
3. Molten lava
4. Hot gas

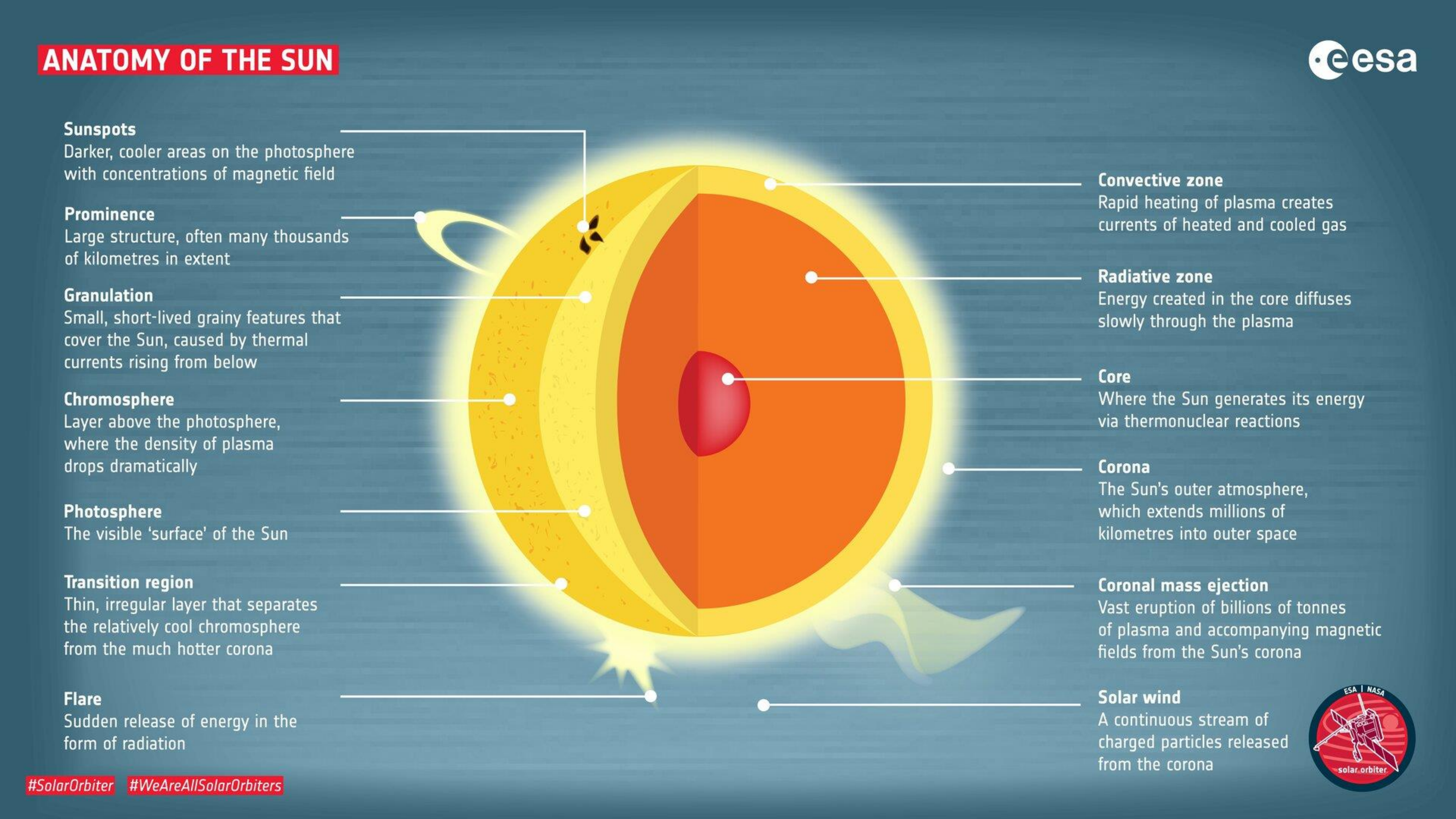
Quiz #4 Answer

What powers the Sun?

1. Nuclear fusion
2. Nuclear fission
3. Molten lava
4. Hot gas



Answer: Nuclear fusion


ANATOMY OF THE SUN
esa
Sunspots
Darker, cooler areas on the photosphere with concentrations of magnetic field
Prominence
Large structure, often many thousands of kilometres in extent
Granulation
Small, short-lived grainy features that cover the Sun, caused by thermal currents rising from below
Chromosphere
Layer above the photosphere, where the density of plasma drops dramatically
Photosphere
The visible 'surface' of the Sun
Transition region
Thin, irregular layer that separates the relatively cool chromosphere from the much hotter corona
Flare
Sudden release of energy in the form of radiation
Convective zone
Rapid heating of plasma creates currents of heated and cooled gas
Radiative zone
Energy created in the core diffuses slowly through the plasma
Core
Where the Sun generates its energy via thermonuclear reactions
Corona
The Sun's outer atmosphere, which extends millions of kilometres into outer space
Coronal mass ejection
Vast eruption of billions of tonnes of plasma and accompanying magnetic fields from the Sun's corona
Solar wind
A continuous stream of charged particles released from the corona
#SolarOrbiter
#WeAreAllSolarOrbiters
ESA | NASA
solar orbiter

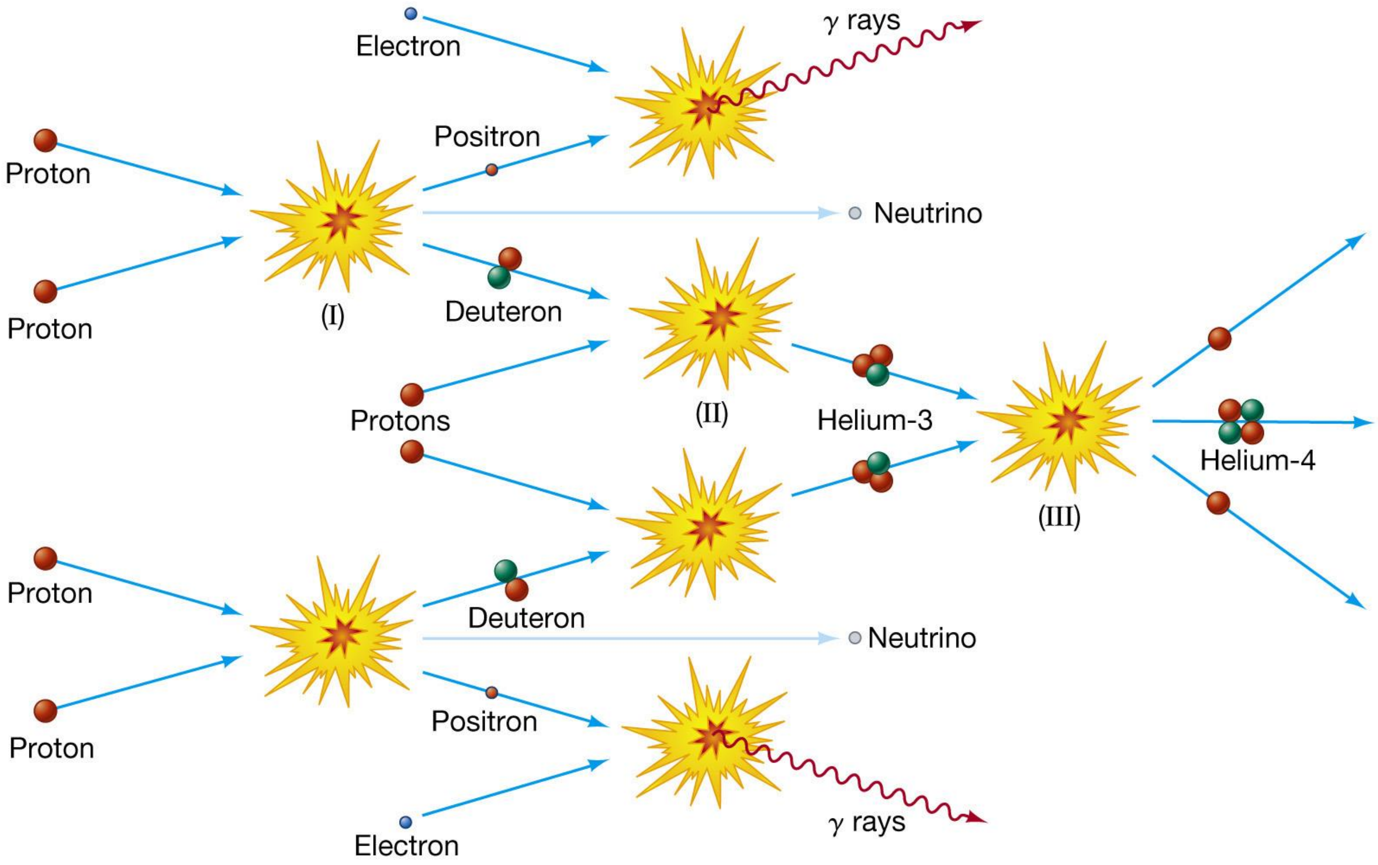
Nuclear fusion is a mechanism of energy generation in which light nuclei are combined, or fused, into heavier ones, releasing energy in the process.

Sun is powered by the chain of fusion reactions, leading from hydrogen to helium.

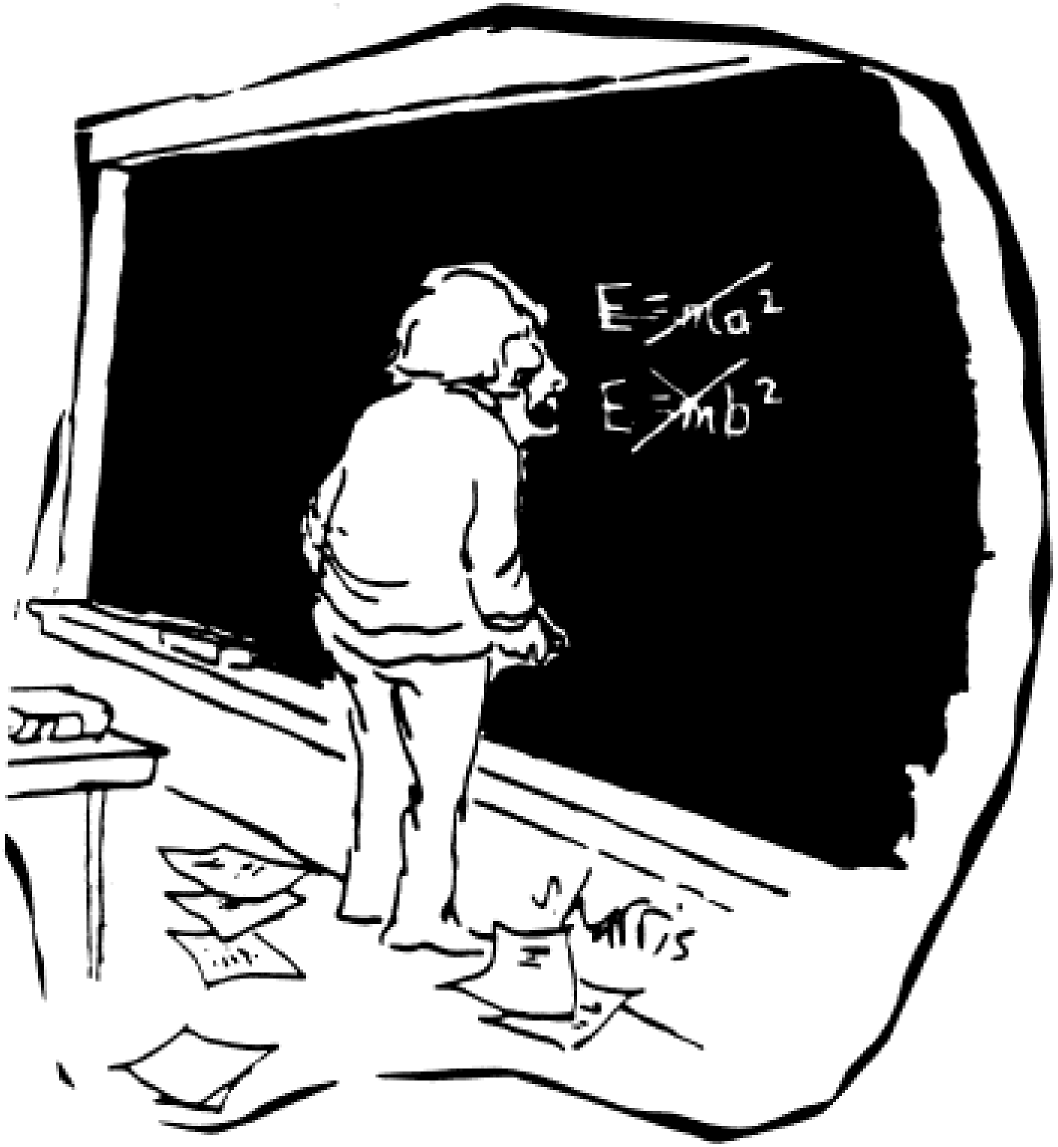
The helium stays in the core;

Gamma rays, which gradually lose their energy as they travel out from the core, are emerging as visible light;

The neutrinos escape almost without interacting.



$$4\,(^{1}\mathrm{H}) \rightarrow {}^{4}\mathrm{He} + \text{energy} + 2 \text{ neutrinos}$$



$$4\,(^1\mathrm{H}) \rightarrow {}^4\mathrm{He} + \text{energy} + 2\text{ neutrinos}$$

Mass of four protons: 6.6943×10^{-27} kg

Mass of helium nucleus: 6.6466×10^{-27} kg

Mass transformed to energy: 0.0477×10^{-27} kg (about 0.71%)

$E = mc^2$

$c = 3 \times 10^8$ m/s

Energy equivalent of that mass: 4.28×10^{-12} J

Energy produced by fusion of one kilogram of hydrogen into helium: 6.40×10^{14} J

Quiz #5

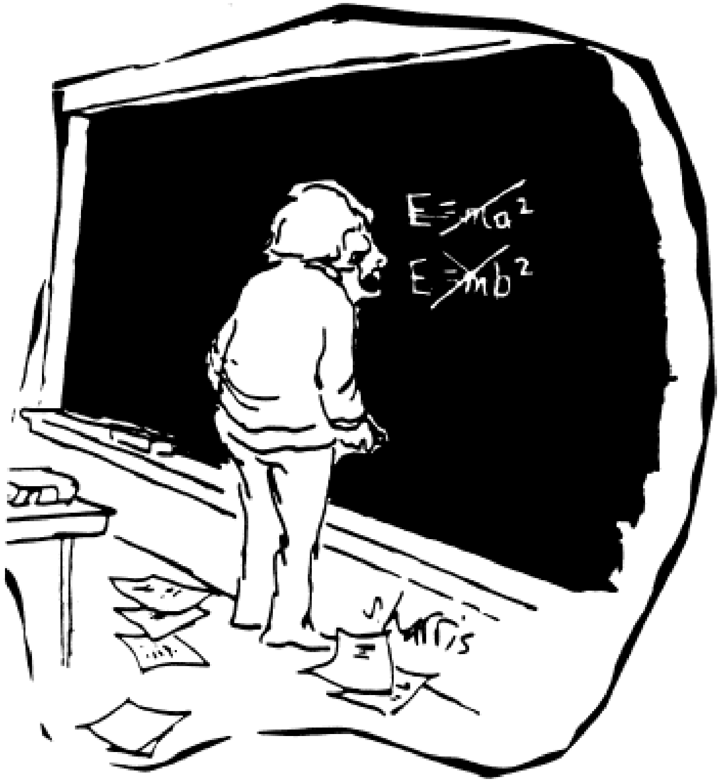
What is the equation describing Sun’s energy generation?

1. $E = ma^2$
2. $E = mb^2$
3. $E = mc^2$
4. $E = md^2$

Quiz #5 Answer

What is the equation describing Sun’s energy generation?

1. $E = ma^2$
2. $E = mb^2$
3. $E = mc^2$
4. $E = md^2$



Answer: $E = mc^2$

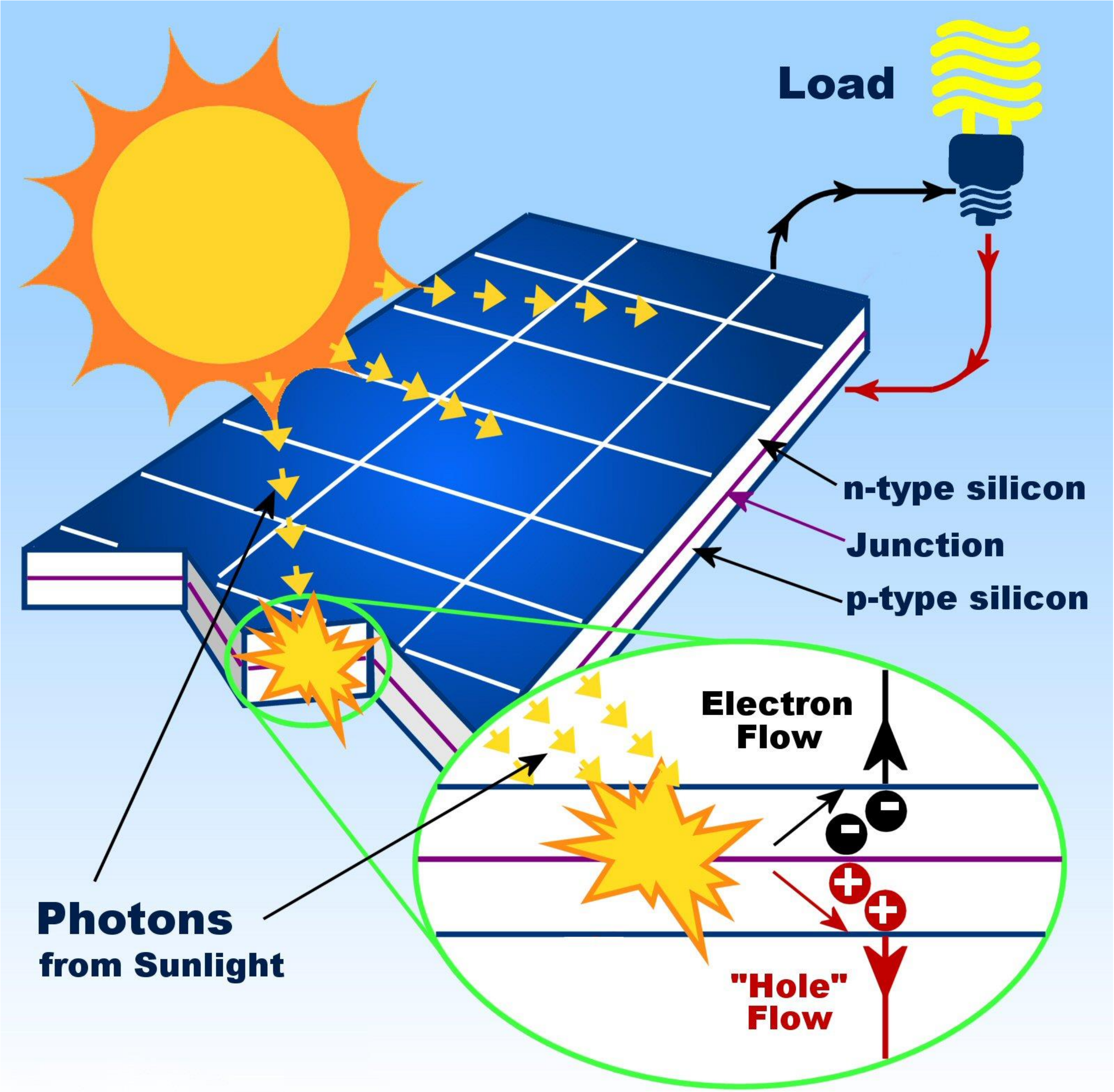
Recall: The amount of Sun's energy reaching the top of Earth’s atmosphere is 1400 W/m^2.

Most solar panels used today have efficiencies between 15% and 20%.

But how do solar panels work?

Solar panels work by allowing photons to knock electrons free from atoms, generating a flow of electricity. The panels are made of many smaller units called photovoltaic cells, which convert photon energy into electricity.

Each photovoltaic cell is a sandwich made up of two slices of semi-conducting material, usually silicon.



[Solar Overview – Ruaha Energy]

Example: Solar Power Assembly for a cabin - several solar panels, controller, batteries and the pure sin inverter.

In September 2021, we had a workshop for Grade 11-12 students so they could learn how to assemble a real-live solar power array to support AC electrical equipment.

More will be offered in 2022; see Grenfell Observatory website for updates.

GRENFELL CAMPUS | MEMORIAL UNIVERSITY

As quoted by the Cabin Depot Ltd., info@thecabindepot.com:

	270 Watt Poly GMA Solar Panel × 2	$539.98
	Rolls S6 L16-HC 6v 445Ah Flooded Deep Cycle Battery × 2	$999.98
	SRNE (ML4860) 60 Amp MPPT Charge Controller × 1	$389.99
	Progressive Dynamics 45 Amp 12V Converter/Charger × 1	$279.99
	Samlex PST-3000-12 Pure Sine 3000w inverter (Hardwire capable) × 1	$1,349.00
	Progressive Dynamics 50 Amp 120/240v Automatic Transfer Switch × 1	$219.00
	TCD #10 wire - 20' Pv to controller (pair) × 1	$42.99
	TCD #4 - 5' controller to Battery (pair) × 1	$45.99
	5' 2/0 inverter cables × 1	$83.99
	TCD - 200 Amp Fuse Assembly × 1	$28.99

Subtotal	$3,979.90
Shipping	$242.56
Taxes	$633.37
Total	$4,855.83

Quiz #6

Which skills do you develop by training in physics?

1. Complex problem solving
2. Critical thinking
3. Creativity
4. Coordinating with others
5. Judgement and decision making

Quiz #6 Answer

Which skills do you develop by training in physics?

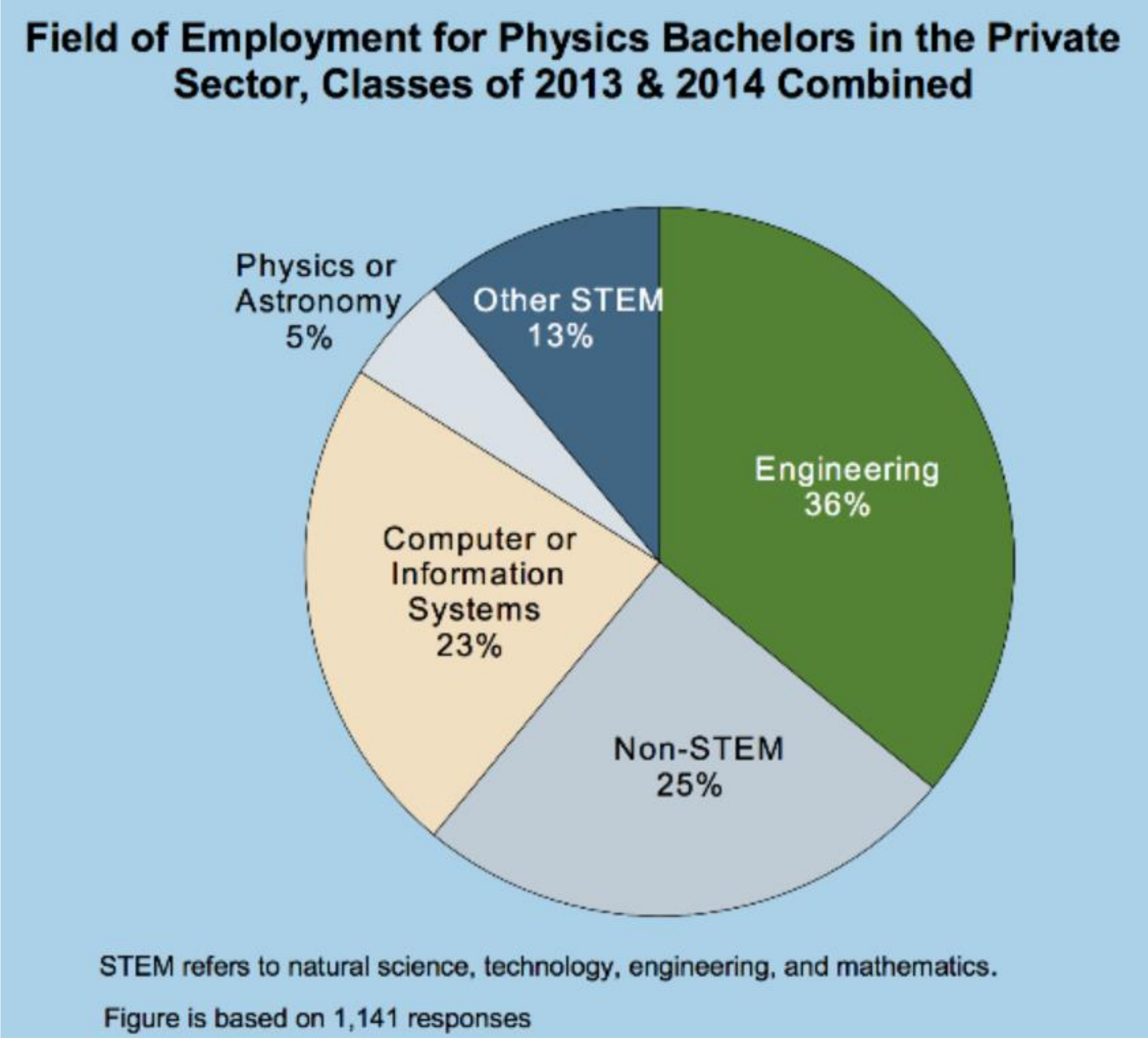
1. Complex problem solving
2. Critical thinking
3. Creativity
4. Coordinating with others
5. Judgement and decision making

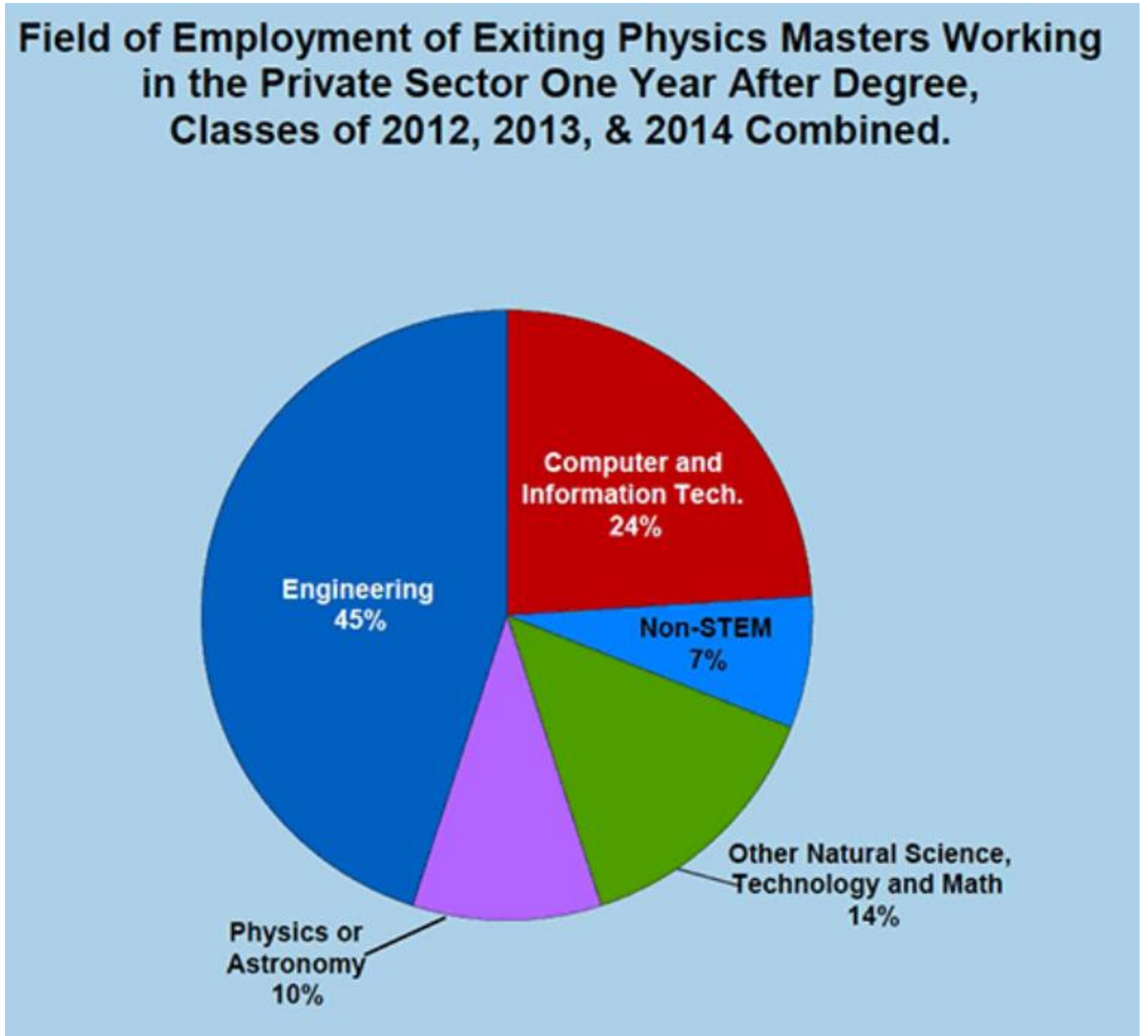
Answer: ALL OF ABOVE

	in 2020	in 2015
1.	Complex Problem Solving	Complex Problem Solving
2.	Critical Thinking	Coordinating with Others
3.	Creativity	People Management
4.	People Management	Critical Thinking
5.	Coordinating with Others	Negotiation
6.	Emotional Intelligence	Quality Control
7.	Judgment and Decision Making	Service Orientation
8.	Service Orientation	Judgment and Decision Making
9.	Negotiation	Active Listening
10.	Cognitive Flexibility	Creativity

[Source: Future of Jobs Report, World Economic Forum]

Want to help to development new, clean and renewable energy sources? Consider a degree in physics!





https://www.aps.org/careers/statistics/index.cfm

Example of potential new clean energy source: nuclear fusion on Earth!

ITER ("The Way" in Latin) is one of the most ambitious energy projects in the world today.
It is an international nuclear fusion research and engineering megaproject aimed at replicating the fusion processes of the Sun to create energy on earth.

Completion: 2026

Location: France

Participants: 35 countries

PHOTOS → LIFE AT ITER

A NEW GENERATION OF MONACO-ITER FELLOWS

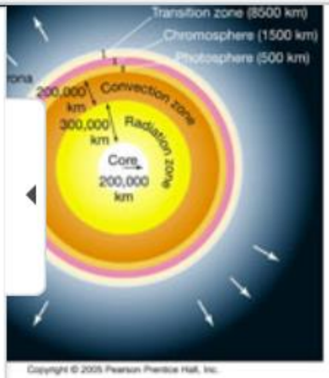
ITER's latest group of Monaco Fellows—Valentina Nikolaeva, Lei Chen, Damien Colette, Anna Medvedeva, and William Gracias (left to right)—have started two-year postdoctoral fellowships in science or engineering under the Monaco-ITER Partnership Arrangement.

https://www.iter.org/album/Media/3 - Life at ITER

Fully Online	**PHYS 2150** **The Foundation of Astronomy**	course emphasizes the scientific method, basic physics, night sky and objects in our solar system. Topics include space science, telescopes, spectroscopy, atomic structure, the formation and evolution of planetary systems, and the detection and properties of exoplanets.	PR: no pre-requisites.	Fall
Fully Online	**PHYS 2151** **Stellar Astronomy and Astrophysics**	Stellar Astronomy and Astrophysics is atomic structure and spectra. The sun: radiation, energetics, magnetic field. Stars: distance, velocity, size, atmospheres, interiors. Variable stars, multiple stars, clusters and stellar associations. Stellar evolution, interstellar matter, structure of the Milky Way Galaxy. Exterior galaxies, quasi-stellar objects, pulsars. Cosmology.	PR: 6 credit hours in Mathematics at the first year level	
Online 2022	**PHYS 2400** **Subatomic Physics**	Subatomic Physics is an introduction to nuclear and particle physics. Topics include nuclear properties and models; radioactive dating; fission; nuclear reactors; accelerators; the detection, classification, and properties of subatomic particles. Applications in areas such as ecology, dosimetry, medical physics and nuclear astrophysics are discussed.	PR: Level III Advanced Mathematics or Mathematics 1090 or 109B. It is recommended that students have completed at least one of Level II and Level III high school physics courses	

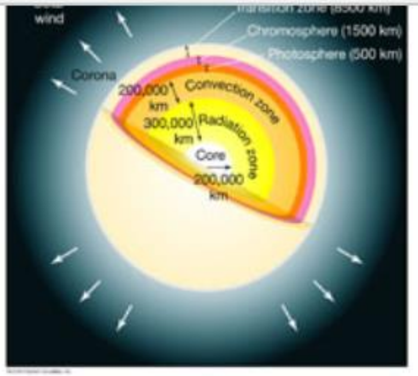
Topic 1: Physical Proper

https://online.mun.ca/d2l/le/content/284838/viewContent/2652550/View

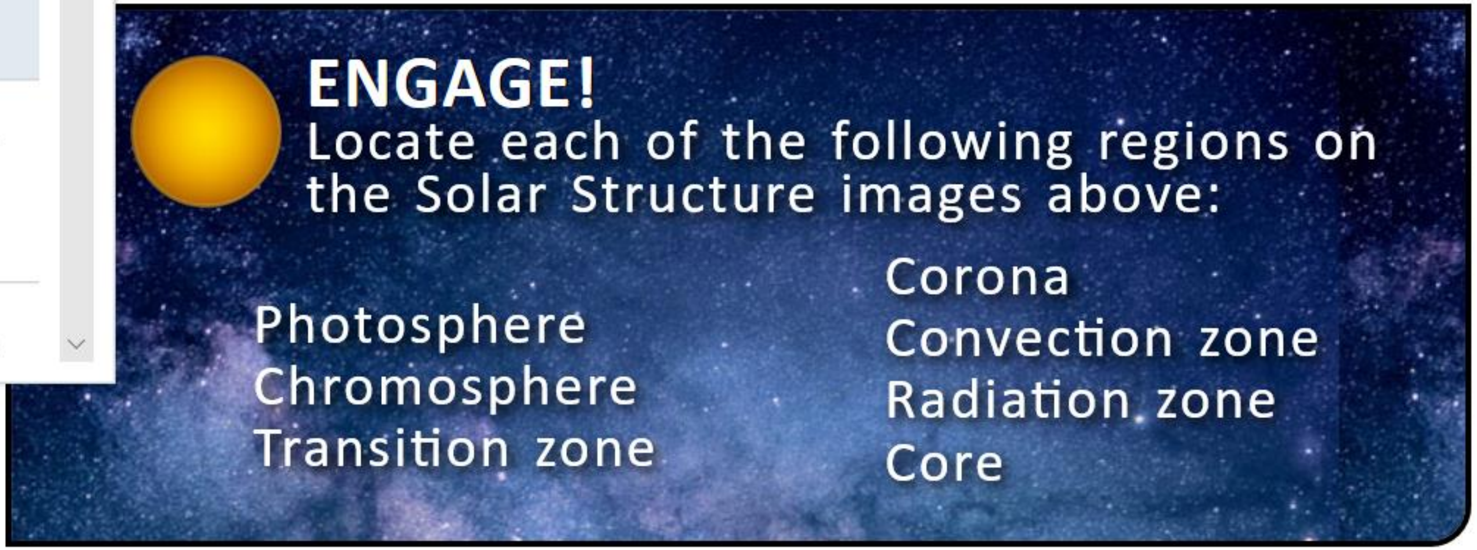


ior structure of the Sun.

Solar structure above photosphere.



Solar Structure.

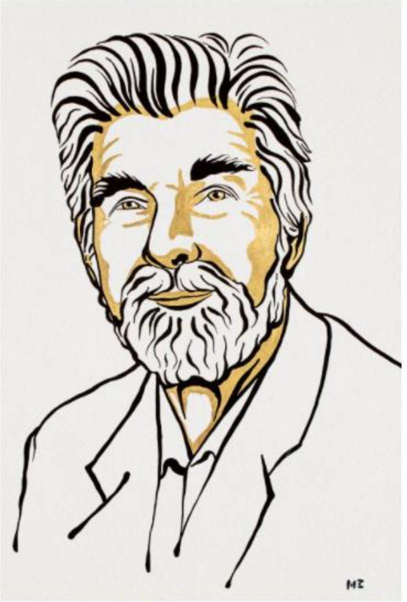


The Nobel Prize in Physics 2021

Ill. Niklas Elmehed © Nobel Prize Outreach

Syukuro Manabe

Prize share: 1/4



Ill. Niklas Elmehed © Nobel Prize Outreach

Klaus Hasselmann

Prize share: 1/4

Ill. Niklas Elmehed © Nobel Prize Outreach

Giorgio Parisi

Prize share: 1/2

The Nobel Prize in Physics 2021 was awarded "for groundbreaking contributions to our understanding of complex systems" with one half jointly to Syukuro Manabe and Klaus Hasselmann "for the physical modelling of Earth's climate, quantifying variability and reliably predicting global warming" and the other half to Giorgio Parisi "for the discovery of the interplay of disorder and fluctuations in physical systems from atomic to planetary scales."

THANK YOU!

Svetlana Barkanova, Professor, Physics, School of Science and the Environment, MUNL

Feel free to contact me at sbarkanova@grenfell.mun.ca.