Committee: Environmental Sub-Commission 1

Issue: Managing Radioactive Waste

Student Officer: Panagiotis Kyriakou

Position: Deputy President

Introduction

For about a century humanity has gained great interest in nuclear power because of its great production of electricity. It is produced through nuclear reactors, which release nuclear energy. In 2013 the International Atomic Energy Agency (IAEA) stated in one of its reports that there are 437 operational nuclear reactors in 31 countries. But not all reactors are used for electricity, as nuclear energy can also be deployed to create nuclear weapons. In addition, there are 140 naval vessels that use nuclear power as their main power source. Now, nuclear reactors provide over 11% of the world's electricity as continuous, reliable base-load power without carbon dioxide emissions.

However, nuclear power has some disadvantages. There have been several accidents in nuclear power plants as well as in submarines. These accidents include the Chernobyl disaster, the Three Mile Island accident and the Fukushima Daiichi nuclear disaster. These accidents are fatal not only to the country's economy but also for the country's flora and fauna, as nuclear radiation is highly toxic and it can thus render an entire area uninhabitable for a really long period of time. Of course, it should be noted that nuclear accidents had occurred less times compared to accidents in other major sources of energy generation and this fact keeps these fatalities per unit of energy ratio low; nonetheless, the impact of nuclear accidents is much more severe and deadly than other kinds of accidents.

Another disadvantage is that by the production of nuclear energy, nuclear waste is also created. This waste contains radioactive materials and because of that it is hazardous to most forms of life, as well as the environment.

That is why many organizations, including the UN, have sought to protect the environment and find solutions in order to support the flora and fauna, and still use nuclear power as it is such a convenient energy source.

Definition of key terms

Nuclear Power: "A form of energy produced by an atomic reaction, capable of producing an alternative source of electrical power to that supplied by coal, gas or oil" [1]

Nuclear reactor: "A device in which nuclear fission initiates a controlled chain reaction, producing heat energy typically used for power generation and neutrons and fission products often used for military, experimental and medical purposes." [2]

Nuclear waste: "Radioactive and extremely toxic byproducts of nuclear fuel processing plants, and nuclear medicine and nuclear weapons industries."[3]

International Atomic Energy Agency (IAEA): "The IAEA is widely known as the world's "Atoms for Peace" organization within the United Nations family. Set up in 1957 as the world's center for cooperation in the nuclear field, the Agency works with its Member States and multiple partners worldwide to promote the safe, secure and peaceful use of nuclear technologies."[4]

Nuclear fission: "Nuclear fission is the main process generating nuclear energy. Fission reactions may be moderated to increase fission or unmoderated to breed further fuel."[5] "When a nucleus fissions, it splits into several smaller fragments. These fragments, or fission products, are about equal to half the original mass. Two or three neutrons are also emitted."[6]

Nuclear Fusion: "Nuclear fusion is an atomic reaction in which multiple atoms combine to create a single, more massive atom. The resulting atom has a slightly smaller mass than the sum of the masses of the original atoms. The difference in mass is released in the form of energy during the reaction, according to the Einstein formula $E = mc^2$" For more information on the difference between fission and fusion, you may have a look at the link provided: http://www.diffen.com/difference/Nuclear_Fission_vs_Nuclear_Fusion

Nuclear Decay: "The disintegration of a nucleus that occurs spontaneously or as a result of electron capture. One or more different nuclei are formed and usually particles and gamma rays are emitted."[7]

Flora: "all the plants that live in a particular area, time, period, or environment" [8]

Fauna: "all the animals that live in a particular area, time period, or environment" [9]

Alpha Radiation: "Alpha radiation is ionizing radiation resulting from the decay of radioisotopes where an alpha particle is emitted."[10]

Nuclear fuel cycle: "The nuclear fuel cycle is the series of industrial processes which involve the production of electricity from uranium in nuclear power reactors."[11]

Background Information

What causes waste production

Nuclear waste is what fuel becomes after it is used in a nuclear reactor. Physically it looks just like the fuel that was put into the reactor in the first place, but since all these nuclear reactions have occurred, the contents of this fuel are not exactly the same. Before it was put in the reactor the fuel was mostly uranium, oxygen and steel. Afterwards, most of the uranium atoms have split into various isotopes of almost all of the transition metals on the periodic table of elements.

The different kinds of nuclear waste

As stated before, nuclear waste is radioactive and extremely toxic byproduct of nuclear fuel processing plants, nuclear medicine and nuclear weapon industries. It remains radioactive for a lot of years and is separated in 4 basic categories (as outlined by World Nuclear Association)[1]:

1) Exempt waste: Exempt waste contains radioactive materials that are not considered harmful to humans and the environment. It mainly consists of demolished material such as concrete, bricks, piping or metal that is produced during rehabilitation or dismantling operations on nuclear industrial sites. Other industries such as the food industry produce exempt waste because of the concentration of natural radioactivity, which is present in certain minerals.
2) Low-level waste: Low level waste is usually generated from industries, hospitals or from the nuclear fuel cycle. It does not require shielding during transport and is suitable for shallow land burial. It comprises some 90% of the volume but only 1% of the radioactivity of all radioactive waste.
3) Intermediate-level waste: Intermediate-level waste contains higher amounts of radioactivity and sometimes it requires shielding. It usually comprises resins, metal fuel cladding as well as contaminated materials from reactor decommissioning. Small items or liquids can be solidified in concrete or bitumen for their disposal. It makes up some 7% of the volume and has 4% of the radioactivity of all radioactive waste.
4) High-Level waste: This kind of waste arises from the burning of uranium fuel in a nuclear reactor. It contains fission products and elements that are generated in the reactor core. It is highly toxic, radioactive and hot due to decay heat, so it requires cooling and shielding. High-level waste accounts for over 95% of the total radioactivity produced in the process of electricity generation. There are two distinct kinds of this waste:
   a) Used fuel itself
   b) Separated waste from reprocessing the used fuel

High-level waste has both long-lived and short-lived components, depending on the time that radioactivity rates drop to a safe amount for human contact and the environment. If the short-lived fission products can be separated from long-lived ones this will help in the management and disposal of this waste.

[1] http://www.world-nuclear.org/info/nuclear-fuel-cycle/nuclear-wastes/radioactive-waste-management/

Waste coming from nuclear energy

According to the IAEA "a nuclear reactor which would supply the needs of a city the size of Amsterdam (a 1000MW nuclear power station) produces 30 tons of high level solid packed waste per year if the fuel is not reprocessed." If we put that in comparison, a 1000MW coal plant would produce 300,000 tons of ash per year. Currently, worldwide, nuclear power generation produces 10,000m^3 of high-level waste per year.

Radiation effects on health

Radioactive materials produce ionizing radiation, which has sufficient energy to separate electrons from atoms or to even break chemical bonds. "Any living tissue in the human body can be damaged by ionizing radiation in a unique matter. The body attempts to repair the damage, but sometimes the damage is of a nature that cannot be repaired" (as the US Environmental Protection Agency stated). Also, mistakes made in the process of natural repair can lead to cancerous cells.

There are two broad categories of health effects that radiation cause: the stochastic and the non-stochastic (as outlined in the book: "Fukushima: Dispossession or Denuclearization?"[2]).

Stochastic Health Effects: "Stochastic effects are associated with long-term, low-level exposure to radiation. Increased levels of exposure make these health effects more likely to occur, but do not influence the type or severity of the effect. Other stochastic effects also occur. Radiation can cause changes in DNA. Changes in DNA are called mutations. The mutations can be teratogenic or genetic. Teratogenic mutations are caused by exposure of the fetus in the uterus and affect only the individual who was exposed. Genetic mutations are passed on to offspring.

Non-Stochastic Health Effects: Non-stochastic effects appear in cases of exposure to high levels of radiation, and become more severe as exposure increases. Short-term, high-level exposure is referred to as 'acute' exposure. Unlike cancer, health effects from 'acute' exposure to radiation usually appear quickly. Acute health effects include burns and radiation sickness. Radiation sickness is also called 'radiation poisoning.' It can cause premature aging or even death. If the dose is fatal, death usually occurs within two months".

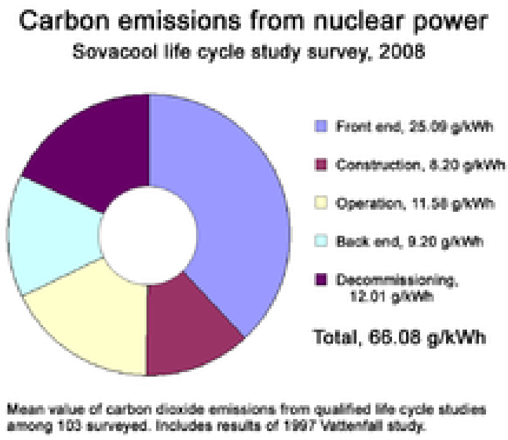
Environmental impacts from nuclear waste

Although all power plants are regulated by laws to protect human life and the environment, there are great environmental impacts concerning power generation technologies.

[2] https://books.google.gr/books?isbn=1312504560

Nuclear power plants do not emit carbon dioxide, sulfur dioxide or nitrogen oxides as part of the power generation. However, fossil fuel waste *is* emitted when the uranium is mined, enriched and transported to the nuclear plant.

Nuclear power plants use large quantities of water for steam production and for cooling. Some nuclear power plants remove large quantities of water from a lake or river, which may easily affect fish and other aquatic life.



"Heavy metals and salts build up in the water used in all power plant systems, including nuclear ones. These water pollutants, as well as the higher temperature of the water discharged from the power plant, can negatively affect water quality and aquatic life. Nuclear power plants sometimes discharge small amounts of tritium and other radioactive elements as allowed by their individual wastewater permits." the US Environmental Protection Agency states.

Countries related to the issue

USA

The USA has currently 100 operational nuclear reactors that produce 19% of total electricity in the country per year. Originally developed in response to the cost of the Manhattan project, officials wanted researchers to find civilian uses for this kind of technology. Nuclear energy matured in the 1970s, as nearly every current reactor in the United States began construction by the middle of the decade.

France

France has found the ability to supply the majority of its electricity through nuclear energy (74.8%) to be a success with 58 operational reactors and 407,438 gigawatt per hour (GWh). Because of its nuclear energy production, France is the world's largest net exporter of electricity, providing Switzerland, Italy, and Belgium with cheaply generated energy. The election of President Francois Hollande in 2012 signaled a shift in nuclear policy, however, as Holland won on a platform of reducing France's reliance on nuclear power from 75% to below 50%. Even so, France still remains a leader in nuclear energy technology.

Russia

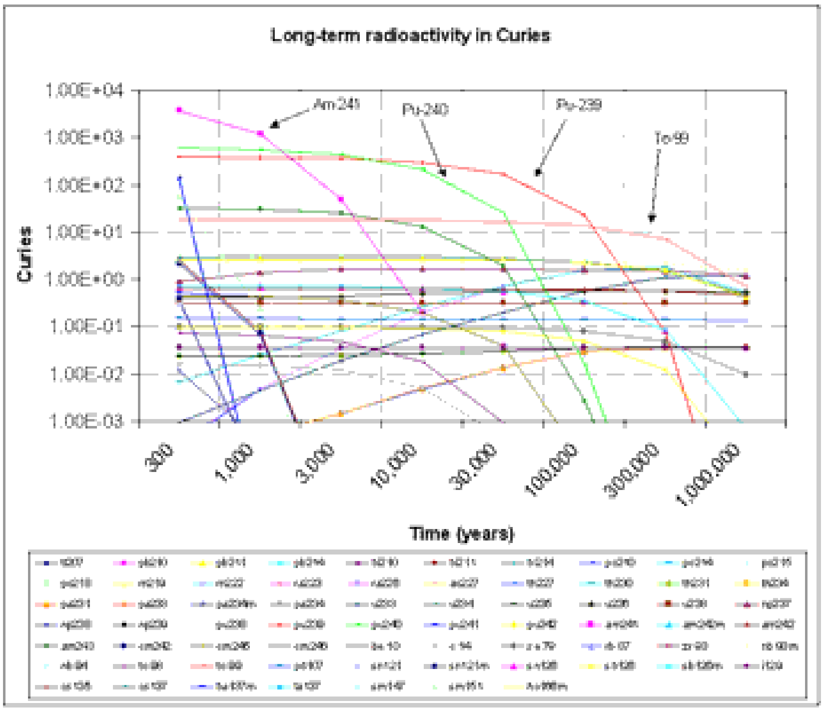
Russia has been in the midst of a huge nuclear expansion over the last one-and a half decade. Russia now has 33 nuclear reactors that supply 18% of total electricity. In 2003, the Russian government set a goal of doubling power produced by nuclear power plants by 2020. This strategy sees nuclear supplying 50% of Russia's energy by the end of 2050 and, in order to reach that, Russia is building 28 additional reactors in the coming decades.

Germany

Germany, despite its success with nuclear power (9 operational reactors and 16.1% of total electricity produced by nuclear) is currently undergoing a total phase-out of nuclear power. "The anti-nuclear movement in Germany has had a long history, after radioactive contamination from Chernobyl reached the country enraged the public. The Fukushima disaster in 2011 only furthered distaste for the technology. In response, Chancellor Angela Merkel permanently shut down 8 of Germany's 17 reactors and announced that the remaining power plants would be shut down by 2022."[13]

IAEA

The IAEA works for the safe, secure and peaceful uses of nuclear science and technology. Its key roles contribute to international peace and security, and to the world's Millennium Goals for social, economic and environmental development. "The IAEA was created in 1957 in response to the deep fears and expectations resulting from the discovery of nuclear energy. Its fortunes are uniquely geared to this controversial technology that can be used either as a weapon or as a practical and useful tool. The Agency's genesis was US President Eisenhower's Atoms for Peace address to the General Assembly of the United Nations on 8 December 1953. These ideas helped to shape the IAEA Statute, which 81 nations unanimously approved in October 1956."[Excerpts from the book, IAEA: The First Forty Years by David Fischer]"



UN INVOLVEMENT: RELEVANT RESOLUTIONS, TREATIES AND EVENTS

There is one resolution which is relevant to this issue. Its number is A/RES/64/45[3] and it was created in January 2010. It was adopted by the General Assembly and it was on the prohibition of the dumping of radioactive wastes. It would be good to read it if you want to know more about previous talks concerning the issue.

TIMELINE OF EVENTS

1895	Roentgen discovers X-rays
1896	Becquerel discovers rays emitted spontaneously from uranium salts
1898	The curies identify 2 radioactive nuclides, coin the term radioactive
1932	Chadwick identifies the neutrons
1939	The first nuclear chain reaction theory
1945	The first nuclear weapon test, the trinity shot, is successful
1951	The first EBR-1 reactor is the first to generate electricity in Arco
2013	James Hansen publishes a paper in which he states that nuclear is a cause of air pollution

Possible Solutions

Managing high-level wastes (HLW)

Used fuel gives rise to high-level wastes, which may be either fuel rods waste, or separated waste arising from its reprocessing. In both cases the amount of waste is modest; a typical nuclear reactor produces about 27 tons of used fuel, which may be reduced to 3m3 per year vitrified waste.

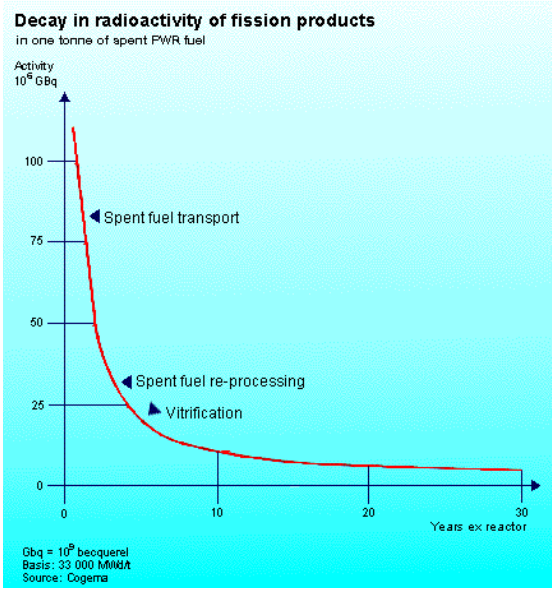
Storage of used fuels is usually in isolated ponds associated with individual reactors or in a common one with multiple reactor sites.

If this used fuel is reprocessed, the high-level wastes comprise highly radioactive fission products and some transuranic elements with long-lived radioactivity. These products are then separated from the used fuel in order for the uranium and the plutonium to be recycled. If these wastes are liquid from the reprocessing, they must be solidified.

[3] https://gafc-vote.un.org/UNODA/vote.nsf/91a5e1195dc97a630525656f005b8adf/84143adbc66233eb852576a8007569ee/$FILE/A%20RES%2064%2045.pdf

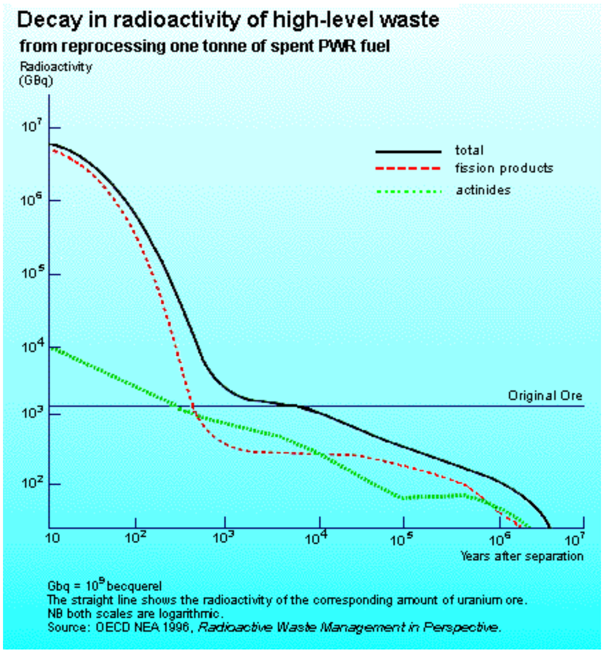
If used reactor fuel is not reprocessed, it will still contain all the radioactive isotopes and then the whole fuel assembly is treated as high-level waste and is directed for disposal. However, since it largely consists of uranium, it represents a really valuable resource and there is an increasing reluctance to dispose it irretrievably.

Recycling used fuel



"Any used fuel will still contain some of the original U-235 as well as various plutonium isotopes which have been formed inside the reactor core, and the U-238c. In total these account for some 96% of the original uranium and over half of the original energy content. Reprocessing, undertaken in Europe and Russia, separates this uranium and plutonium from the wastes so that they can be recycled for re-use in a nuclear reactor. Plutonium arising from reprocessing is recycled through a MOX fuel fabrication plant where it is mixed with depleted uranium oxide to make fresh fuel. European reactors currently use over 5 tons of plutonium a year in fresh MOX fuel.

Major commercial reprocessing plants operate in France, UK, and Russia with a capacity of some 5000 tons per year and cumulative civilian experience of 80,000 tons over 50 years. France and UK also undertake reprocessing for utilities in other countries, notably Japan, which has made over 140 shipments of used fuel to Europe since 1979. Until now most Japanese used fuel has been reprocessed in Europe, with the vitrified waste and the recovered uranium and plutonium being returned to Japan to be used in fresh fuel. Russia also reprocesses some spent fuel from Soviet-designed reactors in other countries"[4].



Storage and disposal of used fuel and other HLW

"There is about 230,000 tons of used fuel in storage. About 90% of this is in storage ponds. Much of the world's used fuel is stored, thus, some of it has been there for decades. Final disposal is not urgent in any logistical sense".

Storage ponds at reactors and those at centralized facilities such as CLAB in Sweden, are 7-12 meters deep, to allow

[4] http://www.world-nuclear.org/info/nuclear-fuel-cycle/nuclear-wastes/radioactive-waste-management/

several meters of water over the used fuel comprising racked fuel assemblies typically about 4 m long and standing on end. The multiple racks are made of metal with neutron absorbers incorporated in it. The circulating water both shields and cools the fuel. These pools are robust constructions made of thick reinforced concrete with steel liners. Ponds at reactors are often designed to hold all the used fuel for the life of the reactor.

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