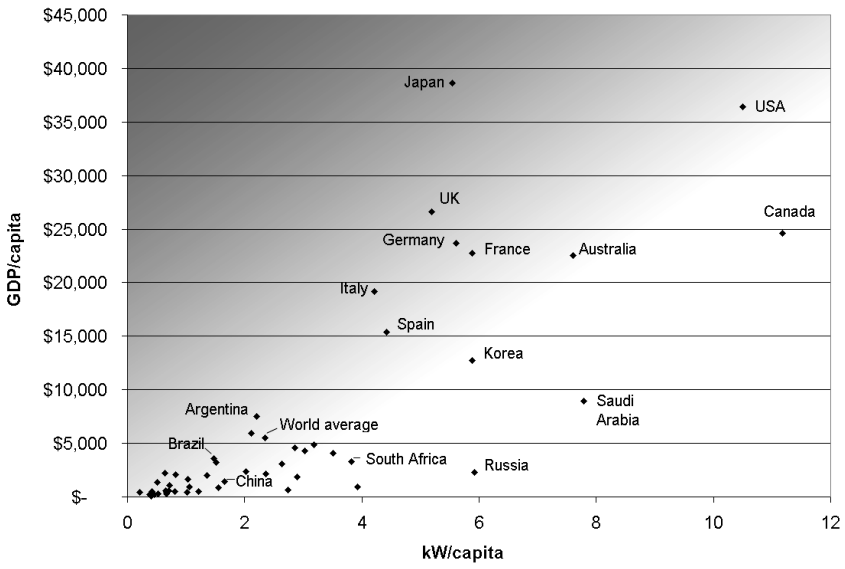
V. Energy Resources and Consumption (10-15%)

A. Energy Concepts

1. **Energy forms** All have the ability to do work by an object, on an object.
    1. mechanical (energy that does work, including transportation)
    2. Thermal / heat energy (greater kinetic energy = higher temperature)
    3. Radiant /electromagnetic energy (light) gamma (smallest wavelength, most damaging to cells), x-rays, ultraviolet rays (from the sun – blocked by ozone layer, damage skin, plants), visible spectrum (violet, blue, green, yellow, orange, red), IR rays (used in detecting objects in the universe), microwaves, radio waves (largest wavelength – least damaging)
    4. chemical energy (photosynthesis, digestion, food chains),
    5. electrical (electricity from coal; electrons "jump" off the nucleus and transfer to other atoms),
    6. nuclear (fission & fusion)
    7. gravitational (gravity – pushes objects to the earth's surface)
2. **Power** the rate at which work is performed or energy is converted.
3. **Units:** Joules (J) = kilowatt-hours & kilocalories, watts (J/sec), horsepower, calories (food energy), BTU (British Thermal Units – measures heat quantity)
4. **Conversions:** 1kWh = 3600 kJ 1BTU = 1.055 kJ
    1. Net Energy Yield = energy you get from the fuel – energy needed to find, extract, process & get to customers.
    2. Net Energy Ratio = useful energy from burning fuel / energy needed to find, extract, etc.
5. **Laws of Thermodynamics:**
    1. 1st Law: energy cannot be created nor destroyed (it moves from one location to another, but is not recycled.
    2. 2nd Law: particles move towards a state of disorder (specifically, heat. Given the opportunity, particles will spread out & move faster – moves towards a gaseous state & a hotter state). Because of this, in any energy transfer some energy is lost as heat (high efficiency = more useful energy transferred)

B. Energy Consumption

1. 99% of all energy comes from the sun (direct – solar, coal, oil, natural gas, biomass; indirect – wind, hydroelectric) 1% comes from the earth (geothermal, uranium, mineral resources)
2. The 20th Century saw a 20-fold increase in the use of fossil fuels
3. US Dept of Energy has an Energy Information Administration (EIA) who collects, analyzes, & publishes energy information to help promote sound policy making, efficient markets, and public awareness. Created as a result of the 1973 oil market disruption (oil crisis)
4. Loosely correlated with GNP & climate; large difference between MDC's & LDC's
5. US consumes 25% of world's energy, has 22% of GDP & 5% of the people. We consume less energy now than in the past b/c of better efficiency.
6. In the world: 37% is used by industry (agriculture, mining, manufacturing & construction); 20% personal & commercial transportation; 11% residential heating, lighting, appliances; & commercial uses, 5%.
7. OPEC (Organization of Petroleum Exporting Countries) – regulates 67% of world's crude oil. US uses nearly 30% of this.
8. Per capita coal consumption in the US likely to increase because: lower overall cost compared to other



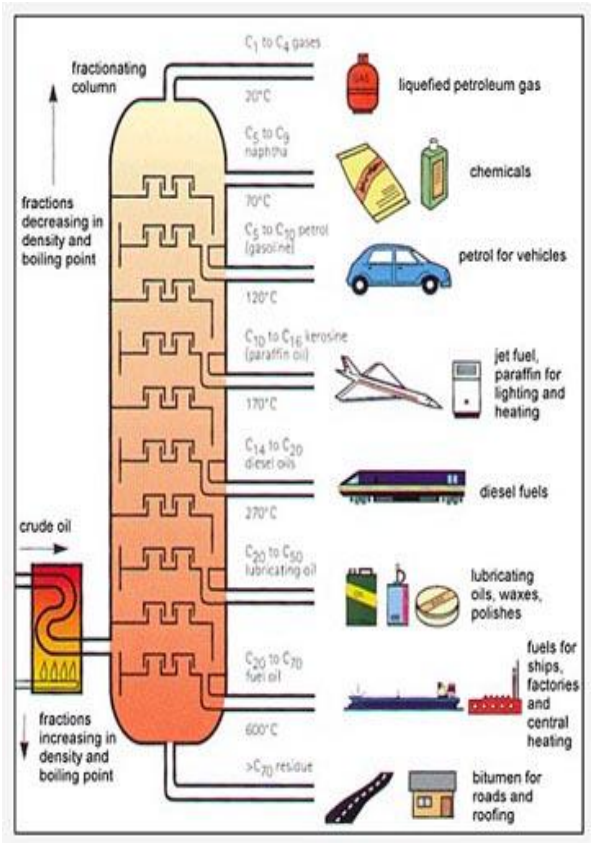
sources; higher availability than other fossil fuels

C. History

1. Industrial Revolution Began with the invention of the internal combustion engine in Europe in the mid-1700's (use of coal). Started in the US in the mid-1800's. Oil became dominant fuel in 20th century b/c of automobiles, airplanes & spreading of electricity. Dropping prices encouraged use.

2. exponential growth: amount of energy used & produced grew exponentially with the invention of mass production – factories & automobiles increased amounts of energy necessary. As less developed nations begin to develop, more energy is going to be needed.

3. energy crisis: 1973 – Oil Crisis (price increased $5 → $45 US per barrel). Result: US autos increased fuel efficiency (doubled).



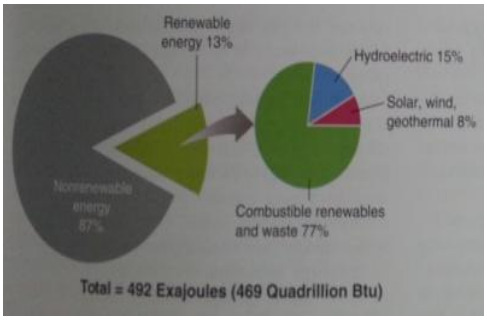
D. Present global energy use : Oil (37%), Coal (25%), Gas (23%), Nuclear (6%), Biomass (4%), Hydro (3%), Solar heat (0.5%), wind (0.3%), Geothermal (0.2%), Solar Photovoltaic (0.04%) **Biomass in the form of fuel wood is used by more people around the world b/c of LDCs.

E. **Future energy needs**: Political considerations, global warming & sustainability of resources are expected to reduce our reliance on fossil fuels. China & other countries use more energy as they develop into more industrialized nations – tend to use energy systems that are very polluting & use resources that are exhaustible.

F. **Fossil Fuel Resources and Use** (nonrenewable)

1. **Formation of coal**: plant remains that have experienced extreme heat & pressure. Most abundant fossil fuel. Fastest growing fossil fuel. Largest fossil fuel reserve – expected to last 130-900 years. In the US, 49% of our electricity comes from coal. Begins at peat (low C content, high in water, burns at low temps), with added heat, pressure & time, it becomes lignite (lowest ranking coal, used to fuel electric power generation), bituminous (most commonly used – for steam-electric power generation, high in heat) & anthracite (highest C content, burns cleanest, least abundant).

2. oil: found in the same location as natural gas (near a water supply – common on continental shelves). Come from plankton. Oil includes petroleum, tar sands & oil shale (waxy, thick oil). Peak oil extraction expected around 2020 at current rates (called peak oil production).



Alaskan National Wildlife Refuge (ANWR):

A. Environmental degradation because of: Construction of & use of drilling sites, roadways, airstrips, housing facilities, gravel mines; seismic surveying; waste disposal

B. Environmental Impacts: Loss / reduction of breeding/calving/nesting areas, food resources, areas for shelters or dens; displacement of populations; disruption of migration routes & hibernation areas; decreases water resources for waterfowl or fish.

3. Natural gas: mixture of gaseous hydrocarbons (mostly methane.) Large supplies are being found in the eastern US.

Energy Source	Pro's	Con's
Coal	• Abundant • Self reliant (we don't need to rely on other countries) • Cheap (b/c technology is old) – high net energy yield. • Easily transported	• Dirty – accounts for 67% of SO_x in atmosphere, leading cause of CO_x, NO_x, heavy metals (Pb, As, Hg) • Severe land disturbance during extraction (surface mining, mountain-top removal) • Black-lung disease (coal miners), believed to cause an increase in asthma • Artificially low prices = less likelihood of conservation. • Air pollution from burning – acid deposition; global warming; heavy metal fallout; particulates; thermal pollution; industrial & photochemical smog

		• Processing related impacts (environmental degradation from transportation & building facilities; aesthetic degradation of landscape)
Oil	• Used in thousands of products (including gasoline, lubricants, oils, plastics) • Old technology = higher net energy yield. • Easily transported	• Reliance on unstable foreign governments • So much is used, generates greenhouse gases – CO_x, NO_x, particulates (causes smog)
Natural Gas	• Cheaper than oil • Easily transported (when under high pressure – forced into a liquid state) • Less air pollution than others • Less pollution extracting than coal	• Releases small amount of toxic hydrogen sulfide • If pipes leak methane – CH_4 is greenhouse gas • Possibility of explosions • Expected to last about 125 years. • Fracking – breaking up the ground to release gas deposits results in contamination of groundwater
Nuclear	• Large amount of energy produced • Low environmental impact (no air, water pollution)	• Low net energy yield • Expensive to build power plants, extract & process U, dispose of waste. • No solution for long-term storage of waste. • Limited amount of time allowed to operate

3. **extraction/purification methods**; Coal: surface mining (includes mountain top removal & open pit mines – less dangerous to workers, more dangerous for environment) & subsurface mining (mine shafts are more dangerous to workers – risk of toxic fume exposure, collapsed mines, mines filling with water, black lung disease). Oil is extracted using oil rigs (pump oil from the ground). Is separated into its different hydrocarbons by distillation (different hydrocarbons evaporate at different temperatures). Different hydrocarbons used to make different things (i.e. gasoline, asphalt, diesel fuel, airplane fuel, plastics, etc) Natural Gas: Fracking – cracking the earth where deposits are found, pumping in hot water to release the natural gas. Pros: Less air pollution (SO_x, NO_x, CO_2, Hg, soot), less mining. Cons: habitat fragmentation, earthquakes, CH_4 leaks,

4. **world reserves and global demand**;

- Coal: (2006) China produced 38%, followed by the US & India. Rate of consumption increasing at 2-3% per year
- Oil: 56% of proven oil reserves in Middle East – 16% in US, 9% in Africa.
  - Natural Gas: The US produces only 3% of world's natural gas, but that meets 95% of our needs. (Russia & Kazakhstan produce 45% of world's supply)
  - Power plant electricity output vs community use: why are they different?
    - Plant doesn't run full capacity 24 hours / day
    - Plant stores energy for future needs
    - Consumption is less/more during different times of the day/week/month/year
    - Loss of energy during transmission
    - Plant supplies energy to businesses & industry, not just homes
    - Plant exports some of its power to the grid for use elsewhere (energy trading among businesses)
    - Households may use alternative sources

5. **synfuels**;

(a) Syngas: primarily H & CO.

(i) Coal Gasification: a thermo-chemical process in which a gasifier's heat & pressure break down coal into its chemical constituents, resulting in syngas. Uses: used in energy-efficient fuel cell technology or as chemical building blocks for industrial purposes, industrial heating, power generation, the manufacture of H_2, removes impurities (S). The heat created is used to create steam to turn the turbines.

(ii) Underground Coal Gasification = a method of converting unworked coal into a combustible gas which can be used for industrial heating, power generation, or the manufacture of H_2, synthetic natural gas or diesel fuel

(iii) Pros: increases energy security, reduces environmental impact of other energy sources, promotes economic development

(b) Clean Coal: involves removing impurities (N & S) from coal before, during & after burning in a power plant.

(i) Coal washing: removes unwanted minerals by mixing crushed coal with a liquid & allowing impurities to separate & settle.

(ii) Wet scrubbers: removes SO_2, NO_x and particulates from the flue gas after the coal has been burned.

(iii) Fluidized Bed Combustor: crushed coal is mixed with limestone & suspended on jets of air inside a boiler. Coal mixture floats in boiler; limestone acts like a sponge capturing 90% of S.

(iv) C capture & Storage: research underway to capture CO_2 from power plants & store in deep underground geologic formations.

6. environmental advantages/disadvantages of sources)

(a) Coal: Good – cheap & easy to extract = high efficiency (old technologies);

(i) Bad - high amounts of air pollution (Hg, SO_2, CO, CO_2); fly ash (ash remaining after burning coal) contains Hg, heavy metals, U, other heavy metals; particulate matter (dust); acid rain; risk of coal-ash basin spill; risk of contamination of groundwater.

1. Methods for reducing S emissions:

a. Input: use low-sulfur coal; "wash" the coal (clean coal); coal gasification ; using alternative combustible fuels (natural gas; synfuels)

b. Output: using wet or dry scrubbers in smokestacks (wet - injected crushed limestone or lime slurry into emission; dry- injected Na_2CO_3 into emission ; treatment with NH_3

c. Other: Conservation education; source reduction (including conservation & more efficient plants)

2. Mining Coal –

a. Impacts: damage to land: Sulfur dissolves in water to produce sulfuric acid

i. CausesAcidification of surrounding soil, groundwater, or adjacent bodies of water

ii. Reduce plant growth / animal distribution

iii. Corrosion of roads / drainage culverts

iv. Increases solubility & transport of heavy metals

b. Remedies:

i. Bioremediation by sulfate-reducing bacteria

ii. Sedimentation ponds / retention basins / catchments

iii. Cover tailings to reduce contact with precipitation

iv. Buffer / neutralize H_2SO_4 with alkaline substances (limestone, NaOH, $NaHCO_3$)

3. Mercury (neurotoxin)

a. Found in 3 states: particulate, elemental & oxidized form.

b. Microorganisms in the soil & water convert inorganic Hg into an organic form (methyl mercury) which moves more easily through the food chain)

c. Released into the environment by burning coal: released into the air and carried by the wind to areas surrounding the power plant; found in coal ash & placed in coal ash basins

d. Enters aquatic ecosystems by: falling as dry particles into water or onto soil; falls as precipitation; transported through the food chain (Minamata Disease from eating too many Hg-rich fish); from the coal-washing process; from groundwater

e. Reducing the amount:

i. Reduce the amount of coal burned / change to alternative fossil fuel (natural gas)

ii. Burn coal with a better Hg rating

iii. Use alternative energy sources (wind, solar, hydroelectric, etc)

iv. Pre-Combustion removal (wash the coal – density separation)

v. Post-Combustion removal (use absorbents; scrubbers in smokestacks; use catalyst system that oxidizes elemental Hg, which can easily be removed; capture flue gas & fly ash)

vi. Enforce the Clean Air Act

vii. Use tax incentives to encourage voluntary reductions

viii. Conserve energy

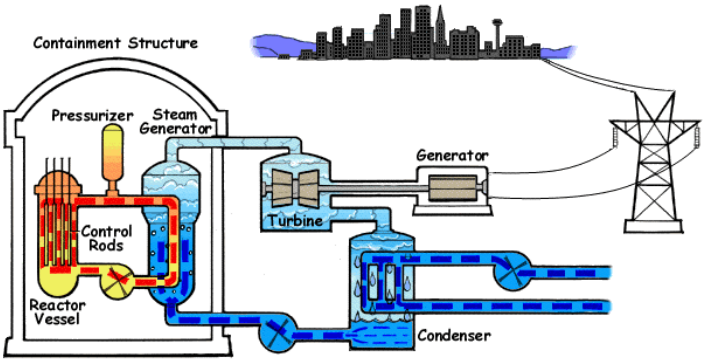
(b) Oil: good – cheap & easy to extract. Bad – CO_2 (global warming)

(i) Tar sands – waxy tar substance extracted through surface mining -treated with hot water to extract the oil

1. Cons: requires large amounts of water to produce; requires conventional oil to produce; combustion = GHGs; mining problems; low net energy yield;

G. Nuclear Energy (nonrenewable)

1. **Nuclear fission process –** U-235 is hit with a neutron "bullet" → breaks U-235 into 2 daughter nuclei & 3 neutrons → neutrons hit more U-235 → chain reaction occurs. Control rods absorb neutrons to keep the reaction from getting out of control.
2. **nuclear fuel –** U-238 is mined from the ground. Undergoes "enrichment" to change it to U-235. Energy intensive process that reduces nuclear's energy efficiency.
3. **electricity production –** U-235 breaks apart producing a large amount of heat. Heat turns water (in the steam generator) into steam → Steam turns turbines → turbines turn magnets → electricity is generated. Steam is cooled down in a condenser (water comes from lakes or rivers → produces small amount of thermal pollution if water is returned to lake. Other option – water is released from the cooling towers).
4. **nuclear reactor types –** Boiling Water Reactor (BWR) – Chernobyl. Not use in the US. Water in the reactor core is the same water that turns the turbines. More contaminated water increases likelihood of human health problems if there's a meltdown. Pressurized Water Reactor (PWR) – what we have in the US. Water is heated to a very high temperature, but is pressurized to keep it in the liquid form. More pipes = water from the reactor never leaves the containment building.
5. **environmental advantages/disadvantages –** Pro's: very safe, when done correctly. No air pollution. Water pollution is minimal (thermal pollution). Cons: radioactive waste needs to be stored for 1,000 – 10,000 years. IF there is an accident (melt down), there is a major risk for harm to people & the environment. Enrichment process produces air pollution. Uranium extraction process causes radioactive tailings / water pollution.
6. **safety issues;** Numerous safety measures are in place to help prevent a meltdown (occurs when a chain reaction is out of control, creating too much heat – the containment building "melts" releasing radioactive steam). Three Mile Island nuclear plant in Pennsylvania had a partial meltdown in 1979 – all radiation was contained in the containment building. Chernobyl was the worst nuclear disaster ever – happened because the former Soviet government was experimenting & left the control rods out of the reactor core for too long. Thousands died or were affected.



7. **radiation and human health;** Kills cells / causes tissue damage / DNA/Chromosomal damage – causing damage to brain, eyes, GI tract, fetuses, ovaries/testes, bone marrow, impaired immune system, blood vessels, hair loss, skin, lungs, thyroid, etc. Causes acute radiation sickness (more likely to contract other diseases, cancer, tumors, genetic damage). Some forms used to kill cancer cells (often kills normal cells as well).
8. **radioactive wastes** – nuclear plants store spent U-235 on site (only use about 20% of the U in a fuel rod) either in swimming pools (first 20-40 years) or in dry containers called "casks" (after 40 years, when less radioactive). Nuclear plants produce "high-level" waste (remains dangerous for long periods of time) which must be stored for thousands of years. Currently – no long-term storage facilities off-site. Yucca Mountain is ready to accept waste (good location b/c it is remote, has impermeable bedrock, not near fault lines or volcanoes, dry climate minimizes percolation), but is in litigation because people who live in areas where the waste would have to travel through are not happy (NIMBY). Alternative options: storage in Antarctica or Greenland (limited technology); rocket to space (limited by cost, danger of accidents); deep ocean storage (danger by leaks); above ground storage (risk of attack); ship to other countries (ethics); reduce demand for energy (public willingness?); reprocess spent fuel (limited by US Law / NIMBY)
9. **nuclear fusion** – process of two smaller atoms coming together to form a bigger atom. How energy is processed in the sun. Produces large amount of energy. Scientists working on making it an energy source, but has a VERY low net energy yield (takes a great amount of energy to fuse the atoms= inefficient)

H. **Hydroelectric Power** – energy from water (dams, tidal energy)

1. **Dams** – stop / control the flow of water in a river. Dam has turbines that water runs through. Behind the dam is a reservoir used for recreation, as a water supply, etc.

2. **flood control** – dam holds water back to prevent flooding downstream.

3. **salmon** – go back to their birthplace to spawn. Dams block the route. One solution – steps on the sides.

4. **silting** – nutrient rich silt builds behind the dam; causes blockages & prevents nutrients from getting downriver

5. **other impacts** – fish get caught in turbines & die; channelization often done, which causes erosion, displacement of people, disruption of natural habitats. Not useful in all parts of the world.

I. **Energy Conservation**

1. **Energy efficiency:** how much useful energy you can get out of a system. (see net energy above)

Electricity Conservation

- Energy Star Ratings placed on appliances – use less energy than traditional.
- CFL's (compact fluorescent lightbulbs) – use a fraction of the energy as a traditional incandescent bulb (which are only 5-10% efficient). Government is trying to ban incandescent bulbs in coming years.
- Installing insulation with a higher R-value; add insulation to attics, exterior walls, ducts, or areas not currently insulated.
- Install double-paned windows / storm windows with low emissivity
- Cover exterior walls / windows with plastic
- Caulk, seal, weather-strip around windows & doors; repair window leaks.
- Lock/close windows and doors
- Use solar heating with a specific example
- Place windows on southern, eastern, and western exposures
- Open shades/blinds during the day and close at night
- Lower (turn off) thermostat during the day when no one is home
- Lower thermostat and wear layers of clothing and blankets
- Lower thermostat to remain a few degrees cooler to use less energy and save money
- Add carpet to improve insulation
- Install programmable thermostat (must give specific heat conserving use)
- Close off unused rooms/areas
- Install a higher efficiency furnace
- Install ceiling fan to more evenly distribute heat
- Install stone flooring/adobe or brick walls/trombe wall to absorb heat/redirect/act as a heat sink
- Plant windbreak or shelterbreak to guide wind over and around building
- Add straw bales between walls or outside exterior walls
- Install woodburning stove (fireplace) with additional vents for heat distribution
- Install darker roof tiles
- Change to darker exterior wall color
- Take thermal picture, IR picture to identify leaks
- Maintain furnace/change filters regularly
- Use residual heat from clothes dryer/oven
- Install insulation behind wall outlets/light switches
  - Remove/avoid planting trees near south windows

Oil Conservation: Drive less, improve efficiency, carpool, mass transit; Less roadway building, less pesticide use; substitution of non-petroleum-based products (alternative energy sources, synthetic lubricating oils, use glass, wood, etc); Recycling / reuse of products, lubricants, plastic products, etc.

1. **CAFE standards (Corporate Avg Fuel Economy)**: Regulate how energy efficient vehicles must be. Came into effect in 1975 because of the oil crisis. For passenger vehicles (cars & light weight trucks), the minimum standard is 26 mpg. Recent changes are being put into place – by the year 2017 for trucks, vans & buses. Passenger Cars = 39.6 mpg; light trucks = 29.1 mpg; combined cars & trucks = 35.1 mpg

    1. NHTSA & EPA estimate that the combined proposed standards have the potential to reduce GHG emissions by nearly 250 million metric tons and save approximately 500 million barrels of oil over the life of vehicles sold during 2014 to 2018, while providing an estimated $35 billion in net benefits to truckers, or $41 billion in net benefits when societal benefits are included. – EPA

2. hybrid electric vehicles – runs on 2 energy sources

    1. Includes mo-peds (gas-human powered), locomotives (diesel-electric), submarines (nuclear-electric). Cars (gas-electric)

    2. In order to be useful, must meet minimum standards (drive 300+ miles before refueling; be refueled quickly; keep up with other traffic on the road)

3. Electric vehicles are slow & inconvenient to recharge.
4. Ways to improve fuel economy
    1. Recover energy & store it in the battery (done while breaking; electric motor takes over when car is slowing down)
    2. Shuts off engine while idling
    3. Use advanced aerodynamics to reduce drag (allows wind to flow over car better)
    4. Low-rolling resistance tires
    5. Lightweight materials
5. US government policies providing incentives for people to buy electric cars

- tax credits
- tax rebates for purchase of electric vehicle
- special travel lanes/no tolls/reduced tolls
- preferential parking
- supplies recharge stations
- investment in R & D (battery research, charging technology)
- mandated production/sales quotas for electric vehicles
- subsidies to companies that supply electric vehicles
- free electricity/reduced electric rate for owners of electric vehicles
- funding to education programs/advertising that promotes electric vehicles
- subsidized loans for the purchase of electric vehicles

Disincentives for gasoline vehicles (must explain how it increases use of electric vehicles)

- • remove gas subsidies
- • increase gas taxes
- • increase gas-guzzler tax or surcharge
- • emission penalties
- • stricter emission standards
- • higher fleet miles per gallon/higher CAFE standards
- • rationing gas
- • limit number of gas cars per family
- • phase out/ban gas cars
- • mandates production/sales limits for gasoline vehicles
- • increase tariffs (taxes on imports) on petroleum
- • boycott petroleum imports

6. Environmental Benefits:

Identify (1 point)	Describe (1 point)
Decreased levels of:	
CO	improved human health (must cite specific, accurate, health impact of CO: reduced O_2 transport, headaches, drowsiness, aggravates respiratory problems, coma, brain damage, death); no point for describing global warming due to CO
CO_2	greenhouse gas therefore less global warming, decreased greenhouse effect, decreased acid precipitation (no point for just identifying CO_2 as a greenhouse gas)
SO_2	improved visibility, decreased acid precipitation, decreased property damage, improved human health (must cite specific, accurate, health impact of SO_2: aggravated respiratory problems)
NO_x	improved visibility, decreased acid precipitation, improved human health (must cite specific, accurate, health impact of NO_x: aggravated respiratory problems, increased susceptibility to respiratory infections)
VOCs/hydrocarbons	decreased secondary air pollutants (must cite specific example: PANs, O_3), improved human health (must cite specific, accurate, impact of VOCs: decreased cancer rates, decreased lung irritation)
Particulates (SPM)	improved visibility, decreased property damage, improved human health (must cite specific, accurate, impact of SPMs: respiratory system irritation and damage, aggravated respiratory problems)
MTBE (from gas spills)	decreased groundwater contamination
Specifically identified secondary pollutant, PANs or O_3	must give health/environmental benefit associated with a decrease in the specifically named secondary pollutant

ll, 2013

NOTE: A decrease in lead emissions is NOT an acceptable identification for the United States, but IS an acceptable identification for a developing country or a country still using leaded gas. A specific health/

Decreased use of petroleum leads to:	Results
Decreased release of toxins from refining	improved human health by decreased cancer rates, lung irritation, decreased ecosystem damage/disruption (must cite specific example)
Fewer oil spills, fewer pipeline leaks	less habitat destruction, decreased water contamination, decreased ecosystem damage/disruption (must cite specific example)
Fewer new oil wells, less extraction, fewer pipelines	less habitat destruction, decreased ecosystem damage/disruption (must cite specific example)
Fewer fluid leaks from gas cars	less surface and groundwater contamination (less oil on streets)
Less noise using electric vehicles	improved human health (must cite a specific problem such as hearing loss, less annoyance in high traffic areas), ecosystem disruption with specific example

3. **NOTE:** It is NOT ACCEPTABLE for a student to use generic terms for their answer such as the following: air pollution, smog, exhaust emissions, depletion of fossil fuels, non-renewable resource, carbon emissions, or sulfur emissions. A specific identification is required, as shown above, to earn credit.

mass transit – city bus system, airplanes, light rail systems, trolleys, etc.

A. **Renewable Energy**

1. **Solar energy** – Using energy from the sun. Passive Solar Energy: no machinery used. Open blinds to let light in. Use sunlight to heat water (for cooking, purifying, hot-water heaters, etc). South-facing windows. Thicker insulation keeps heat in/out. Plant trees / shrubs around dwelling (including roof top gardens). Reflective roofs/walls. Heavy drapes (keeps heat in at night, allows light in during day). Window overhangs. Use thermal mass devices (stone, concrete floors/walls, interior water reservoirs – heats up during day, holds heat at night); solar cookers (using a box lined with Al foil to concentrate sunlight towards a pot)
2. **solar electricity** – Active Solar Energy: uses machinery / equipment to generate electricity
    1. Photovoltaic Cells – solar panels have silicon wafers. As sun hits, electrons get "excited" and move from atom-to-atom, generating electricity.
        1. Government incentives for homeowners: education to homeowners of PV benefits; tax credits; subsidize the cost of PV panels so it's cheaper to purchase; provide tax breaks for companies; offer low-interest loans to homeowners
        2. Government incentives for industry: lower cost of PV panels; develop more aesthetically pleasing systems; purchase excess electricity; allocate additional funds for R & D.
    2. Concentrated Solar Power (solar power-plants) – Parabolic troughs (uses concave mirrors) focus sunlight to a pipe containing water. Water turns to steam, turns turbines.
    3. Stand Alone system – energy produced is used on location
        1. Pros: does not require the installation of grid-exchange equipment; completely independent of the electrical grid.
        2. Cons: Net metering is not available; may require additional secondary electrical-generating systems for reliability or peak demand; limited battery storage capability; large area may be needed for cells
    4. Grid-System – energy goes back onto the electrical grid
        1. Pros: back-up energy source is available; less area is needed than in stand-alone systems; battery system is not necessary; surplus energy can be sold back to electrical companies; systems are smaller than stand alone; excess energy sold back to electric companies reduces need for coal or other sources.
        2. Cons: net-metering hardware may be expensive (hardware used to put it back into the grid); no battery back-up in case of power grid failure; utility may require a large system for net-metering capability.
3. **hydrogen fuel cells**: batteries that combine H_2 & O_2 via reverse electrolysis; can be used in transportation, power generation, heating; produced by "steam reforming" (separates H from CH_4 by high temperatures or from electrolysis (splitting water); biomass gasification (biomass is super heated)
4. **biomass** – Uses plants / plant products for energy. Used extensively in less developed countries where no other energy source is available.
    1. Plant matter: mostly burned for heat for purifying water, cooking food, etc. Includes crop debris

2. Animal matter: includes animal dung, methane from cows or waste water treatment plants
3. Solid waste /landfill gas (cogeneration)
4. Ethanol (via fermentation): creating alcohol product from corn, sugar cane, etc. Use as an additive to gasoline (gasohol) to help reduce gasoline. E10 = 10% ethanol; E85 = 85% ethanol (alternative fuel) used by Flex Fuel Vehicles (FFV).
    1. Cons: tropical rainforests cut down for sugarcane; agriculture problems; more corrosive to engine parts; fewer mpg than gasoline; more expensive than gasoline (but tax advantages make it competitive.
5. Biodiesel: using algae (extract oils that can be burned), ethanol (extract oils from corn, mix in as an additive to gasoline. (puts "new" C back into the atmosphere)
    1. Microalgae: uses less land than ethanol; reduces tilling of soil; decreased pesticide use, fertilizer use, fossil fuels, irrigation of land, nutrient depletion of soil; can be grown in wastewater
    2. Other benefits: renewable; increased jobs (more labor needed in fields); increased profits for agricultural companies; decreased reliance on imported fossil fuels (lessens likelihood of foreign conflict over resources); reduced transportation costs, land disturbance, petroleum use, disposal of used cooking oil; increased nutrient capture from wastewater
    3. Cons: increased corn prices, food prices, land costs, pesticide exposure, costs to cultivate agricultural lands (and all of the associated problems), taxes (subsidies); decreases food for human consumption, aesthetic value of land, jobs, energy (provides less energy than conventional) availability of land for crop generation, water for cities

5. **wind energy** – one of the first electricity sources – began in Europe. Blades of windmill are the turbines. Us produces most electricity from wind, but is 8th in terms of % of our electricity coming from wind (Denmark is highest)1
6. **small-scale hydroelectric**
7. **ocean waves and tidal energy –**
    1. **Tidal Energy:** (aka. run-of-the-river) place a low dam with turbines in inlets, which gets turned as the tide goes in or out, generating electricity.
    2. **Ocean Waves:** pipes are placed over waves. As water rises & lowers, air is pushed upward through turbines. OR waves are forced into narrow pipes that turn turbines.
8. **geothermal** – High Temp: using steam from the earth to turn turbines. (wells may be drilled & steam pumped directly into turbines – dry steam plants). Low Temp: hot springs & spas, agriculture & aquaculture; industry; heating
    1. US uses this method more than any other country; Iceland gets a greater % of their energy from this than any other source.
    2. Often found on sides of volcanoes – magma close to the surface heats water in the ground.
    3. Use ground to maintain a constant temperature of 50-55^{o} – water is run through the pipes & heated / cooled from there.
9. **environmental advantages/disadvantages**

Energy Type	Water pollution?	Air pollution?	How long will it last?	Damage to habitats / land?	Other advantages	Other Disadvantages
Solar Energy	None	None	4.5 billion years	None Minimal Land damage – takes space to have large PV fields	No cost associated after initial investment; can be used anywhere No nuclear waste No mining problems	Can only be used when sun is shining Manufacturing causes air & water pollution, toxic waste; disposal of storage batteries may cause pollution

Solar Electricity	None	None	4.5 billion years	Minimal – solar panels placed on houses; mirrors take space	PV panels on roofs can generate electricity that can be sold back to electric companies; free after initial investment	Sunlight has to be fairly intense – not suitable in all regions. Hard to store electricity
Hydrogen Fuel Cells	None	None	Forever	Found in biomass	Only produce H_2O as byproducts; very efficient; can be found anywhere	Possibility of explosion; H_2 is not found in its elemental form – must be manufactured; expensive ; have to use fossil fuels to obtain H_2.
Energy Type	**Water pollution?**	**Air pollution?**	**How long will it last?**	**Damage to habitats / land?**	**Other advantages**	**Other Disadvantages**
Biomass	None	CO, NO_x, soot, particulates, CO_2	Could run out in certain regions if used faster than grown. (non-renewable?)	Removal of vegetation disrupts habitats	Cheap, easy to use, can be used in LDC's easily. Burning new C vs old C. Use of local vs transported fuel. Ash can be used as fertilizer	Not found everywhere; plant debris doesn't decompose & return nutrients to soil.
Wind Energy	None	None	Forever	Noise disrupts animal migration patterns, breeding. Wind Farms require a lot of land. Ecosystem fragmentation	Can be used over the ocean.	Noise pollution. People don't like the way they look. Hard to store energy. Damaged by tornadoes. Wind isn't steady.
Hydroelectric	See above					
Ocean Waves / tidal energy	None	None	As long as there are tides	Animals get caught in turbines; disrupts coral reefs	Can be used in many locations	Hard to store energy; ugly; hurricanes can knock them offline
Geothermal	none	Very little	As plates move, hotspots may move. Water underground may run out.	minimal		Only found in certain regions of the world.

Miscellaneous:

- Electricity Production: something (gaseous or liquid water / wind) turns a turbine, which turns a huge magnet inside a generator, and generates electricity. Coal-fired, natural-gas fired, solar electricity, & nuclear all involve water being turned to steam. Geothermal uses natural steam. Wind turns turbines in windmills. Water turns turbines in dams.
- Cogeneration: using heat generated through another industry (incineration, waste water treatment, etc) to heat up water & generate electricity.
- Other alternatives: methane collected from manure (feedlots), waste water treatment plants, and landfills.