

**COURSE CODE:** *PHS 364*  
**COURSE TITLE:** *Energy and Environment*  
**NUMBER OF UNITS:** *1 Unit*  
**COURSE DURATION:** *One hour per week*

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## **COURSE DETAILS:**

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## **COURSE CONTENT:**

Energy and power, demand, principles and outlook. The cost of transformation of energy. Thermal pollution, electrical energy from fossil fuels. Hydroelectric power generation. Cost, capacity, storage, reserves, efficiency and environmental effects of these. Electrical energy from nuclear reactors. Prospects for future through the promise (and problems) of breeder reactors, fusion power, solar power, geothermal, tidal and wind power, etc.

## **COURSE REQUIREMENTS:**

This is a compulsory course for all students in the University. In view of this, students are expected to have a minimum of 75% attendance at lectures before they are eligible to sit for the examination.

## **READING LIST:**

## **LECTURE NOTES:**

### **PHS 364 ENERGY AND ENVIRONMENT**

## **What Is Energy?**

Energy makes change possible. We use it to do things for us. It moves cars along the road and boats over the water. It bakes a cake in the oven and keeps ice frozen in the freezer. It plays our favorite songs on the radio and lights our homes. Energy is needed for our bodies to grow and it allows our minds to think.

Scientists define energy as the ability to do work. Modern civilization is possible because we have learned how to change energy from one form to another and use it to do work for us and to live more comfortably.

## **Forms of Energy**

Energy comes in different forms:

- Heat (thermal)
- Light (radiant)
- Motion (kinetic)
- Electrical
- Chemical
- Nuclear energy
- Gravitational

All forms of energy can also be categorized into two:

- Stored (potential) energy
- Working (kinetic) energy

For example, the food you eat contains chemical energy, and your body stores this energy until you use it when you work or play.

## Potential Energy

**Potential energy is stored energy and the energy of position — gravitational energy. There are several forms of potential energy.**

**Chemical Energy** is energy stored in the bonds of atoms and molecules. Biomass, petroleum, natural gas, and coal are examples of stored chemical energy. Chemical energy is converted to thermal energy when we burn wood in a fireplace or burn gasoline in a car's engine.

**Mechanical Energy** is energy stored in objects by tension. Compressed springs and stretched rubber bands are examples of stored mechanical energy.

**Nuclear Energy** is energy stored in the nucleus of an atom — the energy that holds the nucleus together. Very large amounts of energy can be released when the nuclei are combined or split apart. Nuclear power plants split the nuclei of uranium atoms in a process called **fission**. The sun combines the nuclei of hydrogen atoms in a process called **fusion**.

**Gravitational Energy** is energy stored in an object's height. The higher and heavier the object, the more gravitational energy is stored. When you ride a bicycle down a steep hill and pick up speed, the gravitational energy is being converted to motion energy. Hydropower is another example of gravitational energy, where the dam "piles" up water from a river into a reservoir.

**Electrical Energy** is what is stored in a battery, and can be used to power a cell phone or start a car. Electrical energy is delivered by tiny charged particles called electrons, typically moving through a wire. Lightning is an example of electrical energy in nature, so powerful that it is not confined to a wire.

## Kinetic Energy

**Kinetic energy is motion — of waves, molecules, objects, substances, and objects.**

**Radiant Energy** is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays and radio waves. Light is one type of radiant energy. Sunshine is radiant energy, which provides the fuel and warmth that make life on Earth possible.

**Thermal Energy**, or heat, is the vibration and movement of the atoms and molecules within substances. As an object is heated up, its atoms and molecules move and collide faster. Geothermal energy is the thermal energy in the Earth.

**Motion Energy** is energy stored in the movement of objects. The faster they move, the more energy is stored. It takes energy to get an object moving, and energy is released when an object slows down. Wind is an example of motion energy. A dramatic example of motion is a car crash, when the car comes to a total stop and releases all its motion energy at once in an uncontrolled instant.

**Sound** is the movement of energy through substances in longitudinal (compression/rarefaction) waves. Sound is produced when a force causes an object or substance to vibrate — the energy is transferred through the substance in a wave. Typically, the energy in sound is far less than other forms of energy.

We use many different energy sources to do work. Energy sources are classified into two groups — **renewable** and **nonrenewable**. Renewable and nonrenewable energy can be converted into secondary energy sources like electricity and hydrogen.

## Basics of Electricity Generation

### Electric Charge (Q)

- It is quantity of electricity
- There are two types; i.e. positive charge and negative charge,
- Charge is to electricity what mass is to matter,
- An electric charge is a monopole, i.e. it has only one pole
- S.I. unit for charge is Coulomb (C)

### Electric Current (I)

- It is rate of flow of electric charge, i.e.  $I = Q/t$
- S.I. unit of electric current is Ampere

### Electric current can generate magnetic field

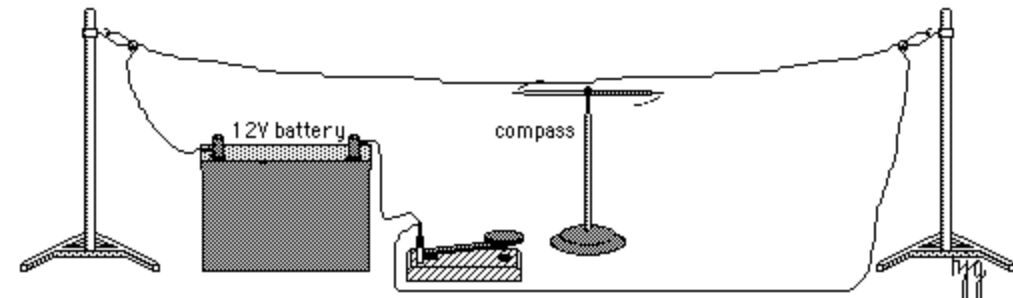
- It was discovered in the early 19<sup>th</sup> century that flow of electric current creates magnetic field, i.e. electricity is the origin of magnetism. Whenever there is variation in an electric field (due to flow of current) it results in magnetic field. Such magnets are called ‘electromagnets’  
Unlike permanent magnets, electromagnets lose their magnetism once current stops flowing through them.

Oersted’s experiment in 1820:

## Magnetic Fields

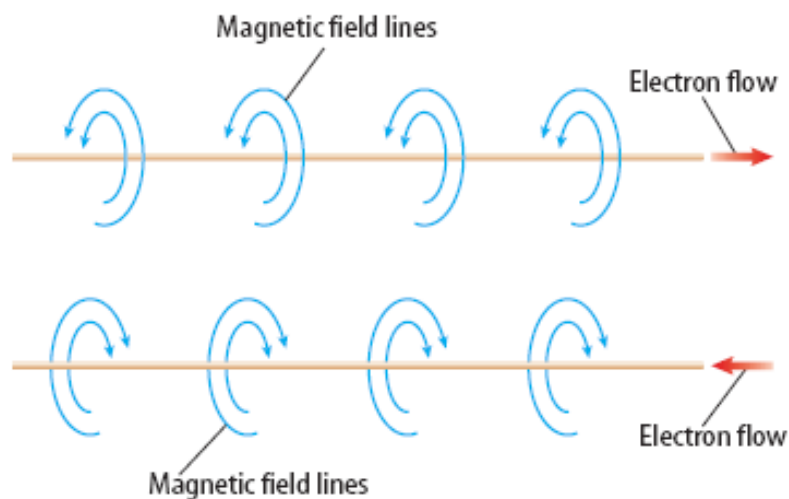
### OERSTED'S EFFECT

- Turn the compass needle so it is approximately parallel to the wire.
- Close the switch to send the current through the wire for about 5-10 seconds.
- The compass will align itself with the magnetic field.



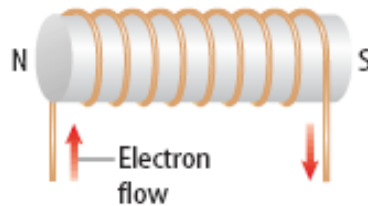
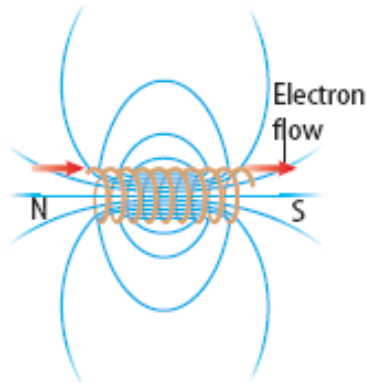
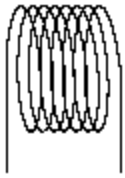
### Examples of Electromagnets:

#### 1) When current flows through a straight wire



When electric current flows through a wire, a magnetic field forms around the wire. The direction of the magnetic field depends on the direction of the current in the wire.

#### 2) When current flows through a wire coil



An iron core inserted into the coil becomes a magnet.

So now we know that a current can create a magnetic field. But can a magnetic field create a current flow? If so then we have a means of generating electricity.

## Electromagnetic induction

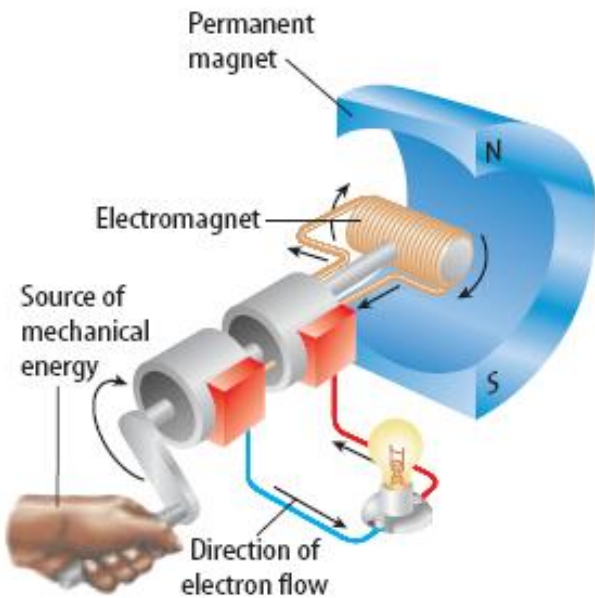
When a loop of wire is moved through a magnetic field an electric current is produced (induced) in the wire loop. This is electromagnetic induction, without any physical contact between the wire and the magnet.

**A generator** is used to convert mechanical energy into electrical energy by electromagnetic induction

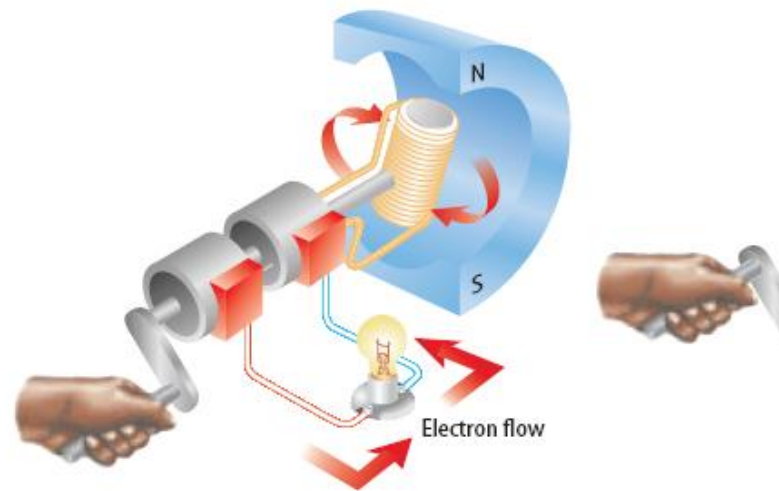
Experiments showed that if a magnet just lie next to a wire loop no current flow is produced or induced in the wire. However, if the magnet is **moving** a current is **induced** in the wire. The faster the magnet moves, the greater the induced current.

This is the principal behind simple electric generators in which a wire loop is rotated between to stationary magnets. This produces a continuously varying voltage which in turn produces an **alternating current** .

See figures below:



The electromagnet in a generator is rotated by some outside source of mechanical energy. In this setup, a student can rotate a crank to turn the electromagnet.



Therefore to generate electricity, all we really need to do is have some (mechanical) mechanism turn a crank that rotates a loop of wire between stationary magnets. The faster we can get this crank turned, the more current we can generate.

#### Popular Methods of Turning the Crank:

- Let water fall on it (Hydro Power)
- Direct a nozzle of steam at it (Coal or Nuclear Fired Steam Plant)
- Let the wind turn it (windmill)

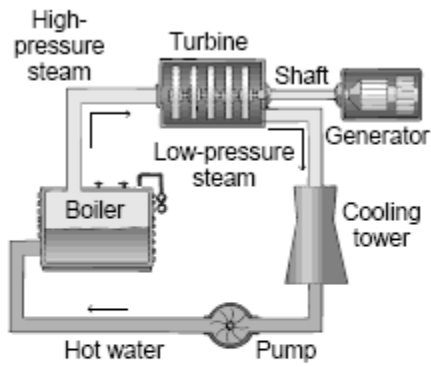
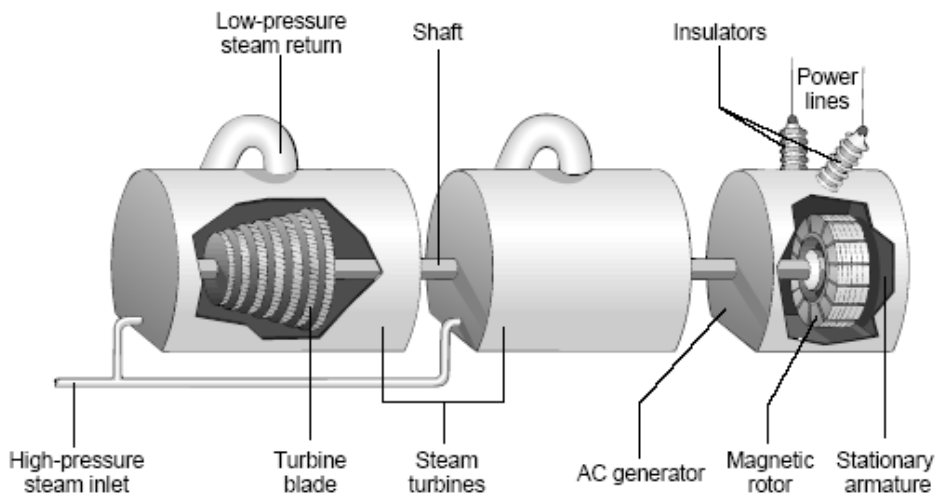


Fig. 9.4.3 - A steam turbine extracts work from steam as that steam flows from a high-pressure boiler to a low-pressure cooling tower. The cooling tower condenses the steam into hot water, which is then pumped back into the boiler.



## Energy Sources

When we use electricity in our home, the electrical power was probably generated by burning coal, by a nuclear reaction, or by a hydroelectric plant at a dam. Therefore, coal, nuclear and hydro are called energy sources. When we fill up a gas tank, the source might be petroleum or ethanol made by growing and processing corn.

Energy sources are divided into two groups — renewable (**an energy source that can be easily replenished**) and nonrenewable (**an energy source that we are using up and cannot recreate**). Renewable and nonrenewable energy sources can be used to produce electricity.

### Renewable Energy Source

Renewable energy sources include:

- Solar energy from the sun, which can be turned into electricity and heat
- Wind
- Geothermal energy from heat inside the Earth
- Biomass from plants, which includes **firewood from trees**, ethanol from corn, and biodiesel from vegetable oil
- Hydropower from hydroturbines at a dam

### Nonrenewable Energy

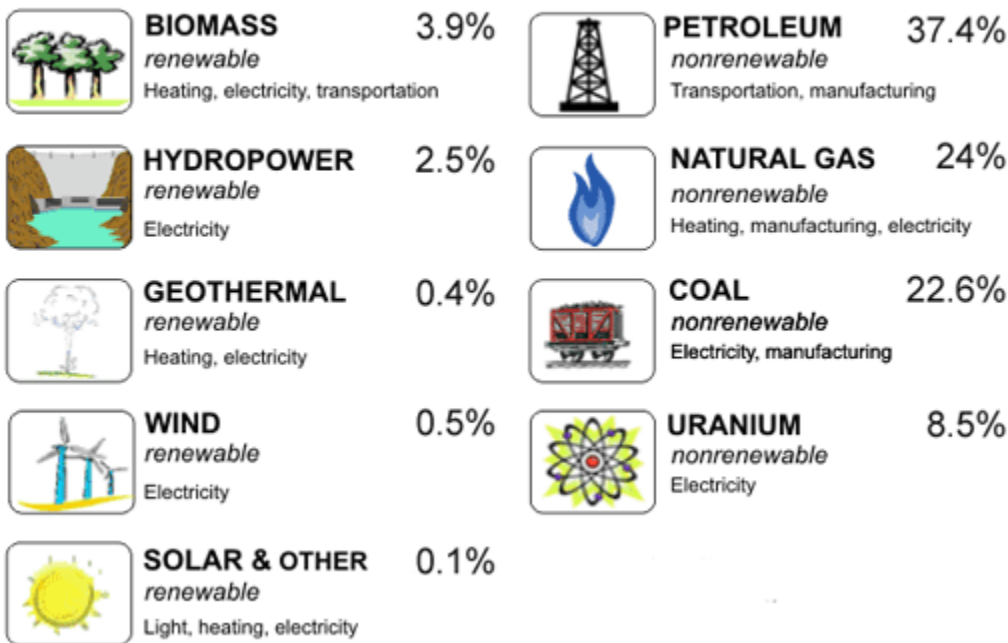
We get most of our energy from nonrenewable energy sources, which include the fossil fuels — oil, natural gas, and coal. They're called fossil fuels because they were formed over millions and millions of years by the action of heat from the Earth's core and pressure from rock and soil on the remains (or

"fossils") of dead plants and creatures like microscopic diatoms. Another nonrenewable energy source is the element uranium, whose atoms we split (through a process called nuclear fission) to create heat and ultimately electricity.

Most of the gasoline used in our cars and motorcycles and the diesel fuel used in our trucks are made from petroleum oil, a nonrenewable resource. Natural gas, used to heat homes, dry clothes, and cook food, is nonrenewable. The propane that fuels our outdoor grills made from oil and natural gas, both nonrenewable.

These energy sources are called [nonrenewable](#) because their supplies are limited. Petroleum, for example, was formed millions of years ago from the remains of ancient sea plants and animals. We can't make more petroleum in a short time.

### U.S. Energy Consumption by Source, 2008



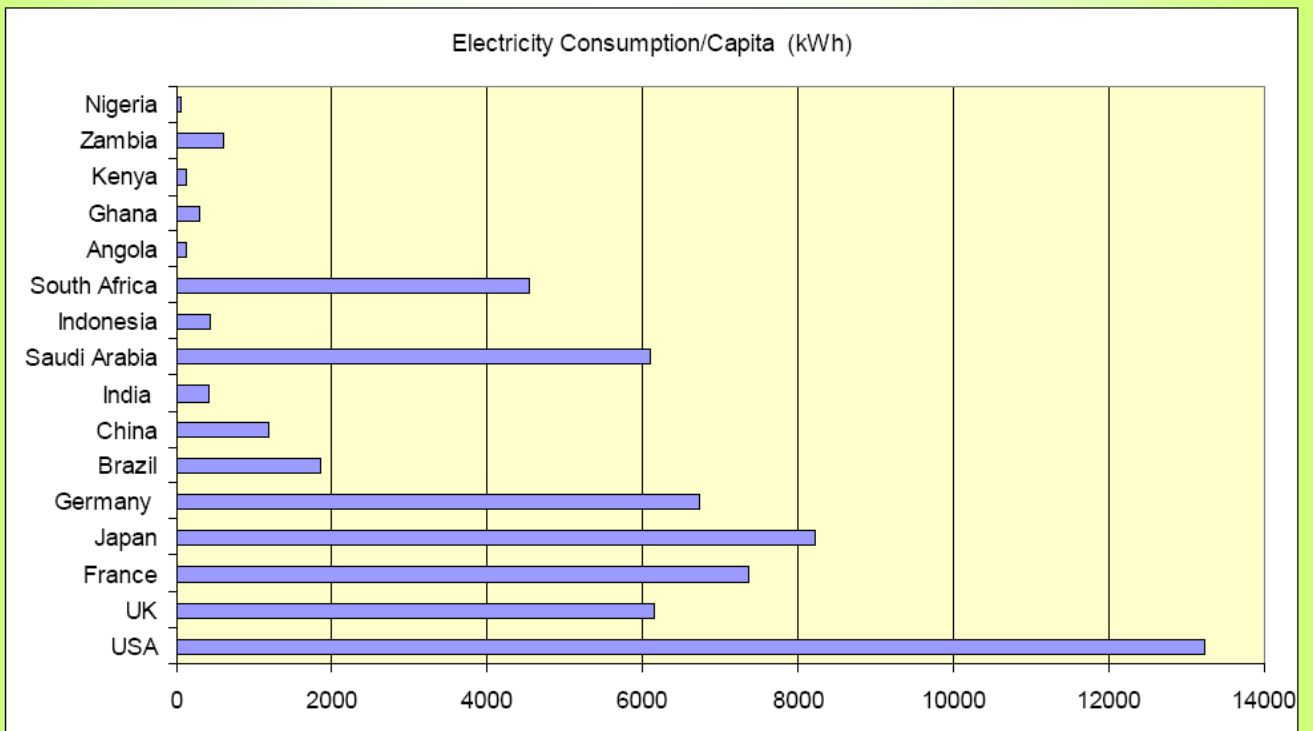
Source: Energy Information Administration, Annual Energy Review (2008)

**Table 3: Nigeria's Energy Reserves /Capacity as at December 2007**

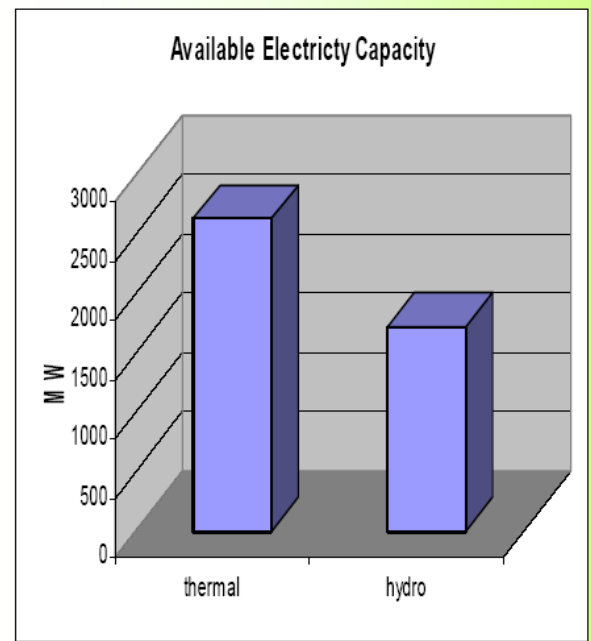
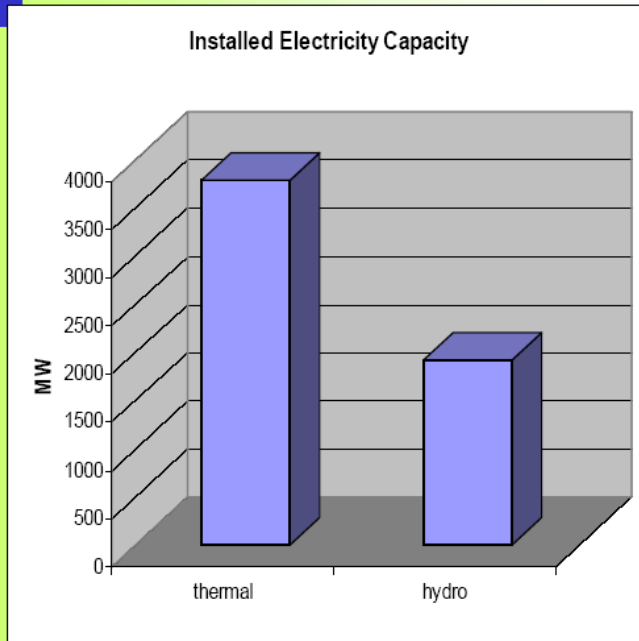
<b>ENERGY RESOURCE</b>	<b>RESERVE</b>	<b>UNIT</b>
Crude oil	36.5	Billion barrels
Natural Gas	187.44	Trillion scf
Tar sands	30	Billion barrels of oil equivalent
Coal & lignite	4	Billion tonnes
Large hydropower	11,250	MW
Small hydropower	3,500	MW
Fuelwood	13,071,464	Hectares
Animal waste	61	Million tonnes/yr
Crop residue	83	Million tonnes/yr
Solar radiation	3.5 – 7.0	kWh/m <sup>2</sup> -day
Wind	2 - 4	m/s at 10m height

Source: Nigeria Energy Commission

## Comparison of Electricity Consumption/Capita



## Nigerian Electricity Sector in 2007



Source: Nigeria Energy Commission

# Electricity Prices

Country	Industrial USc/kW	Residential USc/kW
Belgium	4.8	13.2
Brazil	4.7	9.3
China	3.2	4.6
France	4.8	13.5
Germany	6.5	17.6
Hungary	9.2	14.5
India	8	4
Italy	16.1	19.1
Japan	12.7	19.6
Netherland	5.9	22.1
Romania	6.7	7.3
Turkey	10.5	11.7
U.S	5.6	9.8

Cumhuriyet, 25/7/2006

Country	Nuclear	Coal	Gas	Oil	Hydro	
Belgium	55.5	20.3	18.1	3.1	1.8	98.8
Brazil	1	2.2	0	3.9	90.6	97.7
China	1.2	75.9	0.6	4.5	17.8	100
France	75.9	7.3	1	2.3	12.9	99.4
Germany	29.1	53.8	9.8	1.1	3.8	97.6
Hungary	37.5	26.1	20	16	0.4	100
India	0.3	76.9	4.8	0.8	17.2	100
Italy	0	10.7	27.3	41.3	18.2	97.5
Japan	31.8	18.9	20.9	16.2	9.8	97.6
Netherland	4.2	29.9	57	3.9	0.1	95.1
Romania	9.9	28	19	7.7	35.3	99.9
Turkey	0	22.5	32	11	34.3	99.8
U.S	18.6	52.3	14.6	3.8	8.4	97.7

Turkish Data from TEIAS, Türkiye Elektrik İletim A.S.

Data for other countries from "The Economic Future of Nuclear Energy", a report by University of Chicago sponsored by the US Department of Energy(2004)

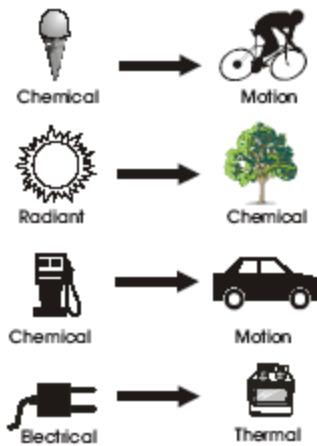
©2006 Halim Gürgenci, The University of Queensland (Australia) and Bogazici University (Istanbul, Turkey)

## Conservation of Energy:

To scientists, "conservation of energy" does not mean saving energy. Instead, the law of conservation of energy says that energy is neither created nor destroyed. When we use energy, it doesn't disappear. We change it from one form of energy into another.

A car engine burns gasoline, converting the chemical energy in gasoline into mechanical energy. Solar cells change radiant energy into electrical energy. Energy changes form, but the total amount of energy in the universe stays the same.

## Energy Transformations



Source: US National Energy Education Development Project (Public Domain)

## Energy Efficiency and Energy conservation

"Energy efficiency" is the amount of useful energy you get from any type of system. A perfectly energy-efficient machine would change all the energy put in it into useful work. In reality, converting one form of energy into another form always involves a loss of useable or desirable energy.

In fact, most energy transformations are not very efficient. The human body is a good example. Your body is like a machine, and the fuel for your machine is food. Food gives you the energy to move, breathe, and think. But your body isn't very efficient at converting food into useful work. Your body is less than 5% efficient most of the time. The rest of the energy is lost as heat.

There are many things we can do to **use less energy** (conservation) and **use it more wisely** (efficiency).

**Energy conservation** is any behavior that results in the use of less energy. Turning the lights off when you leave the room and recycling aluminum cans are both ways of conserving energy.

**Energy efficiency** is the use of technology that requires less energy to perform the same function. A compact fluorescent light bulb that uses less energy than an incandescent bulb to produce the same amount of light is an example of energy efficiency. However, the decision to replace an incandescent light bulb with a compact fluorescent is an act of energy conservation.

## Units for Costing and Comparing Energy

Different types of energy are measured by different physical units:

- Barrels or gallons for petroleum
- Cubic feet for natural gas
- Tons for coal
- Kilowatthours for electricity

To compare different fuels, we need to convert the measurements to the same units.

One practical way to compare different fuels is to convert physical units of measure (such as weight or volume) into a common unit of measurement based on the energy content of each fuel. **The British thermal unit (Btu)** is a widely used measure of energy content.

### What Is a Btu?

It is the quantity of heat required to raise the temperature of 1 pound of liquid water by 1°F at the temperature that water has its greatest density (approximately 39°F).

### Using Btu for Comparing Electricity Generation Fuels

Suppose you have been assigned the responsibility of purchasing fuel for a large electric utility company. You need to keep costs down for you and your electricity customers. Which fuel would you choose to generate electricity — coal, oil, or natural gas? In 2007, average prices of fuel delivered to electric power plants were:

- \$35.48 per short ton of coal
- \$43.50 per 42-gallon barrel of oil
- \$7.31 per thousand cubic feet of natural gas

The prices of each fuel look quite different, but you can compare the prices of their energy content by first converting to Btu.

A short ton of coal contains about 21 million Btu, a barrel of oil contains about 6 million Btu, and a thousand cubic feet (Tcf) of natural gas contains about 1 million Btu. After dividing price by energy content, you can see which fuel is least expensive:

	Price	Btu (Energy Content)	\$/Million Btu
Coal	\$35.48 per ton	21 million per short ton	\$1.69



Oil	\$43.50 per barrel	6 million per barrel	\$7.25
Natural Gas	\$7.31 per Tcf	1 million per Tcf	\$7.31

So coal is actually the least expensive fuel on a price-per-energy content basis.

Of course, cost is not the only factor to consider when selecting a fuel. Environmental restrictions and equipment costs are some of the other factors that should be taken into account.

### **Btu Quick Facts**

A single Btu is insignificant in terms of the energy use in a single household or in the Nation's energy consumption. In 2008, the United States used over 99 quadrillion (written out, 1 quadrillion is a 1 followed by 15 zeros) Btu of energy.

One Btu is approximately equal to the energy released by burning one of these matches.



Source: Stock photography (copyrighted)

### **Btu Content of Common Energy Units**

- 1 barrel (42 gallons) of crude oil = 5,800,000 Btu
- 1 gallon of gasoline = 124,000 Btu (based on U.S. consumption, 2008)
- 1 gallon of diesel fuel = 139,000 Btu
- 1 gallon of heating oil = 139,000 Btu
- 1 barrel of residual fuel oil = 6,287,000 Btu
- 1 cubic foot of natural gas = 1,028 Btu (based on U.S. consumption, 2008)
- 1 gallon of propane = 91,000 Btu
- 1 short ton of coal = 19,988,000 Btu (based on U.S. consumption, 2008)
- 1 kilowatthour of electricity = 3,412 Btu

### **Examples of Converting Different Energy Sources to Btu**

### Example 1:

There is a natural gas furnace in home 'A' that used 81,300 cubic feet of natural gas for heating last winter. Another home (B) has an oil furnace that used 584 gallons of heating oil last winter. To determine which home used more energy for heating, you can convert the natural gas and heating oil consumption figures into Btu, as follows:

Natural Gas: 81,300 cubic feet (your house) x 1,028 Btu per cubic foot = 83,576,400 Btu

Heating Oil: 584 gallons (neighbor's house) x 139,000 Btu per gallon = 81,176,000 Btu

Answer: Home (A) used more energy to heat the house!

### Example 2:

You work for an electric power company. Your company's power generators can run on one of two fuels: natural gas or residual fuel oil. Your job is to switch fuels when the cost of the fuel you are currently using becomes more expensive than the other fuel. This will keep costs down for you and your electricity customers. Your company's generators are currently using residual fuel oil, but fuel oil prices have been going up much faster than natural gas prices. Based on the fuel costs below, you need to decide if it is time to switch to natural gas:

Natural Gas:	\$7.30 per thousand cubic feet	÷ 1.028 million Btu per thousand cubic feet =	\$7.10 per million Btu
Residual fuel oil:	\$57.75 per barrel	÷ 6.287 million Btu per barrel =	\$9.19 per million Btu

Answer: When you convert the fuels into the same units, you see that residual fuel oil now costs more than natural gas. You decide to switch to natural gas to save money.

## Btu Conversion Factors

Energy Source	Physical Units and Btu (Weighted Averages, 2008)
Electricity	1 kilowatthour = 3,412 Btu <i>(but 7,000 to 10,000 Btu of primary energy to generate the electricity)</i>
Natural Gas	1 cubic foot = 1,028 Btu
Motor Gasoline	1 gallon = 124,000 Btu
Diesel Fuel	1 gallon = 139,000 Btu
Heating Oil	1 gallon = 139,000 Btu

Propane	1 gallon = 91,333 Btu
Wood	1 cord = 20,000,000 Btu

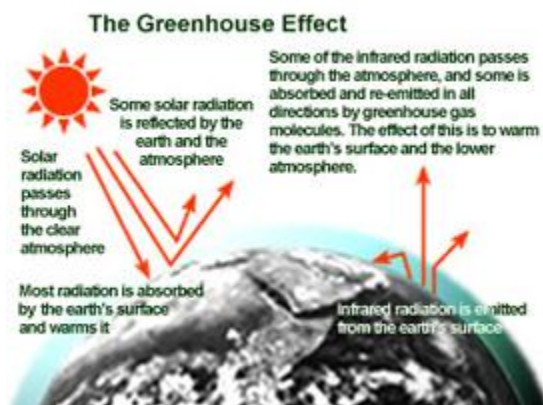
## Impact of Energy Sources on the Environment

Energy sources have different impacts or effects on the environment. Some of these effects may include emissions (of chemical compounds), waste, and land or water use impacts, among others. Many chemical compounds found in the Earth's atmosphere act as "greenhouse gases" and they cause "the greenhouse effect"

### The Greenhouse Effect

The "greenhouse effect" is the heating of the Earth due to the presence of greenhouse gases. It is named this way because of a similar effect produced by the glass panes of a greenhouse. Shorter-wavelength solar radiation from the sun passes through Earth's atmosphere, then is absorbed by the surface of the Earth, causing it to warm. Part of the absorbed energy is then reradiated back to the atmosphere as long wave infrared radiation. Little of this long wave radiation escapes back into space; the radiation cannot pass through the greenhouse gases in the atmosphere. The main greenhouse gases: carbon dioxide, methane, nitrous oxide, and fluorocarbons. The greenhouse gases selectively transmit the infrared waves, trapping some and allowing some to pass through into space. The greenhouse gases absorb these waves and reemit the waves downward, causing the lower atmosphere to warm. ([www.epa.com:180](http://www.epa.com:180))

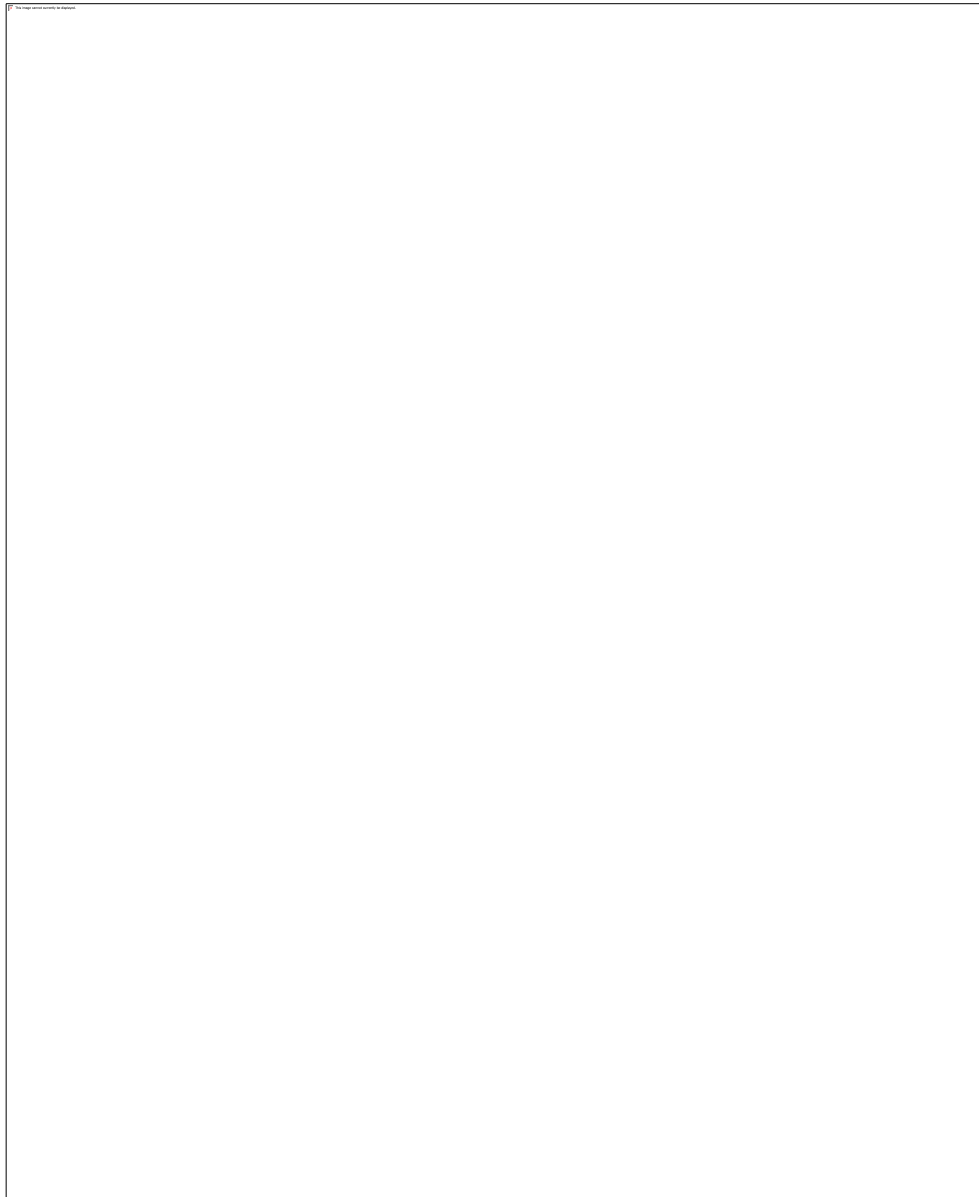
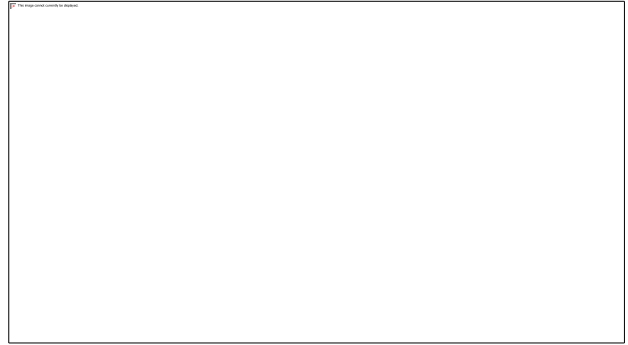
## Types of Greenhouse Gases?



Source: Environmental Protection Agency (Public Domain)

The main types of greenhouse gases are:

- Carbon dioxide (CO<sub>2</sub>)
- Methane (CH<sub>4</sub>)
- Nitrous oxide (N<sub>2</sub>O)
- Industrial Gases:
  - Hydrofluorocarbons (HFCs)
  - Perfluorocarbons (PFCs)
  - Sulfur hexafluoride (SF<sub>6</sub>)



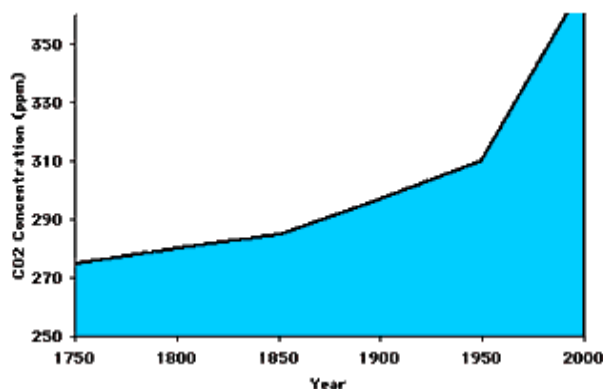
**Diagram to help explain the process of global warming and how greenhouse gases create the "greenhouse effect"**  
[www.eecs.umich.edu/mathscience/funexperiments/agesubject/lessons/images/diagrampage.html](http://www.eecs.umich.edu/mathscience/funexperiments/agesubject/lessons/images/diagrampage.html)

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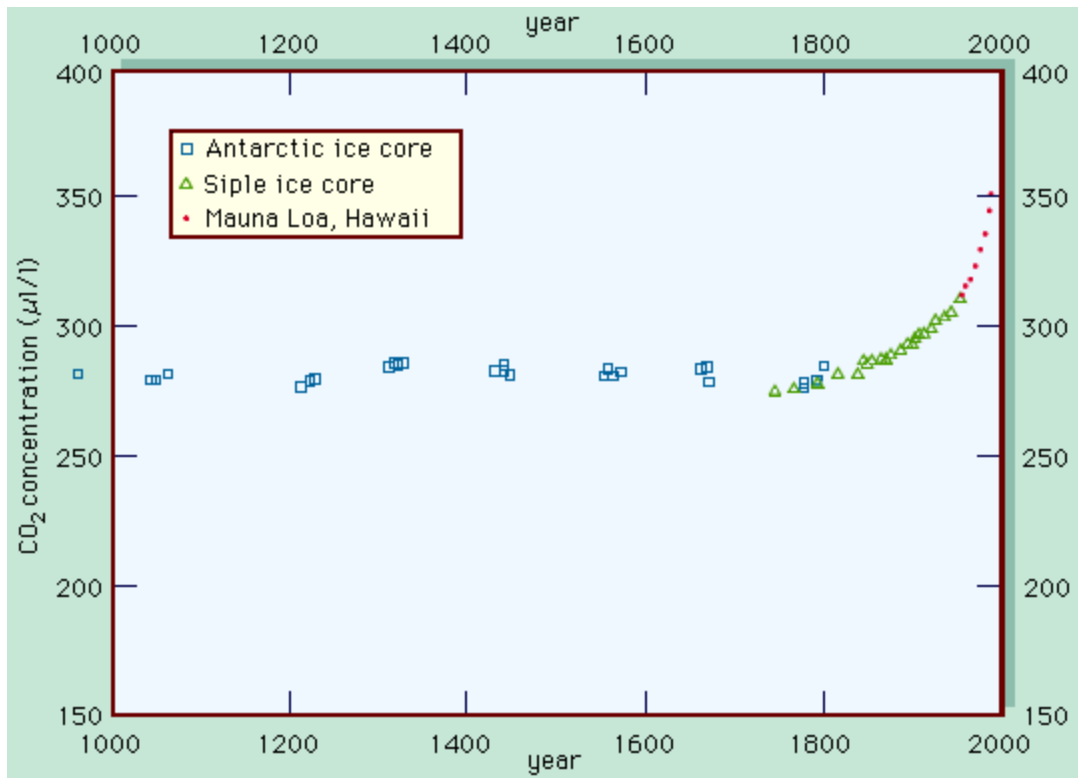
### Carbon Dioxide

Carbon Dioxide (CO<sub>2</sub>) is a colorless, odorless non-flammable gas and is the most prominent Greenhouse gas in Earth's atmosphere. It is recycled through the atmosphere by the process photosynthesis, which makes human life possible. Photosynthesis is the process of green plants and other organisms transforming light energy into chemical energy. Light Energy is trapped and used to convert carbon dioxide, water, and other minerals into oxygen and energy rich organic compounds. (Encyclopaedia Britannica Volume 25) Carbon Dioxide is emitted into the air as humans exhale, burn fossil fuels for energy, and deforest the planet. Every year humans add over 30 billion tons of carbon dioxide in the atmosphere by these processes, and it is up thirty percent since 1750 ([www.envirolink.org/orgs/edf/sitemap.html](http://www.envirolink.org/orgs/edf/sitemap.html)).

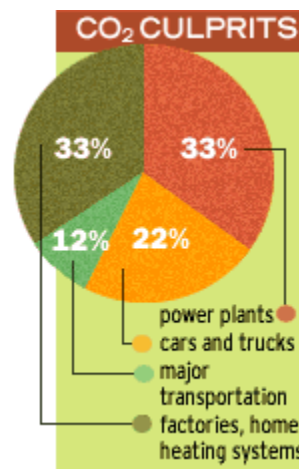
Fossil Fuels were created chiefly by the decay of plants from millions of years ago. We use coal, oil and natural gas to generate electricity, heat our homes, power our factories and run our cars. These fossil fuels contain carbon, and when they are burned, they combine with oxygen, forming carbon dioxide. The two atoms of oxygen add to the total weight.



**This graph shows the increase of carbon dioxide in the air over the past few centuries**



**Ice Core samples and samples at Mauna Loa, Hawaii, reveal an increase CO<sub>2</sub> concentrations**



**Pie chart shows how CO<sub>2</sub> is produced**  
[www.envirolink.org/orgs/edf/sitemap.html](http://www.envirolink.org/orgs/edf/sitemap.html)



**Cars also contribute to CO<sub>2</sub> in the atmosphere.**  
[www.abcnews.com/sections/us/global106/index.html](http://www.abcnews.com/sections/us/global106/index.html)

Deforestation is another main producer of carbon dioxide. The causes of deforestation are logging for lumber, pulpwood, and fuel wood. Also contributing to deforestation are clearing new land for farming and pastures used for animals such as cows. Forests and wooded areas are natural carbon sinks. This means that as trees absorb carbon dioxide, and release oxygen, carbon is being put into trees. This process occurs naturally by photosynthesis, which occurs less and less as we cut and burn down trees. As the abundance of trees declines, less carbon dioxide can be recycled. As we burn them down, carbon is released into the air and the carbon bonds with oxygen to form carbon dioxide, adding to the greenhouse effect.

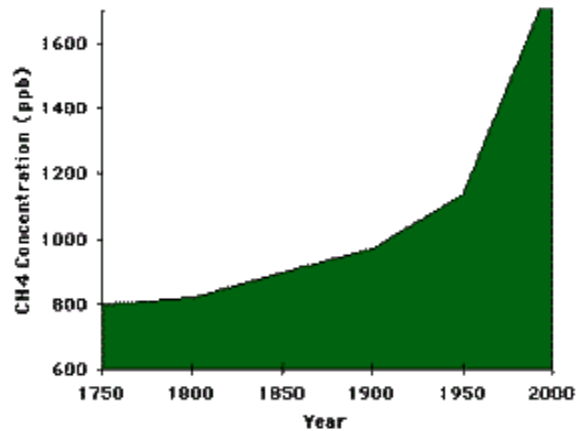


**Deforestation and Forest Fires contribute to an increase in CO<sub>2</sub> levels**  
[www.envirolink.org/orgs/edf/sitemap.html](http://www.envirolink.org/orgs/edf/sitemap.html)

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## Methane

Methane is a colorless, odorless, flammable gas. It is formed when plants decay and where there is very little air. It is often called *swamp gas* because it is abundant around water and swamps. Bacteria that breakdown organic matter in wetlands and bacteria that are found in cows, sheep, goats, buffalo, termites, and camels produce methane naturally. Since 1750, methane has doubled, and could double again by 2050. Each year we add 350-500 million tons of methane to the air by raising livestock, coal mining, drilling for oil and natural gas, rice cultivation, and garbage sitting in landfills.([www.envirolink.org/orgs/edf/sitemap.html](http://www.envirolink.org/orgs/edf/sitemap.html)) It stays in the atmosphere for only 10 years, but traps 20 times more heat than carbon dioxide.



**Methane is on the rise since 1750**  
[www.envirolink.org/orgs/edf/sitemap.html](http://www.envirolink.org/orgs/edf/sitemap.html)

Rice cultivation has developed into a large business; farmland has doubled in the past 45 years.([www.envirolink.org/orgs/edf/sitemap.html](http://www.envirolink.org/orgs/edf/sitemap.html)) It feeds 1/3 of the World's population. It grows mostly in flooded fields, where bacteria in waterlogged soil releases methane.

Livestock such as cows, sheep, goats, camels, buffaloes, and termites release methane as well. Bacteria in the gut of the animal break down food and convert some of it to methane. When these animals belch, methane is released. In one day, a cow can emit ½ pound of methane into the air. Imagine 1.3 billion cattle each burping methane several times per minute!



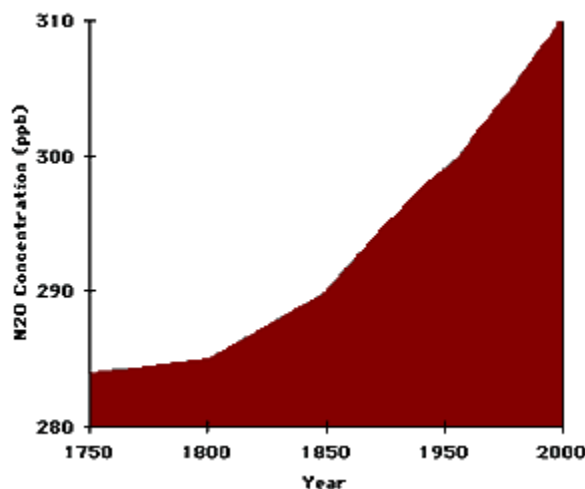
**Cows such as these contribute a large amount of methane to the air.**  
[www.envirolink.org/orgs/edf/sitemap.html](http://www.envirolink.org/orgs/edf/sitemap.html)



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## Nitrous Oxide

Nitrous oxide is another colorless greenhouse gas, however, it has a sweet odor . It is primarily used as an anesthetic because it deadens pain and for this characteristic is called laughing gas. This gas is released naturally from oceans and by bacteria in soils. Nitrous oxide gas risen by more than 15% since 1750. Each year we add 7-13 million tons into the atmosphere by using nitrogen based fertilizers, disposing of human and animal waste in sewage treatment plants, automobile exhaust, and other sources not yet identified. It is important to reduce emissions because the nitrous oxide we release today will still be trapped in the atmosphere 100 years from now. (World Book Volume 13)



**Nitrous Oxide has been on the rise since 1750**  
[www.envirolink.org/orgs/edf/sitemap.html](http://www.envirolink.org/orgs/edf/sitemap.html)

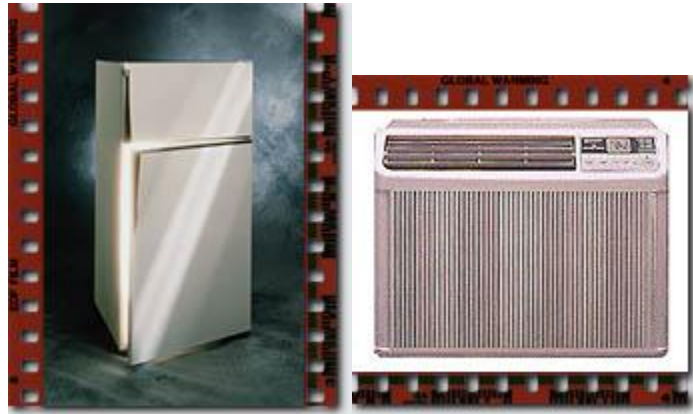
Nitrogen based fertilizer use has doubled in the past 15 years. These fertilizers provide nutrients for crops; however, when they breakdown in the soil, nitrous oxide is released into the atmosphere. In automobiles, nitrous oxide is released at a much lower rate than carbon dioxide, because there is more carbon in gasoline than nitrogen.

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## Fluorocarbons

Fluorocarbons is a general term for any group of synthetic organic compounds that contain fluorine and carbon. Many of these compounds, such as chlorofluorocarbons(CFCs), can be easily converted from gas to liquid or liquid to gas. Because of these properties, CFCs can be used in aerosol cans, refrigerators, and air conditioners. Studies in the 1970s showed that when CFCs are emitted into the atmosphere, they break down molecules in the Earth's ozone layer (World Book). Since then, the use of CFCs has significantly decreased and they are banned from production in the United States.

The substitute for CFC's are hydrofluorocarbons (HFC's). HFC's do not harm or breakdown the ozone molecule, but they do trap heat in the atmosphere, making it a greenhouse gas, aiding in global warming. HFC's are used in air conditioners and refrigerators. The way to reduce emissions of this gas is to be sure that in both devices the coolant is recycled and all leaks are properly fixed. Also, before throwing the appliances away, be sure to recover the coolant in each.



**Refrigerators and Air Conditioners using CFC's were a huge problem for the ozone layer, but now HFC's are a problem for the climate.**

**[www.envirolink.org/orgs/edf/sitemap.html](http://www.envirolink.org/orgs/edf/sitemap.html)**

## Consequences of “greenhouse effect”:

- Global warming (flooding, droughts, desertification, hunger, diseases, poverty, etc.)
- Climate change

Read on :

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### Global Warming

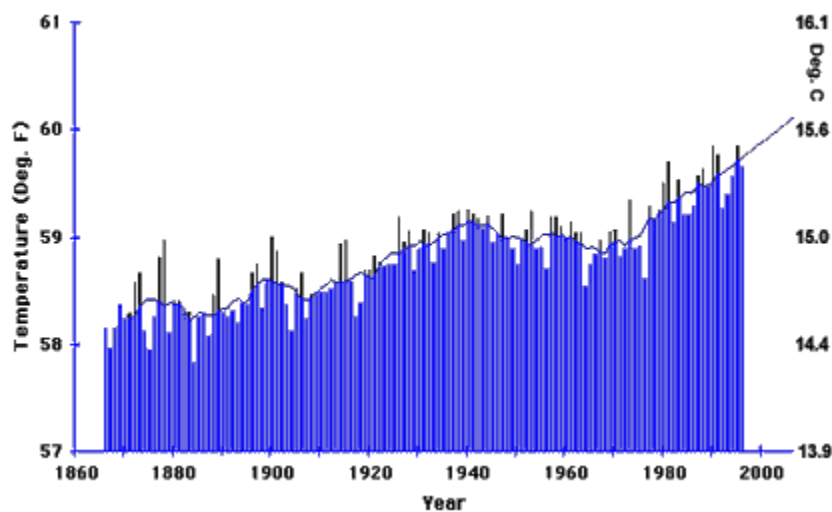
Naturally, if there are more greenhouse gases in the atmosphere, this greenhouse effect will be more significant and raise the temperature of Earth more than if humans didn't emit as much greenhouse gases. Peter Tans, a physicist with National Oceanic and Atmospheric Administrations (NOAA) Climate Monitoring and Diagnostics Lab says, “There is no doubt that both land and ocean surface temperatures have gone up significantly in the last 100 years or so.” (www.abcnews.com/sections/us/global106.html) This statement supports the trend of global warming, but does not acknowledge the source. The director of NOAA's Geophysical Fluid Dynamics Lab at Princeton, Jerry Malhan, says, “The Earth's surface temperature has warmed about one degree Fahrenheit in the last 100 years, and there is no credible hypothesis for this, other than the net effect of greenhouse gases.” (www.abcnews.com/sections/us/global106.index.html) Jerry Malhan offers a quote supporting the theory of global warming and also states that it is directly related to the increase of greenhouse gases. “The planet is heating up and the evidence suggests that human activities are

having a significant impact, ♦ Jane Lubchenco said.

([www.abcnews.com/sections/us/global106/index.html](http://www.abcnews.com/sections/us/global106/index.html)) Jane was the past President of the American Association for the Advancement of Science, who briefed President Clinton on global warming in July, 1997. The world's leading authority on global warming, the Intergovernmental Panel on Climate Change (IPCC), is a United Nations sponsored organization made up of 2500 scientists from around the world. They have concluded by consensus that "The balance of evidence suggests a discernible human influence on global climate." They project that global warming will have severe impacts on human health, natural ecosystems, agriculture, and coastal communities.

([www.toowarm.org/factsheets/basfact.html](http://www.toowarm.org/factsheets/basfact.html))

This evidence supports the common belief that Global Warming is occurring due to the increased concentration of greenhouse gases in the atmosphere, carbon dioxide, nitrous oxide, methane, and HFC ♦s.



**Average yearly temperature rise: 1860-1998**  
[www.evirolink.org/orgs/edf/sitemap.html](http://www.evirolink.org/orgs/edf/sitemap.html)

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### Effects of Global Warming on Environment

There are many environmental problems coming from the increase concentration of greenhouse gases in Earth's atmosphere. As Jeff Rubin of ABC NEWS reported, ♦ Several signs indicate that we've begun changing Earth's climate: increased water vapor in the atmosphere, glaciers and polar ice caps appear to be melting, floods and droughts are becoming more severe, and sea levels have risen, on average, between 4 and 10 inches since

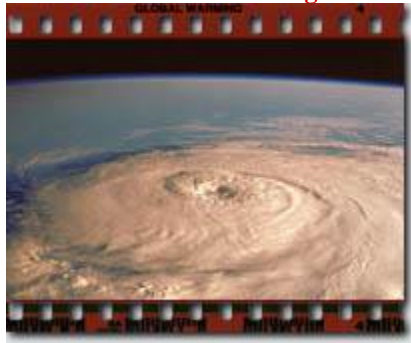
1990. ♦ ([www.abc.com/sections/us/global106.html](http://www.abc.com/sections/us/global106.html)) Experts concur, ♦ We are already beginning to see this (global warming) taking place - a lot more flooding, a lot more droughts, ♦ Jane Lubchenco said. Jerry Malham added, ♦ By 2100, we might get a 2 foot sea level rise, but the catch is, levels might continue to rise 2 or 3 feet per century, for 1000

years. ♦ ([www.abcnews.com/sections/us/global106.html](http://www.abcnews.com/sections/us/global106.html)) These rises in sea level can increase the salinity of freshwater throughout the world, and cause coastal lands to be washed under the

ocean. Warmer water and increased humidity may encourage tropical cyclones, and changing wave patterns could produce more tidal waves and strong beach erosion on the coasts.



**Flooding from global warming may be already happening.**  
[www.abcnews.com/sections/us/global106.html](http://www.abcnews.com/sections/us/global106.html)



**Picture of a typhoon from space**  
[www.envirolink.org/orgs/edf/sitemap.html](http://www.envirolink.org/orgs/edf/sitemap.html)



**The effects of droughts on crops**  
[www.abcnews.com/sections/us/global106.html](http://www.abcnews.com/sections/us/global106.html)

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### **Effects of Global Warming on Society**

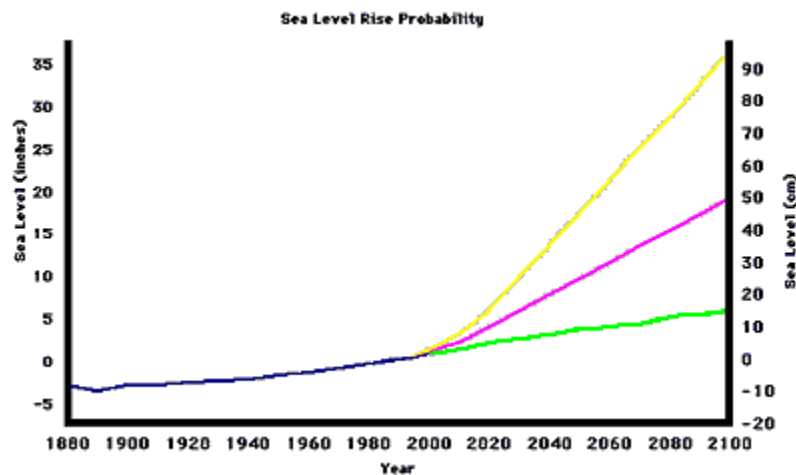
Agriculturally, Dr. Sylvan H. Wittwer believes that global warming is good for the human race, because it helps increase food production. "The most determinant factor in agriculture production is climate. History reveals that for food production, warming is better than cooling." Dr. Wittwer says that carbon dioxide is an essential nutrient for the production of food, and food is one of the most important things in our lives. As the temperature rises, more farmland will be open towards the poles and the length of the growing season will also lengthen. With all the people who go hungry each day, Dr. Wittwer believes food production should be one of our main concerns. Dr. Wittwer is the scientific pioneer who conducted the original studies on atmospheric CO<sub>2</sub> enhancement of the production of food crops. ([www.comnett.net/~wit/food.html](http://www.comnett.net/~wit/food.html))

Increasing amounts of greenhouse gases in the atmosphere and global warming could also lead to more health concerns. A statement released from the Intergovernmental Panel on Climate Change (IPCC) said, "Climate change is likely to have wide-ranging and mostly adverse impacts on human health, with significant loss of life." As temperatures increase towards the poles, similar to farmland, insects and other pests migrate towards Earth's poles. These insects and pests could be allowed to migrate up to 550 Km or 550 miles. Some insects carry diseases such as malaria and dengue fever. Thus, an increase in these particular insects and pests closer to the poles results in an increase in these diseases. This could lead to 50 to 80 million additional cases of Malaria annually, a 10-15% increase. "Malaria and dengue fever are already beginning to spread pole wards", said Jane Lubchenco, past president of American Association for the advancement of science. ([www.epa.gov/oppeoel/globalwarming/impacts/health/index.html](http://www.epa.gov/oppeoel/globalwarming/impacts/health/index.html)) Physician Paul Epstein, of Harvard's School of Public Health, says "Climate change is already a factor in terms of the distributions of malaria, dengue fever, and cholera." ([www.aloha.net/~jhanson/page70.htm](http://www.aloha.net/~jhanson/page70.htm))

The most obvious health effect is directly from the heat itself. With an increase in heat waves, there will be more people who will suffer from heatstroke, heart attacks and other ailments aggravated

by the heat. According to the EPA, "In July 1995, a heat wave killed more than 700 people in the Chicago area alone." ([www.epa.gov/oppeoeel/globalwarming/impacts/health/index.html](http://www.epa.gov/oppeoeel/globalwarming/impacts/health/index.html)) If this is happening already from heat, imagine what would occur in the future with global warming. Hot conditions could also cause smoke particles and noxious gases to linger in the air and accelerate chemical reactions that generate other pollutants. ([www.envirolink.org/orgs/edf/sitemap.html](http://www.envirolink.org/orgs/edf/sitemap.html)) This leads to an increase in risk of respiratory diseases like bronchitis and asthma.

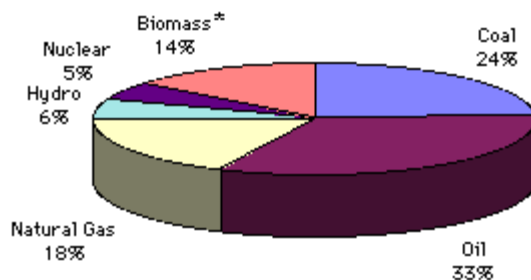
Global warming causes the oceans to warm and expand, inducing a rise in sea level. Eventually, the rising waters could take away land inhabited by people, forcing them to move. Dr. Robert Buddemeir, of the Kansas Geological Survey said, "Bangladesh is massively populated, achingly poor, and something like a sixth of the country is going to go away" ([www.envirolink.org/orgs/edf/sitemap.html](http://www.envirolink.org/orgs/edf/sitemap.html)) Bangladesh cannot afford to build barriers to hold back the sea, so people would have to move inland, increasing the populations density and leading to an increase in hunger and disease. ([www.envirolink.org/orgs/edf/sitemap.html](http://www.envirolink.org/orgs/edf/sitemap.html)) The Maldive Islands in the Indian Ocean have the same problem They are a nation of 1190 islands with an average height of about 1.5 meters above sea level. If the sea level rises, more than 200,000 people will have to abandon their homes. ([www.envirolink.org/orgs/edf/sitemap.html](http://www.envirolink.org/orgs/edf/sitemap.html)) Warming of the oceans could also promote toxic algae which can lead to cholera.



**Graph showing history of sea level and extrapolating possible increases in sea level over the next century**  
**The blue line represents the history of sea level. The yellow line is a high estimate of sea level extrapolated. The red line a central estimate, and the green line is a low projection.**  
[www.envirolink.org/orgs/edf/sitemap.html](http://www.envirolink.org/orgs/edf/sitemap.html)

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## [The Present ways of Producing Energy](#)



**This pie graph shows the breakdown of how the world produces its energy**  
[www.envirolink.org/orgs/edf/sitemap.html](http://www.envirolink.org/orgs/edf/sitemap.html)

Fossil fuels, chiefly coal, oil and natural gas, now supply most of the world's energy. Only a small amount comes from renewable sources, which do not release gases that trap heat in the atmosphere. If we could get more of our energy from renewable sources, we could reduce the amount of fossil fuels we burn. By the year 2050, renewable sources could provide forty percent of the energy needed in the world. Use of renewable energy can help both to slow global warming and to reduce air pollution. ([www.doc.mmu.ac.uk/aric/gcc/cell.html#pos6](http://www.doc.mmu.ac.uk/aric/gcc/cell.html#pos6))

These fossil fuels, coal, oil, and natural gas also emit greenhouse gases when burned. Coal emits high amounts of greenhouse gases, and the world may be supplied with enough of it to last over 100 years. Oil emits high amounts of greenhouse gases and also other types of air pollution harmful to the environment. The world's oil supply is also estimated to last over 100 years. Natural Gas is the lowest of all fossil fuels in greenhouse gas emissions; supplies are projected to last over 100 years. ([www.doc.mmu.ac.uk/aric/gcc/cell.html#pos6](http://www.doc.mmu.ac.uk/aric/gcc/cell.html#pos6))

**1996 Processes Carbon Dioxide was Produced**

Country (region)	OIL	Natural Gas	Coal
World	44.7%	18.4%	36.9%
Canada	51.8%	30%	18.2%
United States	45%	21.3%	33.7%
European Union	56.2%	19%	24.8%
China	17.4%	1.1%	81.5%
Japan	64.6%	9.9%	25.5%
Nigeria			

**This chart shows what percentage of CO2 comes from Oil, Natural Gas, and Coal. For example, in 1996, 44.7% of the world's CO2 emissions came from the combustion of oil.**

<http://infoweb.magi.com/~dwalsh/wfse.html>

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**Solutions for Producing "Cleaner" Energy**



**Hydro power**, currently supplying only six percent of the world's energy, is a renewable energy source. Energy is produced by hydraulic turbines that rotate with the force of rushing water (higher to lower elevation). It is one of the most clean and cheapest way of producing energy, but it can also change the flow of rivers and increase sediment which kills fish. It is a large investment for developing countries. (www.abcnews.com/sections/us/global106)



**Hydro Power plant on a river**  
[www.envirolink.org/orgs/edf/sitemap.html](http://www.envirolink.org/orgs/edf/sitemap.html)

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Denmark is currently the world leader in **wind power**. By 2030, fifty percent of Denmark's energy could be produced by wind power. Randall Swisher, executive director of the American Wind Energy Association says, "If this country made an aggressive development push, by 2020 eighteen percent of the country's energy could be supplied by wind power." (www.abc.com/sections/us/global106.html) Wind power emits no greenhouse gases, but it takes up large amounts of land. In order for it to be a reliable source, scientists must develop better power storage techniques. Another concern of people is noise pollution that the large windmills produce along with the reliability of wind.



**A field of wind mills**  
[www.envirolink.org/orgs/edf/sitemap.html](http://www.envirolink.org/orgs/edf/sitemap.html)

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**Solar power** uses photovoltaic cells (PV's) to gather thermal energy directly from the sun and use it to produce electricity. One community could be supplied by one field of PV's . Passive solar cells could also be used to heat water, replacing the need for today's hot water heaters. PV's do not emit any greenhouse gases, but they are very expensive and more development is needed in order for this to be realistic energy source for the future. (www.abcnews.com/sections/us/global106.html)





**A field of PV's gathering sunlight to produce power**  
[www.abcnews.com/sections/us/global106.html](http://www.abcnews.com/sections/us/global106.html)

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**Nuclear power** is strong in Europe with about forty-two percent of their energy produced by **fission**. Nuclear generation provides about 17% of world electricity, avoiding the emission of up to 2.3 billion tonnes of carbon dioxide annually. France produces 76% and Lithuania produces 85.6% of its energy by nuclear fission. (<http://infoweb.magi.com/~dwalsh/wfsesr.html>) In the United States, people are antinuclear because of 3 Mile Island in 1979 and Chernobyl in 1986. However, many experts say that it is a safe, clean, and reliable source of energy. Nuclear Fission produces no greenhouse gases, but does produce highly toxic radioactive wastes.



**Nuclear power plants have had success in Europe, but not in the United States**  
[www.envirolink.org/orgs/edf/sitemap.html](http://www.envirolink.org/orgs/edf/sitemap.html)

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### **Kyoto Protocol**

One of the major conventions concerning global warming resulted in the Kyoto Protocol, held in Kyoto, Japan, between December 1-11, 1997. Delegates from all over the world were present in order to find a universal agreement to reduce greenhouse gas emissions. The results had most developed nations doing most of the reducing; the United States must cut emissions 7%, Japan 6%, and the European Union 8% below 1990 levels. ([www.state.gov/global/oes/fs\\_kyoto\\_climate\\_980115.html](http://www.state.gov/global/oes/fs_kyoto_climate_980115.html))

The United States proposed a plan to have these levels cut over a five year period between 2008-2013. The United States also said it will not sign the protocol if other developing/undeveloped countries do not sign it as well, fearing the economy will falter. The U.S. was successful in emissions trading with other countries who have less emissions. This means that the U.S. or other developed countries can purchase emission permits from other countries who have extra permits. This stresses the importance of flexibility the U.S. was looking for when it said it cannot lower the emission levels until at least 2008. Again, the U.S. is trying to look out for it's own economy first. If a country shall fail in completing its goal, the country will then not be able to receive joint implementation projects. However, this Protocol is not yet law; it must be ratified by at least 55 countries, accounting for 55% of the world's total greenhouse gas emissions.

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### Opinion

The world's leading scientists project that during our children's lifetimes global warming will raise the average temperature of the planet by 2 to 6 degrees Fahrenheit, or 1-3.5 degree Celsius. In contrast the Earth is only 5 to 9 degrees Fahrenheit or about 3-6 degrees Celsius warmer today than it was 10,000 years ago during the last ice age. Man-made global warming is occurring much faster than at any other time in at least the last 10,000 years.

([www.toowarm.org/factsheets/basfact.html#How](http://www.toowarm.org/factsheets/basfact.html#How)) This information would suggest that the warming Earth is experiencing now is not a natural phenomenon, but caused by the increased concentration of greenhouse gases.

While evidence is strong to support the notion of human contribution to the global warming problem, an alternative view is that recent global warming is a natural occurrence. Some theorists believe that the Earth's climate works in a cycle, cooling, and then warming itself. Scientists point out the fact that 75 million years ago, the Earth's average temperature was ten degrees higher than it is today. Conditions were warmer and more humid, but life sustained.

([www.enviolink.org/orgs/edf/sitemap.html](http://www.enviolink.org/orgs/edf/sitemap.html))

Another phenomenon to take into account is the "little ice age", which occurred from 1550-1850 A.D. Conditions around the world were cooler than usual; many bodies of water froze over. The average global temperature since the little ice age has risen by one degree Fahrenheit! Shouldn't it be expected that after that ice age was over that the temperature on Earth would rise at least one degree?

The bottom line is that it may seem that only human actions are causing global warming, but it is very possible that global warming is nothing to worry about and is just part of the global temperature cycle. Both theories are credible, but neither has yet been proven.

## **Recycling Saves Energy in Production of New Products**

Recycling means to use something again. Newspapers can be used to make new newspapers. Aluminum cans can be used to make new aluminum cans. Glass jars can be used to make new glass jars. Recycling often saves energy and natural resources.

Natural resources are things of value provided by the Earth. Natural resources include land, plants, minerals, and water. By using materials more than once, we conserve natural resources.

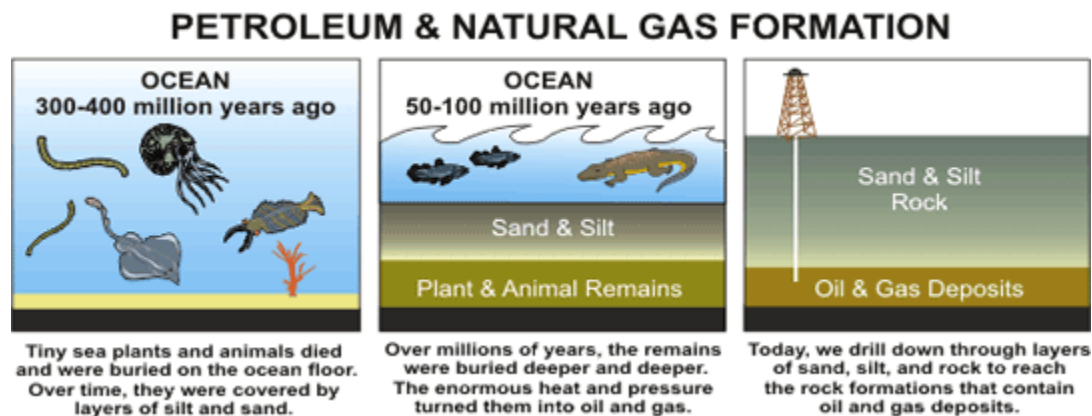
It almost always takes less energy to make a product from recycled materials than it does to make it from new materials. Using recycled aluminum scrap to make new aluminum cans, for example, uses

95% less energy than making aluminum cans from bauxite ore, the raw material used to make aluminum.

In the case of paper, recycling saves trees and water. Making a ton of paper from recycled paper saves up to 17 trees and uses 50% less water.

## How Was Oil Formed?

Oil was formed from the remains of animals and plants (diatoms) that lived millions of years ago in a marine (water) environment before the dinosaurs. Over millions of years, the remains of these animals and plants were covered by layers of sand and silt. Heat and pressure from these layers helped the remains turn into what we today call crude oil. The word "petroleum" means "rock oil" or "oil from the earth."



## Products Made from a Barrel of Crude Oil

### Did You Know Crude Oil Can Be Sweet or Sour?

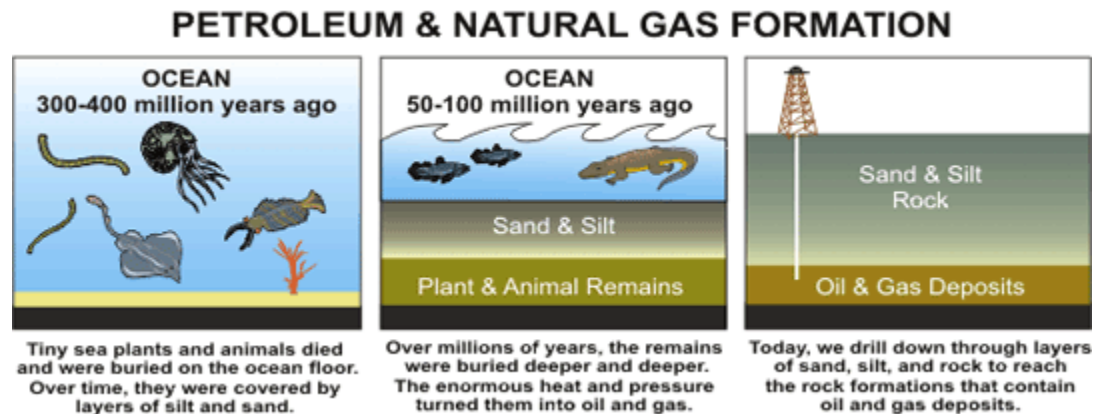
Crude oil is called "sweet" when it contains only a small amount of sulfur and "sour" if it contains a lot of sulfur. Crude oil is also classified by the weight of its molecules. "Light" crude oil flows freely like water, while "heavy" crude oil is thick like tar.

After crude oil is removed from the ground, it is sent to a refinery by pipeline, ship, or barge. At a refinery, different parts of the crude oil are separated into useable petroleum products. Crude oil is measured in barrels (abbreviated "bbls").

## How Was Natural Gas Formed?

The main ingredient in natural gas is methane, a gas (or compound) composed of one carbon atom and four hydrogen atoms. Millions of years ago, the remains of plants and animals (diatoms) decayed

and built up in thick layers. This decayed matter from plants and animals is called organic material — it was once alive. Over time, the sand and silt changed to rock, covered the organic material, and trapped it beneath the rock. Pressure and heat changed some of this organic material into coal, some into oil (petroleum), and some into natural gas — tiny bubbles of odorless gas.

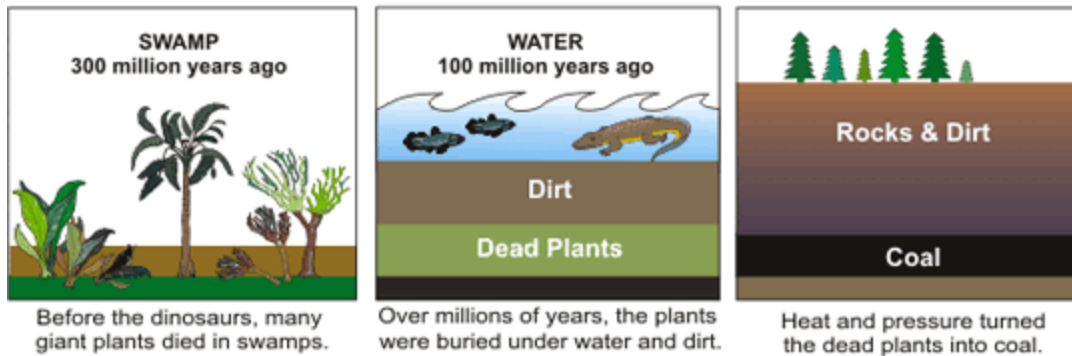


## How coal was formed

Coal is a nonrenewable energy source because it takes millions of years to create. Coal is a combustible black or brownish-black sedimentary rock composed mostly of carbon and hydrocarbons. The energy in coal comes from the energy stored by plants that lived hundreds of millions of years ago, when the Earth was partly covered with swampy forests.

For millions of years, a layer of dead plants at the bottom of the swamps was covered by layers of water and dirt, trapping the energy of the dead plants. The heat and pressure from the top layers helped the plant remains turn into what we today call coal.

## HOW COAL WAS FORMED



## Coal and the Environment

### What Are Some Environmental Concerns In Coal Mining?

Without proper care, mining can have a negative impact on ecosystems and water quality and alter landscapes and scenic views. Debris that chokes mountain streams can result from surface mining like mountaintop removal, and acidic water can drain from abandoned underground mines.

Today restoring the land damaged by surface mining is an important part of the mining process. Because mining activities often come into contact with water resources, coal producers must also go to great efforts to prevent damage to ground and surface waters.

### What Emissions and Byproducts Are Produced from Burning Coal?

The combustion of coal produces several types of emissions that adversely affect the environment. The five principal emissions associated with coal consumption in the energy sector are:

- Sulfur dioxide (SO<sub>2</sub>), which has been linked to acid rain and increased incidence of respiratory illnesses
- Nitrogen oxides (NO<sub>x</sub>), which have been linked to the formation of acid rain and photochemical smog and to depletion of the Earth's ozone layer
- Particulates, which have been linked to the formation of acid rain and increased incidence of respiratory illnesses
- Carbon dioxide (CO<sub>2</sub>), which is the primary greenhouse gas emission from energy use.
- Mercury, which has been linked with both neurological and developmental damage in humans and other animals. Mercury concentrations in the air usually are low and of little direct concern. However, when mercury enters water — either directly or through deposition from

the air — biological processes transform it into methylmercury, a highly toxic chemical that accumulates in fish and the animals (including humans) that eat fish.