Comparative Health Risk Assessment of CdTe Solar PV System and Nuclear Power Plant

Sang Hun Lee[1], Hyun Gook Kang[2,*]

1. Department of Nuclear and Quantum Engineering, Korean Academic Institute of Science & Technology (KAIST), Daejeon, Korea (titanic91@kaist.ac.kr)
2. Department of Nuclear and Quantum Engineering, Korean Academic Institute of Science & Technology (KAIST), Daejeon, Korea (hyungook@kaist.ac.kr)

Abstract: In terms of national energy policy decision-making process, several key factors, including low production cost, negligible risk or impact to environment and population around the facility, must be considered. The purpose of this paper is to assess the public health risk in case of postulated nuclear power plant and CdTe solar PV system accident and compare the estimated public health risk. Both systems release toxic materials to the environment which adversely affect nearby population by exposure from the inhalation and ingestion of the toxic material transported via air. By simulating the airborne transport of released toxic material using Gaussian plume model and modeling exposure pathways to nearby population, average individual health risk is assessed and public health risk per power capacity of each system is compared. The result shows that the average public health risk per power capacity of NPP is less than the case of solar PV system. This implies that NPP has lower risk in terms of public health risk in case of severe accident while it can be used as more reliable energy source than renewable energy source so that NPP would take priority over other renewable energy sources in terms of national energy policy.

Keyword: Probabilistic risk assessment, Solar PV system, NPP, Public health risk

1 Introduction

In an increasingly competitive global energy market, a number of key factors affect not only the energy choice, but also the extent and manner in which different energy sources are used. These factors include: energy efficiency, faster demand response, low generation cost and minimized environmental impact which affects public health[1]. Nuclear power plant (NPP) and renewable energy options, such as wind turbine generator, and solar photovoltaic (PV) system are considered to be most reasonable options existing which can provide national energy services in a sustainable way.

NPP generates large amount of electricity from the fission reaction of nuclear fuel for civilian purposes. Nonetheless of its high efficiency of electricity generation and economic feasibility of NPP, the primary concern has been arisen that radioactive fission products may escape into the environment and cause severe health effect on public in the case of accidental release of radioactive material. After Fukushima accident, human radiation exposure assessment as a result of reactor accident have become important issue and the comparative assessments of the environmental and health impacts for various electricity generation systems, such as NPP, renewable energy and coal power plant, have been studied[2][3].

Solar PV system is considered as one of the most promising renewable energy source which can be used as both residential and utility scale and able to provide significant environmental benefits in comparison to conventional energy sources. Solar PV system generate electricity by converting solar radiation into direct current electricity using semiconductors, such as monocrystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride. Especially, residential PV system has become one of the most prominent dispersed generation system capable of providing enough AC electricity to power a single home even with a small-scaled residential PV system. Although solar PV system is seen to be generally of benign environmental impact, generating no noise or chemical pollutants during its use, studies have shown a potential risk that a fire accident in an array might cause the release of toxic substances into the environment in the case of cadmium telluride (CdTe) PV modules[4][5][6].

In this paper, consequence analysis of postulated NPP accident and fire incident at CdTe solar PV system is conducted in terms of associated environmental release of toxic materials, such as radioactive material in NPP and carcinogenic material in CdTe PV module. Additionally, comparison between two energy options regarding potential health risk on public is discussed using probabilistic risk assessment (PRA) methodology.

2 Methodology

2.1 Probabilistic Risk Assessment

Probabilistic risk assessment is a systematic and comprehensive methodology to evaluate risks by computing real numbers to determine what can go wrong, how likely is it, and what are its consequences[7]. Risk in PRA is characterized by two quantities: 1) the magnitude (severity) of the possible adverse consequence, and 2) likelihood (probability) of occurrence of each consequence. Both consequence and its likelihood of occurrence are expressed numerically and the total risk is the sum of the products of the consequences multiplied by their probabilities.

In the cases of NPP accident and fire incident at CdTe solar PV system, there are potential hazards on public health effect. Inhalation or ingestion of the released radioactive or carcinogen materials may cause severe health hazard to nearby population and the consequence for each case is calculated numerically as health effect case caused by intake of the released hazardous material.

In order to determine the probability of each accident, the general procedures for risk calculation and statistical data bases are reviewed based on specific accident scenarios. The probability of defined accident in the case of NPP accident and the probability of fires at residential houses involving the rooftop installed solar PV fire incidents in the case of residential CdTe PV module and additional data for analysis are investigated.

2.2 Nuclear Power Plant

2.2.1 Approach

Radioactive materials, resulting from nuclear fission reaction in reactor, give significant public health risk in case of accidental release from NPP. When severe accident of NPP which results in release of the radioactive material occurs, some fraction of radionuclides, specified by the accident scenario, are released to the environment and transported via atmosphere. During the atmospheric transfer, radioactive materials are deposited over land and cause the contamination of air, water, soil and food adversely affecting human health by direct exposure, including cloudshine and inhalation, in short period of time and by indirect exposure, including groundshine and ingestion of contaminated food or water, for long period of time.

Assessment of public health risks associated with accidental release of radioactive material in case of NPP accident requires: 1) specifying quantities of byproducts of nuclear fission reaction which is core inventory of NPP, 2) release description, such as release fraction of radionuclides, duration of release, meteorological condition and site-specific data, 3) atmospheric transfer model for simulating airborne transport of released radioactive material, 4) response of exposed population for various exposure pathways, and 5) probability of the specified accident of NPP.

2.2.2 Analysis

For consequence analysis, atmospheric dispersion model is used for accidental airborne radionuclide release from conventional 1000 MW NPP. As a result of level 2 PRA, source term information in case of hypothetical NPP accident is given[7]. Source term information includes not only the amount of the radionuclides, but also the release fraction of each radionuclide group since the release description differs from each accident sequence. For the release fraction of each chemical group, steam generator tube rupture accident with the containment bypass condition (STC-19) case is assumed. The estimated quantities of core inventory are shown in Table 1.

Table 1. Core inventory of conventional 1000 MW NPP[7]

Radioactive Isotope	Radioactivity (Bq)	Radioactive Isotope	Radioactivity (Bq)	Radioactive Isotope	Radioactivity (Bq)	Radioactive Isotope	Radioactivity (Bq)
Co-58	4.78E+13	Zr-95	3.09E+18	Te-131	3.47E+17	La-141	3.37E+18
Co-60	6.40E+14	Zr-97	3.46E+18	Te-132	3.20E+18	La-142	3.19E+18
Kr-85	5.52E+16	Nb-95	3.08E+18	I-131	2.31E+18	Ce-141	3.38E+18
Kr-85m	3.75E+17	Mo-99	4.00E+18	I-132	3.26E+18	Ce-143	3.98E+18
Kr-87	6.65E+17	Tc-99m	3.50E+18	I-133	4.38E+18	Ce-144	2.59E+18
Kr-88	9.23E+17	Ru-103	4.25E+18	I-134	4.77E+18	Pr-143	2.95E+18
Rb-86	1.40E+16	Ru-105	3.45E+18	I-135	4.15E+18	Nd-147	1.44E+18
Sr-89	1.18E+18	Ru-106	2.47E+18	Xe-133	4.42E+18	Np-239	5.84E+19
Sr-90	4.43E+17	Rh-105	3.12E+18	Xe-135	8.58E+17	Pu-238	4.64E+16
Sr-91	1.69E+18	Sb-127	3.00E+17	Cs-134	1.67E+18	Pu-239	8.45E+14
Sr-92	1.98E+18	Sb-129	8.10E+17	Cs-136	3.66E+17	Pu-240	1.62E+15
Y-90	4.71E+17	Te-127	2.99E+17	Cs-137	9.05E+17	Pu-241	5.34E+17
Y-91	1.69E+18	Te-127m	4.14E+16	Ba-139	3.76E+18	Am-241	5.65E+14
Y-92	1.99E+18	Te-129	8.10E+17	Ba-140	3.59E+18	Cm-242	3.70E+17
Y-93	2.52E+18	Te-129m	1.20E+17	La-140	4.02E+18	Cm-244	2.44E+17

Exact analysis of source term requires knowledge of physical, chemical characteristics of each radionuclides and several thermodynamic properties (e.g. heat content of the released radionuclides, time variations according to the release, or probability of release). Release description parameters are assumed to have reasonably conservative values. The release description of radioactive material released used in this analysis is shown in Table 2.

Table 2. Release description of accidental radionuclide release from NPP

Parameter		Value
Plume release height		1 (m)
Duration of plume		86400 (s)
Deposition velocity		0.01 (m/s)
Frequency of STC-19 accident		1.43E-06
Release fraction for each chemical group	Xe group (Kr, Xe)	9.50E-01
	I group (I)	1.30E-01
	Cs group (Rb, Cs)	1.30E-01
	Te group (Sb, Te)	4.90E-01
	Sr group (Sr)	8.60E-04
	Ru group (Co, Mo, Tc, Ru, Rh)	4.60E-02
	La group (Y, Zr, Nb, La, Pr, Nd,, Am, Cm)	1.90E-04
	Ce group (Ce, Np, Pu)	7.10E-04
	Ba group (Ba)	1.40E-02

To simulate the transport of airborne radioactive material released into the environment, Gaussian plume model is used for the atmospheric transport of gaseous radionuclides and calculation of the ground level concentration due to the deposition from plume to ground. Gaussian plume model is a relatively simple mathematical model that is typically applied to point source emitters. Because it is simple and computationally efficient, Gaussian plume model has been used as the standard atmospheric dispersion model for reactor accident risk assessment[8]. Gaussian plume model assumes the diffusion of gas molecules and aerosol particles in the plume during its downwind transport is modeled as a random walk that generates a normal distribution for air concentration in all directions.

MELCOR Accident Consequence Code System 2 (MACCS2), developed by Sandia National Laboratories (SNL), is used to estimate radiological doses, public health effects[9]. The brief MACCS2 flow diagram is shown in Fig. 1. In MACCS2, The principal phenomena considered are atmospheric transport and deposition under time-variant meteorology, short and long-term mitigative actions and exposure pathways, deterministic and stochastic health effects, and economic costs. It includes three primary modules: ATMOS, EARLY, and CHRONC.

ATMOS module employs a Gaussian plume model with Pasquill–Gifford dispersion parameters to calculate the dispersion and deposition of materials released to the atmosphere as a function of downwind distance.

EARLY module performs all of the calculations pertaining to the emergency phase. The exposure pathways considered during this phase include cloudshine, groundshine, and resuspension inhalation. In case of dose calculation, acute dose used for the estimates of early fatalities and injuries, and lifetime dose commitment used for the estimates of associated excess cancer risks resulting from early exposure.

CHRONC module performs the calculations during the intermediate and long-term phases. The associated exposure pathways during the intermediate phase are groundshine and resuspension inhalation, and the pathways during the long-term phase are groundshine as well as food and water ingestion.

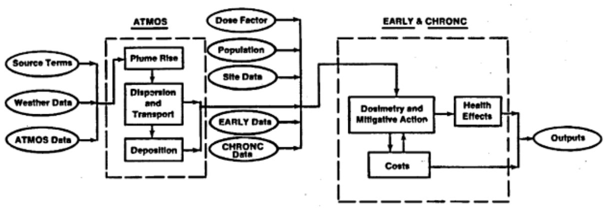

Fig. 1. Flow diagram of MACCS2 code.

Meteorological condition, such as wind speed and wind direction, is important for airborne transport. Population dose and public health effect vary significantly according to population data around specific distance from NPP site. Hourly meteorological data and population data around 20 km buffer from NPP site are prepared to be used as input data for simulation, as shown in Table 3 and 4[10].

Table 3. Population data around 20 km buffer from NPP site[10]

Wind Direction	0.00 to 1.60 km	1.60 to 3.20 km	3.20 to 4.80 km	4.80 to 6.40 km	6.40 to 8.00 km	8.00 to 9.60 km	9.60 to 11.20 km	11.20 to 12.80 km	12.80 to 14.40 km	14.40 to 16.00 km	16.00 to 20.00 km	Total
N	107	321	535	919	1501	2406	3670	4183	3691	2576	3820	23729
NNE	107	321	535	1826	1826	3300	2896	3094	1711	605	4	16225
NE	107	318	487	635	54	49	0	0	0	0	0	1650
NEE	97	56	44	199	0	0	0	0	0	0	0	396
E	60	0	0	0	0	0	0	0	0	0	0	60
SEE	60	0	0	0	0	0	0	0	0	0	0	60
SE	60	0	0	0	0	0	0	0	0	0	0	60
SSE	60	0	0	0	0	0	0	0	0	0	0	60
S	60	0	0	0	0	0	0	0	0	0	0	60
SSW	104	48	0	0	46	40	1762	4214	4552	4319	10090	25175
SW	102	36	32	565	1102	1339	1608	7001	7458	5209	10211	34663
SWW	104	221	448	750	1565	2079	2271	2053	1365	1261	991	13108
W	104	311	518	725	1261	2805	4043	4224	4193	2714	501	21399
NWW	105	312	518	725	932	1595	1641	0	112	182	100	6222
NW	107	315	518	725	1147	1904	2095	1057	1115	738	3329	13050

NNW	107	321	535	957	1463	1947	2301	2655	2734	2018	5366	20404
Total	1451	2580	4170	8026	10897	17464	22287	28481	26931	19622	34412	176321

Table 4. Statistics of hourly meteorological data on NPP site[10]

Parameter		Value
Average wind speed		3.115 (m/s)
Wind direction ratio	N	7.53 (%)
	NNE	20.43 (%)
	NE	5.47 (%)
	NEE	3.30 (%)
	E	3.23 (%)
	SEE	3.18 (%)
	SE	4.54 (%)
	SSE	24.16 (%)
	S	5.43 (%)
	SSW	4.68 (%)
	SW	3.94 (%)
	SWW	2.12 (%)
	W	1.61 (%)
	NWW	1.91 (%)
	NW	4.17 (%)
	NNW	4.29 (%)
Stability class ratio	A (very unstable)	12.18 (%)
	B (moderately unstable)	5.24 (%)
	C (slightly unstable)	6.82 (%)
	D (neutral)	35.29 (%)
	E (stable)	20.43 (%)
	F (very stable)	20.05 (%)

Using the source term data and site-specific data, average individual risk for NPP, calculated as the sum of early fatality risk and cancer fatality risk, is assessed.

2.3. CdTe Solar PV System

2.3.1 Approach

Cadmium telluride is a semiconductor compound used in CdTe PV module, which is an important thin film PV technology that has grown more rapidly than conventional silicon solar technologies in recent years and significant market share for thin film solar modules is forecasted for the year 2020[11]. CdTe PV technology provides low production cost combined with durability, high efficiency compared with other thin film technologies, better performance in high temperature conditions, and the lowest carbon footprint and energy payback among PV technologies. Nonetheless of its advantages over conventional energy sources, concerns exist regarding the health hazards associated with the release of these materials from PV module during fire. Cadmium is considered as a probable human carcinogen, classified as a Group B1 by U.S. EPA, and the major concern is from chronic inhalation or oral exposure of cadmium which leads to a build-up of cadmium in kidneys and causes kidney disease[12].

Assessment of public health risk associated with released carcinogenic material from CdTe PV module during fire incident requires: 1) specifying quantities of cadmium present in PV module made for residential usage, 2) rate of release of the materials during a fire or duration of fire causing release of materials, 3) atmospheric transport of released material from a point of release to nearby populations, 4) response of exposed population due to ingestion of carcinogenic material and 5) probability of fire incident at rooftop of residential house.

2.3.2 Analysis

For consequence analysis, fire involving residential (5 kWp) array for CdTe PV modules is examined. The specific release description of fire incident at CdTe PV module is defined as shown in Table 5. In resident-scale PV module, there are 0.6 kg of CdTe element[13]. Analysis of source term requires knowledge of thermal fluxes in the flame front and several thermodynamic properties of these materials (e.g. heat of decomposition, heat of sublimation, or heat of vaporization). Based on the experiment with CdTe PV modules encapsulated in the glass matrix, assuming the CdTe PV module is heated up to 1100 ℃ and follows standard heating rate and duration, the amount of Cd and Te release is assumed to be 0.5% of total amount of CdTe material in PV module in a conservative manner[14]. In order to specify the release description, the fire gutting a residential house is assumed to produce flames at the roof for approximately 15 minutes[15]. The release of PV material is assumed to be in gaseous form.

To assess chronic cancer risk from oral ingestion of contaminated soil, ground-level concentration of toxic material dispersed downwind from the point of release is estimated using a Gaussian plume dispersion model. For conservative analysis, the worst case meteorological conditions (Pasquill stability class F, constant wind velocity of 1 $\mathbf{m/s}$, flat terrain, ground-level release) is assumed. Ground-level concentration of toxic material is simulated by the deposition from downwind transported plume to the ground, characterized by the molecular weight and size of the toxic particles. Ground-level concentration profiles are made for a minimum distance of 100 m to maximum distance of about 1000 m. The 100 m measurement represents the shortest distance at which accurate dispersion calculation is prepared. Concentration of toxic material at the distance beyond 1000 m is thought to have negligible effect on public health effect compared to the distance below 1000 m.

Table 5. Release description of fire incident at residential CdTe PV module

Parameter	Value
Wind speed	1 (m/s)
Duration of release	15 (min)
Amount of CdTe in residential solar PV array (5 kWp)	0.6 (kg)
Release fraction	0.5 (%)
Plume Release Height	1 (m)
Frequency of roof-top fire on residential house	1.00E-04

As previously mentioned, the most hazardous intake mechanism to nearby population is by chronic inhalation and oral exposure of released cadmium due to fire incident. Since short release duration of toxic substance is defined, the critical exposure pathway is assumed to be via oral ingestion of the ground deposited cadmium. U.S. Environmental Protection Agency (EPA) have proposed evaluation method of defining the relationship between dose and response quantitatively using cancer slope factor[16]. Cancer slope factor is used in risk assessment to estimate an upper bound lifetime probability of an individual developing cancer as a result of exposure to a potential carcinogen material and generally reserved for use in the low-dose region of the dose-response relationship. For the oral ingestion of carcinogenic material, the linearized model expressed in terms of risk per unit concentration of the intake rate of the soil is used, as shown in Equation (1).

$$\mathbf{Slope\ factor = risk\ per\ mg/kg/day} \quad (1)$$

By using the defined cancer slope factor for oral ingestion of deposited cadmium, the cancer risk is computed as for each age interval “i”:

$$\mathbf{Risk_i} = \boldsymbol{C\,\frac{IR_i \cdot EF_i \cdot ED_i}{BW_i \cdot AT} \cdot SF \cdot ADAF_i} \quad (2)$$

where, C is chemical concentration in the soil (mg/kg), IR is the ingestion rate of contaminated environmental medium, EF is the exposure frequency, ED is exposure duration, BW is the body weight, AT is averaging time (equal to 70 years * 365 days/year) for quantifying lifetime cancer risk, and SF is the oral ingestion cancer slope factor$(\mathbf{mg/kg \cdot day})^{-\mathbf{1}}$. In the case of soil ingestion, defined oral ingestion cancer slope factor is $\mathbf{3.80 * 10^{-1} (mg/kg \cdot day)^{-1}}$. ADAF is the age-dependent adjustment factor for age interval "i". Standard default exposure parameters for "reasonable maximum exposure" (RME) of resident cancer risk calculation, recommended by U.S. EPA, is described in Table 6[17].

Table 6. Recommended standard exposure parameters for a RME resident cancer risk calculation

Parameter	Units	Age : 0-<2	Age : 2-<6	Age : 6-<16	Age : 16-<50
IR	(mg/day)	200	200	100	100
CF	(kg/mg)	1.00E-06	1.00E-06	1.00E-06	1.00E-06
BW	(kg)	15	15	70	70
EF	(days/year)	350	350	350	350
ED	(years)	2	4	10	34
AT	(days)	25550	25550	25550	25550
SF	(mg/kg-day)-1	3.80E-01	3.80E-01	3.80E-01	3.80E-01
ADAF	(unitless)	10	3	3	1

According to the ground-level concentration of deposited cadmium simulated by Gaussian plume dispersion model, the chemical concentration in the soil, parameter C shown in Equation (2), is estimated. By using the parameters defined in Table 6, average individual risk is calculated as the sum of the risks across all four age intervals.

3 Result

By the analysis, public health risk from accidental radiological release is estimated by the sum of early fatality during emergency phase and cancer fatality by induced latent cancer risk during emergency phase and long term effective dose from latent exposure pathways during long term phase. Public health risks from fire incident of solar PV system are estimated as the lifetime cancer risk due to oral ingestion of contaminated soil using the cancer slope factor for soil ingestion of cadmium.

3.1 NPP

Average individual risks are assessed for various distances up to 20 km from NPP site. Average individual risk for each distance is obtained by taking the sum of the risk values in all angular sectors at a given distance and dividing it by the number of angular sectors. The result is produced by the risk from both direct and indirect exposure including cloudshine, groundshine and inhalation dose to the population around the population during both early phase and long term phase, simulated by EARLY and CHRONC module. The average individual risk values for each distance is described in Table 7.

Table 7. Average Individual risk around 20 km buffer of NPP

Distance	ERL FAT/TOTAL	CHRONC CAN FAT/TOTAL	ERL CAN FAT/TOTAL	Overall CAN FAT/TOTAL	Overall FAT/TOTAL
0.00 km to 1.60 km	5.07E-02	7.15E-05	3.57E-02	3.58E-02	8.65E-02
1.60 km to 3.20 km	1.46E-02	1.11E-04	5.45E-02	5.47E-02	6.93E-02
3.20 km to 4.80 km	3.13E-03	6.95E-05	4.53E-02	4.53E-02	4.84E-02
4.80 km to 6.40 km	8.63E-04	7.51E-05	3.12E-02	3.13E-02	3.22E-02
6.40 km to 8.00 km	1.47E-04	7.16E-05	2.14E-02	2.15E-02	2.16E-02

8.00 km to 9.60 km	3.75E-05	8.37E-05	1.51E-02	1.52E-02	1.52E-02
9.60 km to 11.20 km	1.63E-05	1.17E-04	1.11E-02	1.12E-02	1.12E-02
11.20 km to 12.80 km	3.39E-06	1.56E-04	8.43E-03	8.58E-03	8.58E-03
12.80 km to 14.40 km	9.86E-07	1.83E-04	6.64E-03	6.82E-03	6.82E-03
14.40 km to 16.00 km	0.00E+00	2.06E-04	5.24E-03	5.44E-03	5.44E-03
16.00 km to 20.00 km	0.00E+00	1.99E-04	3.75E-03	3.95E-03	3.95E-03
Average	6.32E-03	1.22E-04	2.17E-02	2.18E-02	2.81E-02

3.2 CdTe Solar PV system

For the fire incident in CdTe PV module, the risk profile up to 1000 m from the point of release is obtained as described in Fig. 2.

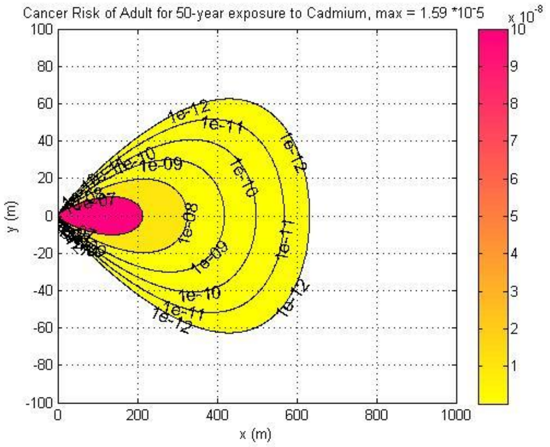

Fig. 2. Cancer risk profile around 1 km buffer from the point of release

In the case of CdTe PV consequence analysis, the critical exposure pathway is defined to be via oral ingestion of the ground deposited cadmium. Average cancer risk, due to ingestion of soil contaminated by cadmium, is calculated for every 100 m from the point of release, as described in Table 8.

Table 8. Cancer risk around 1 km from point of release

Distance	Adult Cancer Risk
100 m	7.67E-07
200 m	1.26E-07
300 m	1.74E-08
400 m	1.61E-09
500 m	9.35E-11
600 m	3.27E-12
700 m	6.82E-14
800 m	8.35E-16
900 m	5.98E-18
1000 m	2.49E-20
Average	9.12E-08

3.3 Comparison

Since two energy options, NPP and solar PV system, are different in terms of utilization purposes and the amount of power production, the criterion must be defined to compare the public health risk due to accidental release of toxic materials for each system. While NPP is usually considered to be base load station which focuses on producing huge amount of electricity requiring continuous operation to consistently meet the demand, residential solar PV system focuses on producing small amount of electricity capable of providing enough electricity to power a single home.

To compensate the different nature of two energy options, public health risk according to the energy generation capacity of each energy source is used as a criterion by dividing the calculated risk to the defined power output for each energy option. The average risk of each power plant is described in Table 9.

Table 9. Comparison of average health risk between NPP and CdTe solar PV system in terms

Parameter	NPP	CdTe Solar PV System
Average Health Risk	2.81E-02	9.12E-08
Probability of Accident	1.43E-06	1.00E-04
Power Capacity (MW)	1.00E+03	5.00E-03

Average Health Risk per Power Capacity (/MW)	4.02E-11	1.82E-09

As the result shown, regarding consequence analysis, the public health risk in the case of NPP accident is more severe than the case of fire incident in solar PV module. In terms of energy production capacity, the residential solar PV system produce much less energy of 5 kW than the case of NPP, 1000MW. By applying these aspects to calculate the public health risk according to the energy capacity, the result shows that average public health risk of NPP is slightly less than the case of solar PV system. It is expected that the estimated health risk of NPP would be much lower when the actual amount of energy produced during a period of time, capacity factor, is considered since the NPP has much higher capacity factor than solar PV system.

4 Conclusion

Several key factors including optimal use of available resources, low electricity generation cost, minimized environmental impact, negligible risk of severe accident which affects public health must be assessed for various energy options and are used as the political decision making process for national energy plan.

In this paper, the consequence analysis on postulated NPP accident and fire incident of solar PV system are assessed and comparison between two energy options in terms of potential health risk on public are discussed using probabilistic risk assessment (PRA) methodology. For the hypothetical accident of NPP, some fraction of core inventory was released to the environment and released radioactive materials were transported in the form of plume. Public health effects, considering early fatality and cancer fatality, were assessed and average individual risk was estimated. For the fire incident of residential CdTe solar PV system is selected for the risk assessment. Some fraction of toxic material, such as cadmium, is released to the environment and deposited to the ground. Public health risk, considering chronic cancer effect due to ingestion of contaminated soil, is assessed. Finally, estimated average individual risk per power capacity for each energy option was compared.

The results show that the public health risk in the case of NPP accident is more severe than the case of fire incident in solar PV module in terms of consequence of the accident. By considering the power capacity of each system, the residential solar PV system produce much less energy of 5 kW than the case of NPP, 1000MW, so the estimated average public health risk of NPP is less than the case of solar PV system. This implies that nuclear power plant has lower public health risk in terms of severe accident condition than CdTe solar PV system so that NPP can take priority over other renewable energy sources in terms of national energy policy.

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