Does nuclear energy produce no CO_2 ?

A look at the full Uranium cycle

Mining

- Ranger Pit Number 1, Northern Territory
- All of the material removed from this hole, over-burden and ore, was moved by truck.

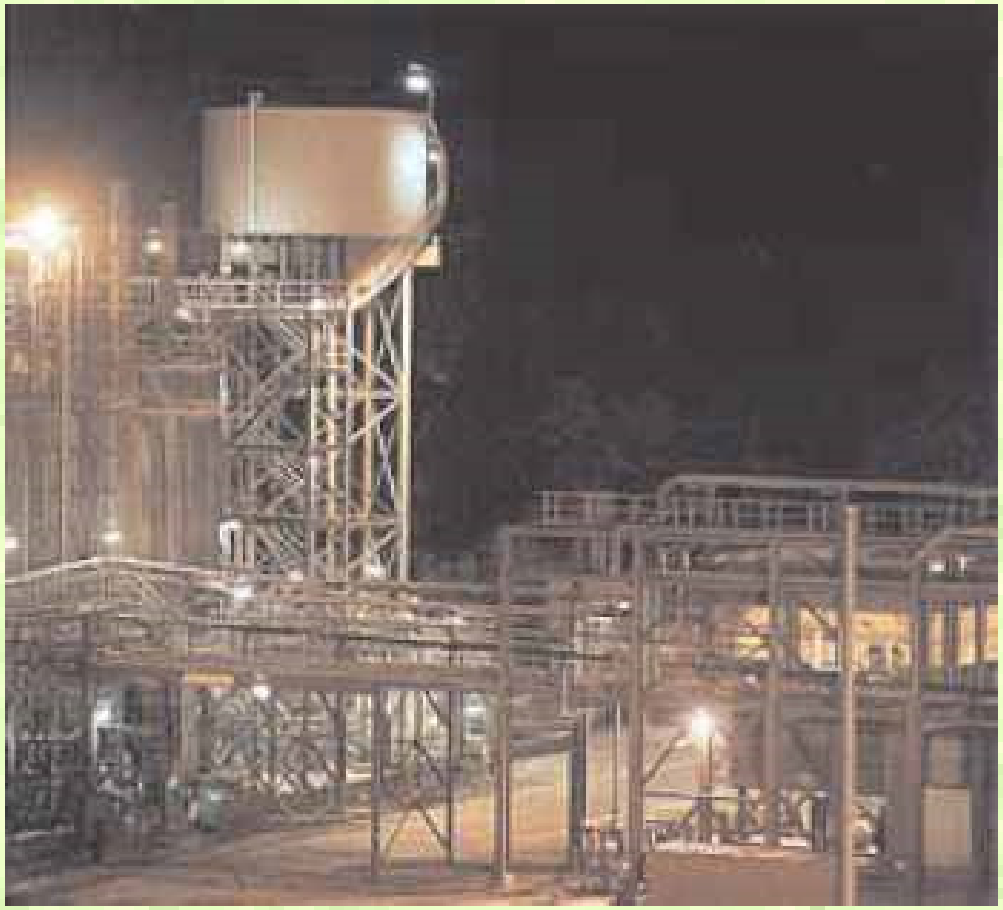
From mine to mill

- These trucks run on diesel
- It would be interesting to know how much diesel is used in a year at Ranger
- More Uranium means more energy spent building and driving these trucks

Milling

- The mill crushes the rock to powder
- The powder is then treated with sulphuric acid to dissolve the uranium, leaving the rock (depleted ore) behind

Neutralisation



- The depleted ore is washed and neutralised using lime
- Lime is made by roasting limestone with fossil fuels to drive off the CO2
- The slurry is pumped to the tailings ponds

Tailings ponds

Maintaining the tailings ponds, with more diesel powered machinery

Hard rock needs more energy

Hard rock ores, such as quartz conglomerates and granites, are approximately 3 to 4 times more energy-intensive than soft rock ores (limestones and shales) to crush.

Yellow cake

The dissolved uranium solution, including other metals, is then treated with amines dissolved in kerosene to selectively separate the uranium, which is then precipitated out of solution using ammonia, forming Ammonium di-uranate, or "yellowcake"

Calcining

- The yellowcake is roasted at 800℃ in an oil-fired furnace called a calciner
- The Ammonium di-uranate is converted to 98% pure Uranium oxide (U_3O_8) which is a dark green powder

Packing for shipment

- The Uranium oxide is packed into 44 gallon drums and transported to a shipping port
- The drums are then shipped, often half way around the world
- All the greenhouse gases produced so far are counted against the country of origin's Kyoto target.

Fluoridation

- The next stage involves dissolving the Uranium oxide in Hydrofluoric Acid and excess Fluorine gas to form Uranium hexafluoride gas (UF_6)
- Hydrofluoric Acid is one of the most corrosive and poisonous compounds known to man.

UF_6 handling

The Uranium hexafluoride gas is then compressed and transported in cylinders to be enriched

Enrichment

- These centrifuges run on electricity, so this stage can be powered by nuclear electricty
- However building the centrifuge cascades requires lots of fossil fuels for mining and refining materials, transport and construction

more transport

Low-enriched (3.6%) Uranium hexafluoride gas is then transported to the fuel fabrication plant

Pelletisation

- The UF_6 gas is converted to Uranium dioxide (UO_2) powder and pressed into pellets
- They are then baked in an oil-fired furnace to form a ceramic material.
- The pellets are then loaded into the fuel rod - a tube made of a zirconium alloy.

Fuel rod fabrication

For every tonne of Uranium in the fuel, up to 2 tonnes of Zirconium alloy are needed for the tubes

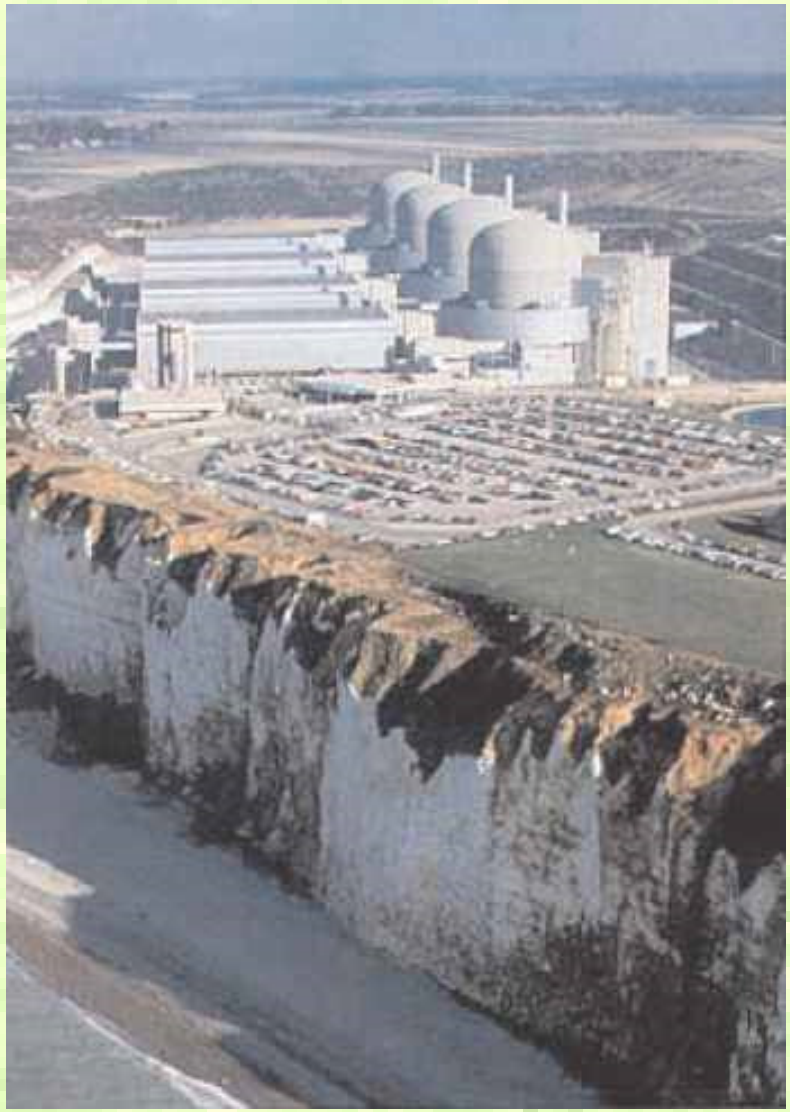
Zirconium

- Zirconium is a metallic element derived from zircon, an ore of Zirconium silicate ($ZrSiO_4$)
- It is a by-product of rutile sand mining (another energy-intensive and environmentally-unfriendly business)
- Naturally occuring Zirconium is always found with Hafnium, which has to be removed (with the application of more energy) for nuclear uses

Fuel assemblies

- Fresh fuel is only mildly radioactive and can be handled without shielding.
- The fuel assemblies are then transported to the reactor by truck or train

The reactor



- The reactor itself does not produce any CO2
- But without transport for the workers, the thing cannot be operated
- The reactor uses electricity, as well as producing it, and this needs to be counted in the net energy budget

CO_2 embodied in steel

- It takes a lot of steel to build a nuclear power station
- Steel is made by smelting iron ore with coking coal, releasing lots of CO_2

CO_2 embodied in concrete

- Building a nuclear power station uses lots of concrete, which is made from cement
- Cement is made by crushing limestone and roasting it, using fossil fuels, to drive off CO_2
- So cement is a particularly CO_2-intensive material.

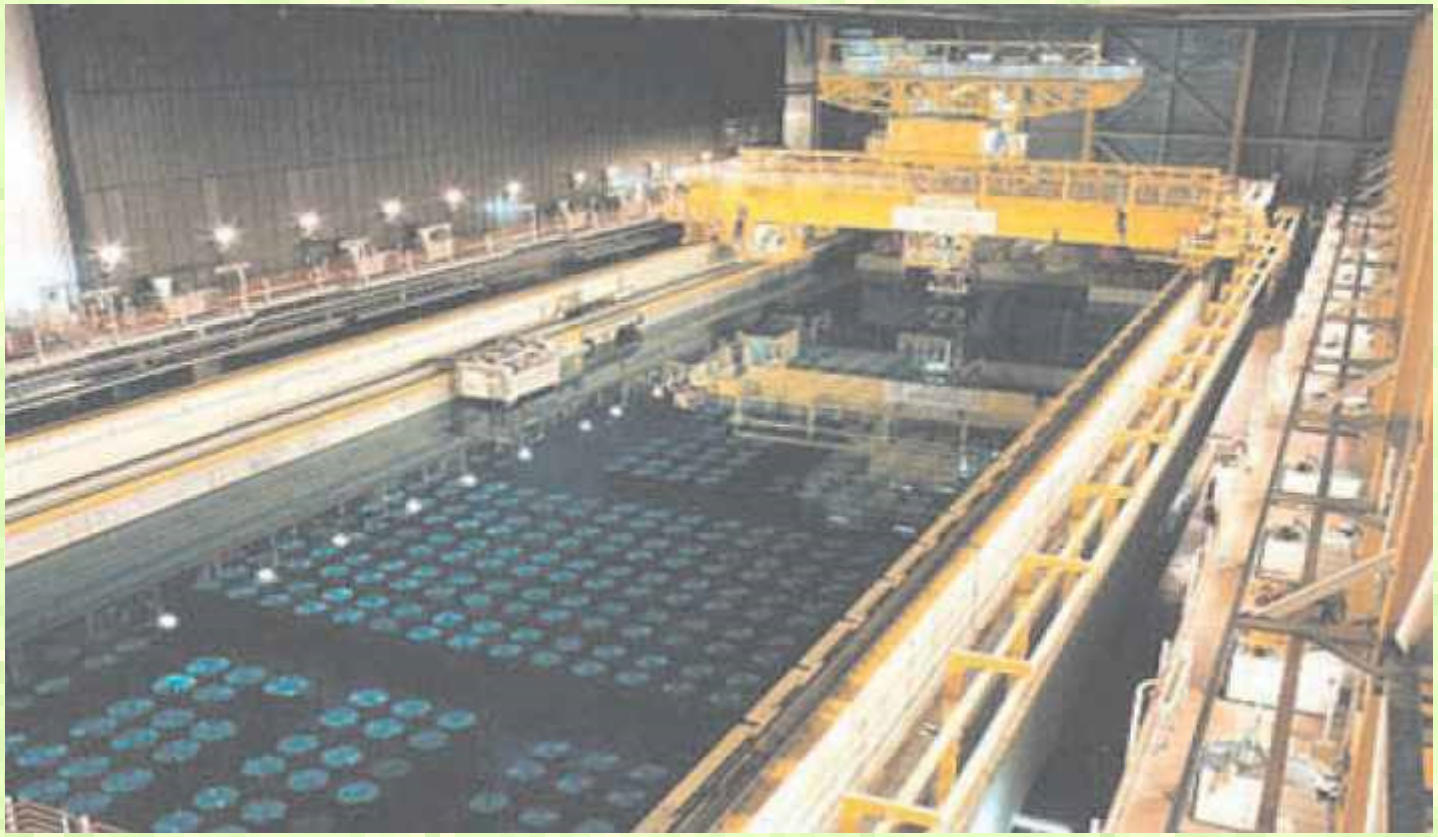
Spent fuel

Spent fuel rods normally spend six months in cooling ponds located within the reactor building, so that short-lived radio-activity can decay, making the material safer to handle

Waste leaves reactor site

- Reactor waste is moved by road and rail
- It is highly radioactive
- There are only a very small number of reprocessing plants in the world, so the distances involved are long.

Short-term storage



This is “The Pond” at Sellafield in the UK. Spent fuel is kept under water until it is reprocessed. This keeps it cool and acts as a radiation shield

Re-processing

- In the 'once through' process, the fuel rods are dissolved in acid, the Plutonium is extracted, and the remainder (including the Uranium) becomes high-level waste
- In the 'recycling' process, Uranium is also recovered
- It is arguable whether recycling is cost-efficient or energy-efficient

Recycled fuel

Recovered Plutonium and mixtures of Plutonium and Uranium oxides (MOX) are sent by road back to the fuel fabrication facility to be used in new fuel rods.

Long-term storage

- There are no long-term storage facilities operating anywhere in the world
- This is the NORAD military bunker at Cheyenne Mountain. This is what one might look like if one was ever to be built

Security

This is a security policeman –
well, it does say POLICE on his bag.
I do hope everything is alright.

More security

- Ah, that's more like it. How many miles per gallon do you get out of one of those ?
- Do we have enough liquid fuel to run these security operations for 250,000 years ?
- Don’t forget that rich Uranium ores will run out in less than 50 years, and perhaps MUCH less, but the security problem will NEVER go away.

Even more security

- Aerial surveillance is needed to prevent terrorists from getting access to radio-active materials.
- Can helicopters be run on nuclear electricity ?

Security against major attack

- Increasingly these days, one also has to defend one's nuclear facilities against attack by a sophisticated enemy.
- Israel blew up the Iraqi nuclear reactor 'Osirak' in 1981
- This is the Tor-M1 - a fully radar integrated combat vehicle with anti-missile/anti-aircraft missiles, that the Iranians are getting from Russia to protect themselves from 'freedom and democracy'.

No nuclear without CO2

- Every step of the nuclear power cycle involves the expenditure of energy derived from fossil fuels, which nuclear-generated electricity cannot replace.
- All the factories, all the transport, all the materials are made using fossil fuels
- Thus it is untrue to say that nuclear energy is greenhouse friendly.
- The nuclear industry are well aware of this, and tell disgraceful lies about it.

The CO2 budget

- In the paper "*Nuclear Power : the energy balance*" by J.W. Storm and P. Smith (2005) the authors calculate that with high quality ores, the CO2 produced by the full nuclear life cycle is about one half to one third of an equivalent sized gas-fired power station
- For low quality ores (less than 0.02% of U_3O_8 per tonne of ore), the CO2 produced by the full nuclear life cycle is EQUAL TO that produced by the equivalent gas-fired power station.
- Uranium concentrations in seawater are about 0.0000002% so they are unusuable, despite being 'very common'.

Conclusion

- The full nuclear cycle produces LOTS of CO_2 at every stage of the process.
- Nuclear energy can only exist in a society that runs on cheap fossil fuels
- As fossil fuels start to run out and get more expensive, building and operating nuclear power stations gets EVEN MORE expensive, if not impossible
- If it wasn't for nuclear weapons, none of this technology would ever have been developed.

END

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