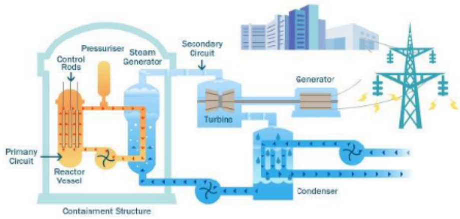
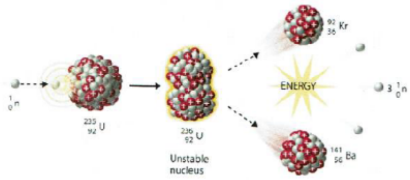
**Student 1: Low Excellence**

NZQA Intended for teacher use only

**Nuclear Power in New Zealand**



Nuclear energy can be gained by converting atomic potential energy into electrical energy this can be achieved by the use of a nuclear reactor. Energy can be gained from the fuel by creating an artificial chain reaction kick started by the addition of neutrons This reaction is caused by shooting neutrons at a heavy element such as uranium 235 or uranium 238. Uranium is a heavy element and on the verge of stability due to its large size (we see this because of its small binding energy (as seen in graph on right) meaning not much energy is needed to fully separate all its nucleons in the nucleus). It is unstable due to the large amount of repulsion inside the nucleus of the atoms. When uranium absorbs a neutron, it becomes super unstable and thus breaks up to make smaller/lighter faster moving elements, more neutrons and lots of energy in the form of radiation. The neutrons given off from this initial reaction results in the exponential increase in rate of reaction this is due to the neutrons starting more reactions with additional uranium atoms. To stop this exponential reaction a moderator is needed. A moderator works by absorbing some of the neutrons given off meaning the rate of reaction stays the same. Nuclear bombs don't have a moderator thus the huge release of energy causing a huge explosion. There are multiple types of reactors but all require a moderator to control the rate of reaction, either by control rods or water. ①



The formula for this equation is:

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{90}_{36}Kr + ^{143}_{56}Ba + ^{1}_{0}n + ^{1}_{0}n + ^{1}_{0}n$$

We can calculate the energy given off by this reaction by using Einstein's $E = mc^2$ equation. The mass of U- (Kr + Ba) will give us the mass deficit of the reaction. This mass is converted into energy in the reaction thus the huge amount of energy given off.

U(mass)- Kr(mass) + Ba(mass) = mass deficit ①

235.0439299 - (89.919517+ 142.92062) = 2.2037859u

This converts into $3.6594722605 \times 10^{-27}$ Kg which is the unit needed for the formula.

$E= mc^2$ $E= (3.6594722605 \times 10^{-27}) \times (3 \times 10^8)^2$

$E= 1.0978417 \times 10^{-10}$ J of energy.

$1.098 \times 10^{-10}$ Joules (3sf) of energy is given off every time one uranium atom goes through fusion.

In pressurised water reactors the heat given off from the fission gets transferred into pressurised water. The water must be pressurised to make sure it stays liquid and doesn't turn into steam. This hot water then transfers its heat to another loop which is unpressurised resulting in the water turning into steam. This transfer of heat energy happens in the steam generator 2 separate water loops reduces the amount of radioactive water produced by the reactor. Although energy is lost (to other forms of energy and transfer not being fully efficient) in this second transfer of heat it is worth it for the reduce in the environmental impact. This water in the second loop gets heated where it turns into steam, this steam is used to power d turbine much like in a steam train. The generator converts kinetic energy to AC electricity by using a "reverse motor" where a magnet is passed through a magnetic field in order to get electrons to move. AC power is generated due to the surges the electrons move when pushed by the generator. The electrons don't move down the wire they push the next one in a longitudinal wave. AC power being generated is good as it travels further and can be easily converted to DC for use in sensitive electronics.

In nuclear reactors, the decomposition of uranium is used as a heat source much like coal, natural gas or geothermal would be used in other power stations. From the heat source, most reactors are similar in how they use steam to turn a shaft which drives a generator-. Other power generation methods such as wind or hydro skip the whole power generation action and have a generator driven straight off the turbines.

**Hazards of Nuclear Power**

Nuclear power is often seen as a big gamble due to the fact that for a large reward, risk is involved. The risk of having a nuclear reactor is that if it goes wrong, it goes really wrong and can result in land being uninhabitable for many years as well as causing serious human harm.

An example of this was at Fukushima in March 2011. It started with an earthquake which cut off the power to the primary cooling loop which was keeping the already turned off boiling water reactor cool. Although the reactor was off it was still hot and was still producing 1.8 MW of heat. The backup cooling loop was turned on and worked for an hour before the power cut thus making it redundant. Soon after that the secondary diesel fueled backup cooling loop kicked in and started to cool the reactor. The secondary cooling loop was thought to have stopped due to the tsunami which hit soon after the power outage. At this point they thought they had the reactor in a stable state so had stopped all additional cooling. Soon after, the reactor then was thought to have leaked cooling fluid thus resulting in a huge increase in heat and thus pressure resulting in an explosion. This was before the third stage (the total kill switch) of backup cooling (a full flood of the reactor) could be engaged. After the explosion, all of Fukushima was evacuated resulting in 31,000 people leaving their homes. Radioactive and highly volatile iodine 131 and caesium 137 were both released into the environment. Radioactive elements are bad for living cells due to them changing the (2) DNA sequence inside the nucleus of the cell. The changing of a cell's DNA results in cell mutations AKA cancer. Fukushima is an example how bad things can result even when having 3 backups in place. Nuclear meltdowns like this can cause huge destruction of human civilization and habitable environment often resulting in huge numbers of indirect deaths due to radioactivity.

Fukushima is an example of why environmentalists don't like nuclear power as they see it as a gamble which is not worth the risk. Another downside to nuclear power is that there is no current way to safely dispose of the radioactive waste. When uranium is broken down it leaves radioactive matter which has a very long half-life (meaning it breaks down into nonradioactive elements) and isn't useful for anything. The water that is used as a coolant in a nuclear reactor also becomes very poisonous due to passing past uranium. For optimal cooling, water has a deuterium isotope added to it. This coolant is called heavy water and although occurs naturally in small amounts cannot be released into the environment. This nuclear waste produced must be stored until it breaks down into more stable elements. With elements like Iodine with a half-life of 8 days to plutonium with a half-life of 24100 years or uranium with the half-life of 703,800,000 years this nuclear waste must be stored somewhere safe as (2) it will literally be around forever. So far America alone has produced 75,000 -tonnes of radioactive waste. It's for this reason it is sometimes seen as a non-clean energy source.

The final con and potentially the worst is that the same technology used to make power is the same to make nuclear weapons. In 1945 2 nuclear bombs were dropped on the cities of Hiroshima and Nagasaki to essentially end world war 2. It is thought that 80,000 people were killed in these 2 bombs in the initial explosions, in my mind one person controlling one country should not have the power to destroy whole cities with one warhead launched inside one missile.7)

**Why nuclear is good**

Nuclear power is great in the fact that its power output js far greater than that of coal or hydroelectric power stations (hydro and wind depend on the environment so are sometimes not preferable). The average nuclear power station produces around 12,000MWh compared to the average of 3,000 of a coal power plant. Uranium used as fuel for nuclear reactors is also easily obtained and is mined similarly to coal. Another positive for nuclear power stations is that they don't give out any greenhouse emissions such as $CO_2$. It is estimated that the effect of nuclear reactors has already prevented 64 gigatonnes of $CO_2$ being released into the atmosphere.

**My recommendation**

I think that by the end of my generation all of New Zealand power generation should be fully renewable and when technology such as batteries and solar arrays become more advanced this will be easily achievable. Currently fully renewable power is not reasonable clue to society's high power usages and the current technology not being up to standard. I think that the burning of coal and natural gas is not good due to the large environmental impact and should be phased out and replaced with the slightly risky but cleaner nuclear reactors until fully renewable sources are possible. 1 believe that the risk involved in nuclear reactors is very slim and shouldn't be a deciding factor due to the rate at which safety precautions are improving. There would be more (3) than just environmental advantages of fully renewable power production. Coal mining kills around 6,000 workers per year this is extremely high compared to any other profession. Renewable power is also good as it needs no fuel and requires no additional cost once built (excluding servicing etc.). Phasing over to a nuclear and renewable sources or fully renewable sources would fully remove the need for coal and other traditional dirty power generation methods. The change would still keep economies in power generation but save lives and the planet at the same time.

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