SECURING SMALL MODULAR REACTOR DEVELOPMENT IN REMOTE AREAS: CASE STUDIES AND CULTURAL ANALYSIS IN INDONESIA

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Abstract

SECURING SMALL MODULAR REACTOR DEVELOPMENT IN REMOTE AREAS: CASE STUDIES AND CULTURAL ANALYSIS IN INDONESIA. Indonesia is committed to achieving Net Zero Emissions by 2060, and one of its strategies involves the construction of a nuclear power plant (NPP). In collaboration with the United States, Indonesia plans to commence the construction of a 462 MW facility in 2023. This facility will utilize NuScale Small Modular Reactor (SMR) technology, representing a significant step towards advancing the clean energy transition in the country. Compared to conventional nuclear power plants, the construction of SMRs offers several advantages, notably in terms of flexible land requirements and a smaller footprint. Moreover, SMRs incorporate advanced safety features designed to withstand extreme weather conditions and various seismic events. Importantly, these reactors can be tailored to meet the specific needs of a country's power grid and scaled up as required. One of the primary objectives of deploying SMRs in Indonesia is to ensure widespread access to electricity across the nation. The initial phase of SMR development is planned for West Kalimantan, with the intention of expanding into other remote areas in the future. However, the implementation of SMR projects in remote regions necessitates thorough security assessments. This paper aims to analyze potential security threat scenarios associated with SMR development in remote areas of Indonesia. Through case studies and cultural analysis of Indonesian society, the study seeks to assess the impact of local culture on nuclear security and identify strategies to mitigate potential risks.

1. INTRODUCTION

The background study of Indonesia's Vision 2045 indicates that nuclear power will be one of the new energy applications that will be particularly prominent in the next two decades. To address the substantial energy demand imbalance in Indonesia, nuclear power (NPP) or coal are the only viable options. Apart from its capacity to generate electricity on a large scale, the selection of a nuclear power plant is also influenced by its environmental impact, which includes its exceptionally low carbon dioxide emissions[1]. The draft document for the 2023-2060 National Electricity General Plan also specifies that the use of nuclear energy is conducted in accordance with National Energy Security by taking into account the security of national energy supplies on a large scale, reducing carbon emissions, and continuing to prioritize the potential of New and Renewable Energy[2]. This is done in accordance with its economic value. After 2030, nuclear energy may be feasible for operational purposes. The operator of a nuclear installation is obligated to oversee safety and accident risks and to provide compensation to third parties who suffer losses as a result of nuclear accidents.

Another factor that must be taken into account is the independence of national supporting services and supporting industries in the utilization of nuclear energy. Increasing the proportion of New Renewable Energy in the energy balance can bolster the Indonesian Government's dedication to reducing Greenhouse Gas (GHG) emissions. Indonesia's Updated Nationally Determined Contribution (NDC) document outlines this commitment, which mandates the energy sector to reduce emissions by 314 million tons of CO2e or 11% of the total national target in 2030. This reduction is in comparison to the Business as Usual (BaU) conditions with self-effort and 446 million tons of CO2e or 15.5% with international support. In addition, the Indonesian Government's objective of achieving Net Zero Emissions (NZE) by 2060 or earlier can be reinforced by increasing the proportion of New Renewable Energy[2].

The U.S. Trade and Development Agency granted PLN Indonesia Power (Indonesia Power) technical support to build the country's first small modular reactor (SMR) nuclear power plant in March 2023. Indonesia Power hired Oregon-based NuScale Power OVS, LLC (NuScale) to help in conjunction with a Fluor Corporation subsidiary and Japan's JGC Corporation. The 462 megawatt station would use NuScale's SMR technology to assist Indonesia's clean energy transition[3]. The Head of the Nuclear Energy and Research Organization BRIN, who

spoke at the Clean EDGE Asia Conference: Energy Transitions and Equitable Development in Southeast Asia in Jakarta on January 30-31, 2024, stated that the deployment of SMR in Indonesia is anticipated to provide coverage for remote areas, particularly those with minimal electricity distribution[4]. The paper's objective is to analyse potential security threat scenarios associated with SMR development in remote areas of Indonesia.

2. INDONESIA'S ENERGY SOURCES BACKGROUND

In 2021, Indonesia, which has a population of 275 million, had a power capacity of 85 GWe. Despite a 99.5% electrification rate, the country experienced frequent outages and low per capita consumption. The nation's objective is to decrease emissions by 29% by 2030 and to establish a nuclear power facility by 2039. The objective of collaborative endeavors with countries such as the United States, China, Korea, and Russia is to increase nuclear capacity and improve regulatory measures [5]. Under Presidential Regulation No. 22/2017 on National Energy Planning (Rencana Umum Energy Nasional – RUEN), renewables are required to be accountable for a minimum of 23% of the total primary energy supply (TPES) in 2025 and 31% in 2050 as shown in the table below[6].

TABLE 1. INDONESIAN GOVERNMENT TPES TARGETS IN 2025 AND 2050

Energy Sources	2025 (in %)	2050 (in %)
Renewable energy	>23	>31
Oil	<25	<20
Coal	>30	>25
Gas	>22	>24

The archipelagic nature of Indonesia, consisting of thousands of islands, presents unique challenges in ensuring consistent and reliable energy supply, especially in remote regions[7]. Inadequate infrastructure in these areas often leads to frequent power outages, which can hinder economic development and negatively impact the quality of life for residents. These regions face logistical difficulties in fuel transportation and energy distribution, resulting in higher energy costs and reduced reliability. Addressing these challenges requires innovative solutions that can provide decentralized power generation and enhance grid stability.

Small Modular Reactors (SMRs) offer a promising solution to Indonesia's energy challenges. SMRs are advanced nuclear reactors that are smaller in size and capacity compared to traditional nuclear reactors. They are designed to be constructed in factories and then transported to the site, which can significantly reduce construction time and costs [8]. SMRs also offer flexibility, power generation to offset renewables' intermittency, a wide range of applications for decarbonizing transport and industry, and greater safety, according to experts [9]. However, the conditions contributing to nuclear power expansion are geographical, environmental, and social[10]. Throughout the 1970s and 1980s, BATAN (now BRIN) conducted several feasibility studies to assess the potential for nuclear power plants in Indonesia. These studies identified several possible sites for nuclear power plants, considering factors such as geological stability, proximity to water sources for cooling, and distance from densely populated areas [11]. Renewed efforts in the 1990s focused on the Muria Peninsula in Central Java, but local opposition caused delays. The 2000s saw policy development and international cooperation with countries like Russia, South Korea, and Japan, but progress was slow due to regulatory and societal challenges. In the 2010s, attention shifted to Bangka Island, but again faced opposition and regulatory issues. Recently, West Kalimantan has been identified for Small Modular Reactors (SMRs) due to its significant energy need and can establish business sectors that contribute to the Gross Regional Domestic Product in energy clusters in West Kalimantan[12], [13], [14].

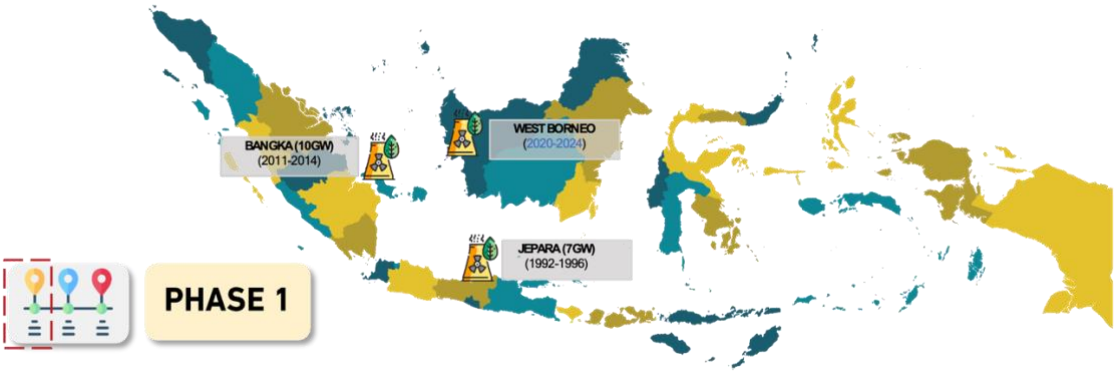

FIG.1 Indonesia's NPP site history overview

3. SECURITY ASSESSMENTS FOR REMOTE SMR DEPLOYMENT

Remote Small Modular Reactor (SMR) deployment necessitates a comprehensive understanding of various security threats specific to isolated regions. Physical threats in these areas can include sabotage, theft of nuclear material, and attacks on infrastructure, compounded by the challenge of ensuring continuous security due to the isolation. Cybersecurity threats also present significant risks, as the digitalization of SMR operations makes them vulnerable to hacking attempts aimed at disrupting reactor functions, stealing sensitive information, or manipulating control systems to cause accidents. Furthermore, societal threats must be considered, including public opposition, local cultural dynamics, and potential civil unrest, which can be exacerbated by misinformation and lack of trust in nuclear technology[15].

Examining past security incidents underscores the importance of thorough security assessments. For instance, the sabotage of a nuclear power plant, where an insider drained lubricant from a turbine causing significant damage and operational disruption, highlights the need for robust physical security measures and insider threat mitigation. The Stuxnet virus attack on nuclear facility is a prominent example of how cyber-attacks can disrupt nuclear operations, emphasizing the necessity for rigorous cybersecurity protocols[16]. Additionally, societal incidents, such as the public protests and opposition to nuclear power in Japan following the Fukushima disaster, illustrate the impact of societal factors on nuclear projects, highlighting the critical role of effective communication and community engagement in building public trust[17].

To analyze these threats comprehensively, a robust methodology must be employed. Case studies of past incidents provide valuable insights into potential security risks by examining the circumstances, response measures, and outcomes of these incidents, allowing for the development of strategies to prevent similar occurrences. Cultural assessments are crucial for understanding local beliefs, attitudes towards nuclear technology, and potential sources of opposition, guiding community engagement strategies to mitigate societal threats. A comprehensive threat analysis framework should be implemented, identifying potential threats, assessing their likelihood and impact, and developing mitigation strategies. This framework must integrate physical, cybersecurity, and societal dimensions to provide a holistic view of security risks.

4. CULTURAL ANALYSIS OF INDONESIAN SOCIETY

Understanding the public's perception of nuclear energy in Indonesia is crucial for the successful deployment of nuclear projects, including Small Modular Reactors (SMRs). West Kalimantan, located on the island of Borneo, is a province with a diverse demographic composition and rich cultural heritage. The province has a population of over 5 million people, consisting of various ethnic groups such as the Dayak, Malay, Chinese, Javanese, and Madurese[18]. The Dayak and Malay communities are indigenous to the region, while the Chinese, Javanese, and Madurese populations have migrated to West Kalimantan over the centuries, contributing to its multicultural society[19].

The cultural values and social structures of these ethnic groups significantly influence their perceptions and acceptance of new technologies, including nuclear energy[20]. The Dayak people, for example, have a deep connection to their ancestral lands and natural environment, which shapes their concerns about environmental impacts and sustainability. The Malay community, which is predominantly Muslim, may have specific concerns related to the halal status and ethical considerations of nuclear energy projects. The Chinese community, with its strong emphasis on business and economic development, may focus on the economic benefits and job opportunities that nuclear projects can bring. In addition, the duration of formal education and gender can also influence the transmission of information or communication concerning nuclear security. The table below displays the average length of formal education that West Kalimantan residents received from 2021 to 2023, as determined by data from the National Statistics Agency[21].

TABLE 1. AVERAGE LENGTH OF FORMAL EDUCATION IN WEST KALIMANTAN

City/Region	Average Length of Formal Study in Each City/Region (in years)					
	Men			Women		
	2021	2022	2023	2021	2022	2023
West Kalimantan	7.94	7.95	7.99	6.93	7.18	7.35
Sambas	7.36	7.38	7.39	6.11	6.13	6.14
Bengkayang	7.25	7.42	7.62	6.18	6.40	6.68
Landak	8.00	8.03	8.04	6.66	6.69	6.96
Mempawah	7.44	7.58	7.59	6.72	6.75	6.95
Sanggau	7.89	7.91	7.92	6.89	6.91	7.14
Ketapang	7.97	7.98	7.99	6.92	7.22	7.50
Sintang	7.49	7.72	7.98	6.51	6.87	7.15
Kapuas Hulu	7.97	7.99	8.22	6.95	7.33	7.52
Sekadau	7.62	7.63	7.64	6.26	6.56	6.59
Melawi	7.48	7.75	7.99	6.45	6.84	7.10
Kayong Utara	6.69	6.71	6.83	5.39	5.69	5.86
Kubu Raya	7.72	7.74	7.76	6.81	6.83	6.85
Kota Pontianak	10.69	10.70	10.71	10.13	10.14	10.15
Kota Singkawang	8.31	8.32	8.34	7.54	7.91	8.06

To effectively engage with the communities in West Kalimantan, it is essential to understand and respect these cultural nuances. Strategies for community engagement should include culturally sensitive communication, involving local leaders and influencers, addressing specific concerns of each ethnic group and mindful with the education background. For example, public consultations and participatory workshops can be organized in a way that respects traditional decision-making processes and includes representatives from all major ethnic groups. Educational initiatives should be tailored to address the specific fears and misconceptions prevalent in each community, using culturally relevant examples and narratives[22], [23].

5. MITIGATION STRATEGIES

Deploying SMR in remote area such as in West Kalimantan need two kind of mitigation strategies, such as:

- Community engagement programs are essential for mitigating the societal and cultural risks associated with the deployment of SMRs. Ensure that the concerns of local communities are heard and addressed by engaging them in regular consultations, town hall meetings, and participatory decision-making processes. This method promotes a sense of ownership and trust among community members. The

efficacy of these programs can be improved and cultural sensitivities can be respected by involving local leaders and influencers.

- Educational Campaigns: It is imperative to dispel misconceptions and advance comprehension of nuclear energy through educational initiatives. The safety, benefits, and environmental impact of nuclear energy should be accurately communicated through these campaigns. A broader audience can be reached by utilizing a variety of media channels, such as social media, local radio, and community seminars. The establishment of a foundation of knowledge and support for nuclear programs among younger generations can also be facilitated by educational initiatives in schools and universities. One of the initiatives that currently has been done by the Women in STEM and could be implemented in West Kalimantan is Nuclear Goes to School, where various number of nuclear expert or employees in nuclear sector go to their previous school in rural area to give education and sharing knowledge about nuclear safety and security.

6. CONCLUSION

Indonesia's energy needs and sustainable growth can be transformed by Small Modular Reactors (SMRs). Indonesia's energy mix requires diversity, and SMRs are a stable, low-carbon alternative. SMRs' flexibility, safety, and adaptability for remote areas make them ideal for Indonesia's diversified energy and geographic setting. SMR deployment, especially in rural areas, requires security considerations. The highlighted physical, cybersecurity, and societal security risks require multifaceted security methods. Historical security incidents demonstrate the necessity of threat analysis and preparedness. To mitigate these dangers and ensure SMR project safety and acceptance, strong physical and digital security and community involvement strategies are essential.

Cultural issues are crucial to SMR planning and implementation. Community engagement and education are needed to overcome nuclear energy fears and misconceptions. Local community participation in decision-making builds trust and acceptability, which SMR initiatives need to succeed. The West Kalimantan case study shows how specialized tactics can solve regional and demographic obstacles, benefiting future deployments. To secure and adopt SMRs, the mitigation solutions include community engagement and education. The examination of West Kalimantan's deployment emphasizes contextual awareness and adaptable techniques, which might inform SMR project development in other remote Indonesian locations.

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