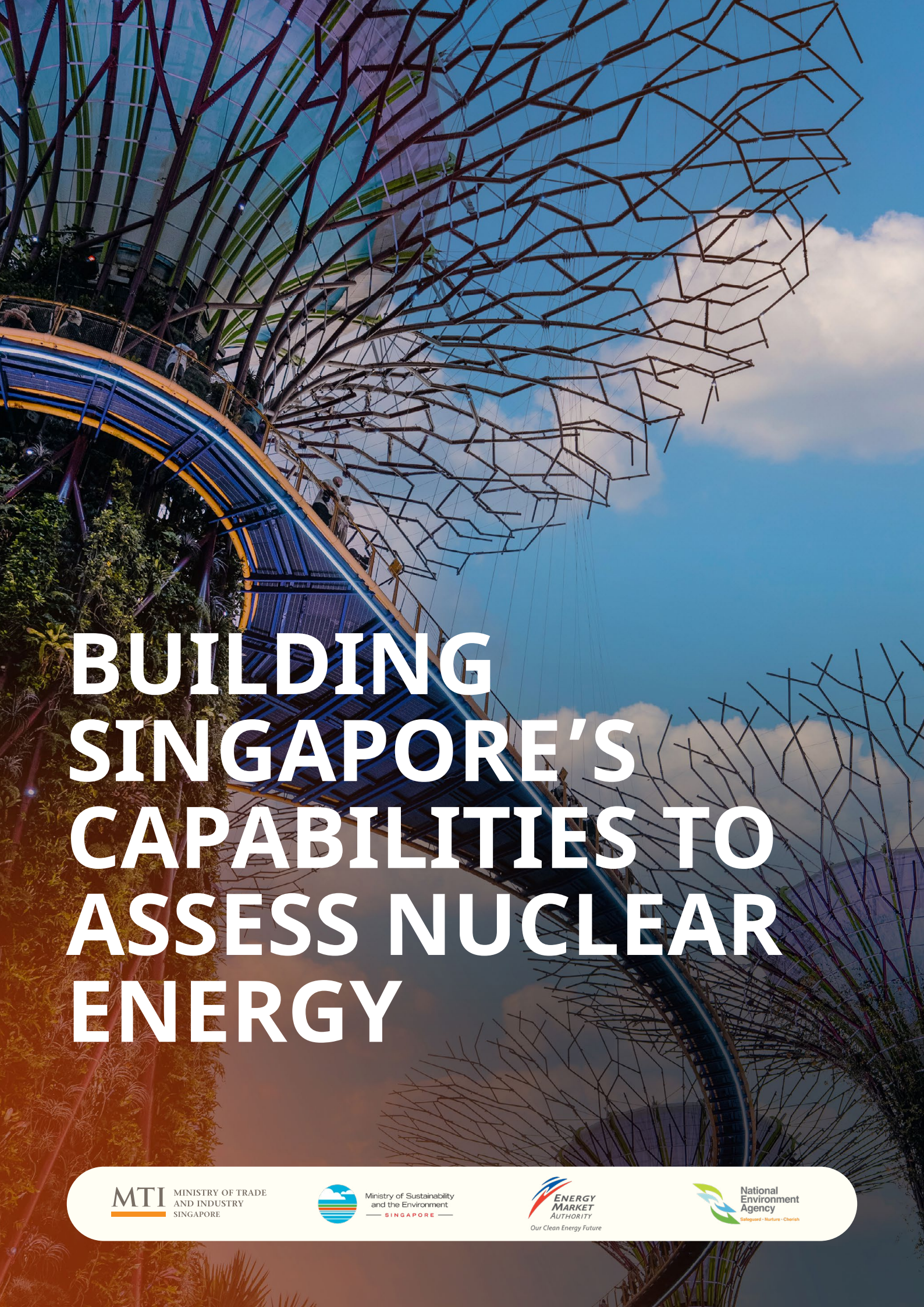


BUILDING SINGAPORE'S CAPABILITIES TO ASSESS NUCLEAR ENERGY

MTI MINISTRY OF TRADE AND INDUSTRY SINGAPORE
Ministry of Sustainability and the Environment SINGAPORE
ENERGY MARKET AUTHORITY Our Clean Energy Future
National Environment Agency Safeguard · Nurture · Cherish

ENERGY IS ESSENTIAL TO OUR EVERYDAY LIFE

Energy powers our infrastructure, drives our industries, lights our homes and streets, and keeps our smartphones running. Like many other countries, Singapore's demand for energy will keep rising in the years ahead.

As a renewable energy disadvantaged small city-state, we must push ahead with efforts to develop viable sources of clean energy that are safe, secure and affordable.

"A generation ago, our critical constraint was water. Today, we face a different challenge... expanding access to clean energy is therefore a major national imperative."

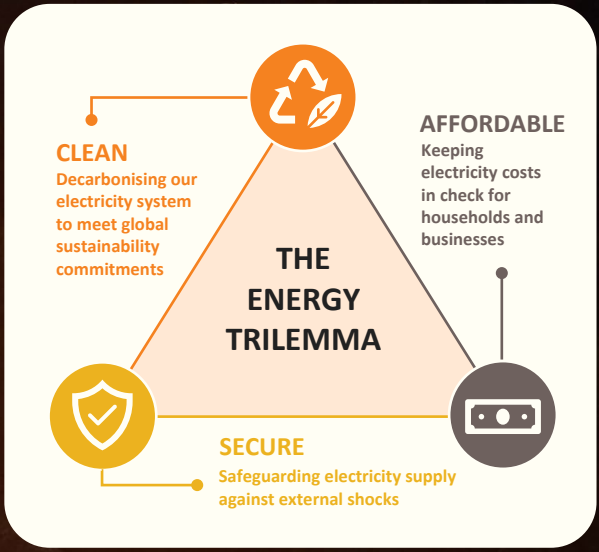
– Prime Minister and Minister for Finance Lawrence Wong, Budget 2025

OUR ENERGY STORY

Singapore does not have the natural attributes, resources or land[1] to deploy renewable energy solutions such as hydropower or wind energy at scale. Even covering all possible spaces with solar panels would only meet up to 10% of our needs.

The Energy Trilemma

In planning our energy mix, Singapore must strike the right balance across three objectives, collectively known as the "Energy Trilemma".



Singapore is pursuing these energy pathways to diversify our options:

Solar energy deployments have reached over 1.7 GWp despite our space constraints, making us one of the most solar-dense cities in the world.

Regional Grids allow us to increase our supply of clean electricity through imports while catalysing new energy investments in the region.

Low-Carbon Alternatives could allow us to generate clean electricity domestically. Some potential options include hydrogen, geothermal, and advanced nuclear energy.

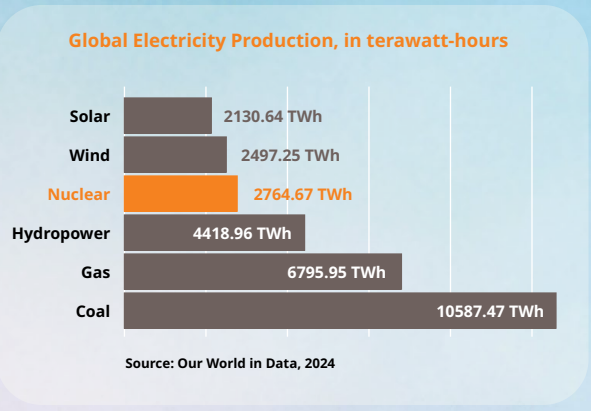
Natural Gas makes up 95% of our energy mix today. It will continue to underpin our energy security as we scale up clean energy deployment.

WHY IS SINGAPORE CONSIDERING NUCLEAR ENERGY?

Nuclear energy has the potential to help Singapore address the energy trilemma.

- **Secure:**
  Supply chains are mature and nuclear fuel can be efficiently and safely stored. This allows nuclear energy to serve as a domestic source of energy that is resilient to shocks to the global market.
- **Affordable:**
  The cost of nuclear energy could potentially be comparable to other energy pathways such as natural gas and solar[2].
- **Clean:**
  Generating nuclear energy does not produce greenhouse gases, hence serving as a stable source of clean electricity.

Nuclear power plants have been in operation since the 1950s, and supply 10% of the world's electricity needs today. There are over 400 operational nuclear power plants, with several new projects in the pipeline across Asia, Europe, America and Africa.



In 2012[3], the Singapore government conducted a Pre-Feasibility Study on Nuclear Energy. While the study concluded that nuclear power plants of the time were not suited for a small and densely populated city-state like ours, it recommended that Singapore continue to monitor the progress of new nuclear energy technologies.

Since then, Singapore has continued to strengthen its capabilities to assess nuclear energy.

"Nothing is off the table. We continue to keep our options open to all kinds of low-carbon energy, including, of course, nuclear energy."

– Minister-in-charge of Energy and Science & Technology, Dr Tan See Leng

IS NUCLEAR ENERGY SAFE?

Nuclear power has lower rates of deaths and accidents compared to many other energy sources[4].

However, the high-profile accidents at Fukushima and Chernobyl have created a worry that nuclear technology is unsafe.

While both events were caused by a combination of poor planning, inadequate human response and flawed designs, the potential for radioactivity is still a major concern that must be addressed as part of any decision on nuclear energy.

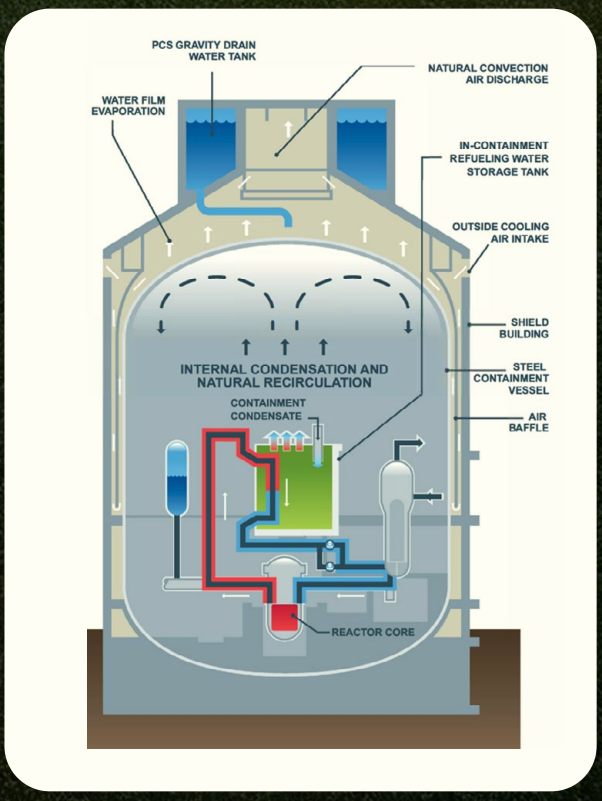
Safety by Design

Newer nuclear reactor designs have evolved alongside regulation to take on board lessons learnt from past incidents, significantly reducing the risks and impact of accidents.

Traditionally, nuclear power plants have required human intervention and the availability of electricity to maintain safety, e.g. human-operated electric pumps that circulate coolant to remove heat from the reactor core.

Many newer reactors now adopt improved safety systems which use natural forces such as gravity and air circulation to keep the reactor cool.

These systems work automatically without the need for human intervention or electricity, and are therefore more reliable in an emergency.



Source: Westinghouse

Example of a nuclear plant incorporating safety features such as a gravity driven water tank and natural recirculation for reactor cooling.

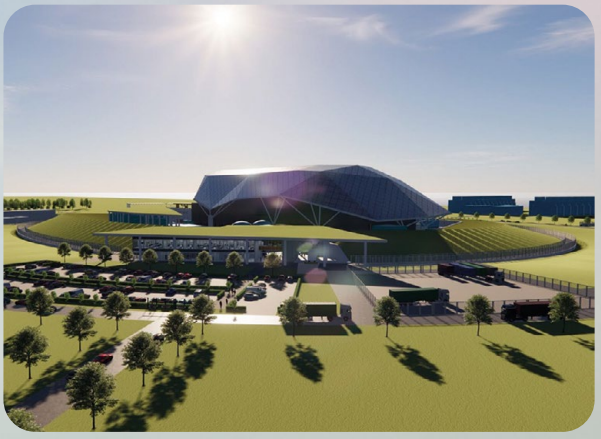
A NEW GENERATION OF NUCLEAR REACTORS

As nuclear reactor technologies evolve, Small Modular Reactors (SMRs) and "Generation IV" (Gen IV) reactors could be even safer than many of the plants operating today. SMRs are designed to be smaller and modular compared to traditional nuclear reactors, which present unique benefits:

- **Small:**
  Significantly smaller power output (one-third or less of the capacity of traditional nuclear reactors). This makes it easier to incorporate improved safety systems into the reactor. Each reactor holds less radioactive material, which reduces the potential impact of an incident within the reactor.

- **Modular:**
  Each reactor can be built in factories as a standardised module, which could cut costs, improve quality, and reduce on-site construction times. The total power output of an SMR plant can be increased by adding more modules, while remaining safer than a conventional plant of equivalent power output. This is because each module has independent safety systems, reducing the risks of large-scale accidents.

- **Integrated:**
  Some SMRs build important parts, like cooling systems and steam generators, directly into the main reactor vessel. This makes the system more resistant to large breakages, making the reactor sturdier, easier to manage, and control.



Source: Rolls-Royce

One unit of the Rolls-Royce SMR (470MWe) could fit within an area of 21,500m² – the equivalent of three football fields.

SMRs and Gen IV reactors also incorporate features that further enhance their safety and efficiency. This includes using new types of fuel that are contained within coatings that can withstand the maximum temperature reactors might reach during an accident. In this way, radioactive material cannot escape into the environment.

WHY SHOULD WE STUDY NUCLEAR ENERGY NOW?

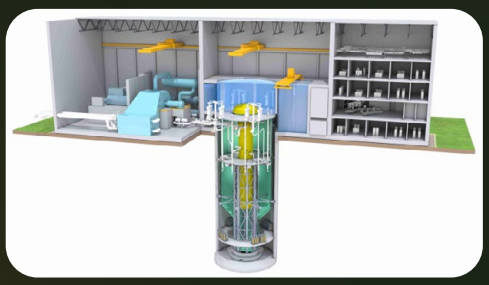
In recent years, many SMRs are moving from concept to implementation[5]. The OECD Nuclear Energy Agency has identified 127 SMR designs globally, nearly half of which are already being reviewed by regulators for potential deployment.

Some of these reactors are slated to start producing power on a commercial basis within this decade.

The US Nuclear Regulatory Commission has issued standard design approval for NuScale's VOYGR SMR, while the Canadian Nuclear Safety Commission (CNSC) has issued a power reactor construction license for Ontario Power Generation to build a unit of GE Vernova Hitachi's BWRX-300 SMR in Darlington. In China, the first Gen IV reactor (HTR-PM) entered commercial operation in 2023.

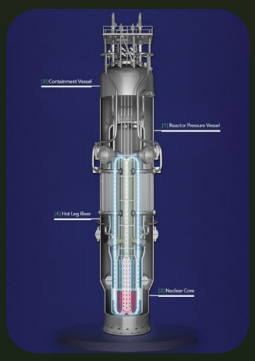
Many global corporations such as Amazon, Google, and Meta are now actively considering nuclear energy as an option to meet their energy needs and sustainability goals. They have signed contracts with nuclear energy companies to build plants to supply electricity to their data centres.

Examples of Advanced Nuclear Reactors Today



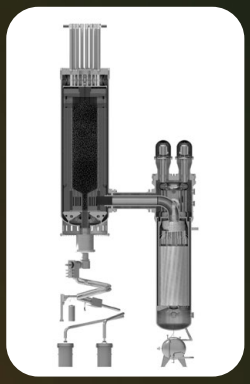
Source: GE Vernova

The BWRX-300 SMR is under construction in Canada with more deployments planned in the US, Poland and Sweden.



Source: NuScale

NuScale's VOYGR SMR received standard design approval from the US Nuclear Regulatory Commission in May 2025.



Source: X-energy

Amazon is partnering X-Energy to bring more than 5GW of new Gen IV reactor capacity to the US by 2039.

Source: Tsinghua

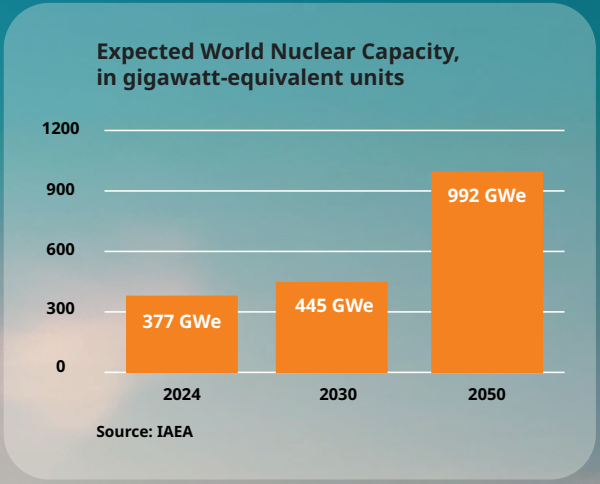
The HTR-PM is a High Temperature Gas-Cooled Reactor and the first Gen IV reactor to enter commercial operation in China in 2023.

THE GLOBAL NUCLEAR ENERGY LANDSCAPE

Spurred by technological developments, an increase in energy demand, and a desire to decarbonise in the face of climate change, more countries have decided to start or restart their nuclear energy programmes[6]:

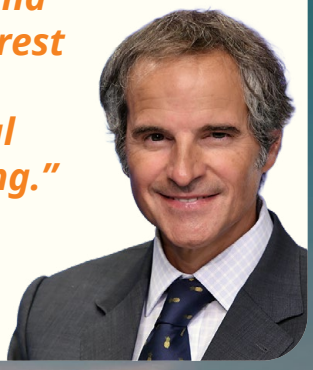
- **Expansion of fleets:**
  During the 2023 United Nations Climate Change Conference, 31 countries including the US, China, France and Canada signed a declaration to triple global nuclear energy capacity by 2050.
- **Reassessments of policy:**
  Countries like Switzerland and Belgium are in the midst of reviewing their bans on new nuclear plants, while Japan has been assessing whether to build its first reactors since the Fukushima nuclear accident in 2011.
- **Interest in Southeast Asia:**
  While no country in Southeast Asia has deployed nuclear energy yet, many of our neighbours are actively exploring the potential of nuclear energy.

  Indonesia and Vietnam have announced plans to build nuclear plants by the 2030s, while Malaysia and Thailand have expressed interest in new nuclear technologies[7].



"Momentum is building, and ASEAN's interest in nuclear energy is real and promising."

– International Atomic Energy Agency (IAEA) Director-General Rafael Grossi



WHAT DOES THIS MEAN FOR SINGAPORE?

We will build the capabilities to objectively and scientifically assess whether the latest nuclear technologies could be suitable for deployment in Singapore.

SMRs and Gen IV reactor technologies are promising, but have not yet been deployed at a commercial scale. We will need to have the expertise to assess these technologies, and will work closely with world-leading partners on this journey.

We will further develop our nuclear safety and radiation protection capabilities to prepare for the possibility of nuclear power deployment by other countries in the region.

It is important for Singapore to understand the types of nuclear technologies that our neighbours may adopt, and to develop the operational capabilities to detect, respond to and protect our people should the unlikely event of an incident at a regional nuclear power plant take place.

RADIATION-READY FOR OVER 50 YEARS

Singapore has been working to keep citizens safe from excessive radiation exposure since 1972, when the Radiation Protection Inspectorate was established to provide radiation protection and environmental monitoring services with support from the IAEA.

The uses of radiation in our daily lives have grown, whether it is through X-ray machines, microwave ovens or other industrial processes. Since 2007, the National Environmental Agency has been responsible for controlling radioactive material and certain radiation-emitting equipment to minimize any potential impact on workers and the public.

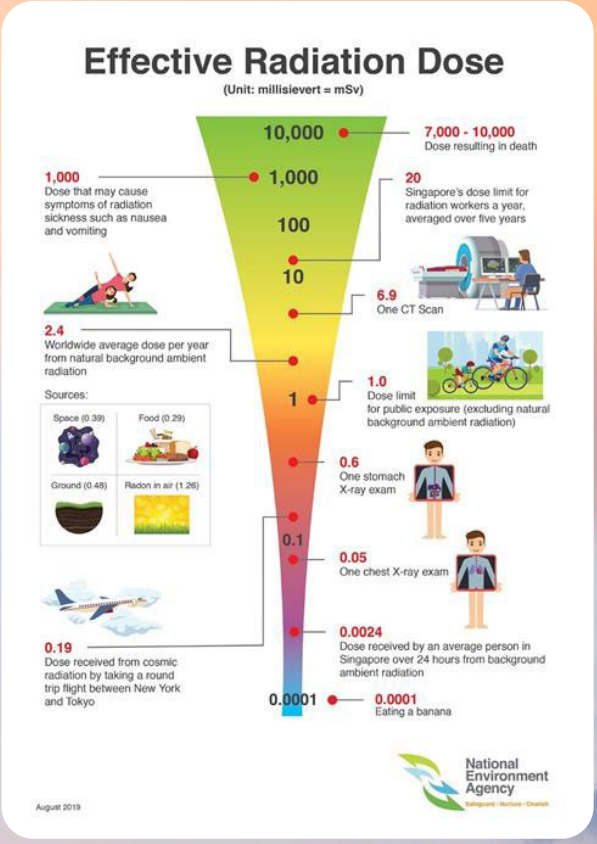
Radiation safety is a shared regional responsibility. NEA has developed a 40-sensor network to detect and respond to radiological events, supporting broader Southeast Asian safety and preparedness efforts[8].

NEA is also working with ASEAN countries to set up a regional Early Warning Radiation Monitoring Network, which allows for near real-time information exchange between countries' monitoring networks.

Did you know?

Radiation may sound scary and dangerous, but there are many sources of radiation around us all the time – the soil, cosmic rays from the sun and space, and even some foods are naturally radioactive.

A typical person living near an operating nuclear power plant will receive an average radiation dosage of around 0.001 millisieverts in a year, which is 2% of the radiation from a chest X-ray, or the equivalent of eating 10 bananas[9].



Source: NEA

Various levels of radiation that you may encounter in your everyday life.

SETTING HIGH STANDARDS FOR NUCLEAR SAFETY AND REGULATION

Nuclear Safety

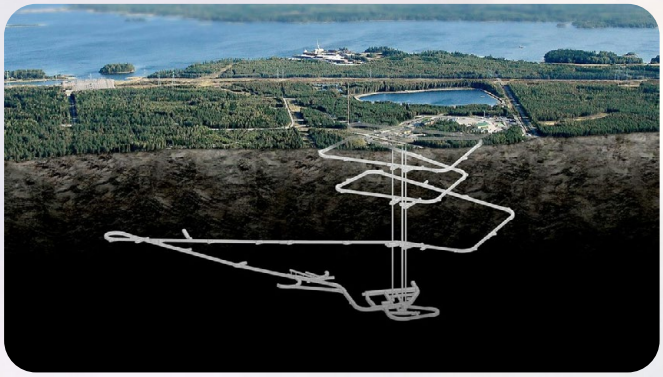
Source: NEA

Singapore took part in the Multilateral Exercise on Nuclear Security Detection in July 2025, alongside Malaysia (host), Indonesia and Thailand.

NEA formed a Nuclear Safety Advisory Panel in February 2025 to guide and strengthen Singapore's capability building in the areas of nuclear safety, security and safeguards. The panel includes distinguished international experts and is chaired by Professor Laurence Williams, formerly Her Majesty's Chief Inspector of Nuclear Installations in the UK.

Regionally, we are collaborating closely with ASEAN countries to build capabilities and establish robust standards in nuclear governance, as part of the ASEAN Network of Regulatory Bodies on Atomic Energy (ASEANTOM) and through bilateral agreements.

Regulation and Waste Management



Source: Posiva

Finland is conducting site tests at Onkalo, the first long-term disposal facility for spent nuclear fuel. Onkalo is a Deep Geological Repository which stores waste underground to prevent environmental contamination.

NEA has expanded its partnerships with regulators such as the French Authority for Nuclear Safety and Radiation Protection (ASNR), Finnish Radiation and Nuclear Safety Authority (STUK) and US Nuclear Regulatory Commission (NRC).

NEA has also consulted experts at the Swedish Nuclear Fuel and Waste Management Company to understand how to safely process, store and dispose radioactive and nuclear waste.

Emergency Planning and Response

Singapore has a national response plan for responding to nuclear emergencies similar to the Fukushima Daiichi accident. The plan was reviewed by an IAEA Expert Mission in 2018[10]. Singapore has since developed response plans for other potential radiological and nuclear incidents.

Singapore is also working with our neighbours to enhance emergency response coordination and cooperation, and has established an 'ASEAN Protocol for Preparedness and Response to a Nuclear or Radiological Emergency'.

GROWING NUCLEAR RESEARCH AND EDUCATION

The Singapore Nuclear Research and Safety Initiative (SNRSI) was established in the National University of Singapore in 2014, to build capabilities in nuclear safety, science and engineering[11].

In July 2025, SNRSI was upgraded to a full institute with a new building to accommodate its growing pool of researchers.

The Institute will broaden and deepen its scope of research to cover other critical aspects of nuclear safety, such as developing a nuclear reactor simulator and new methods to rapidly detect radionuclides in different types of samples.

SNRSI now has a strong base of around 50 researchers studying various aspects of nuclear science, such as radiochemistry, radiobiology and nuclear safety analysis. SNRSI offers post-graduate scholarships to attract, develop and sustain a community of nuclear experts in Singapore. SNRSI also collaborates closely with international partners in its research, and has established a joint laboratory with the French regulator ASNR to undertake research in radiobiology, radiochemical measurements and reactor safety analysis for SMRs.

Beyond nuclear research, SNRSI will develop new capabilities in nuclear policy and provide dedicated facilities to enhance public education to build up awareness of nuclear energy. SNRSI's efforts include laboratory visits and supporting educational activities such as the National Science Challenge.

Source: NEA

SNRSI aims to grow a pool of 100 nuclear experts specializing in reactor safety, radionuclide dispersion and radiobiology by 2030.

Source: MOE

SNRSI led a team of students for the International Nuclear Science Olympiad in Malaysia, 2025. Singapore won 4 Gold medals at the event and achieved the highest score in the competition.

STUDYING POTENTIAL DEPLOYMENT IN SINGAPORE

Singapore is building our capabilities in line with the IAEA's Milestones Approach[12], which helps countries understand the requirements for deploying nuclear energy. This ensures that any future decision is taken in line with global standards on nuclear safety, security and safeguards.

First, we are evaluating the safety features, technological maturity, and commercial readiness of advanced nuclear technologies like Gen IV reactors and SMRs.

The Energy Market Authority (EMA) appointed Mott Macdonald, a leading British engineering, development and management consultancy firm in September 2025, to support this effort.

Source: IAEA

The IAEA Milestones Approach identifies 19 key issues that any country should consider when deciding whether to deploy nuclear energy.

Second, we are strengthening collaborations with international partners to learn from their experiences. This includes international agreements such as the US-Singapore 123 Agreement and Singapore-France Cooperation Agreement for the Development of Peaceful Uses of Nuclear Energy, and an MOU with the UAE's Emirates Nuclear Energy Corporation.

Source: X/@SecBlinken

Singapore signed the 123 Agreement with the United States in July 2024.

Third, we are speaking to companies and countries with capabilities in advanced nuclear technologies to better understand the latest developments. EMA has an ongoing Cooperative R&D Agreement with the Sandia National Laboratory, a recognised global expert on nuclear energy.

We will work with countries and companies that can support our capability-building efforts, in line with our international obligations and commitment to safety.

HAS SINGAPORE DECIDED TO DEPLOY NUCLEAR ENERGY?

Singapore has not made any decision on deployment. However, we are seriously studying the potential for domestic nuclear energy deployment because it is a clean energy source that enhances our energy security.

Any decision to deploy nuclear energy will take into account the safety, reliability, affordability, and environmental sustainability of the technology in Singapore's context.

We will continue our efforts to build up domestic capabilities, supported by international partners.

We will engage the public regularly on the latest developments in nuclear energy, to build an informed understanding of the benefits and risks surrounding nuclear energy.

REFERENCES AND RESOURCES

1. NCCS Website – Singapore's National Circumstances
2. International Energy Agency – Projected Costs of Generating Electricity
3. Singapore's 2012 Nuclear Energy Pre-Feasibility Study
4. OECD Report – Comparing Nuclear Accident Risks with those from other energy sources
5. International Energy Agency – The Path to a New Era for Nuclear Energy
6. International Atomic Energy Agency – Energy, Electricity and Nuclear Power Estimates
7. Southeast Asia Public Policy Institute - Framing a Nuclear-Powered Future for ASEAN
8. National Environment Agency – Environmental Radiation Monitoring
9. National Environment Agency – Understanding Radiation
10. IAEA – Singapore's 9th National Report on the implementation of obligations under the Convention of Nuclear Safety
11. Singapore Nuclear Research and Safety Institute
12. International Atomic Energy Agency – Milestones Approach

Version as at October 2025 – This publication may be updated periodically.

*All images used are for illustrative purposes only.