

Renewable Energies

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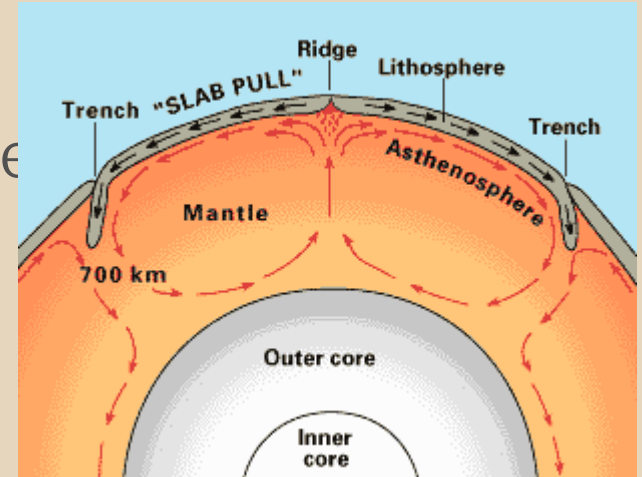
Topics

- Geothermal Energy
- Hydrogen
- Biofuels
- Wind Power
- Solar Energy
- Hydropower & Ocean Energy

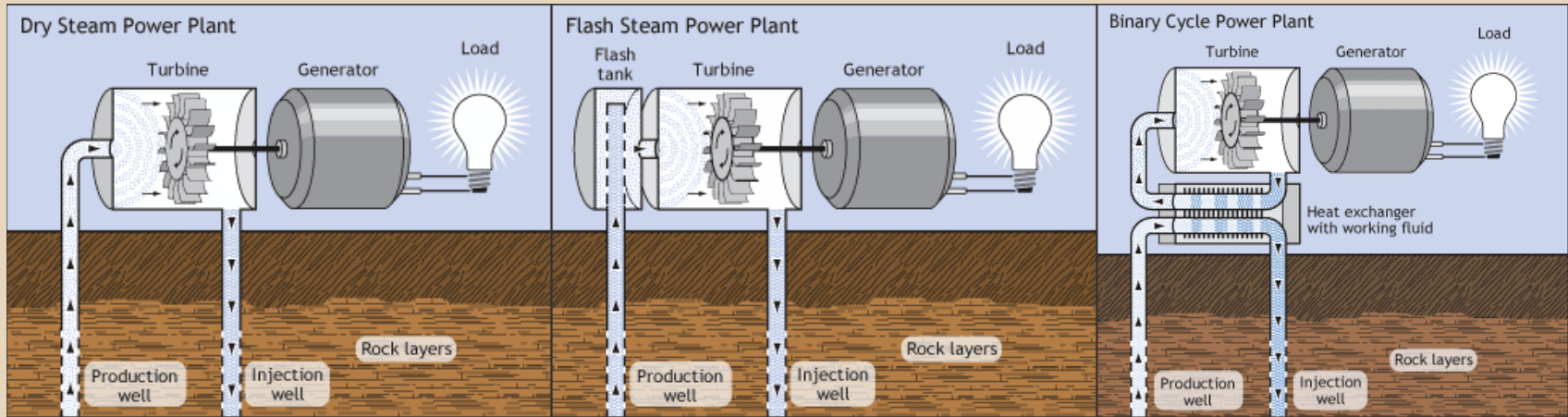


Geothermal Energy

- Heat is generated in the earth's mantle and core via radioactive decay
- Heat is transferred to water and rock in the earth's crust by mantle convection
- The hot water is pumped from the ground and used to drive



Types of Geothermal Plants



Advantages and Disadvantages

- Sustainable
- High energy potential
- Very low emissions
- Economically competitive
- Small footprint
- Can quench wells
- High upstart cost
- Limited by location

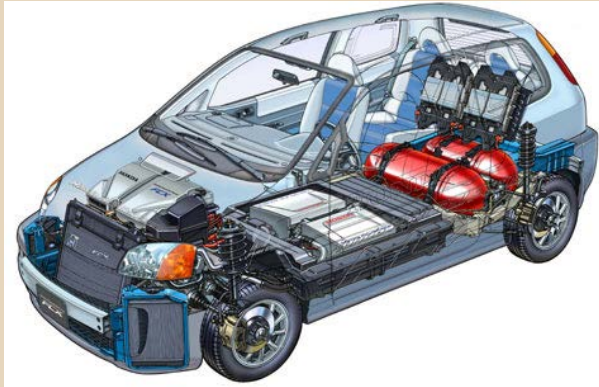


Hydrogen

- Most abundant element in the universe
- Produced by:
 - steam reforming
 - electrolysis of water
- Can be used as a fuel source or an energy carrier

As a Fuel Source

- Burned to drive mechanical work
- Passed through a fuel cell to generate electricity



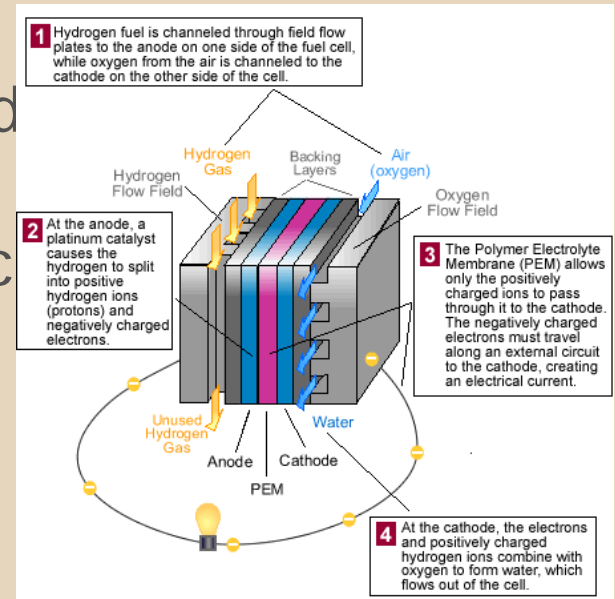
<http://www.pbs.org/wgbh/nova/sciencenow/3210/01-car-nf.html>



<https://mix.msfc.nasa.gov/abstracts.php?p=2388>

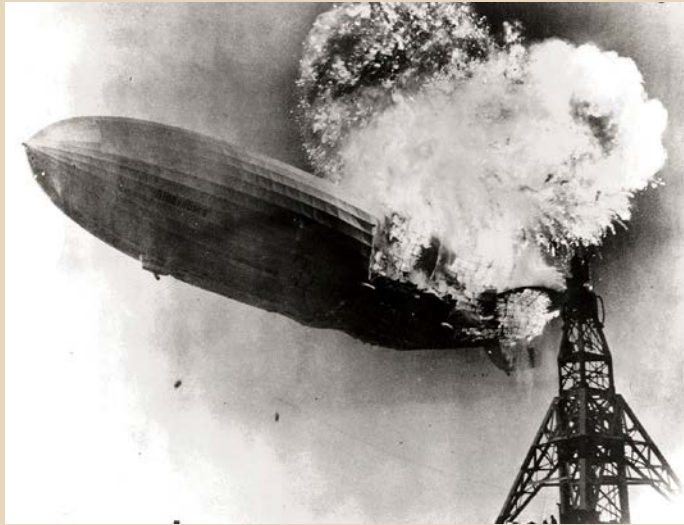
As an Energy Carrier

- Electricity from a primary source is used to electrolyze water
- Hydrogen gas produced can be stored and transported
- Hydrogen gas is passed through a fuel cell when elec



Advantages and Disadvantages

- Near zero emissions
- Abundant



- Hard to store
- Extremely flammable
- Greenness dependent on primary energy source
- Fuel cell cost
- Low density

Biofuels

- Derived from biomass
- Can be directly converted into liquid fuels
- Highly renewable



Bagasse



Corn stover



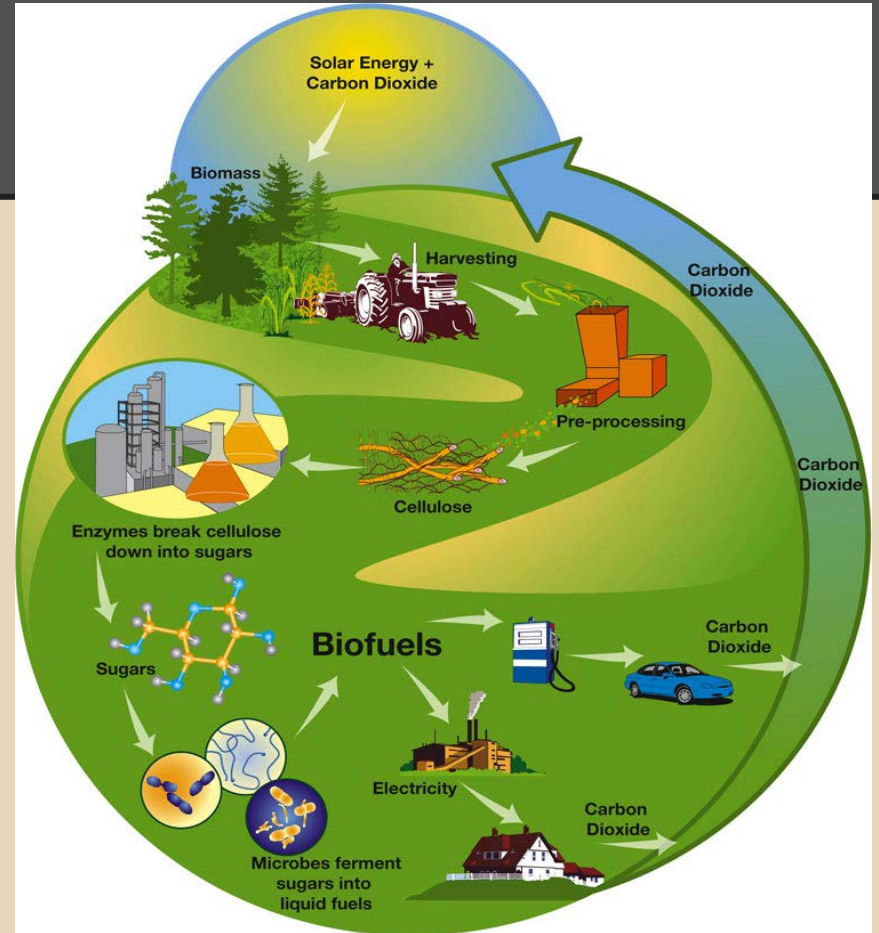
Switchgrass



Sorghum

Process

- Harvest
- Enzyme breakdown
- Fermentation
- Separation
- Transportation
- Repeat



Advantages and Disadvantages

- Can reduce carbon dioxide emissions
- Liquid fuel
- Cheap feedstock
- Not as efficient
- Expensive process
- Plant consumption
- Use of fertilizers
- Water use

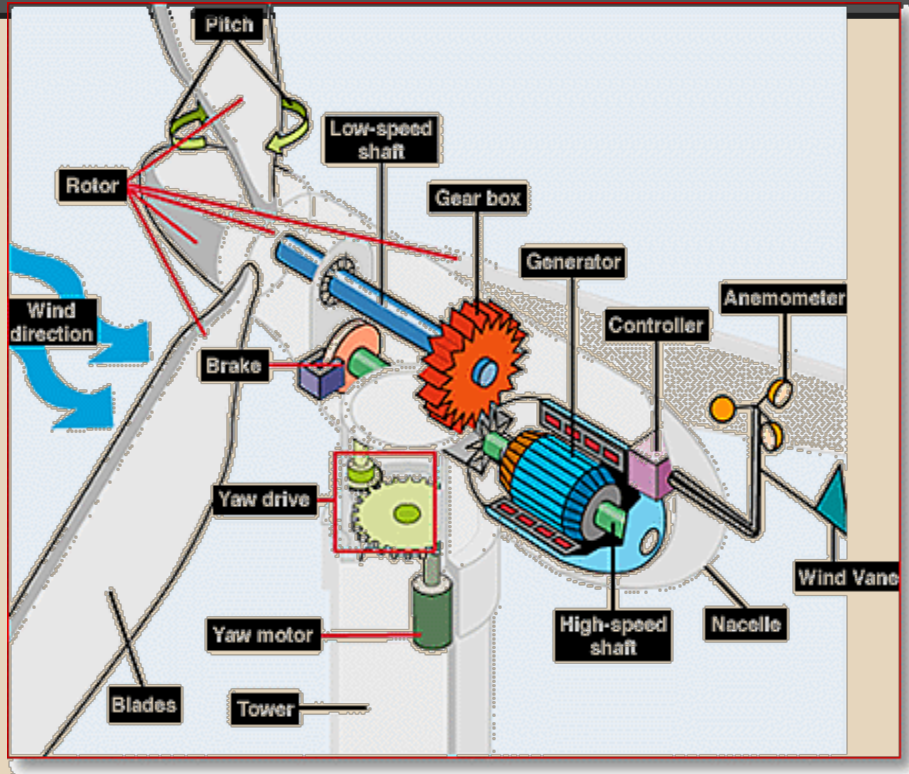
Wind Power

- Power is derived from airflow using wind turbines
- Wind > Mechanical > Electricity
- Three major types
 - Utility-scale wind
 - Small wind
 - Offshore wind



<http://cleangreenenergyzone.com/wp-content/uploads/2010/11/wind-farms-picture.jpg>

Turbine - How it works

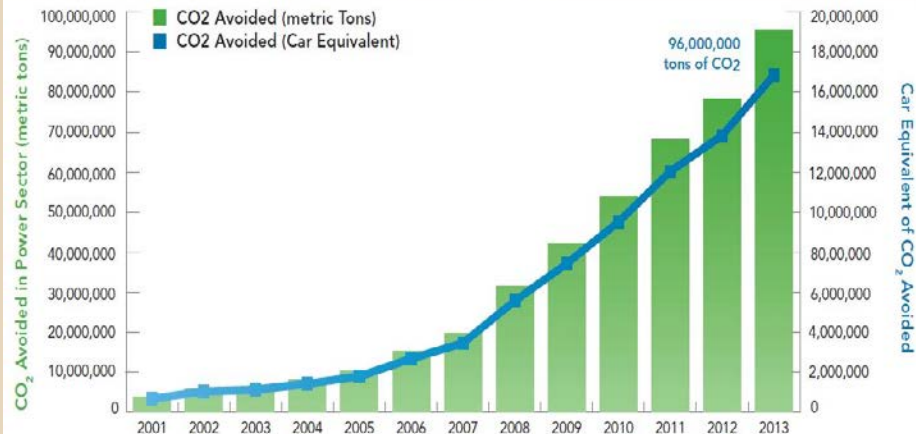


- Pathway
 - Wind
 - Blades
 - Shaft
 - Gear box
 - Generator

Advantages and Disadvantages

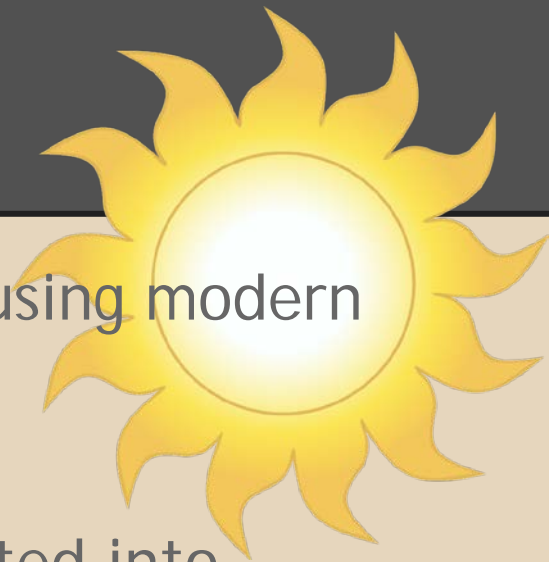
- Clean
- Low maintenance
- Conserves water
- Dependent on wind
- Location limited
- High capital costs
- Noise from turbines

Wind Energy Impact on Avoiding Carbon Dioxide Emissions

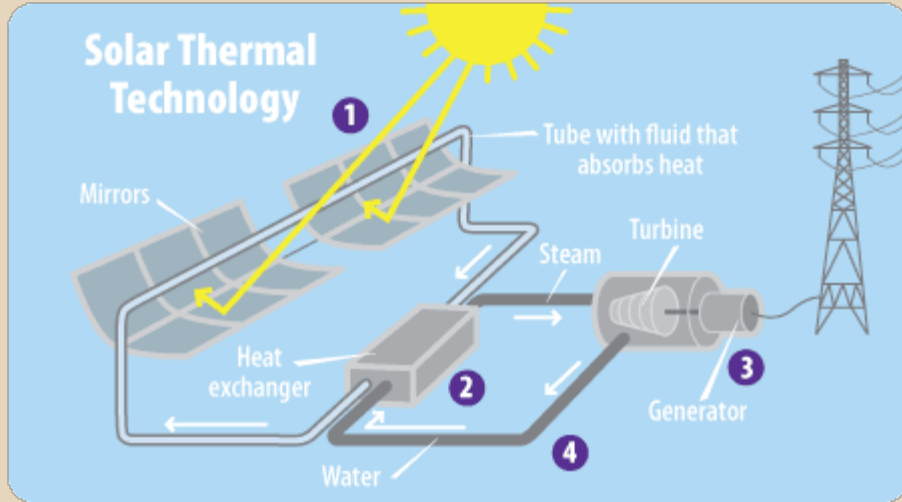


Solar Energy

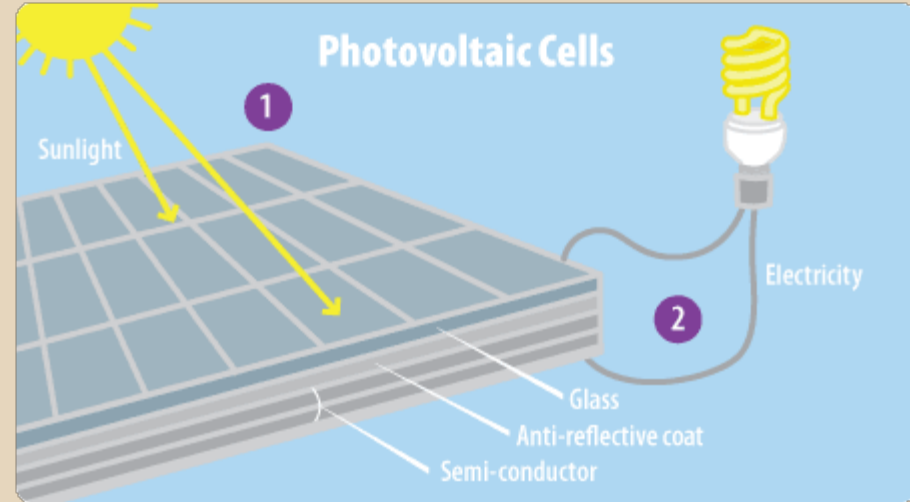
- Light and heat harnessed from the Sun using modern technology
- Clean and extremely abundant
- Two ways of being captured and converted into electricity



Solar Thermal

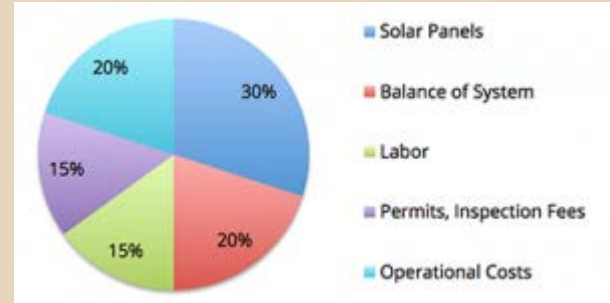


Solar PV



Advantages and Disadvantages

- Indefinitely renewable
- Silent
- Many applications
- Expensive
- Intermittent
- Location



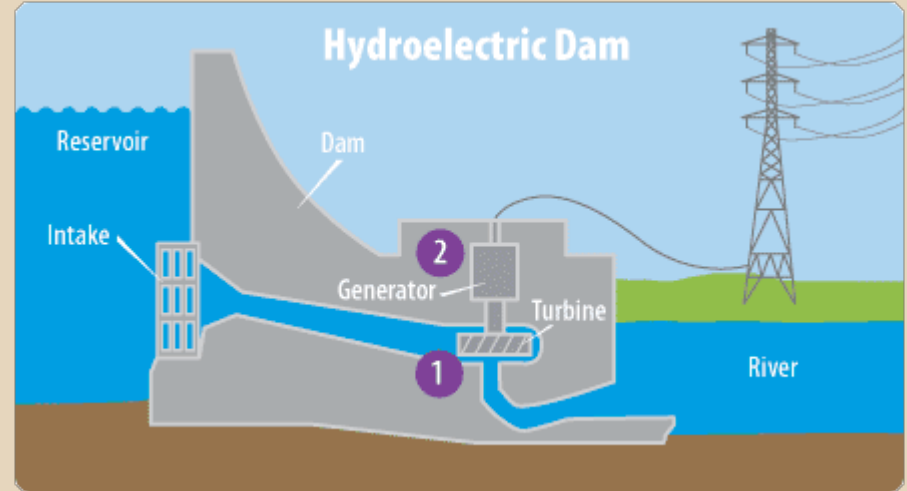
Hydropower & Ocean Energy

- Taking energy from water and converting it to power
- Hydro, wave, tidal, and thermal (OTEC)



Hydropower

- From the energy of moving water
- Nation's largest source of renewable electricity

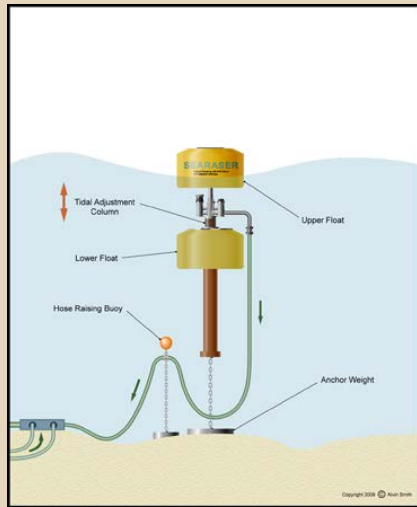


<http://epa.gov/climatestudents/solutions/technologies/water.html>

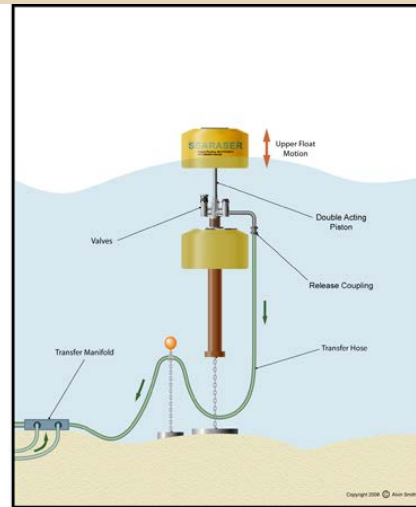
<http://www.triplepundit.com/2011/03/hydropower-expansion-hydropower-improvement-act-2011/>

Wave & Tidal Energy

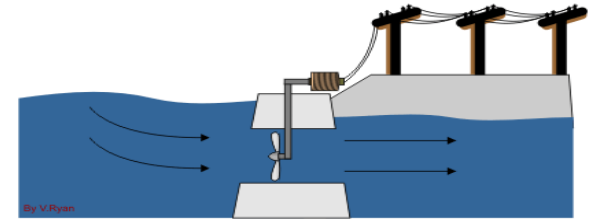
- Harnesses energy from waves and tides to create power
- Waves power uses a wave energy converter (WEC) as waves rise and fall
- Tidal power uses turbines as tides rush in and out of the coast



Upper float lowered in trough of wave

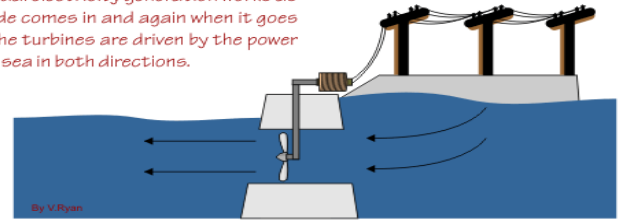


Upper float elevated on crest of wave



TIDE COMING IN

This tidal electricity generation works as the tide comes in and again when it goes out. The turbines are driven by the power of the sea in both directions.



TIDE GOING OUT

Advantages and Disadvantages

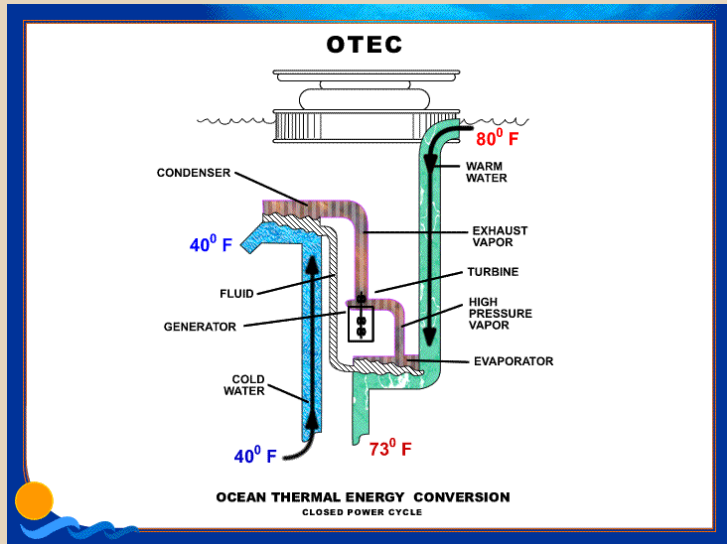
- Green/Clean
- Huge energy potential
- Reliability



- Costs
- Effect on marine life and surrounding environment
- Location

Ocean Thermal Energy Conversion

- Harness solar energy absorbed by the ocean
- Open cycle, closed cycle, & hybrid



Advantages

- Uses clean, renewable, natural resources
- Can produce fresh water in addition to electricity
- Reduced dependence on fossil fuels

Disadvantages

- Needs a large difference in temperature
- Transmitting energy big distances
- Present cost

Conclusion

- There is no single solution to meet the world's energy needs
- A combination of these technologies is needed to meet the world's energy needs
- Fossil fuels remain the most economical way to generate electricity

Plant Type	Comparison of LACE - LCOE (2012 \$/MWh)			
	Average LCOE	Average LACE	Average Difference	Range of Differences
2019				
Dispatchable Technologies				
Conventional Coal	95.6	62.2	-33.5	-48.9 -25.1
IGCC	115.9	62.2	-53.7	-66.1 -43.9
IGCC with CCS	147.4	62.0	-85.4	-104.7 -74.8
Natural Gas-fired				
Conventional Combined Cycle	66.3	62.9	-3.4	-13.7 0.0
Advanced Combined Cycle	64.4	62.9	-1.5	-11.2 0.8
Advanced CC with CCS	91.3	62.9	-28.4	-34.6 -23.7
Advanced Nuclear	86.1	61.7	-24.4	-33.0 -13.0
Geothermal	44.5	60.9	16.4	15.2 18.1
Biomass	102.6	63.3	-39.3	-57.2 -28.5
Non-Dispatchable Technologies				
Wind	80.3	55.7	-24.5	-37.6 -6.3
Wind – Offshore	204.1	62.3	-141.8	-210.1 -107.1
Solar PV	118.6	73.4	-45.2	-96.5 -21.2
Solar Thermal	223.6	73.3	-150.3	-279.3 -83.4
Hydro	84.5	59.9	-24.6	-54.7 -1.0

Acknowledgments

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