# ENE 101: Introduction to Energy Engineering

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# Week 2: Climate

# Energy Challenge

- Energy use is directly proportional to standard of living.
- Things have changed dramatically since the industrial revolution.
- World population is expanding rapidly.
- Energy demand is skyrocketing.
- Global reserves of various types of fossil energy are limited.
- Oil and natural gas will be fully depleted in 50 years, and coal in 300 years.

# Fossil fuels

Fossil Fuels are ***non-renewable*** as they are formed from the remains of microbes, plants, and animals that lived ***millions*** of years ago.

| Advantages | Disadvantage |
| --- | --- |
| •Much less expensive then other sources | •non-renewable<br>•releases CO2 into the air contributing to climate change.<br>•obtaining fossil fuels destroys habitats.<br>•Causes pollution including acid rain. |

# COAL

- When coal is burnt it produces Carbon Dioxide, Nitrogen Oxide and mercury compounds
- Since coal contains impurities like S and N, it produces toxic gases during burning which causes acid rain and air pollution. Gives off sulfur dioxide-harms trees
- Lakes and rivers are contaminated from coal power plants.
- Severe human health threat. (lung)

Pounds per Billion BTU of Energy Input

| Pollutant | |
|---|---|
| Carbon Dioxide | 208000 |
| Carbon monoxide | 208 |
| Nitrogen Oxides | 457 |
| Sulfur Dioxide | 2591 |
| Particulates | 2774 |
| Mercury | 0,016 |

# OIL

- Crude oil is made of many different compounds, each with its specific boiling point. Using distillation, we can separate out these compounds and turn them into commercial products, ranging from gas to asphalt.
- Methane from oil wells & equipment
- Natural gas burned from oil production
- Harmful to fish and plants

Pounds per Billion BTU of Energy Input

| Pollutant | |
|---|---|
| Carbon Dioxide | 164000 |
| Carbon monoxide | 33 |
| Nitrogen Oxides | 448 |
| Sulfur Dioxide | 1122 |
| Particulates | 84 |
| Mercury | 0,007 |

# NATURAL GAS

- Natural Gas is found above the oil in oil well. It is the mixture of 50-90% methane and small amount of other hydrocarbons.
- Release Nitrogen Oxides, Carbon Dioxide & Carbon monoxide when burned.
- Methane (a greenhouse gas) can leak from pipelines.
- Less emissions than coal and oil.
- Methane sometimes emitted or leaked
- Affects people abd animals who depend on aquatic life in lakes and rivers

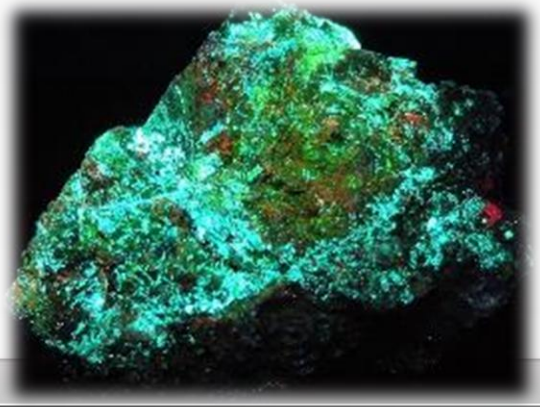
Pounds per Billion BTU of Energy Input

| Pollutant | |
|---|---|
| Carbon Dioxide | 117000 |
| Carbon monoxide | 40 |
| Nitrogen Oxides | 92 |
| Sulfur Dioxide | 1 |
| Particulates | 7 |
| Mercury | 0,000 |

https://www.slideshare.net/pgiffenig/environmental-impact-of-energy-sources

# NUCLEAR ENERGY

- Nuclear Fission uses uranium to create energy
- The nucleus of a uranium atom stores a large quantity of nuclear energy.
- When these atoms break apart, the atoms' nuclear energy is transformed into thermal energy.
- A small pellet of uranium-produces about as much energy as burning ***570 L*** of oil.
- Nuclear Energy is a non-renewable resource because once uranium is used , it is gone !
- Fission of 1 kilogram of uranium releases more energy than does burning 3 million kg of coal.



# History Of Nuclear  Power Plant

First Electricity Production: 20 December, 1951 in Arco, Idaho, USA.

First Commercial Use: June 26, 1954 at Obninsk, Russia.

Present Scenario: 442 nuclear power plant units in 31 countries produce electricity about 384 GW.

Under construction: 66 plants with a capacity of 65 GW are in 16 countries.

Figure 02: First Electricity production by Nuclear Energy.

# NUCLEAR ENERGY

**Pros**

- Fuel required is quite small
- Nuclear power plant requires less space
- Economical for bulk electric power
- Ensure continued supply of electrical energy
- Do not cause air pollution
- Does not emit green house gases

**Cons**

- Non-renewable
- Fuel is expensive
- Capital cost is very high
- Requires greater technical knowledge
- Radioactive fission products/waste
- Mining uranium causes pollution
- Risk of serious accidents
- Radioactive waste from a nuclear reactor is stored ***underwater*** for more than 10 years.
- Then it is stored in a dry storage behind ***concrete*** 1 m thick.
- After another 60 years, the canisters can be moved to ***long-term storage,*** but it is still ***unsafe.***
- It will remain unsafe for ***tens of thousands of years !***
- Aquatic life badly affected because of water removal

# Most Consequential Types of Waste

- Nitrogen Oxides (NO, $NO_2$)
- Carbon Dioxide ($CO_2$)
- Sulfur Dioxide ($SO_2$)
- Mercury Compounds
- Lead Compounds
- Methane ($CH_4$)
- Ozone ($O_3$) at ground level
- Chlorofluorocarbons (CFCs)
- Unburned hydrocarbons

# Summary

| Pollutant | Source | Harmful Effects | Prevention |
|---|---|---|---|
| Carbon monoxide | Incomplete combustion of fossil fuels | Headaches, breathing difficulties, heart damage, death | Fit catalytic converters to cars |
| Sulphur dioxide | Combustion of fossil fuels | Breathing difficulties, asthma attacks, acid rain | Treat waste gases with calcium oxide, fit catalytic converters to cars |
| Nitrogen oxides | Lightning, vehicle engines | Breathing difficulties, acid rain, ozone formation | Fit catalytic converters to cars |
| Methane | Decay of vegetation, cows | Global warming, ozone formation | Improve diets of cattle |
| Ground level ozone | Unburnt hydrocarbons and $NO_2$ | Irritates eyes, throat and lungs; asthma attacks | Fit catalytic converters to cars, reduce vehicle population |

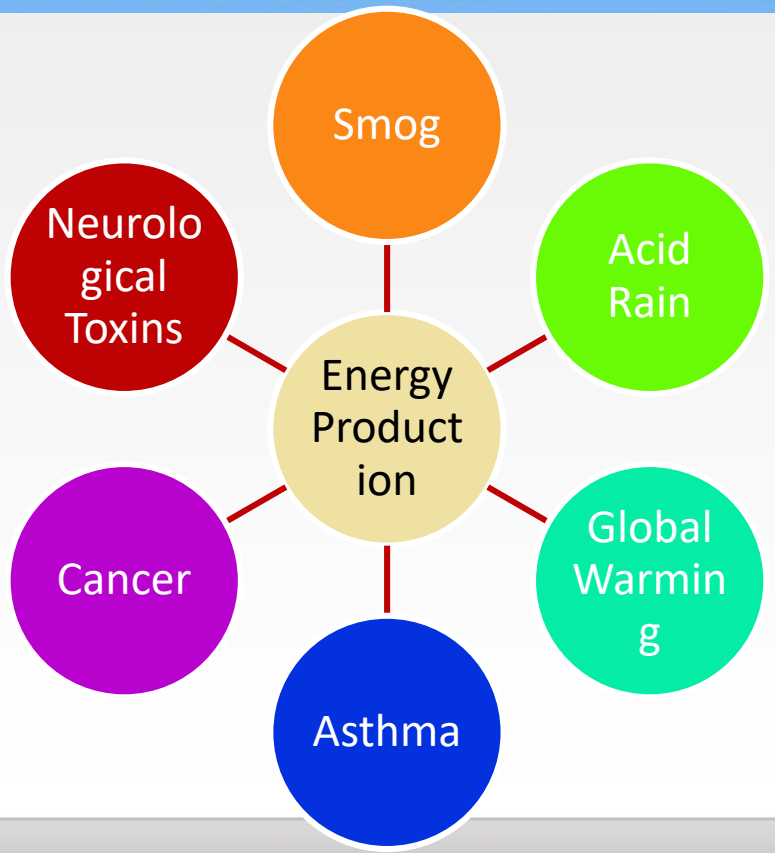
# Energy and Environment

Energy and environment has a strong relationship. The production and consumption of energy is one of the biggest causes of environmental damage on earth.

It leads to large amounts of destruction of natural landscapes and habitants through the process of fuel extraction, pollution of soil, climate change.

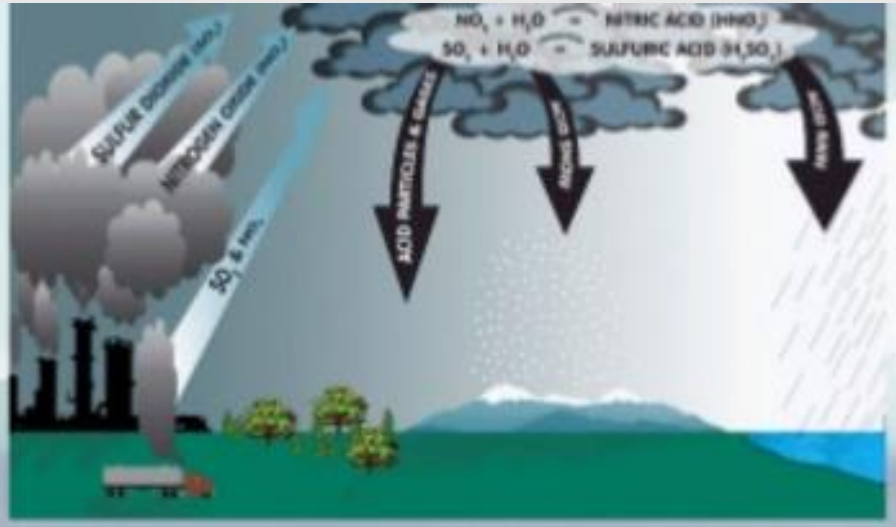
Energy is at the heart of many of the world's current environmental problems, and posses many problems for the sustainable development

# Energy production includes environmental and human health costs



# Acid rain

- Acid rain has a pH of between 1–5 compared to normal rain water which has a pH of about 5.6.
- Acid rain is rain that contains a large proportion of acids such as sulphuric acid and nitric acid.



- When sulphur dioxide in the air reacts with oxygen and water, it forms sulphuric acid:

$$2SO_2 + O_2 + 2H_2O \rightarrow 2H_2SO_4$$

- Nitrogen dioxide in the air reacts with oxygen and water to form nitric acid:

$$4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$$

- These two acids dissolve in the rain water to form acid rain.

https://www.slideshare.net/Chemrcwss/c26-pollution?next_slideshow=1

# Harmful effects of acid rain

- Acid rain corrodes buildings, bridges, statues and other structures made of metal or stone.

- Acid rain kills fishes in lakes and rivers.
- Acid rain kills plants and vegetation by damaging their roots, leading to deforestation in many parts of the world, like Canada and Europe.

# The Greenhouse Effect

The Earth maintains a habitable temperature due to the Greenhouse Effect, which allows heat from the sun to penetrate our atmosphere, where it is absorbed by the Earth's surface or radiated out and reflected back to Earth by greenhouse gases in the atmosphere.

Without it, the Earth would be a cold and hostile planet, and would most likely be uninhabitable.

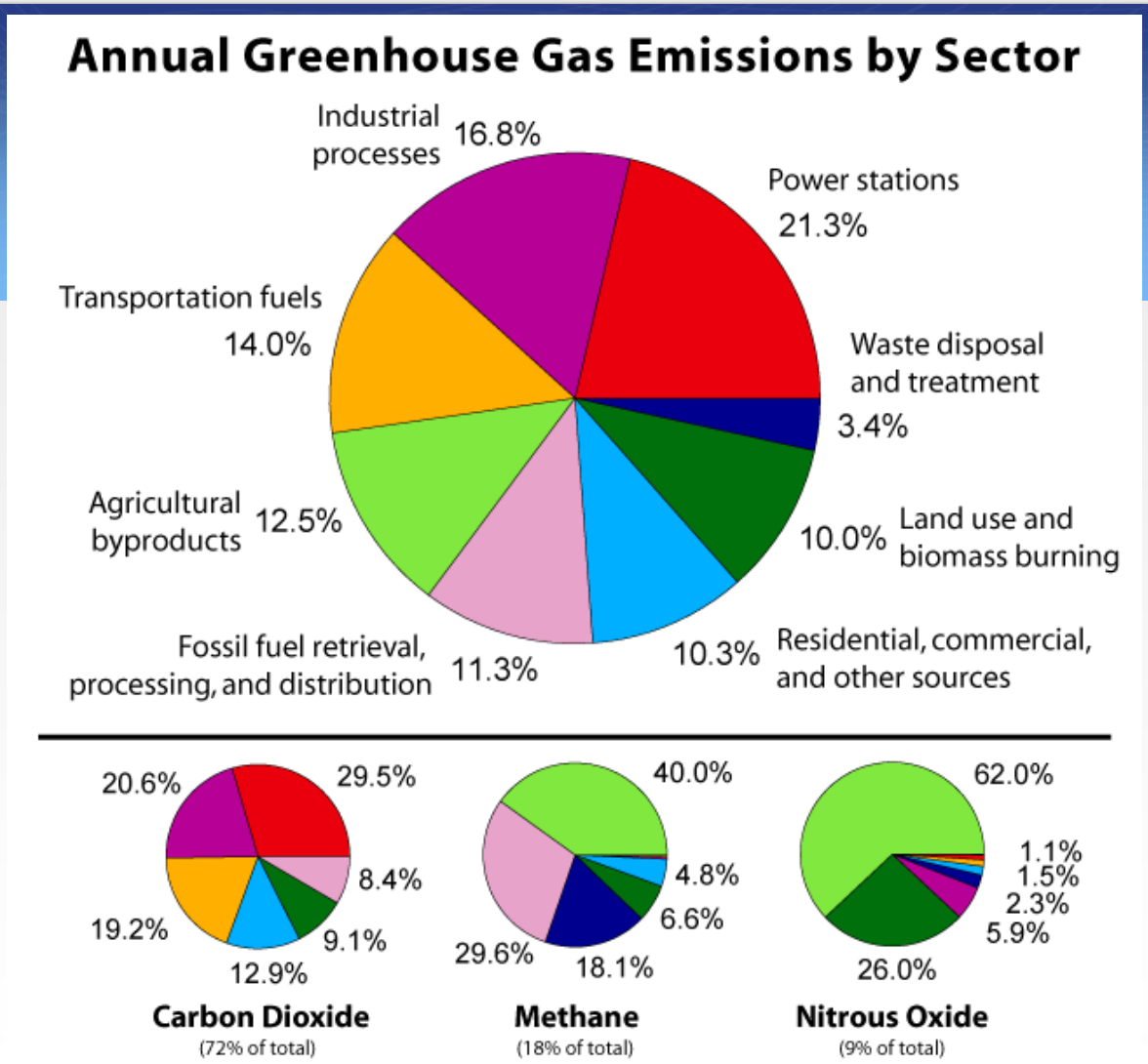
However, maintaining the natural balance necessary to keep the Earth's temperature within a range that is viable for life as we know it is a very fine line that can easily be crossed.

Greenhouse gases are **naturally occurring gases** that pose no harm when they are in balance. However, **when they are present in excess**, the system becomes unbalanced and things start to go awry.

http://globalwarming-facts.info/causes-global-warming-human/

# Green House Gases

- The most important greenhouse gases are **carbon dioxide, methane, nitrous oxide and water vapor**. While all these gases occur naturally in the atmosphere, emissions from human sources has caused their levels to rise to a point that is no longer sustainable.




http://globalwarming-facts.info/causes-global-warming-human/

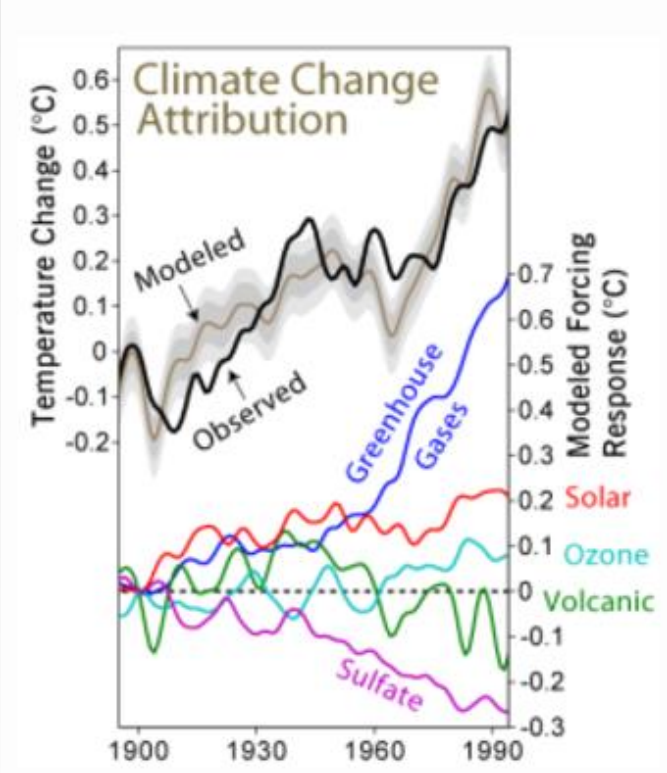
# Evidence That Humans are Causing Global Warming

- Lets take a look at the major human causes of global warming.
- Both natural and human factors contribute to global warming, however, evidence has shown that the warming we are currently witnessing is largely as a result of human forcing. According to the Union of Concerned Scientists, there are **several indications that provide evidence that humans are the cause** of global warming rather than it being due to natural variability – these indicators include:

- **Warming Oceans**: Oceans have absorbed 20 times more heat than the atmosphere resulting in warmer oceans. The recorded increases in ocean temperatures extend **well beyond that of natural climate variation**.

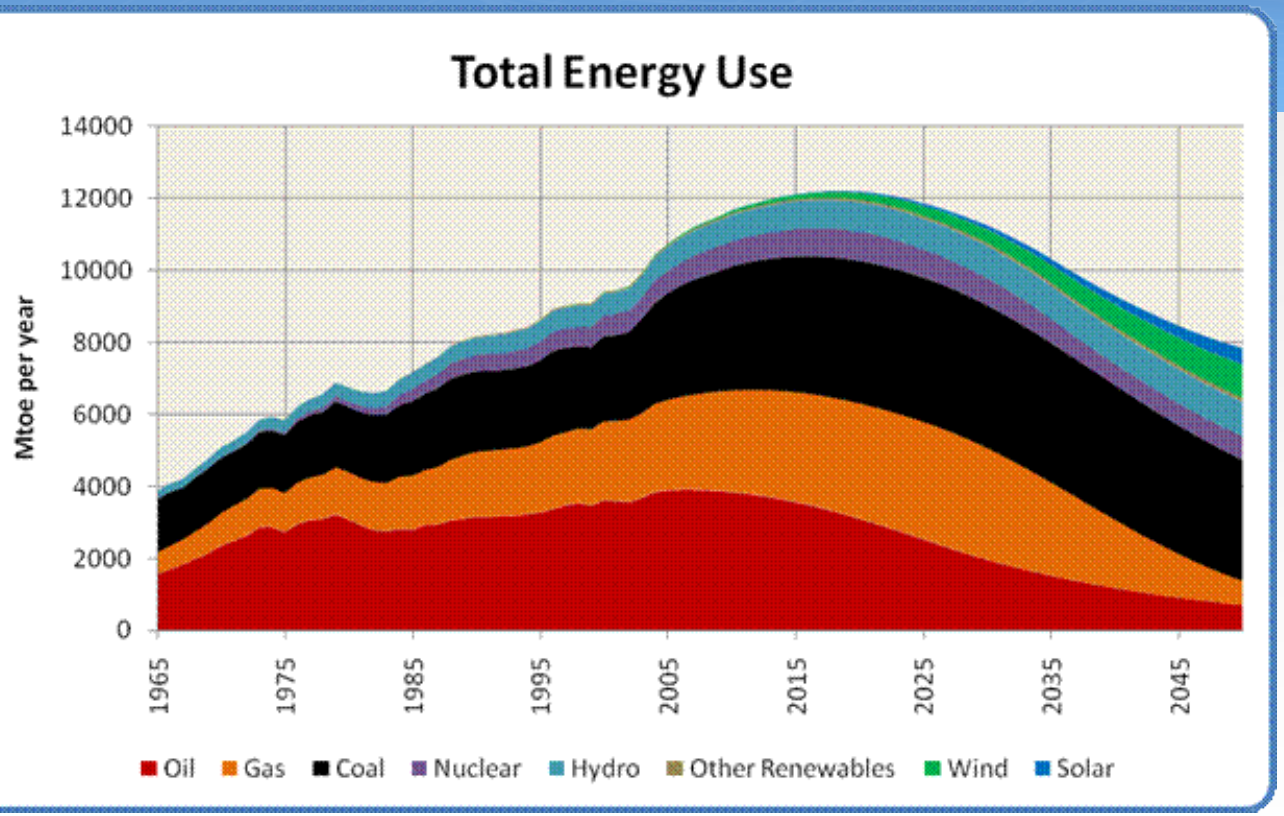
- **Atmosphere Boundary Shifts:** The boundary of the lower atmosphere (troposphere) that contains our weather has risen by more than 900 feet over a twenty year period between 1979-1999, according to a study conducted in 2003. **this has been exacerbated by human activities** which have led to: 1) an **increase in greenhouse gas emissions** that causes heat to remain trapped within the troposphere, and 2) a **decrease in ozone** in the stratosphere, causing less sunlight to be absorbed by the ozone layer, resulting in a cooling of the stratosphere. The **combined effects** of these two phenomena is **responsible for more than 80%** of the troposphere's boundary (known as the tropopause) shift upward.

**Rising Surface Temperatures:** Average global temperatures have increased by 0.8°C over the last century, with the most significant increases occurring in the last 30 years. Scientists have **modeled the Earth's temperature with both natural and human drivers** of climate change and the results show that greenhouse gas emissions are causing the Earth to warm up three times as fast now than in 1950. **Human emissions are primarily responsible** for the rapid rise in temperatures that we have seen over the latter part of last century and what we are witnessing today.



# Observations of Climate Change – Global Warming

- Temperature, Evaporation & rainfall are increasing;
- More of the rainfall is occurring in downpours
- Corals are bleaching
- Glaciers are retreating
- Sea ice is shrinking
- Sea level is rising
- Wildfires are increasing
- Hurricane, storm and flood damages are much larger




We still strongly depend on fossil fuels
and this is not expected to change
anytime soon

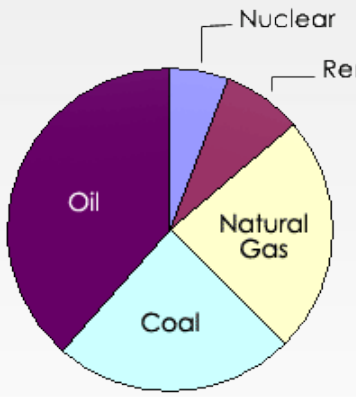
Negative impacts:
*Conflicts of interest on limited resources.
*Increasing cost of energy
*Environmental concerns

http://www.paulchefurka.ca/WEAP2/Energy_GDP_2050.html

# The Energy Solution

- Energy is produced, transferred and stored until it reaches to consumers.
- There are different needs and possible solutions for each of these processes.
- Even for each process there are various specific needs for different applications.
- For this reason, development of **efficient and sustainable energy** technologies is necessary for taking the next big step in **renewable energy usage.**

World Energy Consumption By Type




Data From Energy Information Administration: International Energy Outlook 2006
http://www.eia.doe.gov/oiaf/ieo/highlights.html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