Lessons to be Learned from Fukushima

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Abstract: In the years preceding the Fukushima disaster, most major nations in the world had come to the conclusion that, for reasons of energy independence and environmental responsibility, nuclear power must play a central role in their energy strategies for the 21st Century. A number of these nations, notably Germany, have now decided to phase out their use of nuclear power because of damage to the Fukushima Daiichi nuclear power station by a tsunami. Others have adopted the approach of learning the lessons of Fukushima and incorporating them into their plans for a nuclear future.

Some of the most important lessons are in the field of engineering, as they were in the case of the reactor accident at Chernobyl. In the aftermath of the Fukushima accident, for example, the protection of on-site power supplies from flooding is being reviewed and will be up-graded where necessary.

In the field of radiation protection, there are several notable lessons that should be learned from Fukushima, particularly:

1. The safety features of the reactors provided significant scope for the management of the emergency and the limitation of radiation exposures, even though they were of out-dated design and were partially compromised by damage.
2. The health effects of accidental exposure to radiation were actually quite small.
3. The risks from exposure to radiation at Fukushima were and are substantially less than they were at Chernobyl.

Outside the former USSR, the nuclear industry continues to be one of the safest industries in which to work and the safest way to generate most of the electricity the world needs.

Key Words: Fukushima, tsunami, nuclear power, risks from radiation.

1. Introduction

By the beginning of 2011, most major nations in the world had come to the conclusion that nuclear power must play a central role in their energy strategies for the 21st Century. This was driven mainly by concerns about emissions of carbon dioxide but a necessary factor was that public acceptance of nuclear power had recovered from the shocks of the reactor accident at Three Mile Island in 1979 and the Chernobyl disaster in 1986 [1].

The great tsunami on 11th March 2011 in North-Eastern Japan changed all that when it caused the nuclear emergency at Fukushima Daiichi. A number of nations (notably Germany and perhaps Switzerland) decided to phase out their use of nuclear power or shelve plans for its use. Others, including some that must actually face the risk of a tsunami, have adopted a more realistic approach, *viz*: to learn the lessons of Fukushima and incorporate them into their plans for a nuclear future.

Britain, for example, continues with its intention to embark on a major new programme of nuclear plant construction, and has announced dramatic cuts to its emissions of carbon dioxide that would be difficult to envisage without the use of nuclear power.

However, there are clearly many people in the world who fear a nuclear renaissance. Although such fears are understandable, they overlook several important facts, as follows:

- The health effects and risks from exposure to radiation at Fukushima were quite small.

- The Fukushima accident was solely due to a tsunami.
- Engineers learn from experience. The protection of reactor safety systems from flooding is being reviewed and will be up-graded where necessary.

2. Engineering

The accident at Chernobyl was the worst that could happen – a full core meltdown in a reactor that had no containment [1,2]. Apart from Chernobyl, there has never been a death recorded due to accidental exposure to radiation from any commercial reactor in the 60-year history of nuclear power generation. At Three Mile Island, the reactor had a proper containment: there were no radiation injuries and no radioactive release of any significance [1].

At Fukushima Daiichi, the reactors shut-down safely when struck by the fourth largest earthquake ever recorded, but they were then inundated by a much larger tsunami than had been anticipated in the design. This caused the protracted loss of all power supplies on the power station site, so that the reactor cores overheated. Fission products were released from the fuel and hydrogen was generated by chemical reaction between the fuel cladding and the water coolant. Communications on the site were also lost.

The containments of the 40-year old reactors at Fukushima Daiichi were partially effective although they were damaged by hydrogen explosions and probably by molten fuel. Releases of radioactive materials into the environment were much lower than at Chernobyl. There were more than 20,000 deaths in the vicinity, caused directly by the earthquake and tsunami, but none attributable to radiation.

3. Exposures to radiation

Severe potential hazards have existed on the reactor site at Fukushima Daiichi due to high levels of radiation but health physics controls have mainly been effective. There appear to have been at least two substantial failures of these controls:

- Three workers ignored alarms from their dosimeters for three hours while ankle deep in contaminated water. Two of them were not wearing gum boots and received burns from beta-radiation. They were discharged from hospital after two days. These appear to have been the only radiation injuries to date.
- Two workers, who inhaled iodine-131 while working in reactor control rooms without breathing apparatus, are reported to have incurred internal exposures of about 200-580 mSv (effective doses) in addition to external exposures of 88 and 103 mSv respectively. There have been no ill effects.

Doses of 100 to 250 mSv incurred by about a hundred other workers have been high enough to cause a small risk of developing cancer after 20 or more years. About 25% of the population dies from cancer whether accidentally exposed to radiation or not. This rate might be increased by an additional one or two percent (say from 25% to 27%) for these workers. Exposures to radiation have been nowhere near high enough to cause acute radiation sickness (ARS).

The announcement on 12 April 2011 of an increase of the Fukushima event from 5 to 7 on the International Nuclear Event Scale has given the misleading impression that it is as bad as the Chernobyl accident. This impression has been used and exaggerated in anti-nuclear propaganda. There is actually no possibility that the physical health consequences of damage to the Fukushima plants will get anywhere near those of Chernobyl.

At Chernobyl, there were 134 cases of ARS; 28 of them caused death [1,2]. Altogether, there have been about 50 radiation-caused deaths, and several thousand delayed cancer fatalities are predicted [2]. Several thousand cases of thyroid cancer (typically 5% fatal) have been attributed to inhalation and ingestion of radioactive iodine by children [2].

At Fukushima, there have been no radiation injuries to children or to other members of the public. It is to be expected that every case of cancer that occurs in Japan over the next 40 years, starting now, will be blamed by those affected on radiation from Fukushima. And, probably, many other diseases also, ranging from heart failure to children's nose bleeds – as they were at Chernobyl. This would be entirely understandable but will have no basis in science. As far as is known, no member of the public received a significant dose due to the Fukushima reactor emergency and no physical health effects of radiation should be expected.

The dose rate from natural background radiation normally averages about 1.5 mSv/y in Japan. Although external radiation levels 10 to 100 times normal have been recorded around Fukushima, these have been only temporary in any one place. More than 100,000 residents were evacuated as a precaution (or left voluntarily) from the areas 20 to 30 km from the power station where the dose due to the accident was expected to exceed 20 mSv within the year.

A dose of 20 mSv could be incurred within a few minutes from a diagnostic CT scan. The dose rate from natural background radiation is normally more than 20 mSv/y in some parts of the world without causing any discernible harm. At Ramsar in Iran, natural radiation ranges up to 260 mSv/y. Ramsar is a spa where people go for the good of their health.

As at Chernobyl, the major public health effect of the Fukushima accident has been psychological, due to the forced relocation of population and exaggerated fears about radiation. Fortunately, the Japanese government is undertaking radiation monitoring and decontamination of the evacuated areas at Fukushima, and residents who were required to evacuate are already being allowed to return home for brief visits. At Chernobyl, relocation was permanent.

Unfortunately, the news media have taken an alarmist approach in their reporting. This must be contributing significantly to the mental anguish and psychological damage of the Japanese public.

4. Lessons to be Learned

4.1 Lesson 1

At Fukushima Daiichi, the reactors shut-down safely when struck by the fourth largest earthquake ever recorded. The nuclear emergency was due entirely to loss of on-site power supplies when the power station was inundated by a much larger tsunami than had been anticipated in its design. Clearly, the design of nuclear plants against the risk of flooding (from any cause) needs to be brought up to the level of design against seismic risk.

4.2 Lesson 2

Rating the nuclear accident at Fukushima as 7 on the International Nuclear Event Scale (INES) has given the misleading impression that it was as bad as the Chernobyl accident. At Fukushima, no physical health effects of radiation have been observed among the general public and effects on workers have been far lower than those at Chernobyl. The INES was meant to aid public

understanding of nuclear safety but has, in fact, made it more confused. The INES should be substantially modified or scrapped.

4.3 Lesson 3

As at Chernobyl, the major public health effect of the Fukushima accident has been psychological, due to the forced relocation of population and exaggerated fears about radiation. In such circumstances, of course, the public must be evacuated as a precaution when it is not known how the situation will develop. However, they would be better off being allowed to return to their homes once it is certain that the situation is under control and that potential exposure levels are not dangerous. Using a dose rate of 20 mSv/y as a reference for this purpose is conservative. Many people in the world are exposed naturally to higher levels of radiation than this without discernible adverse health effects. It is counterproductive to behave as though 20 mSv/y is a dangerous dose rate.

4.4 Lesson 4

Outside the former USSR, the nuclear industry continues to be one of the safest industries in which to work and the safest way to generate most of the electricity that the world needs.

Sources of Information

Reference [1] Higson, D.J. (1979 to date), the author has collected copious information on the reactor accidents at Three Mile Island in the US (1979) and Chernobyl in Ukraine (1986) since their dates of occurrence.

Reference [2] The Chernobyl Forum (2005), "Chernobyl Legacy: Health, Environmental and Socio-economic Impacts."

Apart from the above references, this paper is based on information available on the Internet from:

- Tokyo Electric Power Company (TEPCO)
- and the Nuclear & Industrial Safety Agency (NISA, the Japanese regulatory authority)
- through the International Atomic Energy Agency (IAEA)
- and provided directly by the World Nuclear Association (WNA)