

The Comparison of Externalities between Coal-Fired and Nuclear Power Plants

Jongtae Jeong, a Tae Woon Kim, a and Jaejoo Ha

a Integrated Safety Assessment Division, Korea Atomic Energy Research Institute, jtjeong@kaeri.re.kr

1. Introduction

Fuel cycle externalities are the costs imposed on society and the environment that are not accounted for by the producers and consumers of energy. Traditional economic assessment of fuel cycles has tended to ignore these effects. However, there is a growing interest in adopting a more sophisticated approach involving the quantification of these environmental and health impacts of energy use and their related external costs. The fuel cycle externalities can be used for the internalization of them into the electricity price via eco-taxes and on undertaking cost-benefit analysis of available options by the policy analysts. The advantage of using externalities as criteria in the energy planning process instead of the common indicators such as pollutant emissions is that the criteria are expressed in the same monetary terms. The objective of this study is to estimate and compare the externalities for the coal-fired and nuclear power plants in Korea. The results are also compared with the European results.

2. Methods and Results

The fuel cycle externalities of electricity generation differ greatly, depending on the fuel choice, technology, and location. The total amount of electricity generation in Korea is about 41% from nuclear power plants and 37% from the coal-fired plants. Therefore, we estimated and compared the externalities for both coal-fired and nuclear power plants.

According to the results of the ExternE project[1], the impact on global warming and environmental pollution are the key externalities for all fossil fuels. However, the range of estimated results for the global warming effects is so broad that it is not considered in this study. Therefore, we estimate the costs for human health effects resulting from the routine release of pollutants for the coal-fired plants.

For nuclear power most environmental externalities such as those for waste management and decommissioning have essentially been internalized into the generating costs. Therefore, we estimated the externalities resulting from a normal operation and severe accidents for the typical 1,000 MWe PWR and the typical 600 MWe PHWR plant.

2.1 Estimation of the externalities for coal-fired plants

The reference site for calculating the externalities resulting from the release of pollutants from coal-fired plants is the Taean plants[2]. The Airpacts[3] program used in this study calculates the physical and the associated damage costs for the following type of pollutants: particulate matter (PM10), sulfur dioxide (SO₂), nitrogen oxides (NO_x), carbon monoxide (CO), and secondary species such as nitrate and sulfate aerosols.

The emission rates of PM10, SO₂, NO_x in tons per year for the year 2002 are 545.2, 16712.4, 4250.2, respectively. We assumed that the locations of the plant were Ulchin and Wolsong in order to compare the external costs resulting from the nuclear power plants. The unit costs for valuing the health effects suggested by the IAEA are summarized in Table 1[3].

Table 1. Unit costs for valuing the health effects

Health Endpoint	Pollutants	Cost (\$/case)
Chronic mortality	PM10, Nitrates, Sulfates	1.87E+5
Infant mortality	PM10, Nitrates, Sulfates	1.87E+5
Acute mortality	SO ₂	1.49E+5
Bronchitis	PM10, Nitrates, Sulfates	1.26E+5
Restricted activity days	PM10, Nitrates, Sulfates	90

The externalities for pollutants per unit of energy generated resulting from the emission of pollutants are plotted in Figure 1. The most important pollutant for externalities in this study is PM10, which amounts about 99.9% of the total externalities. And the externalities for the case of the Wolsong site are larger than the Ulchin site because the population density of the Wolsong site is greater than the Ulchin site by the magnitude of an order of two. Therefore, the location of the plant is an important factor for the externality estimation.

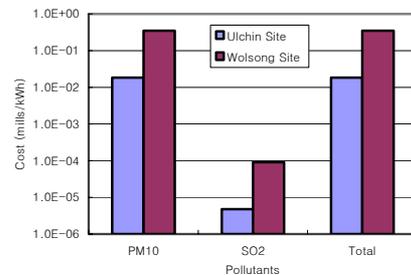


Figure 1. External costs for various pollutants

2.2 Estimation of externalities of nuclear power plants

The externalities resulting from the routine release of radioactive materials are calculated by using the NukPacts program[4]. The external costs for severe accidents of nuclear power plants are estimated by multiplying the total number of fatalities and injuries and the unit costs suggested by the IAEA[4]. The number of fatalities and injuries were derived from the results of Jeong et al.[5]. The unit cost for the fatalities and injuries used in this study are 4.92E+05\$, 3.67E+05\$, respectively.

The results are plotted in Figure 2. For the case of the PWR plant, the external costs of a normal operation are negligible because the effect of C-14 is not considered. However, for the PHWR plant the costs of a normal operation amounts to about 45% of the total cost because of a large population density and large emission of H-3 and C-14.

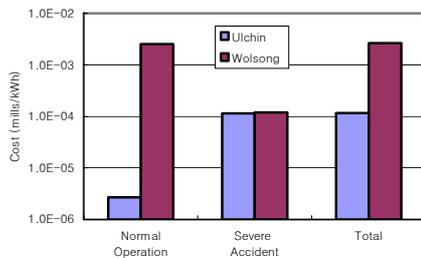


Figure 2. Comparison of external costs for PWR and PHWR

2.3 Comparison of Externalities

The externalities per unit of energy generated for the coal-fired and nuclear power plants are plotted in Figure 3. As can be seen in the figure, the externalities resulting from the health effects for nuclear power plants are much lower than those of the coal-fired plants.

The external costs for other countries adopted from the results of the ExternE project are plotted in Figure 4. They show similar trends in the comparison of externalities of the coal-fired and nuclear power plants. However, the results of this study are lower than those of ExternE project because the regional and global impacts are not considered in this study.

3. Conclusion

The externalities per unit of energy generated for the coal-fired and nuclear power plants are assessed and compared. Although all the external cost items are not considered, we can obtain important insights from the comparison of externalities between the coal-fired and nuclear power plants. The nuclear power plants are superior to the coal-fired plants from the viewpoint of

external costs which are not internalized at the market prices. Therefore, the economic competitiveness of nuclear power could significantly increase if these externalities were taken into account. Although further research is required to estimate the externalities for other power generation sources and all the cost items for each fuel cycles, the results in this study can provide a comprehensive analysis of the human health effects and the resulting external costs from electricity generation.

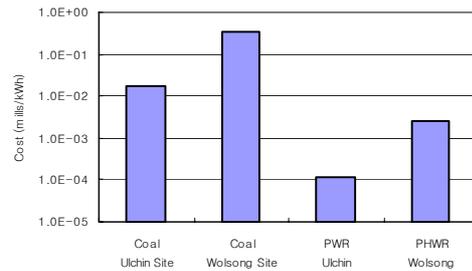


Figure 3. Comparison of the externalities

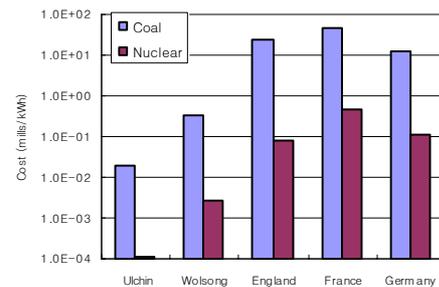


Figure 4. Comparison of the externalities with the results of the ExternE project

Acknowledgement

This project has been carried out under the Nuclear R&D Program by MOST.

REFERENCES

- [1] J. Berry, et al., " Externalities of Energy, ExternE Report," EUR-16522, EC, 1995.
- [2] 한국서부발전(주), "태안화력본부, 2003년도 환경보고서", 2003.
- [3] J. V. Spadaro, "AirPacts Impact Methodology," IAEA, Oct. 2002.
- [4] A. Markandya and R. Boyd, "Valuing the Human Health Effects of Routine Atmospheric Releases from Nuclear Facilities," IAEA, May 1999.
- [5] Jongtae Jeong, et al., "An Assessment of Hypothetical Severe Accident Risks for KSNP and PHWR Plants in Korea," KAERI/TR-2730/2004, 2004.