Nuclear Power (Fission)

By Louis P. Solomon with Dick Van Orden

In a previous column, we discussed various approaches to solving future energy problems of the United States. Now we are ready to take up the most promising—and most near-term—solution for consideration: Nuclear power generation of electricity.

There are two types of nuclear power generation:

Nuclear Fission—The splitting of a heavy atom into smaller atoms, with the release of heat energy and two or three neutrons.

Nuclear Fusion—The combining of two light atoms, releasing large amounts of heat energy.

Today we will discuss only the Fission option, because it is well-known and is in use at the present time. Fusion, still under development after many years, continues to be extremely difficult to initiate and run under controlled conditions.

Nuclear fission is used in a nuclear power plant to produce heat; the heat boils water to produce steam, which is then used to turn a turbine generator to produce electricity. This exactly the same process used in a coal-fired, or oil-fired, or natural gas-fired plant. The only difference is the source of heat to boil the water.

In a standard nuclear power reactor, the principal fuel source is fuel rods. These fuel rods are typically composed of Uranium atoms U235 and U238. These are called isotopes of Uranium. The numbers refer to the atomic mass of the isotopes, and are almost exactly the number of neutrons plus the number of protons in each atom; for example, the U238 atom has three more neutrons than the U235 atom. These two atoms are the Uranium isotopes left after it is separated from its ore, pitchblende. More than 99% of the uranium in the earth's crust is U238, and less than 1% is U235. U235 is the heart of a nuclear reactor because it is "fissile," meaning it is able to be split by a slow moving neutron. If the U235 atom is split when there are other U235 isotopes in close proximity, the neutrons which are released can hit these isotopes and split more, and more, and then still more. Thus, a "chain reaction" is started and tremendous amounts of energy are released in the form of heat that boils water to make steam. The chain reaction is controlled by "control rods" of a metal (usually cadmium) that can absorb neutrons from the "pile" and thereby keep it active, but not too active. There is a constant balancing act to get just the right amount of neutrons released to maintain the chain reaction.

Meanwhile, there is another reaction taking place. Remember, the reactor fuel is both U235 and U238, which is not fissile. But U238 absorbs some of the free neutrons, which transform it into U239. U239 is unstable, and transforms itself to Plutonium 239 (P239, which is fissile), and continues to produce some other plutonium isotopes, P240 and P241, as well. All of these transformations produce heat—in fact much more than the splitting of U235 produces. So the reactor keeps producing great amounts of heat, which generates steam and turns turbines to generate electricity.

The only outputs from the reactor are heat, steam, hot water, and waste products. More about the waste products, later. Thus we have a continuous electric generator at a reasonable cost that produces no contaminants to the atmosphere. Isn't that what everyone wants? Doesn't that solve our energy problem? One would think so, but wait.

There are two main objections to nuclear fission reactors: (1) There may be accidents (such as Three Mile Island and Chernobyl) that might release radioactive materials, causing harm to living beings and the environment, and (2) The waste products remain radioactive for 25,000 years. This requires that they must be disposed of safely. The answers to these are straightforward: (1) Prevent accidents by constant and effective supervision and fail-safe engineering practices, and, (2) dispose of waste by burying it deep in the earth or at sea where tectonic plates will fold it into the earths crust forever. But, amazingly enough, there is an even better way.

The better way is by using what is called a Breeder Reactor. If the radioactive Plutonium and the unused Uranium are removed from the fuel rods after they are "spent," it can be reworked to make Breeder Reactor fuel rods. More fuel is thus received from the "waste" after the process than was there in the beginning! There is no remaining waste, since all of the radioactive products have been turned into more fuel. Wonderful! The system can generate an almost limitless supply of fuel leading to an unlimited supply of electricity.

This means that there are no waste burial problems and less need for new Uranium ore. Great system, one would think. Then why don't we have such a system in the U.S., even though the French, the British, and the Japanese have them? Because, President Carter issued a policy in 1977 that bans the processing of nuclear fuel in the United States. Why? Because such a process produces Plutonium, which just happens to be the principal ingredient of nuclear bombs. There was a fear that some Plutonium might be stolen by terrorists and turned into bombs. It is now well known that only pure P239 can make bombs that explode, and the separation of that isotope from the others is nearly impossible. The Russians, French, and British have tried, but were unable to do it efficiently. Yet, the policy remains in effect in the U.S. We continue to try to find ways to get rid of tons of radioactive waste, while buying and processing more pitchblende. Science has provided the answer, but politics has generated the fuel disposal problem.

So, in the U.S. where less than 25% of our electric generation comes from nuclear power plants, we are forbidden from using the spent fuel rods effectively, while in France where about 75% of the electric power is generated in nuclear plants, there is no waste disposal problem and little need to buy new U235 and U238.

Nuclear Fission Reactors coupled with Breeder Reactors can solve the power generating problem within the United States virtually without limit. There is still the problem of the distribution system growth, but we know how to solve that.