National Certificate of Educational Achievement
TAUMATA MĀTAURANGA Ā-MOTU KUA TAEA

Exemplar for Internal Achievement Standard

Physics Level 3 version 2

This exemplar supports assessment against:

91527

Use physics knowledge to develop an informed response to a socio-scientific issue

An annotated exemplar is an extract of student evidence, with a commentary, to explain key aspects of the standard. It assists teachers to make assessment judgements at the grade boundaries.

New Zealand Qualifications Authority

To support internal assessment

	Low Excellence
1.	For Excellence, the student needs to use physics knowledge to develop an informed and comprehensive response to a socio-scientific issue. This involves: • linking key physics ideas together to provide a coherent picture of the physics relevant to the socio-scientific issue • analysing and prioritising the physics knowledge related to the issue to justify the response. The student has linked binding energy per nucleon to the fission of uranium and the production of energy (1). This student has linked properties of radioactive substance and their long half-lives to the medical problems caused by radioactivity and the problems of storing used radioactive fuel (2). This student has made a very good attempt at justifying a personal response using the pro and cons of the nuclear industry compared to fossil fuel technology (3). For a more secure Excellence, this student could: • analyse the physics knowledge by discussing the minimum amount of fuel required for energy generation and link this to the production of nuclear waste • prioritise information by commenting on sources and information, considering ideas such as validity (date, peer reviewed, scientific acceptance), bias (attitudes, values, beliefs) and weighing up how science ideas are used by different groups (e.g. power companies versus consumers).

Student 1: Low Excellence

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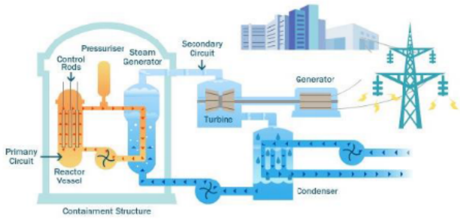
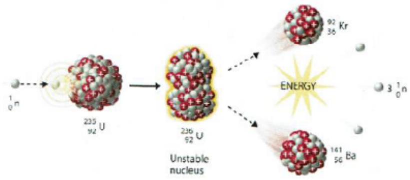
Nuclear Power in New Zealand



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.

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

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

1.098×10^{-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

Sizewell 1Km exclusion zone
Fukushima 20Km exclusion zone
Fukushima 40Km 'stay indoors' / voluntary exclusion zone
US recommended 80Km exclusion zone

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 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. ②

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 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. ②

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 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. ③

References

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http://www.world-nuclear.org/nuclear-basics/how-does-a-nuclear-reactor-make-electricity.aspx

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	Grade Boundary: High Merit
2.	For Merit, the student needs to use physics knowledge to develop an informed and reasoned response to a socio-scientific issue. This involves: • explaining how or why the key physics ideas relate to the socio-scientific issue • justifying the personal response using relevant physics knowledge to explain why the position and the action(s) have been chosen. This student has explained how the climate is determined by the gain of energy by the Earth's system versus the energy loss (1), has calculated the temperature of the Earth without greenhouses (2) and with 100% greenhouse gases (3), and has explained why greenhouse gases are so significant in terms of climate change (4). This student has justified the requirement to control the albedo effect of the planet and prevent its alteration by greenhouse gases (5). To reach Excellence, the student could relate the key physics ideas more clearly to the socio-scientific issue by recommending a course of action to the target audience (the Climate Change Minister of New Zealand).

Student 2: High Merit
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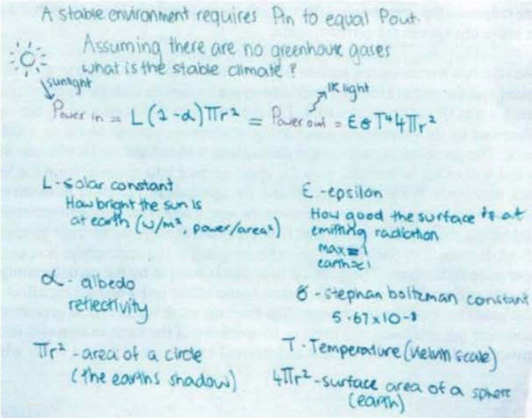
Note: The following is a snippet of the complete report that was written by the student.

To: Paula Bennett – The Climate Change Minister of New Zealand

After researching the physics behind climate change, I have come to a possible solution after investigating the advantages and disadvantages of the production of biochar. I have concluded that this is a very effective way of reducing Carbon Dioxide emissions into the atmosphere and will help decrease the rate at which the climate is changing.

The Physics behind a stable Climate Change: Power in = Power Out

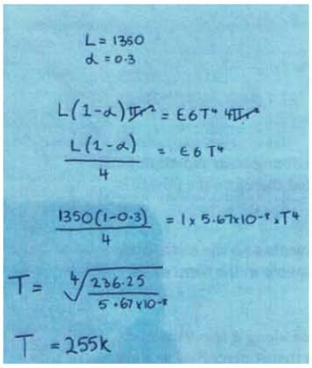
The energy requirements for a stable climate system is that the incoming solar radiation must balance the outgoing IR radiation emitted by the climate system and therefore the power in must equal the power out. The Earths energy system gains energy from sunlight which then warms up the earth, once the earth is warmed up it will emit energy back out into the atmosphere in the form of IR light. Electromagnetic radiation is classified by wavelength and stretched along a spectrum and separated into radio wave, microwave. infrared. the visible region that is perceived as light. ultraviolet. X-rays and gamma rays. The behavior of EM radiation depends on its wavelength.



(1)

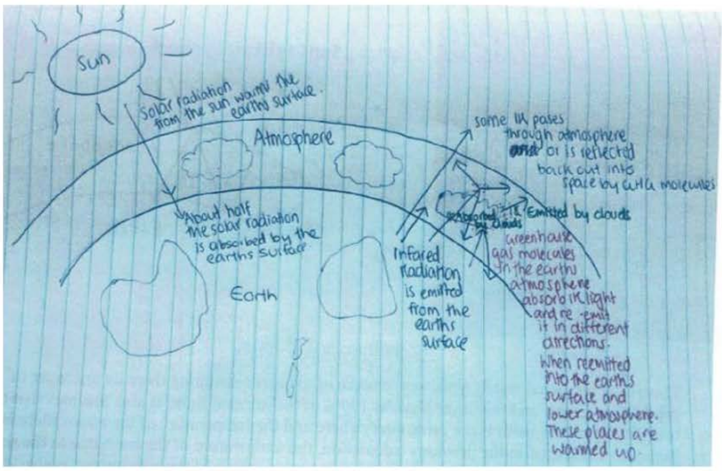
The predicted average stable temperature of the earth if it had no atmosphere

This is the calculation of the temperature of the earth assuming that there are no greenhouse gases. This is also assuming that the earth is not heating up and cooling down due to day and night and the constantly changing temperatures on earth. This calculation is also assuming the temperature across the earth is the same, however in reality it is not because as we know different countries around the world experience different temperatures and some places are warmer than others.
The temperature calculated without greenhouse gases was 255 Kelvins which is equivalent to -18.15 degrees Celsius. This is far too cold for organisms on earth to live so some greenhouse gases are good as they emit IR light back into the earth which makes the surface temperature of the earth warmer than what it would be without greenhouse gases. However, too much greenhouse gas is consequential.



(2)

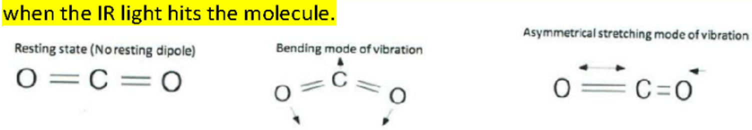
Energy from the sun warms up the surface of the earth. Half of this heat energy is absorbed by the ground and the rest is reflected back into space by clouds and the earth's surface. The warmed earth emits IR radiation upwards. The Infrared heat that is emitted by the earth is strongly absorbed by the greenhouse gases in the atmosphere such as Methane, C02 and water vapour. The greenhouse gases in the atmosphere will radiate the IR photons in different directions and will either be emitted from the upper surface into space or from the lower surface back into earth. Without an atmosphere, the upwards IR radiation from the earth would balance the incoming heart energy from the sun.



(2)

Common types of greenhouse gases include C02, Methane and Water vapour. Greenhouse gases vibrate at a particular frequency and have a natural frequency on the IR Spectrum, they vibrate due to the energy they absorb and can lose that energy by emitting it in the form of IR Radiation.

IR radiation has the same natural frequency of oscillation as the greenhouse gases and therefore the molecule will absorb the energy of the Infrared radiation. When the IR light hits the greenhouse gas molecule, it can create asymmetrical modes of vibration which shuffle the positive and negative charges around and therefore the IR light is absorbed. When the molecule stops vibrating and moving, this indicates that the IR photon has been emitted. C02 is symmetrical in its resting state, as is methane. However, there are modes of vibration that are capable of breaking this symmetry as atoms in these molecules have different electronegativity's which create bond dipoles and therefore allow for bending or stretching modes of vibration. H20 has 2 lone pairs of electrons and therefore has bond dipoles, this indicates an asymmetrical mode in which will be formed when the IR light hits the molecule. ④



This is the predicted steady state temperature of the earth assuming there us one layer of greenhouse gases, and this layer absorbs l00% of the infrared light. It also assumes that the temperature of the earth is the same everywhere and the temperature of the atmosphere is the same. As calculated in the previous calculation, the temperature of the earth due to the solar constant is assumed to be 255k and therefore the temperature of the atmosphere is also 255k. The reason for the Epsilon x Stephan Boltzmann constant x Temperature of the atmosphere half of the equation being multiplied by two is because when the Infrared radiation gets absorbed by the greenhouse gases in the atmosphere, it can be emitted either back into the earth or out to space. However, this calculation is insufficient as we know that there isn't just one layer of Greenhouse gases. The atmosphere is obviously not l00% greenhouse gases, which means that there are gaps where the IR light will be able to pass through without being absorbed and can just travel straight out to space. The real atmosphere does not absorb all the IR light from the ground as the greenhouse gases are very selective. ③

$$\varepsilon \sigma T_g^4 = 2\varepsilon \sigma T_a^4$$

$$T_a = 255K$$

$$T_g = \sqrt[4]{2T_a^4}$$

$$= \sqrt[4]{2}\,T_a$$

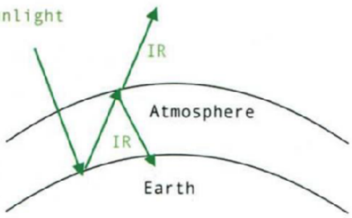
$$= 1.189 \times 255$$

$$= 303.24K$$

$$= 30°C$$

The average temperature of the earth realistically is 15 degrees cooler than this predicted temperature. The steady state temperature of the earth can be predicted with a more sophisticated model http://climatemodels.uchicago.edu/rrtm/rrtm.doc.html.

This model predicts that if the earth has certain properties then it will lose as much energy as it gains (P in= P out). The model has default values whereby the steady state temperature is 284.42 K which is 11.27 degrees Celsius and the C02 concentration in the earth's atmosphere is set at 400 ppm. On the model, I doubled the C02 within in the atmosphere to 800ppm. According to the model, in order for the earth to lose as much energy as it gains with the C02 concentration of 800ppm, the steady state temperature would be 286.9k (13.75 degrees). This shows that as the C02 in the earth's atmosphere increases, so does the surface temperature of the earth.



There are feedback loops in the atmosphere that are either negative or positive and act as a stabilizer or amplifier, therefore the response will either push the temperature up or down to stabilise it or act in the same direction as the imbalance. The ice albedo feedback is a positive feedback to the earth's climate. The higher the albedo the colder the planet, and in this case when the light comes in a high majority of it gets reflected out to space and the sun light doesn't deposit its energy as heat to the planet, therefore will not heat it. Ice and snow is very reflective and therefore have a high albedo. A layer of snow over the ground will reflect visible light to space. Due to the increasing temperature of the earth, ice is melting and therefore there is less of it on earth, this means that there is less ice reflecting the visible light out to space and the planet is warming because the ground is absorbing more heat. The ocean has one of the lowest albedos on earth and therefore will absorb even more than the ground does. If we produce more C02, the ocean will absorb even more excess C02 to bring the C02 in the atmosphere back to equilibrium, therefore the ocean acts as a negative feedback response. ⑤

With the knowledge we have about Global warming, I think that people in today's society should start to take action to do things to set a more positive example for future generations to try and prevent climate change at such an alarming rate. If people in this world are able to consider ways of living that have a positive impact on the environment. by not only taking biochar techniques of riding agricultural wastes into consideration, but all of the many other solutions there are. Then it is possible that we can open our eyes and stop selfishly destructing this earth we were gifted with to live in.

<table>
<tr><td></td><td>Grade Boundary: Low Merit</td></tr>
<tr><td>3.</td><td>For Merit, the student needs to use physics knowledge to develop an informed and reasoned response to a socio-scientific issue.

This involves:

• explaining how or why the key physics ideas relate to the socio-scientific issue
• justifying the personal response using relevant physics knowledge to explain why the position and the action(s) have been chosen.

This student has explained how the nuclear power is generated (1), albeit at National Curriculum Level 7 but then has linked this to the storage of nuclear waste (2), and has described some of the biological effects of different levels of radioactivity. The student has justified their personal response using relevant physics knowledge to explain why the position and the action(s) have been chosen (3).

For a more secure Merit, this student could relate the key physics ideas more clearly to the socio-scientific issue by:

• relate the key physics ideas to the issue more clearly by explaining what nuclear waste is and how it is produced, and/or explaining what a nuclear meltdown is and its repercussions
• relate the key physics ideas to the issue more clearly by explaining the effect of mass deficit on the energy produced by nuclear fission
• justify the personal response better by providing quantitative data on the amount of energy produced per gram of fuel for different fuels and/or that produced by renewable energy resources.</td></tr>
</table>

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 $C0_2$ per kw on average while coal releases a substantial amount; 1001 g of $C0_2$ 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} (1) 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.

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 (2)
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.

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 (3)
danger a possible nuclear disaster presents to society both in New Zealand and internationally. 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 (3)
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. 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.

References

https://en.wikipedia.org/wiki/Nuclear_power

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https://nzhistory.govt.nz/politics/nuclear-free-new-zealand/nuclear-free-zone

https://en.wikipedia.org/wiki/New_Zealand_nuclear-free_zone

Price for coal (June 2010): https://ycharts.com/indicators/australia_coal_price

Price for Uranium: http://nuclearinfo.net/Nuclearpower/WebHomeAvailabilityOfUsableUranium

Historical exchange rates: https://www.oanda.com/currency/historical-rates/

	Grade Boundary: High Achieved
4.	For Achieved, the student needs to use physics knowledge to develop an informed response to a socio-scientific issue. This involves: • explaining the key physics ideas relating to the socio-scientific issue • presenting a personal response and proposing action(s) at a personal and/ or societal level, using relevant physics knowledge. The student has described how the Large Hadron Collider accelerates protons to a very high speed (1), described the standard model and the missing Higgs Boson particle (2), and made a limited presentation of a personal position, proposing action(s) using relevant physics knowledge (3). To reach Merit, this student could: • relate the physics ideas to the issue by explaining how the Large Hadron Collider accelerates protons by electromagnetic induction • explain their position based upon the physics of whether the high-energy particles are safe (as opposed to how much they cost).

Student 4: High Achieved

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Is high-energy particle physics worth the cost?

Particle physics and the LHC

The Large Hadron Collider (LHC) is the world's largest and most powerful particle accelerator with the fundamental purpose of increasing our knowledge of the universe. It was built between 1998 and 2008 by the European Organization for Nuclear Research (CERN) and is the latest addition to CERN's accelerator complex. The LHC consists of a 27-kilometre ring located 100 meters under the border of France and Switzerland near Geneva, Switzerland. Once it is switched on, semiconducting electromagnets within are used to help hurls beams of protons in opposite directions around the LHC at speeds up to 99.9999991% the speed of light. Once up to speed, they are made to collide, releasing energy and creating new particles. Analysis of the debris gives us a glimpse of the subatomic world and the laws that govern it. Through these events, scientists have been able to recreate the conditions that would have been present milliseconds after the Big Bang. During this first moment, time, space, the particles and forces that shape our Universe came into existence, so understanding this event would unlock many mysteries of the universe. This research into high-energy particle physics is exciting and brings us one step closer to understanding the world around us. It has allowed physicists to test different theories of particle physics, in particular the existence of the theorized Higgs Boson. ①

Findings from the LHC

The Higgs Boson is part of the Standard Model and is thought to be responsible for giving matter its mass. The Standard Model is a theory proposed as an attempt to understand our universe. This theory is important because it tries to define and explain the fundamental particles and basic forces that make up the universe. It proposes 12 particles that are divided into two groups, the quarks and leptons. It includes 3 forces, the electromagnetic, strong, and weak forces (the theory excludes the force of gravity). There are also force- carrying particles called bosons. The W and Z boson cause the weak force, photons are responsible for the electromagnetic force, and gluons create the strong force. All of these particles have been confirmed by the experiments at the LHC. Particles can be extremely hard to detect because they only exist for fractions of a millisecond before they decay into or join together with other subatomic particles so the only way to confirm their presence is by analysing the by-products. Thankfully, each particle has a unique decay signature that can be distinguished by software. The Z boson, that has a neutral charge for example, decays into two leptons (e- and e+ or p - and p +). Electrons show up as two yellow lines on the detector software and the direction the electron's path bent is used to determine its charge. Muons show up as a long red line also bending depending on their charge. The W boson (either w- or w+) decays into a single electron or muon plus a neutrino. The neutrino is undetectable but missing momentum in the system accounts for this and shows up as a yellow arrow, whose length is proportional to the amount of missing momentum. The theorized Higgs boson has several possible decays. The most popular is the decay into two Z bosons or into two photons. The Higgs boson is the missing piece to the Standard model and is the main focus of the LHC collisions. The groundbreaking discovery of a Higgs like particle at the LHC in July of 2012 was a huge step forward towards completing the Standard model. It would take its place as the third boson and could also be responsible for being the force- carrying particle for gravity. On the other hand, the results of the high-energy particle physics taken place at the LHC could blow the whole theory apart. If the Higgs particle that has been discovered turns out not to be the one that we expect, this would open the doors for an addition to the standard model or the need to rewrite the whole theory. Scientists are also looking for evidence of dark matter, antimatter, dark energy and super symmetry to support other theories. These discoveries could make the existence of other dimensions possible. No matter what the outcome, this high-energy particle physics will expand our knowledge of the universe and may even give us a different view on looking at reality. The research conducted at the LHC has an obvious beneficial place in our society, but at what cost? ②

How much does it cost?

Both the building and running of the LHC comes with enormous costs. It took a decade to construct that costed a total of over 6 billion dollars. The LHC requires a colossal amount of energy to accelerate and smash beams of protons together. It consumes an estimated 800,000 megawatt hours (MWh) of electricity that costs almost 30 million dollars annually. "Taking all of those costs into consideration, the total cost of finding the Higgs boson ran about $13.25 billion (1)." Although this seems like a lot of money, there are over 50 billionaires on the Forbes List worth more than that. It's not like the money isn't going to a good cause and understanding our universe is priceless.

Are the high-energy particle collisions at the LHC safe?

The LHC can create higher energy than any other particle accelerator for more effective proton collisions but has been a subject of many claims of safety. Groups such as 'Citizens Against The Large Hadron Collider' is a non-profit organization established for the purpose of preventing the operation of the LHC until further safety tests are conducted. It is a website where concerned citizens around the world can protest against the operation of the LHC. The best-known opposition of the LHC came in the form of a lawsuit filed in America by Wagner and science writer Luis Sancho. The LHC Safety Assessment Group (LSAG) has published a review analysing the risks and has concluded the LHC presents no danger. A key focus of the critics' argument has been the creating of black holes. Black holes typically occur when certain stars collapse on themselves at the end of their lives, concentrating a large amount of matter in a very small space, creating such a strong gravitational pull that even light can't escape. In theory, a black hole doesn't have to occur on a planetary scale but at any size. The claim of a microscopic black hole being created in the LHC when protons disintegrate is purely theoretic and LSAG claim that even if such a black hole were created, it would be so instable and evaporate in one-trillionth or one-millionth of a second.

Another argument against the operation of the LHC is the production of potentially harmful cosmic rays (high-energy radiation). However, nature has created these rays some of which have much higher energy than the LHC, which is in a controlled laboratory environment. According to the LSAG, "the Universe as a whole conducts more than 10 million million LHC-like experiments per second. The possibility of any dangerous consequences contradicts what astronomers see - stars and galaxies still exist (2)." Concerned citizens have put forward more small worries about the operation of the LHC that the LSAG have addressed and concluded that the LHC is safe to operate. From their conclusion, it is safe to say that the chance that the LHC will destroy the planet is minimal and the results of experiments at CERN are worth the risk.

Is it worth the cost?

The experiments conducted at the LHC are scientific. The whole point of science is creating theories and then testing them. So far, we have had masterminds such as Albert Einstein and Werner Heisenberg proposing theories about the universe such as the 'standard model' and 'string theory'. Before the LHC, there were no ways of testing these theories. With this new technology, we can scientifically test these hypotheses. The LHC and standard model is a perfect example of the essence of science. While there is no practical application of the discoveries scientists have made at present, we will most likely find some in the future. This isn't the only reason hundreds of scientists and engineers built the LHC though, it is also to further our knowledge. Being humans, we are driven by curiosity and thrive with discovery; so naturally, we have built a device to do just that. When we are so close to unlocking essential secrets of the universe, it seems that the cost doesn't matter. This may seem selfish of the Western World to invest a huge amount of money into smashing protons together but furthering our knowledge of the universe will not only benefit the scientists but the whole world. Teleportation and extra dimensions could mean ending poverty, uniting our planet and maybe even discover extraterrestrial life. Some people argue that until the LHC proves anything it is just wasting money. This is simply not true and work at CERN has already created advancements in our lives. Building the LHC forced engineers to come up with new technologies and designs for large constructions that will benefit our ever-expanding society. The LHC is unique in that it is 100m underground so the builders had to find fast and reliable ways of drilling down and around 27km underground. This advancement is important particularly for the mining industry and allows us to mine more effectively. Another problem that engineers had to solve was constructing the huge circular concrete tubes underground that encased the tubes that the proton beams race through. These types of new innovations could lead to the creation of underground cities in the future if needed. The World Wide Web is another development thanks to the LHC. The amount of data that CERN had to transfer meant new methods of computing had to be created to keep up. The LHC Computing Grid was CERN's innovation to overcome the challenge of transmitting the masses of information to other locations around the world and is now used predominantly by large companies. It combined both fibre optic cables and high-speed Internet connections to allow data transfers of over 10 Gbs/s. this technology is now used to provide superfast Internet to homes around the world. New software methods were developed to analyse the massive amounts of data called midware. There was also the need for them to operate simultaneously to process the data faster, which has allowed computing companies to produce machines that can run much faster. Thirdly, the LHC project requires a lot of staff on the job. This creates much more jobs for people that would otherwise contribute to Switzerland's large unemployment rate.

So what is the next step?

Considering all of the benefits the LHC has already given us, the decision whether to operate it again in September 2014 seems obvious. We should continue the operation of the LHC and possibly even build another one to speed up the process. People around the world and particularly those who live near the particle accelerators should be shown the document by the LSAG showing that the operation of the LHC will not destroy the world and assured that no harm will come of them. (3)

Reliability of sources

- The Forbes website is usually a reliable source because it shows the author and the date. The price of running the LHC is may not be so reliable because the breakdown of cost doesn't quite add up. Also the currency can't be verified- although being an-American Press it is assumed that they are in US dollars.
- The safety article is directly from the CERN website that gives it credibility. There isn't an author or date but it is likely to be written by the CERN press that would include a group of people. The information is updated from 2003, which is a sign of authenticity although it doesn't specify how up to date it is. The source does provide links that of the LSAG report up to 2008 and other detailed information, which overall makes this a reliable source.
- Howstuffworks is a reliable source that shows the author and date but is written in layman's terms that could decrease its reliability. It does reference the information presented in the article that makes it a reliable source.

Websites

- https://www.forbes.com/sites/alexknapp/2012/07/05/how-much-does-it-cost-to-find-a-higgs-boson/#27af3a763948
- https://home.cern/topics/large-hadron-collider
- http://science.howstuffworks.com/science-vs-myth/everyday-myths/large-hadron-collider.htm
- https://en.wikipedia.org/wiki/Large_Hadron_Collider
- https://skeptoid.com/episodes/4109

	Grade Boundary: Low Achieved
5.	For Achieved, the student needs to use physics knowledge to develop an informed response to a socio-scientific issue. This involves: • explaining the key physics ideas relating to the socio-scientific issue • presenting a personal response and proposing action(s) at a personal and/ or societal level, using relevant physics knowledge. This student has attempted to describe how a nuclear reactor works, albeit at National Curriculum Level 7 (1), and attempted to describe the biological damage of gamma radiation and described how half-life is a factor when considering nuclear waste/leakage (2). This student made a limited presentation of a personal position, and proposed action(s) using relevant physics knowledge including a description of the energy benefits and recommendation based upon the dangers of radioactivity in a New Zealand setting (3). For a more secure Achieved, this student could: • relate the key physics ideas to the issue more clearly by describing what nuclear waste is and how it is produced • relate the key physics ideas to the issue more clearly by describing the effect of mass deficit on the energy produced by nuclear fission • relate the key physics ideas to the issue more clearly by linking the biological damage of radioactivity to its properties.

Student 5: Low Achieved

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Nuclear Power

Nuclear power is a highly-debated topic in New Zealand, with our currently nuclear free stance, however the looming "power crisis", as it has been referred to, is nearing, so perhaps it would be a smart idea to consider a change to the nuclear free New Zealand.

Or perhaps a change wouldn't even be necessary.

A closer look at the "New Zealand Nuclear Free Zone, Disarmament, and Arms Control Act of 1987" has no mention that we 'must not have nuclear power stations' (cite 1), however many people claim that it is illegal for New Zealand to be nuclear powered. This is not true, though there are valid environmental, economic, and possible health implications to be wary of, but to gain the full picture of these, it is important to understand how a nuclear power station actually produces power.

Nuclear Power formation can be summed up as the fission (splitting) or fusion (combining) of nuclear elements to produce heat. Current technology has us limited to creating power via nuclear fission. Most nuclear power stations run by the splitting of a uranium-235 into two smaller atoms, usually barium (Br-144) and Krypton (Kr-89), by colliding a neutron into the Uranium-235 nucleus. This reaction also produces 3 more neutrons, and a significant amount of energy. This energy is then used to heat water to produce steam to spin a turbine, which then creates the electricity. All reactants and products of a nuclear fission reaction are highly dangerous due to the radioactive nature of those atoms; however, the risk is reduced dramatically if stored correctly. Generally radioactive products are stored in thick concrete vats, where the external concrete is approximately 7inches (18cm) thick. The other common option is to store the spent fuel rods underwater; however, the water is also usually surrounded with a thick layer of concrete as well. The spent fuel is then able to be disposed of, commonly at this time by being flushed into the ocean, however there are new deep geological repositories being built and used in France. There is very little evidence to see what would happen after a civil disaster currently. The only times when nuclear power is truly dangerous for humans is after a nuclear meltdown or other horrific event. (1)

The world knows the potential hazards of nuclear meltdown after the large scale nuclear fallout of the Chernobyl disaster in 1986, after a meltdown in the reactor released a large amount of radioactive material, all of which cause numerous serious aliments to tens of thousands of people, and makes the surrounding area uninhabitable and unusable for several more years to come. There is also the horrific tragedy of the Fukushima Daiichi nuclear disaster, where the nuclear power station was badly damaged during a large earthquake in 2011, causing large scale nuclear fallout over a country that was already crippled by the effects of the fore mentioned earthquake and the tsunami that followed. Japan's history of strong earthquakes is similar to ours, with multitudes of large earthquakes shaking both countries on a regular basis. The spent fuel vats, containing several radioactive compounds, were fractured in the earthquake leading to the major Fukushima disaster, the following tsunami made it extremely difficult and dangerous to fix the fracture. When the tsunami struck the reactor and fractured fuel vats, the nuclear waste was then washed far inland with the tidal wave, cause a large wide spread fallout of nuclear waste.

So, should we risk the earthquakes damaging a nuclear reactor in New Zealand? Well, the point could be taken that if we do, and it goes wrong, the radiation from the radioactive elements could have significant biological impacts on the general communities. The gamma radiation that is released from radioactive elements is enormous, and is known to cause several types of cancers, as well as skin burns from direct contact. In a nuclear disaster, the radioactive elements can be spread over a very large area, up to about a 30 kilometre radius from the plant, however other causes can spread the fallout a much larger distance, such as the tsunami at Fukushima. The radioactive elements are surrounded by thick concrete walls to provide protection from the radiation, especially in the form of gamma radiation, in normal circumstances, however during a nuclear disaster such as the oh-so-common New Zealand earthquake, these concrete structures could rupture, and causing gamma radiation to be emitted up to a huge 30km away from the reactor. The knowledge of how radioactive elements decay is also a major point to consider. Radioactive elements decay in what are known as half-lives, the time it takes for the amount to be reduced by half. Most radioactive elements only have half-lives of a few days to a couple of weeks, meaning it (2) reduces to a safe amount very quickly. However, some, such as caesium-137, have a half live of 30 years, so it takes generations for the amount to reduce to a safe amount. There have been suggestions that the land surrounding Fukushima Dachii will not be safe again for "hundreds of thousands of years" (2), although it is more likely to be about 300 years, due to the half-lives of the spent fuel deposited on the ground. 2 Combining those ideas, the area surrounding a nuclear accident is dangerous and seriously damaging to everyone for years. Is that really a mark we want on our "Clean, Green" image?

However, nuclear power could be the answer we are looking for to our growing energy demands.

The rise of electrical appliances in everyone's homes is increasing the demand for power, if we continue to have an increasing demand, we will soon have a large deficit of energy, and After all we are already net importers of energy. A nuclear power plant, of an average size, produces approximately 12 million kilowatt hours, that's approximately 6% of the energy that New Zealanders use, in a year, as a whole. Nuclear power facilities also have a far greater amount of energy produced per kilogram of fuel than coal, 23,279,200 KwhKg^{-1} to 6.27 KwhKg^{-1} so perhaps it might just help the energy crisis.

I believe that although this magical idea of a nuclear power plant being able to solve the countries power crisis, it is not the best idea for New Zealand. This is due to the potential of a nuclear accident and the negative affects that that would have on every person in New Zealand. The cancers and skin burns from direct contact with the radioactive compounds, almost all requiring medical treatment, will cost taxpayers a lot of money in the long run. 3

	Grade Boundary: High Not Achieved
6.	For Achieved, the student needs to use physics knowledge to develop an informed response to a socio-scientific issue. This involves: • explaining the key physics ideas relating to the socio-scientific issue • presenting a personal response and proposing action(s) at a personal and/ or societal level, using relevant physics knowledge. There is little evidence of explaining the key physics ideas relating to nuclear power at National Curriculum Level 8. The descriptions are at National Curriculum Level 6. This student has made a limited presentation of a personal position, and proposed action(s) without using relevant physics. To reach Achieved, this student could: • describe the physics of nuclear power generation and nuclear waste based on descriptions of key physics ideas such as mass deficit and binding energy • present a personal position based on physics relevant to nuclear power.

Student 6: High Not Achieved

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***Physics 3.7*: Use physics knowledge to develop an informed response to a socio-scientific issue**

Nuclear power: NO

Processes involved in producing nuclear power and production of nuclear power:

Nuclear power is produced through the nuclear reactor. Nuclear plants just like any other plants that burn oil, natural gases and coal to produce electricity which is done through boiling water into steam. The steam then is produced into electricity. The difference is that the nuclear plants do not burn any substances in order to produce electricity but instead it uses uranium fuel that consist of solid ceramic pellets to produce electricity. This is done through the process called fission reaction. There are initially two type, fusion reaction and fission reaction, but the uranium reacts in a fission reactions which produces more energy therefore more amount of electricity will be produce. The nucleus of the uranium atom is held together with great force "strongest force in nature". When continuously attacked with neutrons which results in the atom splitting apart, the name for this reaction is fission. When neutron is collided with the uranium atom it splits and the atom is discarded, this creates a chain reaction as it then collides again with another atom repeating the process. Releasing large amount of energy is used for heating water at 520 degrees Fahrenheit in the core of the nuclear reactor. The water heated then is released into the spinning turbines to that are connected to the generators to produce electricity.

Hazards associated with the production of nuclear power, malfunction of the nuclear power station and likelihood of the hazards occurring:

Uranium mining is a process of where uranium is extracted from the ground. "The worldwide production of uranium in 2012 amounted to 58,394 tonnes." Uranium mining is used as fuel in the processes of producing nuclear power. The price of uranium has dropped to almost 50% since 2011 due to the Fukushima nuclear disaster. There are two ways of mining uranium, open pit where overburden is removed by bombing exposing the ore body which then the workers work in the enclosed cabins reducing the effect of radiation. The other way is undergrounding uranium mining. This particular way includes the workers directly exposed to the radon gas which affects their body. There are many ways but these are the most influential. There are many health risks of uranium mining which is a hazard during the process of producing nuclear power. First one is lung cancer, there has been many deaths during uranium mining. Radon gas is the product of radioactive decay of uranium and therefore undergrounding mining has very high concentration of the radon which obviously affects the workers badly. There is increase in frequency of workers contracted to lung cancer. In many states for example, Utah, Colorado, New Mexico, and Arizona in Unites States there are many abandoned mines have not been cleaned up which affecting the environment and also increasing health risk for the people in the community. New Zealand being considerably small country unlike the United States cannot overcome the risks of public health. The environment can also cause many problem for the communities and also affects the people in the communities. Being a well-known country for its beauty and a sustainable country where many people around the world wishes to live, New Zealand cannot risk its citizens, costs and the sustainability. Global warming is affecting the whole world and the temperature on Earth is getting warmer which means that the ice in Antarctica and many other cold places is melting and the sea level is rising this is not good news for our future generation and also for a small country like New Zealand where some parts of the country can drown. Therefore, it is our responsibility to minimise the casualties of citizens in New Zealand by providing a safe environment for them.

The other important hazard is when large amount of heat is released in the process of fission reaction and it is very important that the reaction is controlled. "Meltdown" is a term used when the reactor core is not covered fully with water for cooling down when the neutrons have collided with uranium. Not fully covered with water can lead to nuclear fuel to overheat and eventually melt. In the Fukushima Daiichi plant disaster caused by earthquake and tsunami which lead the plant to shut down. Power outcomes followed. During the reaction, the control rods were inserted into the core to absorb neutrons where its function was to slow down the fission reaction but not stopping it immediately. The control rod will slow down the fission reaction and eventually stop it but the other major problem was with cooling down of the fuel system. During the disasters, the water that should have cooled down the fuel system had leaked which increased the temperature and that led to four of six reactors exploding. The likelihood of this hazard occurring in New Zealand is more as the tectonic plates beneath us is very close to it edges and there is high chance of getting earthquakes and large sea sounding a small country like New Zealand also have chances of tsunami and many other disaster, knowing that fact it is not a very acceptable decision to have nuclear power in New Zealand as a clear reason is stated. Also, the hazard of mining; New Zealand does not have the mines but transporting uranium is a risky and very solid job, which also have many risks for example radioactive decay and radiation through where it is getting transported. These risks stated is very likely to happen when producing electricity through nuclear power.

Explanation from Environmentalist to say no to nuclear power:

Some environmentalist in New Zealand from the University of Auckland, John Francis Hamilton who does not prefer nuclear power generation as a "clean" energy source. While more and more of the nuclear waste is produced then the small quantity of the nuclear power, half the century went past by and still we have not come across a solution to safely dispose the nuclear waste. The medium- level waste is considered very dangerous and requires disposal as it is creating many difference in climate change and health of the people in the community. Uranium mining also creates many hazards that has taken many people's lives and it is still doing that. The studies show that uranium mining in Australia had around eight thousand clean-up workers died within the five years' period. Nuclear power is not for New Zealand as the nuclear plant creates large, single and bundle of energies. They cannot be subdivided like Huntly power station in New Zealand currently, if one stops working the others are still operating. Nuclear shutdowns which happen frequently removes 1200 megawatts without any warning while one of the four Huntly power stations removes 400megawatts or 250 megawatts. John also says that nuclear plant risks security of supply because the New Zealand system cannot provide instant back up.

Nuclear power could affect New Zealand economically as New Zealand not being economically stable can be defeated by the uprising of the costs. Armed transport for fuel and waste and all the checks on the workers, constant monitoring of radiation can have very high costs. Having a nuclear plant can offer many jobs but also at the same time can risk many people's lives.

The constant climate change is also a big issue environmentally. "While the halting of the Gulf Stream and the resulting cooling of Europe and the eastern US is a horrific possibility." Says John, which is true and terrifying because knowing that currently climate change is occurring as we continue to harm the environment and the sea level rising and there is a high chance of many cities in many countries including New Zealand drowning, it is not sustainable for the future generation.

Saying no to the nuclear power can save New Zealand in many ways including its citizen's life. Being a country well known for its sustainable efforts and not affecting the climate changes as many other countries are doing really can be said that New Zealand has put in effort to protect the environment. Say no to nuclear power in New Zealand.