

The Sustainability of Nuclear Energy in Southeast Asia: Opportunities and Challenges

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By Mely Caballero-Anthony¹, Alistair D. B. Cook², Julius Cesar I. Trajano³ and Margareth Sembiring⁴

¹ Associate Professor and Head of the Centre for NTS Studies.

² Research Fellow with the Centre for NTS Studies.

³ Senior Analyst with the Centre for NTS Studies.

⁴ Research Analyst with the Centre for NTS Studies.

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Executive Summary and Recommendations

ASEAN member states are moving towards diversifying their energy mix, reducing their over-dependence on fossil fuels, and exploring alternative energy sources such as nuclear energy to ensure that their energy supplies are secure, affordable and environmentally sustainable. Vietnam, Indonesia and Malaysia are the three ASEAN member states that are exploring the nuclear energy option. Although not all ASEAN member states presently have plans to build nuclear reactors, there are crucial reasons why the region has a vested interest in ensuring nuclear security, safety and safeguards (3S) in the region. First, any nuclear accident in the region would threaten public health and the environment through water and soil contamination as well as a radioactive plume which knows no borders. Second, the region's fast-growing economies can be easily jeopardised by a nuclear accident as the operations of key economic sectors, including the supply chain, would be disrupted. Third, the region's vital sea lanes, where radioactive materials will likely pass through, are not tightly guarded by maritime security forces. There is no guarantee that ASEAN member states will be able to fully secure all the radioactive materials and waste from their future NPPs and prevent terrorist threats. Hence, there is a need for ASEAN member states to start discussing possible regional mechanisms on the prevention of the trafficking of weapons of mass destruction and their means of delivery. Lastly, the region is home to the world's major food producers and exporters. A nuclear accident can result in the radioactive contamination of farmlands and marine resources, disrupting the food supply chain. It is therefore in ASEAN member states' interest if the region has collectively institutionalised nuclear safety and security, including the safe and secured transport of radioactive materials.

Currently, Vietnam has the most developed nuclear power roadmap in the region with its first nuclear power plant (NPP) due to be completed by 2023. But a number of challenges need to be addressed first by its government to ensure nuclear safety and security. There are structural concerns of government oversight of the nuclear power plant (NPP) programme in Vietnam. Its regulatory body does not have effective independence which may compromise safety in the future once its NPP starts operating. Vietnam's emergency protocol is still not yet in conformance with the IAEA's emergency preparedness and response standards. In addition, Vietnam has yet to come up with a comprehensive NPP security plan as well as a management plan for spent fuel. To address these issues, the Atomic Energy Law is now being revised and expected to be passed by the National Assembly by 2016. Vietnam works closely with IAEA to meet international safety standards and regulatory practices. To address the shortage of manpower, Vietnam is sending students overseas to take up practical courses and training on nuclear power.

Meanwhile, Indonesia shows increasing confidence in its capacity and capability to build its first NPP. IAEA's 2009 Integrated Nuclear Infrastructure Review (INIR) in Indonesia confirms that Indonesia carried out extensive preparatory work on infrastructure and is ready to begin nuclear power plant construction. Indonesia's commitment for nuclear safety, security and safeguards is reflected in a number of regulations and initiatives that drew guidance from the IAEA standards. Indonesia's NPP programme has thus far stalled largely due to high political costs resulting from strong public opposition.

Indonesia does not have an entity acting as a Nuclear Energy Implementing Organisation (NEPIO). Various ministries and government agencies carry out separate functions in preparing for the establishment of NPPs, and each of them reports directly to the President. The President will make or break the decision for Indonesia to go nuclear, and as public acceptance is a key factor, he is unlikely to make an unpopular decision. The change of leadership from Susilo Bambang Yudhoyono to Joko Widodo therefore does not provide an immediate indicator of the future of NPP plan in Indonesia.

To prepare for nuclear emergency situations, Indonesia has established the Organisation for National Nuclear Emergency Preparedness and Response System (OTDNN). Recently in August 2014, Indonesia established the Indonesian Center of Excellence on Nuclear Security and Emergency Preparedness (I-CoNSEP), a special platform where BAPETEN, BATAN, police, customs, the Ministry of Foreign Affairs, and intelligence communicate and coordinate their efforts for nuclear security and emergency responses. However, their effectiveness remains untested. In terms of human resources, Indonesia has an aging pool of nuclear experts at the National Nuclear Energy Agency and other nuclear facilities. Various government initiatives and

programmes are in place to boost the country's human resource development in the nuclear field, but specific competence needed for nuclear power applications will still need to be developed in co-operation with future NPP investor(s).

While Indonesia has gone a long way in its plans for NPP, in Malaysia the development of NPPs is still at an initial stage as site selection was made based on digital mapping and no fieldwork has been carried out to date. The plan has not moved forward due to concerns over the Fukushima disaster in Japan. Civil society also actively opposes the NPP plan. In addition, there are serious concerns over the safe disposal of nuclear waste and the independence and impartiality of the Malaysian regulatory body, Atomic Energy Licensing Board (AELB).

Malaysia's progressive commitment for nuclear safety, security, and safeguards is evidenced, among others, in the recent incorporation of the IAEA Convention on Physical Protection of Nuclear Material (CPPNM), the International Convention for the Suppression of Acts of Nuclear Terrorism (ICSANT), and the Additional Protocol to the IAEA Comprehensive Safeguards Agreements in Malaysia's Atomic Energy Licensing Act (Act 304) and its involvement in the Global Initiative to Combat Nuclear Terrorism. Regardless of such measures, Malaysia has not succeeded in convincing its public of its capacity and capability in dealing with nuclear power. To respond to nuclear emergencies, Malaysia has established dedicated mechanisms and resources although the effectiveness of inter-agency coordination, communication, and response times remains unknown. With regard to human resources, Malaysia does not have a dedicated human development programme for NPPs nor experienced personnel to teach nuclear engineering courses needed for NPPs.

As Vietnam comes closer to completing its first NPP, and with Indonesia and Malaysia both considering the prospects for a nuclear energy future, there is significant interest for ASEAN to strengthen nuclear governance in the region and strictly uphold nuclear security, safety and safeguards (3S).

It is imperative for ASEAN member states to work together to ensure effective governance of nuclear facilities, materials, and wastes and to adopt a regional disaster preparedness mechanism. ASEAN can facilitate regional cooperation on capacity-building, information dissemination, and emergency preparedness and response frameworks. Finding the right balance between national sovereignty and regional cooperation is often challenging since nuclear security always entails confidentiality as it is considered a national security issue. As such, this report recommends nuclear-aspiring countries in the region to consider the following policy options:

- Strengthen national legislation on nuclear safety, security and safeguards;
- Develop a comprehensive nuclear literacy campaign and human resources training programme;
- Conduct radiation risk computer modelling;
- Increase vigilance on food exports and imports;
- Explore the potential of establishing a regional/multilateral nuclear enrichment centre;
- Establish a regional nuclear crisis centre;
- Pursue joint nuclear emergency drills in region and train medical contingent for nuclear accident relief;
- Organise regular meetings among the ASEAN's academic institutions, think tanks and government agencies on nuclear power, security and safety;
- Establish Centres of Excellence on Nuclear Safety, Security and Safeguards (3S); and
- Explore an ASEAN Management of Spent Fuel Regional Framework.

The Sustainability of Nuclear Energy in Southeast Asia: Opportunities and Challenges

Introduction

The Fukushima nuclear crisis in March 2011 took place when the nuclear power industry in Asia was on the cusp of a period of growth.⁵ However, after an initial ‘wait-and-see’ period, nuclear energy development plans in the region remain mostly in place, despite safety concerns. To ensure that their energy supplies are secure, affordable and environmentally sustainable, Vietnam, Malaysia and Indonesia are moving towards diversifying their energy mix, reducing their over-dependence on fossil energy, and gradually integrating nuclear power into their long-term energy plans (See Table 1).⁶ Nuclear power is projected to enter the region’s energy mix after 2020, if Vietnam completes its nuclear power plant plan on time. The current energy industry structure in Malaysia and Indonesia is public-private partnership in general with the significant involvement of both national oil/gas companies such as Petronas (Malaysia) and Pertamina (Indonesia) and international oil companies such as Chevron, Shell and Total. There are no indications yet as to the possible structure of the nuclear industry in the two states. In Vietnam, nuclear power plants will be government-owned and operated solely by state-owned enterprise Electricity of Vietnam (EVN).

Table 1: ASEAN Electricity Generation by Source

Source	Share	
	2011 (%)	2035 (%)
Coal	32	48
Gas	44	28
Oil	10	2
Nuclear	0	2
Renewables (Hydro, Geothermal, Bioenergy, and others)	14	20
Total	100	100

Source: (International Energy Agency, 2013, p. 45; Vietnam Academy of Science and Technology, 2014)

The appeal of nuclear energy emanates from its three perceived advantages. First, nuclear energy in the long-run is cost-effective. Though initial operations can be expensive, the long-run per unit cost of nuclear energy is lower than fossil fuels (World Nuclear Association, 2014). Second, nuclear energy can reduce the overdependence of most countries on imported fuels. Lastly, nuclear energy can help reduce greenhouse gas emissions as it does not contain carbon.

⁵ In 2011, Asia had 115 nuclear plants located in South Korea, Japan, India, China and Taiwan. Currently, out of 435 operational reactors in the world, 123 are in Asia. There are also 49 nuclear reactors now under construction in Asia, out of the total 72 worldwide (International Atomic Energy Agency, 2014). According to the IAEA projection, Asia displays the strongest projected growth in terms of nuclear capacity, led by China and South Korea. From 83 gigawatts (GW(e)) in 2012, capacity is estimated to increase to 147 GW(e) - 268 GW(e) in 2030 (International Atomic Energy Agency, 2013).

⁶ Vietnam delayed constructing nuclear power plants from 2014 to 2020. It has already made significant developments in its nuclear programme, but NPP security and safety remain key challenges. Alongside Vietnam's nuclear development, other ASEAN member states are reconsidering their nuclear energy future (Nikitin, Holt, & Manyin, 2014). Malaysia could potentially build two nuclear reactors, including one possibly in Johor (Fang, 2014). Indonesia has the potential to implement a nuclear power action plan but currently remains a low priority due to public opposition.

With ASEAN member states moving towards connecting their power grids as part of the ASEAN Economic Community, all member states stand to benefit from more reliable and diversified energy sources. However, the continuing radioactive water leaks at the Fukushima nuclear plant, the unabated spewing of radiation into the environment, and the subsequent social, economic and political consequences demonstrate the transboundary implications, particularly environmental and public health consequences, of nuclear accidents,⁷ and accentuate the need for international cooperation on nuclear governance and investment in the research and development of safer nuclear technologies such as the current US programme to make nuclear fuel less susceptible to extreme heat in order to minimise the risk of explosive chemical reactions during disasters (Richards, 2014).

Another key takeaway from the Fukushima accident is the importance of having an effective and independent nuclear regulatory body. The Japanese parliament's investigation concluded that collusive relationships between Fukushima plant operators and government regulators compromised safety, one major reason why the accident occurred. The conflict of interest between Ministry of Economy, Trade and Industry, the government institution promoting nuclear energy, and the now-disbanded Nuclear and Industrial Safety Agency (NISA), an attached agency of METI, undermined safety and helped explain the inadequate culture of safety that led to the Fukushima accident (Kingston, 2014).⁸ As explained in this report, the existing regulatory bodies in the three countries are not yet fully independent, thus raising concerns over their capacity to enforce safety regulations.

⁷ Nuclear disaster has far-reaching transboundary health and environmental consequences through groundshine, cloudshine, inhalation and ingestion (World Health Organization, 2013). Radioactive exposure leads to acute radiation sickness and increased long-term cancer risks (Christodouleas et al., 2011). After the Fukushima accident, the risk of all solid cancers, breast cancer, leukaemia, and thyroid cancer are expected to increase with those living in the most contaminated area (World Health Organization, 2013). In areas surrounding Chernobyl, over five million people were exposed to excessive radiation (IAEA, 2006). Those affected by Chernobyl were found to suffer from thyroid cancers (United Nations Scientific Committee on the Effects of Radiation, 2011), and anxiety and psychological issues including several thousand children (IAEA, 2006).

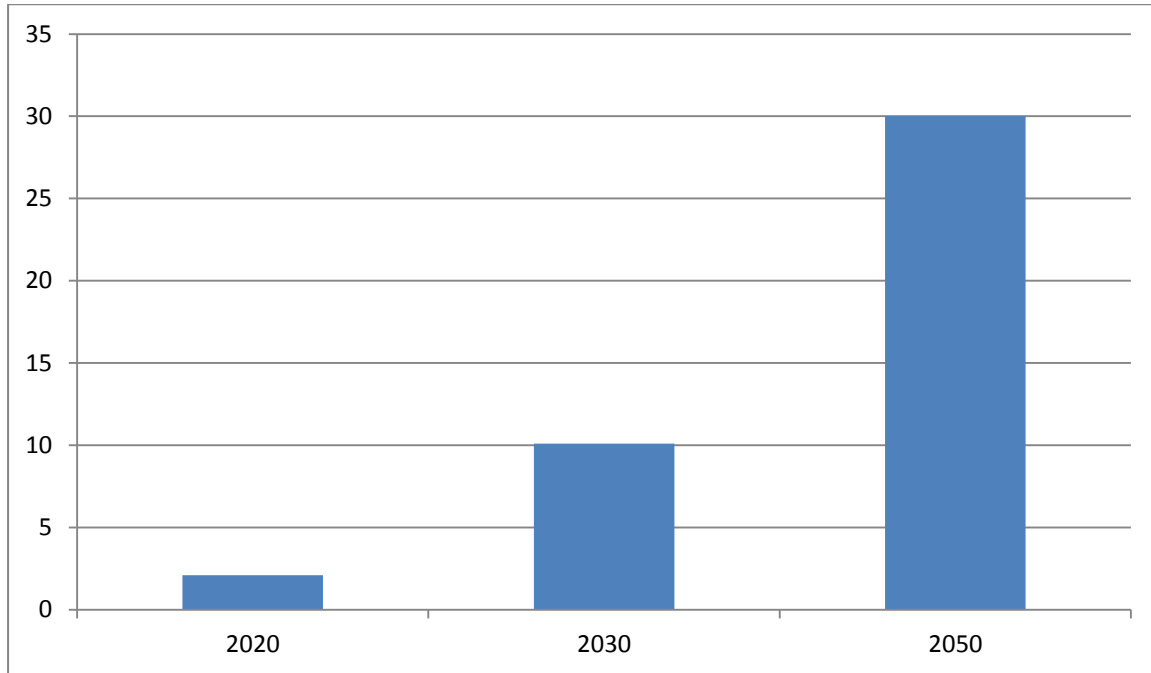
The Fukushima disaster released radioactive materials that contaminated seawater, sediments, and biota in the marine environment of up to 30 kilometres away (Szymczak, 2013). Soil, dairy cow milk, vegetables, foods, fish, spider, wood species, aquatic insects and paddy field were also exposed to the radiation. Deep-dwelling fish, such as cod, flounder, sole, halibut and pollock, caught in waters surrounding the Fukushima plant still show high levels of contamination. Because ocean currents disperse radiation far and wide, the full impact on Pacific Ocean food supply may not be known for years. An intensive study done by the University of South Carolina and University of Paris-Sud and published in *Biological Reviews* in 2012 concluded that even low levels of radioactivity are damaging to human and animal health (Poland, 2013). In Chernobyl, radioactive traces were mostly deposited on open surfaces such as lawns, parks, streets, roads, town squares, roofs, and walls. Contamination also reached sewage systems and sludge storage. After the Chernobyl incident, high transfer of radioactive materials from plantations to animals to humans was seen in the Arctic and sub-Arctic zones of Europe (IAEA, 2006).

⁸ NISA was disbanded and replaced by the fully independent Nuclear Regulation Authority (NRA), which is not under METI's authority as had been the case with NISA.

Nuclear Power Plant Development in Vietnam

In 2011, Vietnam⁹ produced a Master Plan for National Power Development 2011–2020 With the Vision to 2030 which stipulates the country will begin tapping nuclear energy by 2020. Nuclear power is envisioned to account for 10.1 per cent of electricity production by 2030.¹⁰

Chart 1: Projected Share (%) of Nuclear Power in Vietnam's Energy Mix



Sources: (Dung, 2011; Ninh, 2013a)

Vietnam's National Assembly in November 2009 approved plans for construction of the first two Russian-built 1,000 MWe reactors at Phuoc Dinh, Ninh Thuan province by 2014 (*Ninh Thuan 1* plant).¹¹ (Stratfor, 2014; Tuoitrenews, 2014) The Master Plan envisions a further six nuclear power plants.

⁹ Economic growth in Vietnam is surpassing the country's capacity to provide sufficient energy supply to its industrial, agricultural and household consumers. Electricity demand in the past decade rose by 15 per cent annually. Oil consumption doubled from 176,000 bbl/d in 2000 to 388,000 bbl/d in 2012, and Vietnam imports the majority of it. At present, most of Vietnam's power is generated from natural gas, hydropower and coal, with electricity accounting for 52 per cent of consumption (World Nuclear Association, 2014). Vietnam already imports hydropower from Laos and China with nearly 5 per cent of its energy requirements coming from China, a strategic dependency it hopes to limit in view of the two countries' historical animosity and territorial disputes in the South China Sea (Stratfor, 2014).

¹⁰ For further details, please see Nguyen Tan Dung. (2011). Approval of the National Master Plan for Power Development for the 2011-2020 Period with the Vision to 2030. Hanoi, 21 July. Online copy is available at http://www.nti.org/media/pdfs/VietnamPowerDevelopmentPlan2030.pdf?_=1333146022.

¹¹ In October 2010, Vietnam and Russia signed an agreement to build the country's first power plant, the Ninh Thuan 1 nuclear power plant, using two VVER-1000 or 1200 reactors, later specified as AES-91 power plants. An agreement of up to USD9 billion (SGD11.4 billion) finance was signed in November 2011 with the Russian government's state export credit bureau (World Nuclear Association, 2014)

Nuclear energy experts argue that VVER- type reactors are a clean, safe and reliable source of nuclear energy. VVER reactor plants are based on technical solutions that proved their reliability and effectiveness in the course of more than 40 years of operational experience. For a detailed explanation, please see (Kolchinsky, 2013; V. Mokhom & Trunov, 2009).

Map 1: Location of Proposed Sites of NPPs in Vietnam



However, in January 2014, Prime Minister Nguyen Tan Dung announced that the construction could be delayed until 2020, citing advice from the International Atomic Energy Agency (IAEA) that “Vietnam must adopt a strict and effective solution for its nuclear power development” (Stratfor, 2014; Tuoitrenews, 2014).¹² The government wanted to ensure that all accuracy and safety aspects of the programme are addressed properly first before constructing the NPP, given that Vietnam is still developing its human resources in the nuclear field. It admitted that instead of rushing the programme, it is taking a calibrated step-by-step measure while developing the necessary infrastructure, including training the future NPP operating engineers and strengthening relevant laws and regulations (Vietnam Academy of Science and Technology, 2014).

In October 2010, a Japan-Vietnam nuclear cooperation agreement was signed for the construction of a second nuclear power plant at Vinh Hai in Ninh Thuan province by 2015; this plan is also delayed indefinitely. In preparation for the project, Japan committed to train about 1,000 staff for Ninh Thuan 2 (World Nuclear Association, 2014).

¹² Press reports have cited that difficulties in training staff for the planned nuclear power programme as a possible reason for the delay (Nikitin et al., 2014). Doubts about Vietnam’s capabilities to successfully pursue nuclear energy and concerns over safety have been growing for some time. Nevertheless, Hanoi said that the delay will allow it to acquire greater capability to pursue nuclear power in the near future (Stratfor, 2014).

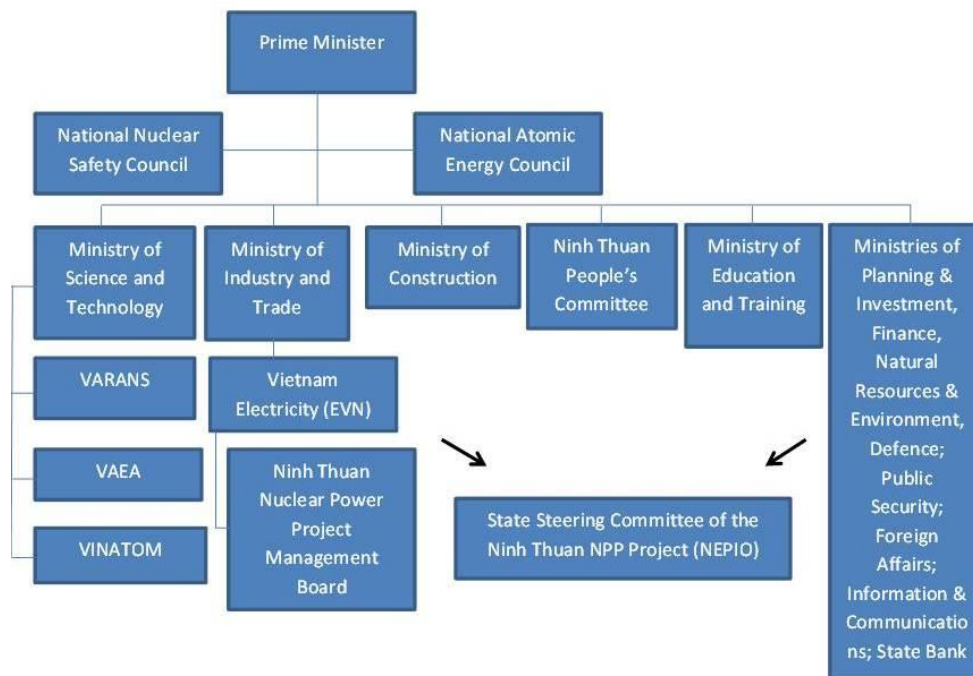
Nuclear waste management

As with other Russian-built nuclear power plants in non-nuclear weapon states, the Vietnam-Russia nuclear commercial deal includes a provision for Moscow to both supply fuel and take back spent (used) fuel. The spent fuel is to be reprocessed in Russia and the separated wastes are to be returned to Vietnam. After reprocessing, the level of radioactivity in the waste is reduced but Hanoi has not yet adopted a comprehensive spent fuel disposal plan. Current plans only include the temporary storing of spent fuel on site for at least 30 years, while studies on permanent disposal are still being undertaken (Vi, 2014). In the case of Japanese-built reactors, there is no arrangement yet for either the reprocessing or disposal of waste so Vietnam needs to explore spent fuel storage and disposal options (Nikitin et al., 2014). The lack of a comprehensive plan on the disposal of spent fuel is one key challenge that has yet to be addressed by Vietnam. Furthermore, while Vietnam has just acceded to Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, its provisions are not in the current Atomic Energy Law and there are no existing domestic regulations that would implement the Joint Convention. The Vietnam Agency for Radiation and Nuclear Safety (VARANS) recommended the inclusion of the Joint Convention in the proposed amendments (Vi, 2014).

Legal and regulatory framework

To strengthen the country's nuclear safety and security regulation, the Vietnamese parliament passed the Atomic Energy Law in 2008.¹³ Currently the Law is under revision to address the independence of the Nuclear Regulatory Body, licensing process, protection of nuclear facilities and materials, emergency response and preparedness, spent fuel management and liability for nuclear damage. The proposed amendments have been submitted already to the National Assembly and are expected to be approved by 2016.

Diagram 1: NPP Development Governance Structure in Vietnam



Source: (Ninh, 2013a)

¹³ The US Department of Energy (DOE) and the US Nuclear Regulatory Commission (NRC) assisted Vietnam in drafting the law (Nikitin et al., 2014). Several decrees were also issued by the Prime Minister to serve as terms of reference of the aforementioned law: implementing guidelines of some provisions of the Atomic Energy Law on nuclear power plants; administrative sanctions in the field of atomic energy; and regulation on nuclear safeguards.

In 2010, the National Nuclear Safety Council (NNSC) was established and directly reports to Prime Minister Nguyen Tan Dung for nuclear safety and licensing.¹⁴ In May 2013, he created the inter-ministerial National Council for Atomic Energy Development & Application, also known as the National Atomic Energy Council (NAEC). It advises the government on "orientations and strategies" on nuclear energy and drafts key policies on nuclear energy development and application. It coordinates ministries and government agencies involved in developing Vietnam's nuclear power programs. The council provides avenues for cooperation with international organisations, such as IAEA, and countries with nuclear power expertise (World Nuclear Association, 2014).¹⁵

Prime Minister Nguyen Tan Dung is due to step down by 2016 and there is no identified successor yet. Nonetheless, Vietnam's nuclear programme has already been approved collectively by the National Assembly (The Economist, 2013b). Leadership change in 2016 does not necessarily mean that oversight of the first NPP would be in question. Decision-making authority in Vietnam is primarily vested in the Politburo (Political Bureau of the Communist Party), a small group of 10-15 high ranking party members, while the Prime Minister is the person who has authority to make decisions on a day-to-day basis regarding internal and external affairs. Hence, an important national decision like a nuclear power programme would have been made collectively by the members of the Politburo rather than merely the PM. Even those in the highest positions such as the State President and the Prime Minister have limited amounts of real power to make independent decisions (Casey, 2009). Any change in fundamental impetus to push ahead with Vietnam's nuclear power programme, after its postponement, will primarily depend on the collective decision of the Politburo, even after the appointment of a new prime minister and cabinet. There has been no indication yet whether the Politburo would significantly change the NPP programme.¹⁶

The Vietnam Agency for Radiation and Nuclear Safety (VARANS), an attached agency of the Ministry of Science and Technology (MoST), currently serves as a nuclear regulatory body. Since 2012, Vietnam began implementing an effectively independent regulatory agency. MoST and Japan's Ministry of Economy, Trade and Industry signed an agreement to enhance the technical and safety competence of Vietnam's nuclear regulatory body. In May 2014, VARANS in collaboration with the European Commission (EC) organised a workshop on technical assistance to further develop the Vietnamese legal framework for nuclear safety. VARANS submitted to the government a plan for a nuclear regulatory agency that ensures its independence from management and R&D agencies as well as its full authority on licensing and inspection of nuclear power plants (Thiep, 2013). One of the proposed amendments to the Atomic Energy Law is to make VARANS an effectively independent regulatory body. VARANS is currently only a "partly independent" regulatory agency since it remains under MoST, the leading agency promoting nuclear energy in Vietnam.¹⁷ It is independent only in regulating radioactive sources and materials, mostly for industrial, educational and medical applications, but not in regulating NPP safety and security aspects. VARANS proposed to take over and centralise the licensing system because nuclear licensing is presently done by three government bodies: Office of the Prime Minister--licenses for nuclear sites; MoST—licenses for the construction of NPPs; and the Ministry of Industry and Trade (MIT)—licenses for the operation of NPPs. It must be noted that Electricity of Vietnam (EVN), which is tasked to operate NPPs, is an attached state corporation of the MIT. Safety may be compromised if the licensing system on NPP operations remains under MIT. The government has yet to act on VARANS' proposed

¹⁴ This inter-ministerial council will last five years, led by the Ministry of Science and Technology (MoST). Its president is the Minister of the MoST and its standing agency is the Agency for Radiation and Nuclear Safety (ARNS). The Council proposes policies on nuclear safety to the Prime Minister and guidelines on the use of atomic energy as well as the nuclear power industry's operational processes and emergency response. It is tasked to hold consultations with Vietnamese and foreign experts in nuclear-related issues. In its first two sessions in 2011 and 2012, the NNSC listened to the recommendations put forward by Japanese and Russian consultants, particularly on the location of Vietnam's NPPs (Vietnam News Agency, 2012). No further details on the recommendations, however, are available. The Council also examines the ARNS's report on the assessment and safety analysis of the future nuclear power plants after their initial operation [see the preceding section for the schedule of the inauguration of nuclear reactors] and the results of the safety inspection of the plant's nuclear reactor (Vietnam News Agency, 2010)

¹⁵ Like the NNSC, the NAEC is headed by the Minister of Science and Technology.

¹⁶ Interviews with Vietnamese officials, Hanoi, 7-8 August 2014.

¹⁷ Interview with a Vietnamese official, Hanoi, 8 August 2014

amendments. However, a fully independent Vietnamese regulatory agency, akin to Japan's Nuclear Regulatory Agency and US Nuclear Regulatory Commission, is unlikely given the tight Communist Party rule in Vietnam.¹⁸

Another important body in the country's nuclear programme is the Electricity of Vietnam (EVN), a state-owned enterprise responsible for building and operating the plants. The estimated USD11 billion (SGD13.9 billion) for these was to be financed with up to 25 per cent EVN equity and the balance borrowed from countries supplying the technology (World Nuclear Association, 2014).¹⁹ But EVN's dominant presence in the power industry has already resulted in inefficiencies.²⁰ Officials at EVN and other state-owned power producers benefit from state regulation, sometimes through corrupt practices, even as the companies they work for operate at a loss, and have a vested interest in blocking structural reform (The Economist, 2013a). If it continues to accumulate debts, it is also uncertain whether EVN can significantly invest sufficient financial resources in safe and secure NPP operations. This again accentuates the structural concerns of government oversight of the NPP programme in Vietnam.

Nuclear safety and security measures

Several Vietnamese nuclear experts have voiced concerns over nuclear safety and the absence of an independent regulatory body coupled with widespread corruption and transparency issues, and a record of poor safety standards.²¹ Mdm Ton Nu Thi Ninh, former Vietnamese envoy to EU and former chair of the Foreign Affairs Committee of the National Parliament, said that the general lack of a 'safety culture' in Vietnam is a hurdle to the country's nuclear programme. This raises the issue of whether personnel manning NPPs in Vietnam would strictly abide by safety rules and procedures. Independent expert supervision and oversight is thus critical (Ninh, 2013). Mr Hien Pham Duy, a former director of the Dalat Nuclear Research Institute, which houses Vietnam's nuclear research reactor, pointed to the high rates of accidents on Vietnam's roads as the most visible example of a "bad safety culture" that pervaded "every field of activity in the country." Dr. Tran Dai Phuc, a Vietnamese-French nuclear engineer who worked in the French nuclear industry for four decades and is now an adviser to Vietnam's Ministry of Science and Technology said potential problems were not related to the reactors' technology but to the lack of "democracy as well as the responsibility of personnel, a culture of quality assurance and general safety regarding installation and impact on the environment (Onishi, 2012)."

The 2011 Fukushima nuclear disaster raised concerns over Vietnam's capacity to administer and regulate a nuclear energy sector. Based on climate modelling exercises, Vietnam is often listed as one of the world's most vulnerable countries to the impacts of climate change such as rising sea levels and stronger typhoons particularly around the location of the Ninh Thuan nuclear power plant. Ninh Thuan is identified as a disaster-prone coastal province (Mulder, 2006). Also, Vietnam's coast has been subject to tsunamis in the past. (Nikitin, Holt et al. 2014, p. 7). But as explained by Vietnamese government scientists, their seismic risk analysis, which was done with the assistance of Japan and Russia, concluded that there is very low probability of earthquakes and tsunamis in Ninh Thuan as it is far enough from a seismic hazard zone.²² However, government studies also found that due to climate change, Ninh Thuan is now more vulnerable to stronger

¹⁸ The Convention on Nuclear Safety and the IAEA Safety Requirements call for the establishment of a regulatory body and the need for its separation, or independence, from the promoters of nuclear technology such as government ministries. The primary reason for having an independent regulatory body is to ensure that judgements are made and enforced without pressure from interests that may conflict with safety and security.

¹⁹ With the average rate of GDP development at about 7–8% per year, EVN believes that financing should not be an insuperable problem. EVN is under the Department of Energy within the Ministry of Industry & Trade (MOIT) (World Nuclear Agency, 2014).

²⁰ Vietnamese households occasionally endure power interruptions which will intensify unless officials reform a state-dominated power market to create a competitive and efficient power sector. The chief problem is the monopoly of Electricity Vietnam (EVN) and other state-owned companies. Vietnamese law requires EVN to sell much of its electricity at an unprofitable average of seven cents per kilowatt-hour. It means the company racks up debts (The Economist, 2013a).

²¹ Vietnam ranked 116 out of 177 countries and territories in the 2013 Corruption Perception Index of Transparency International. In the ASEAN region, Vietnam ranked seventh, after Singapore, Brunei, Malaysia, the Philippines, Thailand and Indonesia (Transparency International, 2013).

²² Interview with Vietnamese officials, Hanoi, 7 August 2014.

typhoons. As demonstrated by Typhoon Haiyan, typhoons' strong winds can generate storm surge which is a tsunami-like phenomenon of rising seawater that can damage infrastructure along its path. Despite this risk, however, the government remains determined to set up its NPPs in Ninh Thuan.

To strengthen state capacity to respond to nuclear emergency during disasters, several measures have been implemented by the government since 2010 including the issuance of the Master Plan for Environmental Radioactive Monitoring and Warning Network. The network was created to promptly detect abnormal radiation levels across a number of provinces. The Guidance on National System for Nuclear Emergency Preparedness was adopted and implemented as a national platform for preparing for and responding to a nuclear emergency situation (Thiep, 2013). Vietnam has received international assistance to develop its nuclear safety and security capability. In 2008, the United States Nuclear Regulatory Commission (U.S. NRC) and VARANS signed a cooperation agreement to share technical information on nuclear energy and exchange information on safety, regulations, environmental impacts, crisis management and nuclear site locations. The US National Nuclear Security Administration (NNSA) assists Vietnam to establish an emergency operations centre and graphic information system that will facilitate information sharing (National Nuclear Security Administration, 2013) and conducts annual training on emergency preparedness and response for VARANS' staff. Meanwhile, Japan's Ministry of Economy, Trade and Industry helps Vietnam reform its legal system on compensation for nuclear damage (Tan, 2012).

Vietnam works closely with IAEA to meet all international safety standards and regulatory practices. The IAEA Emergency Preparedness Review (EPREV) was conducted in 2012 to assess Vietnam's radiation emergency preparedness and response capabilities and provide recommendations (Thiep, 2013). Vietnam's national emergency preparedness and response plan was crafted and issued after the conclusion of the IAEA EPREV. However, VARANS admitted that the Vietnam's emergency protocol is still not yet in conformance with the IAEA's emergency preparedness and response standards. The revision of the Atomic Energy Law is being done to address this issue. VARANS has just started working with relevant national and local government agencies to come up with a concrete emergency response and evacuation plan.

The IAEA also deployed two Integrated Nuclear Infrastructure Review (INIR) missions in 2009 and 2012 and noted that Vietnam has already met many of its recommendations (Tuan, 2013). However, there are still implementation challenges for the remaining IAEA recommendations. The Director-General of Vietnam Atomic Energy Agency claimed that staff in key organisations directly working on nuclear infrastructure development have not been trained systematically (Tuan, 2013). Several forms of IAEA future assistance were recently announced to help Vietnam meet IAEA's recommendations, indicating the robustness of IAEA's assistance to Vietnam and close monitoring of its nuclear programme (UPI, 2014).

Following the IAEA recommendations, Vietnam started devising and implementing nuclear security measures, including a licensing system under VARANS for the transshipment of nuclear material and radioactive sources. The Atomic Energy Law is being amended as the current version does not reflect the provisions of Convention on the Physical Protection of Nuclear Material and Nuclear Facilities. There is no comprehensive plan yet on the security of NPP, but this may eventually fall under the jurisdiction of the Ministry of Public Security. IAEA will provide VARANS with the training on verification on the physical protection system for nuclear materials and facilities. Vietnam also signed the Basic Order Agreement (BOA) with the US under the framework of the Radiological Threat Reduction (RTR) to modernise security equipment at Vietnam's nuclear facilities. Vietnam has also launched the Megaport Initiative aimed at deterring, detecting and interdicting the trafficking of radioactive materials through seaports. The IAEA also provided most of the 12 radiation portal monitors (RPM) and related systems which have been installed at three ports of Cai Mep – Thi Vai, Ba Ria and Vung Tau. Under the IAEA-EU partnership in improving nuclear security, radiation detection equipment was recently installed at Noi Bai International Airport in Hanoi (Vi, 2014). Alongside equipment deployment, various training courses were conducted with international organisations such as the IAEA, US agency NNSA and the Australian Nuclear Science and Technology Organisation (ANSTO).

Map 2: Location of Radiation Portal Monitors (RPM) in Vietnam



Availability of nuclear professionals and experts

Vietnam continues to develop and expand its pool of nuclear professionals. To keep a nuclear power plant running smoothly and safely, it is necessary to build a team of nuclear power staff such as nuclear engineers, reactor operators, and emergency personnel (Ninh, 2013). As it takes years or decades for a country to master nuclear power technology, depending on a country's existing infrastructure, it is not surprising that Vietnam decided to postpone the construction of its first nuclear plant until 2020. Several government initiatives have been implemented to bolster the country's human resource training in the nuclear field. Following the IAEA recommendations made in its first Integrated Nuclear Infrastructure Review mission in 2009, Vietnam established the National Steering Committee on Human Resource Development in the Field of Atomic Energy. After the second INIR mission in 2012, Vietnam cooperated with the IAEA to organise an expert mission to support its efforts to develop the National Integrated Plan on Human Resource Development for its nuclear power programme (Tuan, 2014). In 2010, Prime Minister Dung approved the National Project for the Training

and Development of Human Resources for Atomic Energy, otherwise known as Program No. 1558,²³ with a budget of USD150 million (SGD190 million) to be spent between 2013 and 2020 for this purpose (Thiep, 2013). It is aimed at training in the field of atomic energy 3000 undergraduate students, 500 master and PhD students and 1000 teachers until 2020. Under this project, Vietnam has begun sending students overseas for nuclear energy studies (World Nuclear Association, 2014).

Table 2: Foreign Assistance in Human Resource Development in Vietnam

Training and Education	Location	Number	Time Period
Nuclear research, safety and security	Vietnam, Russia, Japan, Hungary, South Korea and France	650 engineers (150 overseas), 496 faculty members and 250 master's degree and PhD students (100 overseas)	To be completed by 2020
Short courses	Japan, South Korea, France and Hungary	196 staff of Electricity of Vietnam (EVN)	2005-2012
Long-term nuclear training	Moscow Power Engineering Institute and Grenoble University in France	31 students	2005-2012
Enrolled in nuclear-related university courses	Russia	238 undergraduate and graduate students	As of January 2014
Training workshops organised by Japan Atomic Energy Agency	Japan	500 engineers and scientists from nuclear agencies	Since 2001
Basic and intensive training courses organised by Japan Nuclear Energy Safety Organisation (JNES)	Japan	20 participants annually	Since 2011
Two-year training on nuclear engineering funded by International Nuclear Energy Development of Japan (JINED) and Japan International Cooperation Centre	Tokai University, Japan	15 staff of EVN	2012-2014
Training on the strategy for public understanding and acceptance of NPP in local community, funded by Japan METI	The Waka-san Energy Research Centre, Japan	18 Vietnamese professionals	2012
Training on nuclear safety funded by Japan METI	The Waka-san Energy Research Centre, Japan	10 Vietnamese professionals	2012

Sources: (Ninh, 2013a, 2013b; Tan, 2012; World Nuclear Association, 2014)

²³For further details, please see Nguyen Tan Dung. (2010). Approving the Scheme on Training and Development of Human Resources in the Field of Atomic Energy. Hanoi, 18 August. Online copy is available at http://www.nti.org/media/pdfs/VietnamHRDevelopmentPlan2020.pdf?_id=1333145926.

Five universities in Vietnam have been selected to carry out nuclear energy training²⁴ and expected to take in 30 students each every year from 2014 (Ninh, 2013a; Vi, 2014). In preparation for inauguration of the Ninh Thuan NPP, the Ministry of Education and Training (MOET) is to train 1000 students from now up to 2020, while those studying overseas are being trained also in NPP factories for 3 to 5 years in Russia and Japan. As Vietnam's first and second NPP will be using Russian and Japanese technology, respectively, MOET sends two separate groups of students to Russia and Japan. MOET offers scholarships to entice Vietnamese students to pursue nuclear-related courses in local and foreign universities. It provides USD1440 (SGD1823) monthly stipend for each student studying overseas and USD200 (SGD253) for each student in local universities. MOET also allocated USD40 million (SGD50.6 million) to train overseas 40 experts from VINATOM from 2015 until 2025.²⁵ The state-run Vietnam Institute for Atomic Energy (VINATOM) operates a nuclear research reactor in Da Lat City, central Vietnam. Since its establishment 30 years ago, this facility has been training scientific and operational staff for the future nuclear facilities. However, a nuclear programme challenge is the shortage of trained professionals in the construction and operation of NPPs. Although the country is now investing in human resource training and capacity building, there have been criticisms that it emphasises theory rather than practice (Ninh, 2013a). According to a consultant to the nuclear power plant project in Ninh Thuan province, Vietnam's strategy of sending its nuclear scientists and professors for short training stints overseas (average 6 weeks) has so far failed to provide sufficient training because they are too short for them to pick up anything other than basic knowledge. Another major concern is the immediate impact of the postponement of the construction of the Ninh Thuan NPP on manpower development. 30 students trained in Russia will start returning home by next year.²⁶ By 2018-2019, more students studying overseas will be back without the Ninh Thuan NPP, potentially losing an opportunity to apply what they have learned overseas in operating an NPP. To address this issue, MOET plans to send them again overseas to pursue higher education while waiting for the first NPP to become operational.

Moscow and Hanoi signed an agreement to establish Vietnam's nuclear science and technology centre (World Nuclear Association, 2014).²⁷ The Russian State Nuclear Energy Corporation (Rosatom) will construct the centre in Da Lat City in 2015, which will include Vietnam's second research reactor (Vietnam News Agency, 2014). Such a centre will help address the scientific and technological demands for training Vietnamese nuclear professionals (Vietnam News Agency, 2014). The centre aims to provide hands-on experience for nuclear professionals and students in operating a nuclear reactor, which is crucial for an aspiring civil nuclear state. However, it remains to be seen if the centre's capacity would be sufficient to accelerate human resource development adequately by 2020. The U.S.NRC has been regularly conducting training workshops for VARANS's staff and executive education programmes on reactor safety, evaluation and issuance of reactor construction permits, review of site applications and site oversight. Japan also provided Overseas Development Assistance (ODA) for development of VARANS for the period 2013–18. ODA covers the construction of necessary infrastructure, technical assistance and support for capacity building in the areas of safety, security and safeguards, and human resource development. As part of Japan's commitment to train 1,000 Vietnamese, Japanese government agencies have been organising intensive training courses on nuclear engineering, safety and security for the staff of Vietnamese nuclear agencies (See Table 2). Joint efforts by Vietnam and its international partners have already resulted in the gradual increase in the number of VARANS staff although most have limited practical experience in the nuclear field (Tan, 2012).

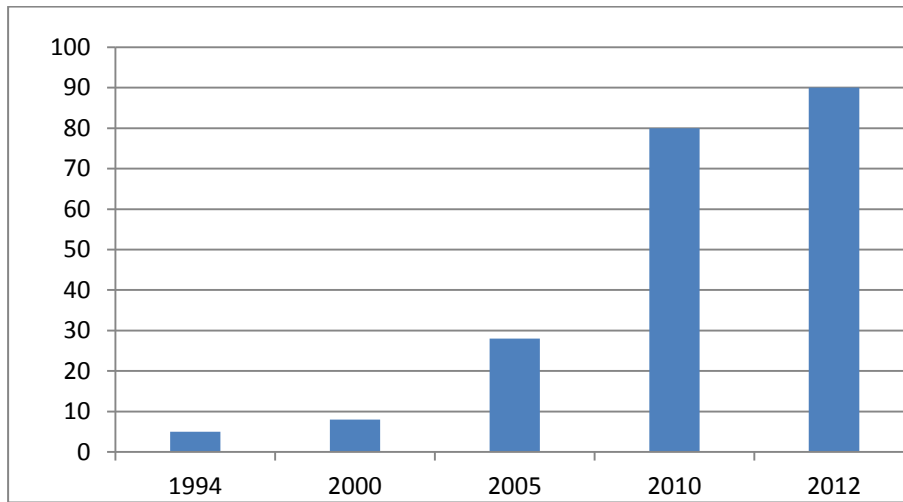
²⁴ These universities are Vietnam National University (VNU Ha Noi), Polytechnic University (Ha Noi), University of Science – VNU (Ho Chi Minh City), Dalat University, and Electric Power University, Ha Noi. None of the five universities are included in the QS World University Rankings 2013.

²⁵ Interview with a Vietnamese official, Hanoi, 8 August 2014.

²⁶ Interview with a Vietnamese official, Hanoi, 8 August 2014.

²⁷ The Centre will be financed by a USD500 million (SGD632.4 million) loan from Russia.

Chart 2: Number of VARANS Staff since its Establishment



Source: (Tan, 2012)

These instances of foreign assistance to Vietnam underscore the importance of bilateral/multilateral cooperation in the field of civil nuclear energy. Joint human resource development could definitely serve as a significant avenue for nuclear cooperation among states in the region and beyond.

Nuclear Power Plant Development in Indonesia

Since 1956, Indonesia has entertained the idea of nuclear power in anticipation of its future energy needs (IAEA, 2001). Extensive preparations in accordance to IAEA guidelines and standards have been performed by the National Nuclear Energy Agency (BATAN) and the Nuclear Energy Regulatory Agency (BAPETEN) – the two main agencies in charge of nuclear power development in Indonesia. Regardless of preparations, public opposition remains a critical factor that hinders Indonesian NPP development. In the early 1990s, feasibility studies identified suitable NPP sites but strong civil society opposition stalled the plans (Amir and Neo, 2011). Points of objection include distrust towards the government's capability in dealing with nuclear emergencies, financial constraints, Indonesia's vulnerability to natural disasters, and corrupt practices.²⁸ One of the leading anti-nuclear personalities is Dr Iwan Kurniawan,²⁹ a former employee of BATAN (See Kurniawan, Iwan, 2007).

In 2007, strong public opposition to nuclear power development led to President Yudhoyono's delayed approval in the establishment of a nuclear task force proposed by the Ministry of Energy and Mineral Resources (Amir, 2010). The need to win public acceptance is so pivotal that President Yudhoyono positioned nuclear energy as Indonesia's last option for alternative energy sources.³⁰ The government's stand on nuclear energy is reflected in the National Energy Policy, passed in the parliament in January 2014, which also places the nuclear option as a last resort (Detikcom, 2014). The ruling government's low appetite for nuclear energy is in stark contrast with national long-term planning that stipulates the nuclear energy share in Indonesia's energy mix by 2025. Nuclear energy is projected to make up 1.2 per cent and 1.7 per cent of Indonesia's energy mix in 2020 and 2025 respectively, a relatively small share in comparison with other alternative energy sources (The Ministry of Energy and Mineral Resources Republic of Indonesia, 2006).³¹

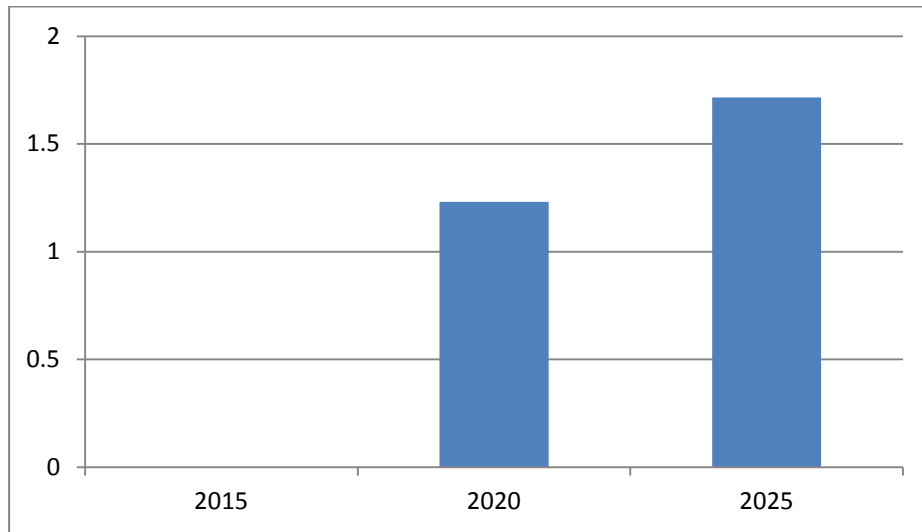
²⁸ Interview with a member of Anti-Nuclear Society (MANUSIA), Jakarta, 15 August 2014.

²⁹ To read his views, please visit <http://iwankurniawan.wordpress.com/>.

³⁰ Interview with an Indonesian official, Jakarta, 13 August 2014.

³¹ Biofuel is predicted to form 4.5 per cent and 5.1 per cent of total energy mix in 2020 and 2025, while geothermal is projected to make up 5.1 per cent and 5.2 per cent.

Chart 3: Projected Share (%) of Nuclear Power in Indonesia's Energy Mix



Source: (The Ministry of Energy and Mineral Resources Republic of Indonesia, 2006)

Despite opposition, relevant Indonesian officials claim that Indonesia has the necessary infrastructure³² and is ready for NPPs although a decision is not expected until 2016 (IAEA, 2013). To address public perception issues, BATAN has launched public awareness campaigns and conducted annual public survey since 2010 (BATAN, 2012). 60.4 per cent of the public supported the nuclear option in 2013, a significant increase from an approximately 40 per cent acceptance level post-2011 Fukushima incident. However, the latest survey was not sufficient to convince the current government to go ahead with the plan. The impending transfer of power to the new president-elect Joko Widodo does not shed any light on the future of nuclear energy development either as the nuclear option was never mentioned during his presidential campaigns. Since Indonesia's nuclear energy is contingent upon political will which BATAN has no influence over, BATAN can only make sure that all the necessary preparations are being made and Indonesia is ready for its first NPP if the political tide turns in its favour.

Legal and regulatory framework

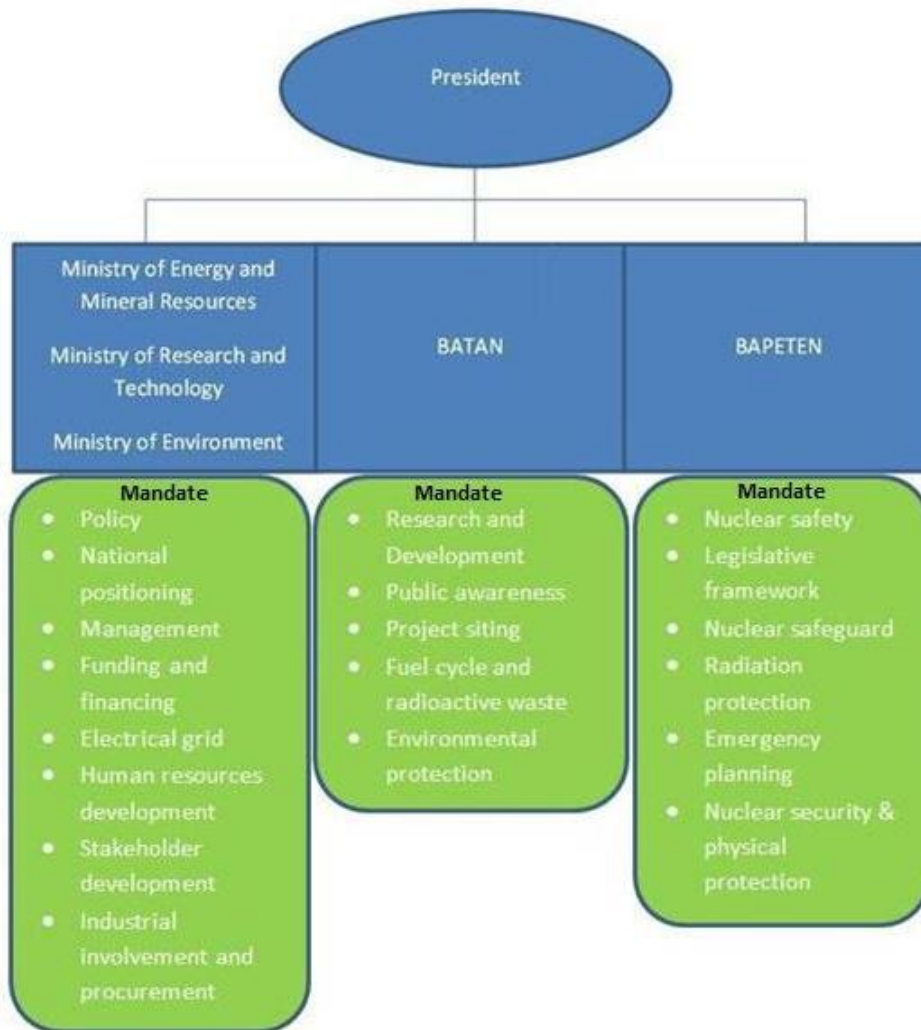
Indonesia does not have an entity acting as a Nuclear Energy Implementing Organisation (NEPIO).³³ The establishment of NPPs has its legal basis in the Parliament Act No. 10/ 1997 on Nuclear Energy.³⁴ A number of government regulations, presidential decrees and BAPETEN Chairman Regulations (BCRs) are in place to further support the development of NPPs. Instead of a NEPIO, several institutions such as BATAN, BAPETEN, Ministry of Energy and Mineral Resources, Ministry of Environment, and Ministry of Research and Technology carry out separate functions in preparing for the establishment of NPPs (IAEA, 2013). BATAN is a non-departmental government agency reporting directly to the President whereas BAPETEN is an independent regulatory body (BATAN, 2012). The funding for the nuclear energy programme goes directly into the annual budgets of these institutions.

³² IAEA identifies 19 key points of nuclear infrastructure: national position, nuclear safety, management, funding and financing, legislative framework, safeguards, regulatory framework, safeguards, radiation protection, electrical grid, human resource development, stakeholder involvement, site and supporting facilities, environmental protection, emergency planning, security and physical protection, nuclear fuel cycle, radioactive waste, industrial involvement, and procurement. (IAEA 2007, p.8)

³³ NEPIO implements 'a nuclear power programme, which may be preparing for a decision to implement, coordinating the implementation among other entities or carrying out the implementation itself' (IAEA 2008) (IAEA, 2008)'

³⁴ This is significant because it suggests endorsement from people's representatives, therefore providing a strong foundation for the pursuit of NPPs.

Diagram 2: NPP Development Governance Structure in Indonesia



Source: (IAEA, 2013; Sriyana, 2012)

The delegation of NPP-related responsibilities to different agencies requires coordination. The absence of a dedicated steering committee signifies a lack of commitment in pursuing NPPs because although BATAN is the primary institution working on nuclear that reports directly to the President, it does not have any authority over other agencies. The lack of political will to pursue NPPs is illustrated in the budget allocations for BATAN and BAPETEN that remained at around 0.12 per cent and 0.02 per cent of the national budget in 2007 and 2013 respectively (The Ministry of Finance of the Republic of Indonesia, 2013).

Nuclear safety and security measures

The plans for NPP development draw concern both domestically and internationally due to the frequent occurrence of natural disasters such as volcanic eruptions, earthquakes, tsunamis, floods and landslides in Indonesia (National Agency for Disaster Response (BNPB)), 2012). Fukushima incidence underscores the catastrophic consequences of natural disasters on NPPs, and reflecting from the Fukushima experience, BATAN is committed to make public transparency and public acceptance part of its nuclear safety regime.

Realising the implications of such geological vulnerability, BATAN has conducted site selection processes based on IAEA guidelines, BCR no. 5/2007 on the Safety Provision for Site Evaluation for a Nuclear Reactor, and best practices from other countries (Ismail, 2013). Muria (Central Java Province), Banten (West Java Province), and Bangka Island (east of Sumatra Island), are identified as areas with low risk of natural disasters as they sit outside the 'ring of fire'. An example of a study on NPP siting in West Java Province looked into external events including seismicity, volcanism, river flooding and coastal flooding within a radius of 150 kilometres (km) from the potential site, and identified Kramatwatu and Pulau Panjang as safe and suitable sites for NPPs (Yuliasuti, 2010).

Bangka Island is currently the most preferred site for the first NPP. BAPETEN has not received any formal application from BATAN however, suggesting that the plan is still at feasibility study stage.³⁵ Separately in early September 2014, Russian state corporation Rosatom expressed an interest in building two 1,200 MW NPPs on Batam Island (Berita Satu, 2014). Rosatom articulated its intention in a meeting attended by Batam Indonesia Free Zone Authority (BP Batam), the Indonesian Ministry of Foreign Affairs, BATAN, and state electricity company (PT PLN), but it was not indicative of an immediate plan for NPP development in Batam as BP Batam acknowledged that the right policy needs to be put in place first.

Map 3: Location of Proposed Sites of NPPs in Indonesia



To further ensure nuclear safety in the proposed sites, BATAN has cooperated with IAEA on technical issues, such as NPP Siting in 1998, Strengthening of Nuclear Safety Infrastructure in 1989, and NPP Site Confirmation and Structural Safety in 1997 (IAEA, 2013). In addition, Indonesia invited IAEA to perform an Integrated Nuclear Infrastructure Review (INIR) in 2009 (Ismail, 2013). The Review report, however, is not publicly available. This is not unusual as only three out of ten reviewed countries have opted to publish their reports

³⁵ Interview with Indonesian officials, Jakarta, 14 August 2014.

(IAEA, 2014). BATAN claims that the INIR mission confirms Indonesia has carried out extensive preparatory work on infrastructure and is ready to begin nuclear power plant construction (BATAN, 2013).

In addition to feasibility studies, Indonesia has also prepared itself for nuclear emergency situations. Under the supervision of BAPETEN, an inter-ministerial and inter-agency Organisation for National Nuclear Emergency Preparedness and Response System (OTDNN) was established. Laws regulating nuclear emergency responses include, among others, Act no. 10/1997 on Nuclear Energy, Act no. 24/2007 on Disaster Management, BCR no. 14/2007 on Nuclear Emergency Team, and BCR no. 1/2010 on Nuclear Emergency Preparedness and Response (Nikopama, 2013). Indonesia has held a number of nuclear emergency exercises and drills, and Fatmawati Hospital in South Jakarta is a designated referral hospital for nuclear emergencies. Although laws and regulations are important legal pillars the real test will come in a nuclear crisis. Reflecting on the current natural disaster responses performed by the Indonesian National Board for Disaster Management or BNPB,³⁶ challenges in inter-agency coordination including division of authority, chain of command and control, and mobilisation of resources; these remain the source of sub-par responses.

In anticipation of such challenges, in August 2014 BAPETEN formed the Indonesian Center of Excellence on Nuclear Security and Emergency Preparedness (I-CoNSEP) (Bambang Sutopo Hadi, 2014), a special platform where BAPETEN, BATAN, police, customs, the Ministry of Foreign Affairs, and intelligence communicate and coordinate their efforts for nuclear security and emergency responses (Hadijahyano, 2014). The formation of I-CoNSEP has previously been mentioned in Indonesia's report submitted at the Nuclear Security Summit in March 2014 (National Security Summit, 2014).

Aside from nuclear safety and preparedness, Indonesia also demonstrates a commitment to nuclear security. At the 2014 Nuclear Security Summit (NSS), Indonesia endorsed the implementation of the Guidance on the Import and Export of Radioactive Sources, a supplementary to the Code of Conduct on the Safety and Security of Radioactive Sources (National Security Summit). Indonesia's existing Radiation Portal Monitors (RPMs) which monitor radiation levels are located in Tanjung Priuk (The Jakarta Post), Tanjung Perak (Surabaya), Batam Island, and Belawan (North Sumatra). These will be extended to other ports in Semarang (Central Java), Makassar (South Sulawesi), and Bitung (North Sulawesi) (Sinaga, 2012).

³⁶ BNPB is an abbreviated form of Badan Nasional Penanggulangan Bencana

Map 4: Location of Radiation Portal Monitors (RPM) in Indonesia



Nuclear energy domestic laws were strengthened with Government Regulation no. 54/2012 on the Safety and Security of Nuclear Installations. BAPETEN in collaboration with National Police, Armed Forces and National Intelligence Agency, will include the security of radioactive sources in the next review of the National Design Basis Threat (DBT) (National Security Summit, 2014). In February 2014, Indonesia's House of Representatives ratified the Law on the International Convention for the Suppression of Acts of Nuclear Terrorism (Maulia and Paath, 2014).

Currently, Indonesia has three nuclear research reactors located in Serpong (30MW reactor), Bandung (1MW Triga Mark II reactor), and Yogyakarta (150kW locally-made reactor), and one source facility located at Pasar Jum'at Jakarta (IAEA, 2013). The purpose of the Nuclear Technology Center for Materials and Radiometry (PTNBR) in Bandung includes a laboratory for physics, chemistry and biology, production of isotopes and labelled compounds. It is also where nuclear medicine was first developed in Indonesia. The Center for Accelerator Technology and Material Processes, Yogyakarta is an education and training facility for occupational radiation safety and environmental radioactivity.

The Serpong nuclear site is a diverse research complex for nuclear technology. It is housed within the larger National Center for Research Science and Technology (PUSPIPTEK) and used mainly for material testing, nuclear analytical analysis, isotope production, neutron beam experiments, and education. It is also home to the Development Centre for Radioactive Waste Management, which collaborated with IAEA to improve its radioactive waste management programme. Technology advancement at this site has enabled BATAN to produce its own nuclear fuel rods. BATAN, with support from the IAEA, plans to build an experimental power reactor (RED) capable of generating up to 10 megawatts of electricity within the Serpong nuclear complex. The project, subject to approval by the government, is estimated to cost about IDR1.6 trillion (SGD1.71 million) (The Jakarta Globe, 2014). BATAN has already submitted to BAPETEN a site evaluation application for this project.

The Pasar Jum'at Nuclear Complex houses three units of Co 60 Gamma Irradiators for Application of Isotope and Radiation Technology and an Exploration Area in West Kalimantan for researching exploration and test mining of nuclear ores. West Kalimantan is home to Indonesia's known uranium deposits.

The protection of these installations is regulated by Government Regulation no. 43/2006, and the security of the radioactive materials in the facility is regulated by Government Regulation no. 33/2007 and Government

Regulation no. 29/2008 (Sinaga, 2012). A visit to the Serpong nuclear complex revealed tight multi-layered security checks at multiple entry points and visitors were accompanied by BATAN staff at all times. The site is open for public and it has received both domestic and foreign visitors over the years. Access to the research reactor and radioactive waste management sites is only granted to authorised staff. Transportation of radioactive materials originating from and towards the facility is guarded by the military. As the nuclear complex is categorised as a strategic facility, both the police and the military are also involved in securing the site.

On the safety front, all visitors need to don special garments before entering the site and radiation checks were conducted upon exiting the facility. The Serpong nuclear complex used to be situated at a considerable distance from residences; however, Serpong city agglomeration has shortened the distance between the two and would likely lead to more catastrophic outcomes in case of a nuclear accident.

Having the mandate to ensure nuclear safety and security, the BAPETEN Chairman issues regulations providing technical details of safety and security measures, many of which are adopted from IAEA standards (Pandi and Harianto, 2013). BAPETEN carries out its functions mainly through inspections, evaluations, issuance of permits. BATAN staff at the Serpong site testified that BAPETEN conducts frequent spot checks on their facility.

Although safety and security measures have been put in practice, the absence of an NPP raises the question as to whether these measures would be sufficient. Visits to NPPs in other countries would provide the needed information to further analyse Indonesia's current state of safety and security readiness.

Map 5: Location of Nuclear Research Reactors in Indonesia



These nuclear complexes are located on Java Island. Considering that the contamination of marine environment resulting from the Fukushima disaster was found at a distance of up to 30km (Szymczak, 2013), the great distance between these nuclear complexes and Indonesia's neighbouring countries suggests that countries in the region face little risk of being directly affected by any nuclear accidents at these facilities. However, transboundary and trade implications such as contaminated food imports cannot be wholly discounted.

Availability of nuclear professionals and experts

Indonesia has a pool of nuclear experts who have worked for over 30 years at BATAN and other nuclear facilities (The Ministry of Energy and Mineral Resources Republic of Indonesia, 2008). BATAN has 3,088 employees; 98 of which have a doctoral degree, 296 with a master's degree, 1,102 with an undergraduate degree, and 1,592 with a diploma. BAPETEN, on the other hand, has 439 employees; 10 of which possess a doctoral degree, 105 with a master's degree, 218 with an undergraduate degree, and 106 with a diploma (Ispiranto, Sitompul and Masdin, 2012). The current head of BATAN, Prof. Djarot S. Wisnubroto and his predecessors have relevant backgrounds in nuclear sciences and are long-time civil servants. The current head of BAPETEN, Prof. Dr Jazi Eko Istiyanto, MSc, is a computer and electronics lecturer at Gadjah Mada University and was appointed by the Minister of Research and Technology in February 2014 (Nuclear Energy Regulatory Agency, 2014).

Long-serving nuclear experts will soon enter their retirement age (AntaraNews, 2013) and Indonesia needs to recruit and develop human resource to replace them. To prepare for a well-qualified and highly-skilled labour force, BATAN established four-year bachelor programmes in Nuclear Techno-Chemistry and Nuclear Techno-Physics at the College of Nuclear Technology (STTN) in 2001. BATAN also cooperates with leading Indonesian universities such as Gadjah Mada University (UGM), University of Indonesia (UI), and Bandung Institute of Technology.

Table 3: Universities Offering Nuclear-Related Subjects in Indonesia

University	Level of Study	Scope
Sekolah Tinggi Teknologi Nuklir (STTN)	Undergraduate	Nuclear Techno-Physics - Bachelor Nuclear Techno-Chemistry - Bachelor
Universitas Gajah Mada (UGM)	Undergraduate	Nuclear Engineering - Bachelor
Universitas Indonesia (UI)	Undergraduate	Nuclear Physics and Theoretical Particle Physics - Bachelor

BATAN invests in engineering and science graduate recruits to develop specialised expertise in nuclear energy through placement in NPP companies including General Electric, Westinghouse, Atomic Energy of Canada Limited, Mitsubishi, Korea Nuclear and Hydro Power (KHNP), Korea Atomic Energy Research Institute (KAERI) and Korea Power Engineering Company (KOPEC) to obtain insights to their NPP design activities in Indonesia and abroad (IAEA, 2013). BATAN's in-house Education and Training Center (PUSDIKLAT) designs its own technical training and development materials in collaboration with IAEA, Japan Atomic Energy Agency (JAEA), and Asian Network for Education in Nuclear Technology (ANENT) (PUSDIKLAT BATAN, 2012b).³⁷ For example in 2013, PUSDIKLAT-BATAN hosted an IAEA training programme on the implementation of an eLearning Platform for Nuclear Education and Training including participants from Asia, ANENT, IAEA, and observers from European Nuclear Education Network (PUSDIKLAT BATAN, 2013).³⁸ In 2012, it hosted a briefing by the IAEA-Asian Nuclear Safety Network (IAEA-ANSN)³⁹ Expert Mission on self-assessment based on the IAEA Guideline for the Nuclear Safety Education and Training Peer Review Service (ETPREs) at

³⁷ ANENT is a regional partnership supported by IAEA that cooperates in capacity building, human resource development, and knowledge management in nuclear science and technology. It has 19 member countries all around Asia, including Indonesia (BATAN), Malaysia (Malaysian Nuclear Agency), and Vietnam (Vietnam Atomic Energy Agency). ANENT was founded in 2004 and is very active in managing and disseminating nuclear-related information and knowledge to its member countries.

³⁸ ENEN is a non-profit international organisation whose members comprise universities; a majority of these are in Europe, offering nuclear-related courses. It aims to preserve and further develop nuclear expertise through higher education and training.

³⁹ ANSN is a regional hub of nuclear safety information. Launched in 2002 and supported by IAEA, it creates human and IT networks in the region. 11 countries participate in ANSN including Indonesia, Malaysia, Singapore and Vietnam.

BATAN-PUSDIKLAT (PUSDIKLAT BATAN, 2012a). PUSDIKLAT-BATAN received ISO9001:2008 quality management certification, which shows that Indonesia has sufficient and sustainable capacity to build the competence of its nuclear personnel through continued international collaboration with key stakeholders.

BAPETEN develops its human resources' regulatory, licencing, and technical competencies through in-house trainings and sending off staff to overseas institutions such as the IAEA and NRC (Nuclear Regulatory Commission) in the US to attend workshops, technical courses, on-the-job trainings (OJTs) and tutorial programmes. Additionally, BAPETEN adopts IAEA standards and uses relevant IAEA documents as guidelines in drafting BAPETEN's training curriculum.

In 2008, Indonesia followed the IAEA Technical Report Series 200 on Manpower Development for Nuclear Power (IAEA, 2013) to establish a National Team of Human Resource Development and draft a plan of action including the establishment of a Nuclear Training Centre (NTC) (The National Team of HRD for NPP, 2013). The formation of NTC began in 2010 and remains a work-in-progress (Pandi and Harianto, 2013).

Nuclear Power Plant Development in Malaysia

Increasing energy needs in Malaysia makes for reasonable justification for development of nuclear power. Malaysian energy policies are formulated by the Energy Section of the Economic Planning Unit (EPU) under the Prime Minister's Department. In 2009, Prime Minister Najib Razak announced a plan to have a small-scale nuclear reactor (Razak, 2009). In 2010, energy mix in Peninsular Malaysia consisted of gas (54.2 per cent), coal (40.2 per cent), hydro (5.2 per cent), and oil (0.4 per cent) (Ramli, 2013). Nuclear energy development is subsequently mentioned in the New Energy Policy 2011–2014 (The Economic Planning Unit, 2010) but without a projected percentage of its total energy mix.

Nuclear energy has always received strong public opposition in Malaysia. At present, the anti-nuclear movement is largely present in the form of statements and petitions in the media and on the internet.⁴⁰ Civil society has also expressed their objections to the nuclear option in a number of forums including the ones organised by the government.⁴¹ Although no public rally has been held due to the absence of information on potential nuclear sites, the presence of 20,000 protesters against Lynas, an Australian rare earth mining company in Kuantan Malaysia (Stop Lynas!, 2011) illustrates public concern over nuclear waste and the capacity and capability to mobilise well. Lynas continues its operations despite intense public resistance.

The Malaysian government does not completely rule out the nuclear option however. Its insistence to pursue nuclear energy is evidenced in a statement made by Minister in the Prime Minister's Department Dato' Mah Siew Keong in early July 2014 which stated that the government will conduct a feasibility study aiming at building an NPP in ten years' time and carry out a comprehensive study including public acceptance and inputs from experts and non-governmental organisations (Bernama, 2014). Subsequently in early August 2014, Dato' Mah mentioned that the Atomic Energy Regulatory Bill, which will separate nuclear energy regulators from operators, will be tabled this year (Looi, 2014). A survey and comparative energy analysis will also be completed by the end of 2014.

Nuclear waste management

The German Oeko-Institute investigated the nuclear waste management facility at Lynas and found that storage of radioactive and toxic wastes on site does not prevent leachate⁴² from leaving the facility and entering the ground and groundwater system. The waste storage system available on site is reportedly inadequate for the pre-drying of waste particularly in the wet and long monsoon period from September to January and risks exposing workers to higher radiation levels. The operator has not demonstrated how it will address this issue. Currently, the company and the regulator (AELB/MOSTI) propose listing the product as construction material, which the institute reported would mean higher radioactive doses to the public via direct radiation. At present, discharged water with toxic constituents is transported via an open earth channel, accessible by humans and animals. Low quality water such as this should be transported via a pipeline to avoid unintended consequences and prevent seepage into the groundwater supply. In addition, existing environmental legislation on water and air quality remains static and does not reflect improved knowledge on adverse technological effects nor does it encourage improved technological capabilities to reduce emissions (Schmidt, 2013). As a result, there are significant capacity concerns around the safe disposal of nuclear waste in Malaysia at present, and the future implications this has for NPP development and the safe disposal of nuclear waste are significant.

⁴⁰ Examples of campaigns against NPP development can be found on www.consumer.org.my (organised by the Consumer Association of Penang) and <http://www.thepetitionsite.com/745/599/785/public-petition-to-stop-nuclear-power-plants-in-malaysia/> (supported by the Malaysian Coalition Against Nuclear of MY-CAN).

⁴¹ Email interview with staff from Consumers Association of Penang.

⁴² Leachate is a liquid that has dissolved or entrained environmentally-harmful substances that may then enter the environment.

Legal and regulatory framework

The main legislation relating to NPP is the Atomic Energy Licensing Act 1984 (Act 304), including detailed provisions on radioactive materials (Bidin, 2013). In 2008, preparatory works began and the development of Malaysia's NPP was initially managed by a special Nuclear Power Development Steering Committee, led by the Ministry of Energy, Green Technology and Water. The structure of the steering committee is represented in the following diagram.

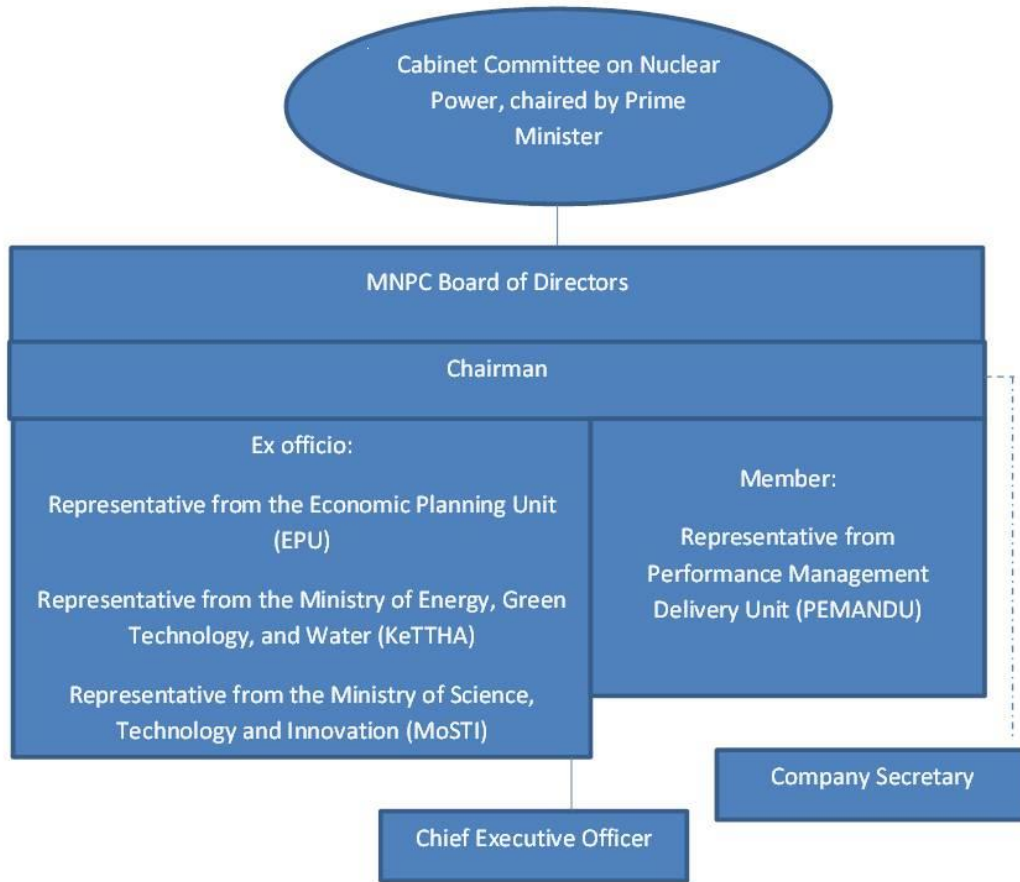
Diagram 3: NPP Development Steering Committee Structure in Malaysia



Source: (Ramli, 2013)

In 2011, Malaysia Nuclear Power Cooperation (MNPC) was established as a NEPIO. MNPC is placed under the supervision of Prime Minister's Department and assumed the functions of the Nuclear Power Development Steering Committee (Markandu, 2013).

Diagram 4: NPP Development Governance Structure in Malaysia



Source: (Ramli, 2013)

The creation of a dedicated NEPIO signifies a serious commitment for NPP development and enables better inter-agency coordination. Although the centralisation of NPP-related work suggests higher efficiency, the assumption of regulator within MNPC raises questions on independence and impartiality of the regulatory body.⁴³ A notable example is the conflict of interest relating to the Lynas project highlighted by IAEA (IAEA, 2011).

In addition to MNPC, a USD7.69 million budget (SGD9.72 million) in 2010–2012 illustrates Malaysia's strong commitment to developing NPP (Ramli, 2013). Malaysia initially planned to have two NPPs by 2021 (AsiaOne News, 2013). However, in 2013, the project was suspended due to concerns over the Fukushima disaster in Japan (Asia Today, 2013). In the period, 2010 – 2014, national budget allocations for Malaysian Nuclear Energy and AELB have remained constant around 0.03% and 0.005% respectively (Ministry of Finance Malaysia, 2014). It remains uncertain whether the next Prime Minister would continue the plan. However, any significant percentage rise in funding for these institutions means the government is becoming more serious about the development of nuclear power plants. Otherwise, it illustrates that the plan is on life support while waiting for a better time to push the agenda forward.

⁴³ IAEA requires that 'the government shall ensure that the regulatory body is effectively independent in its safety related decision making and it has functional separation from entities having responsibilities or interests that could unduly influence its decision making' (IAEA 2010, p.5)

Nuclear safety and security measures

Malaysia is located in a relatively stable environment. Situated outside the 'ring of fire,' Malaysia is not susceptible to external hazards such as earthquakes, volcanic eruptions and typhoons (Disaster Management Division of Prime Minister's Department, 2011). Floods and landslides are among the few natural disasters that hit Malaysia (Asian Disaster Reduction Center, 2011). In 2009, Malaysia completed NPP siting guidelines and in 2011 five candidate sites were identified (Atomic Energy Licensing Board, 2013). The development of Malaysian NPP is still at a very early stage as site selection was made based on digital mapping and no fieldwork has been carried out to date (The Malaysian Insider, 2012). Potential sites, for example, are not made public although some in Singapore are convinced that one of them will be located in Johor (Desker, 2013).

Operating under Directive no. 20, the AELB is in charge of nuclear safety and emergency response and preparedness. AELB established a Nuclear Emergency Team, and first responders are located at northern, southern, eastern, and Sabah-Sarawak parts of Malaysia (I. L. Teng, 2014).

Map 6: Location of Nuclear Emergency First-Responders in Malaysia



First responders are not centralised which enables Malaysia to rapidly react to nuclear crises nationwide. As emergency response requires assistance from other agencies, the National Disaster Centre, Ministry of Health, Royal Customs Malaysia, and Royal Malaysian Police are involved in nuclear emergency planning and cooperation (Mohd Yasin Hj Sudin, 2012). AELB has conducted national radiological emergency response drills, such as the National Radiological Emergency Drill in the event of a transport accident in 2005, a National Field Exercise on Research Reactor Emergency Response in 2007, and a Table Top Exercise on Research Reactor Emergency Response in 2007. AELB has also participated in exercises conducted by the National Security Council (AELB, 2008). Furthermore, AELB engages external organisations such as the Australian Nuclear Research and Development Organisation (ANSTR) who was invited to conduct a workshop on emergency preparedness and response in 2010 (AELB, 2010). The dedicated mechanisms and resources in place indicate that Malaysia has an established radioactive emergency response framework. However, the effectiveness of this inter-agency coordination, communication, and response times remains unknown.

The AELB is responsible for nuclear safety, security, as well as import and export controls. Malaysia's commitment to nuclear security is demonstrated by the incorporation of the IAEA Convention on Physical Protection of Nuclear Material (CPPNM), the International Convention for the Suppression of Acts of Nuclear Terrorism (ICSANT), and the Additional Protocol to the IAEA Comprehensive Safeguards Agreements in Malaysia's Atomic Energy Licensing Act (Act 304) (Malaysia, 2014). Malaysia controls the movement of radioactive materials using RPMs installed at its borders, airports, and seaports. Data is transmitted directly to the AELB and is monitored in real-time. Securing borders, airports and seaports against illicit trafficking of

nuclear materials are carried out in co-ordination with customs, port police, the port authority, and National Security Council (Ghazali, 2010).

Map 7: Location of Radiation Portal Monitors (RPM) in Malaysia



Source: (Sudin, 2007)

Since 1982, Reaktor Triga Puspatti (RTP) is the only nuclear research reactor in Malaysia and is located in Bangi, Selangor operated by the Malaysian Nuclear Agency. The safeguarding of nuclear materials in the facility follows the Agreement for Safeguards of Nuclear Facilities and Material, INFCIRC/182 (1973) through an annual mission (Malaysian Nuclear Agency, 2007). To protect its nuclear facilities, Malaysia forges a close partnership with the US through the Global Threat Reduction Initiative (GTRI).⁴⁴ In February 2012, four Radioactive Sources Category 1 Facilities in Malaysia were assessed under the GTRI framework (Malaysia, 2014). Malaysia also takes part in the Global Initiative to Combat Nuclear Terrorism (GICNT).⁴⁵ As part of its commitment to this initiative, Malaysia hosted a table top exercise with Australia, New Zealand, and the US in 2014 (U.S. Department of State, 2014). In addition, Malaysia was recognised as a Nuclear Security Support Centre (NSSC) by the IAEA in December 2012. Although the concept of a nuclear security support centre is somewhat loose because it essentially encompasses a wide range of institutions in a number of countries that do different kinds of nuclear security-related activities such as education, technical and scientific trainings, research and development, and does not illustrate a proven track-record in nuclear security (Heyes, 2012).

⁴⁴ GTRI is a US-led initiative that aims at protecting and reducing excessive civilian nuclear and radiological materials worldwide.

⁴⁵ GICNT is an international partnership in strengthening collective capacity to prevent, detect and respond to nuclear terrorism. 85 countries take part in GICNT including Malaysia, Singapore and Vietnam, with EU, IAEA, INTERPOL, and United Nations Office on Drugs and Crimes (UNODC) as observers.

Map 8: Location of Nuclear Research Reactors in Malaysia



Availability of nuclear professionals and experts

The AELB functions under the supervision of the Minister of Science, Technology and Innovation and a board of governors including university lecturers, director general of health, CEO of energy commission, deputy secretary general in science of the Ministry of Science, Technology and Innovation, alongside its Director General, Hamrah bin Mohd Ali. The AELB has 165 staff and they receive in-house training in nuclear safety, safeguard, and security (Jais, Hassan and Yasir, 2010).

As a research and development centre, the Malaysian Nuclear Agency houses a number of nuclear experts. The head of the agency since 1981, Y. Bhg. Dato' Dr Mohamad Bin Lebai Juri holds relevant degrees in nuclear technology. Human capital development is carried out by actively engaging personnel in international and regional technical programs such as IAEA, Regional Cooperative Agreement (RCA)⁴⁶ and the Forum for Nuclear Cooperation in Asia (FNCA).⁴⁷ Human resource development also takes place in universities. While UKM is the only university with a nuclear science department (Adnan et al., 2012), other universities also offer nuclear-related subjects. The focus of nuclear knowledge and expertise, however, is primarily on non-power applications such as medical, health, agriculture, industry and manufacturing.

⁴⁶ RCA is a formal inter-governmental agreement that aims to intensify cooperative work in research, development and training in science and technology. Operating under the auspices of IAEA, RCA focuses on nuclear activities relating to agriculture, health care, industry, and environmental protection. Representatives come from Australia, Bangladesh, Cambodia, China, India, Indonesia (BATAN), Japan, ROK, Malaysia (Malaysian Nuclear Agency), Mongolia, Myanmar, Nepal, New Zealand, Pakistan, Philippines, Palau, Singapore, Sri Lanka, Thailand, Vietnam and the RCA Regional Office. More information can be found on <http://www.rcaro.org/>

⁴⁷ FNCA is a Japan-led collaborative work for peaceful use of nuclear technology in Asia in the forms of meetings and project activities. Participants are from Australia, Bangladesh, China, Indonesia, Kazakhstan, Korea, Malaysia (Malaysian Nuclear Agency), Mongolia, Philippines, Thailand and Vietnam. More information can be found on <http://www.fnca.mext.go.jp/english/index.html>

Table 4: Universities Offering Nuclear-Related Subjects in Malaysia

University	Level of Study	Scope
Universiti Kebangsaan Malaysia (UKM)	Undergraduate Postgraduate	Nuclear Science programmes – B.Sc., M.Sc., PHD Radiotherapy and Diagnostic Imaging Programmes – B.Sc. Master of Medicine (Radiology) Master of Science in Radiation Safety
Universiti Malaysia (UM)	Undergraduate Postgraduate	Bachelor of Biomedical – course module includes Nuclear Medicine Technology Medical Physics (Master)
Universiti Sains Malaysia (USM)	Undergraduate Postgraduate	Medical Physics – Bachelor of Applied Science Medical Physics – M.Sc. Medical Radiation Programme Master of Medical (Radiology) Postgraduate Education Certificate (PGEC) in Radiation Protection and Safety
Universiti Putra Malaysia	Postgraduate	Research areas – Applied Radiation (radiation synthesis, medical physics)
Universiti Teknologi Malaysia (UTM)	Undergraduate	Basic nuclear science and technology as core subject in year 3 Health Physics – B.Sc. Application of radioisotope and radiation in industry
Universiti Teknologi MARA (UiTM)	Undergraduate	Basic nuclear science and technology as selective subject in year 4 Diploma in Medical Imaging
Universiti Malaysia Sarawak (UNIMAS)	Undergraduate	Medical Physics – Bachelor of Applied Science
Universiti Darul Imam Malaysia (UDM)	Undergraduate	Diploma in Radiography

Sources: (Narul Khair and Ainul Hayati, 2009)

To operate NPPs, more specialised subjects, such as nuclear reactor design, nuclear safety engineering, nuclear fuels and materials are needed. Since experienced personnel to teach nuclear engineering courses are insufficient, Malaysia is looking into collaborating with universities and international entities such as ENEN and ANENT to enhance its capacity (Narul Khair and Ainul Hayati, 2009). At present, Malaysia does not have a dedicated human development programme for NPPs, and it remains unclear whether Malaysia will have necessary qualified manpower by the time it constructs its first NPP (Narul Khair and Ainul Hayati, 2009).

Implications for the Region

Nuclear security culture

The security of radioactive materials in Vietnam, Indonesia, and Malaysia is a concern for the region and a top priority to prevent their use by terrorists. Since 11 September 2001, the global security of radioactive materials has shifted focus from avoiding unintended radiation exposure for workers and the general public to preventing terrorists from using radioactive materials in a dirty bomb or a radiation exposure device. The security of the transport of nuclear materials passing through the region's vital sea lanes will be a paramount security concern for ASEAN member states, given the fact that these sea lanes cannot be tightly guarded by the region's navies and coast guards. An assessment of the three countries' security programme for radioactive materials needs to ensure the inclusion of key elements including background checks, physical barriers and personnel access controls, security plans or procedures, coordination and response planning, coordination and tracking of shipments, and security barriers to discourage theft.

Food security concerns

Depending on the extent of an accident, the food supply chain can be disrupted as sources of food can be contaminated by either airborne radiation or radioactive water from affected power plants. Locations of sources of different food commodities would determine the extent of susceptibility to a nuclear accident. For instance, transboundary radioactive plumes from any accident in Vietnam's NPP may contaminate agricultural farmlands not just in Vietnam but also in its rice-producing neighbours in mainland Southeast Asia like Thailand and Cambodia. It must be noted that Vietnam and Thailand are the world's top rice exporters (Chomchuen and Steger, 2014). Contamination of farmlands can significantly disrupt the region's and global food supply chain. An accident in Vietnam, Malaysia or Indonesia can also contaminate rich fishing grounds in the region's bodies of water particularly the South China Sea. ASEAN importations of food products from Vietnam from 2011 to 2012 amounted to an average of 4.7 per cent. Between 2011 and 2013, ASEAN importation of food products from Indonesia and Malaysia averaged 8.3 per cent and 8.1 per cent respectively (International Trade Centre, 2013). Food safety is among the paramount concerns of ASEAN member states, given that intra-ASEAN trade in food items (exports and imports) is very robust.⁴⁸

Travel security concerns

Visitors travelling to and from contaminated sites in Vietnam, Indonesia and Malaysia would also be a risk. In 2012, 1.3 million ASEAN nationals visited Vietnam (ASEAN, 2014). The Province of Ninh Thuan, where the region's first two nuclear plants are planned, belongs to a tourism triangle that hosts historical and cultural attractions, and scenic landscapes. In the same year, there were about 8 million visitors to Indonesia, 2.7 million of which came from neighbouring ASEAN countries. About 25 million visits to Malaysia were recorded in the same year, 18.8 million of which came from ASEAN (ASEAN, 2014). Reflecting from the year 2012 alone, about 22.8 million ASEAN tourists and travellers could potentially be at risk of a nuclear accident in Vietnam, Malaysia and Indonesia. The emergency evacuation of ASEAN tourists may be one of the immediate concerns for governments in the region should a nuclear accident occur in the future. Tourism is also one of the largest economic sectors in the region. A nuclear accident can potentially undermine one of the top revenue sources of ASEAN countries.

The siting of a nuclear power plant and radioactive plume

If a Level 7 nuclear accident⁴⁹ occurs in the region, the public health and environmental implications would cross national borders primarily due to radioactive plumes as radioactive material can be carried by wind and rain far away from the source, contaminating water and soil. Atmospheric and ocean plumes may affect farmlands, rich fishing grounds, wildlife and public health in the region. However, a nuclear engineer and

⁴⁸ Total intra-ASEAN trade in food amounted to USD 41.35 billion (SGD 52.34) in 2013 (ASEAN, 2014).

⁴⁹ Level 7 is the highest category of nuclear accidents, similar to the nuclear accidents at Fukushima and Chernobyl.

professor at Nanyang Technological University (NTU) argued that that it is still extremely difficult to predict the distance that a radioactive plume can travel and the amount of radioactive particles that can affect a particular country in the region. Being located thousands of kilometres away from a nuclear accident is not a guarantee that a particular country will be safe from radioactive plume.⁵⁰ In a scientific study made by researchers of the Centre of Excellence for Climate System Science of the Australian Research Council on Fukushima's radioactive plume, radioactive particles in the ocean plume take considerably longer to travel the same distance so it may also be hard to forecast the exact time they will reach a particular destination. Also, there would be uncertainties as to the total amount of radioactive particles released and the likely concentrations that would be observed. Atmospheric and ocean plumes get diluted as it travels away from the source. In the Fukushima plume case, circular wave current and giant whirlpools – some tens of kilometres wide – and other currents in the open ocean continue this dilution process and direct the radioactive particles to different areas along the US west coast (Rossi, Sebille, Gupta, Garcon and England, 2013). A maximum concentration of radiation may still hit a specific area, endangering the ecosystem there (Gutierrez, 2014). The amount of radioactive particles that can reach a particular destination primarily depends on the direction and strength of the prevailing wind system and air circulation.

⁵⁰ Twenty eight years after the Chernobyl nuclear disaster, some areas in Germany, such as in Saxony, are still being affected by radiation in the form of radioactive animals and soil. It must be noted Saxony lies some 1100 km from Chernobyl while wind and rain carried the radioactivity across western Europe. Soil contamination was even detected in some areas in France (Huggler, 2014)

Policy Recommendations

This NTS Report has evaluated the renewed interest in nuclear energy in Southeast Asia, focusing on Vietnam, Indonesia and Malaysia, the multiple and overlapping security, safety and safeguard challenges faced by the three countries, and the implications these have for ASEAN. These areas are particularly focused around institutional and human resource capacity and the need to develop a coordinated approach to nuclear energy safeguards, safety and security. Nuclear capabilities engender a certain level of apprehension among neighbouring countries and this can trigger tensions that escalate over time. It is imperative for ASEAN member states to work together to ensure effective governance of nuclear facilities, materials, and wastes and to adopt a regional disaster preparedness mechanism.

Despite criticisms against ASEAN—that it is slow and ineffective in tackling regional issues, it remains to be among the most relevant platforms for developing policies and frameworks at the regional level. ASEAN can facilitate regional cooperation on capacity-building, information dissemination, and emergency preparedness and response frameworks. As there is a risk of radioactive contamination spreading across borders, ASEAN governments must clearly and transparently manage nuclear waste and explore channels for communication with neighbours to address cross-border impacts. As ASEAN member states work to establish an ASEAN Community, the fostering of an ASEAN consensus on nuclear energy-related issues is possible. One key impediment, however, is the region's principle of non-intervention in another state's domestic affairs. Many states still perceive energy security as a national security issue and are reluctant to discuss their nuclear energy programmes at the regional level. Finding the right balance between national sovereignty and regional cooperation is often challenging since nuclear security always entails confidentiality as it is considered a national security issue. ASEAN can leverage on its strength as an avenue for regional cooperation to address non-traditional security issues such as humanitarian assistance and disaster response in case a nuclear accident occurs. Currently, ASEAN has two sub-groups that promote regional cooperation on nuclear energy: the ASEAN Network of Regulatory Bodies on Atomic Energy (ASEANTOM) and Nuclear Energy Cooperation Sub-sector Network (NEC-SSN). The efficacy of their activities can still be further boosted by a number of national and regional initiatives.

As a result, the following policy strategies are recommended to enhance ASEAN's capacity for regional cooperation on nuclear energy and regional coordination in disaster-response. It must be noted that any nuclear accident in one of the member-countries can potentially have regional implications through transboundary radioactive plumes and contaminated food and drinking water.

- **Strengthen national legislation on nuclear safety, security and safeguards**

ASEAN member states may need to review their existing domestic laws and regulations on nuclear energy and strengthen them based on these international legal instruments that they have already acceded to. Even though Vietnam has already signed all important international agreements on nuclear 3S, the current version of its Atomic Energy Law is still being amended to incorporate all the important provisions of these agreements.⁵¹ Malaysia is not yet a party to most of these international instruments (CSCAP, 2013). Indonesia is still drawing up a draft law on nuclear security with the view to submit it to the parliament in 2015 and revising the government regulation on the safe transport of radioactive materials (National Security Summit National Progress Report-Indonesia, 2014).

One key provision that they need to include in their domestic laws is making their nuclear regulatory body agencies effectively independent, especially in nuclear-aspiring states in the region. As demonstrated by the Fukushima accident, the lack of independence of the regulatory body from the promoters of nuclear energy such as ministries and nuclear industry greatly compromised safety and was identified as one of the causes of the accident. Nuclear –aspiring states in the region should legislate the necessary laws that would empower their nuclear regulatory bodies to independently perform their mandated functions, particularly inspection and licensing, to ensure nuclear safety. In

⁵¹ Interview with a Vietnamese official, Hanoi, 8 August 2014.

addition, when crafting domestic laws, it is essential to comply with the guidelines, standards and codes set by institutions and international conventions. Most important of these are the IAEA guidelines which cover 19 key areas including: licensing, inspection and enforcement; radiation protection and safety; emergency response and management; transport of radioactive material; management of radioactive waste; decommissioning; nuclear liability in cases of nuclear accidents; and international trade of nuclear materials. Each of these needs to be included in the comprehensive nuclear law. Consultation with relevant agencies (health, science and technology, environment, trade, defence, foreign affairs, home affairs, customs, police force, local governments, among others) and stakeholders (civil society groups, media, business sector) is an important part of the process of developing nuclear legislation.

- **Conduct radiation risk computer modelling**

While it is difficult to accurately measure the extent of radiation plumes and the distance that can travel within the region if an accident occurs in any of the future NPPs in the region, ASEAN governments can start creating radiation risk modelling using available software. This modelling can create various scenarios and determine the aggregate radiation risk to their respective territories and constituencies in case of a nuclear accident in the region, using primary factors such as the distance of the accident from their boundaries and the strength and direction of the prevailing wind system. Singapore, for instance, plans to conduct safety analyses by 2016, including using modelling and simulations to assess the possible impact of a nuclear disaster and the how radioactive particle can travel (Tan, 2014). Other ASEAN member countries, including those which have decided not to pursue nuclear energy just yet, may consider to emulate Singapore's initiative as the consequences of a nuclear accident are transboundary in nature. ASEAN member states can draw on their experience in climate change risk and meteorological modelling. For instance, the Training Workshop on Climate Applications in ASEAN was held in 2009 to promote the effective use of the regional ASEAN climate dataset for climate-related applications so as to foster broader understanding of changes in climate to enable better preparation for risk management against the impacts of extreme weather phenomena.

Nuclear-aspiring ASEAN states can seek the assistance of IAEA in enhancing their risk modelling capability. The IAEA has already developed approaches and tools for severe accident analysis for NPPs, including description and status in modelling of severe accident phenomena.⁵² They can apply these approaches and tools to assess the safety features of the region's future NPPs, including radiation accident analysis. ASEAN member states may also wish to engage international institutions which use radioactive risk modelling and radiation early warning systems. The United States National Atmospheric Release Advisory Assistance has carried out modelling exercises to make atmospheric plume predictions and map the probable spread of hazardous material accidentally or intentionally released into the atmosphere. The European Union have been using scientific modelling systems to project the movement and dispersion of the Fukushima plume (Gutierrez, 2014).

- **Develop a comprehensive nuclear literacy campaign and human resources training programme**

One of the common emergent themes through this investigation was the need to engage all stakeholders in the decision-making process, particularly local communities of potential nuclear power plant sites and future nuclear energy plans. At present the limited available training is targeted at nuclear power engineers and other relevant staff of nuclear research reactors, selected employees of nuclear government bodies and students who are now being trained overseas and set to be employed at future nuclear power plants. It cannot be assumed that all workers involved in NPPs are conversant of the safety and emergency protocols. One of the lessons from the Fukushima crisis was the operator's complacency towards safety training. The three major investigations into the Fukushima accident concluded that utility employees were not properly trained to operate emergency equipment

⁵² For further details, please read IAEA. (2008). *Approaches and Tools for Severe Accident Analysis for Nuclear Power Plants*. Vienna: IAEA. Online copy is available at http://www-pub.iaea.org/MTCD/publications/PDF/Pub1327_web.pdf.

and lacked crisis-management skills. There were no evacuation drills because the plant operator did not want to alarm local residents (Kingston, 2014).

For a sustainable safety approach all employees should be conversant in nuclear safety standards, which need to be integrated into human resources training. In addition, a wider public education and engagement program needs to be designed to allow for long term energy planning. Examples such as the public education and engagement programs in the United Kingdom and Finland have ensured a longer term approach to their domestic energy needs. Within a regional context, ASEAN member states especially nuclear-aspiring states like Vietnam, Indonesia and Malaysia can work together to build websites to house reports, assessments, scholarly articles, and other information including local translations of key legal documents for nuclear professionals and scholars in the region.

The NEC-SSN was tasked by ASEAN energy ministers in 2012 to continue to promote and intensify capacity building efforts, in collaboration with the IAEA and other relevant partners, so that the region will be more informed and kept updated on the latest nuclear safety standards, developments and technologies. Hence, NEC-SSN needs to accelerate and strengthen its programmes under the ASEAN Action Plan on Public Education on Nuclear Energy and Nuclear as the Clean Energy Alternative Option with a view to enhancing public awareness and acceptance of the usage of nuclear energy for power generation.⁵³

One of the EURATOM's best practices is its regional human resources training programme. Under the Euratom Fusion Training Scheme (EFTS), a range of training actions have been launched since 2006 to ensure that adequate human resources will be available in the future in terms of numbers, range of skills, and high-level training and experience. The Asia-Europe Meeting is one avenue to facilitate inter-regional cooperation between ASEAN and the EU on human resources development in the nuclear field.

ASEAN member states need to be able to integrate what they have learned from recent regional initiatives enhancing human resources in the atomic energy field into their own domestic training programmes. Such regional initiatives include the ASEAN+3 Human Resources Development (HRD) Programme on Civilian Nuclear Energy (CNE) 2012-2014 and the Integrated Support Center for Nuclear Non-proliferation and Nuclear Security (ISCN) supported by Republic of Korea and Japan.⁵⁴

ASEAN can assess existing regional arrangements, such as Asian Network for Education in Nuclear Technology (ANENT), Regional Cooperative Agreement (RCA) for Nuclear Research, Development and Training, Forum for Nuclear Cooperation in Asia (FNCA) and Asian Nuclear Safety Network (ANSN). While Indonesia, Malaysia and Vietnam are already part of these bigger networks, bringing such efforts down to a smaller scale in Southeast Asia will enable a more focused approach on issues that are of greatest importance to all ASEAN member states. With the assistance of IAEA, ASEAN member states can organise joint training workshops for the region's nuclear-security professionals in evaluation methodology, helping conduct site evaluations, and interpreting the results. ASEAN member states need to ensure that they will be able to conduct the activities already identified during the 2014 meeting of ASEAN Network of Regulatory Bodies on Atomic Energy (ASEANTOM). These activities include a number of regional workshops and training courses on emergency preparedness and response as well as on nuclear security culture and management (ASEANTOM, 2014).

It is important to note that RSIS has just recently joined International Nuclear Security Education Network (INSEN) a group of experts from academia, international organizations and professional nuclear material management associations established, under the auspices of the IAEA Nuclear Security Programme. The network's mission is to enhance global nuclear security by developing, sharing and promoting excellence in nuclear security education. By joining the network, RSIS wants to

⁵³ Joint Statement of the 30th ASEAN Ministers of Energy Meeting, Phnom Penh Cambodia, 12 September 2012.

⁵⁴ Joint Statement of the 31st ASEAN Ministers of Energy Meeting, Bali, Indonesia, 25 September 2013.

comprehensively understand nuclear security and participate in joint research and development activities with international academic and professional nuclear material management associations.

Another latest development on the development of a comprehensive nuclear literacy campaign is Singapore's initiative to implement nine research projects aimed at building up its nuclear expertise. Set to begin by 2016, these research projects are in the areas of radiochemistry, radiobiology and safety analyses. Radiochemistry projects will gather data on background radiation, enabling the Singapore to detect abnormal radioactive levels. Safety analyses include research on the possible implications of nuclear accidents and how radioactive particles can travel. Through these projects, Singapore also aims to develop security protocols in dealing with nuclear terrorism or accidents in the transport of nuclear materials through Singapore waters. Cognizant of the fact that any comprehensive nuclear literacy campaign and HR development initiatives entail robust government support to educational institutions, Singapore's National Research Foundation of the Prime Minister's Office will tap National University of Singapore and Nanyang Technological University to set up nuclear –related programmes aimed at advancing Singapore's capabilities in nuclear research (Tan, 2014). Other ASEAN member countries, which have yet to develop their nuclear energy research capabilities, may want to emulate Singapore's strategies.

- **Increase vigilance on food exports and imports**

Most of the ASEAN member states are both food exporters and importers. Since exports and imports can be contaminated anywhere along the food production chain, ASEAN's food safety inspection agencies should work together to adapt and upgrade their holistic system based on risk analysis, import control, inspection and laboratory testing in order to detect not only diseases but also abnormal levels of radiation. There is a need to harmonise their food safety inspection standards in order to prevent the exportation and importation of contaminated food. To boost their routine surveillance, food regulatory bodies may increase the samples of imported food products that are regularly tested from the nuclear-aspiring states in the future. Agencies can also require a Certificate of Origin (COO), which ensures traceability and a pre-export laboratory report, which certifies that the food is free from radioactive contaminants.

- **Explore the potential of establishing a regional/multilateral nuclear enrichment centre**

ASEAN member states can foster and participate in a uranium enrichment centre in the Asia-Pacific through the ASEAN process to ensure the centrality of Southeast Asia and regional norms. This centre however could only be established in countries with a strong non-proliferation reputation, such as Australia (Carlson, 2013). As such, the East Asian Summit provides the most suitable avenue through which to pursue such a regional centre to ensure participation of states with nuclear power programmes like China, Japan and South Korea as well as those with a strong non-proliferation reputation. While this centre, with regional participation, is mainly aimed at countering the proliferation of nuclear weapons by obviating further national enrichment programmes, ASEAN member states can significantly learn about combatting the illicit flow of radioactive materials and managing spent fuel from dialogue partners with robust nuclear experience. This initiative can complement the efforts made by NEC-SSN in cooperation with dialogue partners to enhance capacity building activities on civilian nuclear energy and in pursuing regional nuclear safety cooperation.⁵⁵

- **Establish a regional nuclear crisis centre**

Considering the need to strengthen responses to nuclear crises for the protection of people, ASEAN can set up a regional nuclear crisis centre in which its first responders, health care practitioners, custom officers, law enforcers, and disaster centre personnel can come together and participate in workshops, trainings and joint drills. This would facilitate information and knowledge exchange, and increase

⁵⁵ Joint Statement of the 32nd ASEAN Ministers of Energy Meeting, Vientiane, Lao PDR, 23 September 2014.

response coordination in case member states will get affected by radiation plumes. In times of crisis, the centre can act as a special coordinating body for regional and inter-ministerial disaster response. The peculiar nature of a radiation-related disaster requires the existence of a special coordinating body, such as a nuclear crisis centre, which is expected to be conversant in the appropriate responses to this type of disaster affecting people in the region. It may also serve as an information clearing house, relaying up to date information regarding radiation risk in the region. One example of a coordinating body is the ASEAN Coordinating Centre for Humanitarian Assistance on disaster management (AHA Centre). However, support from and coordination with all ASEAN countries and existing relief organisations is essential if a regional nuclear crisis centre is to be established and recognised as a regional coordinating body.

- **Pursue joint nuclear emergency drills in region and train medical contingents for nuclear accident relief**

ASEAN defence ministers can pursue the incorporation of joint nuclear emergency drills into the ASEAN Defence Ministers Meeting (ADMM)-Plus Humanitarian Assistance and Disaster Response (HADR)/Military Medicine Exercise. In addition, given the transboundary implications of a nuclear disaster, relevant countries can work together to formulate joint efforts to clean up affected sites from radioactive deposits. To this end, the region can establish a regional contingent of specially trained nuclear disaster emergency responders, similar to the ASEAN-Emergency Rapid Assessment Team found in the AHA Centre. They can first participate in these exercises while acquiring relevant skills from their ASEAN-Plus counterparts.

The medical contingent for nuclear accident relief can be deployed under the existing framework of ADMM-Plus HADR and Experts' Working Group on Military Medicine (EWG-MM). This cooperation platform has developed a set of standard operating procedures (SOP) that synchronises the different operating protocols used by each country, which will enable better cooperation and coordination among countries involved in joint medical relief efforts.

To anticipate a high influx of contaminated victims in a radiological mass casualty incident, ASEAN hospitals and clinics need to prepare themselves with sufficient number of emergency physicians, radiologists, nuclear medicine physicians, radiation oncologists, medical physicists, and health physicist, as well as competent and well-trained medical staff.

Emergency planning also needs to emphasise public preparedness, which is crucial in reducing human losses in the event of an accident, especially when incorporated into strategies for evacuation. To increase public awareness, cooperation between governments, the nuclear industry, and collaboration with civil society organisations, must be further enhanced. Such concerted efforts are critical, particularly in tackling emergencies akin to Fukushima accident.

- **Organise regular meetings among the ASEAN's academic institutions, think tanks and government agencies on nuclear power, security and safety**

ASEAN member states can study and adopt the best practices from the European Union which has a comprehensive and functioning nuclear energy cooperation framework. The cooperation has relevant institutions, funding, and policies needed to make such an arrangement work. The European Atomic Energy Community (EURATOM) was initially established to enable the coordination of EU member states' nuclear research programmes for peaceful purposes. EURATOM has expanded its activities ever since and it now serves as a pool of knowledge, infrastructure and funding for its members. Learning from the experience of EURATOM, ASEAN member states may consider organising regular and informal meetings among the region's academic institutions, think tanks and government agencies to facilitate effective regional coordination and information sharing. ASEAN member states may wish to explore mechanisms enhancing the ASEAN Network of Regulatory Bodies on Atomic Energy (ASEANTOM) which was established in 2012. It has already conducted two meetings since its

establishment. ASEANTOM can serve as a platform for the promotion of regional cooperation among the regulatory bodies and relevant authorities of the ASEAN member states by sharing best practices and experiences, building capacity of HR development, and assist members better adhere to IAEA standards and regulations. One potential challenge to this, however, is the possible reluctance of ASEAN member states, due to political sensitivities, to share with their neighbours what they may consider as a confidential national security issue like their nuclear energy programme. They may want to focus first on developing their nascent domestic nuclear capability before they consider cooperating with their neighbours. Hence, ASEAN member states may first consider establishing preliminary informal meetings among academic institutions and nuclear experts through workshops, seminars and conferences.

- **Establish Centres of Excellence on Nuclear Safety, Security and Safeguards (3S)**

ASEAN member states may consider establishing centres of excellence on nuclear safety, security and safeguards (3S) throughout the region by inviting visiting international experts and identifying local academics who can contribute to the region's capacity to uphold the 3S and nuclear governance. Indonesia has recently established one. Centres of Excellence in the region can collaborate on establishing technical points of contact for information exchange, setting and implementing standards for training, conducting regional threat assessments and assessing possible measures on spent fuel management. Regional collaboration can then be expanded to include ASEAN's dialogue partners in order for the ASEAN member states to significantly acquire the necessary information on nuclear energy from established nuclear-powered states in the Asia-Pacific. Centres of Excellence are promising organisations to broaden understanding of non-proliferation as well as safety and security issues and provide education and training to future nuclear professionals, particularly NPP operators. The Centres of Excellence regional network can complement the efforts of the IAEA, should be more able to discuss regional needs and concerns, and can draw on the experiences of other regional networks like the Network of ASEAN Defence and Security Institutions (NADI).

- **Explore an ASEAN Management of Spent Fuel Regional Framework.**

In the field of nuclear safety, including waste management and radiological protection, the EURATOM Community has developed common legislative frameworks, another best practice that ASEAN should consider. The proposed amendment to the 2009 Nuclear Safety Directive strengthens the role and independence of national regulators; introduces EU-wide nuclear safety objectives; sets up a European system of topical peer reviews of nuclear installations to ensure these common objectives are met; increases transparency on nuclear safety matters; and includes new provisions for on-site emergency preparedness and response. In 2011, the EU ratified binding legislation on spent fuel and radioactive waste management which requires the EU Members to adopt national programmes for handling radioactive waste and developing specific plans for building waste disposal facilities (European Commission, 2014).

In broad terms, radioactive waste is grouped into low, intermediate and high level wastes. Low level waste comes from hospitals, industries and laboratories. Intermediate level waste – generated during operation of a nuclear power plant – is composed of ion exchange resins used to clean the water circulating through the reactor. Both low and intermediate level of wastes can be easily managed while the world is currently facing with challenges of disposing high level waste, which primarily includes the fuel that was used in the nuclear reactor, called "spent fuel (International Atomic Energy Agency, 2009). At present within ASEAN, Indonesia, Malaysia, Philippines, Singapore and Thailand all have facilities to store low and intermediate level nuclear waste, Singapore and Malaysia have nuclear waste disposal facilities, and Malaysia and the Philippines have nuclear waste processing capacities. However, these facilities are not intended to store and dispose high level waste like spent fuel on a larger scale. Vietnam and Indonesia have been managing the spent fuel taken from their research reactors but there are no indications yet if they have already acquired the capacity to comprehensively manage spent fuel, including its disposal, from NPPs. As such, ASEAN member states can initiate an ASEAN working

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group to investigate ways for a more comprehensive approach to environmental protection and hazards of high level waste, particularly spent fuel, in advance of nuclear power plant development in the region.

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