LOWY INSTITUTE
FOR INTERNATIONAL POLICY

APRIL 2008

ANALYSIS

ANDREW SYMON

Tel: (65) 6389 3980
andrew.symon@yahoo.com.sg

Nuclear Power in Southeast Asia: Implications for Australia and Non-Proliferation

Executive summary

Interest in nuclear power is rising in Southeast Asia. Indonesia is set to lead the way, followed by Vietnam, Thailand, and potentially the Philippines and Malaysia. But nuclear power development in the region faces questions about its economics and safety, as well as nuclear weapons non-proliferation. A key issue is whether countries will embark on sensitive segments of the fuel cycle. Approaches to help allay such concerns include international fuel supply mechanisms and the possibility of a co-operative approach to nuclear power development within ASEAN.

Southeast Asia's nuclear energy aspirations connect with Australia's role as a major world uranium supplier. Australia will also want to ensure that nuclear power in the region develops safely and in a context of international co-operation. This could involve using existing frameworks for technical assistance as well as greater attention in high-level regional forums such as the East Asia Summit.

LOWY INSTITUTE FOR
INTERNATIONAL POLICY
31 Bligh Street
Sydney NSW 2000
Tel: +61 2 8238 9000
Fax: +61 2 8238 9005
www.lowyinstitute.org

The Lowy Institute for International Policy is an independent international policy think tank based in Sydney, Australia. Its mandate ranges across all the dimensions of international policy debate in Australia — economic, political and strategic — and it is not limited to a particular geographic region. Its two core tasks are to:

- produce distinctive research and fresh policy options for Australia's international policy and to contribute to the wider international debate.

- promote discussion of Australia's role in the world by providing an accessible and high quality forum for discussion of Australian international relations through debates, seminars, lectures, dialogues and conferences.

Lowy Institute Analyses are short papers analysing recent international trends and events and their policy implications.

NUCLEAR POWER IN SOUTHEAST ASIA

Introduction

Nuclear power is emerging as an additional and significant energy source in Southeast Asia to meet very large increases in power supply required over the medium to longer term. Indonesia is set to lead the way with a first plant planned to be in operation by 2016/17 followed by Vietnam in 2020. These could be the precursors to a much greater commitment to nuclear power generation.

The main reason, as with elsewhere in the world, is the potential for nuclear to provide additional energy security in the face of fossil fuels' rising costs and possible supply restrictions in the longer term. Less pressing in the Southeast Asian context is nuclear power as a means of reducing greenhouse gas emission growth, but longer term that could well be an important factor.

Many questions and issues about nuclear power development face governments in the region. There are concerns about its economics, environmental impact and safety, and security implications in terms of weapons proliferation and terrorism. Indonesia and Vietnam, those countries most advanced in their plans, have acknowledged these concerns and have been strengthening their legal, management and human resources capabilities in preparation for nuclear power. But much more needs to be done by policy-makers and planners in the region. Certainly, there are signs of growing public fears about nuclear power that governments will have to address.

Nuclear energy development in Southeast Asia will touch directly on Australian interests in multiple ways. Australia has commercial and economic interests as a major world supplier of uranium oxide, the basis for nuclear fuel. However, Australia's interests extend well beyond this to environmental, safety and weapons proliferation and security matters.

Frameworks exist for Canberra to work with countries in the region to assist optimal development and help address Australian and regional concerns. These range from international and regional organisations and forums through to established bilateral mechanisms. The former includes, among others, the United Nations' Vienna-based International Atomic Energy Agency (IAEA) and the East Asia Summit. At the bilateral level there is a history of co-operation between Australian Government agencies and regional counterparts.

The key issue from a non-proliferation perspective is whether countries in Southeast Asia will embark on those sensitive segments of the nuclear fuel preparation and reprocessing cycle which give a country the potential to develop nuclear weapons. It needs to be underlined here that all Southeast Asian countries are parties to the Nuclear Non-Proliferation Treaty (NPT) and also have put in a place a regional Southeast Asian Nuclear Weapons Free Zone (SEANWFZ). They have generally established sound international standing in regards to their policies and actions on non-proliferation.

Initially, it is envisaged that nuclear fuel for power plants in Southeast Asia would be imported from existing processing facilities in Europe, the US or Canada. The first plants would almost certainly be developed under turnkey arrangements, where the leading

international nuclear plant supplier and operating companies, probably in partnership with local government agencies and utilities, would build and operate the plants, including providing fuel sourced from overseas and dealing with waste treatment. It would not be economical for a regional country to establish a complete fuel preparation and reprocessing capability for the initial scale of demand.

But successful development of the region's first nuclear plants by the end of the next decade would likely be a precursor to a much larger commitment to nuclear power. The question then will arise as to whether governments will think it desirable to have their own fuel preparation capabilities, including enrichment, on economic and fuel security grounds.

This Lowy Institute Analysis surveys the reasons and prospects for nuclear power plans and proposals in Southeast Asia. It looks at related economic, environmental/safety and proliferation/security issues, how developed are government institutional, legal and regulatory frameworks to address these, and how initial power plant projects will be implemented and managed. The question of whether there should be a consolidated ASEAN-wide approach to management of nuclear power development is considered. Australia's interests in nuclear power development in the region are then examined and the question of what role Australia might play to encourage and support the safest possible development is explored.[1]

Southeast Asia's plans and proposals

The region's first nuclear power plants are planned to be in operation towards the end of the next decade. Indonesia plans to have a first nuclear plant in operation by 2016/2017 and Vietnam by 2020. Both countries see these plants as the first of several. Thailand is also proposing a plant by 2020, subject to further study. The Philippines and Malaysia are also examining the option of commercial nuclear power plants. [See Table 1 in Annexure]

Nuclear power has only come to the fore as a firm option over the last three or four years, coinciding with the region's renewed economic vigour after recovering from the traumas of the 1997-98 financial crisis.

Aspirations for civilian nuclear power in the region are not new. They build on a 40-year history of scientific and medical nuclear research. The region's first small nuclear research reactors were established in the early 1960s in several countries – Indonesia, the Philippines, Thailand and the then South Vietnam – assisted by the US Atoms for Peace Program. National development of nuclear energy appealed to countries newly free from colonial rule as symbolic that they could be modern and technologically sophisticated states.

This early interest in the potential of nuclear power has been maintained, especially in Indonesia. By the mid 1990s, Indonesia advanced proposals for nuclear power generation, but these were abandoned in the wake of the 1997-98 crisis. Vietnam, too, has tentatively had nuclear power on the drawing boards for some years, but again it is only since 2004 that they have firmed up. In the Philippines an earlier push towards nuclear power was made with the construction of the 621 megawatts (MW) Bataan nuclear power

plant, but this was put into mothballs after the fall of Marcos in 1986 because of financial problems and safety concerns.[2]

Indonesia's planned initial tranche of 4,000 MW of nuclear generation would serve the main Java-Bali grid (which meets 75 percent of the country's electricity demand), where total capacity is projected to increase from 15,000 MW in 2006 to 59,000 in 2026 MW. The target is for nuclear power to contribute at least four percent of power output by 2026. In practice, if plans are realised, this would likely be of the order of seven percent, taking into account the high level of operation that would be expected from such baseload plants.

Under a 2006 Law on Nuclear Reactors, the project seems likely to be given to an independent power producer to build and operate, on one of three sites on the central north coast of Java, about 450 kilometres east of Jakarta. Plans are to call tenders in 2008 for two 1,000 MW units, Muria 1 and 2, leading to a decision in 2010 with construction starting soon after and commercial operation from 2016 and 2017. The government says reactors will be purchased from abroad and fuel would preferably be leased. Used fuel would be stored centrally in the medium term. Tenders for Muria units 3 and 4 are expected to be called for in 2016, for operation from 2023.[3]

Public anxieties about nuclear power are becoming more apparent. Galvanising these is the fact that the planned Muria plants are near Mount Muria, a dormant volcano, in an earthquake-prone zone. Protests against the plan have been held by several thousand local people in 2007 and early 2008. The provincial government has called for the plan to be postponed but the central government has been adamant that it will proceed.[4]

Indonesia's nuclear ambitions – and those elsewhere in the region – are the subject of much commercial interest by the world's leading nuclear equipment vendors and plant operators from France, Russia, the US, Japan, and South Korea. Corporate endeavours to gain positions in such new markets are often supported by diplomatic efforts by their respective governments.

In Indonesia's case, there has even been the suggestion of some sort of potential partnership with Iran, a country which is a major focus of international concern over its nuclear program and fears that Tehran is aiming for weapons capability. During a visit to Tehran by Indonesian President Susilo Bambang Yudhoyono in mid-March 2008, Iranian President Mahmoud Ahmadinejad said that Tehran was ready to help Jakarta in nuclear engineering as well as other areas, such as investment in Indonesian petroleum industries.

How likely is an Iran-Indonesia nexus in nuclear development? Certainly Indonesia has shown some sympathy for Iran. President Yudhoyono has urged the international community not to 'politicise' Iran's nuclear program and to permit Tehran to continue its program in co-operation with the IAEA. Indonesia was the only country on the UN Security Council to abstain from a recent UN resolution imposing a new round of sanctions against Iran, but the likelihood of a serious nuclear partnership between Iran and Indonesia remains small. Indonesia is a committed party to the NPT and the SEANWFZ treaty; would come under great pressure from the US and

others were it to pursue nuclear co-operation with Iran; and, in any case, has the option of choosing far more advanced and globally respectable partner states (such as Japan, South Korea or indeed Australia) in its nuclear development. Still, Iran's stated interest in Jakarta's nuclear power plans and Indonesia's position on Iran in the UN do point to the kind of potentially complex international political implications that could flow from civilian nuclear power development in Southeast Asia.[5]

Vietnam seems determined to establish civilian nuclear power plants. Hanoi wants to have 8,000 MW in operation by 2025 with a first plant in operation by 2020 in the central province of Ninh Thuan. Under the government's current power master plan, 48,700 MW of new generation capacity is to come on line between 2006 and 2015. A further 120,000 MW is planned for between 2016 and 2025. These are colossal numbers, especially when measured against the country's existing capacity of just 12,000 MW and many see them as ambit targets with the reality likely to be significantly less, although still a very large increase on present capacity. To ease public concerns over the plans, state power utility Electricity Vietnam, the Ministry of Industry and Trade and Vietnam Atomic Energy Commission (Vinatom) have held public exhibitions about nuclear energy and power generation in Hanoi, Ho Chi Minh City, Ninh Thuan and neighbouring Phu Yen. Regulatory frameworks are being fashioned. A law on nuclear energy is before the national legislature.[6]

Thailand is the most recent ASEAN country to announce its intention to pursue nuclear power. The Electricity Generating Authority of Thailand (Egat) has put forward the goal of 4,000 MW of nuclear capacity by 2020, to make a dent into the additional 30,000 MW projected as needed by 2021 on top of the present 26,000 MW capacity. The government plans to establish safety and regulatory infrastructure by 2014 and commissioned a three-year feasibility study early in 2008. The idea of nuclear power is likely though to galvanise vocal and influential public opposition.

The Philippines is considering reactivating the 621 MW Bataan nuclear power plant in Morong. In April 2007, the Philippine government made the final payment for the plant and the Philippines Department of Energy set up a project to study the development of nuclear energy, in the context of an overall energy plan for the country. In early 2008, Manila asked the IAEA to advise as to whether Bataan could economically and safely be operated, and to recommend a policy framework for nuclear power development in the country. The IAEA in turn has recommended that the government undertake an extensive feasibility study of a possible role for nuclear in the Philippines power system. [7]

Malaysia is also looking at the atomic power option, with an energy policy study including consideration of nuclear power to be completed before 2010. In mid-March 2008, the Malaysian state power utility, Tenaga Nasional (TNB) signed a preliminary agreement with its South Korean counterpart, Korean Electric Power (Kepco) to co-operate in the sale of Kepco's nuclear power technologies in the region and beyond, as well as other energy resources and electricity business segments. Kepco has strong expertise in nuclear power

generation, with a subsidiary operating more than 17,000 MW of nuclear plant. Possible nuclear business in Southeast Asia for Kepco could also incorporate Kepco's interest in the region as a major source of coal and natural gas. Potential nuclear deals in Indonesia, for example, could include Indonesian gas and coal fuel supply guarantees that would help secure Korean finance for Indonesian nuclear development. [8]

Elsewhere in the region, Myanmar's military junta is embarking on a small research reactor, to be built with Russian assistance – through Moscow's Federal Agency for Nuclear Energy, Rosatom – which it says would be in line with international standards and safeguards in place through the IAEA. Nevertheless, the announcement of the project has triggered all sorts of speculation as to where it could lead.[9]

Why nuclear power?

Nuclear power is being seen in Indonesia, Vietnam, and Thailand and possibly elsewhere in the region as part of the solution to meeting the need for very large increases in power generation capacity over the next two decades to fuel industrial and urban growth. Essentially, nuclear power is seen as a means of strengthening energy supply security (for electricity) and diversifying beyond reliance on fossil fuels. Much less of a driver in planning, at this stage, is concern over reducing greenhouse gas emissions and the threat of climate change. Of course, arguments for nuclear power can be made on the basis of its far lower output of carbon dioxide and other greenhouse gases.[10] But the reality in Southeast Asian states, which do not face mandatory emissions reduction targets under the present Kyoto accord to the UN Framework Convention on Climate Change, is that climate change concerns do not impact very much on power sector planning. The very large planned increases in coal-fired power generation in the region attest to this.

While much international attention is focused on the huge projections for China and India (both of which have ambitious nuclear power programs), the electricity needs of Southeast Asia over the next two to three decades are also very large when considered in aggregate and also when looking individually at the larger countries and economies. Meeting future power demand on this scale has enormous implications for fuel choice, finance and the environment. And even where ambitious projections are met, on a per capita basis Southeast Asian power production and consumption will still be low compared to current levels in OECD countries. Commensurate with this, Southeast Asia's contribution to greenhouse gas emission will also rise markedly in aggregate terms although on a per capita basis will still be low compared to, for example, Japan, the US, and Australia. [Tables 2 & 3]

As far as fuel choice is concerned, while Southeast Asia does have reasonably generous energy resources, these are not as abundant as popularly believed, especially taking into account demand growth. For example, the region has been a net oil importer for some years and this dependency is increasing. Southeast Asia does have significant natural gas reserves, although these are often distant from demand centres and this raises the challenge of pipeline supply infrastructure. Coal is fairly

abundant in Indonesian Kalimantan and Sumatra and also in northern Vietnam. Distance from main demand centres can also be an important factor in the economics of coal supply. These three main fuels – natural gas, coal and hydro – provide the energy for large baseload power generation plants. Natural gas is also used for mid-level and peaking plants; that is, plants providing for short-term increases in electricity output to meet increased demand levels at certain times of the day.

All these fuels, though, can have drawbacks in availability, price and environmental impact. In Southeast Asia, as elsewhere, rising prices of conventional fossil fuels make nuclear power more competitive, and from the point of view of combating global warming and reducing greenhouse gas emissions, nuclear power has the advantage of not producing carbon dioxide.

Natural gas is often seen as the best course, as gas-fired combined-cycle plants can operate efficiently and cleanly. The region has generous gas reserves, and there are enormous reserves of natural gas in Australia and the Middle East which could also be drawn upon. Liquefaction and shipping of gas to markets from these regions and also from within Southeast Asia itself to the main urban and industrial demand centres is one way to help meet future fuel demand for power, though it is an expensive option. Still, plans for LNG import development are underway in Singapore, Thailand (Bangkok region) the Philippines (Manila and Luzon) and Indonesia (Jakarta and Surabaya in Java).

But both the harnessing of domestic/regional gas resources and LNG import is stymied by the slow pace of development of domestic and regional pipeline supply infrastructure. As a result, there is increasing reliance on coal in power development planning for baseload generation, especially in Vietnam and Indonesia but also by Malaysia and Thailand – despite the strong public opposition to coal in Thailand. Hydropower is another option, especially in the greater Mekong region, but here there are fears of environmental damage and dislocation to local communities through poorly planned large-scale hydropower dams.

Alternative and non traditional energy sources, such as solar and biomass, while offering the prospect of useful supplementary power sources at the margins, cannot be alternatives to large baseload power generation. Unless there is a revolutionary reconfiguration of power supply and consumption systems and patterns, there seems no alternative to reliance on large baseload power generation.

Thus the constraints on, or objections to, the use of natural gas, coal and hydro give rise to arguments that nuclear energy is the only alternative. Its advocates say nuclear power plants can be cost competitive, with fuel supply based on uranium ore readily available internationally – although no known commercial reserves have been identified in Southeast Asia. In addition, they argue that advanced nuclear technology is safe.[11]

Issues, concerns and fears

Economics

The economics of nuclear power are not as simple as they may seem. While the fuel operating costs of a nuclear power plant are very low, compared with a gas or coal-fired

plant, the capital costs are high compared with coal and especially gas-fuelled plants. A 1,000 MW plant would cost something of the order of $US2.5 billion, and take much longer to build, especially compared to the construction period for a gas-fuelled plant. Nuclear power generation is a high capital and low fuel cost option. The fuel cost as a proportion of total output costs, that is, including non-fuel operations and maintenance costs and amortised constructions costs, is about 10-12 percent of total output costs. In comparison, the fuel component in coal combustion plants is about 25-30 percent and in gas combined cycle plants 60-65 percent. But this does not tell the whole story. The processes involved in preparing the final nuclear fuel rods from the initially-mined uranium oxide are also technologically challenging and expensive.

Nuclear fuel is almost entirely enriched uranium, although it is possible to draw on plutonium, which is a by-product of nuclear power generation, and views vary on the possible eventual use of naturally occurring thorium. Uranium is an abundant element found mineralised in many parts of the world and often in high ore quantities. Australia, Canada and Kazakhstan have the greatest resources and are the largest producers, followed by Niger, Namibia and South Africa. [Table 4] The absence of known commercial reserves of uranium in Southeast Asia may reflect a lack of exploration. There are, from an international perspective, plentiful reserves of uranium ore that can be drawn on to meet any realistic regional demand projections. But there may be short-term shortages of supply because of delay in bringing new mines into production. Concentrated uranium ore, uranium oxide or 'yellowcake' is sold under long-term contracts and on spot markets. Recent price increases have been influenced by the entrance of hedge funds into the market.

There is also what is known as secondary supply, that is, recycled uranium and plutonium from spent fuel and re-enriched tails from processing residues, stockpiles, and ex-military weapons grade uranium and plutonium. Secondary supply is currently very important with primary production from world uranium mines supplying only about 60 percent of the power utility demand. Ex-military material as a result of a US-Russian arms reduction agreement is especially significant. Over the coming decades, though, the role of secondary supply is expected by the industry to diminish markedly.

While the costs of mining uranium ore to produce uranium oxide concentrates are not high, plans for a nuclear generation industry must factor in the mid and final fuel preparation stages. Presently, the geographical disposition and industrial structure of preparatory fuel stages are concentrated in Europe (including Russia) and North America, with some capability also in Japan and China.

Once the uranium oxide (U_30_8) has been mined and concentrated, it must be converted to uranium hexafluoride (UF_6) for later enrichment. The international conversion industry is highly concentrated with four companies in Russia (Tenex), France (Areva), Canada (Cameco) and the US (Conerdyn) supplying more than 80 percent of the world's uranium conversion services. The uranium hexafluoride is then enriched, most commonly by use of gaseous centrifuges, to increase the proportion of the U-235 isotope in uranium

from its naturally occurring 0.7 percent to between three and five percent.

The same technology that is used for civilian purposes can be used for military ones, though weapons-grade enriched uranium needs to be at 90 percent or more U-235. But a much smaller tonnage of concentrate is needed to make a nuclear weapon compared with supporting a power plant. The minimum quantity of uranium ore concentrate as U_30_8 required for production of a nuclear weapon is around seven tonnes. By contrast, 200 tonnes of concentrate are required to operate a 1,000 MW nuclear power plant for one year. As with conversion, the enrichment market is also very concentrated, structured around a small number of suppliers in the US, Europe and Russia with Japan and China also having capabilities.

Finally, the enriched uranium is then fabricated and assembled into reactor fuel. UF_6 is transformed first to another oxide of uranium, UO_2. This powder is compressed into small pellets which are sintered and then ground into a precise shape and loaded into thin zirconium alloy or steel tubes to create fuel rods. The rods are bundled into fuel assemblies for insertion into the reactor. The fuel fabrication market is characterised by customisation, with the specification dependent upon reactor design and the fuel management strategy of each power utility, though there is a trend worldwide towards standardising around a small number of designs.

Currently three main suppliers provide approximately 80 percent of global fuel demand – France's Areva, BNFL Westinghouse (owned by Toshiba of Japan), and Global Nuclear Fuels (GE of the US, and Toshiba and Hitachi of Japan). Forecasts suggest that capacity significantly exceeds demand. Fuel fabricators are typically associated with reactor vendors who supply the initial core and in many cases refuel the reactor.[12]

How economical nuclear power is as an option for Southeast Asian countries will continue to be debated even as the first plants move ahead. Certainly, it would not make economic sense to engage in fuel preparation. There will be financing challenges. It would seem very unlikely that the World Bank and Asian Development Bank, major sources of infrastructure finance, would provide all the funds for nuclear power ahead of support for non-nuclear energy and other infrastructure. Meanwhile, governments and utilities themselves would still be hard-pressed to find funding on the scale needed for nuclear generation from other budgetary and revenue sources. That said, export-import credits could be expected from countries whose companies are employed to build and supply equipment for plants.

Safety and waste disposal

Opponents are wary of claims of the safety of nuclear power technology, especially in earthquake zones such as in Indonesia – although Japan, a country subject to earthquakes, has long had a large nuclear power industry. There is a powerful fear of the potential human and ecological cost of a serious nuclear plant accident if there were a significant radiation release as was the case in the 1986 Chernobyl disaster. Much of Southeast Asia is heavily populated, and areas where nuclear power plants are now planned or

contemplated may be densely settled, as in Central Java.

From an Australian perspective, in any worst-case scenario of a commercial nuclear reactor accident, then, as with natural disasters such as the December 2004 tsunami or the 2006 Central Java earthquake, Canberra would feel it necessary to provide emergency assistance. There would also be the question of radioactive fallout reaching Australia. But the industry argues that modern reactor technology is increasingly safe, with reactors built inside containment structures designed to stop radiation escaping to the outside environment in the event of an accident.[13]

Opponents may also question the nuclear industry's solution to the disposal of high-level radioactive waste by depositing it deep into the earth in geologically inert rocky structures. There is a consensus in the scientific world that the technical issues with high-grade waste disposal are largely resolved. The IAEA says that while no geological repository for high-level waste is yet in operation, repository projects in Finland, Sweden and US have advanced to a stage at which, technically speaking, decisions can be made to begin construction. [14]

Weapons proliferation and terrorism

With any proposed expansion of nuclear energy globally, nuclear weapons proliferation is a key concern that must be addressed. Today there are also fears of the possibility of nuclear weapons reaching the hands of terrorist groups. Proliferation of enrichment or reprocessing capability may make it easier for terrorist groups to obtain highly enriched uranium or plutonium which, in theory, might be used to make small and unsophisticated but nonetheless horrific bombs. Finally, there is the spectre of terrorist groups attacking or attempting to sabotage nuclear power plants. Questions about proliferation risks are examined in more detail presently.[15]

Fuel supply: enrich or import?

The key issue arguably for any government in Southeast Asia or elsewhere planning to establish a nuclear power generation segment is the question of fuel supply and whether the country should undertake all stages of fuel production, especially, as noted above, whether it should have the capability for uranium enrichment. The other capabilities – conversion and fabrication – are not strategically significant.

Arguments for national enrichment capacity rest on the idea of fuel supply security, independence from an otherwise concentrated industry with possibly monopolistic powers, perhaps the idea of eventually being able to export these services along with fabricated fuel, and finally national pride. In addition, of course, it is possible that some countries might see enrichment capability as a hedge to accelerate their ability to develop nuclear weapons were their strategic environment to deteriorate greatly; this is sometimes put forward as a factor in the recent interest in nuclear energy in some Arab states, given Iran's activities.

Set against these arguments are the capital costs of building such a technologically sophisticated industry segment and whether the economics of providing indigenously-made fuel for relatively

small nuclear power plant demand on an individual country basis make sense.

This economies-of-scale argument is one reason to argue for a centralised ASEAN fuel processing capability catering for all demand in the region. But even should aggregate ASEAN nuclear fuel demand be large, importing fuel could still be a better course. South Korea is one country with a large nuclear generation capacity that nonetheless imports fabricated fuel. While the uranium oxide is originally from Canada, Australia and other suppliers, it is processed and enriched in Europe and the US. Taiwan similarly has its fuel fabricated elsewhere. Japan too, despite the size of its nuclear generation segment, the second largest among major countries after France, is not self-sufficient in terms of fuel preparation, although it aims to be. Japan has been progressively developing a complete domestic nuclear fuel cycle industry, based on imported uranium. Yet most of its enrichment services are still imported.[16]

From the perspective of weapons proliferation, there is also a very strong case for importing enriched uranium. The danger of more and more countries having their own enrichment capability is that there is then a correspondingly greater risk of more countries having a head start in the ability to pursue nuclear weapons development.

Of course, the problems associated with fuel supply do not end with its preparation. There are also safety and proliferation concerns over waste storage as well as the treatment of spent fuel. (Plutonium produced as a by-product of nuclear fuel fission can also be used for nuclear weapons if it is separated by reprocessing – although the plutonium in spent fuel from the normal operation of a power reactor is not strictly weapons grade.)

International fuel supply mechanisms

Fuel issues are not, of course, limited to Southeast Asia. In response to the implications of expanded nuclear power generation, the IAEA, supported by various governments, encourages the import of fabricated fuel rods, including, potentially, from future facilities proposed to be built and managed internationally. A number of proposals for international management of the nuclear fuel cycle have been put forward in recent years, though none of them has yet gained a large measure of consensus support from the international community. In theory, however, fuel enrichment for Southeast Asian countries and other countries entering the nuclear energy club would be carried out under the auspices of the IAEA in a limited number of locations. The IAEA would then act as a guarantor for supply to power generation plants. Such a multilateral framework would also include treatment of spent fuel and common waste storage. The concept is not new but it has been given life again by the renewed enthusiasm for nuclear power.

The US is promoting a variation of this approach through its Global Nuclear Energy Partnership (GNEP) under which major Western and Japanese producers of nuclear fuel and reactor technology would undertake to provide other countries with reactors and fuel for the life of plants with the provision to take back spent fuel. The GNEP was put forward in February 2006. Since then the GNEP concept

has been developed and further countries, including Australia, have become members beyond the initial partners, the US, Russia, China, France and Japan. There are now 21 members of the GNEP, although none from Southeast Asia. Australia became a member in September 2007; the Rudd Government is yet to present a clear sense of direction publicly on where it wants to take Australia's GNEP participation. There have also been various other proposals, calls and schemes for enrichment centres under international control, most recently, one presented to the IAEA by the German government in February 2008. [17]

Legal and regulatory conditions and safeguards

Plans for nuclear power generation in Southeast Asia are not beginning in an institutional and regulatory vacuum, though there may be questions as to the adequacy of the frameworks that now exist. These can be developed, strengthened and focused.

As far as broad trends of security and cooperation are concerned, there is the ASEAN tradition of consultation and cooperation as it has evolved for several decades, and in particular the 1976 Treaty of Amity and Cooperation in Southeast Asia in which all ASEAN member states commit themselves to peaceful settlement of disputes. More particularly, all Southeast Asian countries have ratified or acceded to the Nuclear Non-Proliferation Treaty (NPT). All except Brunei and Cambodia are members of the IAEA.

All ten ASEAN countries are signatories to the Southeast Asian Nuclear Weapons-Free Zone Treaty (SEANWFZ), the Treaty of Bangkok, which came into force in 1997. Importantly, the obligations under the Treaty go beyond the banning of nuclear weapons, but also cover the peaceful and safe use of nuclear energy and the disposal of radioactive material or waste. In July 2007, the commission set by the SEANWFZ treaty reviewed compliance with its provisions and adopted a plan to ensure continued compliance. Among other things this includes encouragement of ASEAN countries to sign and implement the complete array of UN treaties and conventions pertaining to nuclear energy and nuclear power.[18]

The Philippines, Indonesia and Cambodia are also parties to the UN Convention on the Physical Protection of Nuclear Material. Vietnam, Thailand, Indonesia, the Philippines, Myanmar and Singapore are signatories to the UN Convention on Early Notification of a Nuclear Accident. Indonesia and the Philippines are signatories to the UN Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.

Countries in the region are to various degrees, then, signatories to a range of international and regional treaties to do with nuclear energy, safety standards and non-proliferation as well as having relevant national laws and regulations in place and under development. But the picture is uneven in terms of coverage and implementation. [Table 5]

As Rodolfo Severino, a former ASEAN secretary-general, says:

> 'ASEAN should ensure that its other members accede at least to these

> conventions and ratify them. National laws and regulations on the peaceful uses of nuclear energy, particularly those on safety, should be open to ASEAN scrutiny. A regional early warning system and the formulation of emergency response teams have been proposed. ASEAN should constantly and intensively monitor compliance with the SEANWFZ treaty and the plan of action adopted in July [2007].'[19]

Implementation of initial nuclear power plans

The extent to which countries in Southeast Asia have the capabilities to implement, manage and operate nuclear power programs is open to debate. In the case of Indonesia and Vietnam, where plans for nuclear power are most advanced, both countries are considered by the IAEA to have done much in terms of development of institutional capabilities to develop, manage and operate a commercial nuclear power generation program.

What will help mitigate risks is the fact that the first nuclear plant projects will almost certainly be undertaken by experienced international companies on a full turnkey basis. Governments and state utilities will contract major international suppliers of nuclear generation technology and equipment to build and operate plant, including the supply fuel rods, and the management of nuclear waste. This would help enlist finance for the projects through government export-import credits and commercial funding.

France's state owned group, Areva, with a position in all segments of the nuclear power industry from mining to plant operation, and Westinghouse, have already signed contracts for projects in China on this basis. Such an approach goes some way to meeting economic, safety and security concerns. Already the major nuclear companies are positioning themselves to do business in Southeast Asia and are being supported in many cases by their home governments – Russia, France, the US, South Korea and Japan. Among other companies showing interest in nuclear in Southeast Asia is US equipment supplier, GE, and power utilities with nuclear power expertise, such as Electricité de France, South Korea's Kepco and Japan's Tokyo. In Vietnam, various Russian companies working with Rosatom are also seeking business. [20]

An ASEAN nuclear power authority?

Severino's comment underlines the argument that, given the various concerns discussed above, there should be a regional, co-operative approach to nuclear power development under the auspices of ASEAN. Southeast Asian countries and ASEAN could follow the example of the European Union, where there is a joint approach to the development and regulation of nuclear power under the 1957 European Atomic Energy Community (Euratom) Treaty. This is implemented and monitored through the European Commission.[21] Nuclear power generation in Southeast Asia might similarly be managed and regulated through an ASEAN nuclear power authority, which would seek to complement and support the role of the IAEA in adoption, implementation and monitoring of international standards and safeguards. Indeed, the idea of an 'Asiatom' was proposed by the

Philippines in the 1990s although it did not gain much attention then, when nuclear power seemed a very distant vision for most in the region.

Just how Southeast Asia might best go about nuclear power development has entered the ASEAN agenda. The question of how the thrust for nuclear power in the region should be best managed was prominent at the ASEAN leaders' summit in Singapore in late November 2007, and the associated meetings between ASEAN leaders and those of Japan, China and South Korea (ASEAN+3) as well as the East Asia Summit – the ASEAN+3 leaders along with those of India, Australia and New Zealand.

In what is known as the Singapore Declaration on Climate Change, Energy and the Environment, the East Asia Summit governments committed themselves to:

> 'co-operating for the development and use of civilian nuclear power, in a manner ensuring nuclear safety, security and non-proliferation, in particular its safeguards, within the framework of the International Atomic Energy Agency (IAEA), for those EAS participating countries which are interested.' [22]

Singapore is one country that is especially concerned about safety and the possibility of fallout from nuclear reactors in its neighbourhood. In August 2007, ASEAN Energy Ministers adopted in principle the Singapore proposal for an ASEAN Nuclear Energy Safety Sub-Sector Network to explore nuclear safety issues. Terms of reference and composition of the network are being determined by energy officials, who are to report to the next ministers' meeting later in 2008.[23]

From the point of view of electricity expansion planning in the region, an ASEAN approach to nuclear power plant development could also make good sense. Nuclear planning could mesh with other aspects of co-operative ASEAN energy programs, in particular efforts to foster cross-border electricity transmission, which could lead to eventual system integration between two or more countries, and the creation of common electricity markets. Given that the economics of nuclear power argue for very large generation capacity plants, the most efficient approach to development could be where planners can factor in markets for output in neighbouring countries as well as domestically.[24]

Another question in the context of a possible ASEAN approach to nuclear power development is whether there is merit in a role for an ASEAN body to manage a regional fuel preparation and enrichment centre.

How Southeast Asian governments go about nuclear development may become a real test of their ability to work together through ASEAN. ASEAN's prospects, many believe, have been bolstered by the ASEAN charter. The leaders signed the organisation's first and long-awaited charter in Singapore in November 2007. The charter, which still must be ratified by all the countries' domestic political processes, promises to give ASEAN more institutional strength.

Although the organisation is 40 years old, ASEAN has operated throughout this time on an almost informal basis, with members

seeking to advance interests through a slow, consensus approach. Many commitments and decisions by member countries are not legally binding. The charter seeks to make ASEAN a more rules-based organisation, strengthening the mechanisms for and improving the likelihood of compliance.[25]

If nuclear power development in Southeast Asia were co-ordinated and monitored under ASEAN, consistent with the international and regional agreements of member states, there would need to be penalties for non-compliance. Managing the development of nuclear power in Southeast Asia will thus be a barometer of the organisation's maturity and effectiveness. But in turn, the imperative of managing nuclear power development safely and economically may help catalyse a general strengthening of ASEAN.

Australian interests and policy

The development of nuclear power in Southeast Asia presents Australia with both concerns and opportunities. Australia certainly has an economic interest as a major world supplier of uranium oxide. But Australia's interests extend also to environmental, safety and proliferation matters.

These wider concerns have a direct bearing on uranium trade policy, as any country wishing to import Australian uranium must meet stringent safety and non-proliferation conditions. Australia also has a say on international standards and conditions as a member of the Nuclear Suppliers' Group (NSG), a 45-member body of fuel and technology producing and exporting countries.

But Australia cannot assume that as a major uranium oxide exporter this necessarily will give Canberra wider influence over how countries go about nuclear power development. Southeast Asian nuclear facilities will also have plenty of other fuel supply options. Aside from Canada and Australia, Kazahkstan is becoming an increasingly large producer of uranium oxide and is forecast by the Australian Bureau of Agriculture and Resource Economics (ABARE) to overtake Canada and Australia as the largest producer and exporter by 2013. [Table 4] Production in several African countries such as Niger, Namibia and South Africa is also projected to grow. Australian mining companies are among those active in uranium projects in these regions.

Aside from its application of uranium export conditions, Australia can also encourage and assist safe development and operation of nuclear power in Southeast Asia though international and regional organisations and established bilateral relationships. Globally, there are specialist nuclear energy organisations and frameworks, most prominently the International Atomic Energy Agency (IAEA), where Australia has enjoyed a semi-permanent seat on the board. Under the auspices of the IAEA, there is a Regional Co-operative Agreement for Research, Development and Training for the wider Asia-Pacific (including South Asia). Another avenue is the Forum for Nuclear Co-operation in Asia (FNCA), a body focussing on technical and scientific matters, established in 1999 through the Japan Atomic Energy Commission. Members include Bangladesh, China, Indonesia, South Korea, Malaysia, the Philippines, Thailand and Vietnam as well as Japan and Australia.

Another international nuclear framework that may prove to be important is the US initiated Global Nuclear Energy Partnership (GNEP), referred to earlier. The GNEP concept has continued to develop since 2006 and its membership has expanded, although there remain no members from Southeast Asia.

At the bilateral level there is a good history of bilateral co-operation between the Australian Government's Australian Safeguards and Non-Proliferation Office (ASNO), the Australian Nuclear Science and Technology Organisation (ANSTO), and the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) and counterpart government agencies in the region.

ASNO, for example, supports Australia's regional outreach on non-proliferation issues as one of the organisation's core business functions. Major goals include providing assurance that regional counterpart organisations are able to fulfil their obligations under the NPT and Convention on the Physical Protection of Nuclear Material (CPPNM). In the case of Indonesia, ASNO has a longstanding working relationship with its Indonesian counterpart BAPETEN and the Indonesian nuclear research agency BATAN in the area of safeguards development.[26]

Australia, through ASNO, has proposed strengthening Southeast Asian safeguards through a wider Asia-Pacific safeguards association and meetings between senior officials of ASNO and their counterparts elsewhere in the region. Australia has gained support for this concept through meetings of APEC energy ministers in 2006. The proposed association would support safeguards authorities in the region by: identifying training, professional development and related needs; co-ordinating bilateral and multilateral co-operation and assistance; facilitating joint projects; and providing a forum for exchange of views and sharing of experience. The association would contribute to capacity building in regional countries and promote the most effective co-operation between national safeguards authorities and IAEA safeguards. [27]

A role might also be possible for Australia's development assistance program administered through AusAID. There is, for example, a well-funded AusAID program, the Regional Economic Policy Support Facility, assisting policy research and formation at the ASEAN secretariat in Jakarta. If ASEAN considered it appropriate, this program could assist thinking on what role ASEAN might play in nuclear power development and whether there is a case for an ASEAN nuclear power authority as discussed above.

Australia, energy and the East Asia Summit

There do appear, then, to be good multinational and bilateral frameworks for addressing many of the scientific, technical and management concerns associated with nuclear energy development in Southeast Asia, such as capacity building, training and management, and safeguards design and implementation. An area of apparent weakness, however, is in forums and processes for high-level policy discussion between Australia and other regional governments about nuclear power and its implications. And given the wide-ranging environmental and security issues associated with nuclear power, diplomacy and policy discussion needs to encompass ministries beyond the narrow energy portfolio. On a

bilateral basis, there is some acknowledgement of the need to incorporate nuclear concerns into high-level discussions. The recently ratified Lombok Security Treaty between Australia and Indonesia affirms, among other things, the importance of co-operation in civilian nuclear energy.

On a regional basis, one framework that has much to offer as a means by which Australia can pursue policy objectives is the East Asia Summit (EAS). Established in 2005 as a forum for leaders of the 10 ASEAN countries, China, South Korea, Japan, India, Australia and New Zealand, the EAS has placed energy prominently on its agenda. Here nuclear power is identified as a key issue, as noted in the 2007 Singapore Declaration.

Uniquely bringing together India with the other major energy consuming countries in Asia, along with Australia, one of the region's most important energy suppliers, the EAS has the potential to develop as a mechanism and a caucus complementing and reinforcing international energy, nuclear power and environmental endeavours under the IAEA, as well as issues relating to greenhouse gas emissions under the UN Framework Convention on Climate Change. Under the EAS, there are plans for ongoing meetings of senior energy ministry officials and energy ministers.

Pressures will mount on Australia in the years ahead to co-ordinate its policies on nuclear energy and on climate change. Australia has embraced the case for urgent efforts to reduce greenhouse gas emissions globally, so has a strong interest in their success in Southeast Asia and elsewhere in Asia. The Asian region has the world's fastest growth in emissions, although from a low base. In the successor framework to the Kyoto Accord, which expires in 2012, the position of Southeast Asia, along with industrialising India and China, will need to be addressed. Under Kyoto they do not face any mandatory emissions targets. But what the situation will be post-2012 is a moot point.

Australia as a major energy supplier to the region – coal, liquefied natural gas and uranium oxide – has a clear commercial stake in the region's energy development. In the case of Southeast Asia, at present only a small volume of coal is exported, but in future this is likely to increase, along with first sales of LNG. Longer term, LNG exports to Southeast Asia could become very significant.

As far as greenhouse issues are concerned, if more obligations are placed internationally on Southeast Asian countries (and India and China) to reduce emissions growth, then nuclear power will come to be promoted more strongly as an option by their governments. Asian energy demand will be a core issue in international efforts to achieve a convergence between a post-Kyoto institutional and regulatory regime and multilateral efforts to provide for a safe expansion of nuclear power. This will be one of the critical international relations issues in the decades ahead, and will influence and be influenced by the decisions Australia takes on policies relating to climate change, uranium export and non-proliferation.

What should be Australia's explicit policy goals in promoting safe nuclear power development in Southeast Asia? Australia would want to see the region's nuclear development and operation carried out under the tightest standards and

controls. Here an objective would be to encourage countries to adopt the IAEA's Additional Protocol to strengthen international safeguards. The Additional Protocol gives the IAEA rights to additional information about and increased access to a country's nuclear programs and operations. For NPT non-nuclear weapons states wishing to import Australian uranium, this has been a pre-condition since 2005.[28] As noted above, accession to and implementation of the Additional Protocol in Southeast Asia is uneven. Indonesia is one country where it is in force. Australia would want to encourage its ratification and implementation comprehensively across the region.

There is a need for transparency about nuclear activities and plans in the region. Australia could initiate a regional forum, possibly through the EAS, for sharing plans and coordinating capacity building, and for considering issues such as fuel supply assurances, in exchange for refraining from acquiring the sensitive nuclear technologies of enrichment and reprocessing.

Australia's choices

The critical questions for Australian policy are whether Southeast Asian countries will want to have their own enrichment and reprocessing capabilities, and what Australia's position on this should be. As non-weapons state signatories to the NPT, Southeast Asian countries have a clear international legal right to undertake the complete nuclear fuel cycle if they wish, subject to IAEA guidelines and inspections. For the initial plants, this should not be an issue, as the economics of undertaking fuel preparation for one or two or even four reactors would not make sense. But longer term, if Southeast Asian nuclear power develops on a much larger scale, as it arguably could, then governments may want to have this capability, possibly in an ASEAN-wide co-ordinated context, both to achieve economies of scale and reduce mistrust or misunderstanding about weapons ambitions.

A key concern for Australian policy then is whether to accept a united ASEAN enrichment and/or reprocessing capability, or whether to encourage Southeast Asian governments instead to embrace arrangements where the sensitive aspects of the fuel cycle were restricted to a minimum number of sites in the world, perhaps managed multilaterally through the IAEA. This could be promoted as a cheaper and safer approach. Australia's membership of GNEP seems at least a partial declaration of a position on this question, in favour of the latter approach. Southeast Asian countries for their part could set an example for other emerging nuclear states by declaring their support for this course.

For Australia, this debate may ultimately lead to sensitive domestic questions: in any multilateral arrangements to limit fuel enrichment and manage reprocessing, should Australia look to play an industrial role? That is, should Australia, as a major world supplier of uranium ore, seek to host conversion, enrichment, and fabrication and waste treatment facilities? From a commercial/economic point of view, some argue that Australia should do this, although there are significant commercial and technological barriers to entry to these industry segments. Present Australia law prevents these activities. Moreover, there is strong public and party political opposition (as the 2007 election

campaign underlined) to the idea of Australia's developing a nuclear fuel industry. Opponents of nuclear power generation in Australia fear it would lead to that outcome and also reject the idea of Australia's ever providing storage for high-level nuclear waste.[29]

Conclusion

So far, declared ambitions for nuclear power generation in Southeast Asia are fairly limited when considered against total projected power demand. But these first plants may be the precursors to a much greater commitment to nuclear power generation if initial plans are successfully implemented.

This development raises a range of issues for Australia extending well beyond commercial/economic interests as a uranium supplier to environmental/safety and security/non-proliferation matters. Importantly, these do not simply arise just because it happens to be Australia's neighbourhood, Southeast Asia, embarking on commercial nuclear power. They are interests and concerns that Australia already pursues internationally and they are already being addressed generally in its foreign, security and trade policies.

But it is also true that Southeast Asia's proximity to Australia and the intertwining of nuclear questions with other aspects of Australian relations with the region and the world mean that Australia now needs to focus much more attention on ensuring that nuclear power generation in Southeast Asia develops and operates as safely as possible.

While there are already good frameworks for scientific and technical co-operation and assistance, Australia should seek a focus on nuclear power and associated issues at the level of high policy discussion in regional forums. The East Asia Summit is one place to start.

Acknowledgements

For their assistance in the course of researching this paper, the author thanks Dr Weerawat Chantanakome, Executive Director, ASEAN Centre for Energy, Jakarta; Rodolfo Severino, head of the ASEAN Studies Centre at the Institute of Southeast Asian Studies, Singapore; and Hans-Holger Rogner, Head, Planning and Economic Studies, Department of Nuclear Energy, International Atomic Energy Agency, Vienna. The author is also very grateful for advice from John Carlson, Director General, Australian Safeguards and Non Proliferation Office (ASNO) as well as suggestions from Rory Medcalf, International Security Program Director at the Lowy Institute for International Policy.

Preparation of this report was also greatly assisted by presentations made at the ISEAS Roundtable on Nuclear Power in Southeast Asia: Towards Co-operation for Security, Safety and Prosperity, Institute of Southeast Asian Studies (ISEAS), Singapore, 1-2 November 2007. The author thanks ISEAS for the opportunity to participate in this roundtable.

This paper was written for the Lowy Institute for International Policy in preparation for a conference dealing with Asia-Pacific perspectives on the nuclear energy revival and global governance in April 2008, convened by the Lowy Institute and the Centre for International Governance Innovation (CIGI).

NOTES

[1] A good overview of nuclear energy and power generation worldwide, including statistics, updates on expansion plans by country, profiles of the industry and its various segments, and legal and regulatory frameworks and discussion of issues can be found at the websites of the World Nuclear Association, http://www.world-nuclear.org, the Nuclear Suppliers Group, http://www.nuclearsuppliersgroup.org, and the United Nations International Atomic Energy Agency (IAEA), http://www.iaea.org.

[2] In Thailand today, the government nuclear research centre is known as the Office of Atoms for Peace, established in 1961. In the Philippines, an Atoms for Peace-supported research reactor came into operation in 1963. In the old South Vietnam, a research reactor was built under Atoms for Peace in the hill town of Dalat. Indonesia was also supported by the US, resulting in the construction of a research reactor in Bandung in West Java. Indonesia's interest in the civilian application of nuclear energy dates back to the mid-1950s. In the early 1960s, Indonesia also sought support from the Soviet Union. Under Sukarno's nationalist rule in the early 1960s, and one increasingly anti-Western and pro-Communist China, the idea of Indonesia's having a nuclear weapons capability was also put forward and there were fears in the West that Jakarta was seeking assistance from Beijing for its development. After China's first nuclear bomb test in 1964, Indonesian officials publicly spoke of Indonesia's desire to build a bomb. In July 1965, Sukarno gave the idea his approval. But the pro-bomb talk came to an end shortly afterwards with the fall of Sukarno and the rise to power of general Suharto in the wake of the failed coup attempt blamed on the Indonesia Communist Party in October 1965. See Robert M. Cornejo, When Sukarno sought the Bomb: Indonesia's nuclear aspirations in the mid 1960s, *The Nonproliferation Review*, Summer 2000 pp 31-41.

[3] Adiwardojo, Indonesia: Nuclear power and infrastructure, Indonesian National Nuclear Energy Agency, Paper presented at ISEAS Roundtable on Nuclear Power in Southeast Asia, Co-operation, Safety and Prosperity, 1-2 November, 2007, Singapore; Emerging nuclear countries, World Nuclear Association, March 2008, http://www.world-nuclear.org/info/inf102.html.

[4] Central Java calls for nuclear power plant postponement, *The Jakarta Post,* 6 March 2008; Indonesia vows to build nuclear plants despite opposition, *The Jakarta Post*, 12 March 2008.

[5] Indonesia's nuclear diplomacy, *The Jakarta Post*, 16 March 2008.

[6] Vuong Huu Tan, Development of the national infrastructure for nuclear power in Vietnam, Vietnam Atomic Energy Commission, presentation to the IAEA Technical Meeting/Workshop on Milestones for Nuclear Power Infrastructure Development, Vienna, 5-9 November, 2007; Emerging Nuclear Countries, WNA, op cit.

[7] Emerging Nuclear Counties, WNA; Gov't eyes 2-year nuclear power study, Abigail L. Ho, Philippine Daily Inquirer, 23 March 2008.

[8] Emerging nuclear countries,WNA.

[9] Emerging nuclear countries, WNA.

[10] There greenhouse gas emissions as a by product of generation although there are carbon dioxide emissions associated with the earlier parts of the

nuclear fuel chain, for example at the mining and milling stage end

[11] For further information about energy in Southeast Asia, see Andrew Symon, Fuelling Southeast Asia's growth: the energy challenge, *ASEAN Economic Bulletin*, Vol 21 No 2, August 2004 pp 239-248. Milton Osborne, *River at Risk: the Mekong and the water politics of China and Southeast Asia*, Sydney, Lowy Institute, August 2004, http://www.lowyinstitute.org/publication.asp?pid=160. Useful overviews, including demand and supply projects, of Southeast Asia's energy sector can be found in the Asia Pacific Energy Research Centre, *APEC Energy Demand and Supply Outlook 2006*, Tokyo: 2006, see **http://www.ieej.or.jp/aperc/** where this and other relevant studies can be downloaded. Another source of information is the ASEAN Centre for Energy in Jakarta, (http://www.aseanenergy.org). The Paris-based International Energy Agency (http://www.iea.org) and the US Department of Energy's Energy Information Administration (http://www.eia.doe.gov) provide consistent and detailed statistical time series for reserves, production, consumption etc. by country in Southeast Asia and for the rest of the world. Another useful statistical source is BP 2007; *BP Statistical Review of World Energy*, London, June 2007. This is updated each year. http://www.bp.com/productlanding.do?categoryID=6848&contetnID+7033471.

[12] Explanation and economic analysis of the various segments of the nuclear power industry, including uranium mining, can be found in the report of a recent study conducted for the Australian Government: Report to the Prime Minister by the Mining, Processing and Nuclear Energy Review Taskforce (UMPERNER), December 2006, *Uranium mining, processing and nuclear energy: opportunities for Australia*, Canberra, Commonwealth of Australia, 2006. http://pandora.nla.gov.au/pan/79623/20071127-1411/www.dpmc.gov.au/publications/umpner/index.html.

[13] For an overview of this topic see ibid, passim, and also Australian Safeguards and Non-Proliferation Office (ASNO) submission to the Australian Government Uranium Mining, Processing and Nuclear Energy Review, August 16 2006, passim.

[14] Report to the Prime Minister by the Mining, Processing and Nuclear Energy Review Taskforce (UMPERNER), passim, and also Australian Safeguards and Non-Proliferation Office (ASNO) submission to the Australian Government Uranium Mining, Processing and Nuclear Energy Review, August 16 2006, passim.

[15] There is a huge amount of literature on weapons proliferations risks. Discussing the relative ease of manufacturing 'small' nuclear bombs is Victor Gilinsky, A fresh examination of the proliferation dangers of light water reactors, in *Taming the next set of strategic weapons threats*, edited by Henry Sokolski, June 2006, Strategic Studies Institute, US Army War College, Carlilse, Pennsylvania. The volume includes other useful papers. A copy of this report can be found at www.strategicstudiesinstitute.army.mil/pubs/diplay.cfm?PubID=707. Other relevant Strategic Studies Institute reports are also available.

[16] World Nuclear Association, http://www.world-nuclear.org.

[17] Global Nuclear Energy Partnership, US Department of Energy, http://www.gnep.energy.gov; IAEA press release, Germany outlines multiparty

approach to nuclear fuel cycle, 18 February 2008, http://www.iaea.org/NewsCenter/News/2008?germany_nfc.html; Lance Joseph, Multilateral approaches to the nuclear fuel cycle, Sydney, Lowy Institute, August 2005, http://www.lowyinstitute.org/publication.asp?pid=293; John Carlson, Director General, Australian Safeguards and Non-proliferation Office, Challenges to the nuclear non-proliferation regime: can the regime survive?, Paper presented to the Carnegie Moscow Center, May 29, 2007.

[18] Philippines Department of Foreign Affairs Press Release, Having overseen adoption of plan of action, RP turns over Chairmanship of SEANFZ Commission, 30 July 2007, http://www.dfa.gov.ph/news/pr2007/jul/pr606.pdf

[19] Rodolfo C. Severino, SE Asian nuclear plants a regional concern, *Straits Times* (Singapore), 24 November 2007; see also Graham Gerald Ong-Webb, ASEAN must keep nuclear cloud at bay, *The Nation* (Bangkok), 27 December 2007.

[20] Areva press release, China: AREVA and CGNPC sign the biggest contract ever in the history of nuclear power and enter into a long-term commitment, 26 November 2007. http://www.areva.com/servlet/news-en.html.

[21] Southeast Asian governments may find the European experience a useful model as to what might be established through ASEAN. In the European Union, nuclear power generation, which supplies one third of the EU's electricity, is regulated under the 1957 European Atomic Energy Community (EURATOM) Treaty. The Treaty was signed in Rome along with the treaty established a European Economic Community. The six founding states of the EU, Belgium, France, Germany, Italy, Luxembourg and the Netherlands, looked to nuclear energy as a means of overcoming power shortfalls. Since the costs of investing in nuclear energy could not be met by individual States, the founding States joined together to develop nuclear power generation capacity.

The Treaty requires signatories to meet high safety standards and forbids nuclear materials intended principally for civilian use from being diverted to military use. It provides for a common approach to fuel supply. The Treaty is administered by the European Commission which ensures member states meet obligations and commitments under the Treaty. The Euratom safeguards are applied in conjunction with those of the International Atomic Energy Agency (IAEA) under tripartite agreements concluded between the Member States, the Community and the IAEA.

With the Commission there is the Safeguards Office which carries out physical and accounting checks in all nuclear installations in the EU. As far a fuel supply is concern, there is a common approach to ensure equal access to sources of fuel, carried out through the Euratom Supply Agency, which was established in 1960, operating under the supervision of the Commission. The agency has the right of option on ores, source materials and special fissile materials produced in the territories of Member States and an exclusive right to conclude contracts relating to the supply of ores, source materials and special fissile materials coming from inside the Community or from outside. In order to be valid under Community law, supply contracts made by individual power utilities in the EU must be submitted to the Supply Agency for conclusion. The Supply Agency and the Commission pursue the objective of long-term security of supply through a reasonable diversification of supply sources and the

avoidance of excessive dependency on any one supply source, and ensure that in a context of fair trade, the viability of the nuclear fuel cycle industry is maintained.

Nuclear power generation plants in individual EU countries are operated by state power utilities. (except in the case of Finland where there is now a private sector, independent power producer operating a nuclear plant). Although the power industries in the EU have under gone privatisation and liberalisation of various degrees, nuclear power generally is seen as a segment that should be operated by the state, given the special concerns surrounding nuclear energy. Relevant also for the operation of nuclear power plants in the EU are efforts to achieve a common and competitive power market analogous to the common market for goods and services. Fuel supply conversion, enrichment, and fabrication are carried out by a mixture of state and private companies. One leading group, Urenco, is a multi-country, private-sector consortia operating enrichment plants in Germany, The Netherlands and the United Kingdom. Urenco supplies nuclear power stations in about 15 countries in Europe and overseas and has a 23 percent share of the worldwide market for enrichment services. Urenco is bound by the Nuclear Non-Proliferation Treaty and cannot deal with any country that has not signed the treaty.

[22] Singapore Declaration on Climate Change, Energy and the Environment, 21 November 2007, www.aseansec.org/21116.htm; see also the statement on energy from the previous East Asia Summit in Cebu, the Philippines: Cebu Declaration on East Asian Energy Security, Cebu, Philippines, 15 January 2007, http://www.aseansec.org/19302.htm.

[23] Joint Ministerial Statement for the 25th ASEAN Ministers on Energy Meeting, Energising ASEAN to power a dynamic Asia, Singapore, 23 August 2007, http://www.aseansec.org/20843.htm.

[24] Under ASEAN, there are several inter-government bodies focusing on co-operative approaches to several energy segments. In the case of electricity, there is the Heads of ASEAN Power Utilities and Authorities (Hapua). In 2003, Hapua completed a study on the cross-country power transmission development in Southeast Asia. See http://www.hapua.org. In the Greater Mekong Sub Region, cross-border power transmission and system integration is being pursued by governments under the Manila-based Asian Development Bank promoted GMS Economic Co operation program. See http://www.adb.org/gms/sector-activity/energy.usp.

[25] ASEAN press release, ASEAN leaders sign ASEAN Charter, Singapore 20 November 2007, http://www.aseansec.org/21085.htm. For discussion of ASEAN's weaknesses in this regard and the potential of the Charter to help overcome these, see Rodolfo C. Severino, *Southeast Asia in search of an ASEAN community*, Singapore, Institute of Southeast Asian Studies, 2006 pp 372-385 and passim.

[26] Australian Safeguards and Non-proliferation Office, *Annual Report, 2006/07,* Canberra, Commonwealth of Australia, 2007, pp 24-25, http://www.asno.dfat.gov.au/annual_report.html, passim.

[27] Australian Safeguards and Non-proliferation Office, *Annual Report, 2006/07*, p 12.

[28] Australian uranium exports policy, Australian Government, Department of Foreign Affairs and Trade, nuclear non-proliferation, trade and security website: http://www.dfat.gov.au/security/aus_uran_exp_policy.html

[29] Report to the Prime Minister by the Mining, Processing and Nuclear Energy Review Taskforce (UMPNER), passim.

ANNEXURE

Table 1: Southeast Asia and other Asia nuclear power outlook [1]
(no. of reactors and capacity, megawatts, MW)

	Operation		Construction		Planned		Proposed		Uranium demand 2008(tonnes)
	No	MW	No	MW	No	MW	No	MW	
Bangladesh							2	2,000	
China	11	8,857	5	4,540	30	32,000	86	68,000	1,396
India	17	3,779	6	2,976	10	8,560	9	4,800	978
Indonesia					4	4,000			
Japan	55	47,577	2	2,285	11	14,945	1	1,100	7,569
N Korea					1	950			
S Korea	20	17,533	3	3,000	5	6,600			3,109
Pakistan	2	400	1	300	2	600	2	2,000	65
Taiwan	6	4,884	2	2,600					n.a
Thailand							4	4,000	
Vietnam							8	8,000	
Total Asia	111	83,030	19	15,701	63	67,655	112	89,900	13,117
World Total	439	372,002	34	27,798	93	100,595	226	197,095	64,615

[1] Building/Construction = first concrete for reactor poured, or major refurbishment underway. Planned = Approvals, funding or major commitment in place, mostly expected in operation within 8 years.
Proposed = clear intention or proposal but still without firm commitment.

Source: World Nuclear Association, January 2008, and author

Table 2: Electricity in Southeast Asia and international output comparisons, 2002-2030[1]

	2002	2010	2020	2030
Southeast Asia[2]				
Installed capacity (GW)[3]	100	155	260	367
Output (Twh)[4]	407.7	673.83	1,116.01	1,668.14
Pop (mil)	464.22	512.99	570.51	616.06
Output per capita (Kwh)[5]	878.25	1,313.53	1,956.16	2,707.76
China[6]				
Capacity	355	670	973	1,278
Output	1,416	2,869	4,505	7,162
Pop	1,285	1,343	1,404	1,436
Output per capita	1,101.95	2,136.26	3,208.69	4,987.47
Japan				
Capacity	147	153	171	179
Output	1,024	1,090	1,210	1,312
Pop	127	128	125	120
Output per capita	8,062.99	8,515.63	9,680	10,933.33
US				
Capacity	880	1,034	1,074	1,248
Output	3,835	4,404	5,129	5,851
Pop	289	310	337	361
Output per capita	13,269.90	14,206.45	15,219.58	16,207.76
Australia				
Capacity	40	48	66	77
Output	219	267	330	398
Pop	19.8	21.3	23.2	25.0
Output per capita	11,060.61	12,535.21	14,224.14	15,920

[1] the economic and energy assumptions in formulating these projections are conservative; they broadly assume a business as usual trajectory with no fundamental departures from historical production and consumption relationships

[2] excludes Cambodia, Laos & Myanmar

[3] GW = 1,000 megawatts; [4] Twh = terawatt hours; [5] Kwh = kilowatt hours; [6] exludes Hong Kong

Source: APEC Energy Demand and Supply Outlook, Asia Pacific Energy Research Centre, Tokyo 2006

Table 3: Carbon dioxide gas emissions from electricity production in Southeast Asia and international comparisons, 2002-2030[1]

	2002	2010	2020	2030
Southeast Asia[2]				
Output (mil tonnes)	226	383	628	943
Pop (mil)	464.22	512.99	570.51	616.06
Output per capita (tonnes)	0.49	0.75	1.10	1.53
China[3]				
Output	1,479	3,083	4,290	5,764
Pop	1,285	1,343	1,404	1,436
Output per capita	1.15	2.30	3.06	4.01
Japan				
Output	380	385	415	427
Pop	127	128	125	120
Output per capita	2.99	3.01	3.32	3.56
US				
Output	2,393	2,629	2,951	3,461
Pop	289	310	337	361
Output per capita	8.29	8.48	8.76	9.59
Australia				
Output	190.6	214.0	249.8	286.8
Pop	19.8	21.3	23.2	25.0
Output per capita	9.63	10.05	10.77	11.47

[1] excludes carbon dioxide produced from other energy uses, e.g, transport and industry, and other sources

[2] excludes Cambodia, Laos and Myanmar [3] excludes Hong Kong

Source: APEC Energy Demand and Supply Outlook, Asia Pacific Energy Research Centre, Tokyo 2006

Table 4: World uranium oxide production outlook, 2006-2013 (tonnes)

	2006	2007	2008[1]	2009[2]	2010	2011	2012	2013
World	46,900	49,300	56,700	64,500	69,400	80,700	89,600	96,000
Africa[3]	8,400	8,300	10,600	12,700	14,700	17,600	19,100	20,300
Australia	9,974	9,594	10,744	10,830	11,200	12,200	13,100	13,360
Canada	11,600	11,100	12,200	12,000	9,300	13,100	17,700	21,500
Kazakhstan	6,200	7,800	10,100	14,500	18,900	21,000	22,700	23.800
Russia	4,100	4,200	4,500	5,000	5,000	5,200	6,000	6,100

[1]2008 forecast, [2]2009 and following years, projection
[3]Niger, Namibia, South Africa, Malawi and Zambia

Source: Australian Bureau of Agriculture and Resource Economics (ABARE), Australian Commodities March 2008

Table 5: Membership of key international nuclear security agreements in Southeast Asia

	NPT	SA	AP	CPPNM	JC
Brunei	Acceded 26/3/85	In force 4/11/87	No	No	No
Cambodia	Acceded 2/6/72	In force 17/12/99	No	No	No
Indonesia	Ratified 12/7/79	In force 14/7/80	Signed 29/11 99; in force 29/11/99	Signed 3/7/86; in force 8/2/87	Signed 6/10/97
Laos	Ratified 20/2/70	In force 5/4/01	No	No	No
Malaysia	Ratified 5/3/70	In force 29/2/72	Signed 22/11/05; not in force	No	No
Myanmar	Acceded 2/12/92	In force 20/4/95	No	No	No
Philippines	Ratified 5/10/72	In force 16/10/74	Signed 30/9/97; not in force	Signed 19/5/80; in force 8/2/87	Signed 10/3/98
Singapore	Ratified 10/3/76	In force 18/10/77	Signed 22/9/05; not in force	No	No
Thailand	Acceded 2/12/72	In force 16/5/74	Signed 22/1105; not in force	No	No
Vietnam	Acceded 14/6/82	In force 23/2/90	Signed 10/8/07; not in force	No	No

Key: NPT Nuclear Non-proliferation Treaty; SA, IAEA safeguards agreement; AP, Additional Protocol; CPPNM, Convention on the Physical Protection of Nuclear Material; JC, Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Joint Convention)

Source: International Atomic Energy Agency

ABOUT THE AUTHOR

Andrew Symon is a Singapore-based analyst and journalist. He is currently Southeast Asia director for UK based Menas Associates, a business consultancy specialising in energy and the extractive industries. From Australia he has been working throughout Southeast Asia since 1992. He is an associate of the South Australian Centre for Economic Studies at the University of Adelaide and Flinders University of South Australia.

LOWY INSTITUTE
FOR INTERNATIONAL POLICY

WWW.LOWYINSTITUTE.ORG