




## NON-RENEWABLE ENERGY



## Non-renewable

ALL ENERGY USE HAS CONSEQUENCES

**Definition:** An energy source with a finite supply. Once they are used up, they cannot be replenished on a human time-scale.

**Two Primary Categories:**

1. Fossils Fuels
2. Nuclear Fuels

 BIOMASS	 COAL	 GEOTHERMAL	 HYDROPOWER	 NATURAL GAS
 PETROLEUM	 PROPANE	 SOLAR	 URANIUM	 WIND

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NATURAL GAS



PETROLEUM



PROPANE



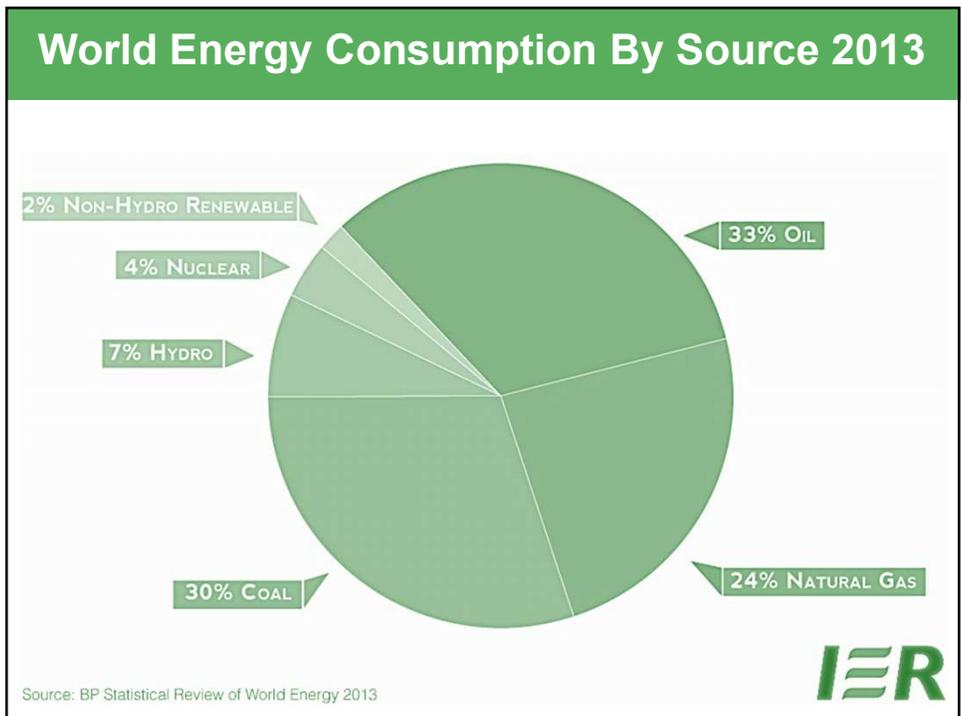
SOLAR



URANIUM



WIND



## Did You Know?

1. Which of the following is *not* a nonrenewable energy source?

- A. Oil
- B. Coal
- C. Natural Gas
- D. Wind
- E. Nuclear Fuels



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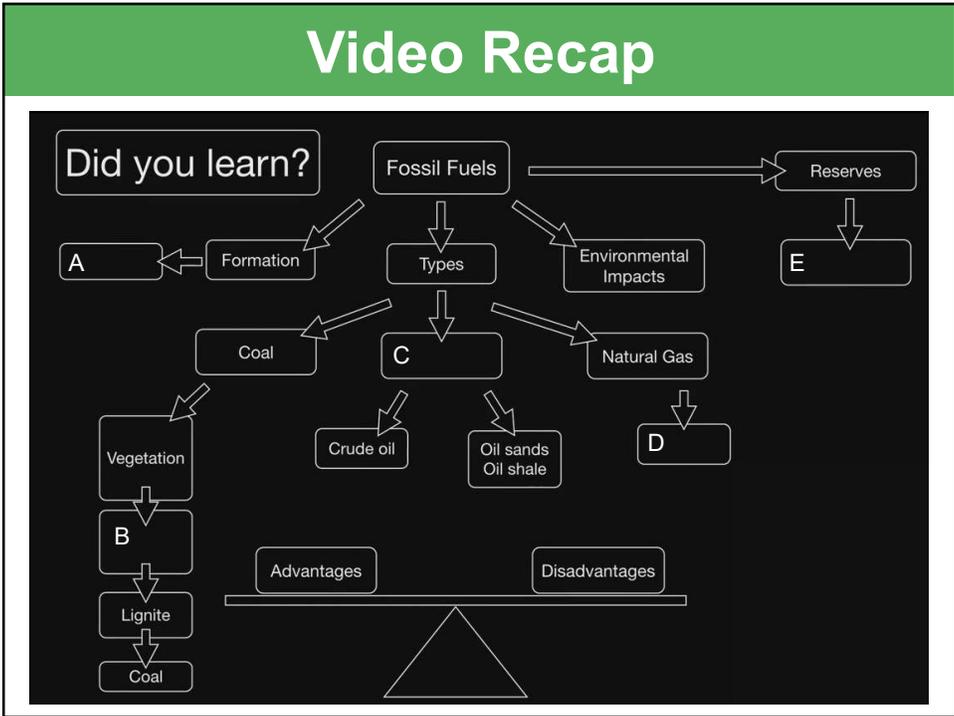
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# Fossil Fuels

**bozeman**  
science.com

presents



## Fossil Fuels

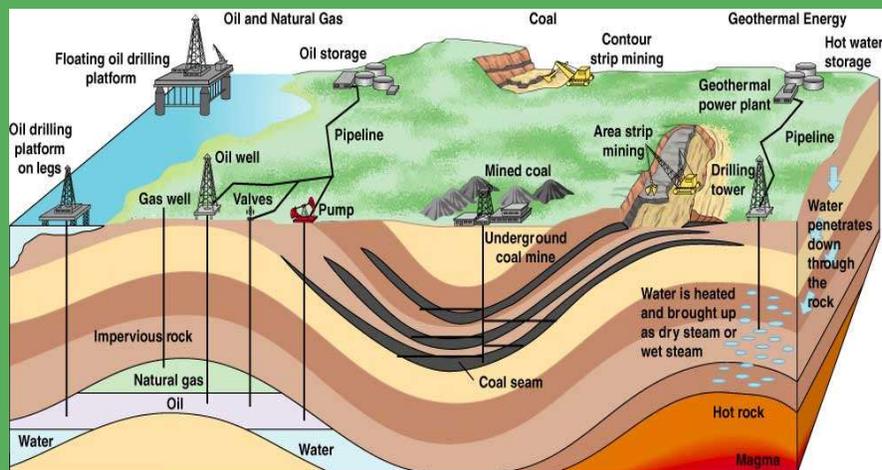
Fossil fuels originated from the decay of living organisms millions of years ago, and account for about 80% of the energy generated in the U.S.

The fossil fuels used in energy generation are:

- A. **Petroleum (Oil)** - extracted hydrocarbons in liquid form
- B. **Natural gas** - 70 to 80 % methane ( $CH_4$ ); gaseous hydrocarbons
- C. **Coal** - a solid mixture of large molecules with a H/C ratio of about 1



## Overview of Energy Extraction

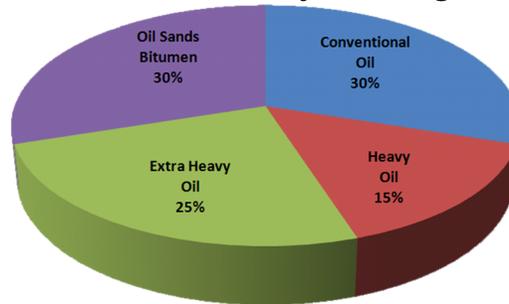


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# Oil

Deposits of crude oil, produced by the decomposition of deeply buried organic matter from plants & animals, are trapped within Earth's crust and can be extracted by drilling a well.

**Crude oil: complex liquid mixture of hydrocarbons, with small amounts of S, O, N impurities**

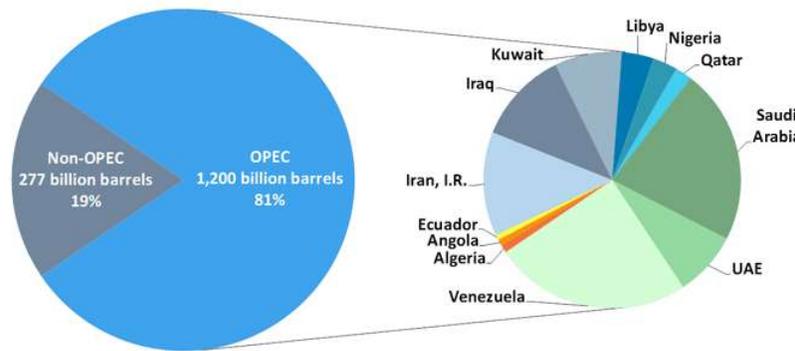


Black Gold, Texas Tea...



# Major Contributors...

OPEC Share of World Crude Oil Reserves 2012



OPEC proven crude oil reserves, end 2012 (billion barrels, OPEC Share)

Venezuela	297.7	24.8%	Iraq	140.3	11.7%	Libya	48.5	4.0%	Algeria	12.2	1.0%
Saudi Arabia	265.9	22.1%	Kuwait	101.5	8.5%	Nigeria	37.1	3.1%	Angola	9.1	0.8%
Iran, I.R.	157.3	13.1%	United Arab Emirates	97.8	8.1%	Qatar	25.2	2.1%	Ecuador	8.2	0.7%

Source: OPEC Annual Statistical Bulletin 2013

# Oil Use in the United States

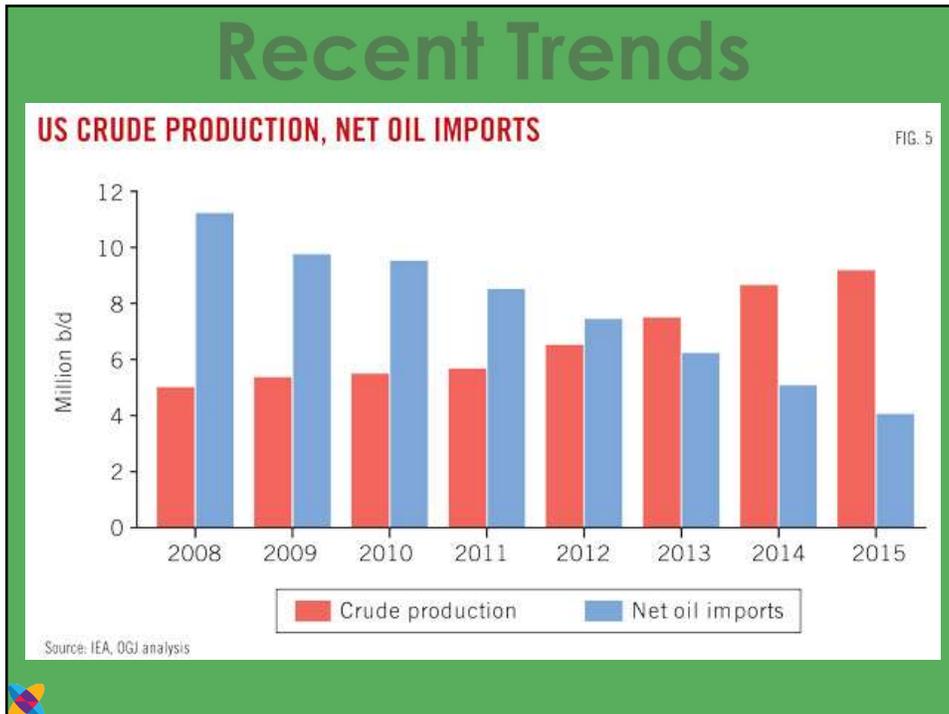
**FACTS:**

*2.3% of world reserves uses nearly 30% of world reserves.*

*65% for transportation.*



*Oil deposits marked in blue.*



# Hydraulic Fracturing

WHAT IS FRACKING?



## Advantages and Disadvantages of Oil



1. Supply expected to last 50 – 85 years
2. Historically low cost due to huge subsidies
3. High net energy yield
4. Easily transportable

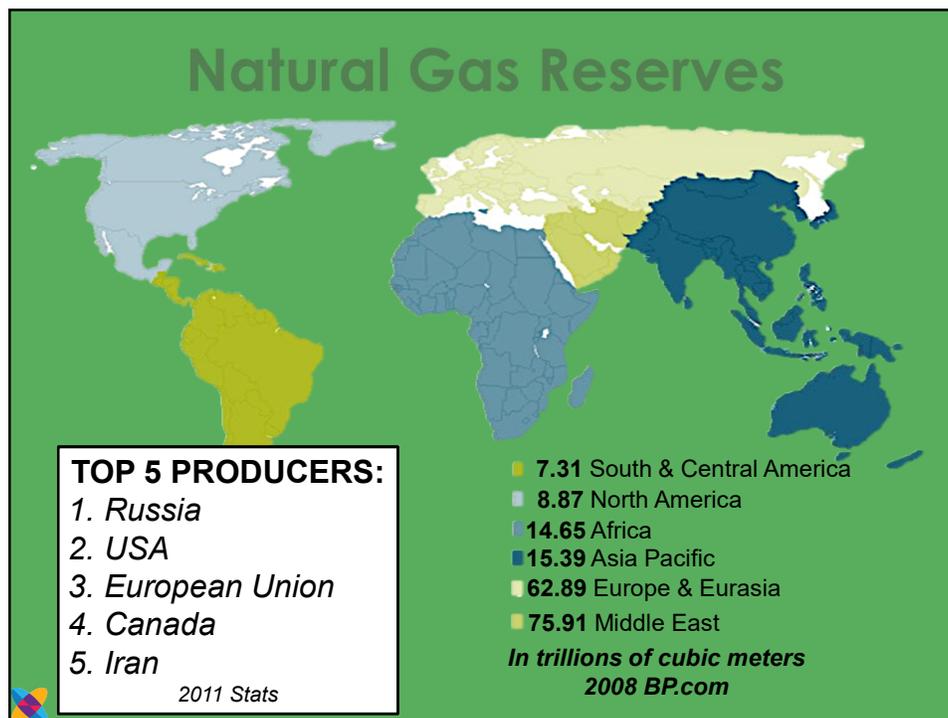
1. Supply expected to last 50 – 85 years
2. Historically low cost encouraged waste and discouraged alternatives
3. Air pollution when burned
4. Releases CO<sub>2</sub> when burned



## Natural Gas

Natural gas is a naturally occurring hydrocarbon gas mixture containing:

- **70–80 % Methane ( $\text{CH}_4$ )**
- **Propane ( $\text{C}_3\text{H}_8$ )**
- **Butane ( $\text{C}_4\text{H}_{10}$ )**
- **Hydrogen sulfide ( $\text{H}_2\text{S}$ )**



## Natural Gas

1. When a natural gas field is tapped, propane and butane are liquefied and removed as liquefied petroleum gas (LPG).
2. The rest of the gas (mostly methane) is dried, cleaned, and pumped into pressurized pipelines for distribution.
3. Liquefied natural gas (LNG) can be shipped in refrigerated tanker ships.



### Advantages and Disadvantages of Natural gas

1. Supply expected to last 125 – 200 years
2. Historically low cost with huge subsidies
3. High net energy yield
4. Easily transportable by pipeline
5. Lower CO<sub>2</sub> emissions than other fossil fuels

1. Leaks of methane (GHG)
2. Shipped as liquid natural gas (LNG) which is highly explosive
3. Releases CO<sub>2</sub> when burned

## Did You Know?

2. Which of the following statements regarding petroleum is correct?

- I. It is formed from the decay of woody plants.
  - II. It contains natural gas as well as oil.
  - III. It migrates through pore spaces in rocks.
- A. I, II and III
  - B. I and II
  - C. II only
  - D. I and II
  - E. II and III



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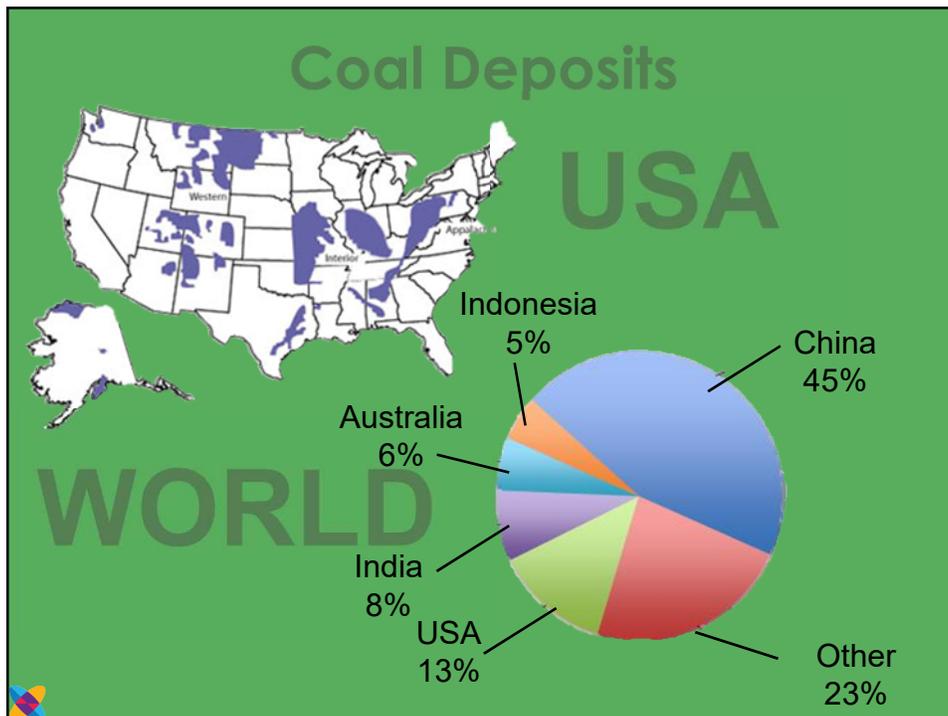
## Types of Coal

**Lignite:** A brownish-black coal of low quality (i.e., low heat content per unit) with high moisture content.

**Sub-bituminous:** Black lignite, is dull black and generally contains 20 to 30 percent moisture.

**Bituminous:** Most common coal is dense and black. Its moisture content usually is less than 20 percent.

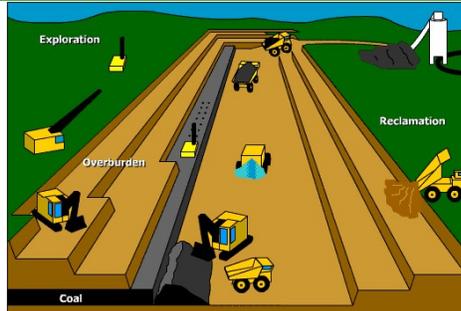
**Anthracite:** Hard, black lustrous coal, often referred to as hard coal. Highest percentage of fixed carbon.



## Types of Coal Mining

Surface mining - used to retrieve shallow mineral deposits

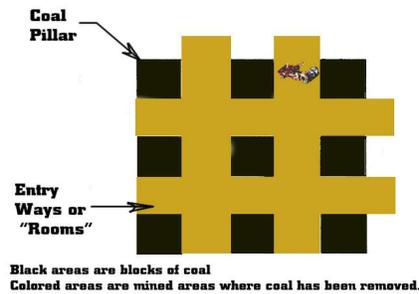
1. Strip Mining - overburden is removed in strips
2. Mountaintop Removal - mountain tops are completely removed. Debris is dumped into the valleys.



## Types of Coal Mining (cont.)

Subsurface mining - removal of deep deposits of minerals

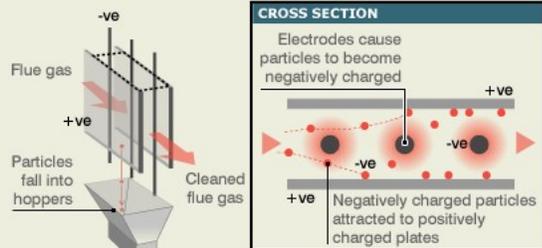
1. Room-and-pillar Method - named, because pillars of coal are left standing to help support the roof of the mine
2. Long-wall Method - More dangerous and more expensive than surface mining; however, damages much less of the surface land.



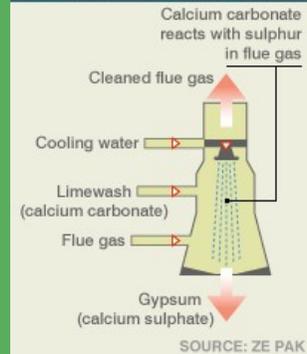
## Cleaning Up Coal

When coal is burned, sulfur is released primarily as sulfur dioxide along with particulate matter.

### ELECTROSTATIC PRECIPITATION



### REMOVING SULPHUR DIOXIDE



## Advantages and Disadvantages of Coal



1. Most abundant fossil fuel
2. Major U.S. reserves
3. 300 yrs. at current consumption rates
4. High net energy yield

1. Dirtiest fuel, highest carbon dioxide emissions
2. Major environmental degradation
3. Major threat to health

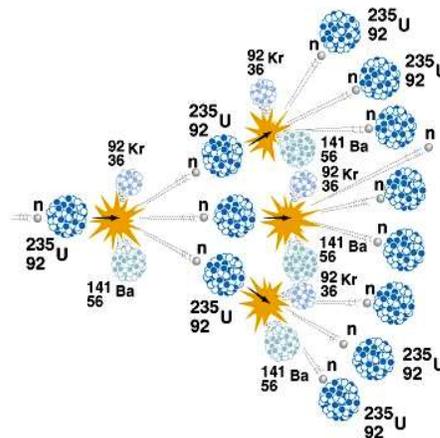
## Problems With Fossil Fuels

1. Fossil fuels are nonrenewable resources -  
At projected consumption rates, natural gas and petroleum will be depleted before the end of the 21st century
2. Impurities in fossil fuels are a major source of pollution
3. Burning fossil fuels produce large amounts of  $\text{CO}_2$ , which contributes to global warming



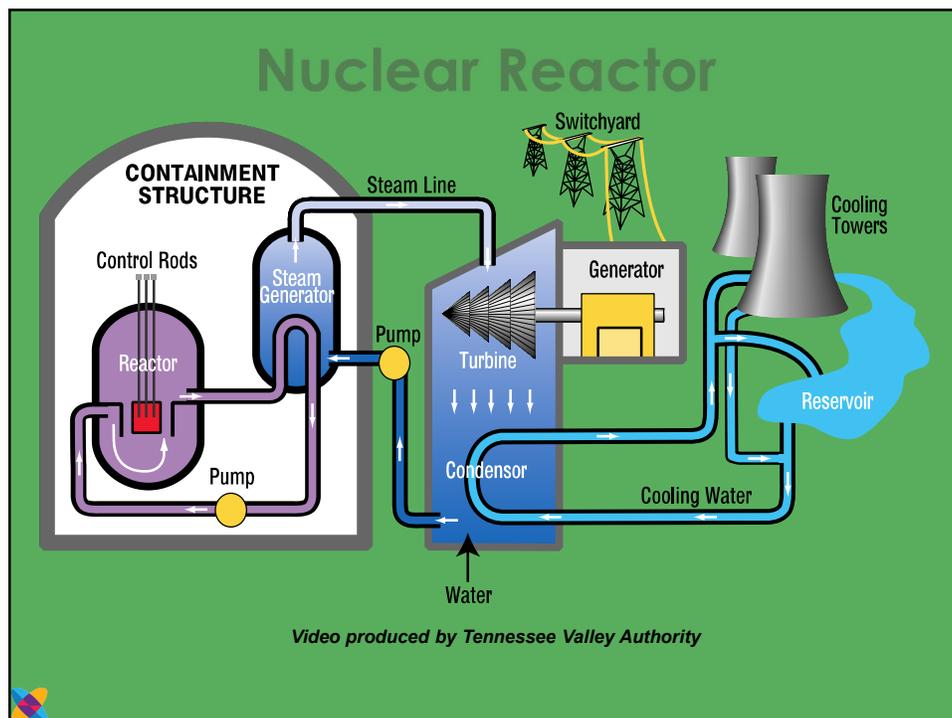
## Nuclear Energy

Energy is released through a chain reaction. Neutrons split the nuclei of atoms (U-235) releasing energy (heat) and additional neutrons that split more atoms.



## Nuclear Energy

In a conventional nuclear power plant a controlled nuclear **fission** chain reaction heats water producing high-pressure steam that turns turbines which generates electricity.

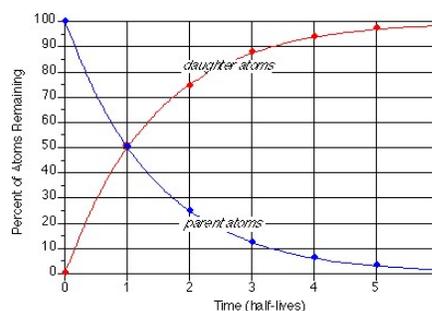


## Half-life

The time needed for **one-half** of the nuclei in a radioisotope to decay and emit their radiation to form a different isotope

Material	Half-life	Emitted
Uranium 235	700 million years	alpha, gamma
Plutonium 239	24,000 years	alpha, gamma

During operation, nuclear power plants produce radioactive wastes, including some that remain dangerous for tens of thousands of years



## Effects of Radiation



1. Genetic damages: from mutations that alter genes
2. Genetic defects can become apparent in the next generation
3. Somatic damages: to tissue, such as burns, miscarriages & cancers

## Radioactive Waste

1. Above ground disposal
2. Geologic Disposal
3. Transmutation
4. Re-use of Waste

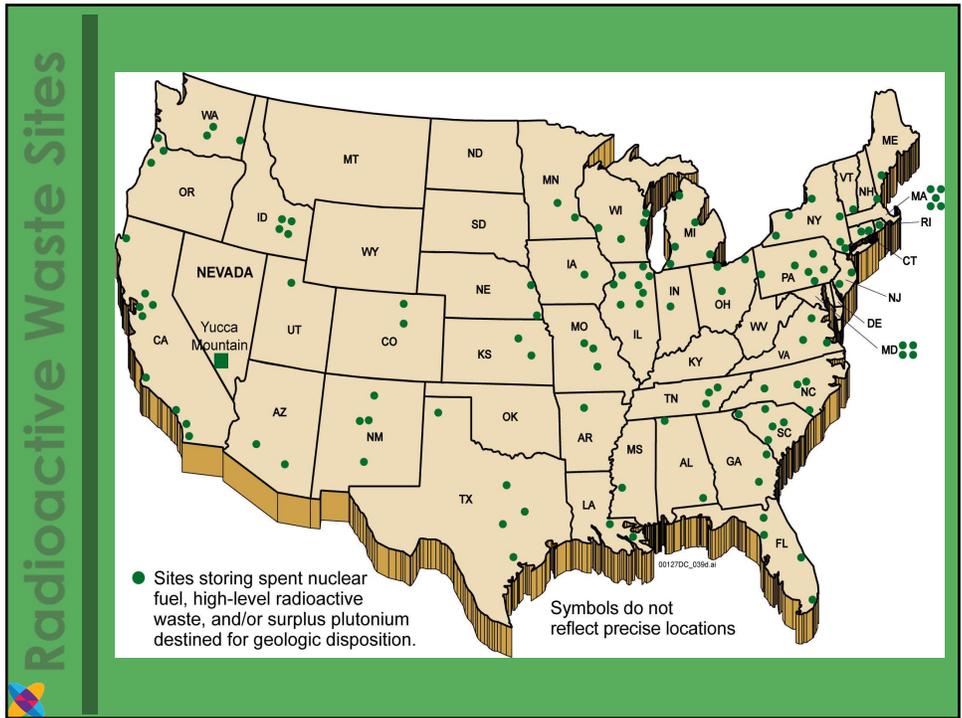


## Radioactive Waste

Currently, spent fuel rods are stored at the nuclear power plants where they were produced.

**Yucca Mountain, Nevada** was intended as a long-term nuclear waste repository. The project was cancelled.





Case 1: Three – Mile Island

**When:** March 29, 1979

**Where:** Near Harrisburg, PA

**What:** Reactor lost coolant water because of mechanical and human errors and suffered a partial meltdown. Fifty thousand people evacuated & another 50,000 fled area. Unknown amounts of radioactive materials released and increased cancer rates. Partial cleanup & damages cost \$1.2 billion

**Case 2: Chernobyl**

**When:** April 26, 1986

**Where:** Ukraine, Former USSR  
Reactor explosion flung radioactive debris into atmosphere. Health ministry reported 3,576 deaths. Green Peace estimated 32,000 deaths. About 400,000 people were forced to leave their homes. Half-million people exposed to dangerous levels of radioactivity. Cost of incident > \$358 billion.

**What:**

**Case 3: Fukushima**

**When:** March 11, 2011

**Where:** Fukushima, Japan  
Caused by tsunami.  
About 10-20% of the radiation released at Chernobyl was released at Fukushima.

**What:** No deaths from short-term radiation exposure. However, people in the area worst affected have an increased lifetime risk of developing certain cancers.



## Advantages and Disadvantages of Nuclear Energy



1. Large fuel supply
2. Low environmental impacts (without accidents)
3. Much lower CO<sub>2</sub> emissions than fossil fuels

1. High costs
2. Low net energy yield
3. High environmental impact with accidents
4. No acceptable solution for long-term storage of waste and decommissioned plants



## Did You Know?

3. Nuclear power plants produce electricity using energy from the radioactive decay of

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- B. Uranium-238
- C. Uranium-239
- D. Plutonium-235
- E. Plutonium-238



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## Did You Know?

4. Currently, most high-level nuclear waste from nuclear reactors in the United States is

- A. stored in deep ocean trenches.
- B. buried in Yucca Mountain.
- C. reprocessed into new fuel pellets.
- D. chemically modified into safe materials.
- E. stored at the power plant that produced it.



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## Did You Know?

5. A radioactive isotope has a half-life of 40 years and a radioactivity level of 4 curies. How many years will it take for the radioactivity level to become 0.25 curies?

- A. 80
- B. 120
- C. 160
- D. 200
- E. 240



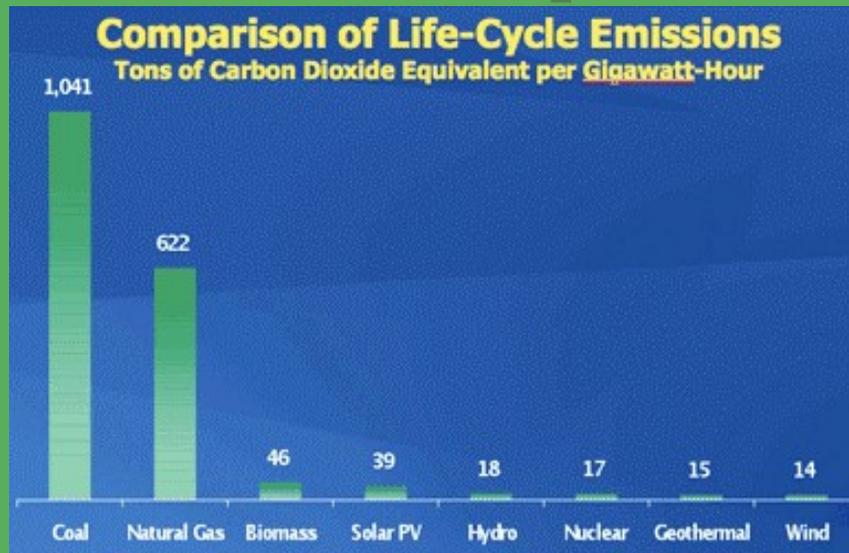
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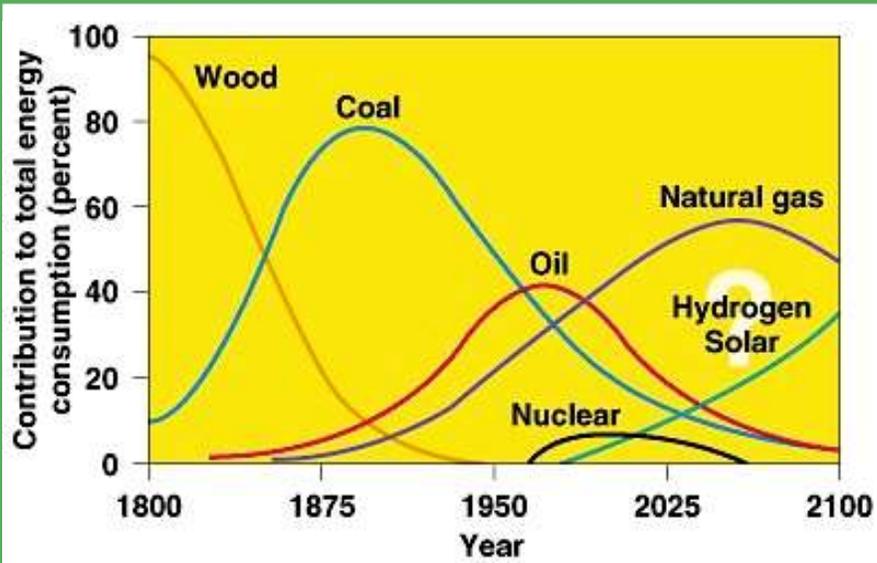
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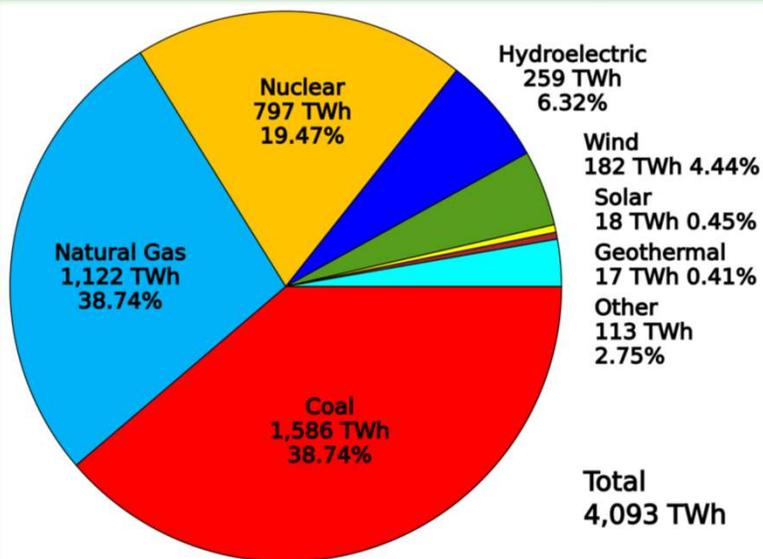
## Comparison of CO<sub>2</sub> Emissions



## Historical Changes in U.S. Energy



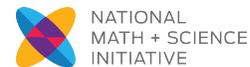
## U.S. Electricity Generation by Source



## Did You Know?

6. Which of the following energy sources is responsible for the largest fraction of *electricity* generation in the United States?

- A. Natural gas
- B. Coal
- C. Uranium
- D. Oil
- E. Wood



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