

The Role and the Essentials of Nuclear Energy in our Future

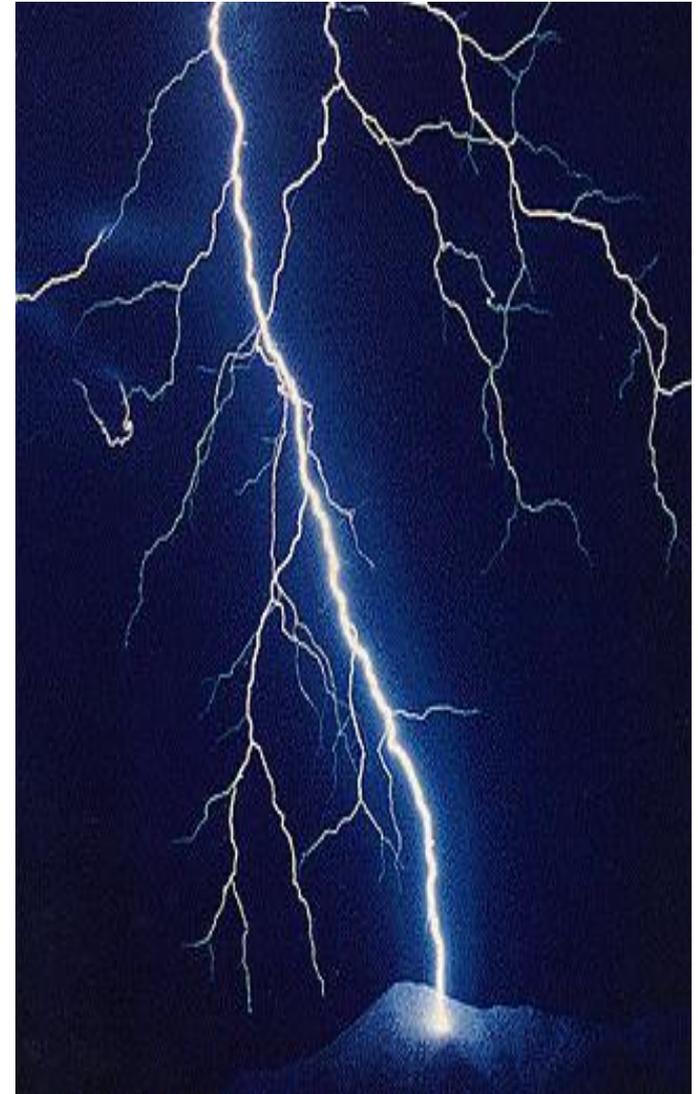
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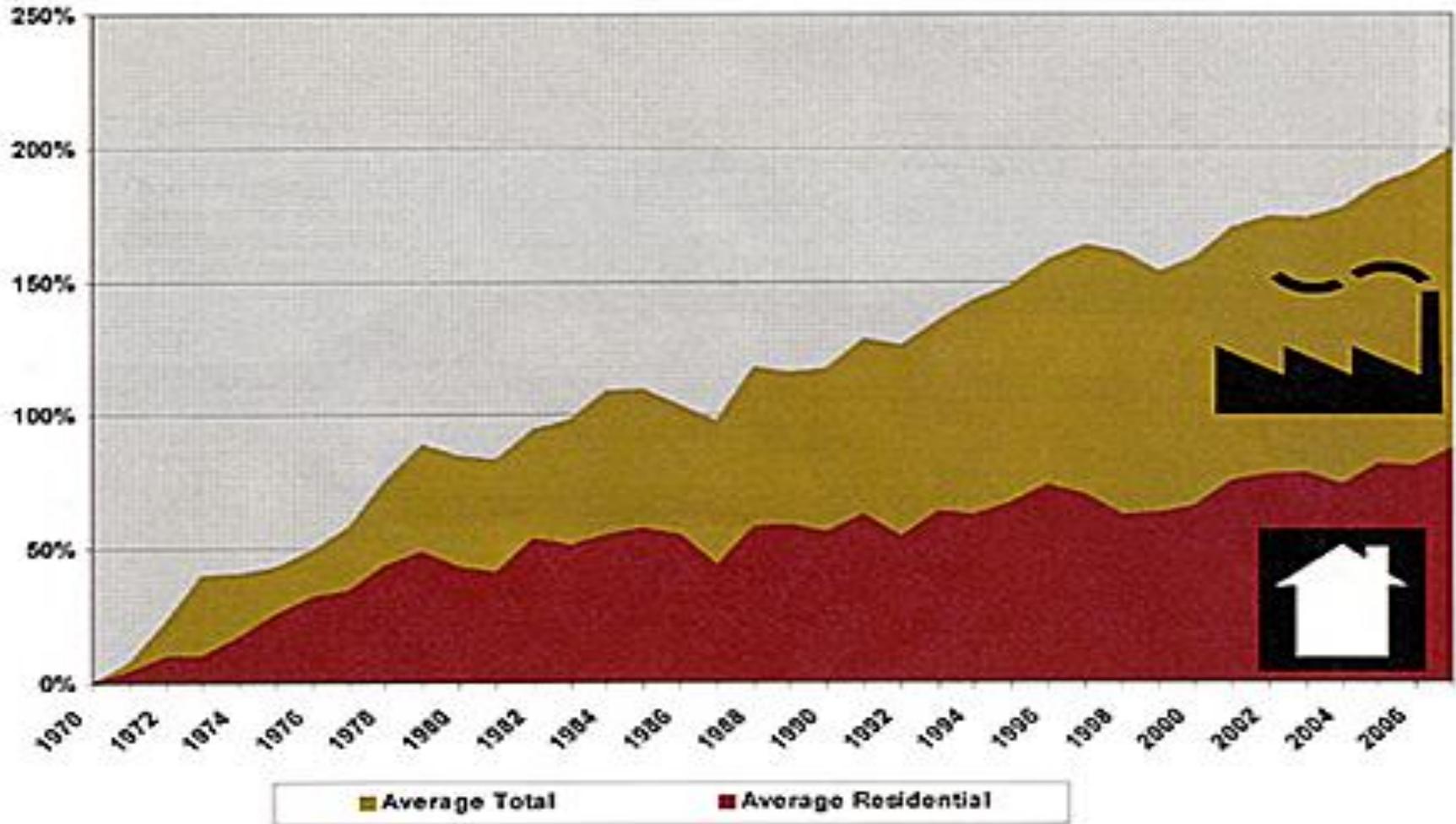
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Energy as a Key to Our Future

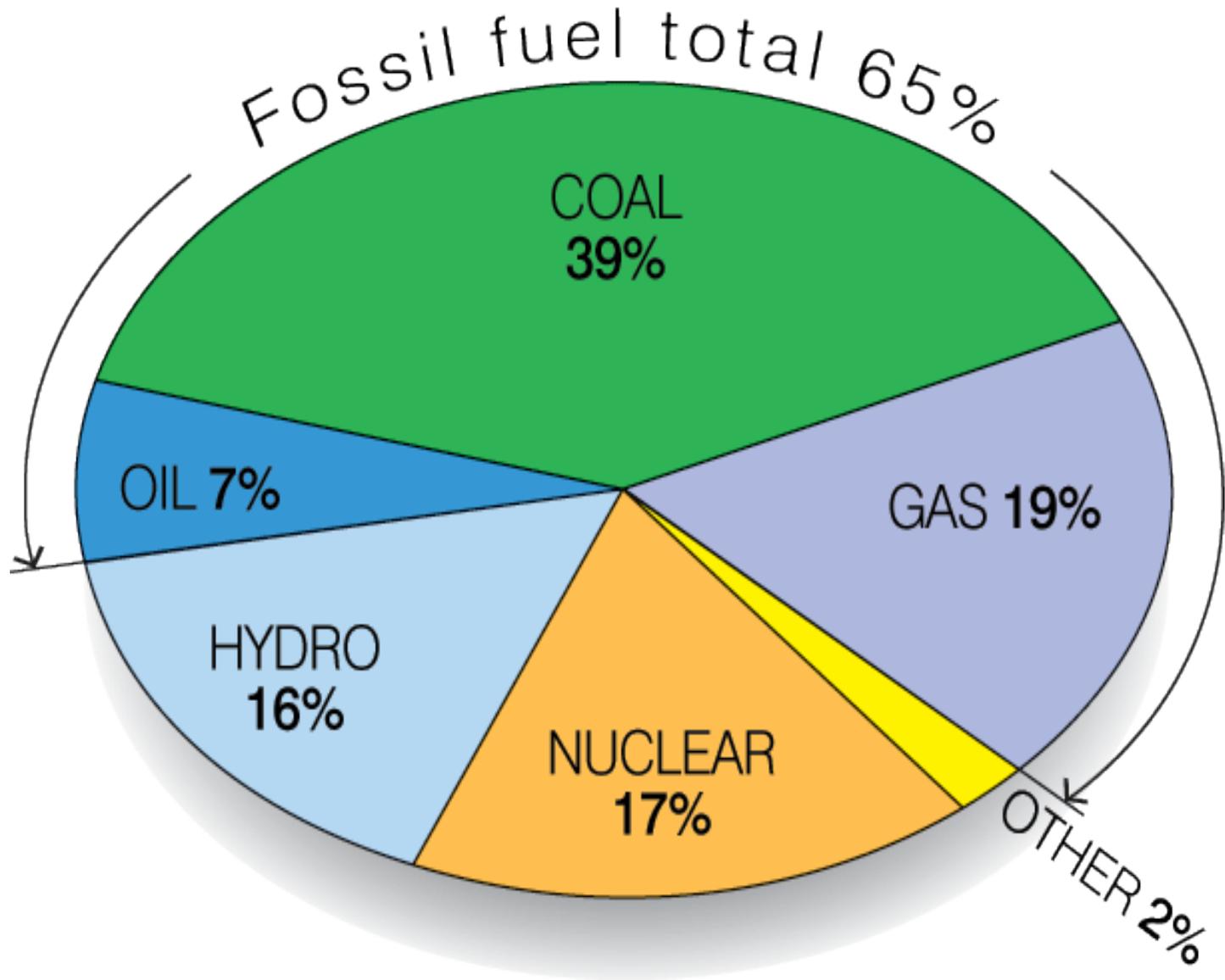
- Energy is the single most important commodity for humanity.
- Without enough energy, production will stop, economics will fall and the civilization will crumble.
- The most widely utilized form of energy for industry and for domestic use is electricity.



The Demand for Electricity has Tripled Since 1970



The Distribution of Energy Sources for Producing Electricity (2008)



Use of Fossil Fuels are Causing Irreversible Damage to our World

- Everyone agrees that the use of fossil fuels are causing irreparable and irreversible damage to our environment.
- Many modern diseases (such as Cardiovascular Disorders, Cancer, High Blood Pressure) are partially caused by Fossil Fuel Pollution in the Environment.
- With the present consumption of fossil fuels, the world's energy needs will not be met sufficiently in 30 years.

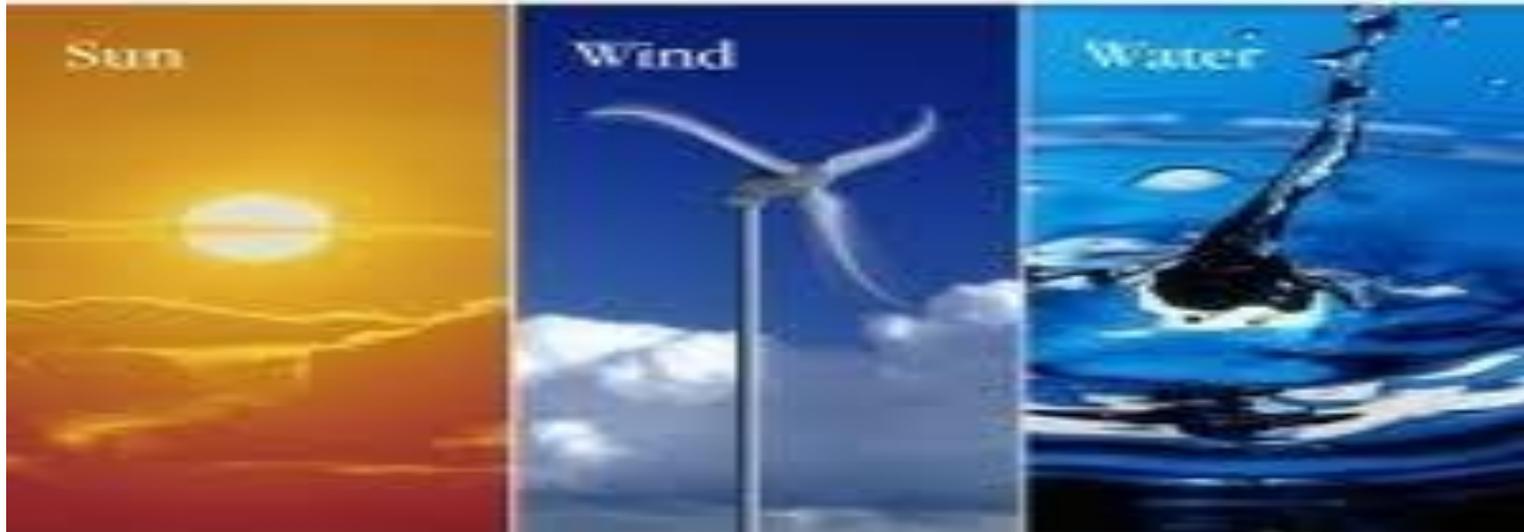


Fossil Fuel Damage to the Environment

- Especially the burning of coal for production of electricity releases carbon dioxide, as well as nitrogen oxide and sulfur dioxide.
- Nearly 50% of the nitrogen oxide in the atmosphere and 70% of sulfur dioxide are direct result of emissions released when coal is burned



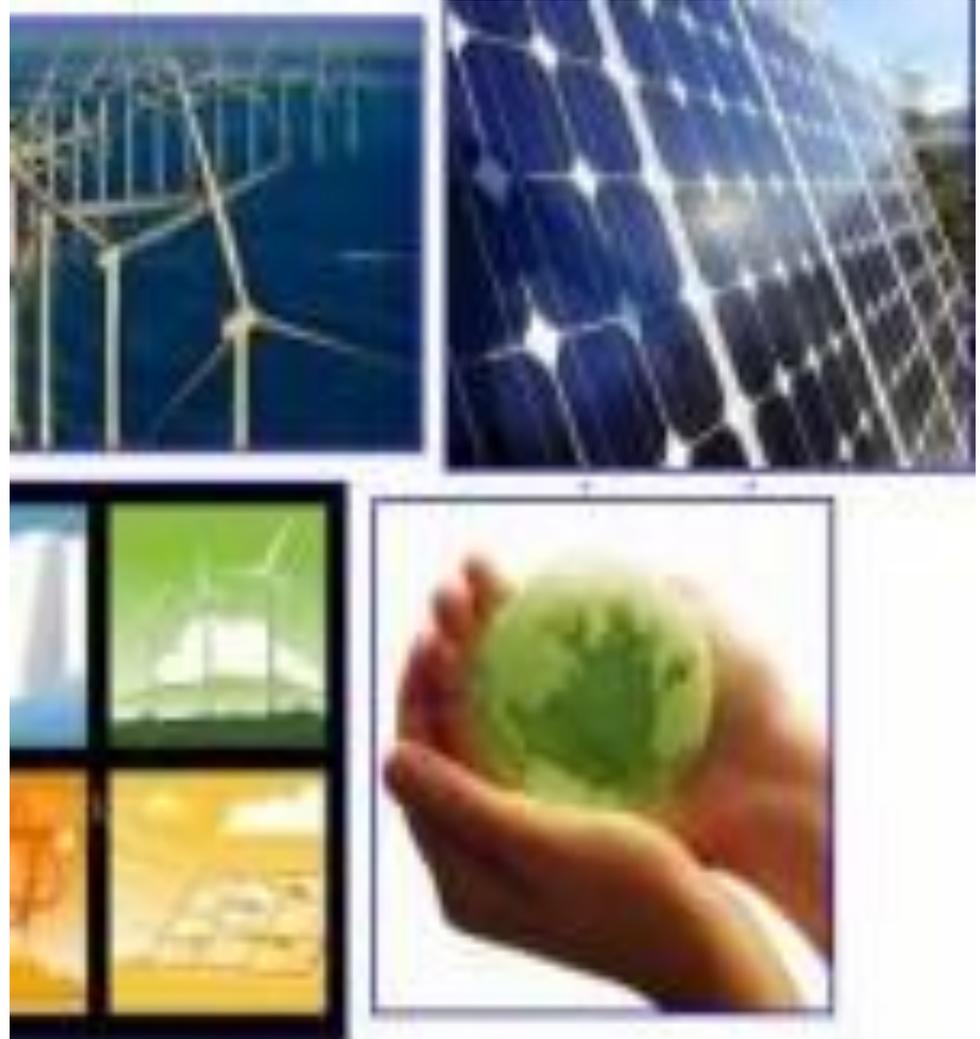
Alternatives to Fossil Fuels for Electricity



- Use of Fossil Fuels for Electricity are Destroying the Environment for Future Generations. The alternatives:
- Renewable Energy Sources
- Hydrodynamic Power Production
- Nuclear Energy Production

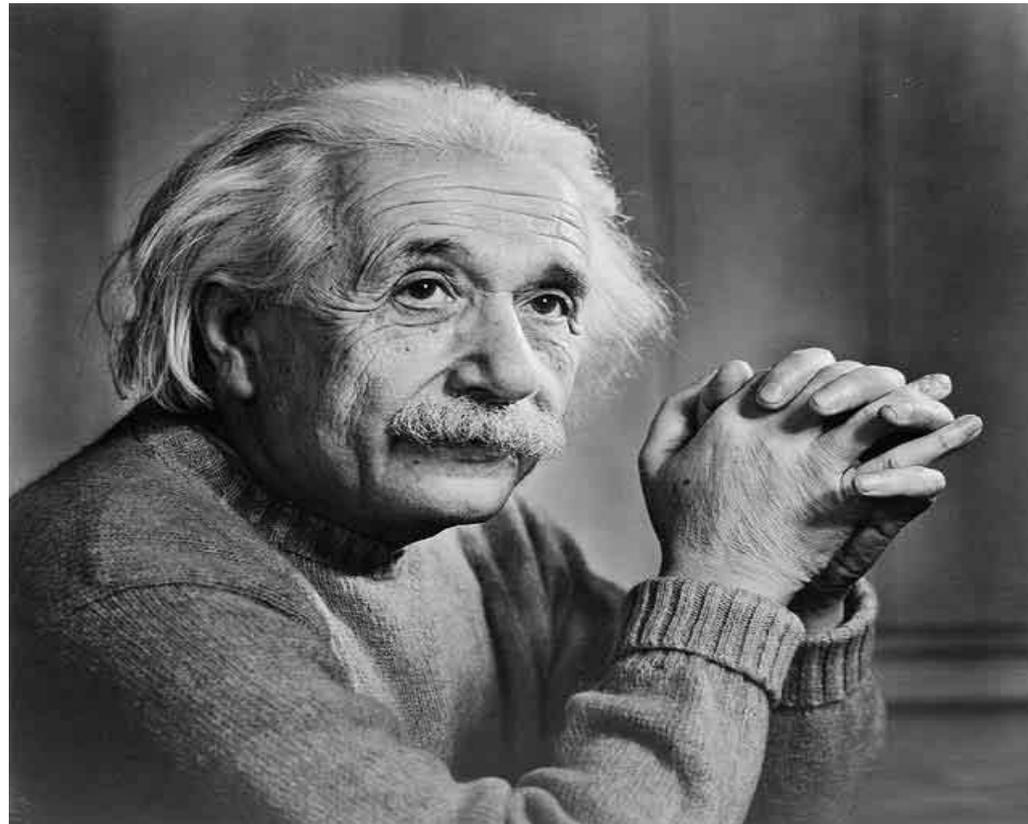
Renewable Energy Supplies Cant Be Used Efficiently

- Renewable energy sources for electricity are diverse, from solar, tidal and wave energy to hydro, geothermal and biomass-based power generation.
- Apart from hydro power in the few places where it is very plentiful, none of these renewable energy sources are suitable, intrinsically or economically, for large-scale base-load power generation.



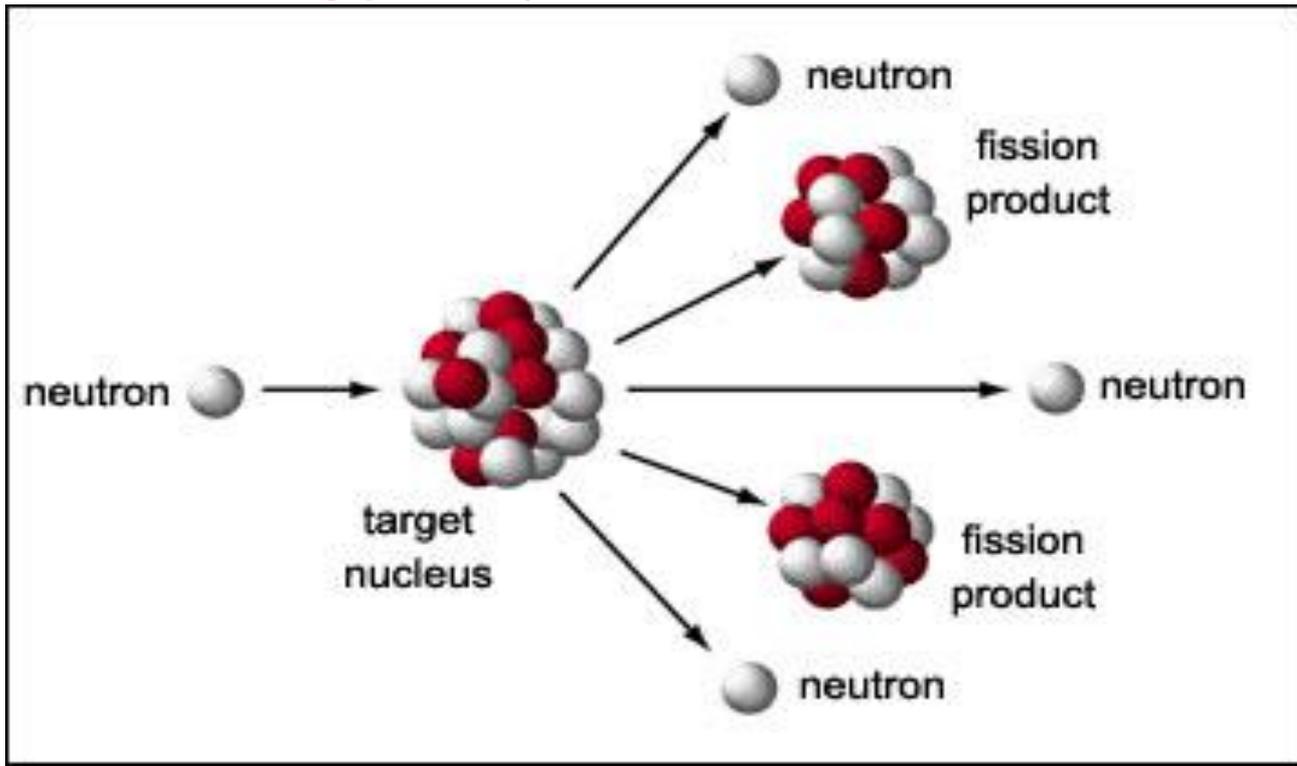
What is Nuclear Energy?

- Albert Einstein with his famous law of $E=mc^2$ was responsible for the idea that mass can be converted into energy.
- In essence, Nuclear Energy is the energy utilized from converting mass to energy through nuclear processes.



Power of Fission

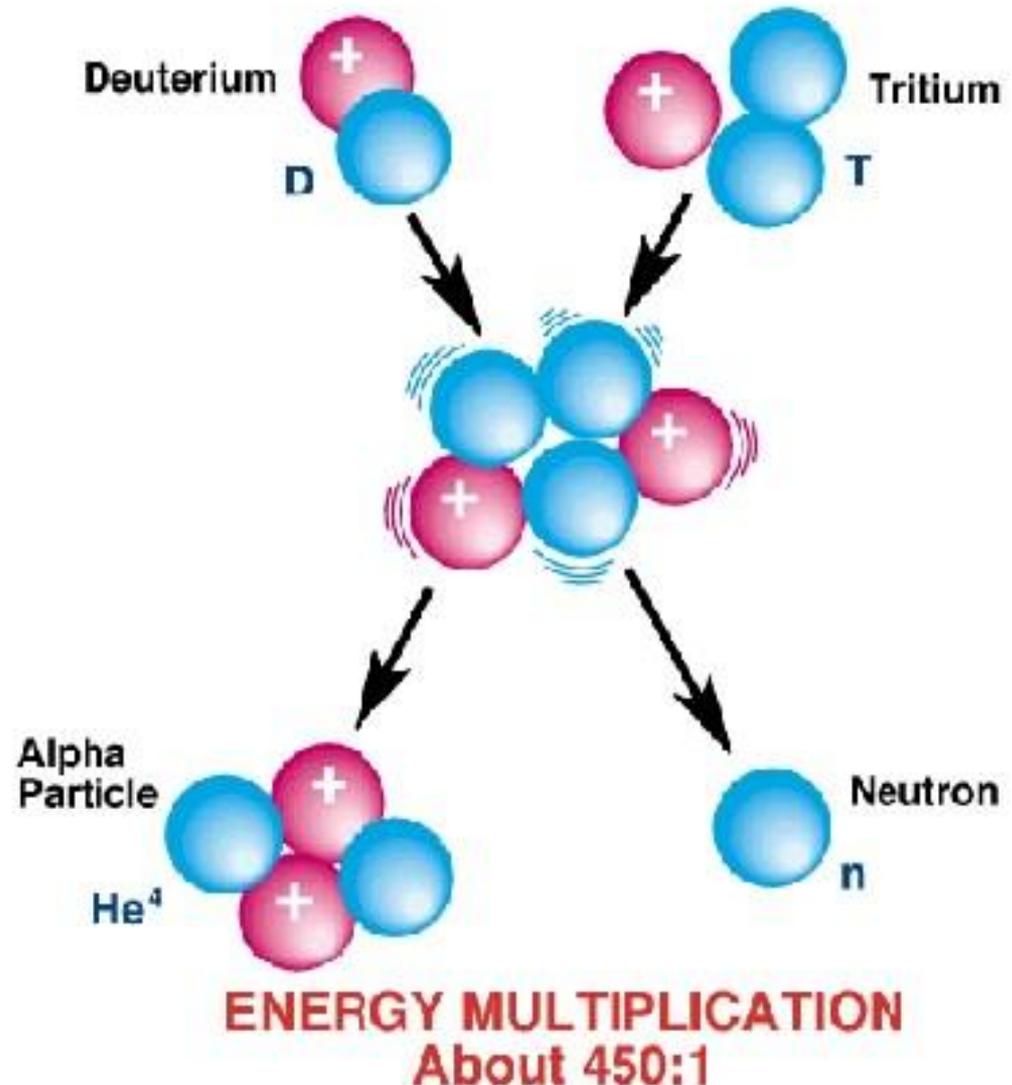
- Fission is one of the most powerful sources of energy in the world. In essence, a molecule of fissile material is bombarded by neutrons, so that it separates into two or more articles. During this process, **some mass is converted to pure energy** (expressed as heat)



Power of Fusion

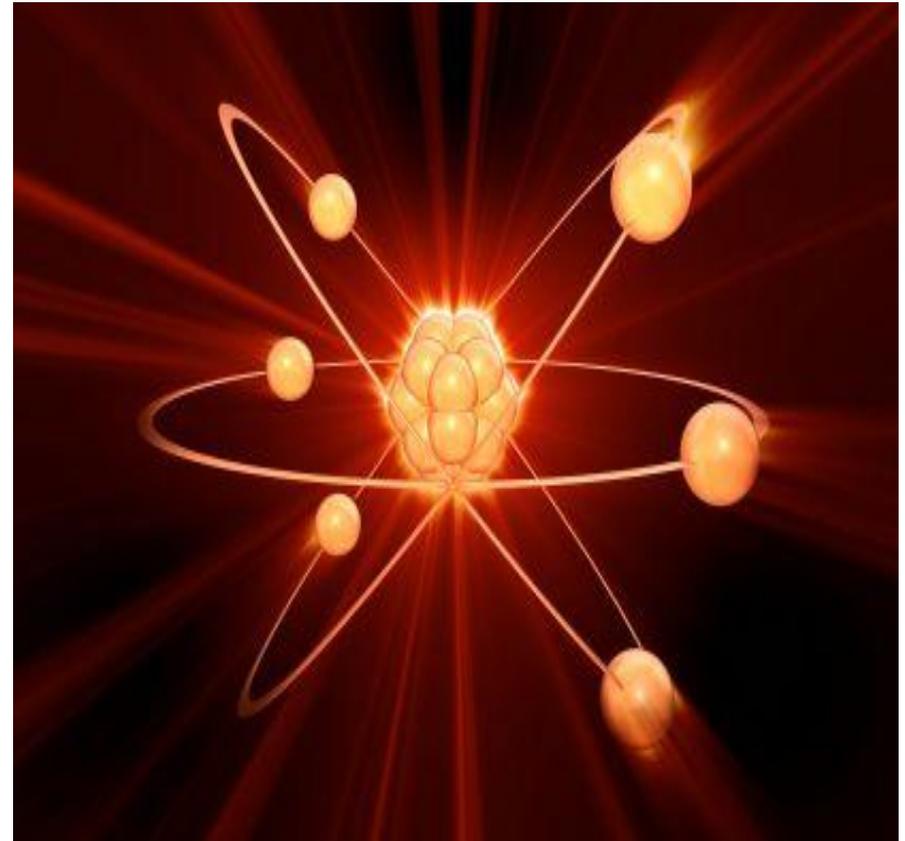
- Fusion is the process of combining atoms to make new ones. During this process, great amounts of energy is released.
- **Sun is the best example for Fusion Energy.**
- In the sun, Hydrogen molecules fuse to become Helium molecules.

Deuterium-Tritium Fusion Reaction



How Can We Harness Nuclear Energy?

- Nuclear Energy is achieved through natural processes and nuclear reactions have been going on for millions of years.
- Nuclear Reactions are abundantly found on our Sun as well as in the billions of stars found in our galaxy. Moreover, even Earth is full with nuclear reactions and natural radioactivity.



World's First Nuclear Reactor?

- The actual first nuclear reactor in the world was working 2 billion years ago.
- The first nuclear reactor was a natural reactor found in Oklo, Gabon in the African continent.



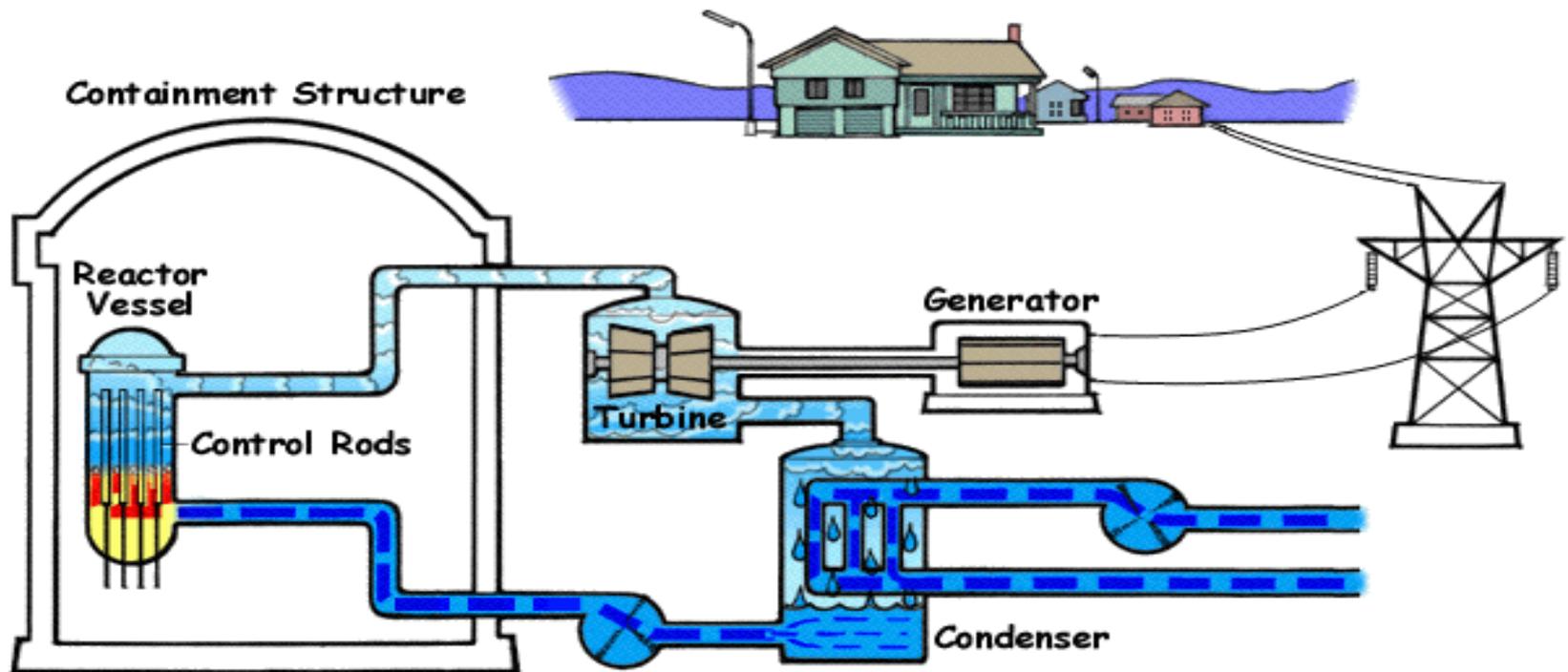
Nuclear Power Plant

- A Nuclear Power Plant is a special type of power plant in which nuclear fission reaction is used to generate electricity through various processes.



A Nuclear Power Plant Operates on the Same Principles

- A nuclear power plant is not really a special thing. Instead of using fossil fuels to generate heat, which in turn produces steam; nuclear reactors produce higher heat through a contained fission reaction.



Components of a Nuclear Reactor

- Components of a Nuclear reactor include:
 - Nuclear Fuel
 - Control Rods
 - Moderator to Slow the Neutrons
 - Reflector to Stop Neutrons from Escaping
 - Coolant to Cool the Core
 - Shielding to Protect Against Radiation from Escaping the Reactor

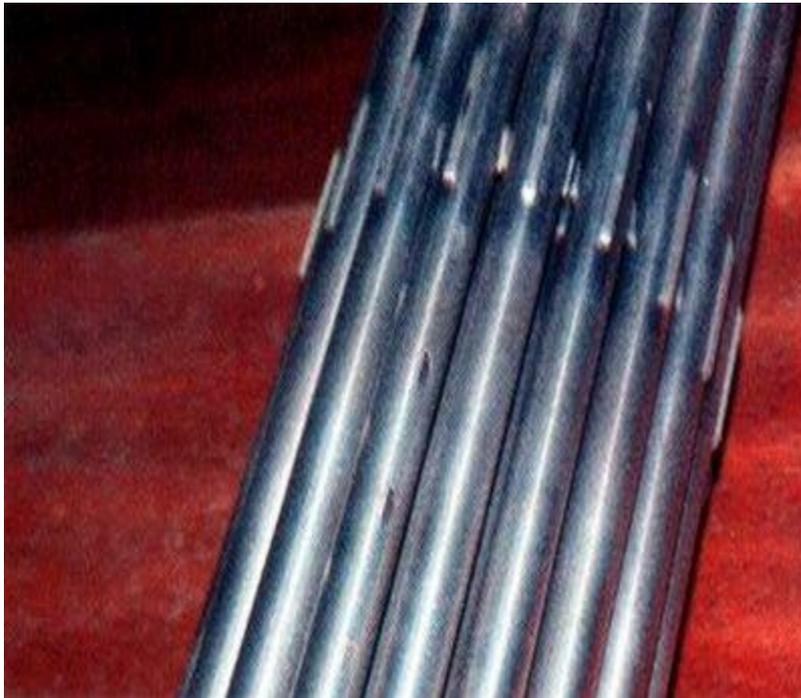


The Insides of a Nuclear Reactor



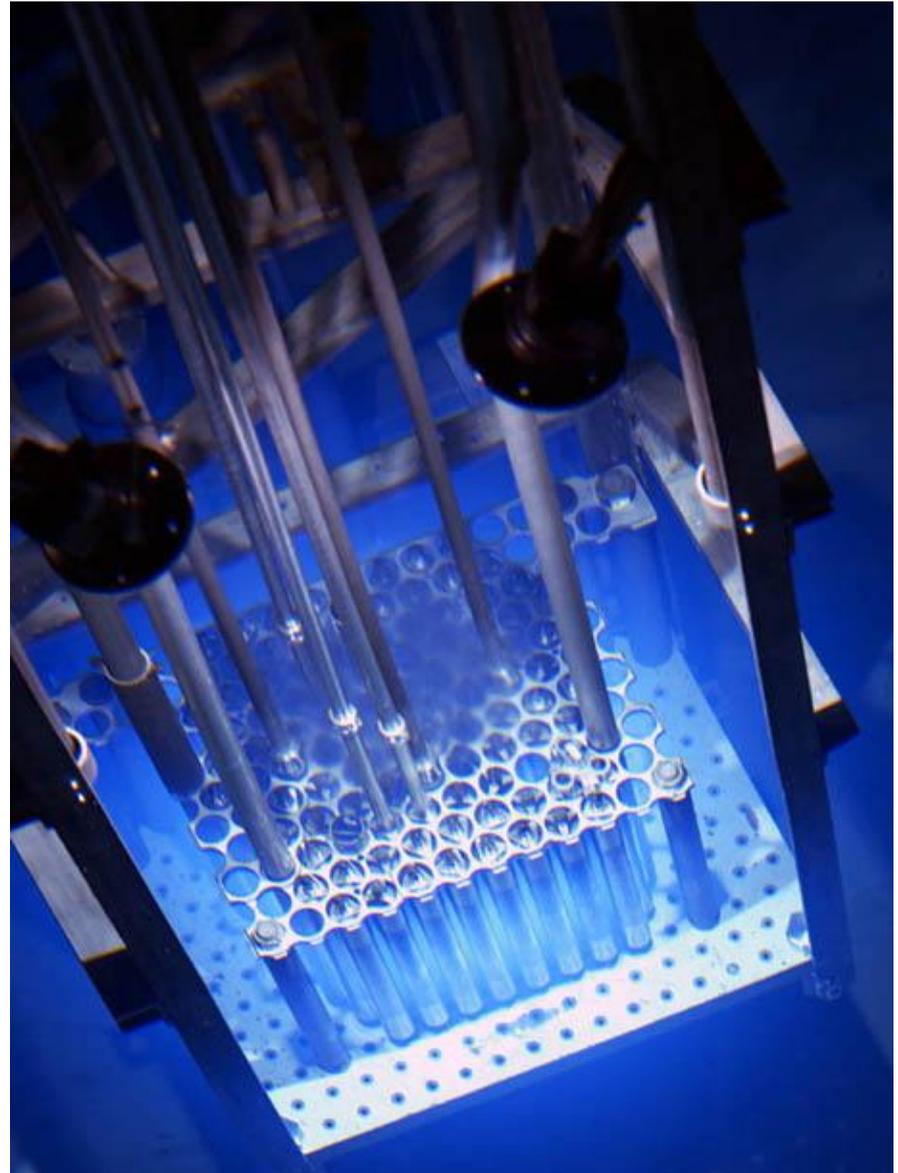
Nuclear Fuels

- Nuclear Fuels can be in different forms made from a fissile material and a decorroser:
 - Solid Nuclear Fuels (in form of fuel rods)
 - Liquid Nuclear Fuels
 - Gaseous Nuclear Fuels



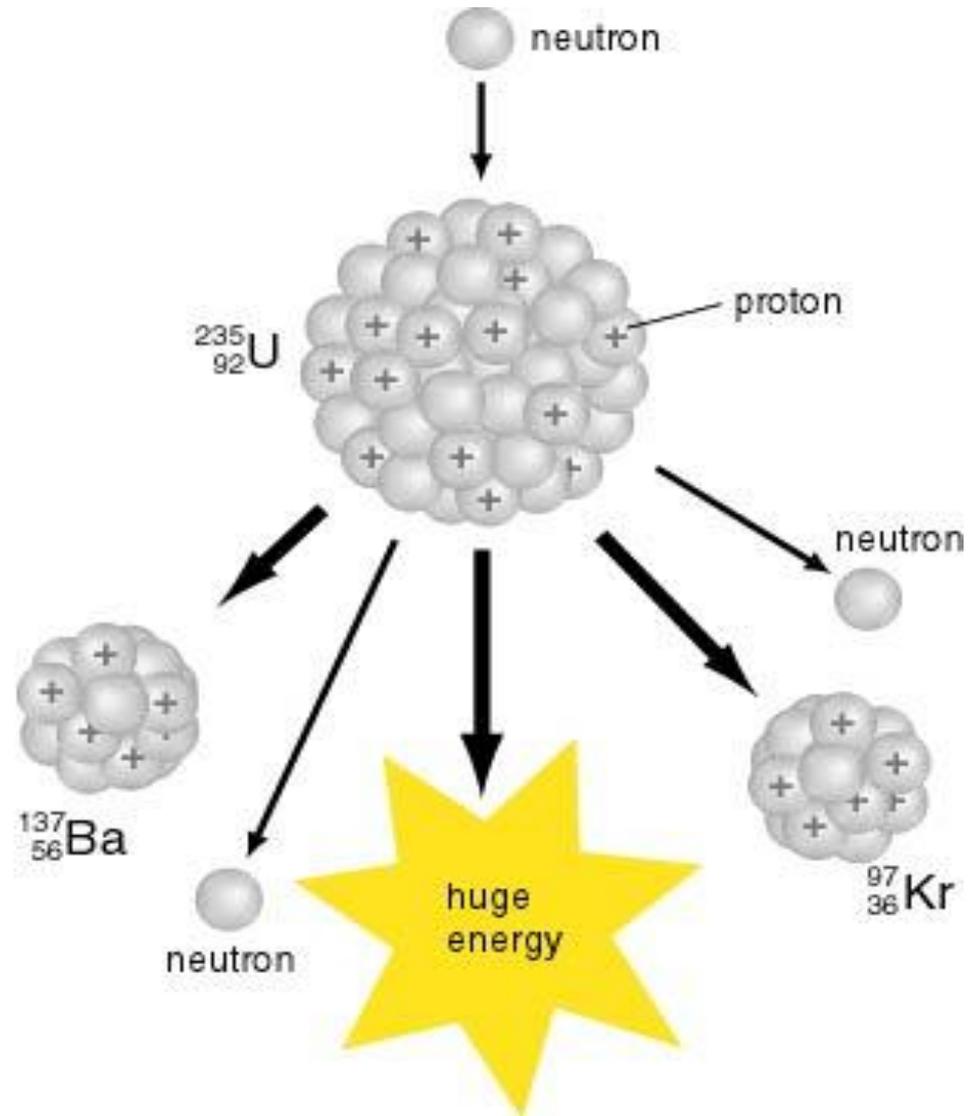
Nuclear Reactivity Control

- Nuclear reactivity (the rate of fission reaction) is controlled by control rods.
- These are the most important components in a nuclear reactor, as they allow you to increase or decrease the rate of the reaction by absorbing the neutrons in the reactor environment.



Nuclear Fuel and Actinides

- In order to sustain a nuclear reaction, the nuclear fuel must be **uranium-235**, **plutonium-239**, or **plutonium-241**.
- Only these actinides will split in two, when they are bombarded by thermalized neutrons. (Neutrons which have lost their speed by lowering their temperature)



Natural Uranium

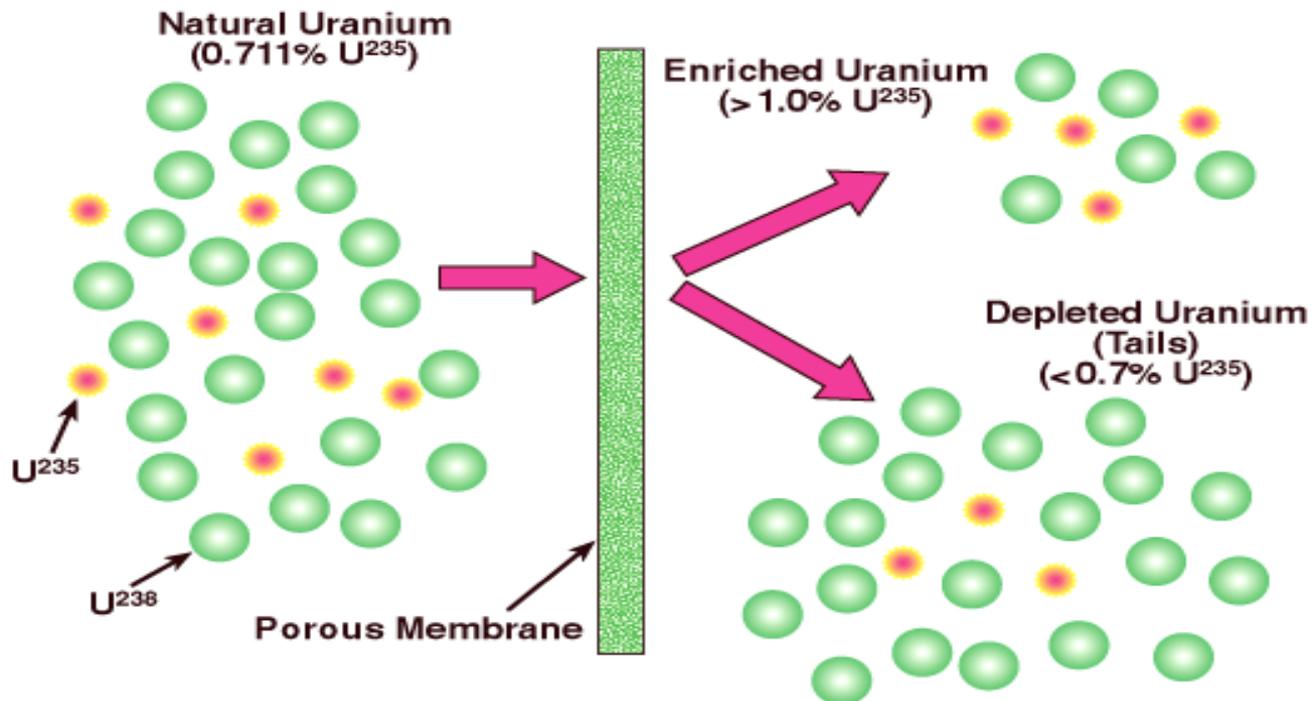
- The only naturally found readily fissile material on Earth is Uranium – 235. It comprises only of 0.7 % of natural uranium, which is a mixture of Uranium-238 and Uranium-235.
- Natural Uranium is abundantly found sometimes even without mining.



Nuclear Fuel Enrichment

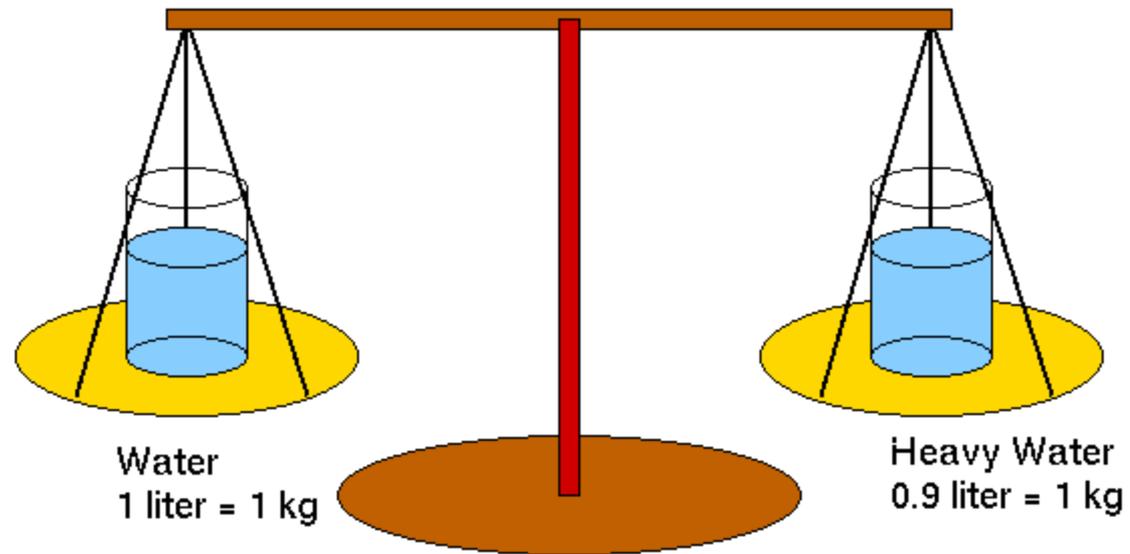
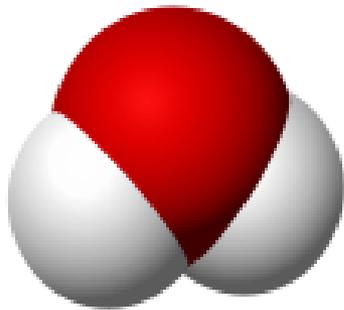
- In order to sustain a nuclear reaction, the nuclear fuel must be [uranium-235](#), [plutonium-239](#), and [plutonium-241](#). However, Uranium 235 is found only in 0.7 % abundance on Earth.
- Thus, the Uranium mined is usually Uranium 238, which can not undergo fission when used with natural water as coolant and moderator. You need to use Heavy Water with Uranium 238 in order to use less enriched fuel.

Gaseous Diffusion Uranium Enrichment Process



Heavy Water

- Hence, if you have abundance of Uranium 235, you can use natural water reactor, which has less costs to operate.
- Or you can use Uranium 238 in which case you must use heavy water (D_2O) as moderator. However, heavy water is expensive to make. Out of every 3200 molecules of water, only one is heavy water in nature.



Nuclear Strategy

- On a national level, if you have abundant sources of Uranium 235, then you can easily use natural water reactors.
- However, most countries possess Uranium 238 and you will need to use heavy water or heavy graphite to moderate the neutrons, so that they will become slow enough to undergo reaction.
- India has enough Uranium 238 to last for 100 years, even with triple capacity of what it can use today.

Future Power Plant Technologies

- In the United States, there is heavy work on using gas core reactors which have less nuclear waste and more efficiency.
- Thorium reactors are the next generation in Nuclear Energy production, as India holds one quarter of the world's thorium reserves.



Nuclear Power Plant Safety

- Contrary to popular belief, Nuclear Power Plants are one of the safest and efficient forms of producing electricity.
- With proper planning and safety procedures (especially with the know-how today), it is practically impossible for a nuclear reactor to have a catastrophic reaction.
- With advanced nuclear waste management techniques, (also from knowledge collected from Gabon Natural Reactor site); we know that we can safely store waste nuclear fuel.



Atomic Explosions can Only Happen with Nuclear Bombs

- As soon as a nuclear reactor starts going critical, its nuclear control rods can easily be lowered in which case the nuclear reaction will stop immediately. A nuclear fission reaction takes place only when it is forced.
- Most nuclear reactor designs (fuel rod and control rod assembly) will stop working immediately when they overheat.
- The only way a nuclear explosion can take place is through a nuclear bomb. In fact, majority of nuclear bombs are fusion bombs and not fission (atom) bombs.

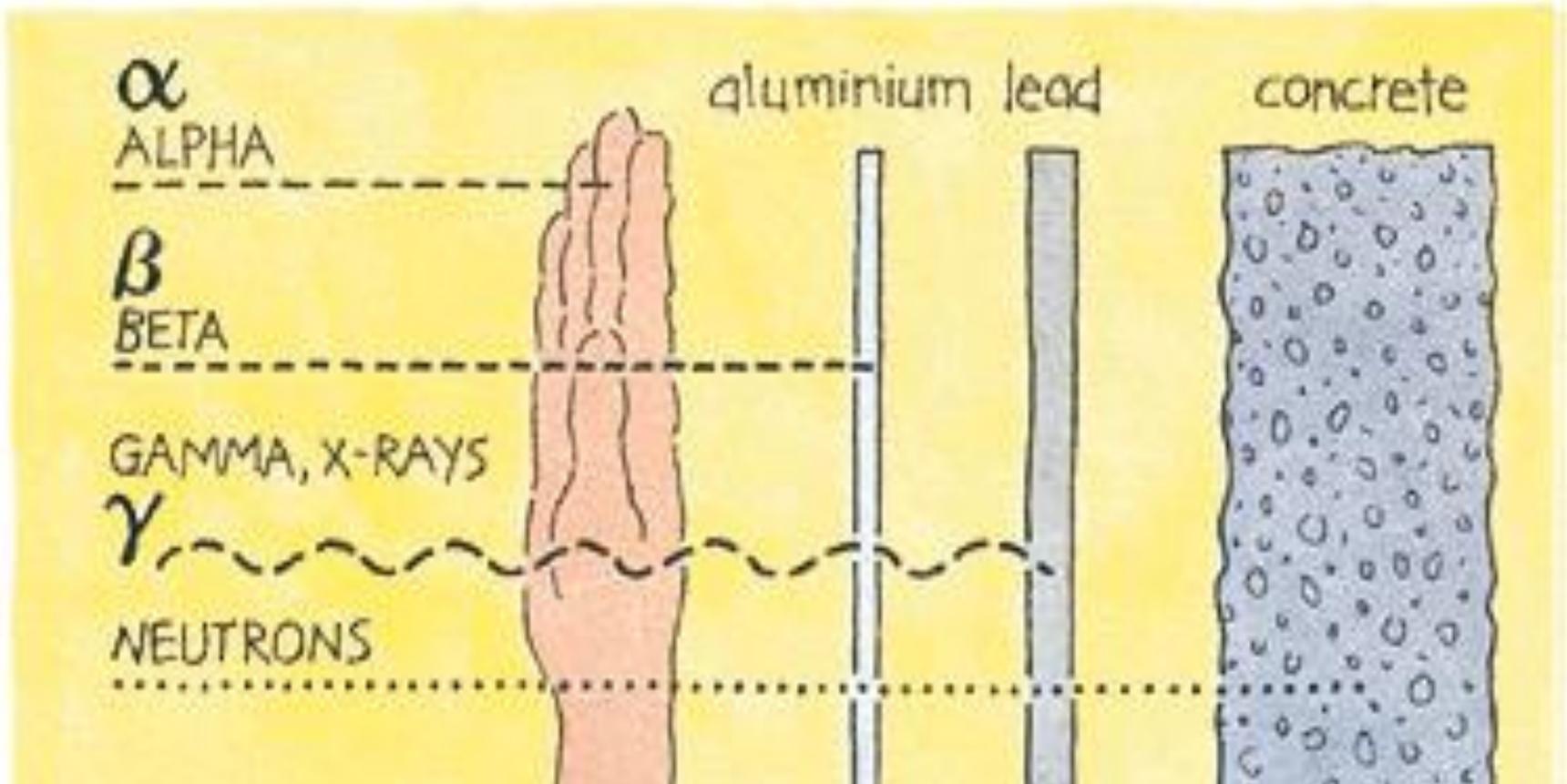


Radiation Safety

- Every human being is subjected to radiation every day. Sources vary from the sun, natural water, the food that we eat, cell phones to even from getting an X-ray for a checkup. There are always trace amounts of radioactive substance in everything we ingest.
- Remember, there is nothing unique about radiation. There are no detrimental health effects caused by radiation that are not also caused by one or more physical, chemical, or biological agents. Keep in mind that giant spiders, mutant crabs, and other fearsome creatures are created in the Special Effects Department of Hollywood — not by radiation.



Radiation Protection



Time, Distance, Shielding. If you reduce the time you are exposed to a radiation source, maximize the distance from the radiation source, and place some object or other form of shielding between you and the radiation source, you can reduce your radiation exposure

Standard Radiation Levels

- A coal plant would emit three times the radiation of a nuclear power plant due to the presence of natural uranium in the coal
- Up to 5000 mRem per year can be taken safely A 40 year old can have a maximum of 200 Rem. Anything above 300 Rem increases chance of cancer by 10%
- Normal exposure is 300 mRem per year
- A person emits about 40 mRem of radiation due to natural Carbon 14 found in the body. Sitting next to two persons would double the exposure
- A person who smokes a pack of cigarettes gains 3.5mRem of radiation corresponding to $\frac{1}{4}$ annual dose. A chain smoker has been exposed to more radiation overall as compared to those near nuclear plants



Radiation Units

Table 5
Units of Radiation and Radioactivity

Common Units USA	Abbreviation	Used to Measure
Roentgen	R	<ul style="list-style-type: none"> — Exposure (obsolete) — Measure of the amount of ionizations in a mass of air, gamma and x-rays only, only in air — $1 \text{ R} = 2.58 \times 10^{-4}$ coulombs per kg of dry air
Rad (radiation absorbed dose)	rad	<ul style="list-style-type: none"> — Absorbed dose, measure of amount of energy absorbed in a material, any type radiation, any type material — $1 \text{ rad} = 100$ ergs per gram of material
Rem (roentgen equivalent man)	rem	<ul style="list-style-type: none"> — Equivalent dose, relates absorbed dose in human tissue to the effective biological damage; "rem" doses which are equal but from different types of radiation produce the same amount of biological damage — $\text{rem} = \text{rad} \times Q$ (the quality factor) — $Q = 1$ for x-rays, up to 20 for neutron or alpha
Curie	Ci	<ul style="list-style-type: none"> — Radioactivity — $1 \text{ Ci} =$ quantity of material that has 3.7×10^{10} disintegrations/second

SI Units International Standard	Abbreviation	Used to Measure
Gray	Gy	<ul style="list-style-type: none"> — Absorbed dose (equivalent to rad) — $1 \text{ Gy} = 1$ joule per kg of material — $1 \text{ Gy} = 100$ rads
Sievert	Sv	<ul style="list-style-type: none"> — Equivalent dose (equivalent to rem) — $1 \text{ Sv} = \text{Gy} \times Q$ — $1 \text{ Sv} = 100$ rem
Becquerel	Bq	<ul style="list-style-type: none"> — Radioactivity (equivalent to Ci) — $1 \text{ Bq} = 1$ disintegration/second — $3.7 \times 10^{10} \text{ Bq} = 37$ billion Bq = 1 Ci

Note: frequently units are prefixed with milli (m) (one thousandth) or micro (μ) (one millionth), i.e., 1 millirem = 1 mrem = 0.001 rem, 1 microCi = $1 \mu\text{Ci} = 0.000001 \text{ Ci}$.

Radiation from Natural Sources

Table 3
Radioactivity of Some Natural and Man-Made Materials

Material	Amount	Becquerels	
Source for radiotherapy	1	100,000,000,000,000	(100 trillion)
50-year old high level nuclear waste	1 kg	10,000,000,000,000	(10 trillion)
Uranium	1 ton	10,000,000,000	(10 billion)
Medical isotope for diagnosis	1	70,000,000	(70 million)
Coal ash	1 ton	2,000,000	(2 million)
Low level nuclear waste	1 kg	1,000,000	(1 million)
Fertilizer — super phosphate	25 kg	125,000	
Human adult	1	3,000	
Coffee	1 kg	1,000	
Bread	1 loaf	70	
Hamburger	4 oz.	29	
Red kidney beans	1/2 cup	29	
Sunflower seeds	3.5 oz	28	
French fries	3.5 oz	20	
2% Milk	1 cup	11	
Banana	Small	9	
Hot chocolate	1 packet	6	
Oatmeal	1 cup	4	

Annual Radiation Doses

Radiation Doses in Millirem from Various Exposures (Annual Dose Unless Otherwise Stated)

10,000.0	Dose to Chernobyl evacuees
5,000.0	U.S. Occupational Dose limit
2,000.0	Tobacco smoking
1,500.0	Underground uranium mines
400 – 800.0	St. Peters Square, Rome
600.0*	Pelvic x-ray exam
500.0*	Barium enema x-ray exam
500.0	U.S. Occupational Dose limit for pregnant women per 9 months
500.0	N.Y. Grand Central Station entrance
480.0	Denver, Colorado
360.0	Average U.S. dose
170.0*	Gall bladder x-ray exam
140.0*	Rib cage x-ray exam
100.0	Airplane flight crew yearly dose
100.0	Dental x-ray dose to center of cheek
20.0	1 Chernobyl per year
15.0*	Chest x-ray
7.0	Nuclear testing (peak year)
4.0	Fallout
2.0	Airplane trip coast to coast
1.0	Nuclear power
0.5	TV at surface
0.1	Sleeping with another human

Sources of Radiation Dose

U.S. National Annual Average Effective Dose Equivalent = 360 mrem

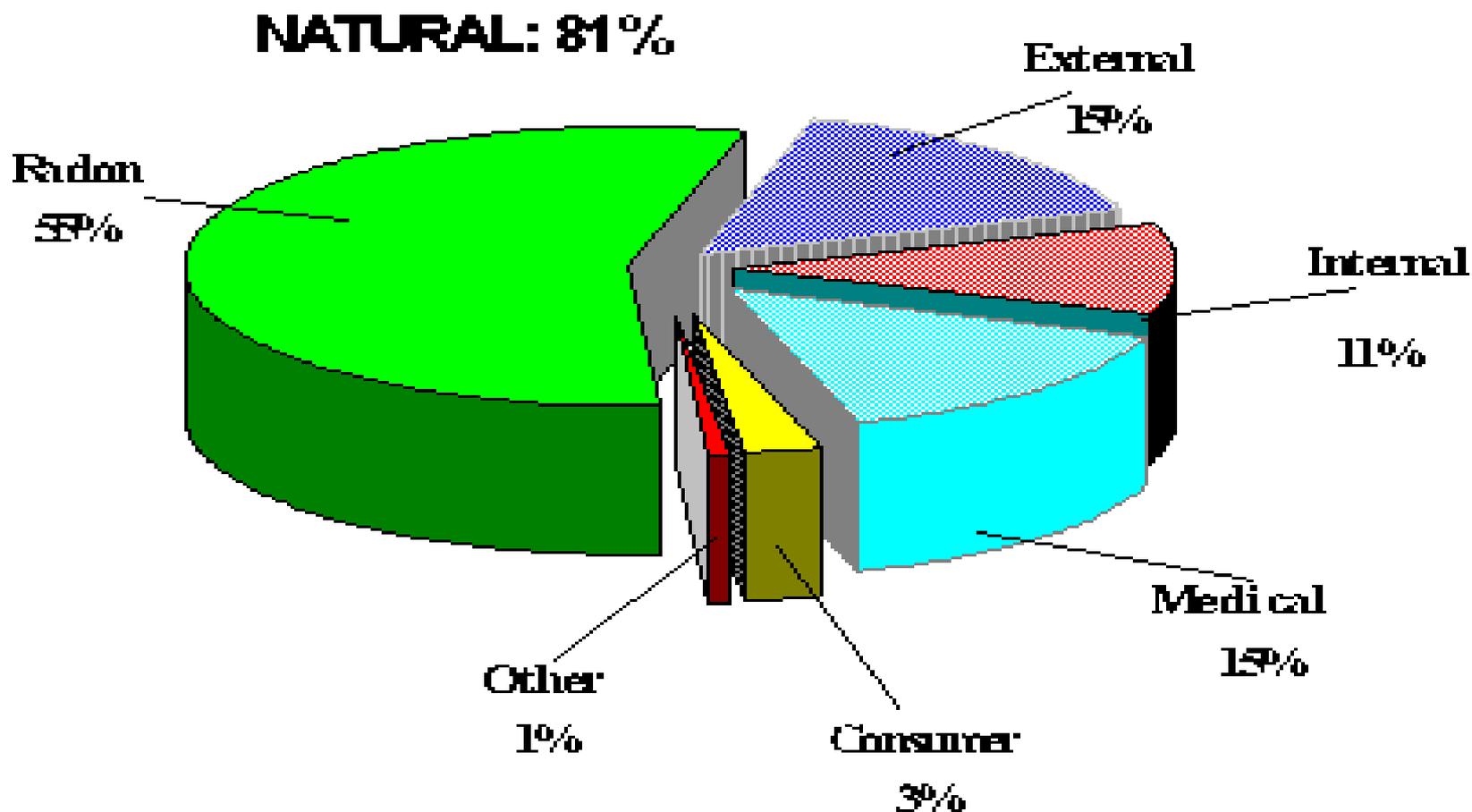


Figure 1

Source: NCRP

MAN MADE: 19%

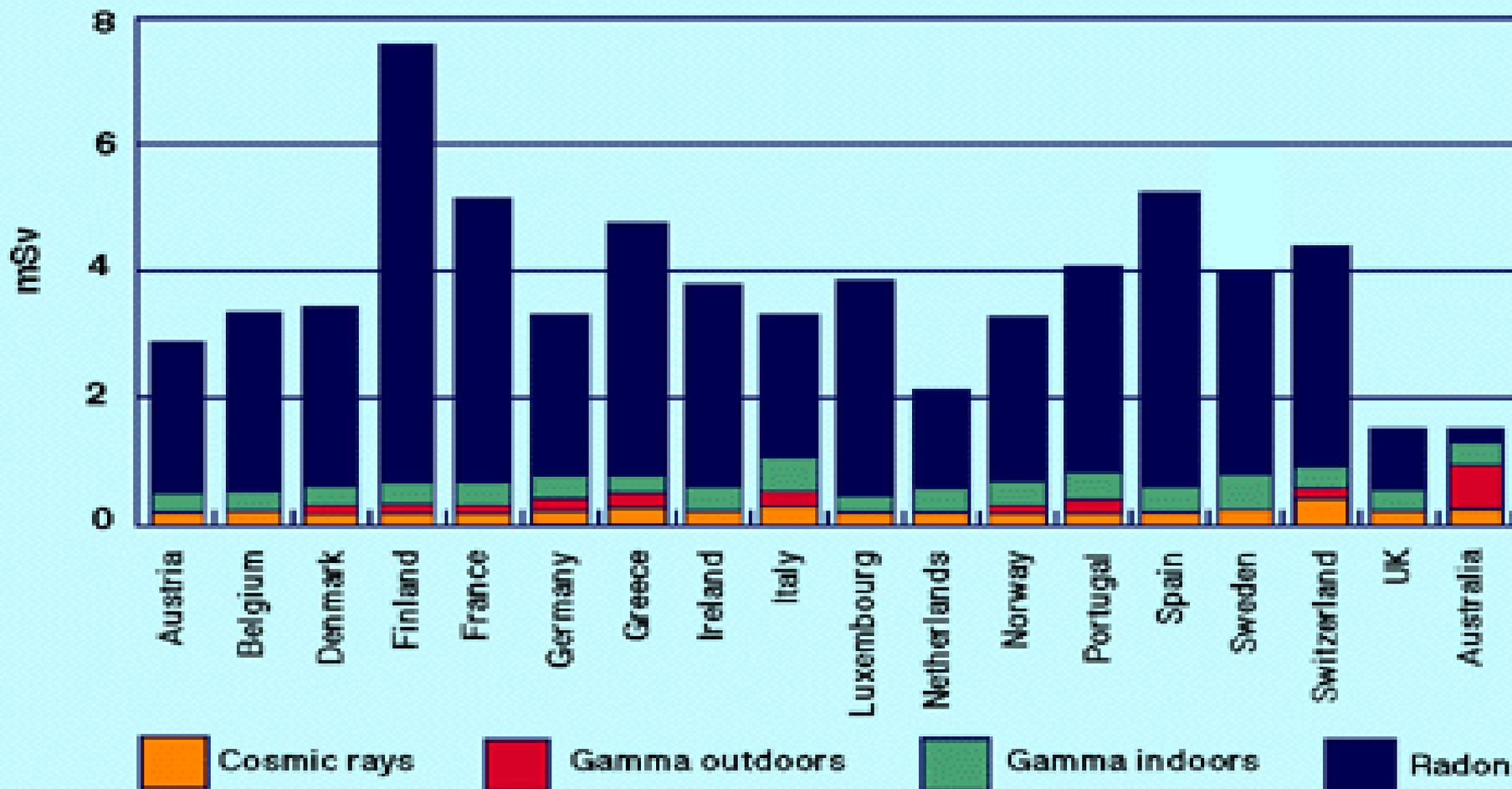
How Much Radiation is Safe?

- The current US Atomic Energy Administration Guidelines state that 5000 Millirems of radiation per year is safe, while for minors it is 500 Millirems per year.
- A person on average is exposed to 400 Millirems of radiation annually. This will increase as the altitude of the city increases.
- Your lifetime exposure should not be more than your age multiplied by 1000 Millirems.



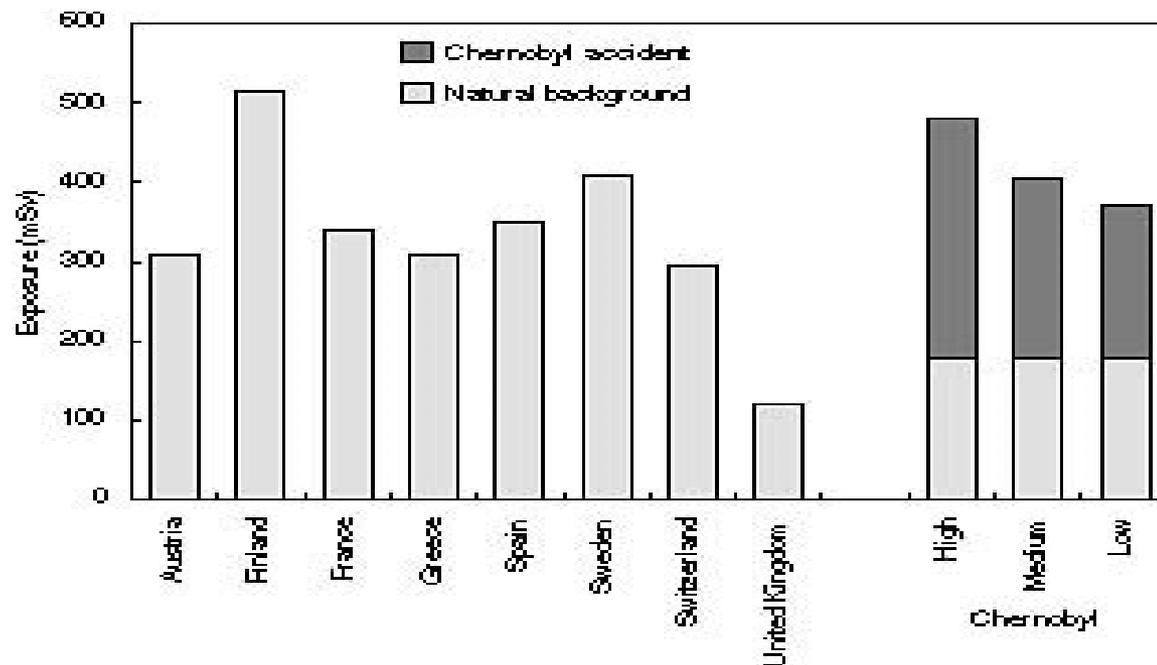
Radiation Exposure in Different Countries

AVERAGE ANNUAL DOSES FROM NATURAL RADIATION SOURCES



Nuclear Incidents

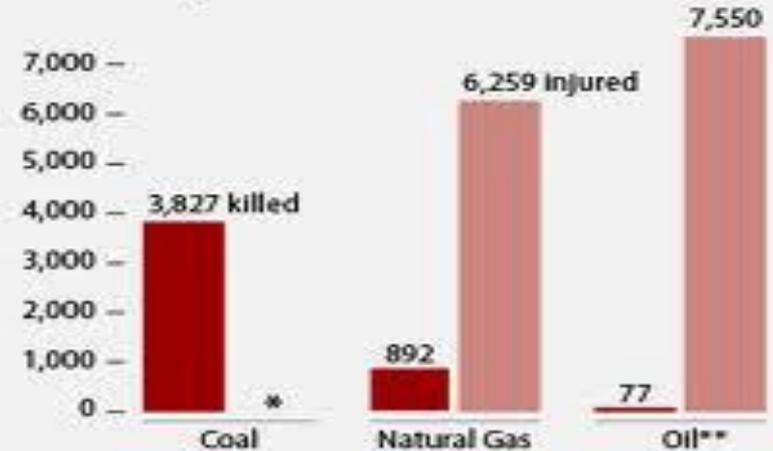
- Almost all nuclear incidents have happened due to some sort of a human errors.
- The only exception is the Japan Fukushima Incident and the French incident which has happened due to natural disasters.



Nuclear Deaths vs Fossil Fuel Deaths

- Fine particles from coal power plants kill an **estimated 20,500 people each year** in the U.S.
- The World Health Organization and other sources attribute about **1 million deaths/year** to coal air pollution
- This would be 161 deaths/TWh.
- According to Kofi Annan, global warming deaths is **300,000 people / year** with **\$ 125 billion in economic losses**

Fossil fuel accidents in the United States
Killed and injured, 1968–2011



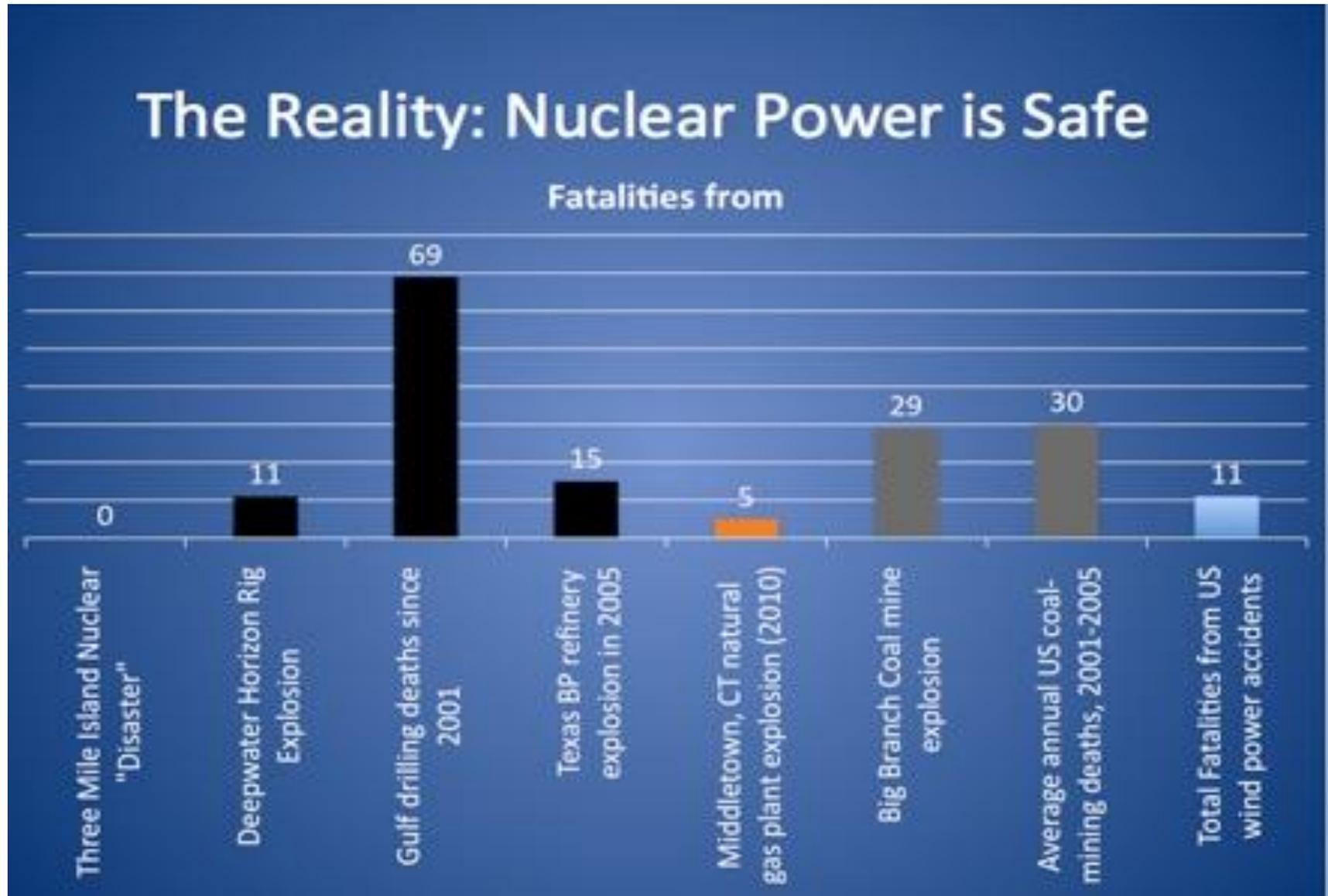
*no data identified for injuries from coal production

**data includes oil production and oil refining; refining data only from 2003–2009

Source: BOEMRE, PHMSA, BLS, MSHA, NIOSH



Power Related Deaths in USA



Nuclear Power Plants Can be Considered Green Energy

- Nuclear power plants do not emit any carbon dioxide, nor any sulphur dioxide or nitrogen oxides. Their wastes end up as solids and, though requiring careful handling, are very much less than the wastes from burning coal.



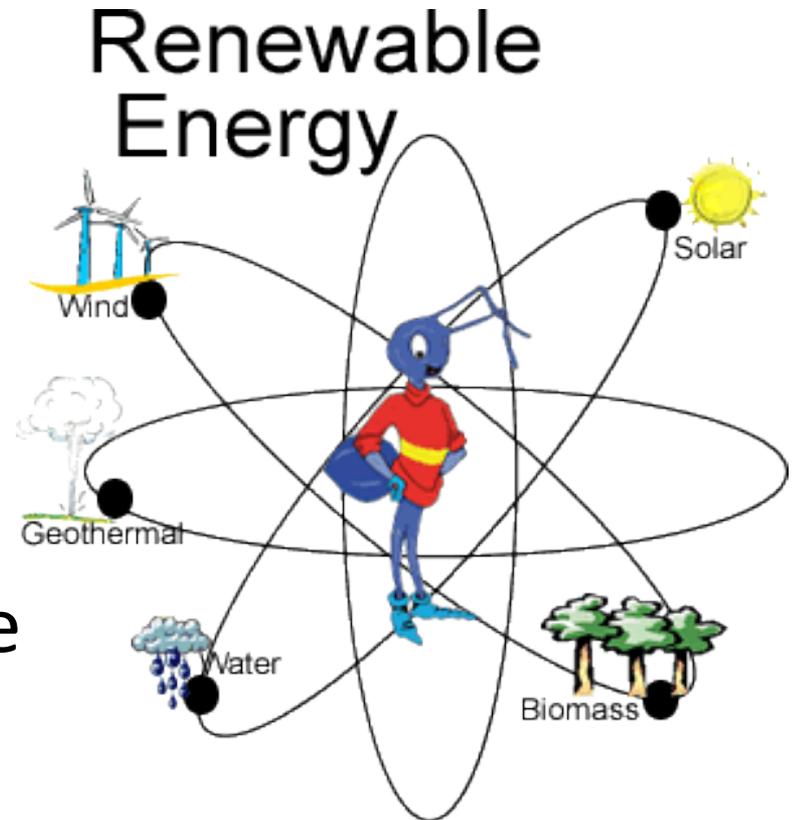
Nuclear Wastes Can Be Managed

- Especially with the new techniques available today (such as Gas Core Reactors), it is possible to make the impact of nuclear energy on the environment virtually non-existent.
- A regular checkup of all nuclear waste sites in the world is mandatory by International Atomic Energy Agency. (IAEA)
- Nuclear Reactors and properly processed Nuclear Wastes don't emit any radiation to the outside environment.



Nuclear Energy can Be Considered as Renewable Energy

- EIA defines Renewable Energy as any source of energy with
 - a) Naturally Replenished
 - b) Virtually InexhaustibleBoth of these conditions are met by Nuclear Energy



Human Error Causes Nuclear Damage

- All major nuclear incidents (Chernobyl, Three Mile Island) have happened due to human error
- In Fukushima incident, the problem was caused by a natural disaster seen only once in 1000 years



Nuclear Reactor Power Plants are a Safe Way to Meet the Energy Demands of our Future

- If they are used and maintained properly, nuclear power plants are the most efficient way of producing enough energy to meet the world's needs.



Nuclear Reactors are Safe

- If properly implemented, nuclear reactors are very safe. However, right technology and correct procedures has to be used. Chances of a nuclear explosion is always zero and it is physically impossible
- All incidents have occurred due to human error.



THANK YOU

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