The Estimation of Chronic Health Effects for the Normal Operation of Nuclear Power Plants Using the NukPacts Model

Jongtae Jeong, Tae Woon Kim, Jaejoo Ha
Integrated Safety Assessment Division, Korea Atomic Energy Research Institute, jtjeong@kaeri.re.kr

1. Introduction

The potential health effects resulting from the atmospheric releases during a normal operation of nuclear power plants are estimated. Also, the health effects resulting from the hypothetical severe accidents of the typical 1,000 MWe KSNP(Korea Standard Nuclear Plant) and the typical 600 MWe CANDU plant were estimated. We estimated the health effects by using the NukPacts[1] model developed by the IAEA. And the results are presented as damage costs in dollars and compared.

2. Methods and Results

In this section the characteristics of the NukPacts model and the necessary input data are described. And the results and discussions for the four sites in Korea are presented.

2.1 NukPacts Model

The NukPacts model implements a method for quantifying and evaluating the potential adverse health effects to people arising from routine atmospheric releases of radioactivity from nuclear generating systems. NukPacts follows an exposure pathway framework as shown in Figure 1, which uses an atmospheric dispersion, deposition to soil and vegetation, and an uptake by various agricultural products. Radiological doses are calculated for local and regional populations. Based on the dose calculations, the model estimates the stochastic health effects and carries out a valuation of the predicted health effects.

Upon the execution of the NukPacts model, a user is asked to enter parameters in four general categories: dispersion and receptor, emissions and meteorology, food consumption, and health effects and valuation. There are four major exposure pathways considered in the NukPacts model, namely: a direct inhalation of radionuclides in the air, an external irradiation from an immersion in radioactive clouds, an external irradiation from radionuclides which have deposited on the ground, and an ingestion of radionuclides through consumption of various agricultural products. NukPatcs calculates the collective dose for all of the pathways for the local and regional areas. The model then calculates potential health risks in cases per year and assigns a dollar value to the potential health effects.

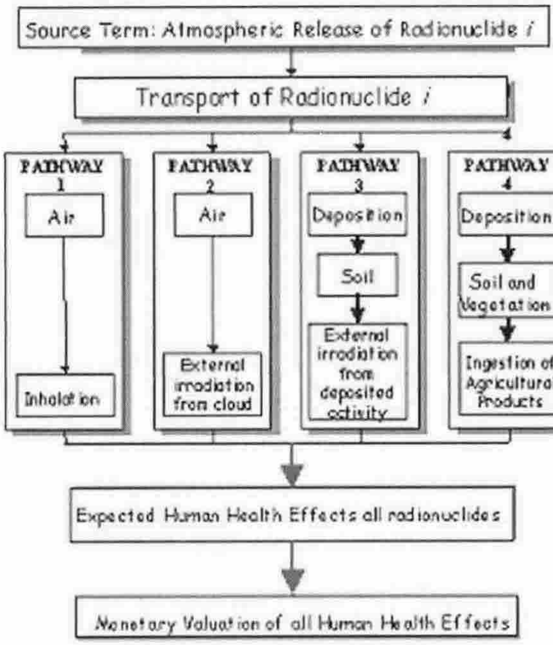

Figure 1. Flow diagram of NukPacts

2.2 Input Data

The most important data for the execution of the NukPacts model are the emissions and meteorology data. The release rates of radionuclides in the year of 2003 for the four sites are summarized in Table 1.

Table 1. Emissions of radionuclides (Bq/sec)

Site / Radionuclides	Kori	YGN	UCN	WS
H-3	1.82×10^{5}	4.20×10^{5}	1.41×10^{5}	1.02×10^{7}
C-14	-	-	-	2.06×10^{4}
Co-58	-	5.46×10^{-2}	3.71×10^{0}	-
Co-60	-	8.66×10^{-4}	7.45×10^{-1}	-
Kr-85	6.67×10^{2}	4.95×10^{4}	5.23×10^{4}	-
I-131	6.90×10^{0}	4.20×10^{-1}	5.45×10^{0}	1.82×10^{-3}
I-133	-	2.04×10^{-3}	2.46×10^{-5}	-
Xe-133	2.10×10^{5}	4.41×10^{5}	7.26×10^{1}	6.80×10^{5}

The site specific data such as population density, average wind speed and the occurrence of stability classes are derived from the report[2]. The stochastic health effects estimated in NukPacts model are fatal cancer, non fatal cancer, and severe hereditary effects. The risk factors for these health effects in cases per man Sv are 0.05, 0.1, and 0.01, respectively[3]. The economic unit value of the three health effects in US$ for the year 2000 suggested by the IAEA are 4.92×10^{5}, 3.67×10^{5}, 1.10×10^{6}, respectively.

2.3 Results and Discussions

The damage costs of each radionuclide based on the assumption of an equal release rate of 100 Bq/sec are plotted in Figure 1. As shown in Figure 2, the radionuclides with a relatively long half life such as cobalt, cesium, and carbon-14 have a greater impact on health effects than those with a short half life. And the noble gases such as xenon and krypton have a relatively smaller impact on the stochastic health effects.

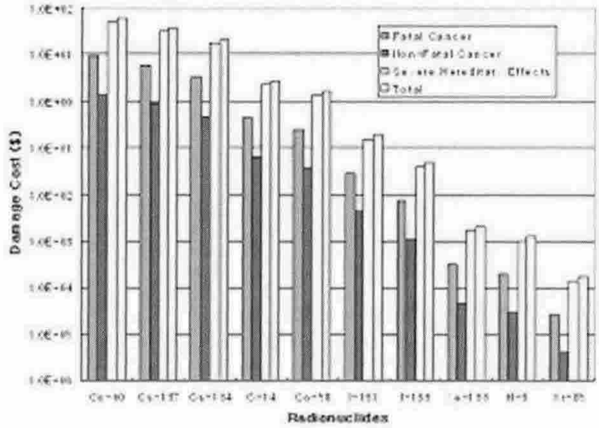

Figure 2. Damage costs of radionuclides

The damage costs of the four sites are shown in Figure 3. The damage costs for Ulchin site is the smallest for the three sites with PWR plants. The main reason for this fact is that the population density of the Ulchin site is lower than the other sites by the magnitude of one order.

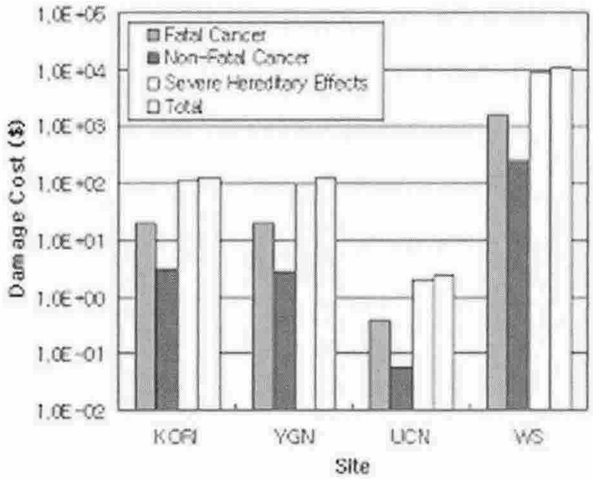

Figure 3. Damage costs for a normal operation

The Wolsong site shows the maximum damage cost among the four sites. Because the Wolsong site has four PHWR plants, the release rate of radionuclides is different from those sites with the PWR plants. That is, the release rate of tritium is higher than the other sites by the magnitude of two. Also, the Wolsong site has a very high release rate of carbon-14 though there is no release of carbon-14 at the sites with PWR plants. Also, the population density of the Wolsong site is the highest among the four sites.

The damage costs resulting from the hypothetical severe accidents of the Ulchin Unit-3 and Wolsong Unit-1 plant were estimated and compared with those arising from routine atmospheric releases of radioactivity for the four sites, as shown in Figure 4. For severe accident cases, the damage costs of both sites are nearly equal. However, the damage costs resulting from severe accidents are higher than those for a routine release of radioactivity.

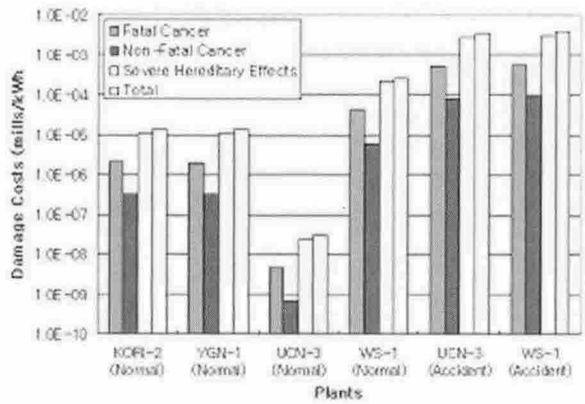

Figure 4. Comparison of the damage costs for a normal operation and severe accidents

3. Conclusion

The estimation of damage costs resulting from the atmospheric releases during a normal operation of nuclear power plants can be a useful measure for comparing the radiological impact on the human health. The release rate of radionuclides with a long half life and the local population density are very important factors in the estimation of the radiological impacts on chronic human health.

Acknowledgement

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