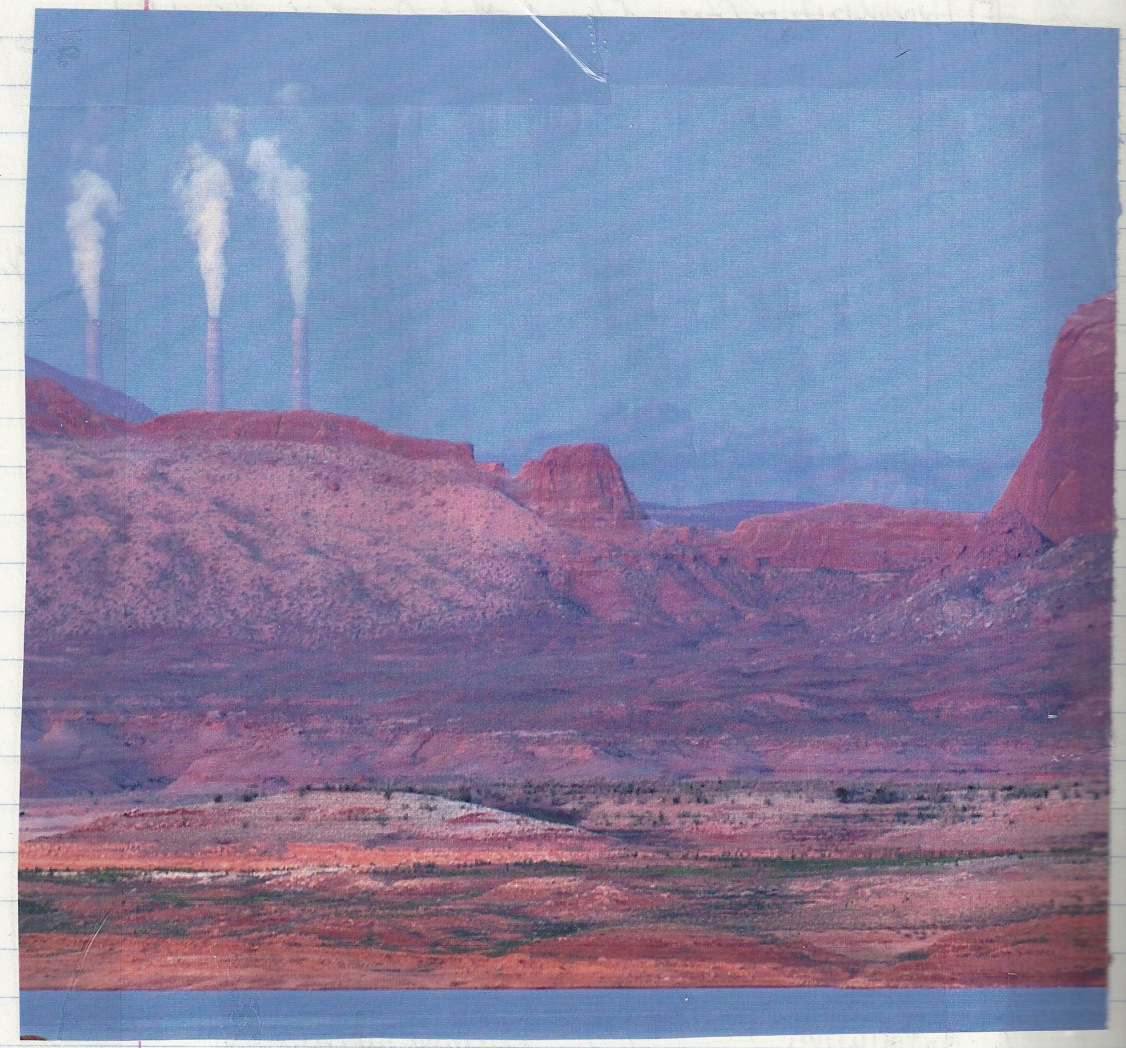


Worlds 20 wealthiest nations (< 1/5 population)
Consume 50% of worlds energy supply!

FULL NOTES UNIT 7

* DON'T FORGET TO USE the Supplement Unit Pages on the Website! *

ENERGY BASICS

Key Concepts:

- Energy is neither created nor destroyed, but is transformed from one kind to another.
- In all transformations, energy goes from more usable to less usable
- Energy efficiency is always less than 100%
- Industrialized countries consume disproportionately larger amounts of world's total energy
- Efficient use of energy & conservation can help make better use of world energy resources.
- Moving towards global sustainable energy planning with integrated energy planning is an important goal

Important Event: August 13, 2003 - East Coast Blackout - 50 million affected

- Demonstrated our dependence on an aging power distribution system; showed need to plan for the future
- American Clean Energy & Security Act of 2009 (4 parts)
  1) Clean Energy: Involves renewable energy, carbon sequestration, developing clean fuels & vehicles, & better electricity grid.
  2) Energy Efficiency: Buildings, homes, transportation, utilities
  3) Reduction of CO_2 & Greenhouse Gases: Reduce global warming
  4) Transition to Clean Energy Economy: Economic incentives for development of green energy jobs, exporting clean tech

All Usable Energy from Sun:
- Open curtains (solar)
- Burn wood (solar stored in tree)
- Fossil Fuels (solar stored in fossils)

The demand for energy (worldwide) is expected to increase by 50% by 2050
- Due To:
  - ↑ technology & it requirements for energy
  - ↑ human population (~9-10 billion)
    - Majority in developing countries

*Fossil Fuels will not meet demand beyond 2030!

Try Yourself

Demo:

Using Energy

Make An Electromagnet

- When electricity passes through a wire, it creates magnetism around it.
- To make stronger magnet wrap coils of wire around steel or iron, increase # of coils, or increase flow of electricity

Need: 9 Volt Battery, 3 ft of thin insulated wire, Large/thick screw (iron demagnetizer — Steel removes weak magnet)
Wire Cutters, Paper clips

1) Strip plastic from each end of the wire 2) Leave about 4 inch of wire & start wrapping ~20 tight & close loops around the screw working from one end to another. Continue by wrapping over the top

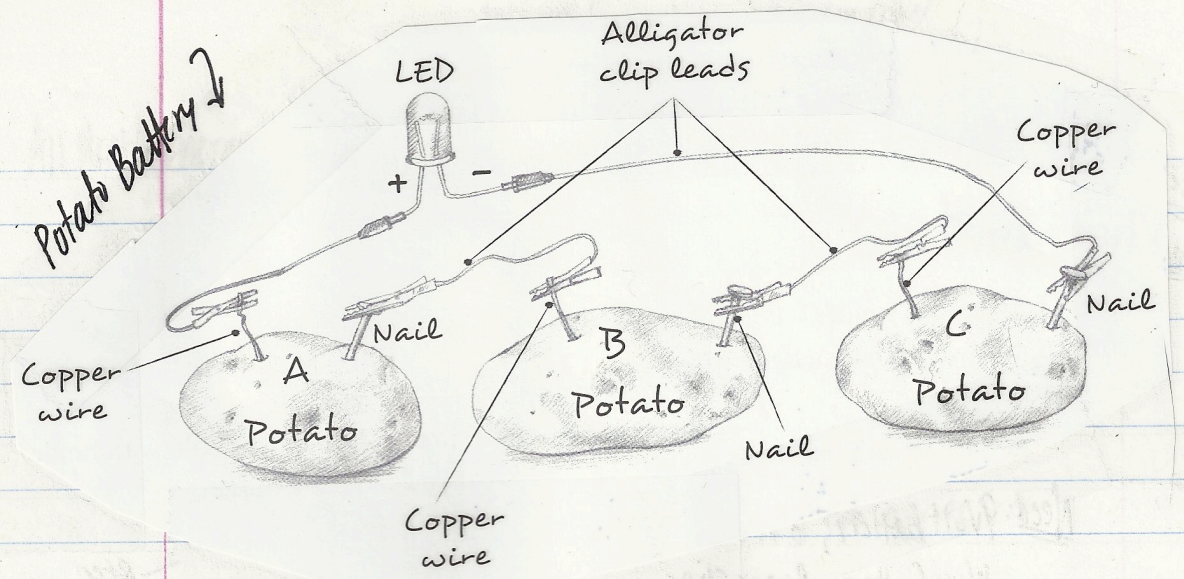
Make a Battery

Need: 3 potatoes, 3 2 inch pieces of single-strand copper wire
3 2-inch galvanized nails, 4 alligator clip leads, an LED
Sandpaper

1) Scruff the nail & copper wire until shiny → Insert w/o touching into potatoes
2) Connect Potato A Cu Wire to (+) of LED 3) Connect Potato C Nail to (-) LED
4) Connect Potato A Nail to Potato B Cu Wire 4) Potato B Nail to Potato C Cu Wire

Batteries produce electricity by a chemical rxn between 2 different metals (ELECTRODES) immersed in a liquid (ELECTROLYTES)
- Usually Copper/Zinc & Acid as electrolyte

Here: Copper Wire = Copper electrode
Zinc Nail = Zinc electrode
Potato = Electrolyte

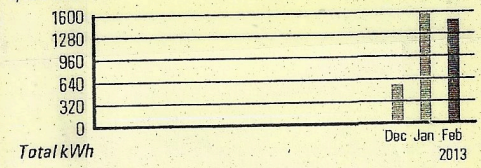


- Electricity is the flow of electrons through a substance
- Utility Companies bill us for the electricity we use → charged based on the # of KILOWATT HOURS (kWh) we have used in a month. (1 kW = 1,000 Watts)
  ... ie: If 1000 Watts (1 kW) of power is used for an hour, that is 1 kWh
- Converting electrical energy to heat energy requires a lot of electricity to obtain usable amounts of heat (stove, water heaters, hair dryers, etc.)

GEORGIA POWER
A SOUTHERN COMPANY

Total Used
1,480 kWh

Next Scheduled Read Date
On or after Mar 27, 2013



	1 Year Ago	Last Month	This Month
Total kWh Used		1,576	**1,480**
Average Daily kWh		49	**51**
Days In Billing Period		32	**29**

Current Electric Service - Residential

Next Scheduled Read Date: On or after Mar 27, 2013

Service Period	Meter #	Reading Type	Meter Reading Current	- Previous	x Constant	= Usage
Jan 29 - Feb 27	4293531	Tot kWh	26169	24689	1	1,480

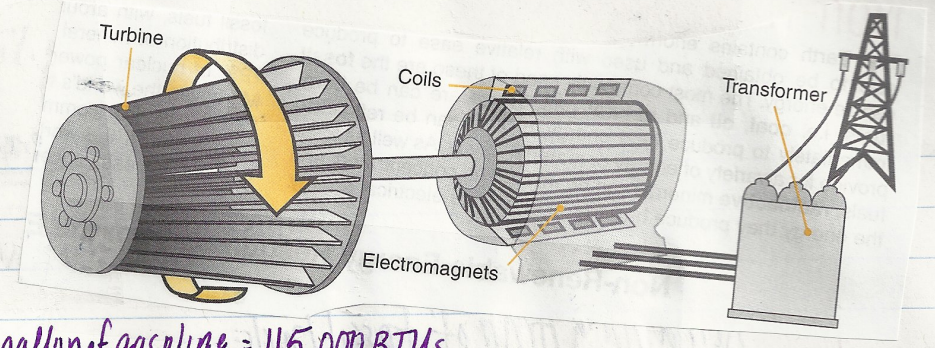
Billing Period
Jan 29, 2013 - Feb 27, 2013

Current Service	$ 129.53
Environmental Compliance Cost	8.13
Nuclear Construction Cost Recovery	6.16
Municipal Franchise Fee	4.19
Sales Tax	11.84
Total Current Electric Service	**$ 159.85**

$159.85 Bill

Total kWh used = 1480

GA Power charges $0.11 / kWh

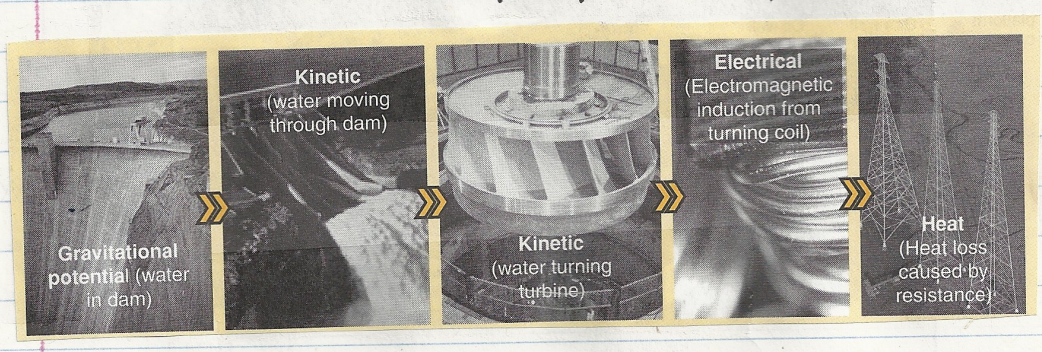


1 gallon of gasoline = 115,000 BTUs
1 kilowatt-hour = 3,413 BTUs

- Most commercial electricity is generated by transforming Kinetic Energy into Electrical Energy

  - KE turns a turbine attached to a magnet housed inside a large set of wire coils (the generator)
  - Moving the magnet through coils produces electricity = ELECTROMAGNETIC INDUCTION

- Energy is easily transformed
- Energy is always lost when it is transformed (Fewer steps = less lost)
  * (Removing reasons for energy loss ↑ efficiency)
  * (Incandescent Bulb = 5% usable, 95% lost as heat)
- The CAPACITY of an electricity generation plant ⇒ the INSTANTANEOUS Power Output
  (Plant with 1000 MW output can produce 1000 Megawatts of electricity at any one point in time)



Although oil fields have since been discovered, his prediction holds true. Regardless of exact amounts.
We identify fuel – we use it

Remaining Amts of Fossil Fuels:

OIL ~40 years
COAL ~200 years

Boom and Town A forest of derricks rises beyond a Signal Hill, California, neighborhood in this photo from the June 1941 *National Geographic*. Oil had been discovered there just 20 years earlier. The caption accompanying this photo notes: "If one man drills and strikes oil, his neighbor at once drills, too, lest the first drain the pool." Today the area's Long Beach oil field is much depleted, but it still yields more than a million barrels a year. According to John Huff, an engineer for California's Department of Conservation, extraction technology has moved on to more efficient pumping units. Huff's team at the Division of Oil, Gas, and Geothermal Resources placed this photo's scene at the corner of present-day Dawson Avenue and Village Way. Some of the houses pictured are still standing, but no derricks compete with the palm trees there anymore. —*Margaret G. Zackowitz*

85% of World Energy
(5% from nuclear)

NON RENEWABLE RESOURCES → FOSSIL FUELS (Oil, Coal, Natural Gas)
→ RADIOACTIVE MINERALS

- Provide immediate, low-cost power in the short term

→ Although we know the supply of fossil fuels is finite, there is discussion whether it matters or not.
  - Many believe we will apply creativity to the development of new energy sources.
  - In the meantime, total energy use continues to increase (even though energy per capita has leveled off).
    "We are using energy more efficiently in order to do what we need to do, but there are more of us and we are doing more things that use energy, our overall energy use has increased"

IN 1969, M. King Hubbert (a geophysicist & oil company employee) published a graph showing oil use.

"Hubbert Curve" - projected the point at which world oil production would reach a maximum & the point at which we would run out of oil.

- Used an upper estimate & a lower estimate.
- Oil extraction & use would ↑ steadily until roughly half the supply had been used up = PEAK OIL
- Extraction & use would then decline.

PETROLEUM (AKA CRUDE OIL)

→ "Petra" = rock, "oleum" = oil [Latin]

→ Fossil Fuel =
- Formed From Remains of ALGAE & ZOOPLANKTON that settled at bottom of shallow seas & lakes
- Buried & compressed under rock

→ Crude Oil can be refined and used for a variety of uses

→ 0.112 kg/kWh CO_2 emitted
0.005 kg/kWh SO_2 emitted

→ Composed of mixture of HYDROCARBONS (5 or more C atoms in a chain)

→ May be found in materials that make conventional drilling impossible.
- Oil Shale (Mined like coal & Oil washed from them)

Oil	
Advantages	Disadvantages
Large supply	Many reserves are offshore and difficult to extract
High net energy gain	High CO_2 production
Can be refined to produce many different fuel types	Potential for large environmental damage if spilled
Easy to transport	Rate of use will use up reserves in near future

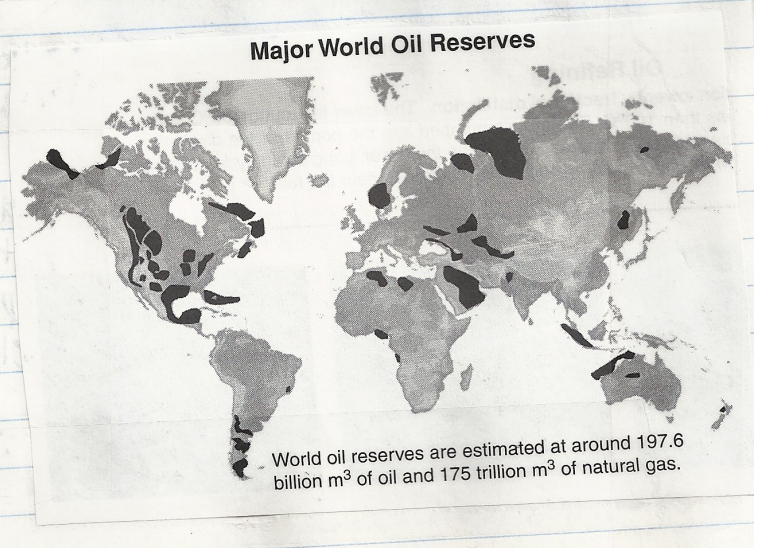
Petroleum & Transportation

- All transportation requires some form of energy
  → Automobiles run on Gasoline (refined product of petroleum)

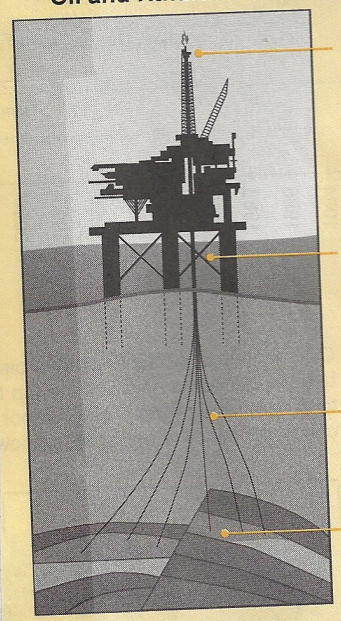
2012 World Gas Prices (per gallon)

1) Norway $10.12
2) Turkey $ 9.41
3) Israel $ 9.28
4) Hongkong $ 8.61
5) Netherlands $ 8.26
7) Italy $8.15
8) Sweden $ 8.14
9) U.K $ 7.87
10) France $ 7.79
25) NewZealand $6.55

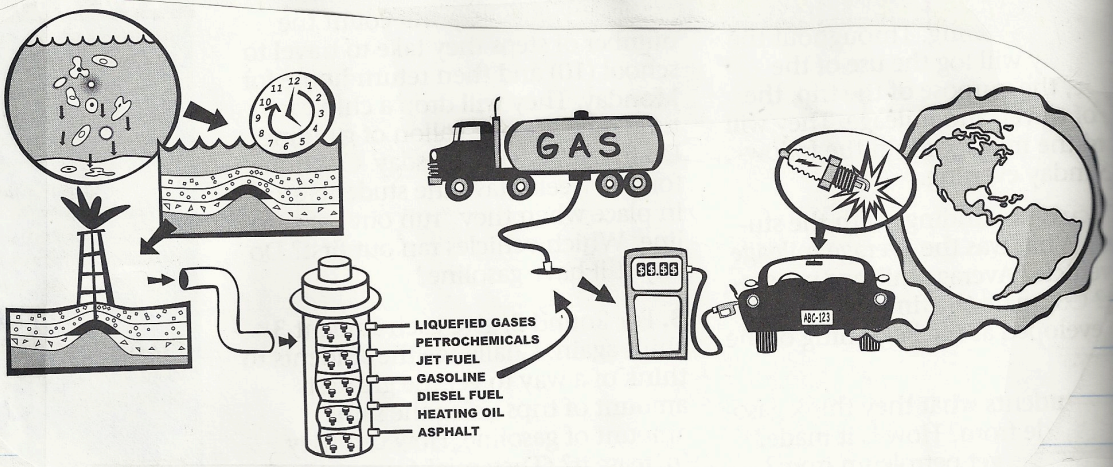
49) United States $ 3.75
Why? Govt Subsidies to oil production/consumption = 4.2 bill $



Oil and Natural Gas Extraction



Oil and natural gas reservoirs are found using a number of techniques including echolocation, gravitational and magnetic fluctuations, and geological surveys. A well is drilled once a reservoir has been located. Steerable drill heads allow multiple wells to be drilled without having to move the platform.

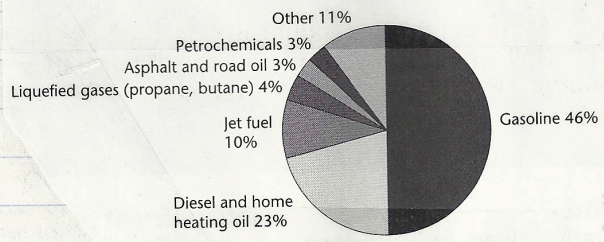


Fractionating Tower

This is a simplified graphic of the automotive fuel cycle.

REFINEMENT PROCESS: Convert Petroleum into useful products
1) Well removal, Pipeline transport
2) Treated to remove S, N, Metals
3) FRACTIONATION: Heat petroleum until boils, evaporates to "trays" at different boiling points → Re-liquifies

Diagram 1: Products from Crude Oil



(American Petroleum Institute, 2000)

* Oil is refined by Fractional Distillation...
The tower is ~400°C at the bottom, but cools towards the top to less than 100°C

Crude Oil is pumped to the bottom of the tower & evaporates. The oil vapor cools & condenses as it travels up the tower.

Short chain Hydrocarbons (condense near the top): ie Butane & Propane

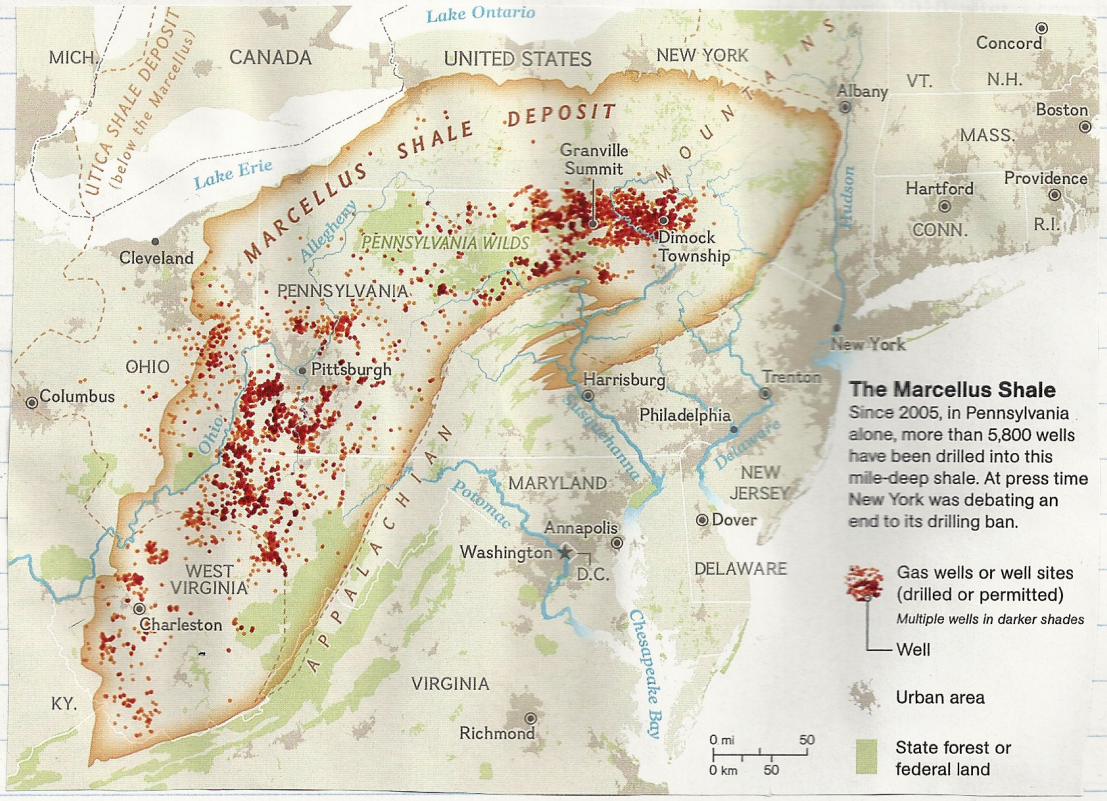
NATURAL GAS (not gasoline!!)

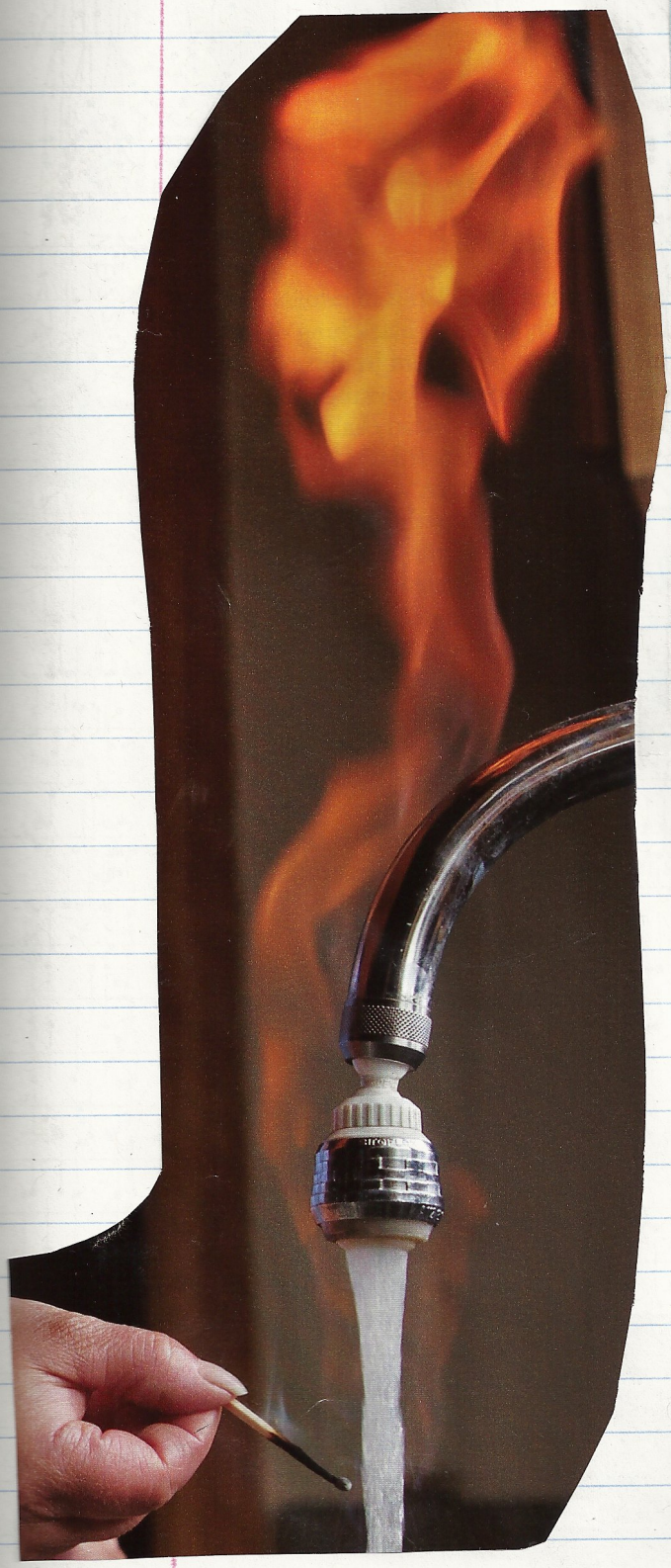
Natural Gas is a fossil fuel → Nonrenewable

- Often found in same reservoirs as oil
- Can be found as Liquid Natural Gas (LNG)

→ Composed of a mixture of hydrocarbons (4 or less C atoms)

→ 0.47 Kg/kWh of CO_2 Emitted
~0.0 Kg/kWh of SO_2 Emitted





Fracking dangers?

Obviously, the future of fossil fuels is looking dimmer than a four-week-old CFL bulb blinking its last flicker. (Just kidding — buy CFL bulbs!). But seriously, it's looking dimmer than a house full of CFL bulbs.

One clean energy source — natural gas — is plentiful and abundant, though vigorously huffing that natural gas out of the earth may have unintended consequences. Besides sounding like a curse word made up by third graders, what is Fracking?

First, a mix of unknown and copyright-protected/none-of-your-damned-business secret chemicals are pumped into the solid aquafer, shattering a once-great shale into pieces — leaving it a shadow of its former shelf. Natural gas is then briefly liberated only to have its hopes cruelly dashed as it is then captured, tamed, and bent to the will of man.

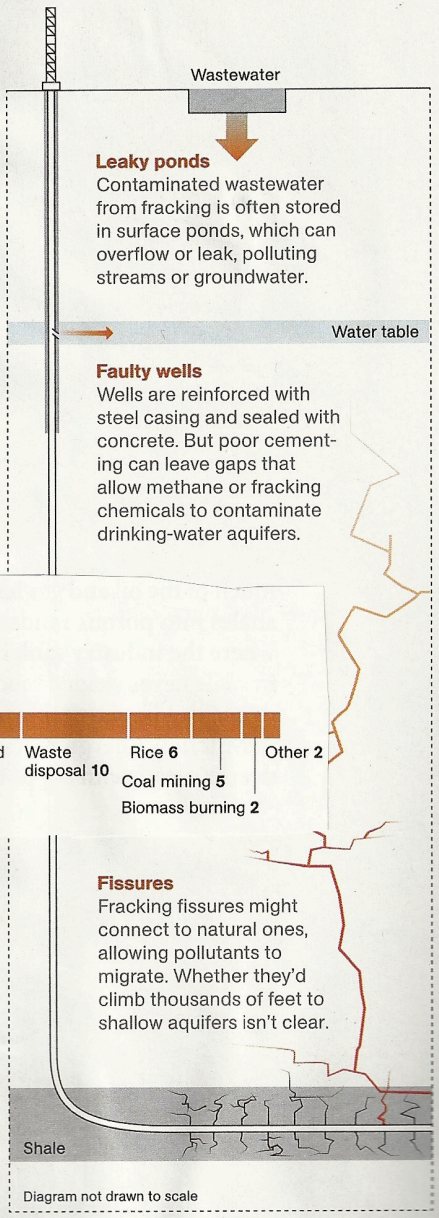
It has been widely reported that fracking has rendered drinking water "fracky-tasting." One man likened the taste to that of a bucket of water in which his beloved pet possum, Fracky Mc Frackerson theThird, expired and began decaying a week before. Another claim has been that showering has been made unsafe by virtue of bathing water being "so fracking explosive that the slightest shower-friction could result in a fracked-out explosion resulting in personal bodily fracture, if you will."

Other experts aren't familiar with the term, so the scientific jury is still out.

How to confirm there's methane trapped in an Alaska lake: pierce a pocket of ice with a spear, dangle a lit cotton swab over it. Escaping methane will create a flare.

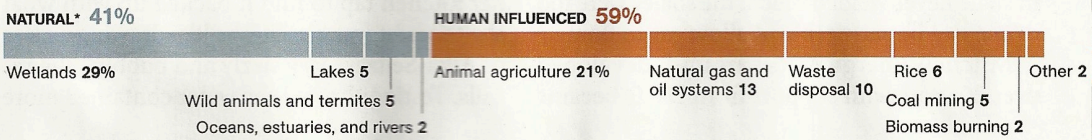
FEAR OF FRACKING

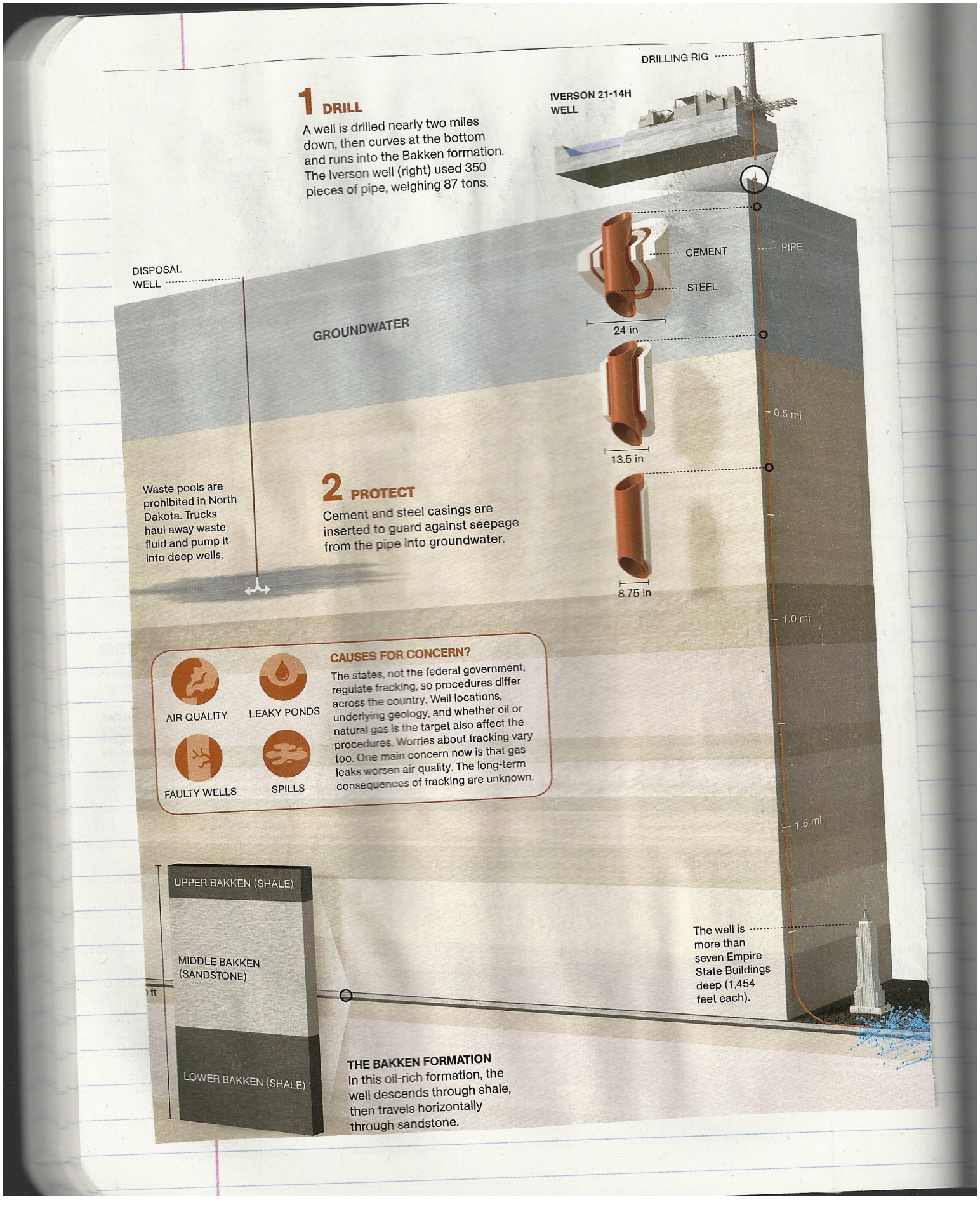
A key technique in shale drilling is hydraulic fracturing, aka fracking. A fluid mix of water, sand, and chemicals is pumped down the well at high pressure, creating fissures in the shale that let gas flow into the well. But the whole drilling process may also create pathways that allow gas or chemicals to pollute drinking water.



METHANE EMISSIONS *(global estimates)*

Human activities account for roughly three-fifths of methane emissions globally. In the U.S. the fossil fuel industry is the biggest emitter, surpassing livestock and manure.




1 DRILL
A well is drilled nearly two miles down, then curves at the bottom and runs into the Bakken formation. The Iverson well (right) used 350 pieces of pipe, weighing 87 tons.
DRILLING RIG
IVERSON 21-14H WELL
CEMENT
STEEL
PIPE
24 in
13.5 in
8.75 in
DISPOSAL WELL
GROUNDWATER
Waste pools are prohibited in North Dakota. Trucks haul away waste fluid and pump it into deep wells.
2 PROTECT
Cement and steel casings are inserted to guard against seepage from the pipe into groundwater.
0.5 mi
1.0 mi
1.5 mi
CAUSES FOR CONCERN?
AIR QUALITY
LEAKY PONDS
FAULTY WELLS
SPILLS
The states, not the federal government, regulate fracking, so procedures differ across the country. Well locations, underlying geology, and whether oil or natural gas is the target also affect the procedures. Worries about fracking vary too. One main concern now is that gas leaks worsen air quality. The long-term consequences of fracking are unknown.
UPPER BAKKEN (SHALE)
MIDDLE BAKKEN (SANDSTONE)
LOWER BAKKEN (SHALE)
ft
The well is more than seven Empire State Buildings deep (1,454 feet each).
THE BAKKEN FORMATION
In this oil-rich formation, the well descends through shale, then travels horizontally through sandstone.

Fracking the Prairie

There are three basic steps in hydraulic fracturing, or fracking, the pumping of fluids at extreme pressure into rock deep beneath the Earth's surface to extract the embedded oil. The oil well depicted here is the Iverson 21-14H, in western North Dakota. It plunges 10,500 feet to frack sandstone and shale in layers of rock called the Bakken formation. The area produces some 660,000 barrels of oil daily, which has created a boom for the state but has also given rise to concerns about the environmental costs.

THIS WELL'S FRACTURING FLUID

80.5% WATER

19% PROPPANT

Proppant is a combination of natural quartz sand and man-made ceramics. It props open fractures in the rock so oil can flow more freely.

0.5% CHEMICALS

Additives, many toxic, are used to inhibit bacterial growth, minimize friction, and increase viscosity.

WHERE DOES THE USED FLUID GO?

80% DISPOSED OF

Most is pumped into injection wells at least 2,500 feet below potable water.

20% RECYCLED

PRODUCTS USED IN LIFE OF ONE WELL

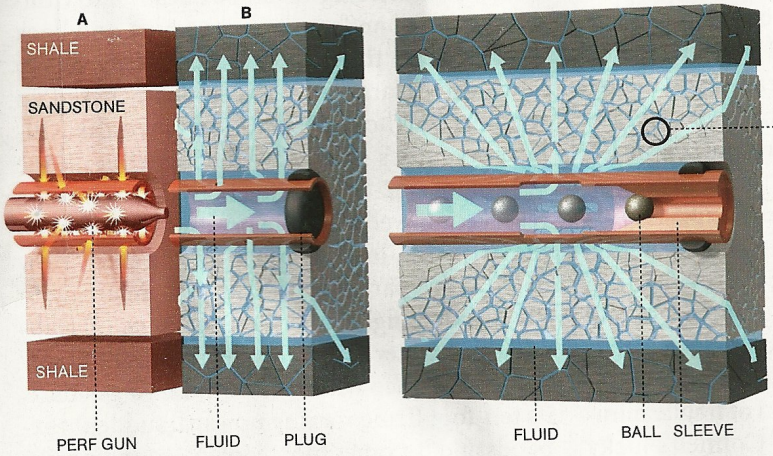
2 MILLION GALLONS OF WATER

4 MILLION POUNDS OF PROPPANT

350+ BARRELS OF CHEMICALS

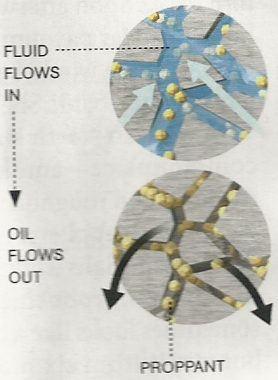
3 FRACTURE AND OIL FLOW

Fluid is pumped under high pressure down the well and into the rock to the end of the pipe, fracturing the rock in stages to release the oil. Two methods are used, with the sliding sleeve (below right) employed first.

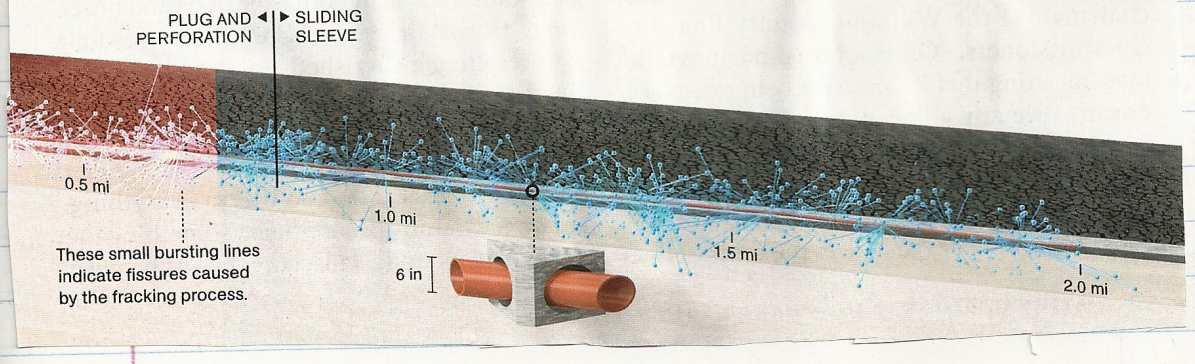


PLUG AND PERFORATION A plug blocks off a section of pipe, and a "perf gun" blasts small holes in the sandstone (A). Fluid is pumped in at high pressure (B), releasing the oil.

SLIDING SLEEVE Plastic balls are forced down the pipe, pushing open sliding sleeves to expose holes in the pipe. Fluid shoots out through the holes, fracturing the rock.



Fracking fluid expands cracks in the rock, releasing oil, which flows back up the well.



COAL

- Formed from remains of terrestrial plants buried in vast swamps during carboniferous era. Compacted under sediment
- Accounts for most of worlds energy needs.

- Removing from ground requires massive amts of energy. & causes intense destruction to the land.
- Produces vast amts of greenhouse gases & pollutants

→ 0.97 kg/kWh of CO_2 Emitted
0.006 kg/kWh of SO_2 Emitted

→ Longer time coal is in the ground = better fuel.
Highest grade (longest time): ANTHRACITE
Lowest grade = PEAT (high moisture content)
Mid-grades: Lignite, Bituminous

Coal	
Advantages	Disadvantages
Huge supplies (at least 500 years worth)	High CO_2 production when burned
High net energy yields.	High particle pollution from soot
Can be used to produce syngas and converted to other fuels (e.g. gasoline).	Low grade coals produce high pollution and contribute to acid rain
Relatively easy to extract when near to surface	High land disturbance through mining
Important in industry as coke (reducer)	

Coal is obtained by Mining...

SURFACE MINING (Strip Mining) - Coal bed near surface
Overburden (layers covering coal)
→ Area Strip Mining (remove coal in long strips)
· Overburden from one strip used to fill previous
→ Contour Strip Mining (similar, but on steep terrain)
→ Open Pit (big hole)

Subsurface Mining
· Room & Pillar (removes large area of coal, but leaves coal pillars to hold ground up)
· Long Wall Mining (cut from seam & falls on conveyor belt)

Major World Coal Reserves

Plant Vogtle.

ENVIRONMENT

Every few years, lawmakers must renew the Hazardous Waste Trust Fund, a program overseen by the Georgia Environmental Protection Division that pays to help clean up brownfields and toxic sites. Since 2004, however, state lawmakers have redirected much of that cash to pad the state budget and fund pet projects. That's not because the state doesn't have any hazardous sites. According to a July report from the EPD, there are currently more than 550 pieces of property on the list. More than 50 of those properties are located in Fulton County. Lawmakers are just more comfortable letting foul pieces of property fester rather than raise revenue to fix the budget shortfalls. When the trust fund comes up for renewal this year, political observers predict that lobbyists for local governments and environmentalists will push for the program's funds only to be spent on their stated purpose. Like last year, state lawmakers will surely try and preserve the funding flexibility they enjoy.

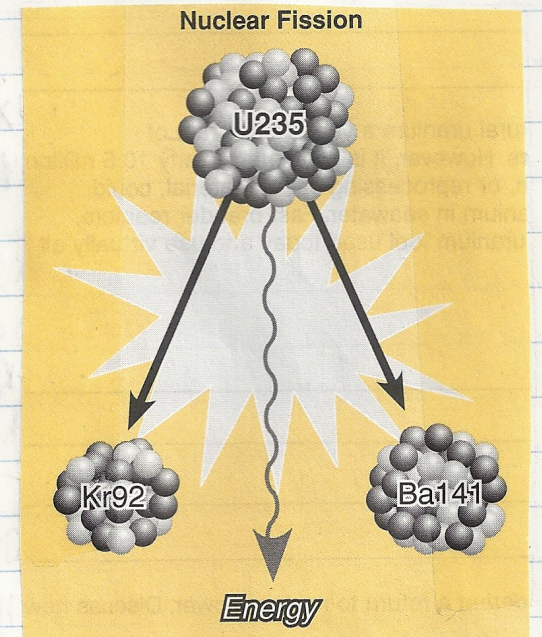
In addition, some lawmakers are expected to raise hell over how much Georgia Power customers should be on the hook for cost overruns of two new nuclear reactors at Plant Vogtle. In 2009, the General Assembly passed a bill allowing the utility to charge most ratepayers (big business's lobbyists carved out an exemption for their clients) in advance for the new reactors, the country's first in decades.

NUCLEAR POWER

Nuclear Power Generation	
Advantages	Disadvantages
Large potential fuel supply	High start up costs
Little fuel is needed so supplies last a long time	Disposal of waste presents major technical and environmental problems
Low air pollution (low CO_2 emissions)	Risk of catastrophic environmental disaster if accident occurs
Little land required	Technology can be adapted to develop nuclear weapons
Large amount of energy generated	Potential terrorist target

- Developed for industry in 1950s; > 400 reactors World wide
  Most located in United States & Western Europe
- Popularity declined in 1970s-80s due to high cost & 2 major incidents
- Today, technology is better & concern grows about energy demands. It is being reexamined as cost effective option for electricity
  - Setback? Fukushima Tsunami (2011)
  - Plant Vogtle (Augusta, GA) - 1st reactors built in U.S. in decades.

- Nuclear Energy is generated mostly from Uranium through FISSION → Splitting of nuclei of atoms, resulting in chain reactions that generate a lot of heat & light. This heat boils water to steam to drive generators

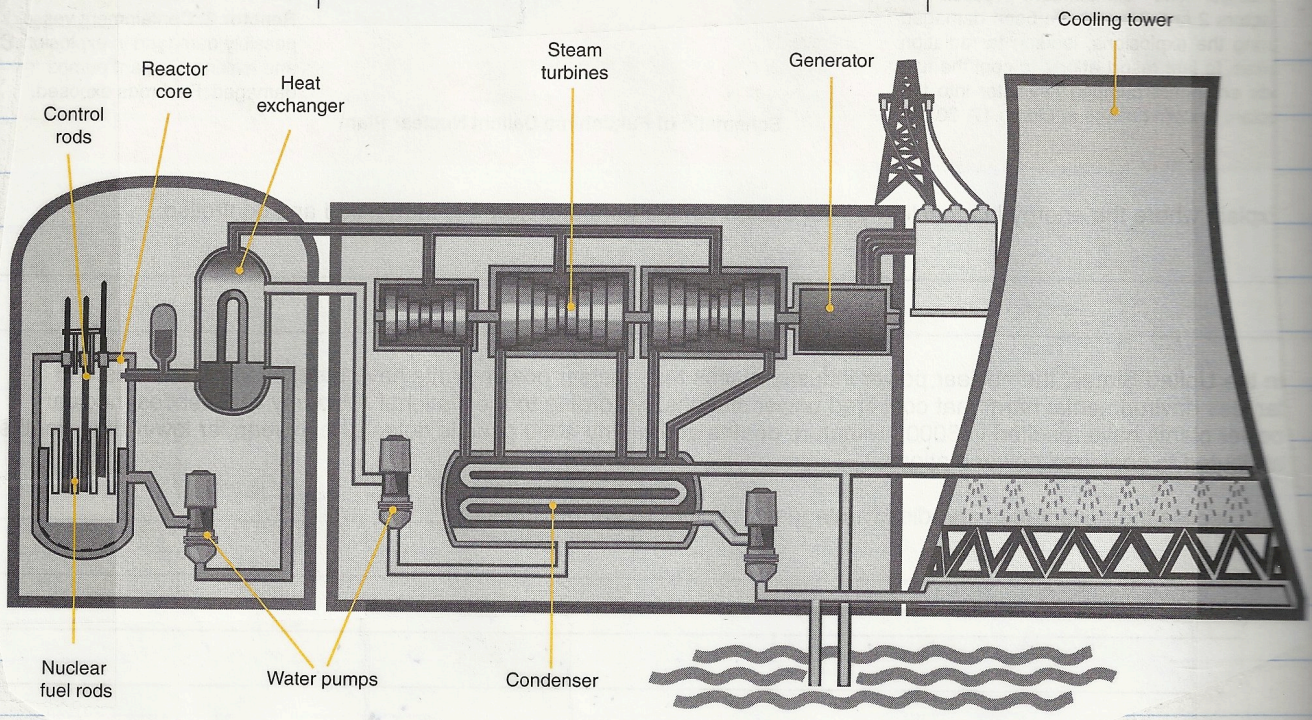


The energy in a nuclear reactor comes from the splitting of a **plutonium** or **uranium** atom. Part of the mass of the atom is converted into energy. The energy released is used to heat a heat sink (water or a metal or molten salt) surrounding the reactor.

The energy produced by nuclear reactions is enormous. **Uranium** subjected to fission produces around three million times as much energy as an equal mass of coal. However only a small percentage of this energy is used in nuclear power plants.

← Large Uranium deposits in New Mexico & Wyoming.

– Layout of Nuclear Power Station –



1 g of ^{235}U = 2-3 million x the energy of 1 g coal.
Uranium-235 is easily fissionable = Good Fuel

Ex Rxn: 1 neutron + $^{235}_{92}U \rightarrow {}^{142}Ba + {}^{91}Kr$ + 3 neutrons in Motion (KE)

The released neutrons energy produces a chain reaction

The Reactor: (containment structure)

- Uranium fuel is processed into pellets → Put into FUEL RODS
- A reactor contains 100s of fuel rods in the center (Reactor CORE)
- Nuclear fission generates heat → heat water circulating in a loop. This passes near another loop of water & transfers heat.
- steam is produced – turns turbine – turn generator

ENERGY CONSERVATION & EFFICIENCY

- Increase efficiency of energy usage!
- There is no <u>one</u> answer to solving all the worldic problems.
- Save Energy = Save Money

WHY? - 76% of all energy from power plants is for BUILDINGS
- Homes produce 2x the greenhouse gases of cars
- When we use electricity, a fuel burning plant is burning coal or natural gas to meet the demand
- CO_2 is produced as waste!
- Biggest Users: Space Heat, Water Heat, Lighting

- Energy Audits = Companies identify "leaks" of electricity

<u>Example Fixes:</u>
- <u>Lighting</u> = CFL (Compound Fluorescent)

(~1000 hrs) - Each incandescent bulb produces 10% light, 90% heat
(10,000 hrs) - CFLs are 75% more efficient (save $45)
- Switch One Bulb = keep ½ ton of CO_2 out of air
- If ALL USA switched to CFL; Retire 90 power plants

- LED (Light Emitting Diodes) "The Future"
  - Use least energy; last longest
- <u>SPACE HEATING</u>: 2/3 of electric bill (in winter)
  - ↑ Insulation, Windows, Caulking
  - Use the Sun
- <u>WATER HEATING</u>: Most electricity use
  - Turn heat to 120°F; add insulating blanket
  - Install tankless heater (heat on demand)
- <u>Power Strips</u>

★ The least expensive & most environmentally sound options for maximizing energy are...

① Conservation: Finding Ways to use Less Energy
- Small Scale = Home habits
- Large Scale = Gov't policy (Public Transportation)
(↑Tax = Use Less)
(Tax Credits for Retrofitting)

② Efficiency: Obtaining same work from smaller amount of energy.
- Switch to "Energy STAR" appliances (EPA program)

PEAK DEMAND

- Demand for Energy varies depending on time of day, season, & weather (When power plants can't handle the demand, Black Outs occur)

- We can reduce our electricity use by 100 kWh and are actually conserving 300 kWh of energy Resources (like coal)... How?
2nd Law of Thermodynamics = 2/3 Energy lost as heat.
∴ We save 100 kWh not used & the 200 kWh that would have been lost in conversion!

MASS TRANSIT: Large-scale public transportation serving a city or metro area.
Determines where people live, work, & amt of pollution
Worldwide = primary transportation; USA = 3%
Types: Light Rail, MagLev, Rapid Transit
Bus Rapid Transit, Tubular Rail

SUSTAINABLE DESIGN - Improve efficiency of buildings & communities

- Efficient building design
- City Planning (Businesses near homes = ↓ cars = ↓ pollution & fuel)

→ Buildings consume a lot of energy (cooling, heating, lighting)

- Utilize Passive SOLAR Design
  - Windows on South-facing wall = Sunlight enters & warms (especially in winter when Sun is prominent in S. sky)
  - Double-paned windows insulate while still allowing incoming radiation to warm.
  - Carefully plaud windows allow max. amt of light in & reduces need for artificial lighting.
  - Dark materials on roof & walls absorb energy
  - Light materials reflect heat away
  - In summer (Sun high in sky), overhanging roof helps block out sun during hottest period, thus reducing need for A/C.
  - Windows/shades reduce incoming radiation.
  - To reduce demand for heating at night & cooling in the day = use materials w/ High Thermal Inertia (ability to retain heat or cold)
    → High thermal inertia Materials stay hot once heated & cool once cooled.
    = Stone/Concrete
    (Wood/Glass have low thermal inertia)
  - Build into side of hill or roofing a building w/ soil & plants
    = Cool & shade buildings
    = Reduce Pollution

→ Use Recycled Building Materials (Reduce need for new materials)

What Is It?

The Governor's Energy Challenge helps Georgians conserve energy and save money.

Who Can Take The Challenge?

All Georgians are invited to take the Governor's Energy Challenge and reduce their energy use 15 percent.

Residents

- Find the best ways to save energy
- Save money on your monthly gas and electric bills
- Increase your home's value and resale potential

Schools

- Set a positive example for your students
- Teach tomorrow's leaders to be more conscious of natural resources
- Save money on monthly gas and electric bills

Businesses

- Attract customers who prefer conservation-minded companies
- Help the state improve its national energy efficiency rankings
- Save money on monthly gas and electric bills

Local Governments

- Support the Governor by matching the state goal
- Lead the challenge in your community
- Save money on monthly gas and electric bills

How Do I Pledge?

Visit **GovernorsEnergyChallenge.org**. Use the easy, interactive calculators to help reduce your energy use by 15% with no-cost, low-cost, and longer-term options. Your pledge will also help Georgia attain national recognition for its conservation efforts.

GOVERNOR'S ENERGY CHALLENGE

Printed on 100% recycled paper using vegetable-based ink.

U.S. Government

Federal law prohibits removal of this label before consumer purchase.

ENERGYGUIDE

Refrigerator-Freezer
x Automatic Defrost
x Top-Mounted Freezer
x No Through-the-Door-Ice-Service

Electrolux
FFTR1814LW
Capacity: 18.2 Cubic Feet

Estimated Yearly Operating Cost

$51

$42 — $52

Cost Range of Similar Models

479 kWh
Estimated Yearly Electricity Use

Your cost will depend on your utility rates and use.

RENEWABLE ENERGY

13% Energy Worldwide (Mostly Biomass)

7% Energy of United States (Biomass & Hydroelectric)

Why Is there demand?
- ↓ in easily obtainable non renewable energy
- ↑ in cost and use of non renewable energy
- Environmental damage from nuclear waste & burning fossil fuel

What is the hold up?
- Requires making changes to infrastructure
- Must meet large start up costs

The Outlook:
- Renewable technology are rapidly becoming more efficient & less expensive.

★ Conventional Energy Resources (Fossil Fuels, Nuclear Fuel) are in limited supply. (Depletion > Replenishment)

Potentially Renewable: Wood, Biofuel (depend on overuse)
Renewable (Non depletable)

★ Although Renewable Energies are More Sustainable, using ANY form of energy has environmental impacts!
Best approach → CONSERVATION & INCREASE Efficiency

Comparisons of Renewable and Non-Renewable Energy

	Capital cost per kW	Electricity cost per kW	Advantage	Disadvantage
Biomass	Low	Medium	Readily available resources	Often inefficient
Geothermal	High	Low	No-low emissions	Few accessible sites
Hydroelectric	Medium	Low	Medium to high net energy gain	River flow restrictions and damming
Solar	High	High	No emissions Can be made portable	Large amount of sunlight needed
Wave/Tidal	High	High	No emissions	Few dependable sires
Wind	Medium	Medium	No emissions	Not fully dependable
Coal	Low	Low	High net energy gain	High greenhouse emissions
Natural gas	Low	High	High net energy gain	High greenhouse emissions
Nuclear	High	Low	No emissions	Radioactive waste

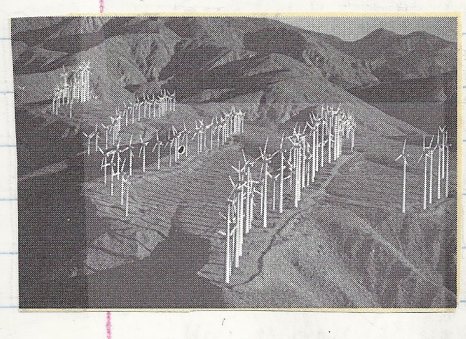
Net Energy = Moderate to High

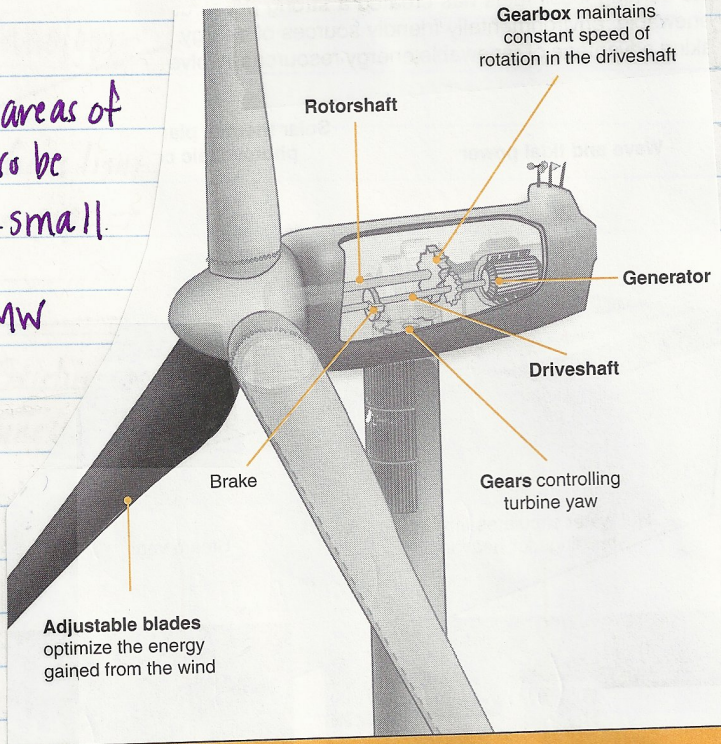
WIND POWER

* Most rapidly growing source of electricity!
* Sun is the source of all WIND! (Solar radiation & ground surface heating)

- Has been used for many years for mechanical energy (water pumps & machinery)... Today, mainly electricity
- 2009: Power output worldwide from wind = 1.5% of Energy
  Growing rapidly in popularity since.
- Harness Kinetic energy of WIND.

WIND FARMS often cover large areas of land, but turbines can also be designed to operate on a small scale & at sea.
- Largest turbines = 7-10 MW





Wind Power	
Advantages	Disadvantages
No emissions	Production of visual and noise pollution
Little ground disturbance during or after construction	Requires steady winds
Compact and transportable to most locations	Can interfere with the flight paths of flying animals
Can be located in many areas (even at sea)	Much of actual cost to user is repaying start up costs.
	Back up systems required in low winds

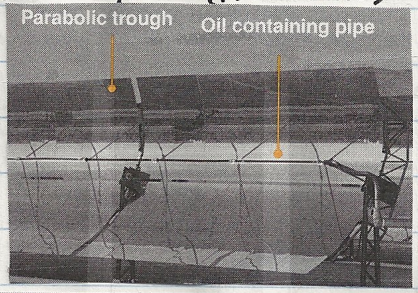
* USA has the largest wind generating capacity in the world!

* ONLY OBTAIN 1% of our energy from it!

↑ Also, can share land w/ farms

SOLAR POWER

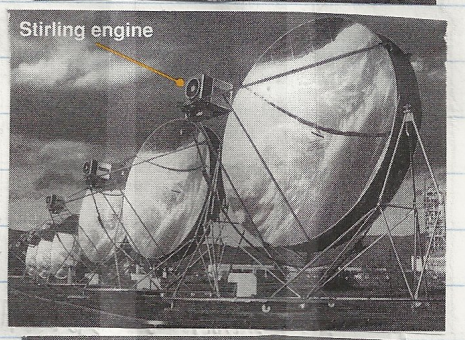
- Harnessing the TRILLIONS of JOULES of energy from the Sun per day.
- Multiple ways to capture this energy
- Currently, most large scale methods include CONCENTRATING SUNLIGHT to HEAT a FLUID (which turns water to steam)
- Solar Power Stations include Central Receiver System (Power Tower) & PARABOLIC DISHES.



I) ACTIVE SOLAR: Capture sun w/ technology →

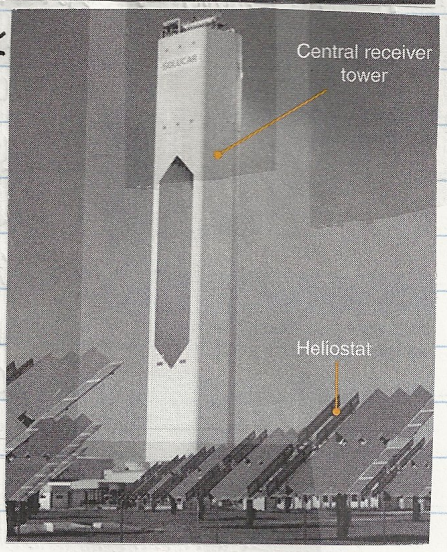
Distributed Receiver Systems

- Use Parabolic troughs to focus light in 1 beam.
- Light beam heats oil in a pipe → Oil heats H_2O



Parabolic Reflector Dishes →

- Focus light directly to a Stirling engine at the dish focal point (connected to a generator)
- Dishes move to follow Sun at most efficient ∡



Central Receiver Station →

- Uses mirrors (Heliostats) to focus rays to central tower
- Focused light heats H_2O or molten salts & is pumped to make steam.

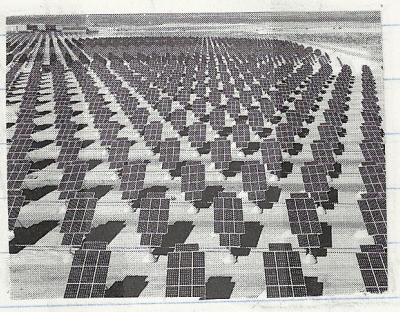
Solar Ponds

- Produce thermal gradient in a pool
- Hot H_2O pumped into heat exchanger & more turbines

← No turbine = produce electricity directly from sunenergy

SOLAR CELLS: Called Photovoltaic Cells - Produce electricity directly from light
- No emissions or fuel costs after install
- Energy can be used immed. or stored in batteries

Electricity is produced when a photon of light hits a semiconductor (ie silicon) and knocks an electron loose.
The electron is captured & forced to travel in one direction around a circuit = DC
-Current efficiency of solar cells = 40%



Solar Power	
Advantages	Disadvantages
Low or no CO_2 emissions	Ground shaded by large solar panels
Relatively high net energy gain	Back up systems required
Small photovoltaic cells are portable and can power many applications	Large land area needed for commercial scale production
Unlimited energy source during fine weather	High sunshine hours required
	High start up costs

↑ The amount of solar energy in a given place varies w/ cloudiness, time of day, & season.

(Reduce Reliance on Imported Energy)

Solar Water Heating Systems (ACTIVE)
- Can provide domestic hot water, heat pools
- Water is heated directly → Pumped to heating system.
  - Cold liquid is heated as it moves thru solar collector mounted on roof.

SOLAR HEATING

II) PASSIVE SOLAR (Passive Solar Heating) ie Windows
- Can efficiently heat homes while requiring no electrical input.
- Positioning house with main windows facing South (in N. Hemisphere) gain large amounts of energy in the day
- Double glazed windows & insulation help store the energy to keep houses warm at night.

*ACTIVE SOLAR Heating uses pumps to circulate heat gathered from a rooftop collector to various parts of the house.

Not a new concept... The Anasazi & Pueblos people of "4 Corners" built homes to capture heat in day & radiate at night.

Re-Emerged in the 1970s.

- In winter, Sun is Lower (South facing windows experience solar gains)
  - Occupants warmed through available windows
  - Must have things inside to absorb heat (thermal mass) → Night Release
    - Ex: Concrete Floors
  - Mass to Glass Ratio (Too much glass = Too hot)

ALSO... SOLAR OVENS
Besides energy implications, have saved many women in developing countries from having to risk gathering fuel.

Takes Advantage of solar radiation to maintain temperature

BIOMASS (2012's most widely used renewable resource)

BIOGAS (Methane)

Includes: Wood
Charcoal
Animal Products: Manure
Plant Remains
Municipal Solid Waste

Ethanol ← (Biofuels)
Biodiesel ←
Corn
Switchgrass
Hemp
Sugarcane

10% of World Energy

3.5% of U.S. Energy

* INEXPENSIVE/ABUNDANT
* "Modern Carbon" - Not "Fossil Carbon"
* Living or Dead Biological Matter used as a fuel

BIOFUELS: Processed or Refined Liquified BioMass

↑ Include Ethanol Gasahol Biodiesel

We're harvesting a new crop of biofuels.

SOLID BIOMASS:

- Wood, Charcoal, Manure -

To help meet the world's demand for renewable transportation fuels, BP is partnering with DuPont to develop an advanced generation of biofuels. The first of these, biobutanol, can be blended in gasoline or coblended with ethanol and gasoline and can be made using locally grown crops such as sugar beet, corn and wheat. This new fuel has the potential to lower overall greenhouse gas emissions while reducing dependence on oil and expanding agriculture markets.
It's a start.

bp

beyond petroleum®

- In the US, most biodiesel is from soybeanoil or processed vegetable oil.
  → ALGAE has great potential
    - 15-300x more fuel per area
    - Grown in as little as 3 days & anywhere.
    - Less emission than diesel

Production of Biomass May Include:

Composting (soil conditioning & fertilizer)
Anaerobic Digestion (produces Methane (CH_4) gas & fertilizer sludge)
Fermentation/Distillation (Produces ethyl alcohol)
Pyrolysis (heat in absence of air → produces flammable gas)
Hydrogasification (produces Methane & Ethane)
Hydrogenation (Converts biomass to oil)
Acid Hydrolysis (Produces sugars from wood waste)

Gasohol

Gasohol is a blend of finished motor gasoline containing alcohol (generally ethanol but sometimes methanol). In Brazil, gasohol consists of 24% ethanol mixed with petrol.

Advantages

- Cleaner fuel than petrol
- Renewable resource
- Creates many jobs in rural areas

Disadvantages

- Ethanol burns hotter than petrol so petrol engines tend to overheat and they need to be modified
- Fuel tank and pipes need coating to prevent corrosion by ethanol
- Fuel consumption 20% greater compared with petrol

Sources of biomass for ethanol production

- Sugar cane (ethanol is produced in this way in Brazil).
- Corn starch (in the USA).
- Grass, certain waste materials (paper, cardboard), and from wood. Fast-growing hardwood trees can be treated to release cellulose. Once released, it may be converted to simple glucose by hydrolytic enzymes and then fermented to produce ethanol.

Biogas

Methane gas is produced by anaerobic fermentation of organic wastes such as sewage sludge at sewage waste treatment stations, animal dung, agricultural wastes, or by the rotting contents of landfill sites.

Stages in methane production

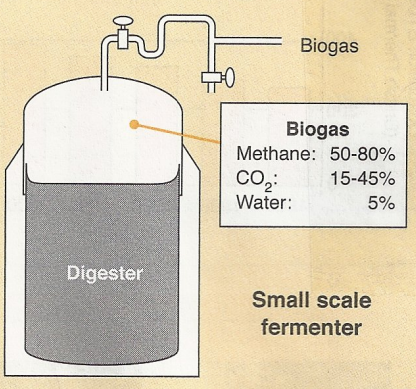
Saprophytic bacteria (facultative anaerobes) break down fats, proteins, and polysaccharides.

↓

Acid-forming bacteria break down these monomers to short-chain organic acids.

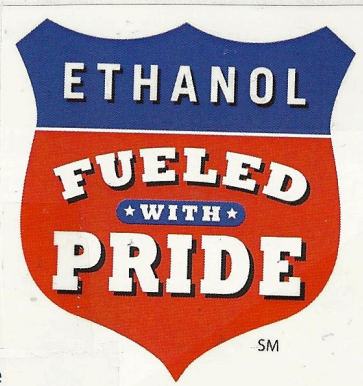
↓

Methanogen bacteria (strict anaerobes) produce methane gas.



Small scale fermenter

ETHANOL (substitute for gasoline)
- Convert starches & sugar in plants into alcohol & CO_2.
- Made from corn, sugarcane



*USA is world leading producer of Ethanol
(But are only 0.6% of US Energy Supply)

Ethanol reduces harmful tailpipe emissions and air pollution. Just as important – it reduces our dependence on foreign oil, because we grow the crops and process them right here at home. You can use E10 in every vehicle manufactured after 1980, E15 in every light duty vehicle manufactured after 2000, and you drivers of flex-fuel vehicles (FFVs) can use blends up to E85 (85% ethanol, 15% gasoline). Today's ethanol is just the first generation of biofuels. There are even better things to come.

BIODIESEL (Substitute for diesel)
- More expensive than diesel
- Typically found in US as B-20
- Because of solidification, higher concentrations of Biodiesel need Modified engines.
- Can run on Waste Vegetable Oil

Usually mixed w/ Gasoline (10% ethanol) = "GASAHOL"

* 7 Million FFV in USA → Most owners don't know they can use E-85

* Are Biofuels any better than fossil fuels? They DO release carbon into the atmosphere...
  - Depends on how the material is harvested & how the land is treated. Also how long the carbon has been stored.
  - With modern carbon, this was recently in the atmosphere with fossil carbon, it has been locked up for millions of years.
  - By planting & burning Biomass, the atm. carbon should be exchanged at a rate that creates no NET increase in CO_2, while fossil carbon creates rapid increase.

IN THEORY → This is Hotly debated

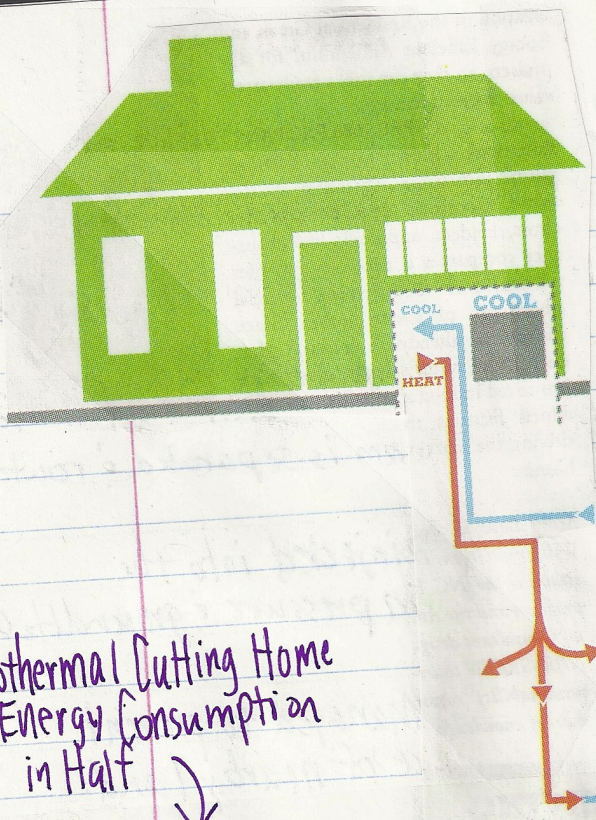
Ethanol Cons: • Bonds have ↓ energy; Gasahol reduces mileage by 2-3%
• Growing corn uses significant amt of fossil fuels
• ↓ land for growing food

GEOTHERMAL <1% of USA Energy

- Geothermal Power Stations operate where Volcanic activity heats ground H_2O to STEAM.
- Holes (bores) drilled into the ground release the steam & transfer it via insulated pipes where dry steam is separated & routed to turbines.
- ★ - Steam is then condensed to water & reinjected into the GEOTHERMAL RESERVOIR to maintain pressure & ground H_2O supply
- Geothermal Fields MUST be carefully managed to prevent depletion of reservoir & subsidence of nearby land.

- Geothermal Energy made from FISSION of radioactive Earth material
  ⇒ Heat release - Heats groundwater
- 20% Efficient; however waste hot water can be used for other industrial operations (heating ponds for shrimp in temperate environments)
- Geothermal heat pumps: Used in many homes
  - Pumps fluid from roof to floorspace into the ground.
  - In summer, this transfers heat from house to ground, cooling the house.
  - In winter, transfers heat from ground to home
  - Don't have to be in geothermal areas.

Geothermal Power	
Advantages	Disadvantages
Moderate to high net production of usable energy	Few suitable sites
Moderate CO_2 emissions	Easily depleted if not carefully managed
Low cost (in suitable areas)	Noise and odour pollution
Low environmental impact if managed correctly	Land subsidence possible



Uses:

① Directly used as a heat source
- Hot groundwater piped into home radiators for heating a home.

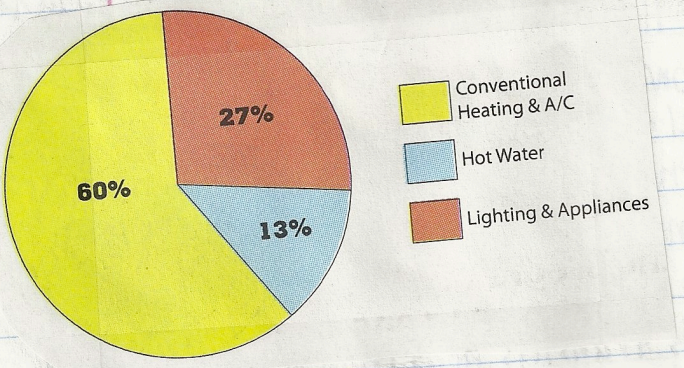
② HEAT EXCHANGERS:
Liquid pumped underground & warmed → returned to surface

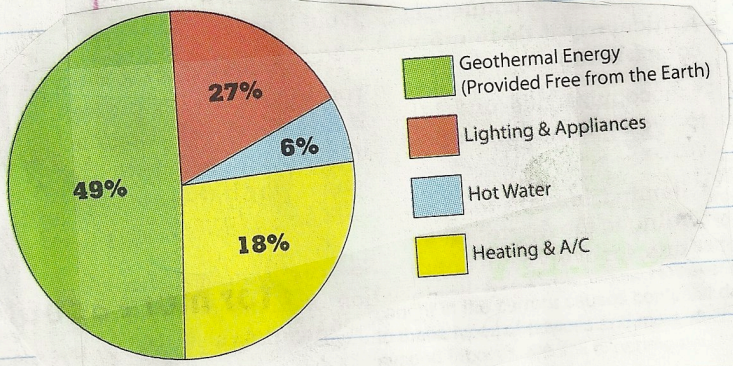
③ ELECTRICITY:
steam turbine
* "DRY STEAM" OR "HOT WATER" *

* Heat is nondepletable, but groundwater that carries it up is not!

To sustain it, H_2O is returned to the ground after it is used.

Geothermal Cutting Home Energy Consumption in Half ↓





(#2)

HYDROELECTRICITY → 7% of US ELECTRICITY → 20% of World Electricity

1) China
2) Brazil
3) USA

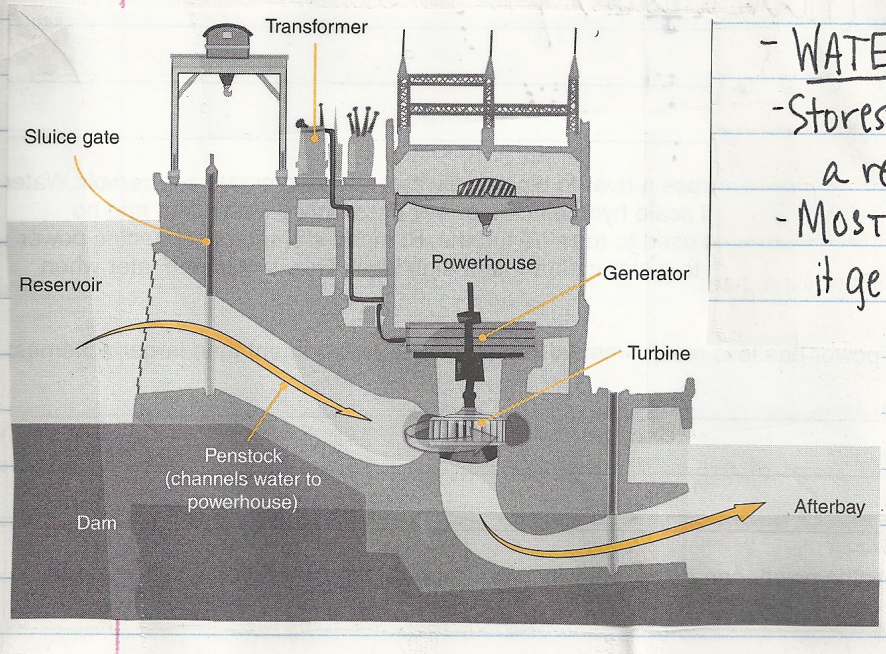
- Produces electricity by utilizing the kinetic energy of water stored in reservoirs behind dams
- Water moves along pipes into the powerhouse where it drives turbines connected to a generator.
  - ↑ Volume of water, ↑ the fall → Greater energy
  - Large dams = Large amt of energy

MOVING WATER CONTAINS KINETIC ENERGY

Hydroelectricity	
Advantages	Disadvantages
High net energy gain	High construction costs
High efficiency (high percentage of energy converted into electricity)	River diversions during and often after construction
Produce reservoirs that can be used for recreation and irrigation	High initial CO_2 production from reservoir as drowned material rots
Provide flood control	Dams Interfere with fish migration
Long life spans	Drown river valleys behind dam

TYPES:

- RUN OF THE RIVER: Water retained behind a low dam and runs thru a channel before returning to the river.
  - Generally smaller scale & rely on Natural waterflows.
    → Can't generate in dry, hot periods w/ low flow.



- WATER IMPOUNDMENT:
  - Stores water behind dam in a reservoir
  - Most Common type because it generates on demand.
    - Gates can be opened or closed.
      = Determine flow thru electricity.

Hydrogen Fuel Cells

"Converts H & O into H_2O & electricity"

- Operates like a battery w/ one key difference
  - → In a battery, reaction occurs in a closed container until reactants are used up.
    In a fuel cell, reactants are continuously added to the cell, so it makes electricity for as long as it is supplied w/ food.

$$2H_2 + O_2 \longrightarrow \text{Energy} + 2H_2O$$

Hydrogen Oxygen Water

(Forces protons (+) from H_2 through a membrane, electrons move different route = generates current)

*Requires supply of Hydrogen (relatively rare in atmosphere)

★ Energy Policy Act of 2005 (EPACT) AND Advanced Energy Initiative of 2006 =

- Hydrogen Fuel Initiative (HFI) = develop hydrogen fuel cell technology and infrastructure to make fuel cell vehicles practical & cost effective by 2020