Bringing Nuclear Energy Back

By Aaron Lutzker

Since Nuclear Energy came into existence in the mid 20th century, there have been many varying opinions about the safety of nuclear reactors. Nuclear energy is known for being an extremely efficient source of power in terms of resources used and waste produced by the process. Compared to other forms of power, nuclear energy has nearly no pollution. The one factor that put people on edge with nuclear power is the destructive nature of Uranium. Because Uranium is radioactive, it is used to make incredibly powerful bombs. When the public thinks of nuclear reactors, they think of a somewhat controlled nuclear bomb. Although this is not the truth about nuclear power, nuclear power does have some danger. The danger we have seen with nuclear power is the meltdown, which occurs when a disaster happens and the plant is no longer able to properly cool the Uranium fuel rods and the reactor explodes. This results in a radioactive threat to the surrounding community if such a meltdown occurs. Although this is a valid concern, there have only been a handful of nuclear meltdowns in the history of nuclear energy. Because of this fear, the development of nuclear energy has been trivial and might decline.

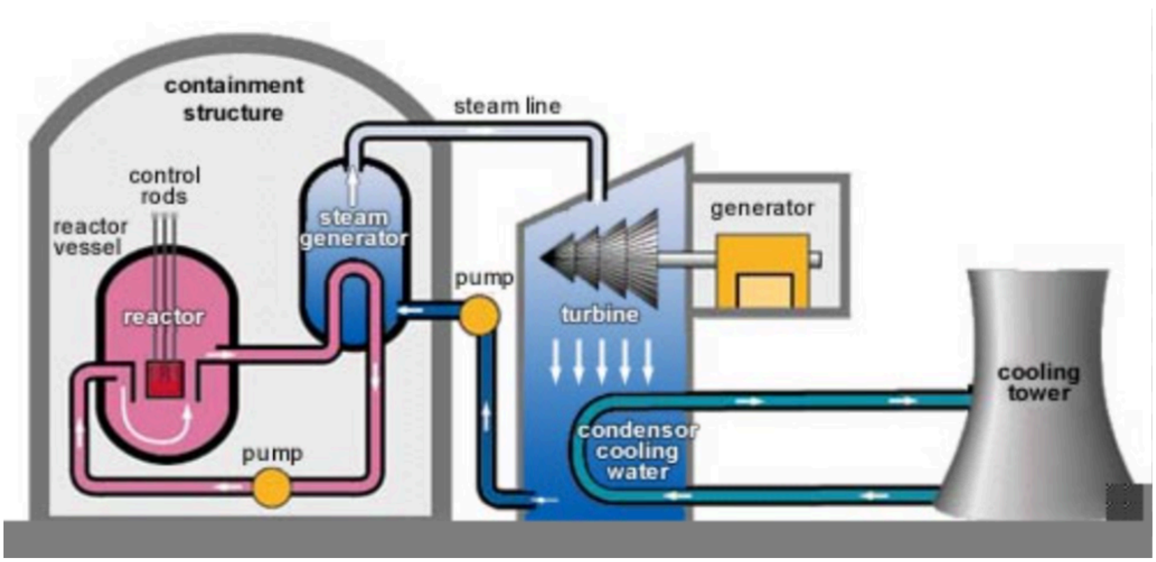
Recently, Nuclear Energy has had a large public push back. The most recent source of public outcry can be found in the wake of the Fukushima nuclear disaster. In 2011, a large earthquake and subsequent tsunami ravaged japan. Fukushima power plant, a nuclear reactor located on the northeastern coast of japan was in operation during the disaster. Through a series of events, the reactor lost the ability to cool itself down and therefore proceeded to meltdown, forcing thousands in the Fukushima area to evacuate and scaring the world once again. The meltdown reignited anti-nuclear sentiment originating from the very beginning of the nuclear era.

Firefighters extinguish flames erupting from the remains of the Fukushima nuclear reactor

http://prn.fm/tag/fukushima-daiichi-nuclear-disaster/page/2/

In the aftermath of the Fukushima disaster, world government’s downsized nuclear development and in some countries phased out nuclear power production because of fears of disaster. Behind these actions was the public, who were very scared of nuclear power. Although the threat of a nuclear meltdown is frightening, the actual dangers that accompany nuclear energy are minute compared to carbon-based fuels. Stewart Brand, a strong proponent of nuclear energy said, “Radiation that looks like a great evil in basically a design problem. Nuclear provides a clean base load electricity that produces waste just a size of a coke can as compared to a coal fired plant that belches out 16,000 tons/year of CO2 emission for the same power supply” (Walsh). When we breakdown the affected area of a nuclear meltdown versus the climate crisis we are currently facing, it seems like the public is scared of a pebble when a boulder is about to fall on them. But, nonetheless, the public will not accept nuclear power until we can eliminate the threat of a meltdown. To better analyze what steps would be needed to make nuclear “safer,” we have to look into what makes nuclear energy unsafe, and hence the process that Uranium is used to create power.

Nuclear reactors chiefly run on Uranium fuel rods. These Uranium rods are not just the Uranium that is mined from the ground, but a chemically enriched compound. The Uranium rods must be enriched in order to be used for nuclear reactors. Nuclear reactors actually do not even harness nearly the full potential of the Uranium they run on, they only use up a fraction of the Uranium before the Uranium needs to be changed out. The Uranium rods are harnessed in the reactor in a reaction that causes them to give off extreme amounts of energy in the form of heat. These fuel rods heat up and are cooled using pressurized water. The cooling water is piped into a steam generator chamber where the super heated water is used to produce steam. The steam is then used to power turbines that are attached to a generator, which creates power. The pressurized cooling fluid is then returned to the core and the steam that turned the turbines returns to water.



Basic layout of a nuclear power plant

http://zidbits.com/2011/04/how-do-nuclear-power-plants-work/

What makes nuclear energy inherently unsafe is the nature of how the steam is made. Recall that steam is produced by quenching hot fuel rods in compressed cool water then sending that hot cooling fluid to a water tank for steam generation. What happens when a reactor melts down is that the fuel rods are not able to be quenched and heat up to dangerous levels. This is often because the systems that pressurize the water that goes to the reactor fail. When this happens, the water when returning to a lower pressure will boil off into steam immediately causing a huge pressure increase and not cooling the fuel rods at all. At this point, the reactor building will often explode. For reference, the reactor building is made out of 2 meter reinforced concrete that requires extreme amounts of pressure to blow open. When the core explodes, it scatters radioactive fuel rod material all over the environment and into the atmosphere. In the event of a natural disaster, the power/systems needed to cool the core go offline or lose ability, causing this meltdown.

The solution scientists have being using is to have more battery-powered backup systems or complex mechanical systems that add excessive costs but offer fast ways to modify existing reactors. Currently, most nuclear power plants use backup generators as their emergency source, but these take a few minutes to start up in the event of a disaster. Not to mention they can sometimes malfunction or break. What we would need to have is a fail proof system that would always be there in an emergency, even better if it automatically worked.

One solution to avoiding the threat of a nuclear meltdown is provided in the design for a passive nuclear reactor. The Advanced Fast Reactor (AFR) as it has been called, uses principles of nature to avoid melting down. By this, we mean the natural properties of the process it uses allow the reaction to go down at close to atmosphering pressure. The first big difference between the AFR and the typical nuclear reactor is that the AFR uses salt as a coolant instead of water. For a typical reactor, water must be pressurized at 100-150 atmospheres to prevent the water from boiling away immediately when exposed to the hot core. Salt has a boiling point of 300-400 Celsius at 1 atmosphere, which is higher than the core will ever get. This allows the salt to cool the core properly at atmospheric pressure. The salt can absorb so much heat that the reactor cannot possibly meltdown (Arora). In fact, at a test reactor in Argonne, Illinois, scientist tried to make an AFR meltdown, and it would not do it. This experiment proved the safety of the AFR (Baurac). Assuming the AFR were the answer to the safety concern in

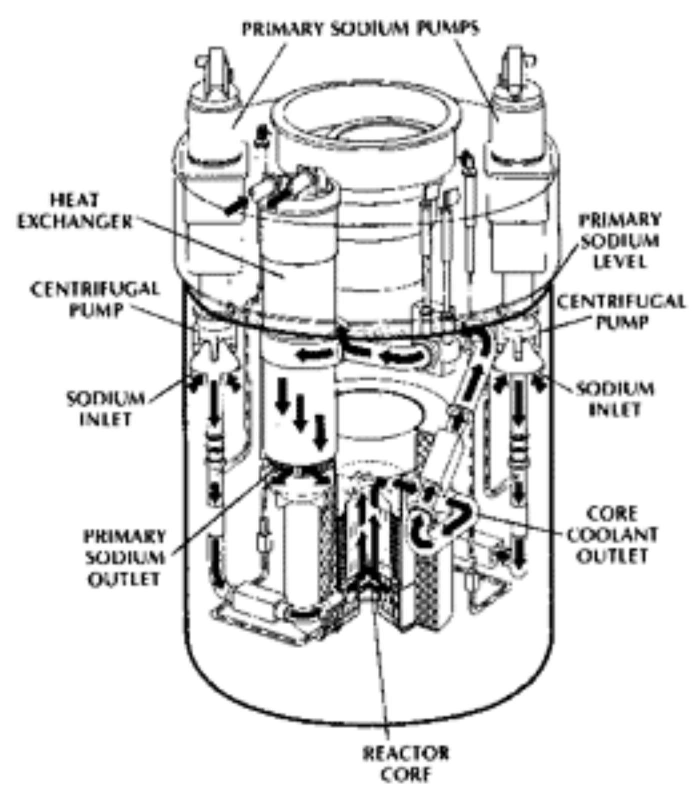
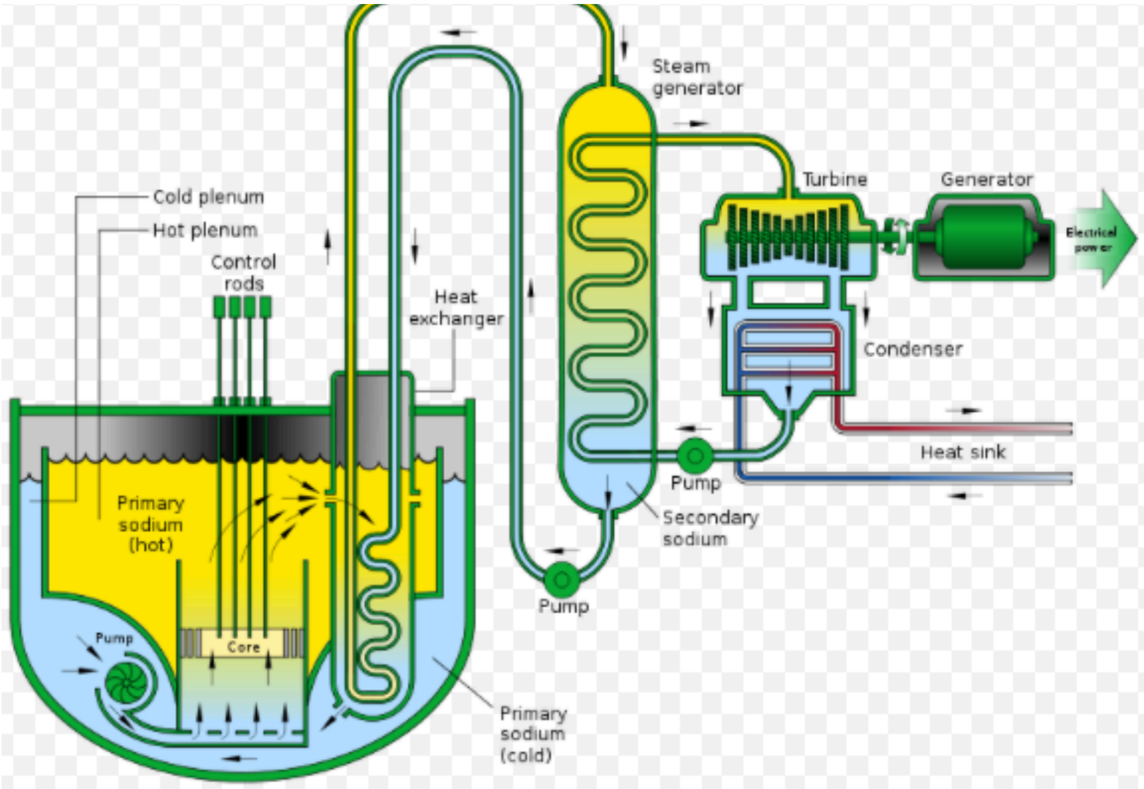


Diagram of an ARF reactor (Arora)



Schematic of an AFR Nuclear Reactor

http://large.stanford.edu/courses/2013/ph241/waisberg1/

modern nuclear reactors, I will now explore the economical standpoint of this technology.

Little is known about the costs of modifying current reactors to AFR reactors, so I will be estimating. Currently, the cost to build a AFR reactor is more than a regular reactor which costs between 6 and 9 billion U.S. dollars (Schlissel). Though this is because the technology is not wide spread and is not offset by mass production factors. Specifically, the AFR reactors save money in fuel and operating costs. To begin, AFR reactors are able to use fuel rods that are more decomposed than those that regular nuclear reactors can use. This would mean that for a while, AFR reactors could use the spent fuel from regular reactors. The AFR reactors would be more efficient with fuel too so the Uranium would go farther. Not to mention the amount of nuclear waste generated would decrease as well. The second economic attraction of the ARF design is that the operating costs would decrease because of the passive system. There would not have to be as many emergency systems or personal to man them given the safe properties of AFR. These factors would put the AFR reactor in the same cost bubble as regular reactors if not lower. This would make the AFR worth it to convert to. So we will assume the AFR would cost around 7 billion U.S. dollars to build. Although we can assume that converting current reactors to AFR format would incur significant costs, this could be avoided by making all new reactors AFR and slowly phasing out the old reactors that still function today. Assuming AFR reactors will cost in the same price range as the current reactors shown by the above estimation, over the rest of the lifecycle of the current reactors in the U.S., the cost to build all AFR reactors in the U.S. would be 427 billion dollars. This is assuming that the 61 reactors operational would all be converted over the rest of their lifetime. This is a sizable chunk of money, but we are getting towards the end of many of the nuclear plants built during the cold war, meaning that they will have to be

replaced anyways. This means that there shouldn't be a question of what kind of reactor to build anymore, we should build AFR reactors.
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