TRENDS IN SOUTHEAST ASIA

NUCLEAR ENERGY DEVELOPMENTS IN SOUTHEAST ASIA

Sharon Seah, Christopher Len and Alvin Chew

ISSUE 14 2025

ISEAS YUSOF ISHAK INSTITUTE

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ISEAS YUSOF ISHAK INSTITUTE

Published by: ISEAS Publishing
30 Heng Mui Keng Terrace
Singapore 119614
publish@iseas.edu.sg
http://bookshop.iseas.edu.sg

ISEAS Library Cataloguing-in-Publication Data

Name(s): Seah, Sharon, author. | Len, Christopher, author. | Chew, Alvin, author.
Title: Nuclear energy developments in Southeast Asia / by Sharon Seah, Christopher Len and Alvin Chew.
Description: Singapore : ISEAS-Yusof Ishak Institute, June 2025. | Series: Trends in Southeast Asia, ISSN 0219-3213 ; TRS14/25 | Includes bibliographical references.
Identifiers: ISBN 9789815306859 (soft cover) | ISBN 9789815306866 (ebook PDF)
Subjects: LCSH: Nuclear energy—Government policy—Southeast Asia. | Nuclear energy—Law and legislation—Southeast Asia. | Climate change mitigation—Southeast Asia.
Classification: DS501 I59T no. 14(2025)

Printed in Singapore by Markono Print Media Pte Ltd

FOREWORD

The economic, political, strategic and cultural dynamism in Southeast Asia has gained added relevance in recent years with the spectacular rise of giant economies in East and South Asia. This has drawn greater attention to the region and to the enhanced role it now plays in international relations and global economics.

The sustained effort made by Southeast Asian nations since 1967 towards a peaceful and gradual integration of their economies has had indubitable success, and perhaps as a consequence of this, most of these countries are undergoing deep political and social changes domestically and are constructing innovative solutions to meet new international challenges. Big Power tensions continue to be played out in the neighbourhood despite the tradition of neutrality exercised by the Association of Southeast Asian Nations (ASEAN).

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THE EDITORS

Nuclear Energy Developments in Southeast Asia

By Sharon Seah, Christopher Len and Alvin Chew

EXECUTIVE SUMMARY

- Southeast Asian countries are once again showing renewed interest in nuclear energy as a means to bolster energy security and meet decarbonization goals.
- Countries in this region have been exploring the use of civilian nuclear energy since the late 1950s, but their commitment has fluctuated over the decades, influenced by factors such as government support for nuclear energy, and global nuclear events affecting public opinion.
- The latest interest follows the revival of global interest in nuclear energy and progress in the development of advanced nuclear reactors as well as small modular reactors (SMRs). SMRs are regarded as a potential entry point for nations new to nuclear energy because of advantages such as lower upfront costs, enhanced safety, flexible power generation, and a less disruptive impact on existing electricity grids.
- There are challenges to SMR deployment in Southeast Asia, however, one of which is the absence of international regulations specifically governing these new reactors, particularly concerning transportation and safeguards. The creation of a robust regional nuclear safety regime harmonized with international rules and regulations would augment the existing governance frameworks and afford the region greater confidence in the deployment of new SMR technology.
- Public acceptance of nuclear energy remains a crucial factor for its successful development in the region. While there is growing acceptance of the potential of nuclear energy in the region, support

levels are still relatively low compared with other clean energy sources. Governments need to actively address public concerns regarding safety, trust, and risk perception connected to nuclear energy programmes.

Nuclear Energy Developments in Southeast Asia

Sharon Seah, Christopher Len and Alvin Chew[1]

INTRODUCTION

Since the start of the Russia-Ukraine war in 2022, followed by the Israel-Hamas conflict in 2023, global energy prices have been subjected to great volatility and challenging issues of security of supply. These challenging trends come at a time when energy demand is growing in Southeast Asia. The International Energy Agency (IEA), in its *Southeast Asia Energy Outlook 2024*, notes that under current policy trajectories Southeast Asia is projected to be responsible for approximately 25 per cent of the world's energy demand growth from 2024 through 2035. With economic growth and population increases fuelling energy demand, Southeast Asia is expected to overtake the European Union in total energy consumption by 2050. It further notes that fossil fuels—predominantly coal—have been meeting approximately 80 per cent of the region's rising energy needs since 2010. The report also notes that ASEAN stands out as one of the few regions, alongside the Middle East, where economic expansion remains heavily reliant on carbon-intensive practices, with economic growth continuing to parallel increases in greenhouse gas emissions.[2] Keen to establish a degree of energy independence to buffer against the adverse effects of these geopolitical uncertainties, Southeast Asian

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[2] International Energy Agency (IEA), *Southeast Asia Energy Outlook 2024*, https://www.iea.org/reports/southeast-asia-energy-outlook-2024.

countries are beginning to realize that renewable energy sources, despite their high upfront capital costs, provide such an avenue.

ASEAN is, however, lagging in meeting the renewable energy goals it has set for itself. The ASEAN Plan of Action for Energy Cooperation (APAEC) 2016–2025 Phase II: 2021–2025 (ASEAN Centre for Energy 2020), which was released in November 2020, sets a target for ASEAN member states to achieve 23 per cent renewable energy share in the total primary energy supply target under APAEC Phase II. But the latest *8th ASEAN Energy Outlook, 2023–2050*,[3] indicates that as of 2022, ASEAN only reached 15.6 per cent renewable energy share and is projected to achieve its target belatedly by 2030 based on the ASEAN Member States Target Scenario, which considers the energy policies of each member state, such as plans for power development, renewable energy, and energy efficiency and conservation.

Decarbonization has also emerged in parallel as a new driver in low-carbon energy pursuits that satisfy national climate mitigation targets in the context of growing energy demand. For the first time, an acceleration of nuclear energy deployment was recognized as a means to achieve deep decarbonization at the 2023 Global Stocktake.[4] The inclusion of nuclear technology to achieve net zero in the UNFCCC Conference of Parties (COP) process, where previously critics had derided nuclear energy as a non-renewable source, shows a clear shift in attitudes, driven by the urgency of keeping global temperature increases to under two degrees. Hence, the regional drive to explore and tap into alternative energy sources, including civilian nuclear energy, has been increasing.

Together with a growing global decarbonization momentum, nuclear energy has emerged as a potential source of clean energy for many countries even if the transition from planning to actual construction has been slow among newcomer countries that currently do not possess

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[3] ASEAN Centre for Energy, *8th ASEAN Energy Outlook*, 2024, https://aseanenergy.org/publications/the-8th-asean-energy-outlook/.

[4] World Nuclear Association, "COP28 Agreement Recognizes Accelerating Nuclear Energy as Part of the Solution", 13 May 2024, https://world-nuclear.org/news-and-media/press-statements/cop28-agreement-recognizes-accelerating-nuclear-as.

nuclear energy capabilities. The International Atomic Energy Agency (IAEA) estimates that increasing the current nuclear energy capacity by 2.5 times by 2050 would require annual investments of more than US$100 billion.[5] The International Energy Agency (IEA) considers nuclear power as the backbone of low-carbon electricity generation;[6] nuclear energy can accelerate the world's clean energy transition through its low-carbon footprint, zero emissions and stable baseload to balance out the intermittency of renewable energy sources in the grid. Likewise, Southeast Asian governments are increasingly exploring nuclear energy's potential, not only to address surging energy demands, bolster energy security and meet net-zero commitments, but also to complement renewable energy infrastructure by providing stable baseload power capable of displacing coal in their national energy mix.

Southeast Asia has had a long history in civilian nuclear energy dating back to the late 1950s. But interest in nuclear energy has ebbed and flowed over the decades. Decisions on whether to advance or delay plans have depended on a few factors, including the government of the day's appetite for nuclear energy, and major nuclear trends and incidents that shaped public perceptions of nuclear safety. In line with the global revival[7] in nuclear energy plans, there is once again growing interest in nuclear energy as part of the domestic energy mix in ASEAN.

This Trends provides an overview of the developments in Southeast Asia's quest for nuclear energy, including regional nuclear energy developments from the 1950s, prospects of adopting new nuclear technology, cooperation at the ASEAN-level, and public perceptions

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[5] International Atomic Energy Agency (IAEA), "Climate Change and Nuclear Power: Financing Nuclear Energy in Low Carbon Transitions", 2024, https://www-pub.iaea.org/MTCD/Publications/PDF/PUB9048_web.pdf.

[6] IEA, "Nuclear Power in a Clean Energy System", May 2019, https://www.iea.org/reports/nuclear-power-in-a-clean-energy-system.

[7] Matt Fisher, "New IAEA Report on Climate Change and Nuclear Power Focuses on Financing", IAEA, 18 October 2024, https://www.iaea.org/newscenter/news/new-iaea-report-on-climate-change-and-nuclear-power-focuses-on-financing#:~:text=According%20to%20the%20report%2C%20global,for%20nuclear%20capacity%20in%202050.

towards nuclear energy. It also contains a discussion on key challenges that will affect the adoption of advanced nuclear technologies incorporated into small modular reactors (SMRs).[8]

TRENDS IN SOUTHEAST ASIA'S INTEREST IN NUCLEAR ENERGY

Despite the early involvement of some countries with nuclear energy stretching back to the 1950s, various plans and proposals over the years have failed to materialize. The early 2000s coincided with a period of high economic growth and expansion in Asia, and despite the 2008 financial crisis, ASEAN continued to pursue free trade agreements before eventually forming an ASEAN Economic Community in 2015. It was during this period of high economic growth—when the countries of Southeast Asia were again exploring the use of civilian nuclear energy to support economic expansion, rapid industrialization and urbanization[9]—that the 2011 Fukushima Daiichi nuclear disaster struck in Japan. This raised concerns about nuclear safety, which led to countries that were exploring nuclear energy plans to put them on hold or cancel them altogether, but it did not dampen the interest.[10]

Indonesia, Myanmar, Thailand, and Vietnam were among the first Southeast Asian countries to join the IAEA in 1957, with Brunei being the

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[8] According to the website of the IAEA, small modular reactors (SMRs) are nuclear fission reactors with a capacity up to 300 megawatts: https://www.iaea.org/newscenter/news/what-are-small-modular-reactors-smrs - :~:text=Small%20modular%20reactors%20%28SMRs%29%20are%20advanced%20nuclear%20reactors,the%20generating%20capacity%20of%20traditional%20nuclear%20-power%20reactors.

[9] V. Chutiprapat, W. Pattaraprakorn, and P. Bhasaputra, "The Successive Development of Nuclear Energy in Southeast Asia", *GMSARN International Journal* 5 (2011): 113–20, http://gmsarnjournal.com/home/wp-content/uploads/2015/07/vol5no2.pdf#page=38); Mely Caballero-Anthony and Julius Cesar I. Trajano, "The State of Nuclear Energy in ASEAN: Regional Norms and Challenges", *Asian Perspective* 39, no. 4 (2015): 695–723, https://muse.jhu.edu/pub/1/article/714014/summary.

[10] Ibid.

last to join in 2014. Aspiring ASEAN member and the youngest country in Southeast Asia—Timor-Leste—has yet to join the IAEA, but it is considering membership as part of its admission processes to ASEAN.[11] Over the last few decades, Southeast Asian countries have made progress in their domestic nuclear safety and security-related legislation to fulfil their obligations under the IAEA conventions and to establish a legal framework for the eventual use of civilian nuclear energy (see Table 1).

The first group of countries passed their legislation already in the 1950s to 1960s. The Philippines was the first to pass its Nuclear Energy Act in 1957, followed by Thailand with its Atomic Energy for Peace Act in 1961. Singapore passed the Radiation Protection Act in 1973, and Malaysia passed its Atomic Energy Licensing Act in 1984. Indonesia passed its Nuclear Energy Act in 1997, and Myanmar its Atomic Energy Law in 1998. In addition, ASEAN countries also actively pursued bilateral nuclear safety and security-related cooperation with the United States, Canada, Russia, South Korea, Japan, China and institutions like the IAEA, International Civil Aviation Organization (ICAO) and International Maritime Organization (IMO), or fora like the Asian Nuclear Safety Network (ANSN), Forum for Nuclear Cooperation in Asia (FNCA), ASEM, and APEC bodies (see Appendix).

An objective way of assessing the readiness of countries to embark on the use of nuclear power is to examine the progress made in their respective IAEA Milestones.[12] The IAEA Milestones Approach consists of three phases in nuclear power deployment: (1) readiness to make an informed commitment to a nuclear power programme; (2) readiness to invite bids and negotiate contracts for its first nuclear power plant; (3) readiness to commission and operate its first nuclear power plant. Countries must address nineteen infrastructure issues across legal, regulatory, safety, security, human resources and waste management during the process. To support countries, the IAEA offers Integrated

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[11] Joanne Lin, Sharon Seah, Sithanonxay Suvannaphakdy, and Melinda Martinus, *Timor-Leste in ASEAN: Is It Ready to Join?*, Trends in Southeast Asia, no. 1/2024 (ISEAS – Yusof Ishak Institute).

[12] IAEA, "Milestones Approach", n.d., https://www.iaea.org/topics/infrastructure-development/milestones-approach.

Table 1: Progress of ASEAN Countries in Domestic Nuclear-Related Legislation

Country	Year	Domestic legislation
Brunei Darussalam	2018	Radiation Protection Act; revised in 2021
	2018	Signed first Country Programme Framework (CPF) for 2017–22 under the IAEA
Cambodia	ongoing	Working to establish a draft law on nuclear power with IAEA assistance
Indonesia	1997	Nuclear Energy Act, which established BAPETEN (Nuclear Energy Regulatory Agency)
	2002	Government Regulation on Radioactive Waste
	2007	Government Regulation No. 33 on Safety of Ionizing Radiation and Security of Radioactive Sources (2007)
	2008	Government Regulation No. 29 on the Licensing of Ionizing Radiation Sources and Nuclear Material
	2010	Government Regulation No. 54 on the Safety and Security of Nuclear Installations and Material
	2014	Government Regulation No. 2 on Licensing of Nuclear Installation and the Utilization of Nuclear Materials
	2014	Government Regulation No. 79 on National Energy Policy
	In progress	New and Renewable Energy Bill (EBET) and draft Government Regulation on National Energy Policy (RPP KEN)
Laos	Ongoing	Country Programme Framework for 2014–18 (1st phase) and 2020–25 (2nd phase) under the IAEA
	2019	Law on Radiation Protection and Safety
Malaysia	1984	Atomic Energy Licensing Act
	1986	Radiation Protection (Licensing) Regulations
	1988	Radiation Protection (Basic Safety Standard) Regulations
	1989	Radiation Protection (Transportation) Regulations 1989
	1990	Radiation Protection (Appeal) Regulations
Myanmar	1998	Atomic Energy Law

		Myanmar also has the following laws that are not directly for atomic energy but which may be relevant: (1) the Science and Technology Development Law 1994, (2) the Environmental Conservation Law 2012, and (3) the Counter Terrorism Law 2014.
Philippines	1957	Nuclear Energy Act
	1958	The Science Act of 1958
	1968	Atomic Energy Regulatory and Liability Act of 1968
	2004	Internal Regulatory Control Program of the Philippine Nuclear Research Institute (PNRI) established through PNRI Office Order
	Published progressively in parts	Code of PNRI Regulations (parts 0–27) covers radiation protection, transport, safety and security, fees and charges, waste and practice
	2020	President Executive Order 116 established the Nuclear Energy Program Inter-Agency Committee (NEP-IAC) to conduct a study on a national position on a nuclear energy programme
	2022	President Executive Order 164 mandating the DOE to develop and implement a nuclear programme
Singapore	1973	Radiation Protection Act. In 2014, upon accession to the IAEA's Convention on the Physical Protection of Nuclear Material and its Amendment (A/CPPNM), as well as the UN International Convention for the Suppression of Acts of Nuclear Terrorism (ICSANT), the act was amended to meet its obligations.
	1974	Radiation Protection Regulations
Thailand	1961	Atomic Energy for Peace Act (replaced by Nuclear Energy for Peace Act)
	2017	Nuclear Energy for Peace Act (amended by the Nuclear Energy for Peace No. 2 in 2019); additional provisions in the form of Ministerial Regulations, Nuclear Energy Commission for Peace (NEC) Rules and Office of Atoms for Peace (OAP) Notifications
Vietnam	2008	Law on Atomic Energy
	2009	Resolution No. 41/2009/QH12 for the Investment Policy of Ninh Thuan Nuclear Power Project
	2010	Prime Minister's Decision No. 446/QD-TTg to establish the State Steering Committee for the nuclear power programme
	2014	Decision No 2241/QĐ-TTg on approval of Master Plan for Infrastructure Development
	2015–20	Various Decisions and Circulars in preparation for new research reactors

Source: Authors' compilation.

Nuclear Infrastructure (INIR) missions to make assessments on their progress. Since the IAEA Milestones Approach is simply a guidance document, which is not legally binding on IAEA members, participation in INIR missions is not mandatory.[13] So far, five ASEAN countries—Indonesia, the Philippines, Malaysia, Thailand and Vietnam—have hosted at least one INIR mission, as shown in Table 2. The following section examines their progress in advancing nuclear plans according to the IAEA's milestones approach.

The Philippines was by far the most advanced in its plans to tap into civilian nuclear energy with the completion of the Bataan Nuclear Power Plant in 1985. Construction of the plant started in 1976 during the time of President Ferdinand Marcos. It cost approximately US$2 billion, but it never saw a day in operation because of accusations of corruption as well as public opposition based on health and safety concerns, particularly following the Chernobyl disaster in April 1986 after the succeeding administration of President Corazon Aquino had taken over.[14] Under Marcos's son, current President Bongbong Marcos Jr, the government is reassessing the feasibility of restarting the Bataan Nuclear Power Plant or adopting SMRs in its plans.[15] The country unveiled its Nuclear Energy Roadmap in September 2024, which announced its aim of having operational power plants by 2032, beginning at 1,200 megawatts and reaching 4,800 megawatts by 2050.[16] In December 2024, the IAEA

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[13] Denise Cheong and Nivedita S., "Enhancing Transboundary Consultation in the Context of Nuclear Power Development in Southeast Asia", *Chinese (Taiwan) Yearbook of International Law and Affairs* 39 (2021): 111–81. https://doi.org/10.1163/9789004532069_004.

[14] Gabriele Suwanto and Maruli Tondi Siahaan, "Waking Up the Sleeping 'Giant': What Should the Philippines Do for Bataan NPP Revival Plan?", ASEAN Centre for Energy, 26 February 2024, https://aseanenergy.org/post/waking-up-the-sleeping-giant-what-should-the-philippines-do-for-bataan-npp-revival-plan/.

[15] World Nuclear Association, "Country Profiles: Nuclear Power in the Philippines", updated 28 March 2024, https://world-nuclear.org/information-library/country-profiles/countries-o-s/philippines.

[16] Philippine Nuclear Research Institute, "Nuclear Energy Milestones in PH Reported at the IAEA General Confab", 1 October 2024, https://www.pnri.

reviewed the development of the country's nuclear infrastructure, noting significant progress in addressing recommendations and the adoption of a national position for a nuclear energy programme.[17]

Though a relative latecomer, Vietnam passed its Law on Atomic Energy in 2008 and quickly moved to put in place plans to build two nuclear power plants in 2011— Ninh Thuan 1 and Ninh Thuan 2. Planned with Russian and Japanese support, respectively, these were to be operationalized between 2020 and 2027 but were put on hold in 2016 in favour of less-costly natural gas and coal. In late 2021, the Vietnamese government indicated that these plans could resume with the building of a ten megawatt nuclear research reactor with Russia's help[18] as a new step and major milestone for restarting Vietnam's nuclear energy programme.[19] In 2024, Vietnam's ministry of trade and industry said that it would formulate a proposal for developing nuclear power for the sake of energy security and economic growth.[20] Vietnam's National Assembly passed a resolution to restart the Ninh Thuan nuclear power project as part of the country's commitment to ensure energy security and to achieve its net-zero targets by 2050.[21]

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dost.gov.ph/index.php/2-uncategorised/817-nuclear-energy-milestones-in-ph-reported-at-the-iaea-general-confab.

[17] IAEA, "IAEA Reviews Progress of the Philippines' Nuclear Infrastructure Development", 6 December 2024, https://www.iaea.org/newscenter/pressreleases/iaea-reviews-progress-of-the-philippines-nuclear-infrastructure-development.

[18] Tomoya Onishi. "Vietnam Poised to Resume Nuclear Project a Decade After Fukushima", *Nikkei Asia*, 19 December 2021, https://asia.nikkei.com/Economy/Vietnam-poised-to-resume-nuclear-project-a-decade-after-Fukushima.

[19] Ibid.

[20] Khanh Vu, "Vietnam Weighs Resuming Nuclear Power Development Plans", Reuters, 13 September 2024, https://www.reuters.com/world/asia-pacific/vietnam-consider-nuclear-power-development-govt-office-document-2024-09-13/.

[21] *The Star*, "Vietnam Resumes Nuclear Power Project", n.d., https://www.thestar.com.my/business/business-news/2024/12/12/vietnam-resumes-nuclear-power-project.

Thailand, Malaysia and Indonesia had plans to open their first nuclear power plants by 2020. Post-Fukushima, many of these plans were put on hold. Thailand shelved its plans indefinitely after the 2011 Fukushima accident, and its Power Development Plan issued in 2018 no longer contained any reference to nuclear energy in the country's energy mix.[22] But as recently as May 2024, former Thai PM Srettha Thavisin said that Thailand was exploring small modular reactor technology.[23] Thailand's Energy Regulatory Commission was set to commence the examination of a legal framework for an SMR project starting in December 2024.[24]

The Pakatan Harapan government in 2018 announced that Malaysia had decided not to use nuclear power, which resulted in the shutdown of its nuclear programme. But in January 2022, Malaysia began to re-explore nuclear power development as part of its energy strategy, citing the need to diversify from fossil fuels and to meet escalating electricity demand.[25] More recently, a media report in December 2024 stated that Malaysia was preparing to incorporate nuclear energy into its energy mix after 2035, with the country seeking to achieve its target of net-zero carbon emissions by 2050.[26]

Indonesia accelerated its original plans of operationalizing nuclear power plants in 2039 forward to 2032, as stated in its national zero carbon

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[22] Office of Atoms for Peace, Ministry of Higher Education, Science, Research and Innovation, Thailand, "National Report of Thailand on the Convention on Nuclear Safety: The 8th Review Meeting", August 2019, https://www.iaea.org/sites/default/files/national_report_of_thailand_for_the_8th_review_meeting.pdf.

[23] *The Straits Times*, "Thailand Exploring Small Modular Nuclear Reactor Technology, Says PM", 31 May 2024, https://www.straitstimes.com/asia/se-asia/thailand-exploring-small-modular-nuclear-reactor-technology-says-pm.

[24] Yuthana Praiwan, "Regulator Prepares for Nuclear Energy", *Bangkok Post*, 15 November 2024, https://www.bangkokpost.com/business/general/2902478/regulator-prepares-for-nuclear-energy.

[25] Julia Abdul Karim, "Exploring the Potential Development of SMR Technology in Malaysia", Malaysian Nuclear Agency, n.d., https://nucleus.iaea.org/sites/INPRO/df22/Day%201/Asia/2.Malaysia.pdf.

[26] Shannon Teoh, "Malaysia Readies Itself for Nuclear Power After 2035", *The Straits Times*, 20 December 2024, https://www.straitstimes.com/asia/se-asia/malaysia-readies-itself-for-nuclear-power-after-2035.

Table 2: Update on IAEA Milestones of Southeast Asian Countries

Country	Milestone Phase	Last INIR mission	Timeline/Targets
Indonesia	Phase 1 moving to Phase 2	November 2009[a]	Operational NPPs by 2032, with 250–300 MW using SMRs
Philippines	Phase 1 moving to Phase 2	December 2024[b]	Operational NPP by 2032
Malaysia	Phase 1	October 2016[c]	Beginning to re-explore nuclear energy with SMRs in view
Thailand	Phase 1	December 2010[d]	Shelved plans
Vietnam	Early to Phase 1	November 2014[e]	

Sources: (a) Suparman Bambang Suprawoto, "Evaluation on the Status of Indonesia Nuclear Infrastructure Development", IAEA, n.d., https://www-pub.iaea.org/MTCD/publications/PDF/P1500_CD_Web/htm/pdf/topic1/1S08_B.%20Suprawoto.pdf; (b) IAEA, "IAEA Reviews Progress of the Philippines' Nuclear Infrastructure Development", 6 December 2024, https://www.iaea.org/newscenter/pressreleases/iaea-reviews-progress-of-the-philippines-nuclear-infrastructure-development; (c) IAEA, "IAEA Reviews Malaysia's Nuclear Power Infrastructure Development", 18 October 2016, https://www.iaea.org/newscenter/pressreleases/iaea-reviews-malaysias-nuclear-power-infrastructure-development; (d) IAEA, "Country Nuclear Power Profiles, 2015 Edition: Thailand (Updated 2015)", https://www-pub.iaea.org/MTCD/publications/PDF/CNPP2015_CD/countryprofiles/Thailand/Thailand.htm; (e) IAEA, "IAEA Reviews Vietnam's Nuclear Power Infrastructure Development", 18 November 2014, https://www.iaea.org/newscenter/news/iaea-reviews-vietnams-progress-nuclear-power-development.

emission road map and its 2033 National Electricity General Plan, which states that nuclear power can be included by 2033.[27] It was reported in December 2024 that Indonesia had set a new target to establish its first nuclear power plant in 2032, which would have a capacity of between 250 and 300 megawatts using SMRs.[28] Indonesia's Energy Council also proposed twenty-nine possible sites for the construction of nuclear power plants in December 2024.[29] This is part of Indonesia's plans to achieve its 100 gigawatt electricity target, in which nuclear energy is expected to contribute 5.3 gigawatts.[30]

PROSPECTS OF SMALL MODULAR REACTORS IN SOUTHEAST ASIA

The IAEA has projected global nuclear power capacity to reach 950 gigawatts by 2050, which will result in an expansion of 2.5 times from current levels.[31] The growth will be driven mainly by the advent of SMRs,

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[27] Nuclear Business Platform, "Indonesia Targets Commercial Operation of Nuclear Power Plants by 2032", 19 June 2024, https://www.nuclearbusiness-platform.com/media/insights/indonesia-targets-commercial-operation-of-nuclear-power-plants-by-2032; *Business Indonesia*, "Nuclear Power Included in Indonesia's 2033 Electricity Generation Plan", 11 July 2024, https://business-indonesia.org/news/nuclear-power-included-in-indonesia-s-2033-electricity-generation-plan#:~:text=The%20Indonesian%20government%20has%20officially,To%20COP%2D29%20in%20Jakarta.

[28] Renold Rinaldi, "BRIN: Preparation Underway on Indonesia's First Nuclear Power Plant", *Indonesia Business Post*, 13 December 2024, https://indonesiabusinesspost.com/insider/brin-preparation-underway-on-indonesias-first-nuclear-power-plant/.

[29] World Nuclear Association, "Nuclear Power in Indonesia", updated 25 April 2025, https://world-nuclear.org/information-library/country-profiles/countries-g-n/nuclear-power-in-indonesia.

[30] Julian Isaac, "Indonesia Advances Nuclear Power Plans, Targets 5.3 GW Contribution by 2032", *Indonesia Business* Post, 11 December 2024, https://indonesiabusinesspost.com/risks-opportunities/indonesia-advances-nuclear-power-plans-targets-5-3-gw-contribution-by-2032/.

[31] IAEA, "IAEA Outlook for Nuclear Power Increases for Fourth Straight Year, Adding to Global Momentum for Nuclear Expansion", *International Atomic*

which offer flexible power generation, enhanced safety and improved security, as well as having a wider range of civilian applications. According to the IAEA, an SMR is classified as a nuclear reactor that has an equivalent electricity output of less than 300 megawatts.[32]

As the countries of Southeast Asia (other than the Philippines) have no experience in constructing or operating conventional nuclear power plants, the deployment of SMRs will be a good introduction to the adoption of nuclear energy that will enable the region to scale up its capacity thereafter. Although some countries in the region have nuclear research reactors, different skill sets will be required when it comes to the operation of nuclear power plants. For example, regulatory bodies will need to adopt different levels of safety parameters such as emergency planning zones. Plant operators will need to be competent in operating the plant, and frontline agencies will need to be trained to respond to a nuclear emergency. SMRs, which are classified as having output capacities of less than 300 megawatts, will be less disruptive for the electricity grids of many Southeast Asian countries. Hence, the adoption of SMRs will be a good lead-in for states newly embarking on nuclear energy.

In terms of economic attractiveness, an SMR has a lower upfront cost compared with a conventional large nuclear power reactor, thus lowering the financial commitments for Southeast Asia to enter the nuclear energy market. Vietnam has recently revived its nuclear option after it halted its plans in 2016, then citing financial constraints as the primary reason to not build large nuclear power plants in the Ninh Tuan region.[33] The Philippines—while pending an assessment by Korean Hydro and Nuclear

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Energy Agency News, September 2024, https://www.iaea.org/newscenter/pressreleases/iaea-outlook-for-nuclear-power-increases-for-fourth-straight-year-adding-to-global-momentum-for-nuclear-expansion.

[32] IAEA, "Small Modular Reactors", n.d., https://www.iaea.org/topics/small-modular-reactors.

[33] H. Huong, "Ninh Thuan Nuclear Power Project Revived After Eight Years", *Saigon Times*, December 2024, https://english.thesaigontimes.vn/ninh-thuan-nuclear-power-project-revived-after-eight-years/.

Power Co. to rehabilitate the Bataan Nuclear Power Plant,[34] which has never been operated—is also considering the SMR option[35] because of the archipelagic constraints on the structure of its national electricity grid.

Indonesia, which has the largest and most advanced nuclear infrastructure in the region, considers the future of the nuclear industry as being dominated by SMRs and advanced Generation IV reactors.[36] In Singapore, the lack of territorial space for solar power has led the country to consider the SMR option as a source of clean and stable energy.[37]

Only two SMRs are currently operational. The first is the Akademik Lomonosov, which is an SMR placed on a floating barge and that has been operating in the remote Arctic town of Pevek in Russia since 2020.[38] The second is the HTR-PM, an advanced generation IV SMR utilizing TRISO pebble-bed fuels that became fully operational in Shidao Bay Nuclear Power Plant, China, in 2022.[39] Interest in SMRs is not constrained to state-level deployments. Major companies such as Google

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[34] "Korea to Assess Rehabilitation of Philippine Plant", *World Nuclear News*, October 2024, https://www.world-nuclear-news.org/articles/korea-to-assess-rehabilitation-of-philippine-plant.

[35] *The Straits Times*, "US Firm Plans to Build Small Nuclear Power Plants in the Philippines", November 2024, https://www.straitstimes.com/asia/se-asia/us-firm-plans-to-build-small-nuclear-power-plants-in-the-philippines.

[36] S. Varadhan, "Indonesia in Talks with US, Russia for Nuclear Power Technology", Reuters, November 2024, https://www.reuters.com/business/energy/indonesia-talks-with-us-russia-nuclear-power-technology-2024-11-29/#:~:text=Indonesia%20is%20in%20talks%20with%20the%20United%20States,Indonesian%20government%20deputy%20minister%20told%20Reuters%20on%20Friday.

[37] T. Zalizan and D. Lau, "Explainer: Why Singapore Is Exploring Nuclear Energy and What Needs to Happen Before Plans Get Underway", *TODAY*, updated May 2024, https://www.todayonline.com/singapore/explainer-singapore-nuclear-energy-plans-process-2387196.

[38] C. Peachey, "Akademik Lomonosov Begins Commercial Operation", *Nuclear Engineering International*, May 2020, https://www.neimagazine.com/news/akademik-lomonosov-begins-commercial-operation-7938482/.

[39] T. Honney, "China's HTR-PM Demonstration Project Enters Commercial Operation", *Nuclear Engineering International*, December 2023, https://

and Amazon have announced plans to purchase nuclear energy generated by SMRs to power their data centres.[40] This is despite the US Nuclear Regulatory Commission having only approved one SMR design licence so far.[41] The need for low-carbon electricity is compelling private sector interest in SMR adoption.

Although generally covered by existing normative frameworks governing nuclear energy such as the IAEA, there are currently no international regulations addressing specific issues related to the governance and deployment of these novel SMRs.[42] The IAEA calls for a focus on the regulatory framework necessary for the deployment of SMRs, recognizing that traditional nuclear regulations for large-scale reactors are not aligned with the unique characteristics of SMRs.[43] For example, international guidelines must be streamlined between the IMO and the IAEA for transportable nuclear power plants—such as the Akademik Lomonosov—to transit through international waters. For generation IV SMRs like the HTR-PM, the IAEA would need to develop feasible safeguard protocols before the SMRs can be exported and operated in any Non-Nuclear Weapons States of the Non-Proliferation Treaty, which all ASEAN member states are party to. The IAEA has launched the Nuclear Harmonisation and Standardisation Initiative to accelerate the process for policymakers and regulators as well as

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www.neimagazine.com/news/chinas-htr-pm-demonstration-project-enters-commercial-operation-11354820/.

[40] D. Chernicoff and M. Vincent, "Google and Amazon Make Major Inroads with SMRs to Bring Nuclear Energy to Data Centers", *Data Center Frontier*, October 2024, https://www.datacenterfrontier.com/energy/article/55235902/google-and-amazon-make-major-inroads-with-smrs-to-bring-nuclear-energy-to-data-centers.

[41] "Amazon.com Joins Push for Nuclear Power to Meet Data Center Demand", CNA, October 2024, https://www.channelnewsasia.com/business/amazoncom-joins-push-nuclear-power-meet-data-center-demand-4682751.

[42] Cheong and Nivedita, "Enhancing Transboundary", pp. 151–54.

[43] IAEA, "Small Modular Reactors: Advances in SMR Developments 2024", presented at IAEA International Conference on Small Modular Reactors and their Applications, 21–25 October 2024, https://www-pub.iaea.org/MTCD/Publications/PDF/p15790-PUB9062_web.pdf.

vendors and operators in deploying SMRs.[44] An up-to-date international governance framework to support the deployment of SMR technology will require greater cooperation and collaboration, but progress in addressing key governance issues so far has been slow, albeit the first SMRs have already been deployed in China and Russia.[45]

Uncertainties surrounding the economic viability of SMRs[46] and the need for a global market directly affect the speed of catch-up of international regulations and guidelines for SMRs, thus contributing to a vicious cycle on the restriction of SMRs being licensed and manufactured.[47] Many of the advanced SMRs are still at the design stage. While vendors will be marketing their potential roll-out, many will not make it to the eventual production stages owing to the high entry barrier of international regulations. With the slow rate of SMRs making it onto the market, Southeast Asia will be handicapped in investing in and building capacities for potential advanced reactor technologies. This is on top of other issues such as supply chain maturity, available financing, and bankability of nuclear projects, which are not unique to Southeast Asia but that will affect the attractiveness of SMR deployment.

NUCLEAR COOPERATION AT THE ASEAN-LEVEL

The Treaty of the Southeast Asia Nuclear Weapon-Free Zone (SEANWFZ Treaty, also called the Bangkok Treaty) explicitly recognizes the right

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[44] IAEA, "IAEA Initiative Advances Efforts to Support the Safe, Secure Deployment of SMRs", *International Atomic Energy Agency News*, June 2023, https://www.iaea.org/newscenter/news/iaea-initiative-advances-efforts-to-support-the-safe-secure-deployment-of-smrs.

[45] Cheong and Nivedita, "Enhancing Transboundary", p. 153.

[46] V. Nian, "The Prospects of Small Modular Reactors in Southeast Asia", *Progress in Nuclear Energy* 98 (2017): 3.

[47] Helen Cook, "Legal and Regulatory Solutions to Facilitate SMR Deployment", presented in a CIL Webinar, "A Multi-Pronged Approach Towards SMR Regulation", 28 July 2021, https://cil.nus.edu.sg/wp-content/uploads/2021/08/Helen-Cook-28.7.2021.pdf.

of member states to use nuclear energy for peaceful purposes, while expressing a strong commitment to maintaining a nuclear weapon-free zone in the region.[48] In doing so, the treaty also requires states to adhere to rigorous safety and security standards in line with the IAEA and other international bodies. In 2007, ASEAN leaders committed "to forge ASEAN-wide cooperation to establish a regional nuclear safety regime".[49] Starting at a technical level, a Nuclear Energy Cooperation Sub-Sector Network (NEC-SSN) was established under the ASEAN Ministerial Meeting on Energy track in 2010 to foster cooperation on the use of nuclear energy for power generation purposes. The NEC-SSN provided a platform for energy officials to discuss nuclear safety and security-related issues. Subsequently, an ASEAN Network of Regulatory Bodies on Atomic Energy (ASEANTOM) was set up in 2012 to enhance regulatory activities and strengthen nuclear safety, security and safeguards within ASEAN. The ASEANTOM reports to the political-security track of ASEAN, unlike the NEC-SSN, which reports through the economic track, thus elevating the importance of nuclear energy as an issue within ASEAN. The ASEANTOM developed the ASEAN Protocol for Preparedness and Response to a Nuclear or Radiological Emergency[50]—a useful arrangement to enhance existing emergency arrangements. In 2017, these efforts were supplemented by a new ASEAN Network on Nuclear Power Safety Research (NPSR), which was initiated by Thailand to gather ASEAN researchers in the field of nuclear power safety "in order to contribute to regional capacity building, and help gain

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[48] ASEAN Secretariat, "Southeast Asia Nuclear Weapon-Free-Zone (SEANFWZ)", n.d., https://asean.org/our-communities/asean-political-security-community/peaceful-secure-and-stable-region/southeast-asia-nuclear-weapon-free-zone-seanwfz/.

[49] ASEAN Secretariat, "ASEAN Declaration on Environmental Sustainability", 13 June 2012, https://asean.org/asean-declaration-on-environmental-sustainability/.

[50] ASEANTOM, "ASEAN Protocol for Preparedness and Response to a Nuclear or Radiological Emergency", n.d., https://asean.org/wp-content/uploads/2023/08/ASEAN-Protocol-on-EPR-.pdf.

public trust toward nuclear power safety in all ASEAN countries".[51] The NPSR promotes research collaboration, knowledge and information sharing, and it provides assessments of benchmark problems.

These are laudable early efforts, but progress towards a regional nuclear safety regime remains slow. ASEAN's cooperation on nuclear energy has been framed by commitment to the international nuclear safety and security governance regimes. In the absence of specific regulations on newer technology like SMRs, it is timely for the region to accelerate nuclear energy discussions. Southeast Asia's growing interest in nuclear power must be accompanied by robust and close coordination in addressing issues of governance, transparency and accountability. The different drivers of nuclear interest—increased demand because of population and economic growth, protection against future volatility in oil prices and supply, and the need to mitigate greenhouse gas emissions—will likely continue propelling discussions of the deploying nuclear power generation. The question is whether ASEAN can create an enabling environment and keep pace with emerging developments in nuclear cooperation.

REGIONAL PUBLIC OPINION TOWARDS NUCLEAR ENERGY

Political determination and technological advancements aside, public acceptance and support is another important aspect in the development of nuclear energy in a country. Public concerns about safety and the environment have historically proven to be a sensitive subject. Although support for nuclear energy remains low among the general population in Southeast Asia, the attitude of the public appears to be changing.

The ISEAS – Yusof Ishak Institute's 2024 Southeast Asia Climate Outlook Survey showed support for nuclear energy in Southeast Asia

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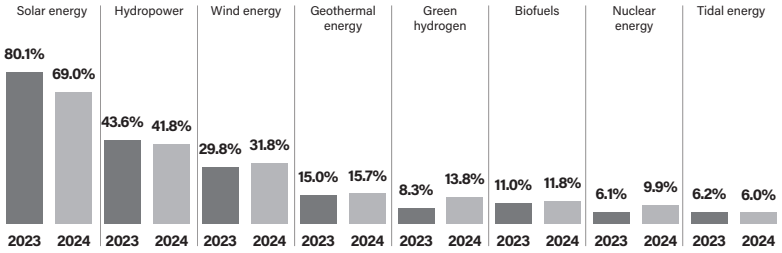
[51] Phiriyatorn Suwanmala, "Exploring and Promoting the Peaceful Use of Nuclear Technology", presented at the 11th ASEAN Regional Forum Inter-Sessional Meeting on Non-Proliferation and Disarmament, 8–9 April 2018, https://aseanregionalforum.asean.org/wp-content/uploads/2019/08/Annex-7-Agenda-2_Thailand_TINT-Presentation.pdf.

increasing, albeit that support remains low in the context of alternative clean energy choices. Over 2,900 respondents from ten ASEAN countries participated in the survey. They were asked, "In your view, which sources of clean energy have the greatest potential in your country (Select your top two choices)?" They were then asked to select two choices among the eight clean energy options presented—namely, solar energy, hydropower, wind energy, green hydrogen, biofuels, geothermal energy, nuclear energy and tidal energy.

Figure 1 shows how regional support for nuclear energy increased from 6.1 per cent to 9.9 per cent between 2023 and 2024. Meanwhile, Table 3 shows a clear trend in terms of support by city type. Respondents from metropolitan areas are significantly more supportive of nuclear energy, at 68 per cent compared with the main profile (57.9 per cent). A possible explanation for this trend is that residents of metropolitan areas have higher energy demands and appreciate the importance of reliable, large-scale power sources. They are also more likely to be familiar with advanced energy technologies and large infrastructure projects. In contrast, the population in smaller cities may be more concerned about the safety risks associated with living near potential nuclear plants, or they may have experienced environmental justice issues, which can influence their perceptions of nuclear energy.

Table 4 shows that acceptance of nuclear energy has increased across ASEAN countries since 2022 when this question was first included in

Figure 1: Support for Various Clean Energy Types in ASEAN



Source: Sharon Seah et al., *Southeast Asia Climate Outlook: 2024 Survey Report* (ISEAS – Yusof Ishak Institute, 2024)

Table 3: Support for Nuclear Energy by City Type

City type (residing within the region)	Main sample (%)	Those who chose nuclear (%)
Metropolitan	57.9	68.0
Mid-size	17.1	14.9
Town	17.3	11.7
Rural	7.7	5.4

Source: Survey data collected for Sharon Seah et al., *Southeast Asia Climate Outlook: 2024 Survey Report* (ISEAS – Yusof Ishak Institute, 2024).

the survey, with the exception of Brunei. The countries with the highest level of support in 2024 were Singapore (20.3 per cent), the Philippines (17.6 per cent), Thailand (12.5 per cent), and Vietnam (10.3 per cent); support increased between two- and fourfold during this period. Fifth-ranked Cambodia witnessed the most remarkable growth in support, from 0.5 per cent in 2022 to 10.2 per cent in 2024. Support in Malaysia increased from 2.6 per cent in 2022 to 6.4 per cent in 2024, while support in Indonesia nearly doubled from 3.3 per cent to 6.4 per cent during the same period.

While there has been an increase in acceptance of its use, the level of support remains low in the context of other clean energy options. An earlier in-depth survey published in 2021 provides further context for the low level of support for nuclear energy compared with other forms of clean energy.[52] Based on surveys conducted in 2018 across five Southeast Asian countries—Indonesia, Malaysia, Singapore, Thailand and Vietnam—the authors concluded that, in addition to scientific knowledge, the public relies on value predispositions such as trust in various stakeholders, as well as an individual's own perceptions of risks and benefits, as key perceptual filters to interpret the relationship

[52] Shirley S. Ho and Agnes S.F. Chuah, "Why Support Nuclear Energy? The Roles of Citizen Knowledge, Trust, Media Use, and Perceptions Across Five Southeast Asia Countries", *Energy Research and Social Science* 70 (September 2021), https://www.sciencedirect.com/science/article/abs/pii/S2214629621002486.

Table 4: Support for Nuclear Energy by Country

Country	2022 (%) (Ranked 7/8)	2023 (%) (Ranked 8/8)	2024 (%) (Ranked 7/8)
Brunei	2.5	4.4	1
Cambodia	0.5	5.5	10.2
Indonesia	3.3	4.7	6.4
Lao PDR	3.0	4.4	6.3
Malaysia	2.6	5.0	6.4
Myanmar	0.0	8.4	8.2
The Philippines	7.7	8.5	17.6
Singapore	10.7	14.7	20.3
Thailand	3.0	7.2	12.5
Vietnam	5.6	5.7	10.3

Source: Sharon Seah et al., *Southeast Asia Climate Outlook: 2024 Survey Report* (ISEAS – Yusof Ishak Institute, 2024).

between their knowledge about nuclear power and their support for nuclear energy. This means that governments in Southeast Asia must engage their populations more in addressing issues of trust and risk perception. They must also recognize that public attitudes are shaped by socio-emotional factors rather than scientific facts alone as they seek to build public confidence towards nuclear energy.[53]

CONCLUSION

The plans of ASEAN member countries to tap into civilian nuclear energy have gone through a few decades of starts and stops. In line with the global revival of plans for nuclear energy, ASEAN countries are likewise making renewed effort in reassessing the role of nuclear energy in their domestic energy mix as part of their quest towards energy

[53] Ibid.

security and sustainability. The move to develop nuclear energy entails adhering to the standards of the international nuclear regime, the creation of national institutions, the establishment of relevant legal and regulatory frameworks, and building up technical expertise, as well as public acceptance and stakeholder engagement.

Southeast Asian countries today are looking to SMRs as part of their nuclear energy plans. Their deployment will, to a large extent, depend on external factors, such the pace of commercial developments in the countries where the technologies are developed, as well as the setting up of an international regulatory framework with feasible safeguard protocols in place for SMR export. Although there is growing acceptance for the use of nuclear energy, support levels are still relatively low compared with those for other clean energy sources. ASEAN governments will need to increase and improve their efforts at public outreach to build trust and gain public support for their energy programmes.

The creation of a robust regional nuclear safety regime, harmonized with international rules and regulations, will augment the existing governance frameworks and afford the region greater confidence as countries progress in their plans to deploy new SMR technology.

Appendix: Nuclear Cooperation of ASEAN Countries with External Partners

Country	Year	Partnership Description
Brunei Darussalam		No MoUs, but it has national projects with the IAEA
Cambodia	2015	MoU signed between the NCSD and ROSATOM on cooperation in the use of atomic energy for peaceful purposes
	2016	Signed two MoUs with Russia to create the Nuclear Science and Technology Centre; there is also a joint Cambodia-Russia working group on the peaceful uses of atomic energy
	2016	Signed an MoU with China (under the China National Nuclear Corporation in implementing One Belt One Road)
	2021	Signed an MoU with the Russian Atomic Energy Corporation (ROSATOM) and China National Nuclear Corporation to boost cooperation on nuclear energy and nuclear technology in industry, agriculture, food safety, medicine, etc; has set up an information centre backed by China to raise public awareness on nuclear power
Indonesia	2006	PLN-KEPCO agreement on "Promotion of Nuclear Power Plant in Indonesia"
	2015	Signed an MoU with ROSATOM on partnership in research and exchange of learning
	2022	Signed an MoU with the United States on developing SMRs
	2023	Memorandum of Agreement, grants and contracts with the United States to assess a proposed nuclear power plant in West Kalimantan
Laos	2016	Signed memorandum of cooperation with ROSATOM
	2017	Signed road map with ROSATOM on cooperation in peaceful uses of atomic energy to study possibility of nuclear power projects
Malaysia	2009	TNB-Korea Electric Power Corporation agreement for a preliminary feasibility study of a Nuclear Power Programme in Malaysia
	2022	Memorandum of Cooperation between the MEMR of the Republic of Indonesia and the METI of Japan on the Energy Sector – includes cooperation on nuclear energy

Myanmar	2015	MoU on Cooperation in the Field of the Use of Nuclear Energy for Peaceful Purposes
	2022	MoU in the field of shaping positive public opinion on nuclear energy
	2023	MoU with Russia on nuclear infrastructure development in Myanmar
Philippines	1969	Agreement on the Peaceful Use of Nuclear Energy
	1983	Nuclear Cooperation Agreement with Canada
	2017	Signed two nuclear cooperation agreements with ROSATOM
	2019	DOE-ROSATOM agreement to assess feasibility of a small nuclear power plant
	2022	MoU with the United States on developing the Philippines' nuclear energy programme
	2023	123 Agreement with the United States
	2024	Agreement with South Korea to assess feasibility of constructing a nuclear energy facility
Singapore	2000	MoU on the Third Country Training Programme (TCTP) with the IAEA
	2015	Enhanced Singapore-IAEA TCTP MoU
	2015	Signed MoU to cooperate on training and education in nuclear safety with IRSN of France
	2024	123 Agreement with the United States
	2024	MoU with Emirates Nuclear Energy Company of the UAE
Thailand	2010	Signed MoU with China on nuclear cooperation
	2010	EGAT-Japan Atomic Power Co agreement on building nuclear power plants (information sharing)
	2014	Thailand Institute of Nuclear Technology-ROSATOM nuclear cooperation agreement
	2017	Agreement with China to cooperate on peaceful uses of nuclear energy
	2025	Draft MoU between the Ministry of Higher Education, Science, Research and Innovation and the National Atomic Energy Organisation of China on Cooperation in the Peaceful Utilisation of Nuclear Technology

Vietnam	1986	Intergovernmental agreement with India for nuclear energy cooperation
	1996	Signed nuclear cooperation agreement with Korea
	2000	Signed nuclear cooperation agreement with China
	2001	Signed nuclear cooperation agreement with Argentina
	2002	Signed nuclear cooperation agreement with Russia
	2006	MoU with Korea for nuclear cooperation
	2008	VARANS signed a cooperation agreement with the US Nuclear Regulatory Commission to share technical info on nuclear energy and regulations, environmental impact and safety (renewed in 2013)
	2009	Signed nuclear cooperation agreement with France
	2010	Signed an MoU with the United States in 2010 for increased cooperation in the peaceful use of nuclear energy, including fuel service arrangements
	2010	Intergovernmental agreement for Atomstroyexport to build Ninh Thuan 1 nuclear power plant
	2010	Intergovernmental agreement with Japan to build Ninh Thuan 2 nuclear power plant
	2011	MoU between EVN and JINED for design, construction and operation of the plant
	2011	Agreement with Russia for up to $9 billion in finance to build Ninh Thuan 1 and $500 million loan for establishing the Centre for Nuclear Energy Science & Technology (CNEST)
	2012	Nuclear cooperation agreement with South Korea on nuclear power plant construction to be used as a basis for future projects, with a joint preliminary feasibility study conducted
	2014	Signed the 123 Agreement
	2016	Signed agreement with France on cooperation in training nuclear energy human resources
	2016	Signed MoU with India on civil nuclear energy cooperation, followed by another in 2018

Source: Authors' compilation.

ISSN 0219-3213

ISEAS
PUBLISHING

30 Heng Mui Keng Terrace
Singapore 119614
http://bookshop.iseas.edu.sg

TRS14/25s

ISBN 978-981-5306-85-9