Working Towards Energy Sustainability

Renewable energy technologies

Why sustainability?

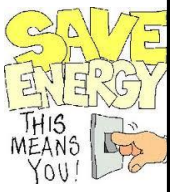
- Sustainability: managing Earth's resources in such a way that they will not be depleted for future generations
- The basic necessity for environmental health and the future of humanity on Earth

Renewable Energy

- Anything that is not finite in its amounts
- Potentially renewable: materials that are renewable as long as we do not overconsume
  - Biofuels, biomass, etc.
- Nondepletable: energy sources that we physically cannot exhaust or won't be exhausted within foreseeable human existence
  - Sun, wind, Earth heat, etc.

Energy Conservation

- Using less energy and researching ways to accomplish this
- Many approaches for this, often government run or funded
  - Incentives (tax rebates for solar panels, for example)
  - Penalties (carbon tax, energy taxes)
  - Increasing availability of more sustainable options like public transport



Energy Efficiency

- Obtaining the same amount of work/output from a lesser amount of energy
- Largely technology based
  - Energy Star
  - Example: Fluorescent vs. Incandescent light bulbs

Challenges in achieving conservation…

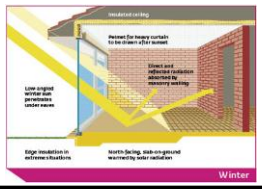
- Electric availability needs to meet the greatest needs (peak demand)
- Means that systems are often over-designed and output way more than the average need
- BUT we still can't run out of energy at peak times
- Only solution to this is reducing peak demand

Sustainable Design

- Improving the design of a structure so that it wastes less energy
- Often relate to heating and cooling

Passive solar design

- Using the sun to stabilize indoor temperatures
- Example: lighter or darker roofs depending on climate, double-paned windows, shades
- Thermal inertia: a material's ability to retain a given temperature



Sustainable Energy Technologies

- Any piece of tech that improves energy efficiency or conservation
- Almost exclusively rely on natural cycles for a source of energy

Biomass

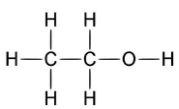
- Taking living or once living portions of the biosphere and burning them for combustion energy
- Trees, crop residues, bush fuel, etc. are all considered **modern carbon** as opposed to the fossil carbon of fossil fuels

Biofuels

- Processed, liquid biomass in the form of biodiesel, ethanol, or a similar fuel
- Ethanol: one of the most common biofuels, primarily produced from corn biomass

Ethanol

- Biggest producer is US (corn), second is Brazil (sugarcane)
- Much gas in the US is 10% ethanol (gasahol)
- E-85 is a fuel that is 85% ethanol and made available for special flex-fuel vehicles



Biofuels: Advantages

- Renewable
- Sugar cane in particular is often harvested by hand, so less FF input
- Ethanol burns cleaner with fewer pollutants than petroleum

Biofuels: Disadvantages

- Still combusting a fuel (bad!)
- Air pollution
- Solid biomass fuels like wood and charcoal deforest and cause habitat destruction
- Production of some biofuels is at the expense of food production
- Need a carbon (often fossil fuel input) to create biofuels

Hydroelectricity

- Generating electricity from the kinetic energy of moving water
- Water flows through turbines which turn to power generators
- 7% of the energy in the US, half of which is in Washington, California, and Oregon
- 20% of energy worldwide
- China is the biggest user, followed by Brazil, then USA
- Three main types of HE power

Run-of-the-river Systems

- Harness running rivers, streams, etc.
- Smaller scale with no reservoir
- Do not rely on extensive damming, so little upstream flooding
- Reliance on natural flow means you might lose electricity in the dry season

Water Impoundment Systems

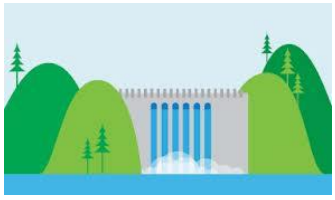
- Construction of a giant reservoir holds water back behind a dam
- Floods upstream areas
- Pushes water through smaller channels via gravity to turn turbines
- Largest in US: Grand Coulee Dam in Washington (6,800 MW at peak)
- Largest in world: Three Gorges Dam on the Yangtze in China (18,000 MW at peak = 11% of China's energy demand)

Tidal Energy

- Harnesses tidal flow to generate electricity
- Windmill like structures are turned to power generators
- Since tides come in and out constantly, power plants can take in energy both ways
- Not useful for much of the world because tidal differences are not great enough
- Roosevelt Island in NYC = first in USA

Hydroelectricity: Advantages

- Once built, require minimal FF inputs
- Reservoirs have economic and recreational purposes as well as down-stream flood control



Hydroelectricity: Disadvantages

- Construction of dam is a major sink for fossil fuels
- Flooding destroys natural ecosystems
  - Covers forest and grasslands with water
  - Plants in those flooded areas break down and release methane gas
  - Altered river patterns can hurt downstream environments
- Siltation: buildup of sediments on the reservoir floor. Reservoirs might need to be dredged with machines that use fossil fuels)→ perhaps not so sustainable

Solar Power

- Using the sun's energy to increase efficiency
- Can be passive (heating, for example) or active
  - Active harness energy using small scale tech, photovoltaic cells, or large-scale plants
  - Collect heat (solar water heaters) or light



Photovoltaic Cells

- Collect solar energy as **light**, not heat and convert it to electric energy
- Cells are made of thin layers of semiconductors (generate electricity when exposed to light)

Concentrating Solar Thermal Systems

- Use mirrors and lenses to focus sun's heat on a contained water source
- Water turns to steam and turns a turbine just as in a fossil fuel plant

Solar Advantages

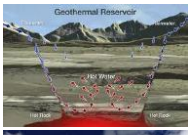
- Almost no pollution in operation (no air, H_2O, or CO_2 pollutants)
- Can be small-scale and economically feasible in many places
- Can produce electricity primarily during peak hours and lower peak demand

Solar Disadvantages

- PV cells are expensive to make and install
- Payback period is fairly long
- Toxic chemicals in manufacturing along with lots of water
- Need batteries to store energy

Geothermal Energy

- Heat from convection currents caused by radioactive decay in the Earth
- Can heat homes and heat water to turn turbines in electric plants alike
- 3rd most used renewable energy in US, but some countries rely on it heavily (Iceland is 20%!)
- Ground source heat pumps good for transferring heat from Earth to homes



Geothermal Pros and Cons

- Pros: free source of energy once installed with no chance of depletion
  - Also uses less input energy than standard heating
- Cons: Primarily not available everywhere
  - Also can be rather expensive

Wind Power

- Fastest growing power source
- Sun heats and cools air causing atmospheric convection currents and thus winds
- US has largest capacity for wind power in the world

Wind Turbine Parties

- Turbines are primarily found in large clusters
- Many offshore

Wind Advantages

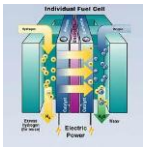
- Nondepletable
- Clean and free
- No FF input once installed
- No pollution and no greenhouse gases

Wind Disadvantages

- Off-grid systems need batteries
- Kill birds and bats who fly into them (National Academy of Sciences estimates up to 40,000 bird deaths annually)
- Can be loud and unsightly

Hydrogen Fuel Cells

- Use hydrogen gas to create energy and water as waste
- Transfer of protons generates electricity
- A good way to store fuel
- Can generate H2 by hydrolising water (H2O → H2 + O2)

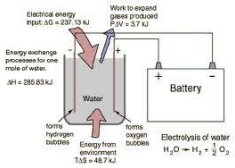


H2FC Advantages

- More efficient than FF
- If made safe for cars, could power more efficient electric motors
- Could be produced with renewable energy and would thus be very sustainable and clean

H2FC Disadvantages

- H2 is rare on Earth, expensive, and requires energy to generate
- Explosive gas (uh-oh)
- Need a way to store and distribute H2 efficiently



Challenges for Sustainable Energy

- The electric grid: largely inefficient
  - Need to invest in new tech AND replace old tech
  - 5-10% of electricity is currently lost in transport
- Storing energy
  - Need solutions to battery tech

The Necessity

- Regardless of the solutions, we MUST find sustainable options to replace the nonrenewable tech we currently rely on