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Stage 2 Geology

Uranium as an Alternative to Fossil Fuel

How enriched Uranium can be used to generate electricity

There are many countries in the world that now use nuclear power to produce some of their electricity. This is how uranium is used in the process of producing electricity:

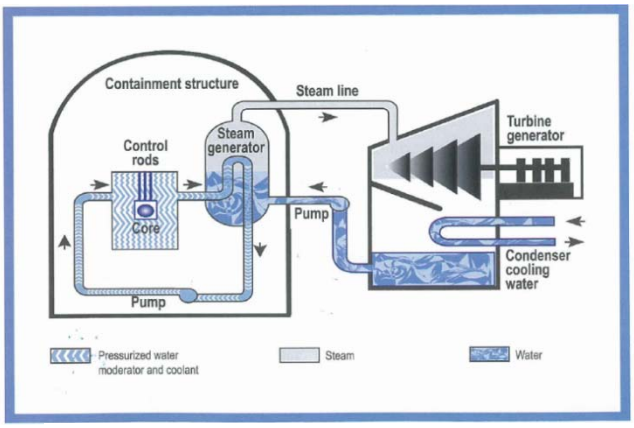

Fig. 1 diagram of a nuclear power plant

The diagram above is of a nuclear power plant. The Core is the central part of the reactor; this is where the fission reaction takes place. The coolant circulates the core and absorbs heat which is produced by fission, coolant then passes through the steam generator. The steam generator contains water so when the coolant passes through its heat on the water creates steam. This steam turns the turbines which turn the generator so that it produces electricity.

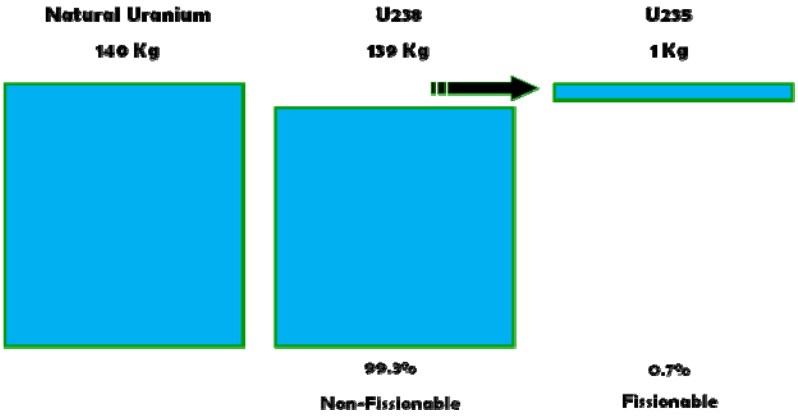

Fig. 2 diagram of how much usable uranium there is in the natural

Fuel rods are the part of this process which is to do with enriched uranium. An ore of uranium when mined contains approximately 0.7% uranium-235 which is the isotope which is required for fission reactions; the rest of the ore contains uranium-238. A nuclear reactor must have fuel about 3% uranium-235 so the fuel is enriched meaning more uranium-235 is added. These fuel rods contain this enriched uranium.

Safety

When first looking at the safety of nuclear power it is easy to see how many people take one look at incidents such as Chernobyl or Three Mile Island and automatically perceive nuclear power as bad. Though it has to be pointed out that from the Chernobyl incident 1000 people can be expected to die over the next 50 year. It must be noted though that 10,000 a year die from black lung related diseases from coal every year. It is clear to see that nuclear isn't as bad as the media seem to be portraying it.

Over half of the capital costs for nuclear power are put towards bettering the safety of the plant. There are even strict rules in which the company must comply with so that the community and their works are kept safe, not complying with these could leave them with huge fines or even having to close down the plant. The table below from the *World Nuclear Association* show just how much we have to worry about immediate fatalities due to nuclear plants; we have a lot more to worry about with coal.

Fuel	Immediate fatalities 1970-92	Who?	Normalised to deaths per TWy electricity
Coal	6400	workers	342
Natural gas	1200	workers & public	85
Hydro	4000	public	883
Nuclear	31	workers	8

Fig. 3 table of fatalities from coal and nuclear plants

Generally we tend to think of nuclear power as more of a safety hazard because the uranium and therefore radiation. Most people are under the perception that coal doesn't release any radiation, but in fact it does. The combustion of coal releases many naturally radioactive materials, which is not a good sign seeing as coal combustion has been rising rapidly over the years. So coal and nuclear are on a par in that department.

The graph, right, show the amount of immediate deaths of the many main electricity generators. It has coal and nuclear power and shows that coal has a far greater number of deaths than nuclear in all the areas

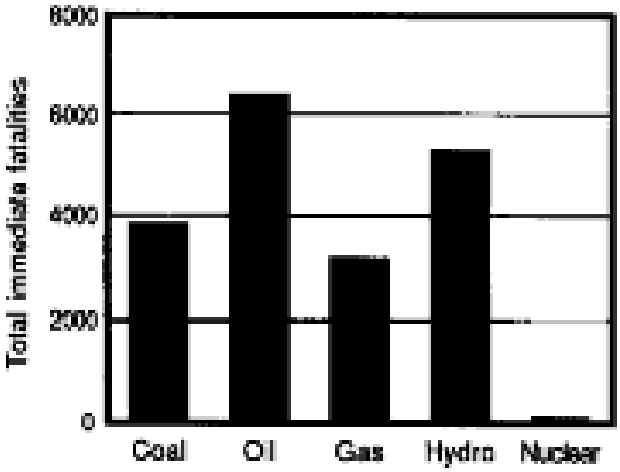

Fig. 4 graph of immediate fatalities

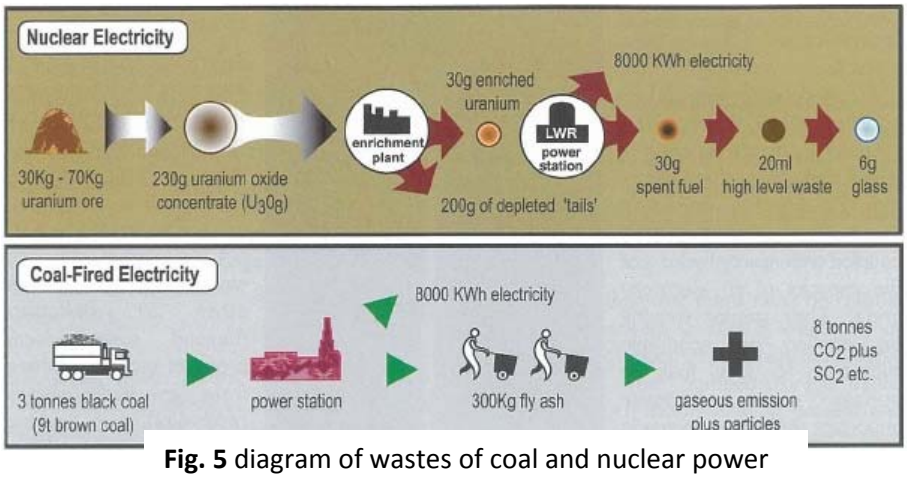

Fig. 5 diagram of wastes of coal and nuclear power

The last aspect of safety is waste disposal and is it safe in coal and nuclear power. One of the main concerns of nuclear power are its wastes. The waste of nuclear power plants is the most radioactive part of the process. We don't need to be concerned about this though as hardly any waste is actually produced as shown in the above diagram. There is definitely not enough yet to discard, by the time there is enough we may even have the technology to re-use this waste or spent fuel. All the spent fuel now is kept quite safely in a water tank similar the one shown right. It is carefully kept in copper coated canisters; therefore there should be no concern over the nuclear waste.

Fig. 6 a nuclear waste storage tank

It seems that all aspects of nuclear power safety seem to far out way coal especially when you look at all the dangers in the coal mining industry. As seen in the diagram below from NMA, the light blue line represents fatalities; although the fatalities have generally decreased over the years in 2006 there was a significant increase. This is likely to happen again as china is building more and more coal mines. Consequently there are a lot more cave ins every year. This is something that just doesn't happen with the uranium mining industry.

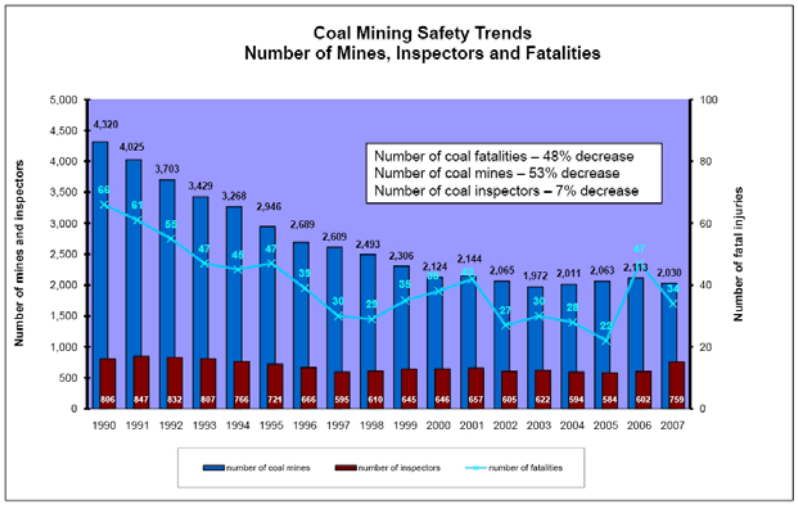

Fig. 7 graph of coal mining fatalities

Economics

Fuel

The fuel costs of nuclear power a significantly lower than the cost of coal which is surprising since there is a much extensive process in preparing uranium. The main tipping factor in coals cost is the transport of it. A significantly larger amount of coal is needed so it can produce the same energy as nuclear does with a small amount.

Cost - Coal $11/Mw-hr Nuclear $5/Mw-hr

Capital Costs

This includes initial construction and modifications of the plant. For nuclear these costs are quite high as they need to comply with very strict safety regulations. Although the capital costs of coal are also significantly higher as well because scrubbers are required so that the air remains minimally polluted. Other power sources would not have to concern themselves with these types of costs.

Cost - Coal $9/Mw-hr Nuclear $9/Mw-hr

Operating and Maintenance

The everyday cost of operating a nuclear power plant include: labour and overheads, expendable materials, NRC and state fees and local property taxes. Coal power plants also have to pay all these costs but things such as fees are significantly less.

Cost - Coal $9.1/Mw-hr Nuclear $11/Mw-hr

Decommissioning and Waste Costs

The waste product of a coal plant is ash, this cost no money to dispose of. On the other hand the waste product of nuclear power costs to store as it is high level waste. It also incurs a fee from the Department of Energy (DOE) as it is high level waste.
This cost also includes the restoration of the site so it essentially is the same as before the plant was set up. This generally takes about 20 years.

Cost - Coal $0/Mw-hr Nuclear $5/Mw-hr

The table opposite compares the costs nuclear versus coal for similar age and size plants:

(10 $/Mw-hr = 1 cent/kw-hr)

As you can see by the total the overall cost are very similar

Item	Cost Element	Nuclear	Coal
		$/Mw-hr	$/Mw-hr
1	Fuel	5.0	11.0
2	Operating & Maintenance - Labour & Materials	6.0	5.0
3	Pensions, Insurance, Taxes	1.0	1.0
4	Regulatory Fees	1.0	0.1
5	Property Taxes	2.0	2.0
6	Capital	9.0	9.0
7	Decommissioning & DOE waste costs	5.0	0.0
8	Administrative / overheads	1.0	1.0
Total		**30.0**	**29.1**

Fig. 8 table of costs of each process for coal and nuclear power

Greenhouse Gas Emissions

Nuclear power plants emit very little green house gas emissions over their life cycle. They are in fact comparable powers such as wind and hydro and produce far less emissions than coal fired plants.

The chart below put together by NEI shows the massive difference between the greenhouse gas emissions of coal and that of nuclear over the whole of their life cycles:

Generation Option	Greenhouse gas emissions gram equiv. (in CO2/kWh)	Sulfur dioxide emissions (in milligrams/kWh)	Nitrogen oxide emissions (in milligrams/kWh)	NMVOC (in milligrams /kWh**)	Particulate matter (in milligrams /kWh)
Hydropower	2 – 48	5 – 60	3 – 42	0	5
Nuclear	**2 – 59**	**3 – 50**	**2 – 100**	**0**	**2**
Wind	7 – 124	21 – 87	14 – 50	0	5 – 35
Solar photovoltaic	13 – 731	24 – 490	16 – 340	70	12 – 190
Biomass forestry waste combustion	15 – 101	12 – 140	701 – 1,950	0	217 – 320
Natural gas (combined cycle)	389 – 511	4 – 15,000[*]	13 – 1,500	72 – 164	1 – 10
Coal – modern plant	**790 – 1,182**	**700 – 32,321**	**700 – 5,273**	**18 – 29**	**30 – 663**

Fig. 9 table of greenhouse gas emissions

The chart shows that nuclear is one of the smallest emitters but coal is in fact the largest emitter and that is on a modern plant. The bad coal situation may be halted in the future though due to the extensive research which is going into geo-sequestration or clean coal energy. Though this may get the CO_2 out of the atmosphere storing it in rock may lead to some catastrophic accidents and leakages. This still doesn't help the situation now as coal plants still keep emitting a rather large amount or greenhouse gas.

The graph below from the World Nuclear Association also consolidates the fact that coal is the largest emitter of greenhouse gas. The graph also shows that nuclear power doesn't emit any emission directly but still does emit some indirectly through its life cycle. The emissions from the life cycle are those emitted by anything but the production of the power from the plant.

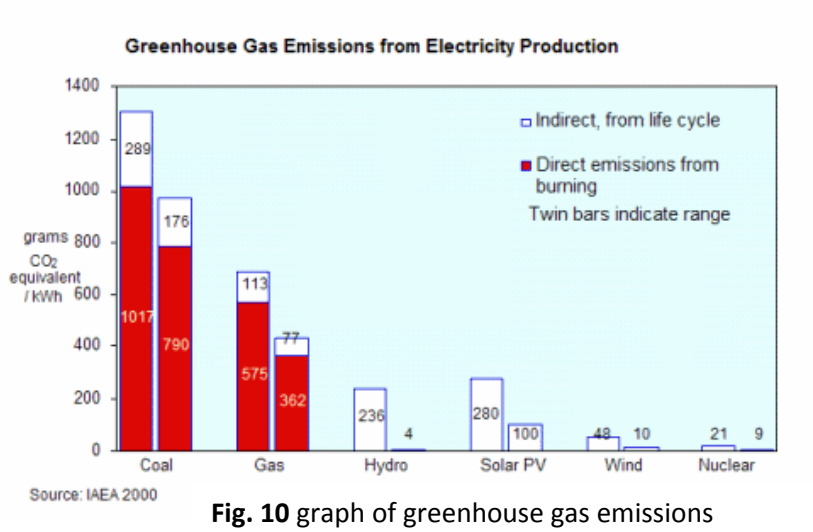

Fig. 10 graph of greenhouse gas emissions

There are many different components of the uranium cycle. The greenhouse gas emissions are released from all parts of this except the actual nuclear plant when operating to produce the electricity. Although only a maximum of 21 grams of CO_2/KWh are released.

On the other hand most of the emissions from coal are actually from the burning of coal. That has to be done to produce the power so there will always be emissions coming from coal. Whereas nuclear will only have emissions being produced when the plants have to be made.

Comparison (for maximum emissions, grams CO_2/KWh)

	COAL	**NUCLEAR**
DIRECT EMISSIONS	**1017**	**0**
EMISSIONS THRUOGH LIFE CYCLE	**289**	**21**

Danger of Proliferation of Nuclear Weapons

Many people seem to be under the mistaken idea that coal power is much better that nuclear because there is no risk of weapons being made. This is just a massively big misconception because there is just no likely hood of a Nuclear power station detonation like a bomb. The main reason for this is that the uranium hasn't being enriched enough to create a large enough reaction to cause this type of thing. The reaction of the uranium also in a nuclear plant is created under controlled conditions where as bombs just aren't.

It is possible but unlikely that the uranium which is to be used as fuel for a nuclear power plant could be secretly enriched again so that it can be used to make nuclear bombs. Because of this Australia has everyone which we sell uranium to sign an agreement so that they won't, that is why we won't sell to Russia. This is one of the many reasons why coal power is still very popular throughout the public, especially in Australia.

The graph right from the APS shows the countries in the world that have nuclear weapons and a rough guide if who will have them. If a country is going to have nuclear weapons they will regardless of whether they have a nuclear power plant or not. It is illogical to think that the two come hand in hand. If a county is going to enrich uranium to an amount that is used for a nuclear powered weapon they will do that to start with and not use uranium already destined for the power plant.

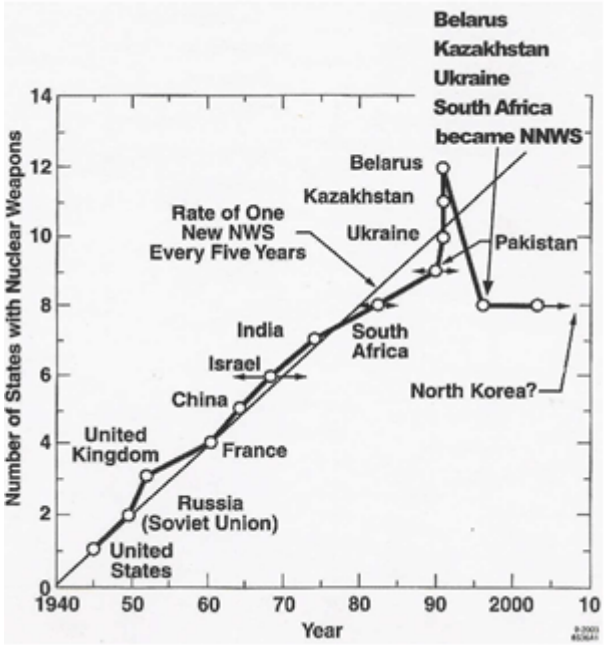

Fig. 11 graph of countries with nuclear weapons

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