|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| STSE Category | | Risks | Ranking | |  | Benefits |  | Ranking | |
| Science/Technology | **1.Proliferation of Nuclear Weapons** With the proliferation of civil nuclear energy has come the proliferation of nuclear weapons and the capabilities for nations to generate weapons grade uranium. The World Information Service on Energy claims that “The borderline between civil and military use of nuclear energy evidently exists more in theory than in practice”  (World Information Service on Energy, 1999) and that most civil nuclear energy reactors can be utilized by rogue nation states to generate nuclear weapons. This appears to be an issue however most nations pursue civil nuclear energy project but do not pursue a nuclear weapons arm. This is largely due to the nuclear non-proliferation act which prevents most nations from being able to stockpile nuclear weapons and proliferation of nuclear weapons has been shown to make nations less want to use them. No nation after the bombing of Japan has used a nuclear weapon as an attack on a nation due to the fear that a nuclear strike would result in nuclear retaliation.  **2.** | | | **1.**4 | | **1.Radioactive Isotopic Production** Many modern medical procedures require radioactive isotopes. According to the International Atomic Energy Agency “Growing tumour cells are sensitive to irradiation  damages, and that is why therapies often employ radioactive isotopes” (International Atomic Energy Agency, 2016). The proliferation of nuclear reactors has resulted in the proliferation of radioactive isotopes which can be used for medicinal purposes.  **2. The potential of development for better reactors for energy production or research**  Through the massive funding of the Canadian nuclear program in the mid 1900s Canada was able to research into making the best designs for nuclear reactors as well as ways to implement nuclear technology for civilian purposes. Canada developed the modern standard for nuclear reactors known as the CANDU design, “All nuclear power plants in Canada use the CANDU design” due to its “safe, reliable, reactor technology” (Canadian Nuclear Safety Commission, 2016). These advances have also helped the research field where Canada is the hub for medical radioisotope production, due to its technology and expertise in the nuclear field.  **3. Production of Hydrogen**  Hydrogen production today uses coal and other fossil fuels which are non-renewable and release greenhouse gas emissions. The heat released from nuclear fission reactors can spark electrolysis in water and cause the release of hydrogen, which can be used in research applications as well as civilian applications to potentially in the future power automobiles and electronics. According to the American Chemical Society, “nuclear power plants are ideal for hydrogen production”, if hydrogen production is able to become mainstream with nuclear power it could “fuel the ‘hydrogen economy’” (Bernstein & Woods, 2012). | | | **1.** 2  **2.** 3  **3.** 4 |
| Society  Cultural  Legal  Economic  Ethics | **1.Health risks of living near nuclear power plants** There are conflicting reports on whether nuclear power plants result in an increase in cancer rates in surrounding areas. One study found “no evidence of excess numbers of cases in any local 25km area around any of the nuclear power stations” (Milne, 2005). Anecdotal evidence and reports however show that there are communities who have a disproportionate amount of cancer rates that surround nuclear reactors. Researchers have studied the teeth of children and found “higher levels of Sr-90 near nuclear power plants,” (Riley, 2004). If these risks are to be founded, then nuclear power must and will be stopped as a proliferation of nuclear power would result in a significant amount of despair however the scientific consensus is appealing to the side that there is insignificant risk.  **2. Violation of religious ideals** Many religions and cultures oppose the advancement of nuclear power. Many scholars argue that nuclear power generation goes against the teaching of Buddha. It is argued that the generation of immense power through the fission of radioactive material poses a great risk to the environment and people which goes against the Buddhist principles. It is also claimed that “Rather than asking how we can generate the enormous amounts of energy that a consumerist economy needs, we need to restructure our societies according to the amount of renewable energy” (Loy, 2013). Modern, western society especially in Canada is becoming more secular so the religious conflicts are becoming less significant but for many this is a significant issue and if nuclear energy is to become universal it must appeal to all people and culture  3. **High upfront construction costs.**  Nuclear power has been plagued by high construction costs that cause the power plants to be financial burden for many years despite its low operation costs. According to a report by a professor at the University of South Wales nuclear power plants entail “very large economic risks” and “the rapid growth of nuclear energy is impossible” (Diesendorf, 2010).  **4. Nuclear power plant negatively affecting local economy**  Many people are wary about living near power plants possibly due to concerns about the negative health effects or potential meltdown risks. In Japan residents within the surrounding area of a nuclear reactor receive tax benefits and subsidies. A study in Japan concluded that the value of properties surrounding nuclear reactors did show a statistical decrease however that the benefits provided by the Japanese government improved the resident’s welfare so that there was effectively no change (Yamane, 2011). This issue can be significant for many people living in areas with plans for nuclear reactors, as Canada has no current subsidy for residents and if nuclear power is to become more prolific it may be necessary to implement such measures. This may be insignificant though as a widespread use of nuclear reactors would result in buyers feeling more comfortable residing in properties near such reactors. | | | 1. 4  2. 3  3. 2  4. 5 | | **1. Creation of skilled jobs.**  Nuclear power plants are massive projects that generate a massive amount of jobs and a large percentage of those jobs are high paying due to the skill involved. According to a report by the Bruce Power nuclear power plant, each year their facility will create 18000 indirect and direct jobs annually (Bruce Power, n.d.). This is an astounding figure considering that these jobs are high skill and the pursuit of further nuclear reactors will contribute to the livelihood of many people.  **2. Spurs Economic Growth**  Nuclear power has been shown to have a great effect on the economy and nuclear power is a great contributor to the Canadian economy. Canada has invested approximately 14 billion dollars over 50 years into nuclear power and this has resulted “160 billion in GDP benefits” as well as annually “create C$1.5 billion in government revenue” (World Nuclear Association, 2017). These are extraordinary statistics and if this trend were to continue with continued nuclear energy production it could be a massive benefit for the Canadian government. | | | 1.3  2.2 |
| Environment | **1.Issues with Radioactive Waste disposal.**  Modern nuclear fission reactors result in a significant amount of energy however have a disturbing by-product of hazardous waste. The current solution is to bury the radioactive waste underground in repositories to prevent leakage and future human contact. However the International Atomic Energy Agency says that “waste repositories represent possible sources of radiation exposure to humans” (International Atomic Energy Agency, 1996). The issue is that with the proliferation of nuclear power generation there is an increased number of repositories which are taking up an increasing amount of area that is running out. These repositories also face the risk of unintentional human contact, if humans were to accidentally drill and reach one of these repositories this could lead to leakage and a devastation of the surrounding environment and potentially human population. The issue of radioactive waste disposal is important because if nuclear power generation is to become more widespread, another solution must be found as there is only a finite amount of space on the planet and these repositories risk contaminating the outside. However the International Atomic Energy Agency claims that the risk for contamination to the environment is low and that any such risks would occur centuries in the future (International Atomic Energy Agency, 1996).  **2. Emissions caused by reactor meltdown**  Nuclear reactors emit very little dangerous emissions or greenhouse gases during standard use. However in the event of a reactor meltdown many dangerous gases can enter the atmosphere and cause devastating effects. When the Fukushima reactor was hit by an earthquake it caused a meltdown. According to a report by the Fukushima Disaster organization when Fukushima melted down it emitted many heavy isotopes such as Strontium-90 and Caesium-137, these emissions turned into radioactive clouds and when they fell to the earth contaminated the marine environment and soil (Rosen, 2012). The emissions were very dangerous however the likelihood of such nuclear meltdowns is decreasing as technology improves and is a very rare occurrence with modern technology. | | | 1. 2  2. 3 | | **1. Nuclear Power Greenhouse gas emissions**  Nuclear fission generation has been shown to output less greenhouse gas emissions compared to other major energy sources. According to a report by Intrinsik, prepared for Ontario power generation that compiles data, shows that nuclear power generates approximately 0.15g CO2e/kWh compared to other sources such as Natural gas which outputs 525g CO2e/kWh. That is a 3500x increase in carbon emissions. One of the biggest benefits of nuclear power is its lack of greenhouse gas emissions compared to other sources of energy. This is extremely important as greenhouse gas emissions are an incredible factor in global climate change which unless stopped will cause devastation to the environment including mass migration of people and animals and the transition of once fertile lands into inhospitable wastelands. By converting sources of energy such as coal and natural gas to nuclear power would reduce these greenhouse gas emissions and thus lessen the impact of climate change.  **2. Land use of Nuclear power**  Nuclear power uses a very insignificant portion of land compared to other sources of energy and large land requirements is one of the biggest issues for low carbon emission sources of energy. The Arkansas Nuclear One Station used up a measly 1.7 square miles to produce 1.8 gigawatts while to produce the same amount of energy with wind energy would require 169 square miles and for solar 21 square miles (Stevens, Anderson, Cowan, Colton, & Johnson, 2017). Land use has a significant environmental impact, these energy sources cannot be placed in urban settings so often they are placed in remote rural areas which can cause displacement for local wildlife and result in destruction of ecosystems. | | | **1.** 1  2. 2 |

# Bibliography

Bruce Power. (n.d.). *Affordable Power. Jobs and Growth*. Retrieved from Bruce Power: http://www.brucepower.com/wp-content/uploads/2014/12/140368\_EconomicImpactStudy-5med.pdf

Canadian Nuclear Safety Commission. (2016, January 20). *Nuclear Power Plant Safety Systems*. Retrieved from The Canadian Government: http://nuclearsafety.gc.ca/eng/reactors/power-plants/nuclear-power-plant-safety-systems/index.cfm

Crane, C. (2011). NUCLEAR FALLOUT. *Science World, 68*(2), 18-21. Retrieved from http://web.b.ebscohost.com/scirc/detail/detail?vid=4&sid=12b2ede8-b847-4246-b292-77d1685ae4ea%40sessionmgr120&bdata=JnNpdGU9c2NpcmMtbGl2ZQ%3d%3d#AN=70591976&db=sch

Diesendorf, M. (2010, December 3). *Comparing the economics of Nuclear and Renewable sources of Electricity*. Retrieved from University of New South Wales: http://www.ies.unsw.edu.au/sites/all/files/Solar2010\_NucVsRElecEconPaper.pdf

International Atomic Energy Agency. (1996, October). *Issues in radioactive waste disposal*. Retrieved from International Atomic Energy Agency: https://www-pub.iaea.org/MTCD/Publications/PDF/te\_909\_web.pdf

International Atomic Energy Agency. (2016). *Research Reactors: Purpose and Future*. Retrieved from International Atomic Energy Agency: https://www.iaea.org/OurWork/ST/NE/NEFW/Technical-Areas/RRS/documents/RR\_Purpose\_and\_Future\_BODY.pdf

Intrinsik. (2016, October). *Greenhouse gas emissions associated with various methods of power generation in Ontario*. Retrieved from Ontario Power Generation: https://www.opg.com/darlington-refurbishment/Documents/IntrinsikReport\_GHG\_OntarioPower.pdf

Loy, D. (2013, Jun 1). *The Three Nuclear Poisons*. Retrieved from The Huffington Post: https://www.huffingtonpost.com/david-loy/the-three-nuclear-poisons\_b\_2983534.html

Milne, R. (2005, June 17). ELECTRICITY; Report clears nuclear plant as cancer cause . *Utility Week*, 8. Retrieved from http://go.galegroup.com/ps/retrieve.do?tabID=T003&resultListType=RESULT\_LIST&searchResultsType=SingleTab&searchType=BasicSearchForm&currentPosition=19&docId=GALE%7CA133285389&docType=Brief+article&sort=DA-SORT&contentSegment=&prodId=GPS&contentSet=GALE%7C

Riley, T. (2004, May-June). The nuke next door: do cancers cluster around atomic plants? *E*, 14.

Rosen, A. (2012, March 9). *Effects of the Fukushima nuclear meltdowns on environment and health* . Retrieved from Fukushima Disaster: http://www.fukushima-disaster.de/fileadmin/user\_upload/pdf/english/ippnw\_health-effects\_fukushima.pdf

Stevens, L., Anderson, B., Cowan, C., Colton, K., & Johnson, D. (2017, June). *THE FOOTPRINT OF ENERGY: LAND USE OF U.S. ELECTRICITY PRODUCTION*. Retrieved from STRATA: https://www.strata.org/pdf/2017/footprints-full.pdf

World Information Service on Energy. (1999, May 11). *The link between nuclear energy and nuclear weapons*. Retrieved from WISE International: https://wiseinternational.org/nuclear-monitor/509-510/link-between-nuclear-energy-and-nuclear-weapons

World Nuclear Association. (2017, December). *Nuclear Power in Canada*. Retrieved from World Nuclear Association: http://www.world-nuclear.org/information-library/country-profiles/countries-a-f/canada-nuclear-power.aspx

Yamane, F. (2011). Social Factors Affecting Economic Welfare of the Residents around Nuclear Power Plants in Japan. *Energy Procedia*, 619-629.