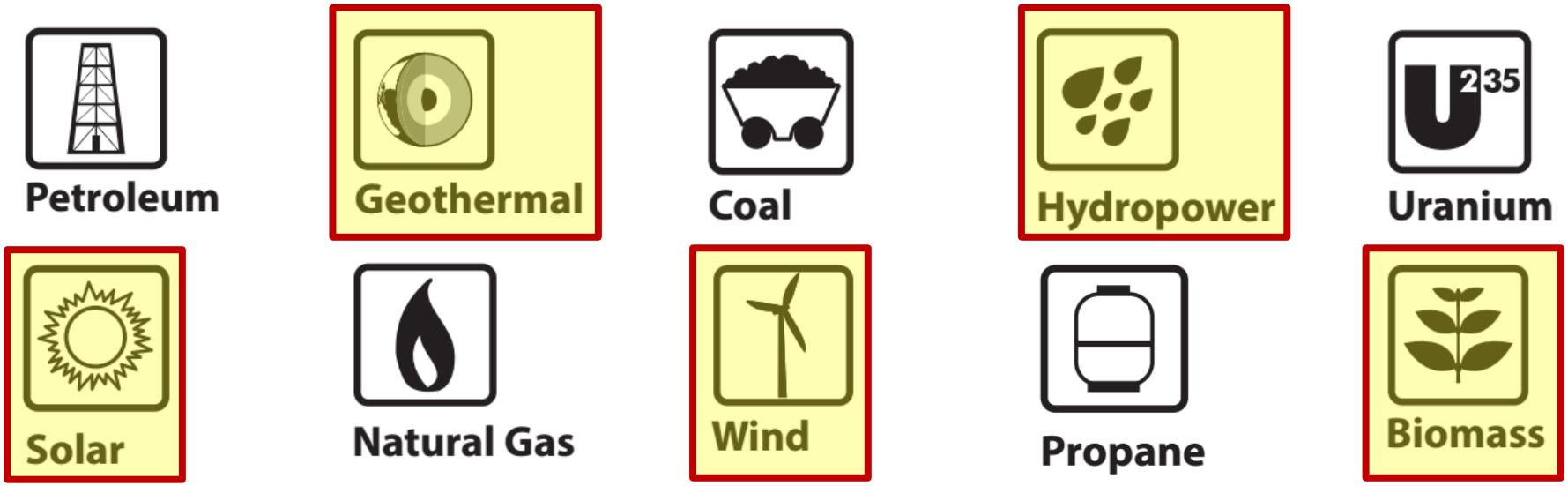
The Renewables

IB PHYSICS | ENERGY PRODUCTION

Renewable vs. Non Renewable

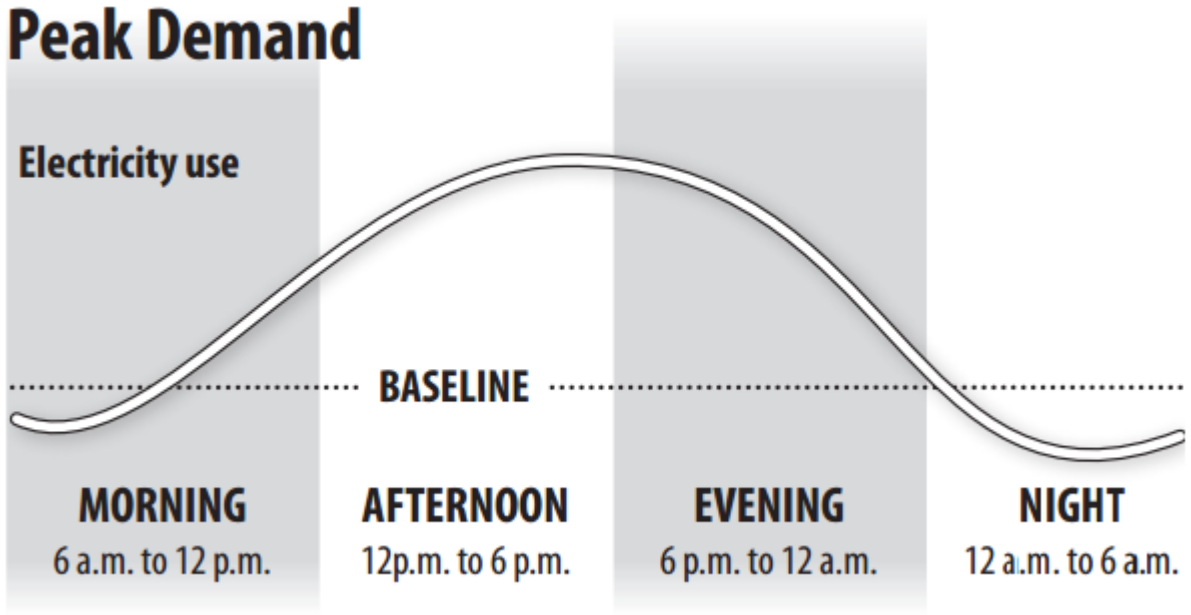
Highlight the primary energy sources that are considered renewable



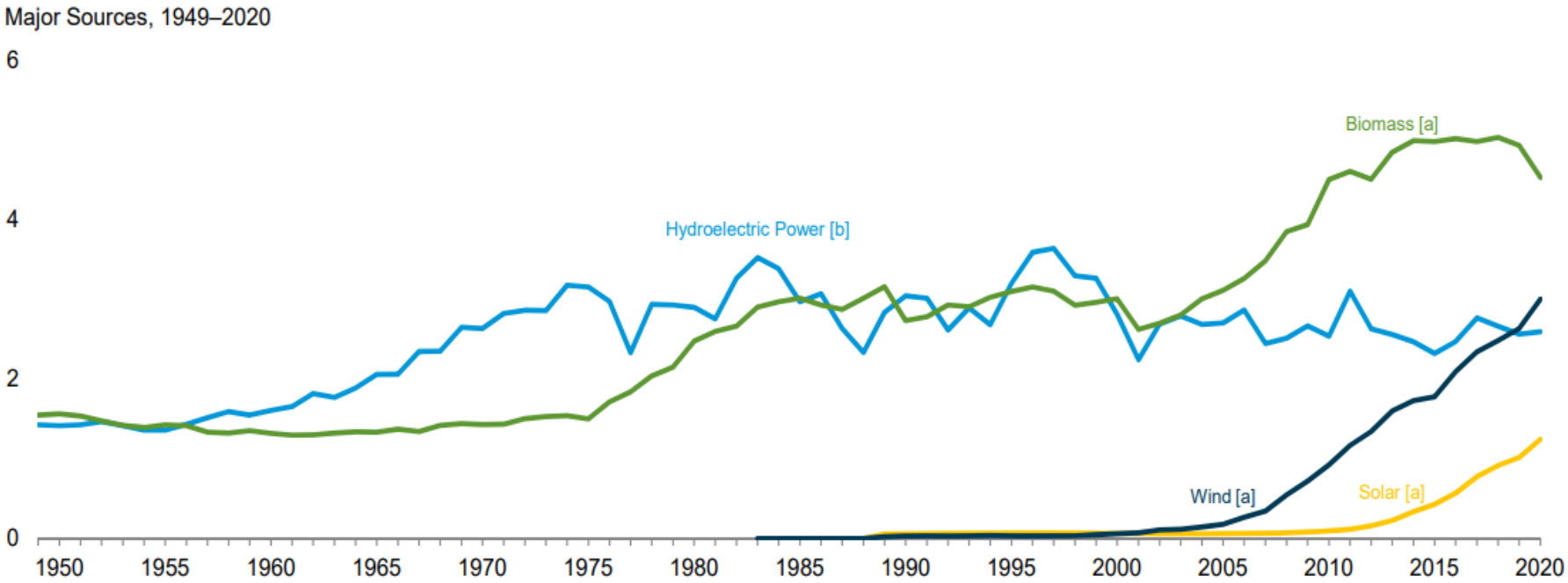
*Note: this doesn't mean that it cannot **ever** be replaced, just that it won't happen in any sort of useful time frame…

Energy Load Requirements

Energy needs to be available when electricity is most needed but should also be available other times as well.

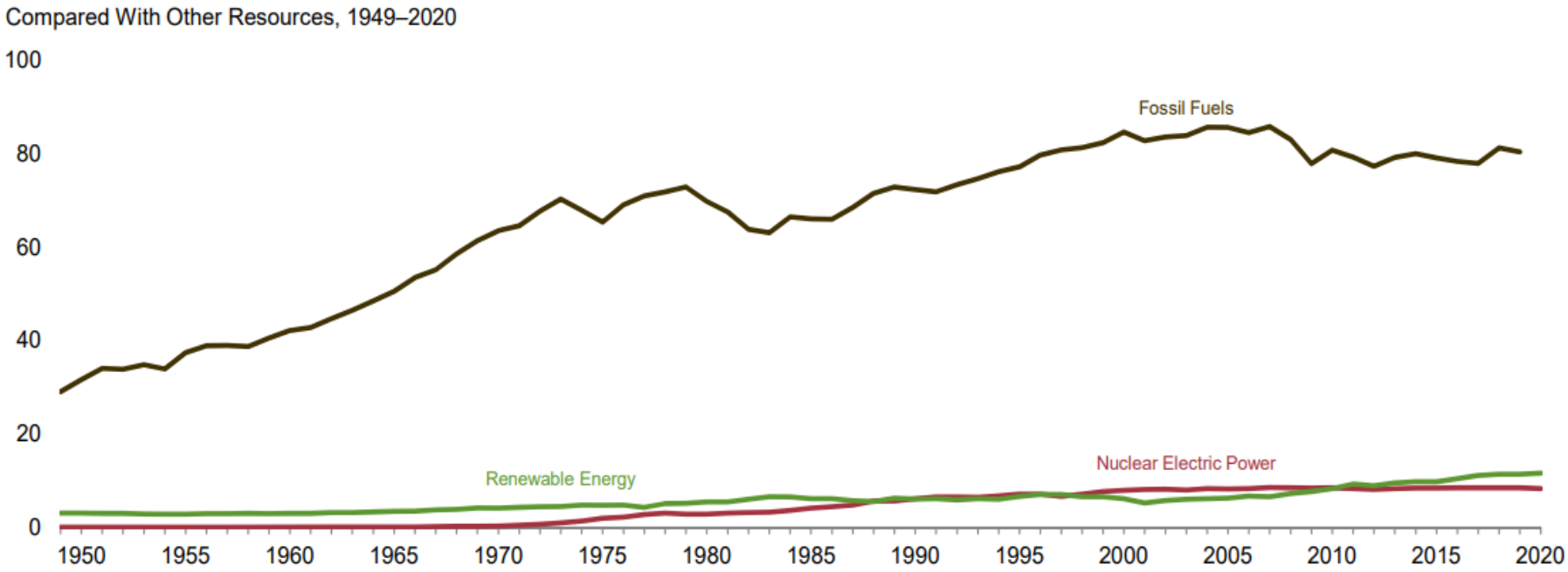


Renewable Energy in the US



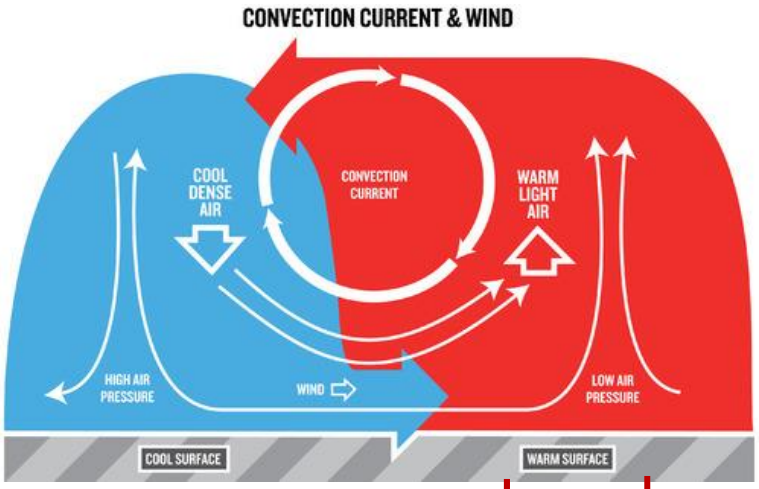
https://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf

Renewable Energy in the US

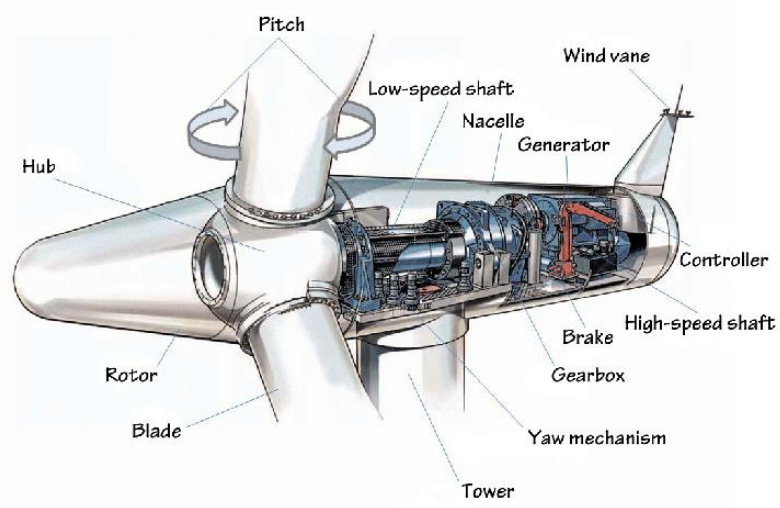


https://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf

Wind Power

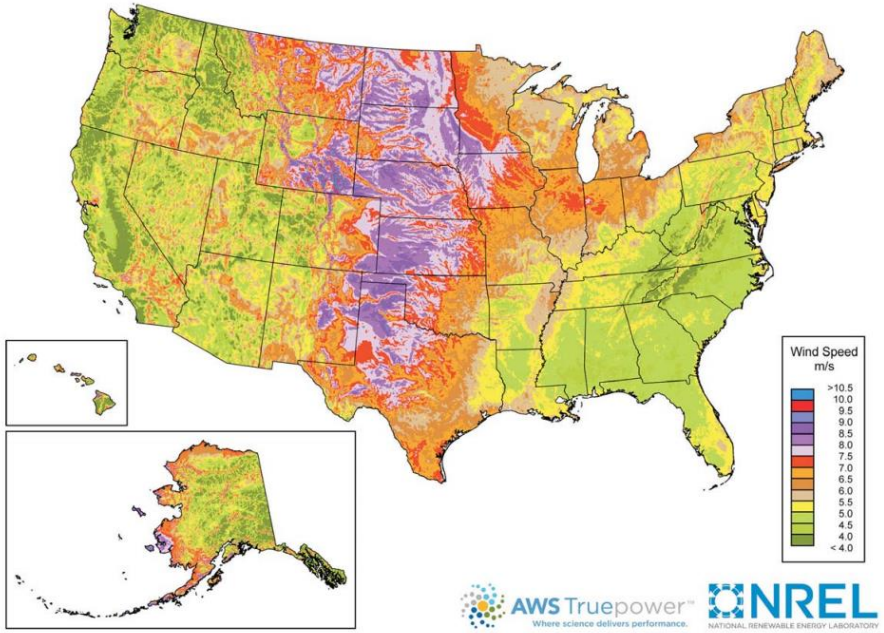


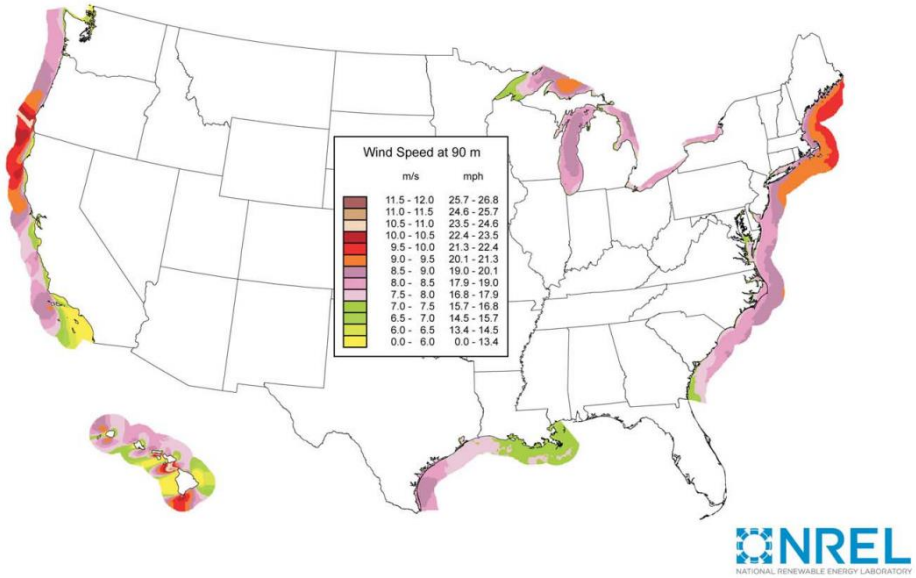
Land



Solar Energy → **KE of Wind** → **KE of Turbine** → **Electricity**

Wind Speeds


Wind Speed
m/s
>10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
< 4.0
AWS Truepower
Where science delivers performance.
NREL
NATIONAL RENEWABLE ENERGY LABORATORY


Wind Speed at 90 m
m/s
mph
11.5 - 12.0
11.0 - 11.5
10.5 - 11.0
10.0 - 10.5
9.5 - 10.0
9.0 - 9.5
8.5 - 9.0
8.0 - 8.5
7.5 - 8.0
7.0 - 7.5
6.5 - 7.0
6.0 - 6.5
0.0 - 6.0
25.7 - 26.8
24.6 - 25.7
23.5 - 24.6
22.4 - 23.5
21.3 - 22.4
20.1 - 21.3
19.0 - 20.1
17.9 - 19.0
16.8 - 17.9
15.7 - 16.8
14.5 - 15.7
13.4 - 14.5
0.0 - 13.4
NREL
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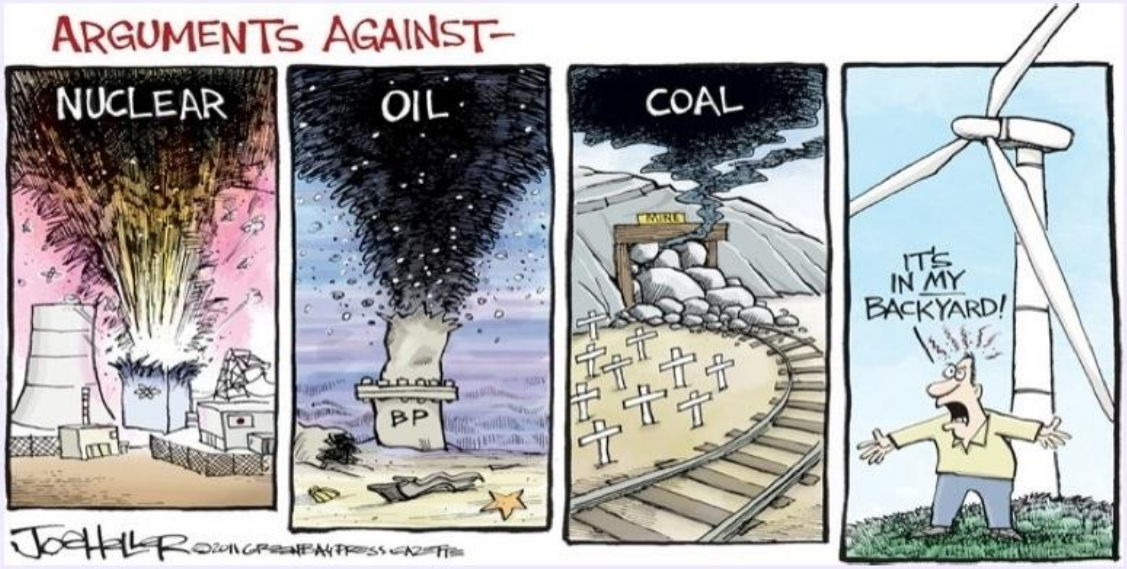
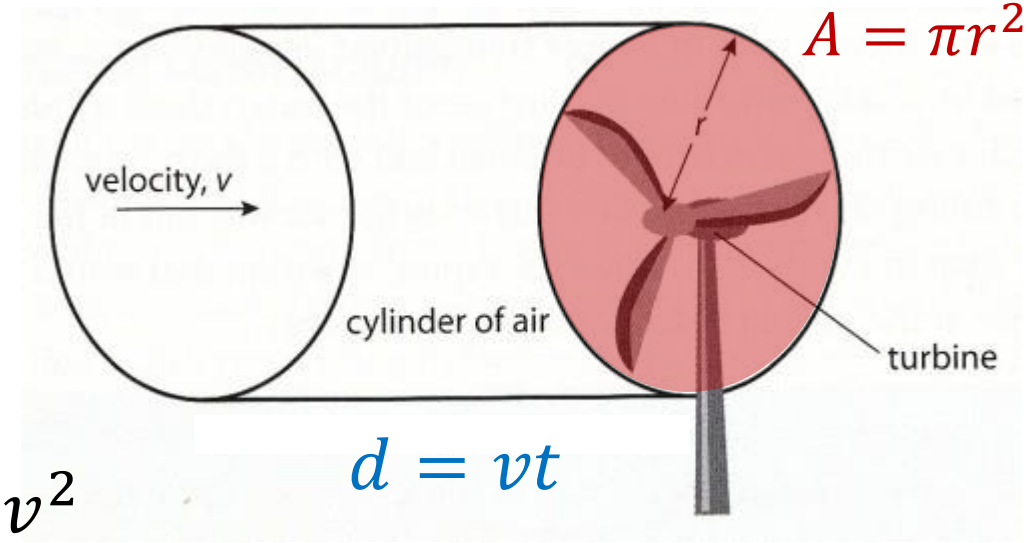
NIMBY


ARGUMENTS AGAINST–
NUCLEAR
OIL
BP
COAL
IT'S IN MY BACKYARD!


WIND POWER
NOT IN MY BACK YARD

Calculating the Wind's Energy

$$E_K = \frac{1}{2}mv^2$$



$A = \pi r^2$

$d = vt$

$$Power = \frac{E_K}{t} = \frac{\frac{1}{2}[Avt\rho]v^2}{t}$$

$\rho \rightarrow$ air density

$$Power = \frac{1}{2}A\rho v^3$$

$$V = A \times vt$$

$$m = (A \times vt) \times \rho$$

IB Physics Data Booklet

$$Power = \frac{1}{2} A \rho v^3$$

Velocity [m s^{-1}]

Area [m^2]

($A = \pi r^2$)

Air Density [kg m^{-3}]

Sub-topic 8.1 – Energy sources	Sub-topic 8.2 – Thermal energy transfer
$\text{Power} = \frac{\text{energy}}{\text{time}}$	$P = e\sigma AT^4$
$\text{Power} = \frac{1}{2} A\rho v^3$	$\lambda_{\max}(\text{metres}) = \frac{2.90 \times 10^{-3}}{T(\text{kelvin})}$
	$I = \frac{\text{power}}{A}$
	$\text{albedo} = \frac{\text{total scattered power}}{\text{total incident power}}$

Conceptual Meaning of Equation

$$Power = \frac{1}{2} A \rho v^3$$

If the wind speed is doubled, then the power is multiplied by a factor of **8** 2^3

If the wind speed is tripled, then the power is multiplied by a factor of **27** 3^3

Try This...

$$Power = \frac{1}{2} A \rho v^3$$

Given a turbine having a blade length of 12 m, and a wind speed of 15 ms^{-1} find the power output if the density of air is ρ= 1.2 kg m^{-3}.

$$P = \frac{1}{2}(\pi \times 12^2)(1.2)(15)^3 = 916{,}000 \text{ W}$$

$$= 0.916 \text{ MW}$$

What is the actual power output if the efficiency is 45%?

$$0.916 \text{ MW} \times 0.45 = 0.412 \text{ MW}$$

Try This...

$$Power = \frac{1}{2} A \rho v^3$$

Air of constant density 1.2 kg m^{-3} is incident at a speed of 9.0 m s^{-1} on the blades of a wind turbine. The turbine blades are each of length 7.5 m. The air passes through the turbine without any change of direction. Immediately after passing through the blades, the speed of the air is 5.0 m s^{-1}. The density of air immediately after passing through the blades is 2.2 kg m^{-3}.

$$P = \frac{1}{2}(\pi \times 7.5^2)(1.2)(9)^3 = 77{,}300 \text{ W}$$

$$P = \frac{1}{2}(\pi \times 7.5^2)(2.2)(5)^3 = 24{,}300 \text{ W}$$

$$53{,}000 \text{ W}$$

Solar Power

Photovoltaic Cells

Solar Energy → **Electricity**

Solar Concentrator

Solar Energy → **Thermal Energy** → **Electricity**

Solar Heating Panel

Solar Energy → **Thermal Energy**

Efficiency of PV Cells

Photovoltaic Cells

10%-20% Efficient

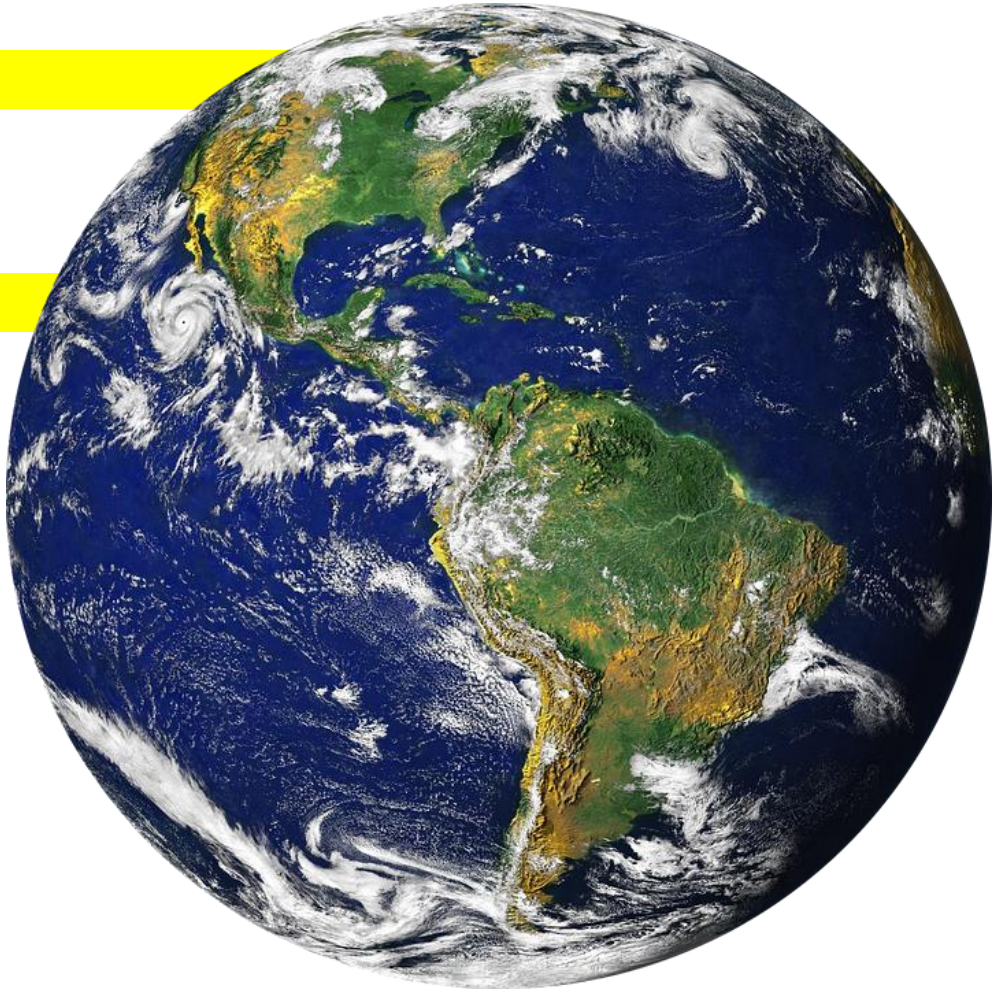
Solar Power

What Would It Take To Power The United States With Solar Energy?

Issues

- Infrastructure to transport electricity
- Storage for non-sun times
- High up front cost

Solar Power Intensity

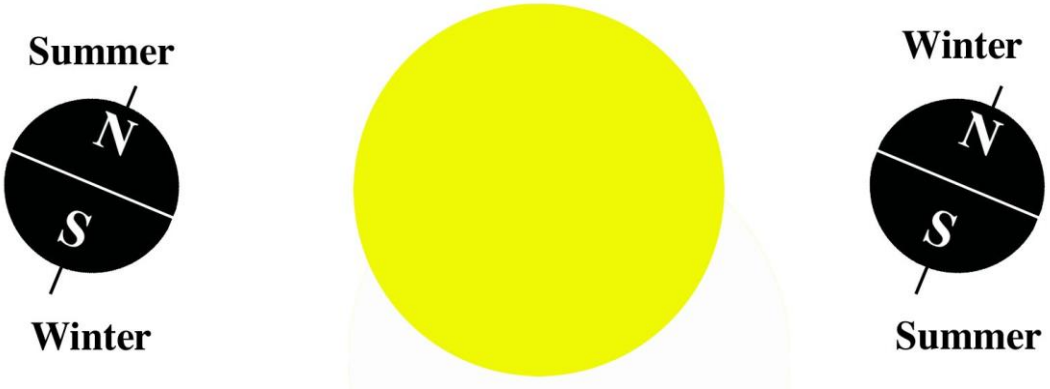


Same Power

Different Area

Solar intensity depends on the latitude

This also affects the seasons



27. The annual variations of solar power incident per unit area at a particular point on the Earth's surface is mainly due to the change in the

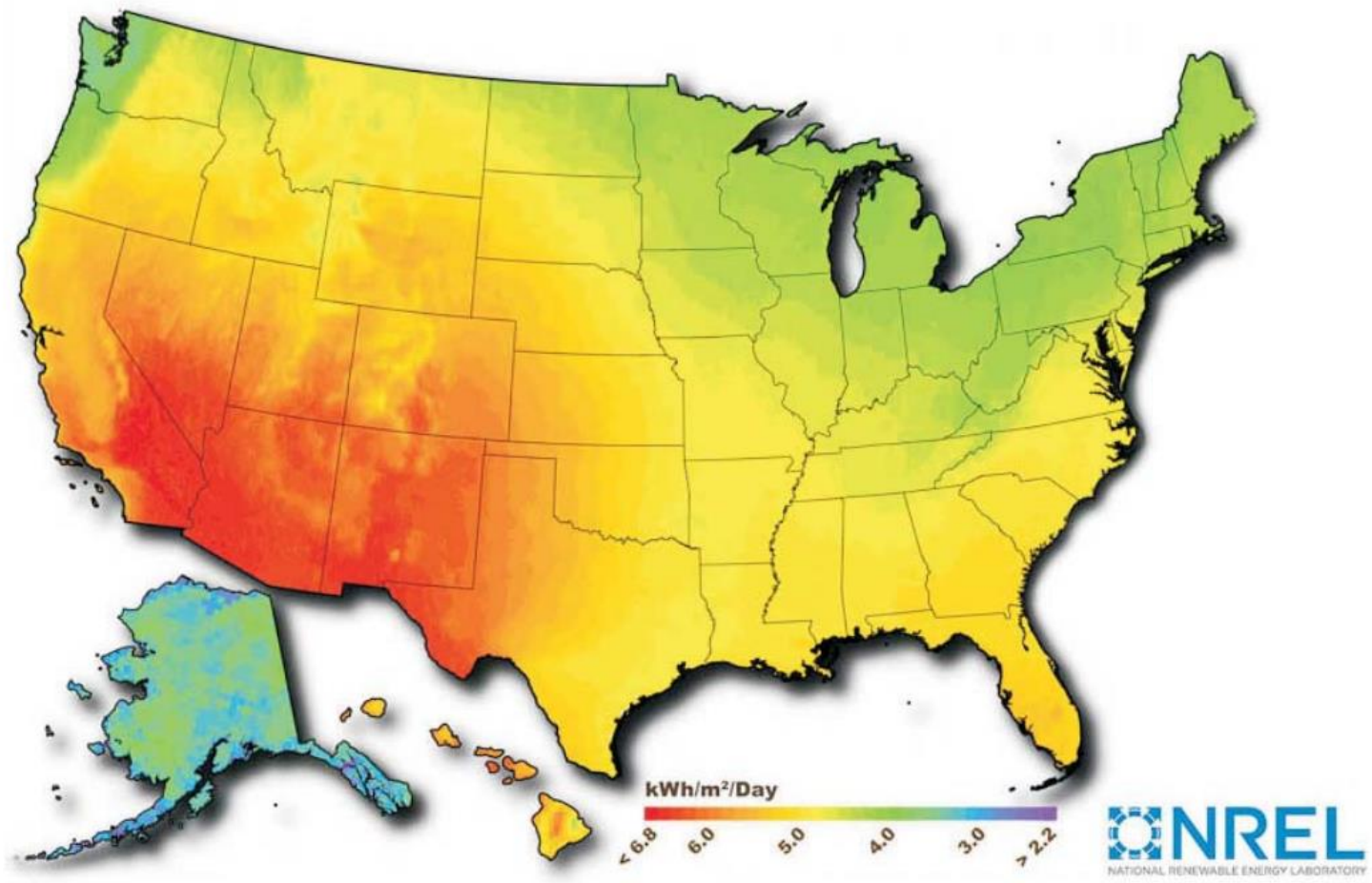
A. distance between the Earth and the Sun.

B. angle at which the solar rays hit the surface of the Earth.

C. average albedo of the Earth.

D. average cloud cover of the Earth.

Solar Map


kWh/m²/Day
< 6.8
6.0
5.0
4.0
3.0
> 2.2
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Calculating Solar Power

A photovoltaic cell has an area of 1.00 cm^2 and an efficiency of 10.5%. If the cell is placed in a position where the sun's intensity is 1250 W m^{-2}, what is the power output of the cell?

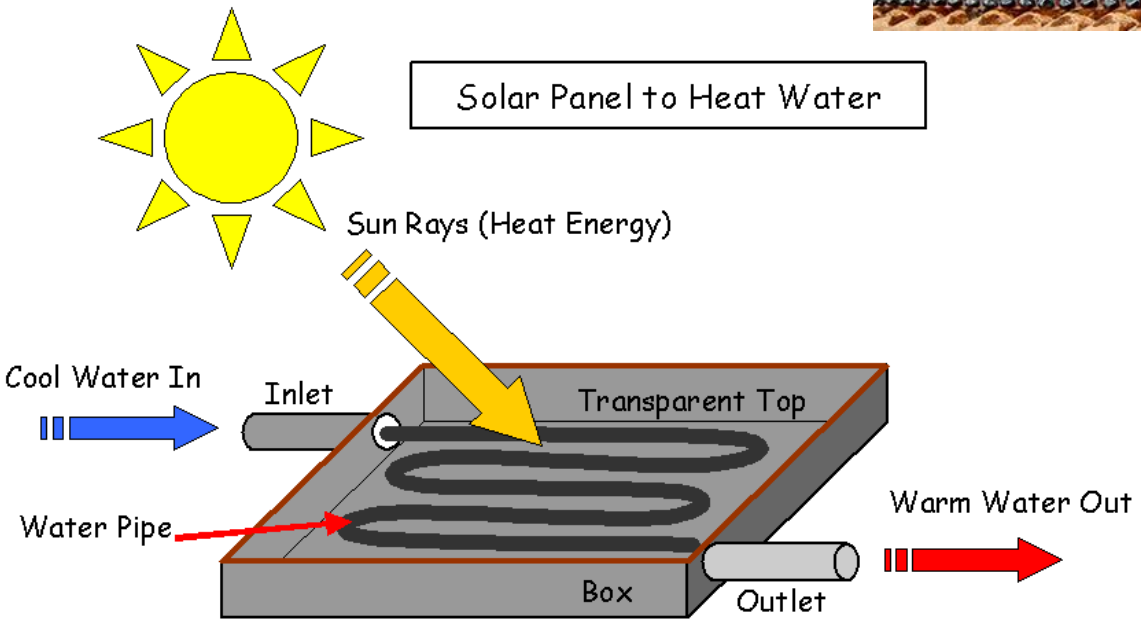
$$1\ \text{cm}^2 \times \frac{1\ \text{m}}{100\ \text{cm}} \times \frac{1\ \text{m}}{100\ \text{cm}} = 0.0001\ \text{m}^2$$

$$\frac{1250\ \text{W}}{1\ m^2} \times 0.0001\ \text{m}^2 \times 0.105 = \boxed{0.0131\ \text{W}}$$

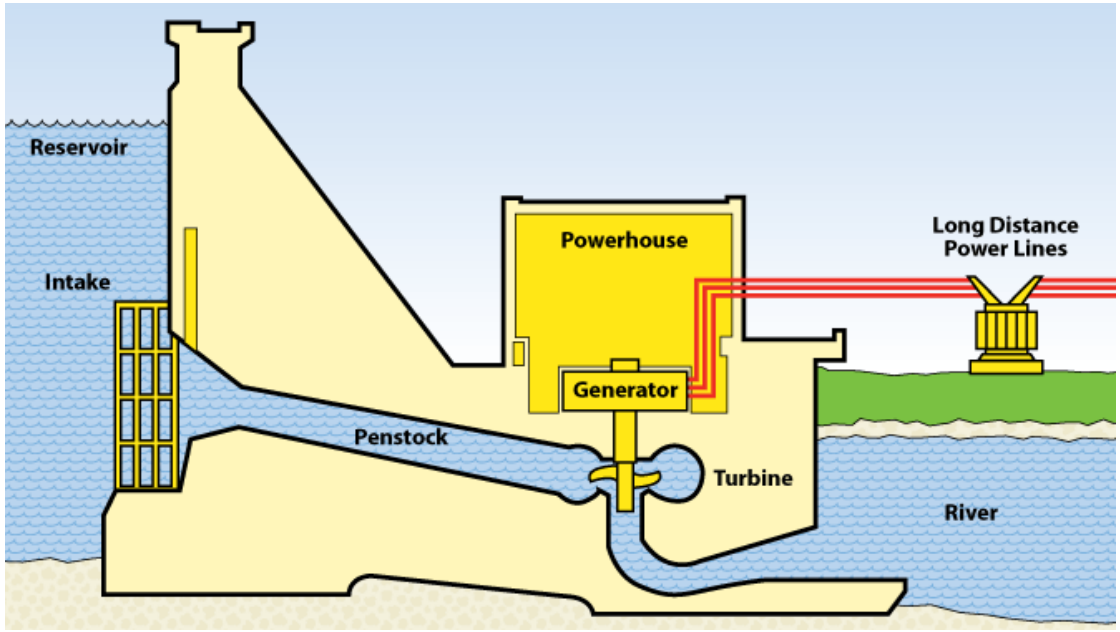
Area

Efficiency

Solar Heating Panel



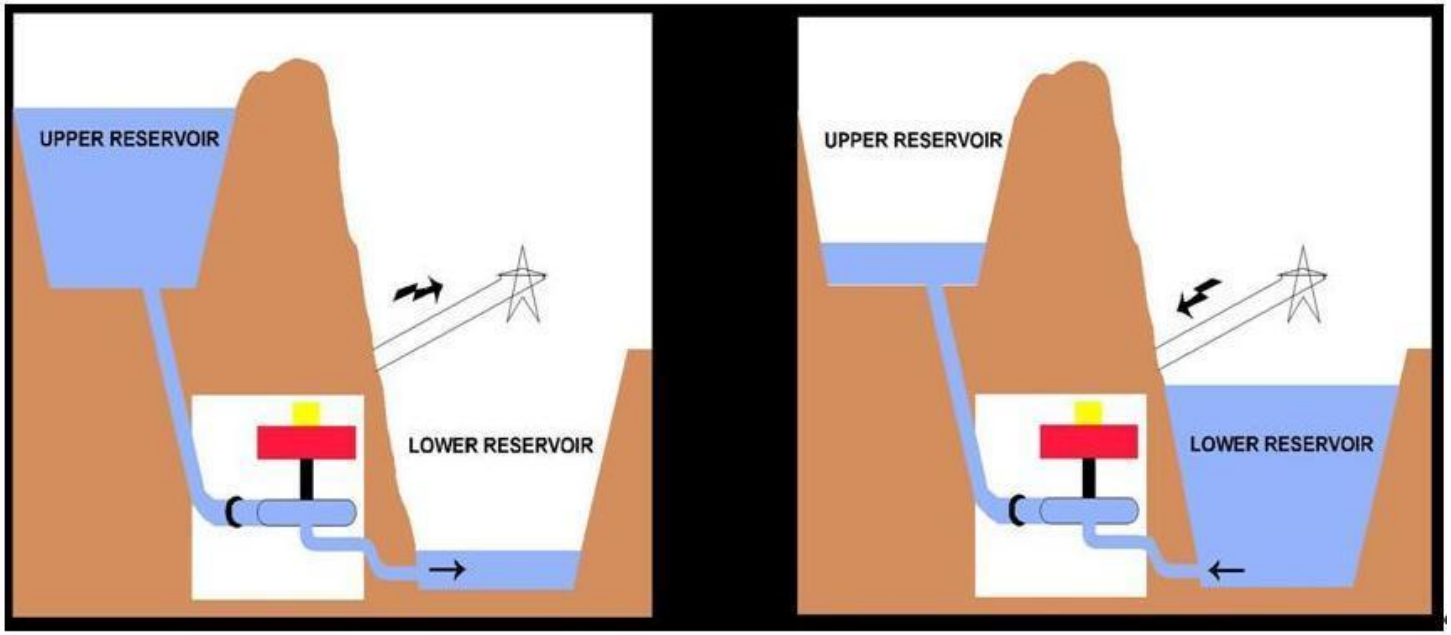
Hydropower



PE of Water → KE of Water → KE of Turbine → Electricity

Storing Energy in Hydropower

If there is excess electricity, this energy can be stored by pumping water back up to the reservoir



pumped hydro operating principals

Issues of the Renewables

- Storage
- Upfront cost
- Control over timing