Environmental assessment of pre-feasibility of smart offshore npp (onpp) technology for indonesia: a-review

Sigit Santosa¹, Khusnul Khotimah¹, Hanna Yasmine¹ and Rusbani Kurniawan¹

¹Center for Nuclear Standardization and Quality, National Nuclear Energy Agency, Indonesia

Email : titos@batan.go.id, khusnul.khotimah@batan.go.id, hanna@batan.go.id

Abstract. Land needs for energy infrastructure needs, such as the construction of the planned NPP in Jepara, Central Java, often lead to conflicts with the communities because they consider the existence of this infrastructure will Cause environmental damage. One of the solutions studied to improve the development and move the nuclear power plant is to move the location of the nuclear power plant from land to offshore. Besides, Indonesia has a potentially special offshore site on the eastern Sumatra coastline, northern Java coastline, and the Kalimantan coastline. The purpose of this paper is to review the environmental aspects of the implementation of GBS Nuclear power plant in Indonesia. The method used is the review of the literature and subsequently conducted a descriptive analysis. The results showed that SMART offshore NUCLEAR power plants should be considered because it offers clean energy sources, improved safety aspects, availability of offshore sites, and better community of acceptance.

1. Introduction
Each country has a New Renewable Energy source (EBT) that supports the development of fossil energy substitutes, one of which is the development of Nuclear Energy. But the construction of nuclear power plants is still so controversial, including in Indonesia. From an economic point of view, PLTN has many interesting dimensions to discuss. Among them the most important is the aspect of environmental financing, including the cost of handling waste and the risk of pollution in the use of land for land for nuclear power plant infrastructure, as was the case for the construction of nuclear power plants in Jepara where the community refused their land to be a nuclear power plant construction area.

In addition, the occurrence of natural disasters such as the 2011 Japanese tsunami that resulted in the Fukushima Daitichi nuclear power plant accident, had an impact on the growing resistance of the Indonesian people to the use of nuclear power plants that were feared to have a negative impact on environmental pollution [1] so that the terms and slogan Not In My Backyard (NIMB) and Build Absolutely Nothing Anywhere Near Anybody (BANANA) makes PLTN still an alternative for fulfilling energy in Indonesia [2,3]. As stated in Government Regulation (PP) No 79 of 2014 concerning the National Energy Policy (KEN). The condition of Indonesia's energy in realizing the use of EBT of 23% in 2025 still has many challenges. Like, the still low utilization of EBT which is around 8% until March 2019 [4] so that only through nuclear sources for the construction of nuclear power plants, the target of achieving large-scale EBT can be obtained.
To improve the safety system after the Fukushima Daiichi nuclear power plant accident and overcome land limitations on land, South Korea developed offshore nuclear power plant (ONPP) technology based on gravity-based structural technology (Gravity Based Structure, GBS) which has been widely used in offshore oil and gas drilling technology. One that was developed was the SMART-100 MWe NPP technology (System integrated Modular Advanced Reactor) [5,6,7]. This nuclear power plant has a passive safety system, which utilizes a passive cooling system from differences in seawater pressure and the pressure in a nuclear power plant room, where seawater is an unlimited source of cooling. Therefore, with Indonesia's geographical condition as a maritime country, which has an ocean area of 7.9 million km² consisting of 3.1 million km² of territorial waters, 2.1 million km² of 12-mile ocean waters and 2.7 million km² of Economic Zone waters Exclusive (EEZ) makes Indonesia has a potential offshore footprint location for offshore nuclear power plant technology. Especially in the eastern Sumatra coastline, the northern Java coastline, and the Kalimantan coastline.

Therefore, through this paper, a review of the use of offshore Smart NPP technology is used to minimize land use so that it can be one of the solutions to minimize the impact of the development and operation of NPP.

2. Result and discussion
The Technology Concept of Offshore SMART Nuclear Power Plant has the following characteristics: (a) small power with a power of 330 MWt (equivalent to 100 MWe); (b) in the integral form where all the main components of the reactor (reactor core, primary pump, steam generator) are in the reactor vessel. This aims to reduce the interconnection of the piping system so that the possibility of accidents can be minimized; (c) Modular, i.e. the reactor is assembled on the site so that the time to construct the plant is faster than conventional models. The cross-section of the SMART nuclear power plant is shown in Figure 1 [1].

![Figure 1. Cross-section of the SMART nuclear power plant](image)

The terrace of the SMART nuclear power plant reactor contains 57 fuel rods with enriched uranium (UO2) smaller than 5% [9,10]. The general characteristics of this reactor are shown in Table 1 [8].
### Table 1. General characteristics of the npp smart

| Operational characteristics | Power     | Thermal  | 880 MW<sub>t</sub> |
|-----------------------------|-----------|----------|---------------------|
|                             | Electric  | 100 MW<sub>e</sub> |
| Operating life              |           | 60 years |
| Reactor core                | Diameter  | 1.8 m    |
|                             | Power density | 62.6 kW/l |
|                             | Type      | 17 x 17 |
| Fuel                        | Material  | UO<sub>2</sub>/4.95% |
|                             | Cycle     | 3 years |
The GBS offshore SMART nuclear power plant is a modular reactor constructed with an environmentally friendly concept in the onshore shipyards in steps 1 and 2, then pulled by tugboat to the offshore site pound site specified in step-to-step 3. This nuclear power plant can be pulled to the site by tugboat if the density of the nuclear power plant must be smaller than the density of seawater ($\rho_{\text{seawater}}$). When on-site, the total density of NPP ($\rho_{\text{NPP}}$) installations must be greater than the density of seawater ($\rho_{\text{seawater}}$). The total density of NPP ($\rho_{\text{NPP}}$) installations is as follows $\rho_{\text{NPP}} = \text{mass of NPP} / \text{Volume of NPP}$. The PLTN building can tread on the seabed if the density of the NPP is greater than the density of seawater or the total mass of the building is greater than the mass of the displaced seawater. Therefore, the walls of nuclear power plant buildings must be able to withstand the hydrostatic compressive forces of seawater. The pressure on the wall of a nuclear power plant building is equivalent to the hydrostatic pressure at a certain depth, where $p = \rho \cdot g \cdot h$.

This NPP building has compartments (space) that serve to increase and reduce the density of NPP when needed. These compartments can be filled and emptied as needed and also function as a ballasting and de-ballasting system when located at a seafloor site. Buildings are mostly in the sea and some are above sea level. Based on the height of the tsunami that occurred in Japan in 2011 and seawater pressure for the passive cooling system in the event of an accident. By using the shallow water equation and the theory of conservation of energy, tsunami wave heights can be estimated at certain sea depths. This is the main reason that the offshore Smart nuclear power plant is more environmentally friendly if a nuclear power plant accident occurs because the height of the building above sea level is higher than the tsunami height that may occur and seawater is a shock absorber and wave energy absorbers of the earthquake waves that occur. In the event of a tsunami, the passive safety system implemented on this nuclear power plant technology will naturally cool the reactor core by utilizing the difference in seawater pressure with the pressure inside the nuclear power plant. The core cooling system when a tsunami does not depend on the electric power supply. Table 2 shows that the height of the tsunami that will occur at a depth of 30 m is as high as 10.8 m. Therefore, the height of the building is designed more than 20 m above sea level [6].
Table 2. Illustration of 2011 earthquake in Japan and smart site review

|                | epicenter | npp smart |
|----------------|-----------|-----------|
| Sea level      | 204 m     | 30 m      |
| Tsunami height | 6.7 m     | 10.8 m    |

If implemented in Indonesia, the offshore Smart NPP is indeed untested because it is still limited to the regulation of Government Regulation No. 2 of 2014 concerning Nuclear Installation Safety and Security listed in article 1 states that the site is a land location that is used for construction, operation and decommissioning, 1 (one) or more nuclear installations along with other related systems [12] so that the implementation of the offshore Smart NPP cannot yet be applied. The issue of physical protection is a sensitive issue from external threats, such as terrorism, sabotage, and others). Underwater attacks are a threat that is difficult to detect so it needs to be considered in more detail. To reduce the impact of external threats, concrete walls are constructed in two layers. This will also have an impact on increasing construction costs. The factor of ocean waves and whirlwinds will have an impact on the mobilization of workers from land to the reactor and vice versa.

3. Conclusions

Safety Standards Series No. NS-R-3 on-site evaluation for nuclear installations published by the International Atomic Energy Agency (IAEA) states that the NPP site can be on land or at sea. However, in Indonesia even though the offshore Smart NPP cannot be implemented yet because it is limited by Government Regulation No. 2 of 2014 concerning Nuclear Installation Licensing and Nuclear Material Utilization, which states the site is a location on land. Nevertheless, the advantages of the offshore Smart nuclear power plant are more environmentally friendly because the potential risk of a nuclear accident can be minimized by utilizing a passive cooling system from the difference in seawater pressure and indoor pressure, where seawater is an unlimited source of cooling compared to land-based nuclear power plants which requires more land.

References

[1] Sahala M, dkk 2017 *Kajian Pra Kelayakan PLTN Smart Lepas Pantai Jenis Struktur Berbasis Gravitasi untuk Indonesia* (Jakarta: Jurnal Pengembangan Energi Nuklir Vol 19, No 1) p 33-41
[2] M. Wester-Herber 2004 *Underlying Concerns In LandUse Conflicts-The Role Of Place Identify In Risk Perception* (Elsevier: Environmental Science and Policy, volume 7, issue 2) p 109-109
[3] S. W. Kidd, 2013 *Nuclear Power-Economics and Public Acceptance* Energy Strategy Reviews Volume 1, Issue 4 (Elsevier) p 277-281
[4] Presiden Republik Indonesia 2017 *Peraturan Presiden Republik Indonesia Nomor 22 Tahun 2017 Tentang Rencana Umum Energi Nasional* (Jakarta: Sekretariat Kabinet RI)
[5] S. M. Lumbanraja, dkk 2015 *Implementasi PLTN Lepas Pantai di Indonesia*, dalam Prosiding Seminar Teknologi Energi Nuklir 2015 (Denpasar 15-16 Oktober 2015)
[6] Kihwan Lee 2012 *An Offshore Nuclear Power Plant Mounted on Gravity based - structure and its seismic performance*, (KAIST,http://library.kais.ac.kr/thesis02/2012/2012M020104378_S1Ver2.pdf, downloaded 29 August 2019)
[7] P. A. Frieze 6 Januari 2015 *Offshore Structure Design and Construction Encyclopedia od Life Support Systems* (EOLSS), http://www.eolss.net/Sample-Chapters/C05/E6177-OD-01.pdf
[8] S. M. Lumbanraja, Yuliastuti 2006 *Kajian Pemanfaatan PLTN SMART untuk Kawasan Barelang*, Jurnal Pengembangan Energi Nuklir, Volume 8, Nomor 2
[9] K. B. Park 2011 *SMART an Early Deployable Integral Reactor for Multipurpose Application*, INPRO Dialogue Forum on Nuclear Energy Innovations: CUC for Small & Medium-sized Nuclear Power Reactors (Vienna, Austria, 10-14 October)

[10] S. G Hong, J. S. Song 2013 *A Preliminary Simulation Study of Dynamic Rod Worth for the SMART (System-integrated Modular Advanced Reactor) reactor* (Elsevier: Annals of Nuclear Energy, Vol 60) p 350–356

[11] S. M. Lumbanraja, dkk 2011 *Manajemen Keselamatan PLTN Paska Kecelakaan Fukushima Daiichi Unit 1~4* (Jurnal Pengembangan Energi Nuklir, ISSN, Volume 11, Nomor 2) p 122-130

[12] BAPETEN 2014 *Peraturan Pemerintah Nomor 2 Tahun 2014 Tentang Keselamatan dan Keamanan Instalasi Nuklir* (Jakarta: Bapeten)