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Reprocessing vs Direct Disposal of Spent Nuclear Fuel

Nuclear power offers a source of energy that is potentially cleaner than other sources. A nuclear reaction is significantly more powerful than a chemical reaction and as a result, requires significantly less starting material to produce the same amount of energy. This means that there is less waste produced by nuclear power reactors than by burning fossil fuels. While the waste from nuclear power is much less than the waste from fossil fuels, it is extremely dangerous because it remains radioactive for thousands of years. This complicates the tail end of the nuclear power cycle because waste from a power reactor cannot simply be dumped in a civilian landfill. The nuclear waste instead needs to be buried deep underground in an environment that is projected to remain stable while the waste continues to decay. An alternative to direct disposal is to reprocess the spent fuel to be able to use as fuel in another nuclear reactor. This method drastically cuts down the amount of nuclear waste but it is more expensive than disposing the fuel and current technology does not ensure that the process used to reprocess the fuel is as environmentally friendly as waste disposal.

The subject of nuclear energy is somewhat controversial because it is often claimed to be a source of completely clean energy. While it is true that nuclear reactions do not emit greenhouse gasses, the environmental impact from obtaining, processing, and disposing of or reprocessing the fuel is not negligible. Mining the uranium leaves a large footprint, water sources can become contaminated, and the heavy machinery used can produce a large amount of emissions. In order to properly understand the environmental impact that nuclear energy would have, normalized data regarding its impact should be compared to that of other sources of energy. This comparison is illustrated by Poinssot et al. in their work “Assessment of the environmental footprint of nuclear energy systems. Comparison between closed and open fuel cycles”. Poinssot et al. provide a histogram of environmental impact data of the French fuel cycle compared to other sources of energy. The histogram separates the data into 10 different categories of impact. In all but one category, nuclear has a lower environmental impact than both coal and oil/gas and in many categories, it has a smaller impact than solar (Poinssot et al. 9). This data suggests that even though nuclear energy is not the overall cleanest energy source, it is significantly cleaner than energy obtained from fossil fuels.

Once the fuel in the nuclear reactor is spent, it can either be disposed of or reprocessed into another usable fuel. While reprocessing the fuel would reduce the amount of spent fuel that would need to be disposed of and would require less mining and initial processing, it provides many complications. One such complication is the ability to produce plutonium that can later be used for nuclear weapons. In 1974 India tested a nuclear explosive made with plutonium obtained by using the reprocessing technologies supplied by the United States (Von Hippel 1). Using this technology and providing it to other nations could be catastrophic because it would give greater access to nuclear weaponry to irresponsible and power-hungry nations or terrorist groups. With this under consideration, the radioactive nature of spent nuclear fuel is beneficial because it can be disposed of and the chances of it being concealed and transported are greatly reduced.

Another negative aspect of reprocessing the fuel is it is currently much more expensive than safely disposing of the spent fuel. In the year 2000, there was an economic forecast study of France’s nuclear spending. The study suggested that if France stopped reprocessing the spent fuel in the year 2010, it would have saved $4 to 5 billion over the remaining lifetime of their then-current operating reactors (2). This money could be used for other needs that the nation may have, or even fund research projects that would further develop nuclear technology.

As described above, it seems that direct disposal of spent nuclear fuel is an excellent option compared to reprocessing, but it still comes with its challenges. First of all, the spent fuel would need a stable environment to be stored in. Since the spent fuel remains radioactive for such a long time, there needs to be assurance that the environment wherever it is stored will not change dramatically while the spent fuel continues to decay. If the environment were to change significantly, the radioactive material could leak into the surrounding environment and cause problems that the surrounding population would not be prepared for. With current technology it is possible to design models that provide an idea of possible environmental changes around the world but it is impossible to determine exactly what will happen during such a long time. Reprocessing offers a potential solution to this because the waste produced by reprocessing the spent fuel decays much faster than spent fuel from a once through cycle so the storage environment would not need to be stable for as long (Processing of Used Nuclear Fuel).

Along with producing waste that is less radioactive than the once through cycle, reprocessing the fuel also produces less overall nuclear waste because much of the fuel can be continuously recycled. The lower amount of waste means that there would be less of a need for transporting spent nuclear fuel across borders to a permanent storage facility. If the fuel was reprocessed, there would also be a smaller need for mining and depleting the earth's natural store of uranium. A reprocessing facility could also provide more jobs for those who work in industries that are growing outdated.

It is still a concern that reprocessing the fuel would make it easier for the world to obtain plutonium and create nuclear weapons. It is possible that this is an outdated concern. The US and Russia combined have over 10,000 nuclear warheads. China and North Korea also have a considerable amount that could devastate their enemies (Number of Nuclear Warheads Worldwide as of January 2021). It seems that currently, any increase in nuclear weaponry would not be strategically beneficial due to the amount that is currently possessed. There are also other means of plutonium production so refusing to reprocess the spent fuel will not necessarily stop the world from producing and using nuclear weapons.

An entry in the "International Journal of Energy Research" discusses a model that compares direct disposal of spent nuclear fuel to three different reprocessing techniques. The conclusion was that even though it is more economical to directly dispose the spent fuel, "the recycling of [spent nuclear fuel] can benefit the nuclear power program by reducing the generation of high-level waste, saving natural [uranium] resources, and reducing Pu management risk in the long-term" (Gao et al. 11). This model suggests that the benefits of reprocessing spent fuel may outweigh the cost in the long run. I believe that the benefits of reprocessing the spent fuel are slightly greater than the costs, but not enough to justify replacing direct disposal with reprocessing, especially since the waste produced by reprocessing would have to be handled and disposed of similarly to the spent fuel that is disposed of after one cycle. In order for benefits to greatly outweigh the costs, continuing research needs to be done to attempt to develop a process that is considerably cheaper, safer, and more efficient. A significant problem is that current policies prevent reprocessing spent nuclear fuel. These policies impede and can sometimes completely prevent the advancement of the research needed to design an acceptable reprocessing technique that better competes with the direct disposal strategy. The best solution to these problems, whether the answer is direct disposal or reprocessing, is to properly educate the public and politicians about what nuclear power actually is and what it can become.

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