

7-10-2020

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Recommended Citation

Trajano, Julius Cesar and Caballero-Anthony, Mely (2020) "The Future of Nuclear Security in the Asia-Pacific: Expanding the Role of Southeast Asia," *International Journal of Nuclear Security*: Vol. 6: No. 2, Article 8.

<https://doi.org/10.7290/ijns060208>

Available at: <https://trace.tennessee.edu/ijns/vol6/iss2/8>

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The Future of Nuclear Security in the Asia-Pacific: Expanding the Role of Southeast Asia¹

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Abstract

The nature of regional cooperation on capacity building taking place in Southeast Asia certainly provides a good foundation to pursue a more robust collaborative framework for nuclear security in the wider Asia-Pacific region. A step in this regard is to have a regional action plan/roadmap for nuclear security in the Asia-Pacific that could institutionalize cooperation between the Association of Southeast Asian Nations (ASEAN) and other countries in the wider region, fostering closer collaboration. This paper recommends three practical mechanisms to expand cooperation frameworks in Southeast Asia to the broader Asia-Pacific region: (1) strengthening regional capacity building in nuclear security; (2) establishing an ASEAN-Northeast Asia network of nuclear security centers of excellence (COEs) and knowledge centers; and (3) enhancing regional nuclear emergency preparedness and response. The article also explores the future of collaboration among International Nuclear Security Education Network (INSEN) members in the Asia-Pacific region, with Southeast Asian members as key drivers, to further strengthen regional nuclear security governance through sustainable nuclear security education.

Keywords: ASEAN, nuclear security, nuclear security education, INSEN, Centers of Excellence, nuclear governance

I. Introduction

Nuclear security is a global concern, and not just for states that have nuclear weapons and nuclear power plants, but also those that do not have one or the other. This is so since nearly all states have nuclear and radioactive materials being used for other civilian applications. As defined by the International Atomic Energy Agency (IAEA), nuclear security is “the prevention and detection of, and response to, theft,

¹ This article is an updated and expanded version of the conference paper titled “Nuclear security governance in the Indo/Asia-Pacific: Building-out from Southeast Asia?” presented at the IAEA International Conference on Nuclear Security (ICONS 2020) in Vienna, Austria on February 11, 2020.

sabotage, unauthorized access, illegal transfer or other malicious acts involving nuclear material, other radioactive substances or their associated facilities” [1]. Given that nuclear security is a shared concern, enhancing leadership and getting more stakeholders in nuclear governance are therefore important. In spite of the holding of the Nuclear Security Summits (NSS, 2010-2016), which significantly increased global awareness on the issue of nuclear security [2], there remains concern about the lack of progress on nuclear security governance across the world. With new challenges in the international security environment, including the implications of growing technological rivalry among nuclear weapons states, there is a compelling case for other actors at the national and regional levels to exert more efforts in advancing nuclear security and contributing to global nuclear security regime.

One recent regional initiative on nuclear security is the *East Asia Summit (EAS) Leaders’ Statement on Safe and Secure Use, Storage, and Transport of Nuclear and other Radiological Materials*. It urges all EAS participating states² to build a robust domestic nuclear safety and security regime and conduct exercises to prepare their communities for incidents involving radioactive materials [3]. It is the first high-level joint statement on nuclear security governance from Association of Southeast Asian Nations (ASEAN) member -states³ and other Asia-Pacific countries – Australia, China, India, Japan, South Korea, New Zealand, Russia, and the United States. More significantly, the statement highlights that the security governance of nuclear and radiological materials has become a regional concern in the Asia-Pacific.⁴

Aside from putting forward 25 key recommendations to bolster both nuclear safety and security at the regional and national levels, the EAS Leaders statement paid particular attention to the ASEAN Network of Regulatory Bodies on Atomic Energy (ASEANTOM) and its role in advancing regional cooperation on nuclear security governance. ASEANTOM is a network amongst nuclear regulatory bodies or relevant authorities in the region, which would enable regulators to exchange nuclear related information and experiences on best practices, enhance cooperation, and develop capacities on all three aspects, namely, nuclear safety, security, and peaceful uses of nuclear energy. Since its inaugural meeting in 2013, ASEANTOM has achieved key progress in providing a number of capacity building programs and raising the level of knowledge and expertise on nuclear safety and security [4]. It does so through numerous expert missions/exchange programs, technical meetings and workshops, and capacity building cooperation projects with international organizations, such as the IAEA and the European Union (EU), to strengthen nuclear security [5].

In this regard, this paper explores pathways toward building a robust framework for nuclear security governance in the Asia-Pacific, building out from the nuclear security cooperation frameworks and developments in Southeast Asia. It argues that the progress on building nuclear security cooperation in Southeast Asia can be expanded to the wider Asia-Pacific region. It recommends three practical mechanisms to expand ASEAN cooperation frameworks to the broader Asia-Pacific region to advance nuclear security governance: (1) strengthening regional capacity building in nuclear security; (2)

² The East Asia Summit (EAS) is an annual meeting of 18 regional leaders for strategic dialogue and cooperation on the key political, security, and economic challenges facing the Asia-Pacific region. The EAS comprises the ten member-states of the Association of Southeast Asian Nations (ASEAN) – Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam – as well as Australia, China, Japan, India, New Zealand, the Republic of Korea, Russia, and the United States.

³ The Association of Southeast Asian Nations (more commonly known as ASEAN) is an intergovernmental regional organization in Southeast Asia aimed mainly at advancing economic growth and regional stability among its members. There are currently 10 member-states: Indonesia, Malaysia, the Philippines, Singapore, Thailand, Brunei, Laos, Myanmar, Cambodia, and Vietnam.

⁴ Asia-Pacific varies in area depending on the context, but generally, it is mainly composed of EAS participating states.

establishing an ASEAN-Northeast Asia⁵ network of nuclear security centers of excellence (COEs) and knowledge centers including members of the International Nuclear Security Education Network (INSEN); and (3) enhancing regional nuclear emergency preparedness and response. The article also explores the future of collaboration among INSEN members in the Asia-Pacific region, with Southeast Asian members as key drivers, to further strengthen regional nuclear security governance through sustainable nuclear security education.

II. Why is Nuclear Security a Key Agenda in Southeast Asia?

Several Southeast Asian countries are studying whether to include nuclear energy in their future energy development plans so as to bolster their energy security and cut their CO₂ emissions from fossil fuels. Studies have shown that nuclear power will be added to Southeast Asia's energy mix between 2030 and 2040 [6–8]. While Vietnam cancelled its first nuclear power plant (NPP) project in 2016, Indonesia and the Philippines are carefully evaluating their nuclear energy option. The Philippines, in particular, is currently acting on the recent findings and recommendations by the IAEA's review mission that assessed the country's infrastructure development for a nuclear power program [9]. An option being proposed in the Philippines and Indonesia is the possible use of small modular nuclear reactors (land-based and floating) as an emerging nuclear technology [10]. The deployment of floating nuclear reactors may provide an alternative power generation source to archipelagic countries in the region at a much cheaper price and as less politically controversial than large, land-based NPPs. However, the deployment of floating reactors has raised concerns about radioactive leaks or accidents that may cause grave environmental impact on the South China Sea, affecting the safety, public health, and sources of livelihood of coastal communities. Furthermore, the region's maritime security concerns, such as piracy, the presence of terrorist groups, unsecured maritime borders, smuggling, hijacking, and territorial disputes, could pose serious security threats to these floating reactors if states are not adequately prepared to address these issues.

While there are no operable nuclear plants currently in Southeast Asia, there are three Chinese nuclear power plants located near Vietnam, and Chinese offshore nuclear reactors may be deployed in the South China Sea in the future. Meanwhile, Bangladesh began construction of its first NPP in 2017 with Russian collaboration, and completion is slated for 2024. It must be noted that this first NPP is just 500 kilometers away from Myanmar [11]. ASEAN member-states have a collective interest in ensuring that nuclear power plants or small modular reactors located in the Asia-Pacific and even within Southeast Asia are safe and secure.

Radiological security is currently an important security issue in Southeast Asia given that radioactive materials are, in fact, already widely used for peaceful applications in the region, especially in industrial facilities, health and medicine, soil and water management, pollution monitoring, and agricultural production. However, without adequate regulatory oversight on the use and handling of radioactive materials, there is a risk that such materials could be used in criminal, terrorist, or intentional unauthorized acts by a malicious non-state actor, posing a threat to both national security and human security. From 2013 to 2018, as Figure 1 shows, five cases involving missing, illicit trafficking, or theft of radioactive materials were monitored in Southeast Asia and 43 cases in Northeast Asia [12]. Nuclear security incidents could cause radiological emergencies that might have health, societal, economic, and environmental consequences.

⁵ Northeast Asia is composed of China, Japan, South Korea, North Korea, and Mongolia. China, Japan, and South Korea are included in this article. Meanwhile, the term "East Asia," in the context of geographical proximity and cultural commonality, could also be interchangeably used to specifically refer to Northeast Asia.

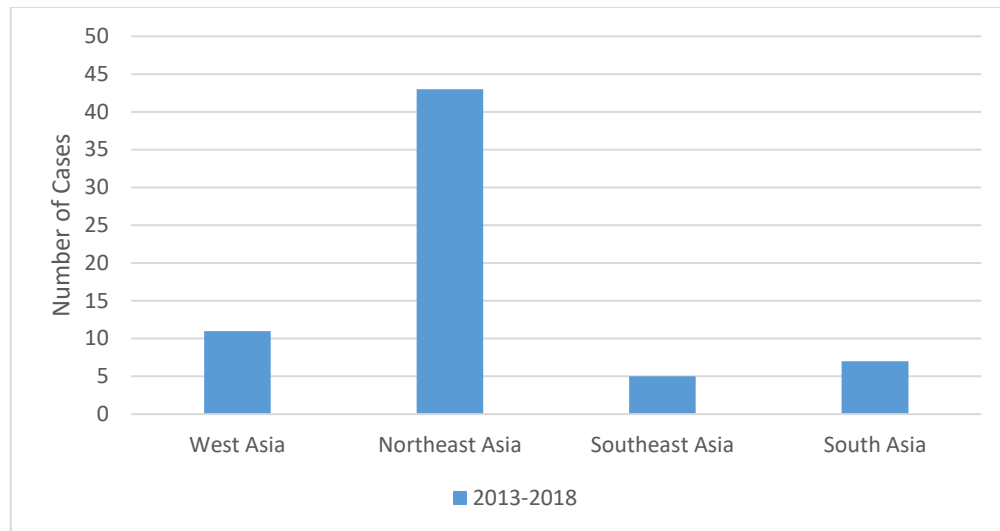


Figure 1. Number of Monitored Cases of Missing, Illicit Trafficking, or Theft of Radioactive Materials in Asia from 2013 to 2018 [12]

III. Strengthening Regional Capacity Building in Nuclear Security

The EAS leaders' statement on nuclear security "encourages all States to maintain and improve their nuclear security infrastructure and encourage States in a position to do so to assist others in this regard... and to promote international exchanges of experience, knowledge and good practices" [3]. In Southeast Asia, ASEAN has been dealing with the broader issue of nuclear security— starting with nuclear safety and the development of nuclear security culture. ASEAN member-states have been forging regional cooperation on civilian nuclear energy to address shared challenges to nuclear safety and security. In this regard, the ASEANTOM has been driving regional cooperation on civilian nuclear capacity-building among ASEAN member-states. The ASEANTOM Work Plan 2018–2022 [13] details the action programs, key objectives, milestones, and deliverables for the five-year period from 2018 to 2022, to work towards achieving ASEANTOM's objective of applying peaceful uses of nuclear energy in compliance with the IAEA safety, security, and safeguards standards. As stipulated in its work plan, ASEANTOM has ongoing regional projects with the EU and the IAEA pertaining to nuclear emergency preparedness and response as well as on nuclear and radiological security capacity-building.

In 2019, ASEAN and IAEA inked Practical Arrangements to drive cooperation in nuclear science and technology, applications, nuclear safety, security, and safeguards. As stated by the ASEAN Secretary-General Dato Lim, "the signing of this framework for cooperation represents a significant milestone in the cooperation between the ASEAN and IAEA and provides the foundation for our organizations to expand the work on already existing as well as new projects in Southeast Asia." The Practical Arrangements will serve as the overall framework for future collaboration between the two organizations. The IAEA has been an important partner to ASEAN, given its advanced expertise and vast resources in the areas of nuclear safety, security and safeguards, and peaceful uses of nuclear energy, through its robust technical assistance with ASEANTOM over the years [14].

Nuclear security is a key regional agenda set by ASEANTOM in view of the need to increase awareness among state and non-state actors on the importance of nuclear security governance in Southeast Asia. Highlighting the importance of collectively adhering to the Convention on the Physical Protection of Nuclear Material (CPPNM) and its Amendment, ASEANTOM has begun to work on a series of capacity

building programs aimed at boosting cooperation and collaboration among ASEAN member-states. Among these include the joint cross-border nuclear security exercises in their maritime and land borders done by regulatory and law enforcement officers in ASEAN to prevent and investigate illicit use and trafficking of radioactive materials. ASEANTOM has also worked with the IAEA in conducting regional workshops on *Security Management and Security Plan on Radioactive Materials and Associated Facilities*, amplifying the growing attention being given by the region to the security of radiological materials.

As part of ASEANTOM's knowledge sharing program, targeted assistance on boosting nuclear security is also provided to members that need more knowledge and expertise. For instance, Cambodia and Laos do not have enough well-trained staff and regulatory infrastructure, especially for the regulation of radioactive materials. Since 2017, Thailand, which has more robust nuclear expertise, has extended capacity building assistance to Cambodia and Laos on the regulation of nuclear activities and online monitoring of radiation in the environment through technical cooperation workshops.

The nature of regional cooperation on capacity building taking place in Southeast Asia certainly provides a good foundation to pursue a more robust collaborative framework for nuclear security in the wider Asia-Pacific region. A step in this regard is to have a regional action plan/roadmap for nuclear security in the Asia-Pacific that could deepen cooperation between ASEAN and other countries in the wider region and foster closer collaboration. The action plan may contain necessary mechanisms to facilitate and expand cooperation on knowledge transfer, emulating Southeast Asia's examples. Convening ASEANTOM regional workshops and technical projects on nuclear security could be included in the action plan with the aim of expanding such regional activities to include Asia-Pacific countries. Such expansion could also leverage on existing Asia-Pacific-wide and Asia-wide regional networks, e.g., Forum for Nuclear Cooperation in Asia, Asian Nuclear Safety Network, and Asia-Pacific Safeguards Network.

Another key regional collaboration in ASEAN on nuclear security is the Regional Radiological Security Partnership in Southeast Asia (RRSP). Launched by Australia in 2004, RRSP primarily aims to improve the physical protection and security management of high-risk radioactive sources in Southeast Asia through technical training and assistance, providing radiation detection devices, sharing of best practices, and facilitating collaborative efforts on searching of missing radioactive sources and on nuclear emergency response. Given that all Asia-Pacific states possess, use, and transport radioactive materials across national borders, it would be strategic to strengthen training, information exchange, and joint nuclear security drills among countries in the wider region.

IV. Role of INSEN Members in the Asia-Pacific

Complementing the ASEANTOM network, knowledge centers, like universities and research institutions which are members of the International Nuclear Security Education Network (INSEN), can also further strengthen, and even deepen, nuclear security in the region through educational and capacity building initiatives. Established in 2010, INSEN is a partnership between the IAEA and educational and research institutions and other stakeholders, dedicated to advancing sustainable nuclear security education. Simply put, it is a collaboration network among higher education institutes that are involved in any form of nuclear security education. INSEN can help realize one of the recommendations in the EAS Statement: “[e]ncourage all States to strengthen national nuclear safety and security through capacity building efforts, including through training and education, and through regional or international networks, and to include nuclear security centers of excellence.”

Table 1. Southeast Asia's INSEN Members

Country	Institution	Nuclear Security Educational and Training Activities
Indonesia	Universitas Gadjah Mada	MSc in Nuclear Engineering; draft MSc in Nuclear Security and Safety; regular professional development courses; training courses for law enforcers
Malaysia	Universiti Kebangsaan Malaysia	Draft regional MSc course on nuclear security, safety; provides subject matter experts in national workshops
Singapore	S. Rajaratnam School of International Studies, Nanyang Technological University (authors' institution)	Seminars, policy roundtables, faculty development courses on nuclear security; generation of academic and research articles on nuclear security; inclusion of nuclear security in an MSc course
Thailand	Chulalongkorn University	M.Sc. in Nuclear Technology with Nuclear Security and Safeguards Concentration; Trainings for Customs Officers
Myanmar	Technological University (Kyaukse)	Undergraduate degree in nuclear science and engineering

In Southeast Asia, INSEN's impact on nuclear security is reflected on the educational activities of its members in the region. Singapore, Malaysia, Myanmar, Thailand, and Indonesia have universities actively participating in INSEN meetings and activities (see Table 1). INSEN members in the Southeast Asian region could consider establishing stronger collaboration among them and then expand their linkages with other INSEN members from other Asia-Pacific countries. One major INSEN contribution that should be expanded is public education and outreach. Public education could be utilized as an effective counter to the threats of nuclear terrorism and other nuclear security incidents. It is therefore important to educate the society on the impacts of a "dirty-bomb" attack as well as minor radiological security incidents [15]. INSEN members, together with relevant security agencies with domain expertise, can contribute immensely by raising public awareness on the importance of nuclear and radiological security measures in preventing nuclear security incidents, including radiological sabotage, theft, smuggling, and nuclear terrorism so as to allay the psychological fears that the malicious actors are after. With a more informed society, there is less motivation for terrorists to carry out a dirty-bomb attack.

Given the rationale for nuclear security education for the public and key stakeholders, INSEN member-universities in the Asia-Pacific can both individually and collectively organize activities to educate not only their students but also relevant stakeholders and the public on the basics of nuclear security. In conducting these activities, they can form collaboration with nuclear security experts and academic institutions from the Asia-Pacific and beyond through INSEN. As shown in Table 1, they can also collaborate in educational and training activities, such as outreach to security and law enforcement agencies, radioactive sources security awareness seminars, and emergency preparedness and response planning workshops. For example, the S. Rajaratnam School of International Studies (RSIS) in Singapore actively collaborates with fellow INSEN members through its nuclear policy roundtables, workshops, and faculty development courses. RSIS has been an active member of INSEN since 2014. Convened annually since 2015, RSIS policy seminars, which are open to the public, feature nuclear safety/security experts and practitioners from selected Asia-Pacific countries and beyond; the majority of them are from Southeast Asia and Northeast Asia. These experts and practitioners are from INSEN-affiliated academic institutions, present and former officials from national nuclear energy regulatory bodies, national nuclear energy agencies, COEs, country-representatives to the ASEANTOM, the civil society, and nuclear industry. The discussions facilitate policy deliberations and constructive debates among nuclear experts on post-Fukushima nuclear safety and security issues in Asia-Pacific.

Another key area where INSEN members in the Asia-Pacific could collaborate is organizing a regional faculty development course. In fact, one of the mandated areas of collaboration among INSEN members is "faculty development in the different areas of nuclear security through faculty development courses, faculty exchanges and joint development and implementation of nuclear security education programs or courses"[16]. In October 2019, RSIS co-organized the IAEA Regional Faculty Development Course (FDC) on Nuclear Security, involving INSEN members from the Asia-Pacific. Regarded as the first regional FDC in the Asia-Pacific organized by IAEA in cooperation with RSIS, an INSEN member, it was aimed at providing faculty members from universities in the Asia-Pacific region with assistance in designing and implementing nuclear security curricula based on IAEA guidance and recommendations. Furthermore, it served as an opportunity to encourage participants in the FDC to spearhead their respective institutions in joining INSEN, if they are not yet members. In the FDC, around 20 faculty members and trainers from universities and nuclear security training institutions in the Asia-Pacific region participated in a series of lectures and activities aimed at developing academic programs and training courses on nuclear security education in their respective institutions. An important outcome of the course was getting participants to design their own curricula for graduate programs and training course.

The faculty development course provided both substantive information teaching methodologies as well as assistance in curriculum development. To determine their specific training needs and teaching plans,

participants were asked to present the existing and future programs of their respective institutions on nuclear security education and training. Following the sharing session, participations were introduced to the IAEA's model academic curriculum in nuclear security. The model curriculum provided a useful reference for designing curricula and training programs [17]. The faculty development course also included lectures, which were intended to provide participants with basic knowledge and information on nuclear security. Such lectures covered an introduction to nuclear security, legal and institutional frameworks for nuclear security, conducting threat assessments, nuclear security detection architecture, physical protection systems and principles, cyber security and information security, nuclear security culture, emergency preparedness and response measures, and radiological crime scene management and nuclear forensics.

Based on the model academic curriculum in nuclear security designed by the IAEA, any educational institution can design its own programs in nuclear security, such as a graduate (MA/MSc) program or a certificate training course, using any of the 32 courses included in the model curriculum. The courses can be further categorized into areas of expertise, such as science and engineering, policy and international relations, legal/regulatory, response/law enforcement, management, and intelligence/security. In this regard, an important exercise done during the 5-day RSIS-IAEA FDC was on being able to design a sample curriculum in each of the three fields: engineering, policy and international relations, and natural sciences. The curriculum development exercise was indeed useful in that it allowed participants (faculty, government officers/staff, and prospective trainers) to identify the kinds of courses relevant to and needed by their targeted students/participants. It also introduced them to a range of teaching tools and available educational resources. INSEN, which is actively supported by the IAEA, is an important source of educational materials, experts, and resources in teaching nuclear security.

After the conclusion of the RSIS-IAEA FDC, a survey was taken to get the assessment of the participants on the course. A majority (81%) of the participants indicated that attending the FDC will encourage them to develop and introduce curricula on nuclear security in their institutions. Furthermore, 87% stated that it will encourage them to seek closer cooperation with similar institutions for the development and implementation of nuclear security education programs. Learning from the achievements of the first IAEA's FDC in the region, INSEN members from Southeast Asia and the rest of the Asia-Pacific region can also consider jointly organizing regional FDCs on a regular/annual basis. This proposed short training course can be initially designed to provide a basic introduction to nuclear security threats and risks through exploring the following four subthemes: (1) what is nuclear security?; (2) nuclear security culture; (3) radiological security; and (4) understanding nuclear security risk assessment and threat mitigation. The large pool of nuclear security experts from INSEN could serve as a key pillar to institutionalize INSEN-led FDCs in the Asia-Pacific.

Another potential area that INSEN members in the region could consider is the enhancement of the nuclear security detection capability of regional countries. Nuclear security detection architecture is a framework that integrates the various technical and non-technical elements necessary to detect the illegal activities of nuclear material and other radioactive sources. Nuclear security detection architecture should be developed based on a national nuclear security system or national detection strategy [18]. ASEAN member-states have just begun developing a regional roadmap for building a nuclear security detection architecture for radioactive material out of regulatory control [19]. Such a future roadmap must include the participation of and collaboration among INSEN members on enhancing nuclear security detection architecture through their educational and training programs in Southeast Asia and eventually in the broader Asia-Pacific.

One major observation in Southeast Asia is the difficulty in building and maintaining the continuous capacity for frontline security agencies to perform tasks related to nuclear security detection. It poses a challenge to frontline agencies in protecting national borders from any attempt to smuggle nuclear and

radioactive materials into the country. INSEN members, in collaboration with nuclear security support and training COEs, can organize a regional Train-the-Trainers Course for Instructors of Front-Line Officers (FLO) on the Detection of Nuclear and Other Radioactive Material out of Regulatory Control. Malaysia's COE, the Nuclear Security Support Centre, has been conducting a FLO Train-the-Trainers course, with the support of the IAEA and the US Nuclear Smuggling Detection and Deterrence (US NSDD) program, since 2017 [20]. INSEN members in the region can consider expanding it at the regional level. This recommended initiative can produce a new batch of qualified instructors developed through a well-defined program in ensuring the standard of the FLO training programs in Southeast Asia and the broader Asia-Pacific.

V. Creating an ASEAN-Northeast Asia Network of Nuclear Security Centers of Excellence and Knowledge Centers

Nuclear security education guarantees that there will be a sustainable pool of experts who are highly qualified to conduct effective regulatory oversight of nuclear and radioactive materials and uphold a robust nuclear security regime in a state [17]. The EAS Statement recommends that regional states must strengthen capacity building efforts through training and education, including COEs [3]. The primary role of COEs is to “facilitate the development of human resources and the provision of technical and scientific support on several levels to ensure the long-term sustainability and effectiveness of nuclear security in a State” [21]. COEs foster nuclear security culture and facilitate coordination and collaboration among government agencies and other stakeholders in nuclear security.

The creation of COEs in Southeast and Northeast Asia is considered to be a tangible result of the NSS process [22] (see Table 2). In Southeast Asia, Indonesia and Malaysia had already established their COEs, while the Philippines, Vietnam, and Thailand also plan to set up their respective COEs. Malaysia's regional NSSC is active in disseminating best practices and information sharing within the region [23]. In August 2018, as a regional Nuclear Security Support Centre (NSSC), Malaysia hosted a Trilateral Exercise jointly with Indonesia and the Philippines, given that they share maritime borders with persistent common security threats. The table-top exercise and workshop on cooperation to manage and respond to security threats within their shared maritime borders was supported by the IAEA in collaboration with the Global Initiative to Combat Nuclear Terrorism. The table-top exercise helped participants strengthen their capacity to detect and respond to nuclear security events in coastal and maritime areas. The workshop looked at mechanisms to create national preparedness strategies, models for regional and international coordination, and cooperation during the detection and response to a nuclear security event [24]. Indonesia's BATAN Centre for Security Culture and Assessment is proactive in promoting nuclear security culture. Its self-assessment project has generated important and tangible outcomes in that it not only offered an assessment of the status of security culture at the country's three research reactors, but it also provided a learning experience for management and the workforce of BATAN in identifying the gaps and improving their security culture [25]. These training projects now need to be expanded to include assessments of security culture in hospitals, industrial facilities, and other stakeholders that utilize radioactive material, apart from the government's research reactors.

The Indonesia Centre of Excellence on Nuclear Security and Emergency Preparedness (I-CONSEP) serves as the nuclear security support and training center with a mandate to undertake human resources development, foster security culture, and conduct support functions for nuclear security and emergency preparedness through its training, awareness, and educational activities for frontline officers, emergency responders, security officials, and border officers [26]. With the establishment of these two specialized centers, Indonesia now aims to ensure that the efforts towards effective nuclear safety and security and the work towards security culture are sustainable. In this regard, synergies can be developed between Southeast Asian COEs and Northeast Asian COEs since the latter provide significant help in developing

the human resources and providing technical support services to their counterparts in ASEAN, as well as the ASEAN Centre for Energy, and also to the wider Asia-Pacific region [27].

Table 2. Nuclear Security COEs in Southeast and Northeast Asia [27, 28]

COUNTRY	CENTERS OF EXCELLENCE	OVERSEEING NUCLEAR AGENCIES	YEAR OF ESTABLISHMENT	MAIN RESPONSIBILITIES
China	State Nuclear Security Technology Center (SNSTC)	China Atomic Energy Agency	2015	nuclear security education, training and certification activities
Indonesia	Centre for Security Culture and Assessment	National Nuclear Energy Agency (BATAN)	2014	Performs nuclear security culture assessment, security trainings and drills
	Indonesia Center of Excellence on Nuclear Security and Emergency Preparedness (I-CoNSEP)	Nuclear Energy Regulatory Agency (BAPETEN)	2014	Provides policy, technical and scientific support to nuclear security regime; ensures nuclear emergency response coordination and capacity building; advances regional collaboration
Japan	Integrated Support Center for Nuclear Nonproliferation and Nuclear Security (ISCN)	Japan Atomic Energy Agency (JAEA)	2010	Extends capacity building assistance, technical support to state agencies; delivers policy research; shares best practices with other nuclear security officials from Asian countries
Malaysia	Nuclear Security Support Centre (NSSC)	Atomic Energy Licensing Board	2012	Offers trainings on nuclear security to security officers and law enforcers; shares Malaysia's experiences and best practices with countries in the region
South Korea	International Nuclear Nonproliferation and Security Academy (INSA)	Korea Institute of Nuclear Nonproliferation and Control (KINAC)	2014	Develops educational program and training on IAEA safeguards, nuclear security and export control; Provides capacity building support to newcomer countries in Asia and eastern Europe

How can INSEN members and COEs in the Asia-Pacific collaborate? Complementing the COEs, knowledge centers, like universities and research institutions that are members of the INSEN, can help promote nuclear security culture. The state has the responsibility to develop national education and continuous training programs on nuclear safety and security cultures. In the context of nuclear security, INSEN members and COEs in the Asia-Pacific, as key training organizations in this area, are well placed to help strengthen security culture by broadening their activities beyond technical training to include human factors and serving as a platform for knowledge sharing among regional and global experts [28]. Given the increased attention to training and the human factor in nuclear security, the establishment of a COE signifies a good practice and a strong commitment by the state to enhance nuclear security. By focusing on the human factor in securing nuclear facilities and materials, COEs serve as a mechanism for ensuring employees, managers, and organizations are trained on a wide number of important nuclear security issues.

The educational activities of Southeast Asian institutions, particularly INSEN member-universities and the capacity building assistance from Northeast Asian COEs, certainly provide a strong foundation for establishing an ASEAN-Northeast Asia Regional Network of Nuclear Security COEs and Knowledge Centers. A collaborative network of COEs and INSEN members in the Asia-Pacific can complement the work of ASEANTOM in terms of promoting security culture as well as sharing of best practices, resources, expertise, and training materials.

The importance of promoting a nuclear security culture cannot be understated given the long-term plans by several Southeast Asian states to build NPPs and recent incidents of missing radioactive sources in the region. Furthermore, a network of COEs and INSEN member-universities does not only facilitate knowledge transfer but also help build capacity and develop regional expertise. More importantly, they can engage with industry and civil society through various platforms and in turn promote public confidence in nuclear and radiological security in the Asia-Pacific.

VI. Enhancing Regional Nuclear Emergency Preparedness and Response

Any radiological security incidents and even security threats to NPPs in several Asia-Pacific countries may trigger radioactive leaks and emergencies. In this regard, EAS leaders “[e]ncourage all States to implement measures nationally, regionally and internationally to ensure nuclear, radiation, transport and waste safety, as well as emergency preparedness and response [EP&R], taking into account IAEA Safety Standards” [3]. In Southeast Asia, the foundations of nuclear EP&R at the regional level have already been laid out through the regional projects of ASEANTOM. These projects are essential at both national and regional levels to protect the people and the environment in cases of nuclear or radiological accidents, as well as the malevolent use of radioactive material. Most recently, ASEANTOM has been working with the ASEAN Coordinating Centre for Humanitarian Assistance on disaster management (AHA Centre) to draft the ASEAN protocol on nuclear EP&R.

In collaboration with the IAEA, ASEANTOM launched a regional project on *Supporting Regional Nuclear Emergency Preparedness and Response in ASEAN Region* in 2016, which was aimed at creating a regional environmental radioactivity database, providing technical assistance to member-states, and fostering a more organized and coordinated regional response for radiological emergencies [29]. ASEANTOM and the IAEA also completed the technical report titled *A Review of the Nuclear and Radiological Hazard Assessment in ASEAN* among the outputs of the regional project. This regional study is extremely important in identifying potential radiological and nuclear hazards that can be found in all ASEAN member-states. Meanwhile, the EU is also assisting ASEANTOM on an EP&R project aimed at developing a regional platform for decision-making and coordination during a nuclear or radiological

emergency. The project's expected outputs include the *Action Plan for Implementing the ASEAN Strategy for Regional Cooperation on Radiological and Nuclear EP&R*, technical support for decision-making, and an ASEAN Early Warning Radiation Monitoring Network equipped with a regional data exchange platform (expected to be implemented in 2020).

Building on these regional projects, ASEAN's framework on EP&R could also be used in building a much broader EP&R framework for the Asia-Pacific. The regional hazard assessment on nuclear and radiological materials and facilities could be expanded to include all Asia-Pacific countries, given that all states possess radiological materials for various civilian applications. In addition, Asia-Pacific states could establish an integrated, early-warning, radiation-monitoring network and data exchange platform spearheaded by ASEANTOM. Building on the ASEAN EP&R Strategy, an East Asia Summit (EAS) Strategy on Radiological and Nuclear EP&R could be pursued in order to implement the EAS declaration. The EAS strategy could be based on and fully explore existing mechanisms at the regional (i.e., ASEAN) and national levels. It must have a flexible approach to accommodate different countries' priorities. Such a strategy could help institutionalize ASEAN's EP&R collaboration with neighbors from Northeast and South Asian⁶ states that have significant activities involving nuclear and radiological materials.

VII. Challenges to Southeast Asia's Nuclear Security Governance

Despite notable progress in Southeast Asia in enhancing nuclear security cooperation in the region and the potential to build and expand their regional mechanisms to the broader Asia-Pacific region, there remains significant challenges and gaps in its nuclear security governance. One key challenge is getting all ASEAN member-states to be parties to global conventions. As Table 3 shows, several ASEAN member-states have not yet signed and ratified important global nuclear conventions, including nuclear security treaties and the non-legally binding Code of Conduct on the Safety and Security of Radioactive Sources. And in the absence of NPPs in the region, the CPPNM and its Amendment have also not been signed or ratified by some ASEAN member-states. In addition, not all ASEAN member-states have made political commitments with regard to the execution of the non-legally binding Code of Conduct on the Safety and Security of the Radioactive Sources. Given that many hospitals, research reactors, laboratories, and factories utilize radioactive sources, physical protection is of utmost importance. Since the risks to the physical protection of nuclear facilities and materials, such as stealing of radioactive materials and nuclear terrorism, have regional consequences, it is imperative for all ASEAN member-states to collectively adhere to the CPPNM Amendment as well as the Code of Conduct. The Amendment broadens the scope of the CPPNM to also include physical protection requirements for nuclear facilities and nuclear material in domestic use, storage, and transport. It also criminalizes nuclear smuggling, trafficking, and sabotage. It provides for expanded cooperation among countries on locating and recovering stolen or smuggled nuclear material [30]. It is essential for countries with nuclear activities and radioactive sources for non-power applications to ratify all treaties and to implement even non-legally binding IAEA guidelines, thereby contributing to the enhancement of nuclear security architecture at all levels [31].

⁶ South Asia is composed of Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka.

Table 3. ASEAN Member-States' Participation in Key Nuclear Agreements [32–35]

	Safeguards Additional Protocol	Convention on Physical Protection of Nuclear Materials (CPPNM) 2016 CPPNM Amend- ment	1980 CPPN M only	Nuclear Terrorism Convention (ICSANT)	Comprehensive Nuclear Test- Ban Treaty (CTBT)	Convention on Nuclear Safety (CNS)	Joint Convention on Spent Fuel and Radiological Waste	Convention Early Notification of a Nuclear Accident	Code of Conduct on the Safety and Security of Radioactiv e Sources (Political Commitm ents/non- legally binding)
Brunei					✓				
Cambodia	✓		✓	signed	✓	✓		✓	
Indonesia	✓	✓	✓	✓	✓	✓	✓	✓	✓
Laos	signed		✓		✓			✓	
Malaysia	signed			signed	✓			✓	✓
Myanmar	signed	✓	✓		✓	✓		✓	✓
Philippines	✓		✓	signed	✓	signed	signed	✓	✓
Singapore	✓	✓	✓	✓	✓	✓		✓	✓
Thailand	✓	✓	✓	✓	✓	✓	✓	✓	✓
Vietnam	✓	✓	✓	✓	✓	✓	✓	✓	✓

Note: A check mark means that the country has not only signed the convention but also ratified it to become part of its legislative framework.

A weak nuclear security culture is another evident gap in nuclear security governance in Southeast Asia, accentuating the significance of human factors, such as attitudes, awareness, and behaviors [36]. Harnessing nuclear energy and the utilization of radioactive material for non-power applications are not just about the technological aspects. Human failures due to complacency and the lack of critical thinking are significant factors in most reported incidents involving radioactive materials, including cases of loss and theft [12]. Hence, the development and strengthening of the security culture of individuals, organizations, and institutions that handle radioactive material must be pursued. With the exception of Indonesia [37], most of the Southeast Asian countries have yet to develop policy frameworks that engender a strong safety culture and a security culture. Without these regulatory frameworks, it would be challenging for licensees and users of radioactive and nuclear materials to develop their safety and security plans that advance nuclear security [38].

Meanwhile, the kinds of training courses, workshops, and seminars offered by training centers in the Philippines, Malaysia, Thailand, and Vietnam focused more on building capacity at the more technical level and less on safety-security cultures. While these technical-oriented training activities enhance the domestic technical expertise in nuclear safety and security, a more comprehensive program that includes enhanced training and educational activities on security culture and safety culture would be ideal.

Another significant gap is the lack of nuclear training COEs in other Southeast Asian countries. As shown in Table 2, only Malaysia and Indonesia have established their national COEs on nuclear security. It would be more difficult to inculcate safety-security cultures without even a training institution, such as a nuclear security support center/COE. These countries should therefore consider setting up their national COEs that are mainly dedicated to fostering a nuclear security culture.

How can INSEN help plug this gap? INSEN members, such as universities and research institutions, can also fill in the gaps in countries where there are no established COEs. The collaboration among INSEN members can develop the human resources and technical support services needed for a sustainable nuclear security regime. COEs and INSEN member-universities signify a bright future for nuclear security and safety education in East Asia, a region that will definitely need significant capacity building in the coming decades.

VIII. Conclusion

This paper explored some of the potential mechanisms as to how the future nuclear governance in the Asia-Pacific region can be enhanced building on the progress made in ASEAN. The pivotal role that ASEANTOM may play in the future landscape of nuclear governance of the Asia-Pacific region should be explored. Moving forward, future research or policy studies on the issue of nuclear security governance spearheaded by ASEAN mechanisms would need to continue addressing critical issues that might hamper regional nuclear security cooperation in Southeast Asia and the broader Asia-Pacific. These issues include whether ASEANTOM would be able to acquire the capacity to be the lead driver of regional nuclear governance and the issue of sustainability of current funding, financial, and technical assistance mechanisms through the IAEA, EU, and bilateral grants.

Meanwhile, there should also be greater synergy and collaboration among COEs, INSEN member-universities, and other knowledge centers in building nuclear security culture of excellence in the Asia-Pacific. INSEN members should be proactive in building sustainable collaboration in the Asia-Pacific so as to contribute to stronger nuclear security governance in the region with Southeast Asian INSEN members as key drivers. Education is a powerful tool to raise awareness about educating students and training professionals, thereby strengthening nuclear security culture and practices at the national level. It is recommended that an institutionalized collaboration among the COEs, universities, and knowledge centers in Northeast and Southeast Asia can be a good start, given that East Asia is a region that will definitely require more enhanced capacity building cooperation in the coming decades. To this end, the contribution of informal networks of knowledge centers like INSEN and other expert communities must be tapped further in order to plug the gaps in nuclear security governance in East Asia and beyond.

IX. ACKNOWLEDGEMENT

This study was supported by the Singapore Ministry of Education (MOE) Academic Research Fund (AcRF) Tier 1 Grant (Reference No. RG52/19). Authors would also like to thank anonymous reviewers of this paper for their helpful comments.

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