Millennial Gen.
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Dear Dr. Digiorno,

The purpose of this report is to inform Millennial Gen. about the ethical dilemmas involving the currently unsustainable cleanup solutions to the Fukushima Daiichi nuclear disaster and to suggest a logical recommended course of action.

The main problem with the present-day solution to the Fukushima Daiichi nuclear disaster is that it is completely unsustainable. Each day, tens of thousands of gallons of water are being contaminated as cool seawater is being pumped through the nuclear reactors in order to cool the nuclear fuel rods. Similarly, tons of groundwater seep under the nuclear power plant and get contaminated. The result is an incredible amount of contaminated water and contaminated soil on a scale that cannot be sustained for the duration of the projected cleanup timeline. This strategy of containing the waste is only prolonging the problem.

In this report, we will discuss potential solutions that actually tackle the heart of the problem - the fuel rods, and the plants offline cooling systems. We will discuss the pros and cons of each potential solution and compare them to one another.

If you have any questions, comments, or concerns, please feel free to contact our research team at _____.

Sincerely,
Team Four
December 2017

Ethics in the Fukushima Nuclear Disaster Cleanup

By Team Four
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December 2017

Executive Summary

In 2011 in Fukushima Japan, a tsunami that hit a nuclear power plant created a catastrophic nuclear waste disaster that would plague the landscape for decades to come. Part of this disaster is a lengthy cleanup process, and in the past, the administration behind the cleanup has chosen to contain the contaminated soil and water in specially made containers outside the facilities. This report argues that the current practices create waste at a level that is unsustainable for the given cleanup timeline.

This report will identify the main stakeholders, and it will outline which entities provide funding, which innovates solutions, how entities affect each other, and how the current solution (situation) affects each stakeholder.

This report argues that there are many solutions available that will help stem or stop the production of secondary nuclear pollution coming from the nuclear plant. It contrasts that although some of the extraction methods can be risky and expensive, it outweighs the long-term consequences of contaminated waste storage. After outlining many different approaches to the cleanup, it is argued that the government entities in charge of the clean up are only interested in solutions for the short term and that long-term solution must be implemented to minimize the environmental effects of the disaster.

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Introduction

The purpose of this paper is to explain the consequences of the Fukushima nuclear disaster fully and introduce and compare possible solutions to deal with the unsustainable amount of nuclear waste generated. Although the cataclysmic events that caused the disaster are in the past, the cleanup solutions are in the present and can be changed. Through correct planning and strategizing, the consequences of the disaster can be dealt with while minimizing the damage to the surrounding environment. The following report hopes to detail some of those options moving forward.

Firstly, this report will detail the events that caused the disaster, followed by cleanup work that has been done in the years following. Next, the following section will outline the inherent ethical conflict between the cleanup entities and the populous that live around the disaster site. Finally, solutions to the unsustainable waste generation will be compared and contrasted in order to outline options that would lead to clean up practices that are sustainable.

Background

On March 11, 2011, the safety precautions of the Fukushima Daiichi Nuclear Plant complex were put to the test. An 8.9 magnitude earthquake erupted off the Japanese coast forcing the plant's safety measure to be put into effect (Chao-Eoan, 2011). The reactors immediately shut down, and the power needed to cool the fuel rods were supplied by the backup diesel engines that were located offsite. The nuclear plant was designed to sustain such a disaster without causing a meltdown. However, it was not designed for a tsunami that followed (Holt, 2012). This tsunami ravaged the coastline and flooded the facility that contained the backup generators. As a result, all power to the plants went offline, and the power plants were no longer able to cycle water to cool the radioactive fuel. As the fuel heated up, it reacted with steam to produce hydrogen gas, which caused explosions and fires in many vital regions in the facilities, as shown in Fig.1.

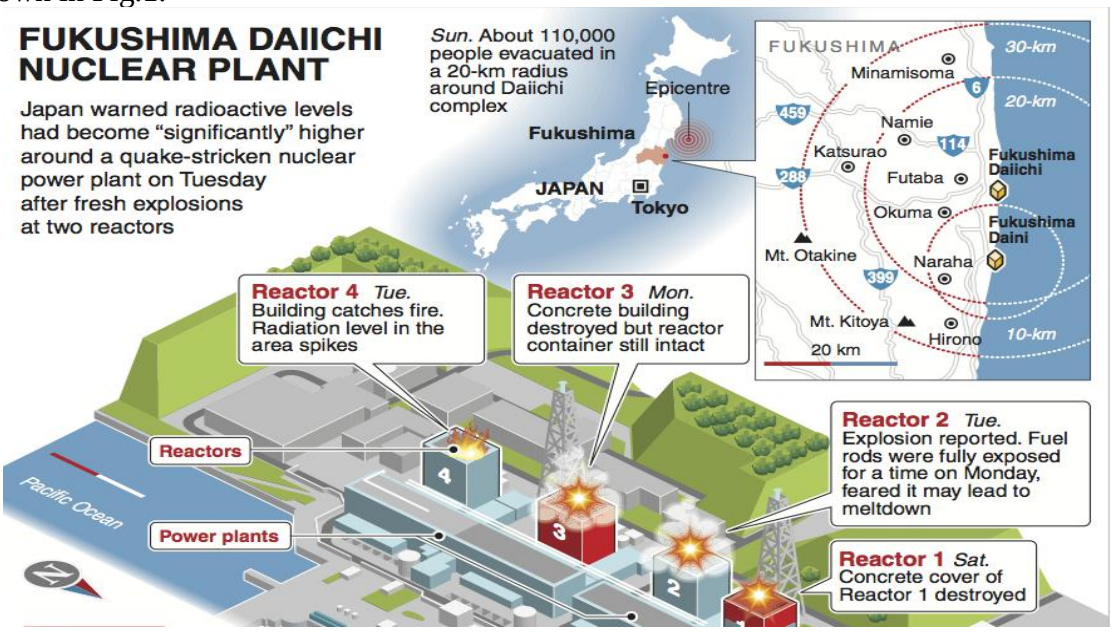

Fig.1. Reactor Damage Infographic (Rubin, 2013) Adapted.

The results were catastrophic. The overheated nuclear fuel rods melted down the reactor cores, and radioactive materials leaked into the environment. 100,000 residents were forced to be evacuated, and it rendered all land a 25-mile radius away from the nuclear plant uninhabitable, as seen in Fig.2. (Holt, 2012). The environmental consequences were massive. And more importantly, the consequences of this failure created problems that would take a vast amount of resources and time to deal with (Front Matter, 2014).

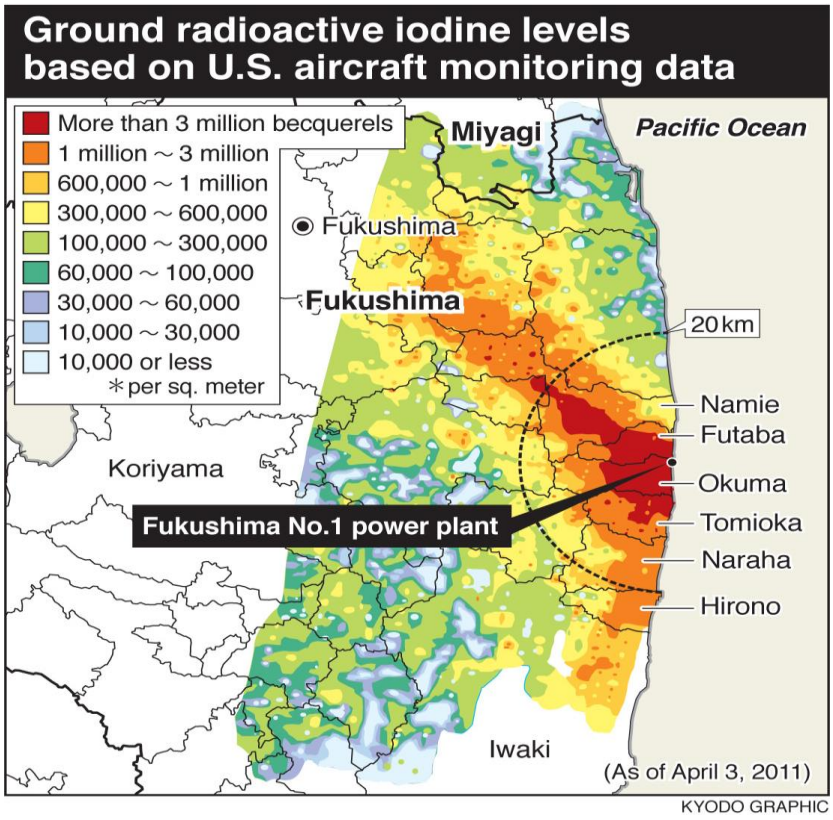

Fig.2. Map of radiation in Japan 23 days after the disaster (Nagata, 2013).

The Expedient Action after Disaster

The destruction of earthquake and tsunami at the Fukushima Daiichi Nuclear Power Station resulted in significant challenges for nuclear waste cleanup (ANS Committee, 2012). Nuclear waste contaminated the soil for acres. The surrounding landscape became very radioactive, making it unsafe to be close to the plant. Many plant workers were given dangerously high levels of radiation exposure. Contaminated water became an international incident. So the Japanese government and related companies worked quickly to begin the cleaning process in order to prevent further nuclear pollution (World Nuclear Association, 2014).

Right after the disaster, the Tokyo Electric Power Company (TEPCO) started to cool down the reactor cores using seawater as an expedient action. Initially, all the reactors were using about 25 m^3/hours water in total, which means approximately 600 tons of water per day (ANS Committee, 2012). As the water traveled through the reactors, the clean water became polluted by the radiation leaked from the nuclear fuel rods. Although TEPCO filtered the

contaminated water, the radioactive materials could not be removed completely. Without a better solution at that moment, TEPCO decided to store all the radioactive wastewater in huge tanks.

Storing Contaminated Waste Is Not a Long-term Solution

Storing all the contaminated waste wasn't enough to stop secondary nuclear pollution. Even though it has been six years since this disaster, TEPCO didn't make any significant progress on resolving the meltdown of nuclear fuel rods yet. To keep the reactor cores from overheating and further getting damaged, workers were still pumping about 400 tons of cold water every day into the three of the six reactors (Rich, 2017). The amount of radioactive materials kept increasing. In 2016, the contaminated water contained about 3.4×10^{15} becquerels (Bq) of tritium, the high radioactive by-product of the nuclear reaction, in total (Mathiesen, 2016).

TEPCO was creating an increasing number of tanks to store the even increasing amount of wastewater. Currently, about 1000 tanks have been placed around the space of nuclear power station, holding approximately 962,000 tons of water. The scale of the storage containers can be seen in Fig.3. Before doing any effective action, they would have to keep pumping water into reactors and building more tanks for storing radioactive water. Experts struggle to predict the total amount of wastewater that will be generated over the course of this cleanup process. "We cannot continue to build tanks forever," said Shigenori Hata, an official at the Ministry of Economy, Trade, and Industry (Rich, 2017).

Fig.3. Tanks for contaminated water, with Reactors 1 and 2 in the background (Sasaki, 2017).

Ethical Dilemma(s)

The main problem with the current state of the Fukushima nuclear disaster is that the Japanese people's present solution is unsustainable. The current solution is to continually run about 400 tons of water each day in order to keep the radioactive fuel from becoming active again by maintaining a cold temperature state (Rich, 2017). This present solution is unsustainable because it produces tons of contaminated water each day, coupled with the fact that scientists are unable to decontaminate the water completely. Furthermore, the longer the radioactive fuel rods linger around, the more nuclear waste gets contaminated as it seeps into the nearby region surrounding the nuclear power plant. In essence, the current solution is not a permanent solution to the problem.

So the dilemma becomes the following; do we continue with an unsustainable solution with long-term damages and wait until an advancement in technology or a new strategy is created, or do we take immediate action with immediate potential danger to human life and suffer short-term consequences?

Impacts and Potential Mitigation on Stakeholders

Residents

The residents want to return home to a radioactivity-free environment (World Nuclear Association, 2014). They also want for the local water to be clean. Government entities and TEPCO's choice of solution will affect how long residents remain relocated, whether or not their homeland will be safe to return to, and whether or not the water will be safe to fish in. Impacts on the residents' lives can be mitigated if the nuclear fuel rods are dealt with swiftly to avoid this prolonged relocation and radioactive contamination.

IRID & NDF

The International Research Institute for Nuclear Decommissioning (IRID) is directed to focus on developing mid- and long-term decommissioning technologies (World Nuclear Association, 2014). The Nuclear Damage Compensation and Decommissioning Facilitation Corporation (NDF) was commissioned to develop innovative strategies for handling contaminated water and removing radioactive debris. In essence, these entities are responsible for deciding on the cleanup solution that is taken. They're impacted by the funding via the Japanese government, who commissioned them to create viable solutions to the problem and by the overall success or lack thereof with current clean-up efforts. Impacts via the Japanese government can be mitigated on the IRID and NDF if solutions by said entities are successful and generate public favor.

The Fund & The Ministry of Economy, Trade, and Industry

The Nuclear Damage Liability Facilitation Fund (the Fund) finances TEPCO in their effort to clean-up the nuclear power plants (World Nuclear Association, 2014). The Ministry of Economy, Trade, and Industry also finances TEPCO in their efforts to clean-up the nuclear power plants. In addition, the Ministry administers the clean-up efforts, approves or rejects TEPCO's clean up plans, and essentially owns most of TEPCO now. Both financial entities are heavily impacted by public opinion, as well as by the success of the cleanup itself. Financial impacts on these entities can be mitigated by IRID, the NDF, and TEPCO and are solely dependent on their ability to cost-effectively resolve the cleanup within a reasonable timeline in order to not waste the Japanese people's money and resources.

TEPCO Fukushima Daiichi D&D Engineering Company

TEPCO is the company responsible for the management and operations of the nuclear power plants that got hit by the tsunami. TEPCO has to bear the bulk of the burden since they are responsible for the nuclear disaster. Therefore they are responsible for the cleanup. They are impacted by every other stakeholder. Firstly, they are responsible for cleaning up the nuclear waste for the impacted residents and compensating them for their relocation. Secondly, they are responsible for implementing solutions suggested by the IRID and NDF. Lastly, they are responsible for using their funding from the Fund and The Ministry of Economy, Trade, and Industry in a cost-effective manner to resolve the issue. Impacts on TEPCO by all stakeholders are currently being mitigated by their attempts to devise new solutions to the cleanup effort aside from running water through the nuclear power plants and storing it.

Solutions

During the tsunami, the backup generators could have, if built into a risk-free engineering scheme, survived the tsunami and remained functional. However, as shown in Fig 4, the insufficient altitude they were constructed on significantly increased the risk of them being flooded. The generators serve a critical role because if they were repowered, the cooling system would be able to run, which would greatly help with reducing the amount of contaminated water while dissipating heat. There is a list of potential resolutions that could bring the power back to the system, and thus get the cooling process going under sustainable circumstances.

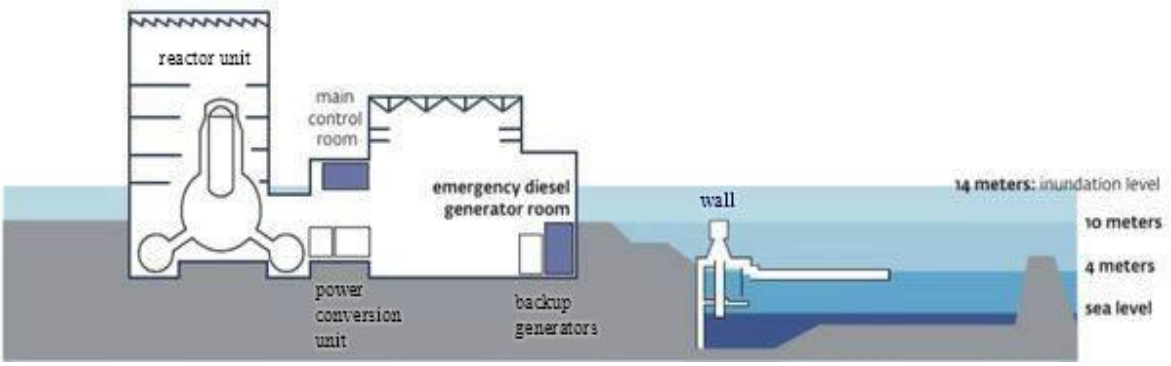

Fig.4. Fukushima nuclear plant diagram after the disaster. Adapted by the author (Zeiss, 2015).

Restore the Backup Generators

Since the most backup generators were flooded and damaged, specific actions need to be taken to bring them back to a functional status, and these actions can be expensive and difficult ones. One potential course of action is to drain the water and have workers or robots sent to repair the generators. Once the generators are back online, the circulation can then be carried out preventing the need for exterior water circulation.

The downside of this solution is that, given the severity of the damages, it could be highly difficult to recover the generators. In addition, a great deal of financial and human labor input is needed. If the generators cannot be recovered, the Japanese government would have to either change the plan or to build new generators, which would cost even more input and precious time.

Take Actions on the Fuel Rods

Removing the fuel rods is another option. TEPCO has already conducted missions on the reactors in the hope of successfully locating and removing fuel rods. “There are essentially three options for the strategy,” says the Tokyo-based International Research Institute for Nuclear Decommissioning (IRID). “One option is to flood the containment vessels with water and use a crane above the reactors to hoist up the melted fuel. The second option is to carry out the same process but without water. The third is to install removal equipment through the side of the containment vessel.” (Nagata, 2017).

These three options all have their benefits and drawbacks, which mean risks cannot be completely avoided. To remove the nuclear fuel in water would help prevent radiation leakage, but once the fuel dissolves into the water, we risk the possibility of the system going back to the excited state and causing irreversible catastrophe. On the contrary, removing the fuel rods without water around it would free the risk of criticality, but the massive radiation would not be blocked in any way. These options would be risky, but with the right engineering and technology, it would significantly reduce the amount of nuclear waste created by the disaster.

Solidifying the Fuel Rods

Although removing the fuel rods may be a possible resolution, it can still be challenging because there are technological issues in locating the fuel rods with robots and cameras. “Scientists need to know the fuel's exact location and understand the structural damage in each of the three wrecked reactors to work out the safest and most efficient way to remove the fuel.” (Yamaguchi, 2017). And during the process robots can be entangled by the debris, made malfunction by the heat, or interfered by the massive radiation. Given the tough situation, solidifying the fuel rods is also a doable resolution comparing to removing them. The Chernobyl accident was dealt with a gigantic sarcophagus that seals up the reactor, and that was a lesson Fukushima could learn. Building an envelope with metal and cement which seals up all the debris of the reactor could efficiently hold the radiation in place and keep the rest of the area free from its further influence. This resolution is still under question because Chernobyl and Fukushima weren’t facing the same kind of situation. Because the debris is dispersed at the bottom of the ocean, it can be rather hard to ensure full coverage.

Recap

Collectively speaking, all the potential resolutions have their pros and cons that people have to judge and weigh before taking actions. But the increasing need for a solution is not granting the Japanese government too much time. If the problem is to be addressed, the government departments' primary concern should be to come up quickly with a sustainable resolution rather than a makeshift that could cause even more serious problems in the future.

Conclusion

The disaster that struck Japan in 2011 left a cleanup effort that would continue into the next generation. No matter what, dealing with the consequences of nuclear meltdown will always be a long, difficult, and expensive process. Processing nuclear waste presents a massive challenge both in terms of public safety and the environment. Although the damage is in the past, there is still time to change the way the cleanup is done in order to minimize the effect.

The administration's current approach is to continue extracting and storing the waste. However, due to the scale waste being generated, this is an unsustainable practice. Creating more and more storage containers for the contaminated soil, water, and other nuclear waste is not a real solution. Many options will help to decrease the amount of waste produced. Whether it involves cycling the water or removing the fuel altogether, these solutions will help to move the disaster toward a sustainable state. Though these solutions can be hazardous and expensive, so too does the long drawn out process of nuclear waste storage. Technological advancement and creative engineering design solutions have opened the way for solutions that do more than sustain the damage. These options must be pursued to the fullest extent.

It is vital for the government to continue to seek out and utilize new approaches to nuclear waste solutions. Many environmental agencies and governmental entities may prefer to utilize the safest option instead and delay the problem to the next administration. However, this is unfair to the people affected by the disaster. The groups managing the clean must be committed to seeking solutions that will be the most beneficial in the long run.

Thankfully, there is progress being made. During the writing of this paper robot put into the reactors have identified some of the nuclear fuel rods (Fackler, 2017). This means that if research and development are continued to be put into these areas, these solutions may come to fruition. With the right approach, the currently unsustainable waste containment will be able to be resolved much quicker, benefiting future generations that will have to manage the nuclear waste.

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