**Student 3: Low Merit**

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**Nuclear Power in New Zealand, should it be used?**

Nuclear power is created by nuclear reactions; the process of either nuclear fusion or what is more commonly used nuclear fission. Nuclear power is used in 31 countries and there are a reported 437 operational nuclear power plants. Many people and organisations in New Zealand view nuclear power as a huge environmental cost and it would destroy our reputation as a clean green country. Currently there is no legislation prohibiting nuclear power stations in New Zealand. Some supporters of nuclear power even go as far to say that it is cleaner than other forms of non-renewable energy as the only emission of well-functioning nuclear power is steam. Reports even mention that in terms of lives lost per unit of energy created nuclear energy creates fewer fatalities then other forms of energy. Coal, petroleum and hydro power have contributed to more estimated deaths from air pollution and energy production related accidents. The process of nuclear fission is the reaction in which the nucleus of an atom is fired upon by neutrons. When a neutron successfully bonds to the atom which is most commonly $U^{235}$ (an isotope of uranium) it becomes an unstable $U^{236}$ isotope. This causes the atom to split into two smaller and more stable atoms as well as release three high energy neutrons and gamma rays, these two atoms are called the fission products. Some of the neutrons will react with other $U^{235}$ atoms to cause a chain reaction and others will be absorbed by the control rod. The control rod is a component of a nuclear reactor that is used to control the chain reaction and to prevent it from increasing at an exponential rate. It absorbs some of the neutrons with the rest passing by and reacting with more $U^{235}$ to create more $U^{236}$ and even more neutrons. The control rods primarily consist of boron, silver or cadmium. These materials can absorb a high amount of neutrons without fission occurring. This allows them to be utilised in nuclear reactors where only the fission of the fuel, Uranium is desired. Control rods are crucial in the operation of all nuclear reactors in order to prevent serious disasters from occurring. One of the most major nuclear disasters in history was the Chernobyl disaster in which the control rods of one of the reactors failed to decrease the chain reaction, leading to a catastrophic explosion. Nuclear fusion is when two non-radioactive isotopes of hydrogen are shot at each other. They release energy and a free neutron and create a helium atom. The reason nuclear fusion is not used is because a huge amount of energy is required to fire the isotopes at each other and not much energy is released, neither is a sustainable chain reaction able to be created.

**Possible Problems**

During the production of nuclear power there can be a few dangerous accidents. There is a possibility of the reactor core having a meltdown if the chain reaction during fission goes out of control and increases at an exponential rate. Causing a huge amount of heat to be released and possibly damaging the protective casing around the reactor. This may release the radioactive material within the reactor. To prevent this problem control rods are used to keep the chain reaction at a constant rate so that a constant amount of energy is being produced and thick concrete walls are used as casing for the reactor. The control rods are constantly monitored to ensure that they are still regulating the reaction correctly. 1

**Implications: Environmental Advantages**

There is no direct carbon emissions associated with nuclear power unlike other forms of power production such as coal and oil. Reasons for this are that nuclear power's only waste product is steam during the production of energy. Studies of the release of carbon dioxide of various power production methods throughout their full life cycle have shown that nuclear power only releases 16 g of $CO_2$ per kw on average while coal releases a substantial amount; 1001 g of $CO_2$ per kw. Nuclear power is not seen as a renewable power source however it is cleaner than both forms of solar power as well as geothermal it is the third cleanest power source with only hydroelectric and wind being cleaner forms of energy production.

**Implications:Environmental Disadvantages**

The environmental impacts of nuclear power are primarily caused by both radiation accidents and the emission of carbon dioxide and radiation during pre and post production processes. Uranium needs to be collected from the ground in the form of ore. The ore is ground down and the desired Uranium is extracted and through several different processes (depending on the mining process) turned into a yellow powder called 'yellow cake' Uranium. The problem associated with the extraction of Uranium is that excess rocks and dust are exposed to the atmosphere. When in the air the radioactive waste products could contaminate water.

The other major environmental problem is the disposal of nuclear waste. On average nuclear fuel will last up to 18 months in a reactor. Once the fuel is spent it will be processed further to be used again to reduce the volume of radioactive material. Instead of this nuclear waste is more commonly stored above ground in spent fuel containers at special facilities or it will be stored deep underground. It is strongly believed that nuclear waste must be stored up to millions of years before it is safe. The time taken for the spent fuel to become safe is determined by the half-lives of the dangerous radioactive materials. Half-life is a term used for the time that it takes for an unstable atom to break down half of its mass. In order for a radioactive material to become what is considered safe, it needs to have less than one thousandth of the original substance. To do this it would need to go through 10 half-lives. The two major radioactive substances in the spent fuel of the reactor are plutonium$^{239}$ and uranium 235 and 236 making up approximately 4% of the spent fuel. This may not seem like much however these highly radioactive materials have very long half- lives. Plutonium's half-life is 24000, once plutonium has been through 10 half-lives it will have accounted for 240000 years. Plutonium$^{239}$ decays into uranium$^{235}$ which is relatively safe. For the longer lived fission products such as $I^{129}$ which has a half-life of 15 million years it would take a substantial amount of time for the nuclear waste to become safe. During this time the radioactive material may escape the containment, possibly because of natural disasters like earthquakes releasing the material into water systems. The risk of nuclear waste polluting natural resources like water and contaminating the air is what creates many ethical questions such as where is it safe to store nuclear waste and will the presence of buried nuclear waste decrease the value of property in certain areas. These questions cause many political groups to opt out of nuclear power because they and the populations they represent are scared of losing the value of their land as well as the negative effects on the area's eco system. The most concerning environmental impact would be the release of radiation into the atmosphere through a reactor disaster. If the chain reaction inside the reactor was to go out of control, possibly because of a control rod malfunction it would increase its speed at an exponential rate, dramatically increasing the output of heat. This would cause a radiation leak in the reactor and a huge release of radiation carried by the working fluid that would now be released as steam. 1

**Implications:Economic Advantages**

The major economic benefits of nuclear power are the running costs. The cost for fuel is dramatically higher than coal, costing $143.16 NZD (at mid-2010 exchange rates) per kg as of mid-2010 (although prices have decreased from $429.48 NZD per kg in 2007) compared to coal which was $0.14 NZD in mid-2010. The benefit of nuclear power is that uranium will generate 72000000 MJ/kg whereas coal will only generate 24 MJ/kg. This means that nuclear power creates 3 million times the amount of energy than coal. Coal would cost $5.83 NZD per GJ of energy but

Uranium would only be $0.0019 NZD per GJ of energy making Uranium effectively 3068 times cheaper for each GJ it creates.

**Implications:Economic Disadvantages**

The major economic downsides of nuclear power are the start-up costs and the legal situations associated with the construction and running of a new plant. When a plant is first suggested there will be situations where many people oppose the decision, possibly even environmentally focused parties of government. This may cause petitions or other legal situations that postpone the plant's construction, resulting in a serious loss caused by no revenue. Al Gore once stated that if the construction of a nuclear power plant is delayed for one year it will cost the power company $1 billion USD. Another big cost associated with running the plant is mandatory insurance which each company must have in order to create a nuclear power plant. In New Zealand, the other main contender with nuclear power would be hydroelectric dams. The start-up costs of a dam are similar to the costs of a nuclear power station. The benefit of hydroelectric is that there are many water systems in New Zealand. This would allow a renewable way of generating electricity with a lot less money spent on fuel. There are also a lot less negative environmental effects provided by hydroelectric as there is no pollution. With hydroelectric there would be some social backlash from groups of environmentally friendly people disagreeing with the construction of dams. However, there would be significantly less social disagreement as there is with nuclear power.

**Biological Problems**

The radioactive decay of radioactive materials associated with all the processes of creating nuclear energy causes ionizing radiation. This radiation can be produced by the gamma rays released during radioactive decay. The radiation has the capability to strip away electrons from atoms or change the structure of chemical bonds. This can cause unique damage to the tissue in the human body, when the structure of cells is damaged the affected area may be too large or the damage may be too severe for the cells to repair themselves. During irradiation, the DNA of the cells and their repair sequence may be altered causing problems during repair. This may result in the creation of cancer cells in the human body and this is why all radioactive substances are known as carcinogens. The most biologically dangerous situation is acute radiation, it occurs when the human is exposed to high levels of radiation over a short period of time and the effects will occur within 24 hours of exposure. Exposure is measured by Grays (Gy) and 1 Gy is equal to 100 rads. When a human is exposed to 1-2 Gy they will exhibit symptoms of nausea, vomiting, headache, fever as well as serious burns. When exposed to 6-8 Gy (600-800 rads) majority of patients will experience these symptoms as well as cognitive impairment of the central nervous system for up to 24hours. The symptoms for patients up to 8Gy will not be apparent for up to 7 days. Any patients with exposure over 8 Gy will die within at least 2 weeks without latency. If patients are fortunate enough to be exposed to levels of radiation under 8 Gy they will survive provided that there is sufficient treatment. This kind of radiation would occur during a radioactive disaster such as a radiation leak caused by a reactor meltdown. Employees of nuclear power plants are constantly around low levels of radiation which would have no short term negative effects; however, a constant exposure to radiation over many years will result in health complications. These are called stochastic health effects and are health problems of which there likelihood will be increased by constant low level exposure to radiation. The main problem associated with radiation is the development of cancer and there are cases of employees being diagnosed with cancer at younger ages than the average population. To prevent this, employees must wear radiation suits in areas with higher radiation, this does not always prevent radiation and some stochastic effects will still occur. (2)

**Personal Position**

In my opinion I believe that nuclear power should not be used in New Zealand. I believe that foremost the environmental benefits of low carbon emissions are heavily outweighed by the heavily negative effects disposal of radiation will have over a long-time period as well as the danger a possible nuclear disaster presents to society both in New Zealand and internationally. (3) A disaster could cause pollution of water streams or soil, causing a decline in the available farm land in New Zealand. The risk of nuclear waste polluting natural resources like water and contaminating the air is what creates many ethical questions such as where is it safe to store nuclear waste and will the presence of buried nuclear waste decrease the value of property in certain areas. A disaster like this would result in a sharp decline of New Zealand's agricultural sector, negatively affecting the economy causing tax to rise and further political unrest from opposing parties. I believe the presence of these negative environmental effects will dramatically decrease the image of New Zealand as an environmentally-clean country decreasing another important sector of the economy, tourism.

I also believe that the economic benefits of nuclear power's high energy per Kg characteristic would be heavily shadowed by the government and public's argument that hydroelectric dams would have dramatically cleaner production and far more bountiful resources (provided by the presence of so many lakes and rivers in New Zealand). I admit the absence of fossil fuels in the future may cause an increase in the demand for cleaner forms of energy. This leads to my argument that until nuclear power is further developed and far safer than it is currently I do not wish to see it being utilised in New Zealand. (3) I believe for New Zealand to prepare for the eventual depletion of fossil fuels it needs to be investing in innovations in safe and clean forms of energy such as solar or wind energy production.

**Validity**

I believe my information is all accurate and relatively unbiased. Most of my information has been gathered from Wikipedia and multiple members of the website (a community based website that is often checked for errors) will be adding their own information of which most is accurate. Different people posting information causes the facts to be unbiased as they will all have different views on the topics.

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