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Nuclear Powered Air-conditioners

We all use electricity. 22 percent of our electricity comes from light water nuclear power plants (Raja 308). These reactors produce 10,000 tons of spent-fuel every year. The recent accident at Fukushima, where several spent-fuel storage locations lost coolant water, illustrates some of the hazards of storage in pools (Alvarez). A typical US power plant stores approximately 1000 tons in such pools (Union - Safer Storage of Spent Fuel). Something needs to be done with this fuel. I propose we reuse it to power our central air-conditioners. The fuel is readily available and we have the technology to use it safely. These air-conditioners could reduce the electrical demands during hot days and reduce our waste at the same time.

The function of an air-conditioner is similar to a refrigerator. Most refrigerators in use by recreational vehicles (motor-homes, trailers and campers) use propane as a heat source to power compressors. Using this same technique, we can substitute spent reactor fuel as the heat source and power our air-conditioners. These AC units will be slightly larger than normal to accommodate extra radiation shielding required for safety. The spent fuel core would be powered by decay heat. Using this method, they would function as a self regulating power source for up to 30 years, depending on the concentration of the spent fuel.

Decay heat is produced by the radiation from the decay of radioactive substances. Gamma rays are converted to Infrared rays (heat) by passing near heavy nuclei, such as lead. Alpha and Beta particles are larger fast moving particles that transfer kinetic energy (heat) to nearby materials such as steel. Fast moving neutrons (neutron radiation) can transfer their kinetic energy to hydrogen rich materials, such as plastic or water, or by being absorbed by other elements, such as Boron. The decay heat from spent fuel is high enough to melt the fuel rods if not kept cool (Write). Encasing in steel would prevent the hot fuel rods from moving about, if they should meld.

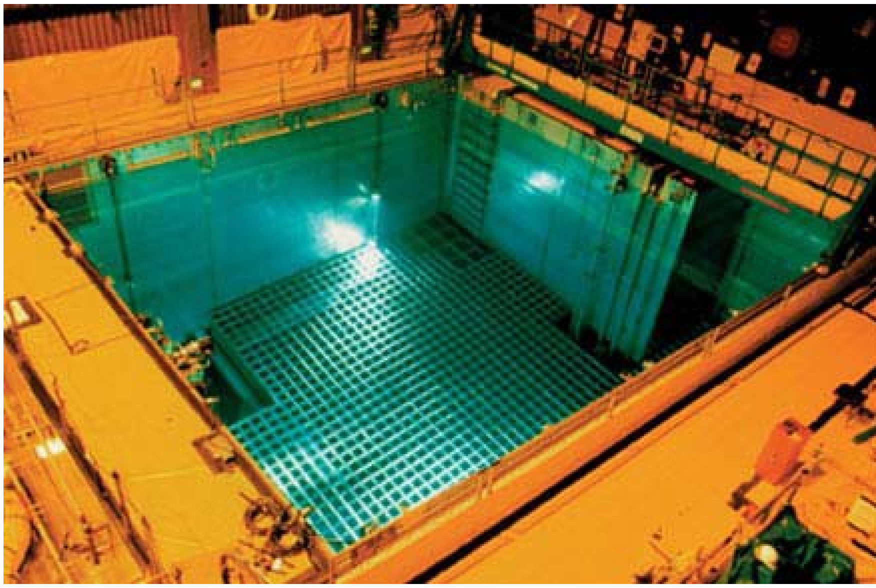
Illustration 1: Carter – Fuel Rod Storage Pool

Normally, spent-fuel is stored in pools for 5 years or more (see illustration 1), before being transferred to concrete casks for long term storage (Union "Spent Nuclear Fuel Storage"). If this fuel were to be concentrated, not enriched or reprocessed, it would be more radioactive and hotter for a longer period of time. Normally, this would be a bad idea. But, by raising the radioactivity we raise the heat generated and increase the length of time the spent fuel remains hot. By *concentrating,* I refer to the cutting up of a fuel rod while monitoring the radiation level. When a specific amount is reached, it would be sealed in steel. The heat generated by the spent-fuel would not be hot enough to melt steel, but would be more than hot enough to power our AC unit. The Freon system, for the AC unit, would surround this steel block. The primary purpose of this block is to seal the core and prevent radioactive materials from moving about.

This type of core is very tamper resistant. The only way to gain access to the fuel would be by cutting the steel with a diamond saw, or simply melting it down. Both options are extremely hazardous and difficult. Even if someone should manage to safely gain access, the retrieved material would not be useful for any purpose. A block of metal, even if highly toxic, is not an effective weapon. To use this material to create a fission bomb would require the accumulation of several tons of spent fuel before enriching it using a gaseous centrifuge the size of a large warehouse. This is completely beyond the capabilities of most countries, and just not possible to any private enterprise.

The steel block, the power core, requires more shielding to protect consumers from gamma radiation. Normally, gamma radiation can be shielded by using lead shielding. Lead, or any heavy metal, works by absorbing the gamma ray, and releasing other gamma rays at lower wavelengths, such as infrared or heat. Today, plastic can be substituted for lead (GE), resulting in a safer product. This plastic works by embedding tungsten into the plastic matrix. Tungsten, being a heavy element, works as a substitute for the lead. By being included into the plastic matrix, it is very easy to work with and bonds well with other materials. This material lacks the safety hazards normally associated with lead.

The core will still need some neutron shielding. The high radioactive output of our core releases many fast neutrons, which lead cannot block. To effectively shield neutrons from people, you need to find something of similar weight. Hydrogen has the same weight as a neutron. This makes water a good shielding solution for wet storage of fuel rods, but water is unsuitable for our AC unit. Plastic can also be used for neutron shielding (Smock). This material has Boron embedded into the plastic matrix. Boron tends to absorb neutrons. Plastic also has a lot of hydro-carbons. Hydrogen tends to slow down neutrons much the way pool balls will slow down the cue ball. Adding these layers of plastic will reduce the radiation to a safe level.

For additional safety, two GPS units can be installed. The first transmits hourly position, radiation, temperature, and Freon levels to a tracking satellite, much like a cell phone. The other is a backup that turns on if the other should fail. These features assist in ensuring the AC units are operating properly, and can be quickly located if they are not. The GPS units, the steel, and the plastic casing will prevent these units from being used for any other purpose than air-conditioning. At the end of the fuel life cycle, the old cores can be easily stored as low level radiation sources, and new cores installed.


Illustration 2: Carter – Fuel Rod Casks

Storage of spent cores is much safer than the original spent-fuel rods; the spent cores do not require cooling, sealing or shielding. They can be safely stored “as is”, making storage much easier than using the concrete cask method used for high level spent-fuel storage (see illustration 2). Spent-fuel rods are vulnerable to loss of coolant accidents, while these sealed cores are stable. These spent cores are not suitable for reprocessing, which helps to prevent proliferation.

Some have suggested the spent-fuel rods be reprocessed. Reprocessing requires a breeder reactor. Spent fuel rods are placed into a breeder reactor where they are bombarded with neutrons. This will create a buildup of Plutonium within the fuel rods. The US does not have any breeder reactors, due to anti-proliferation treaties. The US does not have any reactors that can use this type of fuel, called mixed oxide fuel (MOX). Since the Fukushima incident, Japan has started production of MOX fuels at a reprocessing facility located in Rokkasho Village. This fuel is to be used at 18 of their power plants.

Breeder reactors are some of the most dangerous devices ever designed. The most common cooling methods include Mercury or Sodium systems. These metals are used because they remain liquid at room temperatures and will not boil away at higher temperatures. But, neither material is something you want to be around in the event of a “minor” accident. Mercury vapor will kill. Sodium reacts violently with air and water and was a contributing problem at Chernobyl. There are other designs for breeder reactors, but in my opinion, they all suffer from a common problem. If the main coolant loop leaks, or is lost, the back-up plan seems faulty. In a sodium cooled reactor, when a leak happens, sodium creates a major fire hazard that is difficult to control, and greatly complicates the *minor* leak. In a high pressure gas (helium), if the gas leaks, you release alpha particle radiation in gaseous form. If coolant is lost, water is a bad substitute for such reactors.

The reactors at Fukushima were all light water reactors. When they lost primary coolant, they also lost all back-up coolant systems. The back-up systems ran on generators, which were damaged by the tsunami. Much of the resulting hazards could have been prevented by resorting to sea water faster. But, we can't really fault such decisions. The value of these reactors in about $500 Billion. Introducing sea water into these facilities caused irreparable damage. Naturally, that kind of decision was not made lightly. This accident shows the safety of this technology. Compare this environmental impact to those cause by oil drilling and transportation, and you can see this impact is only minor. The decision to place these plants on the coast permits the use of sea water for such emergencies. Japan will recover from this very rapidly. Chernobyl may never recover.

I believe that, out of concern for keeping spent-fuel cool, Japan has re-activated their Monju breeder reactor. They intend to reprocess this fuel into MOX to be used by their light water reactors. This method has proliferation concerns; this could provide stable sources of Plutonium or Thorium which may be used for weapons. On the bright side, they are trying to reduce their waste and make it safer.

Here, in America, we are only stock piling it. By inclosing it in steel and plastic, the spent-fuel becomes safe to handle. This will also make it useless as a weapon source. Using my method to reuse our spent-fuel is safer than building a breeder reactor and reprocessing plant. Making our AC units nuclear powered will help to remove our biggest electricity consumer from the electrical grid. This should work for our water heaters too. Something must be done. We need to stop depending on high pollution fuels such as coal and oil for electricity. Even clean burning propane is a problem to extract; it has the possibility to destroy the water table. Lets do something useful with our waste. Lets make air-conditioners.

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