

Nuclear fuel cycle layout environmental sciences essay



**ASSIGN
BUSTER**

**INTRODUCTION TO NUCLEAR ENGINEERING
PROPOSAL – NUCLEAR TECHNOLOGY EXHIBITION**

NAME

ID

COURSE

YEAR/SEMESTER

DAVIN A/L SUGUMAR

0908137

ME

Year 4 Semester3

WONG SU HSIEN

0906412

ME

Year 4 Semester3

JOSHUA LAU YEW LUNG

0907302

ME

Year 4 Semester3

YUI CHENG HANG

0907586

ME

Year 4 Semester3

Bachelor (Hons) of Mechanical Engineering

Faculty of Engineering and Science

Universiti Tunku Abdul Rahman

January 2013

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

1 Executive Summary

2 Poster

NUCLEAR WASTE MANAGEMENT

3 Introduction

3. 1 Type of Waste

3. 2 Conventional Method Of Disposal

3. 3 Effectiveness of Conventional Disposal Method

3. 4 The Effect Of Nuclear Waste To The Environment And Human Beings

4 Fuel Reprocessing

4. 1 Purex

4. 2 UREX

4. 3 UREX+

4. 4 Pyroprocessing

5 Advantages and Disadvantages of Fuel Reprocessing

6 Submarine Transport Vehicle (STV)

6. 1 Nuclear Fusion is Still Under Research

6. 2 Comparison between Nuclear Fusion and Fission

6. 3 Conclusion

REFERENCES

Recycling spent nuclear fuel: the ultimate solution for the US?. Retrieved January 29, 2013, from <http://analysis.nuclearenergyinsider.com/operations-maintenance/recycling-spent-nuclear-fuel-ultimate-solution-us>

Eric W, (2009) A Green Method of Nuclear Waste Disposal. Retrieved February 2, 2013, from <http://www.greentechmedia.com/green-light/post/a-green-method-of-nuclear-waste-disposal-122130>

CHAPTER

INTRODUCTION

6 NUCLEAR WASTE MANAGEMENT

8 REFERENCES

29 Recycling spent nuclear fuel: the ultimate solution for the US?. Retrieved January 29, <https://assignbuster.com/nuclear-fuel-cycle-layout-environmental-sciences-essay/>

2013, from <http://analysis.nuclearenergyinsider.com/operations-maintenance/recycling-spent-nuclear-fuel-ultimate-solution-us30> Eric W, (2009) A Green Method of Nuclear Waste Disposal. Retrieved February 2, 2013, from <http://www.greentechmedia.com/green-light/post/a-green-method-of-nuclear-waste-disposal-122130>

TABLE TITLE PAGE

Table 2. 1: LLW Classes 10
 Table 2. 2: Conventional Method of Waste Disposal 11
 Table 2. 3: The Effects of Nuclear Waste Radiation towards the Environment and Human Beings 15
 Table 2. 4: Radioactive emission which could affect human organs 16
 Table 2. 5: Main Difference Between Nuclear Fission And Fusion 28

FIGURE TITLE PAGE

Figure 2. 1: Nuclear Fuel Cycle 8
 Figure 2. 2: Nuclear Fuel Cycle Layout 9
 Figure 2. 3: Yucca Mountain 13
 Figure 2. 4: Schematic of PUREX 18
 Figure 2. 5: Schematic of UREX 19
 Figure 2. 6: Schematic of UREX+ 20
 Figure 2. 7: Shape of STV 23
 Figure 2. 8: Path of submarine transport vehicle 23
 Figure 2. 9: Path of submarine transport vehicle 24
 Figure 2. 10: Schematic of Deuterium-Tritium Nuclear Fusion 25

Executive Summary

This project proposal is about an exhibition about nuclear technology, which will be held in Faculty of Engineering and Science (FES) at Tunku Abdul Rahman University, Setapak Campus. This exhibition is intended to educate the FES community about the benefits of nuclear technology in many different fields of area and also new ways to manage nuclear waste. As we

<https://assignbuster.com/nuclear-fuel-cycle-layout-environmental-sciences-essay/>

all know, the need to use nuclear energy has been increasing in numbers where many developed countries are using nuclear energy as their electricity source. Coal and fossil fuel have gradually been replaced by nuclear energy for electricity generation. This is due to the emission of pollutants that cause air pollution, which linked to global warming. For example, statistics show France derives over 75% of its electricity from nuclear energy, and is known to be the world's largest net exporter of electricity. The generation of nuclear energy is cheap and low in cost, since a small amount of nuclear source produces abundant amount of electricity. Besides, 17% of France's electricity is obtained through fuel reprocessing which further reduces the cost of acquiring raw material. However, nuclear energy is not a perfect alternative to our current fuel source. Although nuclear energy does not emit any carbon dioxide during heat generation, it produces radioactive waste. This waste may cause harmful environmental effects if it is not properly managed. The nuclear waste may need years to reduce its radioactivity before it could be exposed to the environment as an ordinary waste. Nuclear waste management has always been a major concern, or in other words, a critical decision as to whether a country decides to agree or disagree to use nuclear energy as an alternative source. We believe through this exhibition the FES community will be more aware of the nature of nuclear technology and also able to decide by themselves as to whether such powerful source of energy could be used in our country. Therefore, our exhibition will focus more on management and disposal of nuclear waste and the effectiveness of the methods used to manage them. We also have a glimpse of the conventional method used by the current nuclear facilities to manage such waste.

Poster

Poster 2 Advantages vs disadvantages of conventional method Side effects to the public and surroundings
Poster 3 Methods to curb this problem Fuel Reprocessing Description Flaws Effectiveness
Poster 1 What is nuclear waste management? What are the risks levels involved? What is the conventional method implemented? For this exhibition, we will be using 4 posters to present our facts and materials. All these four posters will summarise our facts from this proposal by using more images, mind maps and figures so that viewers are able to grasp the idea of nuclear waste management and digest the related facts tied with it easily. Below are the related contents that will be presented in the respective posters: Poster 4 Submarine Transport Vehicle (STV) Description Flaws Effectiveness Nuclear fussion (A different method to produce energy) NUCLEAR WASTE MANAGEMENT

Introduction

Nuclear wastes are end-products of any materials or objects that emits radioactivity, which refers to the by-products of nuclear fuel cycle. The radiation produced from these wastes could harm many living organisms including humans, and the amount of damages caused are dependent on amount and the type of radiation produced. To understand nuclear waste management is to understand the waste that our society is dealing with. As mentioned earlier, the by-products of a nuclear fuel cycle are general known as nuclear wastes. This fuel cycle is made up of three parts; the front-end, the service period and the back-end Back-End Service-Period Front-End

Figure 2. 1: Nuclear Fuel Cycle

Figure 2. 2: Nuclear Fuel Cycle Layout

Based on the diagrams above, nuclear wastes are produced throughout the whole nuclear fuel process. Hence, a proper waste management technique must be implemented to contain those wastes from exposing it to the atmosphere.

Type of Waste

Generally, nuclear waste is broken down into several classifications; Low Level Waste (LLW), Intermediate Level Waste (ILW) also known as moderate level waste, High Level Waste (HLW), and also another type of waste known as the Transuranic Waste (TRUW). Linking it back to nuclear fuel cycle, the front-end wastes are made up of LLW and ILW of depleted uranium and radium. The service-period wastes are mostly made up of ILW which are produced during usual operations of the nuclear reactor. Back-end wastes are the most dangerous waste produced throughout, whereby the majority of the wastes are HLW. To further understand about the classes of wastes mentioned earlier, it is best to analysis each class in-depth. The Low Level Waste (LLW) does not necessarily carry any radioactivity, since it involves items that have been contaminated by nuclear radiation. However, it does make up almost 90% of nuclear waste produced through this nuclear fuel cycle. LLW is segregated into four classes based- A, B, C and GTCC (Greater Than Class C). These classes progressively have higher levels of concentration of radioactive material with class A items having the lowest level and GTCC having the highest level. The items that fall under LLW

includes shoe covers, lab coats, cleaning cloth, paper towel and gloves, since this items generally emits a low level alpha particle.

Table 2. 1: LLW Classes

Low Level Waste ClassDescription
A Low levels of radiation and heat, no shielding required for protection and it decays to acceptable levels within 100 years.
B Higher concentrations of radioactivity than Class A and requires greater isolation and packaging.
C Requires isolation from the environment for 500 years. Must be buried at least few meters below the surface with a strong barrier.
GTCC Near surface burial is prohibited and the waste must always be contained.
The Intermediate Level Waste (ILW) exists at both the front-end and during service period. Unlike LLW, ILW always requires shielding and protection when being handled. About 7% of the wastes produced by nuclear reactors are moderate waste where items such sludge from spent fuel cooling and storage area, reactor components and other contaminated materials from the reactor decommissioning. These materials are capable of emitting beta particles.
High Level Waste (HLW) is waste which have large amount of radioactivity and is also thermally hot. Despite only forming 3% of the total volume of waste of nuclear plant, 95% of the radioactivity emission, especially both beta and gamma particles, comes from this set of waste. Unfortunately, this 3% of waste makes up a total of 12000 metric tons per year. These wastes include reprocessing waste streams, isolation of fissile radionuclides from irradiated materials of weapons productions, and nuclear reactor core. Besides, this nuclear waste contains high concentrations of radioactive fission product. When the spent nuclear fuel is chemically processed, these by-product of it will include

nuclides obtained from an aqueous phase (one of the phases during nuclear fuel cycle), thus containing high level of radioactive fission products of radionuclides. This is reason for HLW being thermally hot. Hence, before being ready to be disposed, these items that are categorized under HLW will be cooled down in a pooling at the nuclear reactor itself. This cooling process will last about 10 years. HLW elements have half-lives ranging up to 200000 years, which has been a major concern when it comes to nuclear waste disposal until this very day. The elements that are involved are Pu-238, Pu-239, Pu-240, Pu-241, Pu-242, Np-237, and U-236 (Pu - Plutonium; Np - Neptunium; U - Uranium). Transuranic Waste (TRUW) are only common in United States of America (USA), since it a by-product of the manufacturing of nuclear weapons. TRUW consist of all the by-products that have radionuclides above Uranium, where Plutonium is known to be the prominent type of nuclear element in transuranic waste. A radionuclide is an atom with an unstable nucleus, characterized by excess energy available to be imparted into a newly created radiation particle within the nucleus. Compare to other wastes, TRUW tend to have longer half-lives. Some transuranic waste consists of items such as rags, tools, and laboratory equipment contaminated with radioactive materials. Other forms of TRUW include organic and inorganic residues and also enclosed contaminated cases in which radioactive materials were handled. This type of waste does not emit high levels of penetrating radiation. However, it poses a danger when small particles of it are inhaled or ingested, causing damage to lung tissue and internal organs.

Conventional Method Of Disposal

Despite the introduction of nuclear plant in early 1960s, today's society still could not agree nor come out with a proper solution to get rid of nuclear waste. Below is the conventional method used currently for treating the nuclear waste:

Table 2. 2: Conventional Method of Waste Disposal

Near surface disposal

Near-surface disposal facilities at ground level:-

These facilities are on or below the surface where the protective covering is are about few meters thick. Waste containers are placed in constructed vaults and when full the vaults are backfilled. Eventually they will be covered and capped with an impermeable membrane and topsoil. These facilities may incorporate some form of drainage and possibly a gas venting system.

Near-surface disposal facilities in caverns below ground level:-

Unlike near-surface disposal at ground level where the excavations are conducted from the surface, shallow disposal requires underground excavation of caverns but the facility is at a depth of several tens of metres below the Earth's surface and accessed through a drift. Implemented for LLW in many countries, including Czech Republic, Finland, France, Japan, Netherlands, Spain, Sweden, UK and USA. It is also implemented in Finland and Sweden for LLW and short-lived ILW

Deep Geological disposal

A repository is comprised of mined tunnels or caverns into which packaged waste would be placed. In some cases the waste containers are then surrounded by a material such as cement or clay to provide another barrier called backfill. The choice of waste container materials and design and backfill material varies depending on the type of waste to be contained and the nature of the host rock-type available. Excavation of a deep underground repository using standard mining or civil engineering technology is limited to accessible locations to rock units that are reasonably stable and without major groundwater flow - depths as deep as between 250m and 1000m. Deep geological disposal remains the preferred option for waste management of long-lived radioactive waste in several countries, including Argentina, Australia, Belgium, Czech Republic, Finland, Japan, Netherlands, Republic of Korea, Russia, Spain, Sweden, Switzerland and USA. Yucca Mountain (USA) uses the concept of deep geological disposal.

Figure 2. 3: Yucca Mountain

Effectiveness of Conventional Disposal Method

Despite the safety and security measure undertaken by many parties involved in this field, problems could occur during the disposal process. Many of these issues arise due to the nature of the element, where some of their half-lives are extremely long and these elements tend to retain half of their dangerous properties 100, 000 years after production. The disposal and storage of nuclear waste is one of the major factors limiting society's use of nuclear power as a widespread energy source. The world's nuclear power plants generate spent fuel from the production of electricity in about 30

<https://assignbuster.com/nuclear-fuel-cycle-layout-environmental-sciences-essay/>

countries. All of the spent fuel is stored either on-site or off-site in engineered storage facilities or sometimes in the pool of the reactor itself while pending for final decisions on its disposition. Spent fuel is differently regarded by countries as a resource by some and as a waste by others. Until today, no country has a geological repository for spent fuel storage or disposal. Neither has most countries decided on a final destination for spent fuel. Many countries are now trying to decide either to expand the existing storage capacities they have for spent fuel at the nuclear plant or to provide additional storage space to accommodate upcoming spent fuel which is rapidly increasing. When these people decided to extend their storage period in their respective reactors, some hopes for an extension of 100 years and even beyond. Hence, new challenges start to arise, such as challenges in the management of liabilities and knowledge, experience and information over longer time spans, and also challenges in technical aspects like the longevity of spent fuel packages and behaviour of fuel and structural materials in storage facilities. It is true that deep geological disposal is the most appropriate solution to control this problem, which is why Yucca Mountain is chosen for that very same purpose. However, this mountain will not last long, in which probably for another 1000 years. Besides, transporting these wastes all the way to Yucca Mountain is itself risky, since it needs serious extensive overland transport requirements. Not to mention the risk of terrorism and biosphere contamination.

The Effect Of Nuclear Waste To The Environment And Human Beings

Imagine what will happen if the disposal of nuclear waste is not executed well enough? Below are the effects of the radiations of nuclear towards the environment:

Table 2. 3: The Effects of Nuclear Waste Radiation towards the Environment and Human Beings

To the environment When soil is contaminated by radioactive substances, the harmful substances are transferred into the plants growing on it. It leads to genetic mutation and affects the plant's normal functioning. Some plants may die after such exposure, while others may develop weak seeds. Eating any part of the contaminated plant, primarily fruits, poses serious health risks. Since plants are the base of all food chains, their contamination can lead to radioactive deposition all along the food web.

To the human beings The impact of radioactive pollution on human beings can vary from mild to fatal; the magnitude of the adverse effects largely depends on the level and duration of exposure to radioactivity. Low levels of localized exposure may only have a superficial effect and cause mild skin irritation. Effects of long, but low-intensity exposures include nausea, vomiting, diarrhea, loss of hair, bruises due to subcutaneous bleeding etc. Long-term exposure or exposure to high amounts of radiation can have far more serious health effects. Radioactive rays can cause irreparable damage to DNA molecules and can lead to a life-threatening condition. Prolonged exposure leads to a large number of molecules in the body being ionized into free radicals. Free radicals promote the growth of cancerous cells, i. e. tumors, in

the body. People with heavy radiation exposure are at a very high risk for cancers. The rapidly growing/dividing cells, like those of the skin, bone marrow, intestines, and gonads are more sensitive towards radioactive emissions. On the other hand, cells that do not undergo rapid cell division, such as bone cells and nervous cells, aren't damaged so easily. Skin cancer, lung cancer and thyroid cancer are some of the common types of cancers caused by radiation. Below shows another table of the nuclear elements, their respective radioactive emission and the target organs that will be affected.

Table 2. 4: Radioactive emission which could affect human organs

Radionuclide	Main emission	Physical Half-life(Years)	Biological Half-life(Time after which one half of the element is eliminated by the biological pathway)	Gut transfer factor f1	Distribution in body target organ(s)	
³⁶ Cl	Beta	10 days	1	Uniform		
⁷⁹ Se	Beta	Triexponential elimination, with half-lives of 3(10%), 30(40%), and 200(50%) days	0.8	Fairly uniform	liver, kidneys	
⁹⁴ Nb	Beta, Gamma	Biexponential elimination, with half-lives of 6(50%) and 200(50%) days	<0.01		Lungs, skeleton, liver	
⁹⁹ Tc	Beta	0.5 day in the thyroid	75%	of the technetium retained in the thyroid is eliminated, with a biological half-life of 1.6 days	0.5	Fairly uniform thyroid, salivary glands, gastrointestinal tract (GIT)
¹²⁹ I	Beta	80 days in the thyroid	1	Thyroid		
¹³⁵ Cs	Beta, Gamma	Biexponential elimination, with half-lives of 2 and 110 days	1	Fairly uniform		
²³⁸ U	Alpha, Gamma	100 days	0.02	Skeleton, kidneys		
²³⁹ Pu	Alpha	24,13010 years in the liver, up to several tens of years in the skeleton		Liver, skeleton, gonads		

Fuel Reprocessing

When we talk about the topic of nuclear, majority of the people will think that it is not a good thing because during the nuclear processes, it will emit radiation that is harmful to human and also the environment. Nowadays in the period of depletion of natural resources, people tend to seek for alternative. Nuclear is a resource which is cheap yet powerful but it brings disasters to people too. As a result, many researchers doing research to make the nuclear "green" which reduces the side effect of radiation to the lowest. One of the methods to manage nuclear waste or byproducts is reprocessing the byproducts. In reprocessing, the spent nuclear waste is chemically separate into its major components again. The products of reprocessing are Uranium, Plutonium, minor actinides such as Americium, Neptunium, Curium and also some fission products such as Strontium-90, Cesium-137, Iodine-129, and Technetium-99.

Purex

Figure 2. 4: Schematic of PUREX

The most widely used methods for reprocessing is call Plutonium and Uranium Extraction (PUREX). PUREX is a process for liquid-liquid extraction ion-exchange method used to reprocess spent nuclear fuel in order to extract out primarily uranium and plutonium. The spent nuclear fuel undergoes PUREX process is applied consists primarily of certain very high atomic weight elements along with smaller amounts of material composed of lighter atoms, notably the so called fission products. PUREX process also ability to extract nuclear weapons materials from the spent fuel

UREX

Figure 2. 5: Schematic of UREX

Technique number two for reprocessing is Uranium Reduction Extraction (UREX). It is a replacement for PUREX which could be used to save space inside high level nuclear waste disposal sites. In this technique, uranium is removed and results in making up the vast majority of mass and volume of used fuel and recycling it as reprocessed uranium. UREX is modified from PUREX to prevent the plutonium from being extracted by adding a plutonium reductant into the first metal extraction step. 99.9% of uranium and more than 95% of technetium are separated from other fission products and actinides. The key is the addition of acetohydroxamic acid (AHA) to the extraction and scrub sections of the process to diminish the extractability of plutonium and neptunium.

UREX+

Moreover, UREX+ is the refinement of UREX process which is mentioned previously. In UREX+, plutonium is not extracted in pure stream but it remains mixed with neptunium and americium. Neptunium and americium are two long-lived actinides that may act as proliferation deterrents by making the plutonium too toxic to handle without special equipment. UREX+ is closer technologically to PUREX and is better than pyroprocessing for reprocessing the spent fuel from the current type of U. S. nuclear reactors known as light water reactors.

Figure 2. 6: Schematic of UREX+

Pyroprocessing

As we come to Pyroprocessing, it is a generic term for high-temperature methods. It also known as electro-metallurgical processing. Spent fuel rods are mechanically chopped and fuel is electrically separated into consisuent products. This isolates the uranium while leaving the plutonium and other actinides mixed together. Solvents are molten salts and molten metals rather than organic compounds. In pyroprocessing, electrorefining, distillation, and solvent-solvent extraction are common steps. This techniques purpose is to reduce the liquid waste that remains in the UREX process.

Advantages and Disadvantages of Fuel Reprocessing

Advantages:

Readily applied to high-burnup spent fuel and requires little cooling timeDoes not use solvents that contain hydrogen and carbon which are neutron moderators creating risk of criticality accidents and also can absorb fission product tritium and the activation product carbon-14 in dilute solutions that cannot be separated later. Allowing on-site reprocessing at the reactor site which avoids transportation of spent fuel and security issues. Storing a much smaller volume of fission products on site as high-level waste. Reprocessing can separate many actinides at once and produce highly radioactive fuel which is harder to manipulate for theft or making nuclear weapons. PUREX process is designed to separate plutonium only for weapons and it also leaves the minor actinides such as americium and curium behind, producing waste with more long-lived radioactivity. Most of <https://assignbuster.com/nuclear-fuel-cycle-layout-environmental-sciences-essay/>

the radioactivity in roughly 102 to 105 years after the use of nuclear fuel is produced by the actinides. These actinides can fuel fast reactors so extracting and reusing them reduces the long-term radioactivity of the wastes.

Disadvantages:

The used salt from pyroprocessing is less suitable for conversion into glass than the waste materials produced by PUREX process. If the aim is to reduce the longevity of spent nuclear fuel in burner reactors, then better recovery rates of the minor actinides need to be achieved.

Submarine Transport Vehicle (STV)

One of the methods to dispose nuclear waste is using Submarine Transport Vehicle (STV). Most of the nuclear waste needs about hundreds of thousands of years to become safe. Thus, the nuclear waste must be managed well so that it will not harm to environment and human being. This method is conducted by send the waste to center of the earth using a pressure-compensating Submarine Transport Vehicle (STV) via a subduction fault in the ocean. The dangerous nuclear waste will be buried under the earth's crust until it is destroyed by the planet's own heat. Before the nuclear waste becomes safe, none of this waste will ever reenter the biosphere. This method will able to remove the nuclear waste completely and permanently from the biosphere. The Submarine Transport Vehicle (STV) sends the waste until it reaches the ocean's bedrock. Then natural forces will take over and protect the waste until the center of the earth. The material of making STV has sufficient lifetime to contain the nuclear waste for the time required.

Furthermore, the active seals of STV are strengthening as pressure
<https://assignbuster.com/nuclear-fuel-cycle-layout-environmental-sciences-essay/>

increases. When the STV goes deeper, the pressure inside the STV equals to the pressure at outside without breaking the seal. The STV is designed to withstand earthquake by being of the shape of STV allows itself to deflect from rock in a manner similar to squeezing a watermelon seed.

Figure 2. 7: Shape of STV+

The active seals, cylindrical shape and hemispherical end caps will keep the contents separated from the exterior for much longer than it needs to be. Once the STV is in place, it is simultaneously being undetectable and recoverable by anyone by any means. So that, the terrorist will not able to take the nuclear waste to do any terror event. Other than that, the STV would be loaded into a reusable Transport/ Recovery Rask (T/RC) which is used for protection during the transport phase. It makes STV to be recovery possible in case of accidental sinking. Once the STV placed, it does not need maintenance forever.

Figure 2. 8: Path of submarine transport vehicle

Figure 2. 9: Path of submarine transport vehicle

The figures show the path of STV goes. When the STV reaches mantle region, the steel of STV will start melting. After the steel is melted, then the waste will be released and sink to the center of earth. The gravity of earth will ensure the waste moves to the center of the earth because of its greater density. The nuclear waste will not come out to the biosphere through volcano because the waste is much heavier than the basalt lava. Moreover, how would the nuclear waste is transferred to the STV? Each site of generating nuclear waste would empty the contents of the spent fuel rods

and load them into the STV. Once the wastes are loaded into the STV, they are never unpacked again. Next, ships or barges will send as much as possible of the waste. However, some of the waste would be transported by rail to rivers or ocean.

Nuclear fusion

Nuclear fusion is the process of forcing two light nuclei together under extreme heat and pressure until they fuse into a single larger atom. This process releases a huge quantity of energy, even more than what nuclear fission produces. When light nuclei are forced together, they will fuse and produce some amount of energy because the mass of the combination will be less than the sum of the masses of the individual nuclei. If the combined nuclear mass is less than that of iron at the peak of the binding energy curve, then the nuclear particles will be more tightly bound than they were in the lighter nuclei, and that decrease in mass comes off in the form of energy according to the Einstein relationship. For elements heavier than iron, fission will yield energy.

Figure 2. 10: Schematic of Deuterium-Tritium Nuclear Fusion

The fuels used in the fusion reaction are deuterium and tritium. These fuels are less hazardous as compared to uranium that used for the nuclear fission. Deuterium and tritium both are isotopes of hydrogen. . The reaction yields 17. 6 MeV of energy but requires a temperature of approximately 40 million Kelvins to overcome the coulomb barrier and ignite it. The deuterium fuel is abundant, but tritium must be either bred from lithium or gotten in the operation of the deuterium cycle. Tritium is the reactive isotope and has a <https://assignbuster.com/nuclear-fuel-cycle-layout-environmental-sciences-essay/>

very low energy beta emitter and has a half-life of about 12.6 years.

Besides, it is highly mobile and can contaminate most materials it comes in contact with. The products or we also called wastes from the nuclear fusion reaction will be helium and fast neutrons. The neutrons can lead to activation of materials as they pass through. However, when compared to the nuclear fission, the production of waste from nuclear fusion is relatively modest. The main concern with the waste is radioactive contamination both from tritium and activation products will be relatively short lived. On the other hand, much of the waste will be below the thresholds to even be considered as radioactive waste, there is some low level waste and a very small proportion will be classified as intermediate level waste. However, all of this material can be recycled or disposed of conventionally within 100 years. Thus, leaving no long-term radioactive legacy for future generations to deal with as compared to nuclear fission wastes. The irradiated nuclear fission waste will be stored into a confinement cask or it also called as hot cells. The operation such as cleaning and dust collection, detritiation, refurbishment and disposal will be performed within the hot cells. The waste is classified as medium level, will be stored in hot cells. Since this kind of energy source still under research, thus, all of these procedures are a part of the International Thermonuclear Experimental Reactor (ITER) operation. Detritiation is a process to remove tritium from liquids and gases for reinjection into the fuel cycle. After that, remaining effluents will be well below authorized limits. For which, gaseous and liquid tritium releases to the environment from ITER are predicted to be below 10 μSv (micro sievert) per year. However, the well under ITER's is 100 μSv per year, it is 10 times lower. It also 100 times lower than the regulatory limit in France of 1,000 μSv per year. From the cost <https://assignbuster.com/nuclear-fuel-cycle-layout-environmental-sciences-essay/>

effectiveness point of view, there is contrast between deuterium and tritium. Deuterium is extracted from seawater and supplies are therefore virtually limitless. But for tritium is more of a problem as its natural abundance is low and it must be produced from lithium in nuclear reactors. A fusion reactor generating 1GW at 40% thermal efficiency will burn about 0.5kg of tritium per day and the burn-up fraction of the tritium is approximately 3%, so 15kg of tritium must be circulated to generate that 1GW. Given that the current world civil tritium stock is around 30 kg, it is essential for the fusion reactor to have an efficient tritium breeding system.

Nuclear Fusion is Still Under Research

As mentioned before, this kind of energy is still under research. This is because, the majority of experiments are carried out by using deuterium only. It intended to further verify that this energy source is reliable. Besides, the overall use of tritium at is limited, as D-T fusion neutrons cause radioactivity in the vessel and the cumulative radioactivity of the vessel is limited due to decommissioning requirements. For example, one of the problems encountered in the D-T experiments was the in-vessel retention of tritium in carbon-based deposits. This problem was resolved with the installation of all metal plasma-facing components, avoiding the use of carbon. Hence, the research is going on to inspect the problem and solve the problem occur ensure safety and reliable of this energy source. Lastly, the International Thermonuclear Experimental Reactor (ITER) was established under the auspices of the International Atomic Energy Agency (IAEA) for a fusion reactor development by the year 2030. The objective of the prototype reactor is to demonstrate that fusion can produce useful and relatively safe

energy. Fusion energy production via a commercial reactor is assumed to start around the year 2050.

Comparison between Nuclear Fusion and Fission

Nuclear fusion and nuclear fission are two different types of energy. The main difference between these two processes is listed below.

Table 2. 5: Main Difference Between Nuclear Fission And Fusion

Nuclear Fission

Nuclear Fusion

Definition

Fission is the splitting of an atom into two or more smaller ones. Fusion is the fusing of two or more lighter atoms into a larger one.

Natural Occurrence

Fission reaction does not normally occur in nature. Fusion occurs in stars, such as our sun.

Energy Requirements

Takes little energy to split two atoms in a fission reaction
Extremely high energy is required to bring two or more protons close enough that nuclear forces overcome their electrostatic repulsion.

Energy Ratios

The energy released by fission a million times greater than that released in chemical reactions, but lower than the energy released by nuclear fusion. The

energy released by fusion is 3 to 4 times greater than the energy released by fission.

Conditions

Critical mass of the substance and neutrons are required. High density, high temperature environment is required.

By products

Fission produces many highly radioactive particles. Few radioactive particles are produced by fusion reaction, but if a fission "trigger" is used, radioactive particles will result from that.

Conclusion

As compared to fission reactions, fusion reactions have the advantage that large amounts of highly radioactive nuclides are not obtained as by products which may pose a problem of safe storage. The used up uranium fuel rods from nuclear reactor power plants are very harmful to mankind. It can cause cancer and birth defects. Thus, nuclear fusion is more preferable than nuclear fission.