Understand 'residual risk' for nuclear safety

We live in societies in which we are subjected to all kinds of hazards that threaten our lives and well-being. For example, we may get involved in an automobile accident, we may live in an area where major tsunamis may happen, or we may contract a disease such as cancer. These hazards do not occur every day. There is some uncertainty as to when and where they may occur.

Of course, the occurrence of a hazard by itself does not mean that we automatically suffer the relevant consequences. We, as a society or individuals, take measures to protect ourselves from these hazards. For example, we build seawalls to protect us against tsunamis and we impose stringent construction requirements so that buildings can withstand strong earthquakes.

Yet, there is still some uncertainty as to whether these protective measures will actually work. This brings us to the concept of risk. In general terms, risk is the likelihood and consequences of an adverse event (hazard).

For example, statistics in Japan show that about 5 people out of 100,000 die every year in transportation accidents. This is equivalent to saying that the probability of death for an individual resident of Japan per year is about 0.005 percent, a very small number indeed. This is the residual risk for a Japanese resident. That is, in spite of all the measures that society has taken to protect people from transportation accidents, there is still a chance of dying from such accidents.

The concept of residual risk is very important, especially in a highly technological society. We demand that hazardous industrial facilities, such as chemical process plants, nuclear power plants and others, be "safe."

Although this is a popular way to refer to these facilities, it is not meaningful. As discussed above, there is always some uncertainty about accidents that may lead to undesirable consequences. The proper way to phrase it is to demand that these facilities be safe enough. In other words, there are no facilities that are safe in an absolute sense because safety is a continuum. When we say that a facility is safe enough, we recognize that there is a residual risk that is deemed acceptable or tolerable.

The question then naturally arises as to why we should accept or tolerate any residual risk. The answer is that these facilities provide benefits to society that outweigh the residual risk. If there is no benefit, there is no reason for us to tolerate any residual risks. For example, in the case of nuclear power plants, the benefit to society is the electricity they provide without the emission of greenhouse gases as well as their contribution to Japan's energy security. These benefits are, of course, instrumental to

the well-being of a modern society.

The conclusion is that the tolerability of any residual risk involves a risk-benefit evaluation. However, this evaluation is never done explicitly with numbers because, unlike the residual risk, it's very difficult to calculate the benefit numerically. As individuals, we trade off risks and benefits all the time. An interesting research finding is that we are willing to tolerate relatively high risks when we feel that we have control over the activity and we undertake it voluntarily. For example, some people enjoy piloting small airplanes even though statistics show that the risk of death is fairly high, certainly much higher than that from flying in commercial airplanes.

In the case of industrial facilities, the risk-benefit tradeoffs are made by society and its representatives. In particular, in some countries, the regulatory agencies have set goals for the residual risk from nuclear power plants. These goals are stated as policies and are the results of expert deliberations and public debates. For example, the United States Nuclear Regulatory Commission has set a goal that the residual risk of acute death from nuclear accidents should be significantly smaller than the risk of death from all other societal accidents. This policy was established after six years of deliberations among the NRC staff, the Advisory Committee on Reactor Safeguards, and external stakeholders. These goals are supplemented by "subsidiary" goals in terms of core damage accidents and the release of large amounts of radioactivity. For example, it has been proposed that, in Japan, in addition to subsidiary goals for core damage frequency and containment failure frequency, there should be another subsidiary goal for the frequency of accidental release of large amounts of cesium, a long-lived radioactive material. A similar proposal has been published by the Canadian Nuclear Safety Commission.

In summary, it is not meaningful to say that an activity or facility is safe or unsafe. The proper way to say it is that the residual risk is tolerable or acceptable given the benefits that are derived from this activity or facility. The NRRC is helping Japanese utilities to accurately quantify the residual risk from nuclear power plants so that measures can be taken to reduce it to as small a number as possible.