Group 15: NASA Lunabotics – White Paper

Shannon Berger, James Fadool, and McKenzie Reed

September 13, 2011

Currently nuclear power plants pose a major liability in the event of a natural disaster. While power plants use the "Defense in Depth" approach to prevent this from being an issue, it is impossible to make a system perfectly defensible. As evidenced by Fukushima, the standard methods of "Defense in Depth" are not always enough. The method we propose will fix the problems that Fukushima had, as well as provide an improved approach to "Defense in Depth." It will be a simplistic self-generating power source, which due to its simple nature will be easy to repair in the event that it fails.

Nuclear power plants contain Uranium Oxide (the nuclear fuel), which has a melting point of 2800°C. The tube the fuel is contained in is made of Zircaloy (termed fuel rods), with a failure temperature of 1200°C. Then the core is placed in a pressure vessel made of thick steel, which can withstand pressures exceeding 7MPa. This is then housed in a hermetically sealed containment structure made of thick steel and concrete. In the event of a complete core meltdown, this structure is built to indefinitely contain it. Then there is what is termed a secondary containment, which is a concrete structure poured around the containment structure to an additional defense.

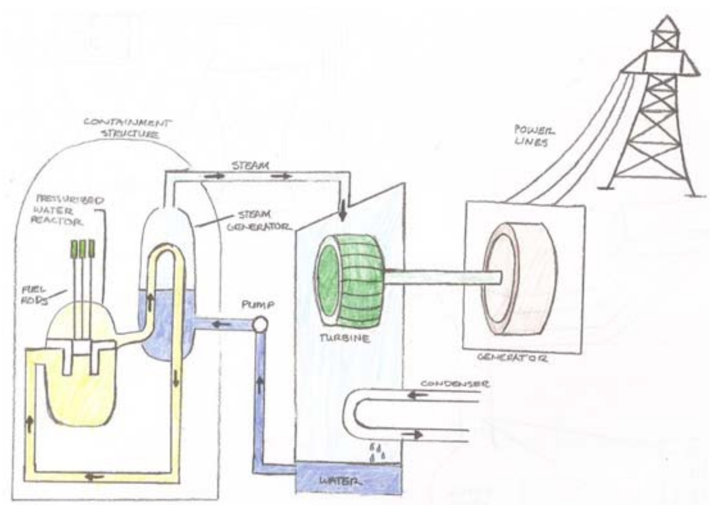

Figure 1: A drawing of the current standard "Defense in Depth" approach for Nuclear Power Plant (it is the approach Fukushima utilized).

In the case of the Fukushima Nuclear Power Plant, the primary issue was a single failed generator. The generators pump the water, which cools down the fuel rods, and therefore the nuclear fuel as well. With partial cooling capability lost, a nuclear fuel meltdown was inevitable in Fukushima. Additionally, they were unable to monitor water levels and the temperature of the fuel rods. This meant they were unaware of how much of the nuclear fuel was actually immersed in cooling water and they were not aware of when the rods were too hot to contain the fuel. As a result, scientists could not prepare for the magnitude of the hydrogen reaction, nor the timing.

To prevent future nuclear core's from melting, we propose a system which self-generates power as well as sensors to monitor water levels and fuel rod temperatures, which will be run by the self-generating power source. The design utilizes an off-site water tower, located near a natural water source. There will be a generator next to the water source running a water pump which will pump the water from a natural source up to the water tower. Then the water tower will then use a water turbine to generate power. This power will be transferred back to the power plant using underground wires. This power will run the cooling water inside the power plant to maintain the nuclear core at safe temperatures, as well as run other necessary sensors – including the water level and fuel rod temperatures.

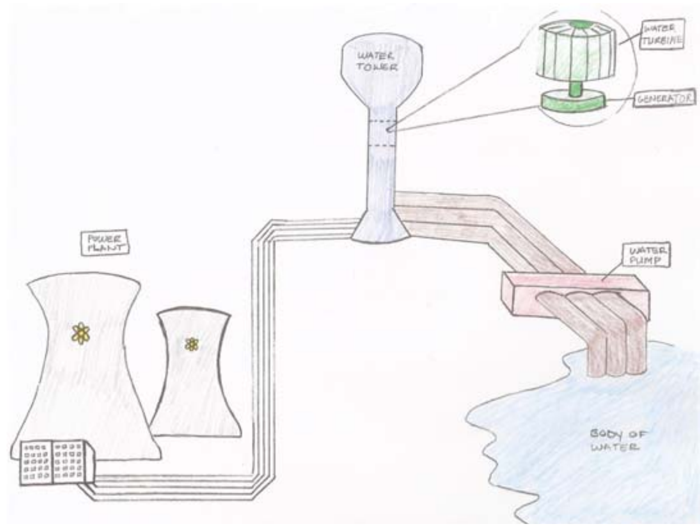

Figure 2: The new system we propose. It uses an offsite water tower and fuel pump to generate electricity. The power generated will then be sent via underground wires back to the power plant to provide it with a backup power source. The parts would be very easy to replace and with an unlimited water source, this system could run indefinitely.

The advantages of this system are that since all the components are located off site and above ground the will be easily repaired if they are damaged. Additionally, the system requires no electrical power (other than a small generator to run the water pump at the natural water source) since it generates its own power source and the system can work indefinitely so long as there is a water source. It is a very simple system so it can be quickly and easily repaired with readily available technology. It will also have easy to access parts in the event that it does need to be repaired. We believe our system is a better alternative to current use of generators to maintain nuclear power plants in the event of a power failure. It will also have the additional failsafe of being able to monitor cooling water levels and fuel rod temperatures so that this important information can be made available to scientists.