Innovative Reactors Invite Innovative Licensing

In the U.S. (and elsewhere), there is a move towards "risk-informed regulation," or licensing of reactors where the extent of the regulations (or restrictions) would be made proportional to the extent of the risk posed by a particular process or function. This move has come about to correct a natural tendency to "over-regulate just to be on the safe side." It is also an acknowledgment of the fact that application of overly conservative regulations may result in unnecessarily expensive corrective measures. This tends to make an otherwise attractive reactor design too expensive to build or too cumbersome to operate efficiently. A much-needed early nuclear revival, driven by honestly-economical innovative reactor designs, should be achievable with the help of a more balanced regulatory climate.

However, we must deal with the fact that NO industrial process is risk-free. In the U.S., we have people so dead-set against nuclear plants, we hear "even if the chances [of harm] are only one in ten million, that's too much." They may even grant the fact that driving to work or taking baths may be more hazardous, but that would be "their choice," whereas having to live near a nuclear plant, or in a state with radioactive waste, would not be their choice.

People willingly take a risk only if they perceive it to be outweighed by the benefits. To this end then, let's take risk-informed regulation one step further. For the case of the new "Generation IV" reactors, which include the Modular High-temperature Gas-Cooled Reactor (MHTGR) and other "passively safe" designs, we suggest reconsidering the scope of the reactor regulations in a manner similar to the way it is done in medicine. For drugs and medical procedures, the possibilities of bad outcomes (harmful side-effects, death from surgery, etc.) are weighed against the chances of good outcomes (cures, life extension, etc.). Alternative treatments are ranked with consideration of both risk/benefit and cost.

A reactor parallel, where in this case the "patient" would be "society," opens the possibilities of considering a wide variety of both short- and long-term risks AND benefits. We propose that effective counter-arguments for licensing an MHTGR could be made that evaluate and balance the relative risks of either: a) building a competing (alternative) process; or b) not doing anything. This point is illustrated by five examples.

The first example is a simplified comparison of the incremental risks and benefits from building a Plutonium-burning MHTGR. One could weigh (quantitatively) the risks from worker and public exposure to Plutonium due to reactor construction and operation against the benefits from reducing the risks of terrorist diversion of weapons-grade Plutonium, resulting in a bomb that destroys a city.

A second example is the comparison of the collective risks of a new Generation IV MHTGR (with LEU or Pu fuel) with the risks of a fossil-fired plant. Consumption of the fossil fuel means depletion of its non-renewable reserves. Conflicts are more likely if nations become more dependent on fuel imports and access is jeopardized. Another alternative to the MHTGR is not building any plant, say in an area deprived of electricity (a third of the 6 billion people on earth are now without such access). Reduced life spans of these people can be attributed in part to this deprivation. A related point is that the Brayton (gas-turbine) cycle MHTGR is well suited for cogeneration options such as district heating and desalination, which can also make big improvements in a region's quality of life.

Example number three: compare the risks due to the pollution from an MHTGR (near-zero) to that from a coal-fired plant, which even releases about 100 times more radioactivity into the environment than an equivalent (electrical output) reactor. A Harvard School of Public Health study claimed that pollutants from coal-burning cause 15,000 premature deaths annually in the U.S., and air pollution (globally) causes 3 million deaths per year -- per the World Health Organization (Ref. 1).

A fourth example: the waste storage or disposal issue. It is amazing the amount of grief given the nuclear power industry for its "long-term waste storage problem." A classic one used in the U.S. is the fear that someone a few millennia in the future ("your great-great-.... grandchildren!") will come across a radioactive waste dump, not understand the warning signs, and get a lethal dose. They neglect to say how upset this generation would be with us for depleting their oil and coal reserves had we not used reactors instead. The point of the differences in waste volumes for competing electrical energy sources is best made graphically (Ref. 1) in Fig. 1, also noting that the annual radioactive waste from the nuclear plant (when compacted) is roughly the volume of two automobiles.

The fifth and final example is safety. Even considering the effects of the Chernobyl accident, nuclear power has had a good overall safety record relative to other processes. The safety features of the MHTGR can readily be shown to be even better than those of the current generation reactors. Today's reactors would also fare very well in the "balanced" risk evaluations suggested here. Even hydropower ("friendly and renewable") has been responsible for thousands of deaths from dam breaks, a recent one drawing much less attention in the press than "Japan's worst nuclear accident [at Tokai]," which eventually took the lives of two workers.

The MHTGR community now faces the task of getting its "first license" for a prototype power plant module. Licensing a new concept would, on our plus and minus ledger sheet, have a big additional benefit, that of proving to be a safe and successful concept that could be marketed and sold world-wide. The benefits claimed here could stack up quite high, resulting in the demonstration of an economical non-polluting electrical energy source that helps stabilize economies, enhances standards of living, and reduces chances of wars, etc. With this type of risk/benefit thinking, the net benefits from licensing a first-of-a-kind plant would be even more attractive than subsequent net risk/benefits in licensing an already-proven "safe" plant.

Quantifying the net risks as proposed may require some innovation. While one could derive the risks from reactor operation by conventional methods, quantifying the societal benefits is more challenging. One possibility would be to draw on the socioeconomic-political system simulation models that have been developed, refined, and validated over the past few decades.

While these models cannot predict the future with much certainty, they are able to show trends and near-term effects of changes in economic conditions and resource availability.

In summary, by accounting for benefits as well as risks in the licensing process for the new generation of MHTGRs, particularly in comparison with alternatives, a more convincing case may be made for public acceptance and favorable licensing outcomes.

Reference 1: Rhodes, Richard, and Denis Beller, "The Need for Nuclear Power," *Foreign Affairs*, January/February 2000 (Vol. 79, No. 1)

Fig. 1 Annual solid-waste production (by a 1,000-MWe power plant in one year) from Ref. 1.