

Screening of Potential Extreme Natural Hazards for Nuclear Power Plant Sites

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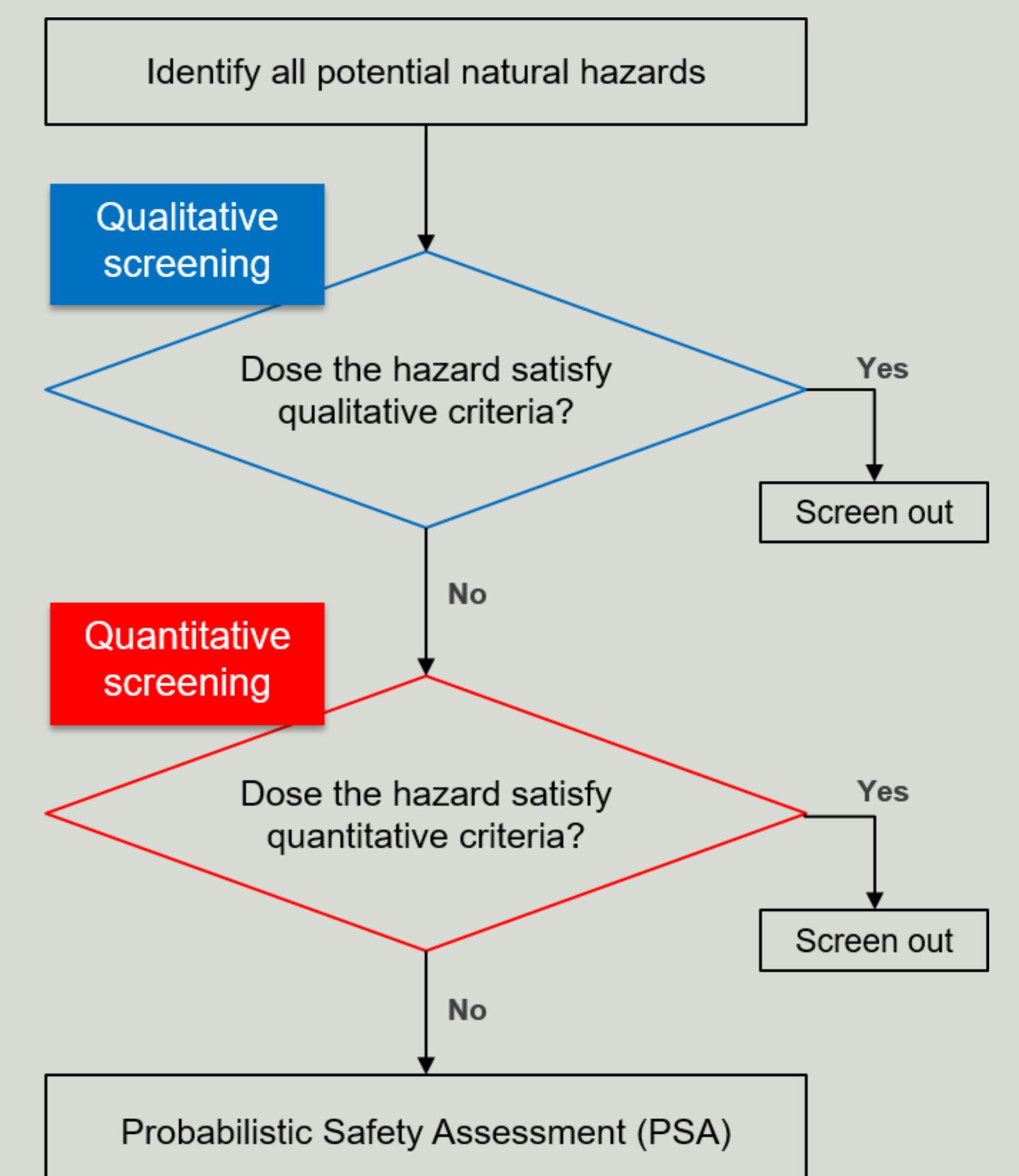
1. Introduction

This paper screened potential extreme natural hazards for the NPP sites. To achieve our goal, we compiled a comprehensive list of 68 natural hazard events that have the potential to impact NPP sites, excluding those caused by human activity. This list was created after conducting pertinent research from domestic and international sources. In addition, the screening procedures and standards for overseas natural hazards were analyzed and the screening procedures and standards were established for application in Korea. Based on this, potential extreme natural hazards were screened through qualitative and quantitative screening processes for each NPP site.

2. Natural hazard screening procedures and criteria for NPPs

In this study, a list of external events including 68 natural hazards was derived by referring to existing studies such as SKI report [1] and EPRI report [2], in order to consider the impact of climate change on the intensity and frequency of natural hazards. Then, in order to prevent the error of duplicate evaluation in qualitative and quantitative analysis and improve the efficiency of the screening process, it was reclassified only to natural hazards excluding human-caused external events.

In addition, by referring to overseas standards and literature, we developed a screening procedure and criteria that consider the characteristics of NPP sites and potential natural hazards caused by climate change. As for the screening procedure, all external natural hazards that may occur in the NPPs were identified and preliminary screening was performed for each NPP site through qualitative criteria. Then, to distinguish in detail natural hazards not excluded in the preliminary selection process, the relevant hazards were evaluated for each NPP site based on quantitative criteria. Finally, the potential natural hazards for each site that were not excluded through qualitative and quantitative criteria were selected.



< External hazards screening procedure for NPPs [4]>

3. Screening of potential extreme natural hazards for each NPP site

3.1 Investigation and analysis of NPP site characteristics

- Kori/Shin-Kori NPP site: Due to the site's coastal location, the coastal barriers for Units 1 through 4 have been reinforced in preparation for inundation by tsunamis.
- Wolsong/Shin-Wolsong NPP Site: Wolsong Units 1 through 4 are protected from tsunamis by a seawall, and the breakwater was expanded in 2009.
- Hanul NPP Site: The plant site is adjacent to the coast, and the site is protected from tsunamis by a breakwater in front of the plant.
- Hanbit NPP Site: The plant site is adjacent to the coast, so the hydrologic characteristics of the site are influenced by the West Sea, while the NPPs are oriented inland to the southeast.

3.2 Investigation of events by external hazards at the NPP sites

[Number of events caused by external hazards at each NPP site (Excluding LOOP)]

Site	Kori #1~#4	Shin-Kori #1~#2	Wolsong #1~#4	Shin-Wolsong #1~#2	Hanul #1~#6	Hanbit #1~#6
Extreme rain	2	0	1	0	0	0
Typhoon	2	2	1	0	4	0
Lightning	3	0	1	0	0	3
Organic material	2	0	0	0	17	0
Earthquake	1	1	8	2	0	0
Low air temp.	0	0	1	0	0	0
Sum	10	3	12	2	21	3

3.3 Qualitative screening

- Typhoon - Storm surge: Due to climate change, the combination of sea level rise and super typhoons may cause surges larger than the design criteria.
- Typhoon - Wind pressure: Climate change-induced super typhoons can cause wind pressures that exceed design criteria for NPPs.
- Typhoon - Extreme air pressure (including negative pressure): The east coast of Korea, where NPPs are located, is directly affected by typhoons every year, and the risk is increasing due to climate change. In addition, roofs and steel panels of turbine buildings can be damaged by negative pressure.
- Typhoon - Externally generated missiles: The impact of solar panels in the Hanbit Solar Park around the Hanbit NPP site needs to be reviewed during extreme winds.
- Extreme rain - Flooding: The possibility of flooding due to extreme rain is increasing due to climate change.
- Forest fire: Forest fires have occurred adjacent to the Hanul NPP site.

3.4 Quantitative screening

Quantitative screening was performed for extreme natural hazards that were qualitatively screened for each NPP site. For quantitative screening, the final safety analysis report (FSAR) and stress test reports were the primary references, and the stress tests were conducted with a frequency of 10,000 years. Therefore, the quantitative screening performed in this study at a frequency of 100,000 years was based on the results of the stress test conducted at a frequency of 10,000 years.

3.5 Potential extreme natural hazards

[Results of screening potential natural hazards at NPP sites]

NPPs	Natural Hazards	Classification	Qualitative Screening	Quantitative Screening	Potential Extreme Natural Hazards
Kori/Shin-Kori	Typhoon	Storm surge	○	○	1st (Kori)
		Wind pressure	○	×	-
	Extreme air pressure	○	□	Determine through walkdown	
Wolsong/Shin-Wolsong	Typhoon	Storm surge	○	○	3rd (Shin-Wolsong)
		Wind pressure	○	×	-
	Extreme air pressure	○	○	1st	
Hanul	Typhoon	Flooding	○	○	2nd
		Storm surge	○	×	-
	Wind pressure	○	×	-	
Hanbit	Typhoon	Extreme air pressure	○	□	Determine through walkdown
		Externally generated missiles	○	□	Determine through walkdown
	Extreme rain	Flooding	○	○	1st

○: Screened in ×: Screened out
□: Requires a walkdown ■: Performed a walkdown

4. Conclusions

As a result of screening potential extreme natural hazards, flooding due to extreme rain and extreme air pressure (including negative pressure) due to typhoons were selected as potential extreme natural hazards common to all sites. For the Kori NPP site, storm surge from typhoons was selected due to the characteristics of the NPP site.

In the future, we will select vulnerable facilities for potential extreme natural hazards, develop fragility analysis models for vulnerable facilities, and conduct probabilistic safety assessments.

References

- [1] SKI, Guidance for External Events Analysis, SKI Report 02:27, Helsinki, Finland, 2003.
- [2] EPRI, Identification of External Hazards for Analysis in Probabilistic Risk Assessment, EPRI Report 1022997, Palo Alto, CA, 2015.
- [3] IAEA Safety Standards Series No. SSG-2, Deterministic Safety Analysis for Nuclear Power Plants, IAEA, 2010.
- [4] H.S. Park, H.K. Park, Y.S. Choun, S.H. Chang, "Natural Hazard Screening Criteria in Probabilistic Safety Assessment for Nuclear Power Plants", Transactions of the Korean Nuclear Society Autumn Meeting, October 20-21, 2022.