



Workshop on Nuclear Energy and Human Security

Organised By The RSIS Centre For Non-Traditional Security (NTS) Studies

CENTRE FOR
NON-TRADITIONAL
SECURITY STUDIES



WORKSHOP ON NUCLEAR ENERGY AND HUMAN SECURITY

REPORT

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THE RSIS CENTRE FOR NON-TRADITIONAL SECURITY (NTS) STUDIES

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This report summarises the proceedings of the workshop as interpreted by the assigned rapporteurs and editors of the RSIS Centre for NTS Studies. Participants neither reviewed nor approved this report.

The workshop adheres to a variation of the Chatham House Rule. Accordingly, beyond the speakers and paper presenters cited, no other attributions have been included in this report.

Executive Summary

Energy security is more than just the security of supplies; it is multifaceted and intertwined with economic, environmental and socio-political issues, among others. For the rapidly developing Asia-Pacific, alternative energy sources represent feasible solutions towards balancing socio-economic growth and environmental protection. In particular, nuclear energy has been viewed in recent years as an attractive option in the region.

The aim of the workshop on Nuclear Energy and Human Security was to bring out the complexities involved in the expansion of nuclear energy usage. These complexities were brought out through the debates articulated here on the pros and cons of adopting nuclear energy, from the environmental, economic and security perspective. In addition, the role of Civil Society Organisations (CSOs), which play a vital role in centering the issue on human security concerns, in nuclear energy policymaking was discussed.

Notwithstanding the lower probability of nuclear accidents compared to that of fossil fuel-fired power plants and even plane crashes, past nuclear accidents such as Chernobyl in 1986 have shaped public perceptions towards nuclear energy. The advent of sophisticated nuclear technologies and risk management measures also did not end intense debates on pertinent issues – environmental, economic, and security – revolving around nuclear energy.

Nuclear operations cannot be deemed environmentally and economically risk-free. Rather, these issues remain contentious due to lack of data and scientific consensus. Since a complete moratorium on nuclear expansion is almost impossible to achieve, the environmental and economic risks entailed in nuclear operations need to be better understood and managed in a broader context involving other energy alternatives.

Given the salience of nuclear terrorism risk and weak global nuclear security regimes, the expansion of nuclear energy use encompasses potential security issues for the Asia-Pacific. A coherent international framework based on greater interstate cooperation and coordination to secure existing inventories of nuclear armaments and fissile materials is needed and it will have significant ramifications for the region.

Beyond the technical aspects of nuclear operations, more research focus in nuclear energy policy planning needs to be placed on addressing other equally crucial areas that could also shape public perceptions towards nuclear energy. A culture of safety needs to be inculcated, especially in nuclear-aspiring Southeast Asia, whose track record of industrial safety has been less than perfect.

A decision-making culture espousing transparency, and accountability to the public, can go a long way towards enhancing sound nuclear energy planning. Multiple stakeholdership involving the government, but also nuclear industry, scholars and CSOs, is essential for ensuring holistic nuclear energy policymaking.

Rather than adopting a partisan approach to nuclear energy, a sustainable and diverse energy portfolio that considers a whole range of possible alternative energy sources is the way forward. In this holistic equation, nuclear energy remains a viable option whose risks need further research and better understanding in order to devise sound policies to better regulate its expanding use. It is hoped that the debate arguments fleshed out at the workshop will help policymakers arrive at policy decisions more effectively and persons interested in nuclear energy understand the debated issues more thoroughly.

Opening Remarks

Associate Professor Mely Caballero-Anthony
Head
Centre for Non-Traditional Security Studies, and
Secretary-General
Consortium of Non-Traditional Security Studies
in Asia
S. Rajaratnam School of International Studies
Nanyang Technological University
Singapore



Prof. Mely Caballero-Anthony

In her welcome remarks, Prof. Mely Caballero-Anthony first underlined the salience of Non-Traditional Security (NTS) risks for the contemporary world, stressing the transnational implications of such threats no policymaker can ignore. With particular regard to the Asia-Pacific, energy security constitutes an important facet of a range of existing and potential NTS risks. She also pointed out that energy security is not merely concerned with the securing of adequate and affordable energy supplies.

Energy security, according to Prof. Caballero-Anthony, needs to be multifaceted in considering a range of intervening factors – environmental degradation, socio-economic development and political stability for example – that can potentially impinge on the welfare of mankind. She highlighted the importance of looking at energy security in the Asia-Pacific through a holistic lens: the need to sustain socio-economic development has to be balanced with environmental protection.

The way forward in attaining this delicate balance is to embark upon energy diversification as one of the strategies. To date, there has been much interest shown by Asia-Pacific countries in the use of alternative energy sources; nuclear energy being one of the most attractive options. Notwithstanding talks of a ‘nuclear renaissance’, however, nuclear energy development in Southeast Asia especially, has been beset by intense public debates over nuclear-related environmental, economic and security issues.

To sum up, Prof. Caballero-Anthony reiterated the need to examine critical areas of concern in order to better understand the role of nuclear in Asia-Pacific energy security. The discussions during the workshop, she added, could potentially contribute an NTS perspective to the nuclear energy knowledge field thus aiding policymakers to devise sound nuclear energy development policies.

Session 1: The Environmental Aspects of Nuclear Energy

Chairperson:

Associate Professor Mely Caballero-Anthony
 Head
 Centre for Non-Traditional Security Studies, and
 Secretary-General
 Consortium of Non-Traditional Security Studies in Asia
 S. Rajaratnam School of International Studies
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Nuclear Power and the Environment: Facts vs Fiction

Dr T S Gopi Rethinaraj
 Assistant Professor
 Lee Kuan Yew School of Public Policy
 National University of Singapore
 Singapore



Dr T S Gopi Rethinaraj

Dr T S Gopi Rethinaraj first briefly ran through the history of nuclear energy. He highlighted that, between the 1940s to the 1950s, nuclear energy was not so much conceived as a form of power utility than as a weapon, due to the abundance of fossil fuels. As mankind began to recognise its usefulness, nuclear energy became increasingly more expensive. Nonetheless, due to government financial support, the nuclear industry has remained buoyant despite stiff competition.

The nuclear accidents on Three Mile Island (1979) and Chernobyl (1986), however, changed the face of nuclear energy. Both incidents illustrated the underlying risks of nuclear energy and left a lasting impact on public perception. Although measures have since been devised to minimise the environmental risks within the nuclear fuel cycle such as reprocessing and permanent storage, Dr Rethinaraj pointed out that nuclear energy has been stigmatised due to its association with accidents of such magnitude. He then proceeded to debunk some myths about nuclear energy.

Contrary to public perception, Dr Rethinaraj argued, nuclear energy does not pose 'dramatic' environmental risks. First, he pointed out, the radiation levels of nuclear reactors are often lower than the background radiation human beings are typically exposed to – a fact often overlooked by the public. Furthermore, there is no scientific consensus on the implications of low-level radiation. Human beings have all along been subjected to background radiation that have by now surpassed permissible levels.

Second, Dr Rethinaraj said, nuclear reactors do not explode like a nuclear bomb since a reactor meltdown in the event of an accident is well contained within the reactor core, as the Three Mile Island accident had shown. Modern reactors have evolved significantly to be safer, but at the same time risk management strategies are also increasingly costly. Contemporary reactor designs possess stringent containment features that comprise multiple layers of defence to guard against a core meltdown.

Further, Dr Rethinaraj likened the public aversion towards nuclear energy to the public prosecution of witchcraft witnessed in the Salem witch trials of the 17th century. Similar to public fears of witchcraft, public fears of environmental dangers associated with nuclear energy are largely unfounded. There is a lower probability of an accident occurring in a nuclear reactor than that of one occurring in fossil fuel-fired plants or plane crashes. To

stress his point, Dr Rethinaraj remarked that one is 'more likely to be killed by a meteorite impact than by a reactor core meltdown'.

In the present context of rising energy needs and climate change, minimisation of environmental risks of nuclear energy through the reprocessing of spent nuclear fuel is commonly pursued by major nuclear energy users. However, a complete halt in nuclear power plant construction and spent fuel processing is almost impossible to achieve. Dr Rethinaraj concluded that the environmental risks associated with nuclear energy can actually be effectively controlled through attainable levels of safety in nuclear energy operations.

Critical Environmental Questions: Nuclear Energy and Human Security in Asia

Associate Professor Simon Tay

Chairman

Singapore Institute of International Affairs

Singapore



Prof. Simon Tay

Two schools of thought currently dominate the nuclear energy debate: one school deems carbon emissions as the greater evil compared to the risks of nuclear energy while the other school opposes nuclear energy due to the perceived risks involved. Prof. Simon Tay pointed out that a third school of thought which adopts a conservative

approach exists. This school of thought stresses sustainable development and perceives nuclear energy as playing an important role in the balance between socio-economic growth and environmental protection.

Traditionally, economic imperatives remain central to the issue of energy security while environmental considerations are usually regarded as an afterthought. Besides radiation risks from nuclear operations, Prof. Tay pointed out that there is already thermal pollution from nuclear reactors. Thus, it is wrong to conclude that there are no environmental risks associated with nuclear energy production. The environmental risks of nuclear energy have to be viewed from a broader perspective.

Rather than just focus on the technical aspects of nuclear operations, Prof. Tay argued, one should also examine the culture of safety in civilian nuclear energy countries. It should not be assumed that the culture of safety is always assured in those countries, especially those that have no prior experience with operating nuclear reactors. The culture of safety in the region, particularly in Southeast Asia, leaves much to be desired if one were to examine country records of standard industrial accidents that occur daily, which are not necessarily associated with nuclear operations.

Compounding the rather dismal record of safety culture has been the prevailing culture of secrecy. This latter aspect essentially prevents better public understanding and thus reinforces the perception that nuclear energy is risky. As the case of Japan has illustrated, negative public perceptions towards nuclear energy are often reinforced when nuclear industrial players and even government officials attempt to cover up truths or delay appropriate action in the face of nuclear accidents.

In addition, Prof. Tay remarked that the so-called nuclear experts have often underestimated the public's ability to understand issues and have regarded them as 'witch-hunters' that focus on unfounded fears. He further argued that 'the public does not fail to understand; rather, it has been the experts who have failed to convince'. He

emphasised the need to better understand the risks of nuclear energy rather than simply focusing on the fact that risks exist. In view of the issues raised, it is clear that the critical questions surrounding the environmental risks of nuclear energy are not merely technical, but encompass a broader range of considerations.

The conservative, sustainable development approach does not exclude the nuclear option and requires long-term as opposed to short- and medium-term strategic thinking. Still, the precautionary principle needs to be heeded. Above all, Prof. Tay emphasised the need for policymaking in the context of nuclear energy development to be transparent and made accountable to the public. Efforts should also be channelled towards changing the traditional top-down decision-making process in Asia. More efforts should be made to explore other alternative energy options as well.

The Environmental Aspects of Nuclear Energy – Commentary

Dr Michael Quah

*Principal Fellow and Chief Scientist, Energy Systems and Technology
Energy Studies Institute
National University of Singapore
Singapore*



Dr Michael Quah

Dr Michael Quah pointed out that popular perceptions of nuclear risks are largely shaped by the media. Still, nuclear operations are not 100 per cent safe, and hence public negativity towards nuclear-associated risks is simply unavoidable. For instance, radioactive waste disposal represents a thorny issue since the international community does not have sufficient experience in handling it. However, he argued, nuclear energy is often perceived as an 'abnormal and strange' system when it is not the case in reality.

In apparent agreement with Dr Rethinaraj on the need to moderate fears of the dangers of nuclear energy, Dr Quah remarked that the probability of death from a 'dirty bomb' is 20.16 per cent; scarcely a significant increase compared to the 20 per cent chance of death from cancer due to background radiation. Moreover, he pointed out, terrorists would probably prefer using chemical weapons to dirty bombs in their attacks as the former produces higher casualty figures. For example, the number of casualties in the 1984 Bhopal chemical plant accident exceeded that of Chernobyl. Therefore, Dr Quah suggested, it is probably better not to regard Chernobyl as a point of reference for assessing the prospects of future nuclear contingencies. Rather, it might be more worthwhile to delve into other less obvious but no less important aspects of nuclear energy such as the culture of safety, as Prof. Tay had earlier highlighted in his presentation. In addition, Dr Quah stressed the need to better understand the roles played by not just nuclear but also renewable sources in energy development. He pointed out however that a sustainable energy portfolio cannot feasibly exclude nuclear energy.

In concluding his commentary, Dr Quah stressed that in the present Internet age, the massive amounts of available data and information do not by themselves constitute knowledge. Rather, knowledge has to be derived from sound analyses of data and information which exist aplenty in the context of nuclear energy. He also emphasised the need to explore the 'system-of-systems' approach in synergising all plausible energy sources – nuclear energy being one of those considered.

The ideal framework for nuclear energy and its future, Dr Quah proposed, should be sustainability instead of one-sided, partisan frameworks proposed by different schools of thought. It is better to perceive the role of nuclear energy constructively, as part of an energy diversity mix, given the fact that climate change represents an arguably more pressing issue than nuclear risks as it is also probably true that the risks related to nuclear operations are low when viewed within the framework of sustainable development.

The Environmental Aspects of Nuclear Energy – Discussion

The issue of controlling the environmental risks of nuclear energy was raised during the discussion with some participants expressing doubts over the ability of some countries with poor institutional governance to control such risks. Dr Rethinaraj pointed out that it might not be fair to by default equate countries with poor governance with poor safety cultures. ‘Islands of excellence’, he suggested, may exist in countries plagued by governance deficit, citing the case of India whose nuclear safety standards are among the highest worldwide.

Questions were also raised among participants regarding ways to cultivate a culture of safety in countries, especially those that suffer from ‘governance deficit’. One participant commented that governments surely bear the key

responsibility in ensuring a culture of safety. Some other participants observed that the nuclear industrial sector also has the primary role in ensuring this aspect. In general, participants agreed that governments have a duty to ensure that the nuclear industry adopts high safety standards.

At the regional level, Prof. Tay pointed out that within the Association of Southeast Asian Nations (ASEAN) in particular, there is still a tight veil of secrecy surrounding the issue of nuclear safety despite the presence of an ASEAN sub-regional nuclear network (which ironically seems to have seen little progress or activity). One participant suggested that due to a widely-held view that there is little likelihood of nuclear weapons coming into the possession of ASEAN member states, regional governments tend to overlook the need for transparency and collective mechanisms.

Touching on the point of sustainable energy development, as repeatedly raised by Dr Quah, one participant questioned the role of nuclear energy in rural electrification and whether it should be integrated within the national grids in some countries. To that, Dr Quah replied that it is more feasible to rely on renewable sources for rural electrification. Due to the technical complexities and costs involved, he added, nuclear energy appears unfeasible and unrealistic for countries that are barely able to meet basic needs, especially for improving rural electrification.

Session 2: The Economic Aspects of Nuclear Energy

Chairperson:

Dr Michael Quah

Principal Fellow and Chief Scientist, Energy Systems and Technology

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Singapore

Nuclear Energy and Economic Costs

Professor Kazuaki Matsui

Executive Director

Institute of Applied Energy

Japan



Prof. Kazuaki Matsui

Prof. Kazuaki Matsui candidly admitted that he is a nuclear proponent although he acknowledged that issues brought up in the earlier discussions, such as the culture of safety, needed to be addressed. He further added that notwithstanding the attractiveness of nuclear energy, several challenges mitigate against its expansion. He also pointed out that by 2050 a total of 1,250 gigawatts of nuclear power would be required; about three times the present installed capacity. Nevertheless, nuclear energy by that time will make up merely 23 per cent of the total world energy mix.

Some 46 per cent of the total world energy mix by 2050, according to Prof. Matsui who cited the *Energy Technology Perspectives 2008*, will be fulfilled by renewable sources.

However, it is important to note that the nuclear option cannot be totally excluded from a holistic energy portfolio despite its inherent risks. While the dangers associated with nuclear safety and security for instance are relatively well-known, it is crucial to consider the risks regarding cost issues. In particular, Prof. Matsui argued, investment risks constitute an area that requires concern since it has direct relevance to the potential expansion of nuclear energy use worldwide.

Indeed, among several factors that need to be considered for the costing of nuclear-generated electricity, expenses associated with facility siting, licensing, uncertainty risks and construction capital costs are arguably most critical. These investment capital costs, according to Prof. Matsui, constitute a full 60 per cent of the total cost of nuclear-generated electricity, compared to 25 per cent for operation and maintenance; and about 15 per cent for the fuel cycle. Natural uranium costs make up merely five per cent in this overall equation.

As such, Prof. Matsui argued, nuclear-generated electricity is highly sensitive to construction costs and investment capital. Nonetheless, in comparison with other clean energy options, nuclear energy remains attractive in terms of cost risks. In fact, he pointed out that some viable clean energy technologies such as Carbon Capture and Sequestration (CCS) remain encumbered by high uncertainty costs. Moreover, most of the costs associated with decommissioning and waste disposal have already been internalised for nuclear energy.

According to Prof. Matsui, the key uncertainty cost factor for nuclear energy lies mostly in investment risks which need to be better understood and limited to acceptable levels in order to facilitate new projects. The eradication and mitigation of investment risks, especially those related to licensing for instance, can provide an investment climate conducive for nuclear industries. He concluded that nuclear energy remains a promising, economically sound alternative to fossil fuels despite being a long-term, high capital-cost project.

Economics of Nuclear and Renewable Electricity

Dr Mark Diesendorf
Deputy Director
Institute of Environmental Studies
University of New South Wales
Australia



Dr Mark Diesendorf

In order to accurately evaluate the costs of nuclear-generated electricity, Dr Mark Diesendorf pointed out at the beginning of his presentation, one needs to examine various other clean energy alternatives. Comparing different types of nuclear technologies, he argued that nuclear energy is only economical at the commercial and pre-commercial stages. Yet, he stressed, 'commercial' does not equate to cost effectiveness but implies merely economies of scale.

Dr Diesendorf highlighted the reality of modern nuclear technology in terms of cost estimation. The so-called Generation-III nuclear reactors remain unproven commercially since they are still stagnant at the pre-commercial stage and there is no operating experience gained as yet. The even newer Generation-IV nuclear reactor technologies are either still in the Research and Development (R&D) phase or have been plagued by partial technical failures. On the last point, he argued, nuclear power still requires backup in times of contingency, so the hidden costs are actually higher than estimated.

Furthermore, pitfalls exist with respect to nuclear-generated electricity cost estimation due to the limited availability of data that mostly originates from the UK and the US. Accurate gauges of real nuclear-generated electricity costs are also hindered by the tendency of planners to accept nuclear plant manufacturers' cost estimates and their inclination towards the choice of unrealistically low discount rates. This is not to also forget the proclivity of nuclear planners to use accounting methods that actually shrink capital costs while overestimating the operating capacity of Nuclear Power Plants (NPPs).

Using the US as a case study, Dr Diesendorf pointed out that true nuclear-generated electricity costs such as estimates of R&D, waste management and decommissioning expenses are often distorted. Loan guarantees extended in NPP construction and planning are frequently borne by taxpayers who will also have to pay for the liability costs in the event of nuclear accidents. Over the period of 2003 to 2009, he added, estimates of nuclear-generated electricity cost have skyrocketed in the US.

Dr Diesendorf also took to task the common perception about nuclear energy and carbon costs, pointing out that in every stage of nuclear energy production, save the reactor operation, carbon emissions are also produced. A range of viable, carbon-free alternatives can be efficiently utilised. These options include the reduction of energy demand through energy efficiency measures and pursuing renewable energy options such as wind power. Dr Diesendorf went further by suggesting that a sustainable energy mix can be made up almost wholly of renewable sources, especially in the case of Australia.

While recent efforts have been made to develop more sophisticated and feasible nuclear technologies, such as modularised small reactors, major financial hurdles have stifled these attempts. Moreover, while criticisms are commonly made about renewable sources being saddled with higher uncertainty costs than that of nuclear energy, the cost of nuclear-generated electricity can potentially

escalate to be on par with that for solar photovoltaic power by the year 2020.

Finally, Dr Diesendorf concluded, the two biggest threats to humanity are climate change and the spread of nuclear weapons. To mitigate these two threats, he argued, renewables instead of nuclear energy can ideally meet the need for a secure, sustainable energy mix for the future. The key drawback of nuclear energy remains the risk of proliferation, something that renewable energy technologies are not saddled with in the expansion of their use.

The Economic Aspects of Nuclear Energy – Commentary

Dr Chang Youngho

Assistant Professor

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Dr Chang Youngho

Dr Chang Youngho argued that it is difficult to adopt a partisan view of the economic aspects of nuclear energy. In apparent concurrence with Dr Diesendorf's view, he said the means to accurately estimate the actual costs of nuclear-generated electricity have yet to be adequately developed. In terms of investment capital costs associated

with nuclear energy planning, he proposed that a more market-oriented approach is needed to provide accurate, albeit imperfect, estimations.

While investment capital costs constitute the bulk of cost estimates, according to Prof. Matsui's presentation, this was by no means a foregone conclusion. The costs for other aspects of nuclear energy planning may actually be higher than estimated. For instance, the actual costs for NPP decommissioning are 15 times what has been regularly publicised. As such, while these costs constitute a smaller portion in the overall nuclear energy cost equation, they remain highly significant.

Dr Chang said that, while Dr Diesendorf's argument about nuclear energy costs was more convincing, it remains a puzzle why renewable sources and energy efficiency technologies are not fully utilised if they really constitute the 'low-hanging fruits' to be plucked. He pointed out that energy efficiency measures may not necessarily reduce costs since such technologies might actually encourage power consumption, thus leading to increased energy costs borne by the end-users in the long run.

The economics of energy sources, Dr Chang proposed, will have to consider the following: 1) available, viable energy resources, 2) the ability to develop requisite technology to harness those resources, and 3) broad societal acceptance. Therefore, within such a framework, the cost consideration for energy sources becomes more holistic, beyond the 'hard' economic aspects associated with fiscal factors. The last consideration – societal acceptance – needs to be taken seriously into account by nuclear energy planners.

In conclusion, Dr Chang agreed with what Prof. Matsui had alluded to in his presentation, that renewable sources might not totally satisfy future energy needs. In concurrence with several speakers and commentators, he proposed that a diverse energy portfolio – one which includes all possible alternative types such as nuclear energy and various forms of renewables – constitutes a realistically more viable way forward.

The Economic Aspects of Nuclear Energy – Discussion

The difficulty of evaluating nuclear-generated electricity costs, one participant opined, stems from the general lack of consensus on standards in measurement and concept. It was suggested by some participants that an international mechanism be established for countries to ‘speak a common language’ in the area of nuclear policy planning.

Dr Diesendorf commented that renewables proponents generally regard international energy bodies as being inclined towards nuclear energy. According to him, the fact that pro-nuclear experts think differently from their pro-renewables counterparts already precludes the possibility of a collective consensus. As such, the debate over the pros and cons of nuclear energy and renewables will continue to persist without a consensus in sight.

One participant remarked that carbon taxes are absolutely essential and that feed-in tariffs are necessary. When the discussion moved to Singapore’s stance on feed-in tariffs and subsidies as the city-state studies the prospect of going nuclear, another participant noted that the Singapore Government remains in the exploratory phase of nuclear operations. The participant added that, unlike the case of Europe, the general policy adopted by the Singapore Government is to rely on market forces while precluding interferences in the policy on feed-in tariffs and subsidies. Instead, Singapore’s Energy Market Authority (EMA) – the country’s official energy regulatory agency – encourages energy firms to explore modern clean energy technologies and apply for EMA funding to conduct R&D on potential technological solutions.

The issue of societal acceptance of nuclear energy gained traction during the discussion. One participant posed a question on ways for nuclear energy experts to change or improve public perceptions on nuclear energy. Prof. Matsui suggested that transparency in policymaking – harking back to the earlier discussion on improving the culture of decision-making – is the way to go. He added that the media is also responsible for ensuring fair dissemination of information so as not to mislead the public on nuclear energy. However, Dr Diesendorf disagreed with this by pointing out that the public is discerning of the information it is presented with. He remarked that the notion of the public’s inability to discern information has always appeared to be the central assumption of nuclear energy experts who lay the blame squarely on the media for shaping public perceptions. Rather, he suggested, industrial and government policymakers should not attempt to withhold or distort information to the public.

The point about renewables wholly constituting the future world energy mix invited debate. One participant remarked that it is difficult to envision Australia’s national energy mix wholly made up of renewables when Canberra is actively exporting uranium abroad. Another participant proposed Dr Quah’s ‘system of systems’ concept as the way forward in crafting the future energy mix – a more holistic framework which does not necessarily preclude nuclear energy notwithstanding its inherent drawbacks. This opinion gained general agreement among participants.

Dr Diesendorf’s final point about the inherent security risks of nuclear energy – thus making it less appealing than renewables – also garnered significant attention. Some participants pointed out that nuclear arms can be built even without a civilian nuclear programme; hence the security fears of civilian nuclear energy are generally alarmist in nature.

Session 3: The Security Aspects of Nuclear Energy

Chairperson:

Dr Alvin Chew

Associate Fellow

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Nuclear Energy and Security Risks: Is the Expansion of Nuclear Power Compatible with Global Peace and Security?

Professor Jor-Shan Choi

Professor

Global Centre of Excellence Program

Nuclear Education and Research Initiative

University of Tokyo

Japan



Prof. Jor-Shan Choi

Prof. Jor-Shan Choi noted that although there are currently 437 NPPs in 29 countries, totalling a net installed capacity of 371.5 GW, half of this capacity is contributed by France, Japan and the US. Various drivers for the expansion of civilian nuclear energy include rising/volatile fossil-fuel prices, energy security, environmental concerns, and rise in living standards.

Nuclear energy has certain inherent advantages, according to him, in the form of its negligible contribution to

greenhouse gas emissions, relative invulnerability to climate change, as compared to other renewable sources, proven base-load capacity generation, and ability to offset transportation emissions by supporting hybrid and electric cars (in the future, through production of hydrogen). However, other key issues have to be considered: the issue of costs compared to other energy sources, avenues for financing, safety and reliability of NPPs, and development of nuclear-related human resource as well as infrastructure.

Moreover, despite its contributions and great potential, Prof. Choi pointed out, the expansion of nuclear energy stands at a crossroads. It faces significant challenges in nuclear proliferation, security, and spent-fuel/waste management. These are intractable techno-institutional issues hindering the expanded use of nuclear energy for peaceful purposes. To illustrate the potential risks in this regard, he gave a detailed account of the global inventories of spent nuclear fuel (250,000 tonnes), highly enriched uranium (1,900 tonnes) and separated civil plutonium (250 tonnes) stock in 2010. Other threats to the expansion of nuclear energy include nuclear terrorism executed by rogue actors, weak enforcement of the non-proliferation regime, the potential of nuclear weaponisation under the guise of peaceful uses, and closed fuel cycle as a 'latent proliferation' concern.

Prof. Choi stressed that the world can no longer afford to continue a 'business-as-usual' approach and urged the adoption of a new approach. He outlined some major aspects of this new strategy: 1) secure and draw down excess weapons-usable materials; 2) cooperate and coordinate on nuclear security (materials and facilities); 3) provide economically-competitive nuclear power with the assurance of reliable fuel supplies, and perhaps, spent-fuel take-back/take-away (cradle-to-grave fuel cycle services); 4) the reduction of 'proliferation and spent-fuel' burden for countries that desire only nuclear electricity generation; and finally 5) R&D of advanced partitioning technologies to treat and dispose the long-life and problematic radionuclide in spent fuel.

Security Aspects of the Growth of Nuclear Power

Mr Miles A. Pomper

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Mr Miles Pomper

Joint Paper with

Mr Cole Harvey

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Mr Miles Pomper pointed out that although the projected growth of nuclear power varies over a broad spectrum, according to the International Atomic Energy Agency (IAEA) nuclear power generating capacity will expand by 27 to 101 per cent by 2030. This nuclear energy resurgence will be spearheaded by Asian countries, especially China, India, Japan and South Korea. Countries with smaller nuclear sectors are also looking to expand (or initiate) investments in nuclear power. However, this resurgence in nuclear power encompasses associated risks.

Uranium enrichment and spent fuel reprocessing can support the civilian nuclear power industry, but they can also be exploited to generate fissile material for nuclear weapons. The technologies and skills associated with these processes, Mr Pomper explained, are not inherently limited to peaceful use and can be used for weaponisation once

a political decision is taken. Moreover, more enrichment and reprocessing facilities, as well as more fissile material in transit, provide greater target opportunities for terrorists seeking to acquire fissile material. One way of circumventing this risk, he suggested, would be to substitute processes involving highly-enriched uranium (HEU) with low-enriched uranium.

Another risk associated with the expansion of nuclear power is that NPPs can also serve as a source of 'dirty bombs' or become 'dirty bombs' themselves. In this regard, Mr Pomper noted that, in the aftermath of the terrorist attacks on 11 September 2001, the US Nuclear Regulatory Commission has substantially upgraded nuclear security levels. On the global level, however, this security enhancement is not uniformly implemented by countries, thus providing a possible avenue for terrorists.

Mr Pomper also broached various issues that are straining the international nuclear safety net. The proliferation activities undertaken by Pakistani nuclear scientist A.Q. Khan tested the nuclear non-proliferation architecture that was devised in the 1960s. Also, the failure of IAEA to detect the covert nuclear programmes in Iran, Iraq, Libya and Syria until they were publicly exposed constitutes another issue of concern. Moreover, the Nuclear Non-Proliferation Treaty (NPT) allows parties to withdraw without restriction or penalty, as North Korea did in 2003.

Even though in recent times the international community has taken steps, such as the adoption of the Convention on the Physical Protection of Nuclear Material (CPPNM), to rectify some of the lacunae, it was more a series of patchwork arrangements than a concrete, focused effort to achieve an overarching international agreement on nuclear security. The Nuclear Security Summit of April 2010 may be a step in this direction nevertheless. During the summit, states pledged to secure all vulnerable nuclear material within four years and also agreed to move forward on various treaties and agreements.

Mr Pomper concluded by noting that there should be a balance between nuclear energy growth and proliferation resistance. He put forth several recommendations: 1) minimise and eliminate civilian use of HEU, 2) make the IAEA Additional Protocol a requirement for nuclear fuel

trade, 3) boost the IAEA safeguards budget, 4) enter into force the amended CPPNM, 5) work towards a multilateral approach to the fuel cycle (using the International Uranium Enrichment Center at Angarsk, Russia Federation, as a potential model), 6) increase reliance on open fuel cycle and dry cask storage (no reprocessing), and finally 7) foster a nuclear security culture.

The Security Aspects of Nuclear Energy – Commentary

Dr Ron Huisken

Senior Fellow

Strategic and Defence Studies Centre

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Australia



Dr Ron Huisken

Commenting on the two presentations, Dr Ron Huisken pointed out that the basic difference between them is one of tone. He noted that Prof. Choi's presentation was more optimistic about the expansion of nuclear energy use and its implications from the nuclear fuel cycle. He added that Prof. Choi not only put forth the concerns associated with these issues but also suggested various solutions. On the other hand, Mr Pomper's presentation was more cautious on the expansion of nuclear power.

Dr Huisken further dwelt on four themes deemed relevant in the near future: 1) terrorism (especially nuclear-related), 2) accessibility to nuclear weaponisation capacity, 3) whether powerful incentives would arise for states in the Asia-Pacific to acquire nuclear weapons, and 4) how these

issues could be prioritised within a policy context. He first argued that it is not easy for terrorists to obtain weapons-grade fissile material; and even if they managed to, it remains difficult if not impossible to assemble a nuclear weapon. The greatest worry, he pointed out, is the difficulty in negotiating with terrorists should they manage to obtain fissile materials. It is also difficult to find means to deter them from using nuclear weapons.

The fundamental science of nuclear technology and its weaponisation has not changed much over time. Yet at the same time, nuclear technology has become increasingly accessible to more countries. This, Dr Huisken felt, represents an issue which needs to be addressed. He brought in the case of A.Q. Khan's network and North Korea's nuclear weapons programme as notable examples to illustrate his point. Initially, technology denial was the cornerstone for restricting states from acquiring nuclear weapons but that era has passed. Now, he argued, the strategy involves persuading states that they do not need nuclear weapons.

On whether more states in the Asia-Pacific would acquire nuclear weapons, Dr Huisken highlighted three factors that would influence decisions to do so: 1) the political environment in the region remains volatile, 2) the Asia-Pacific has long been the venue for nuclear power politics during the Cold War period, and 3) the nuclear dynamics involving lesser states have risen to prominence. Also, the role of the US in the Asia-Pacific will dramatically transform regional security calculations. On these grounds, therefore, countries in the Asia-Pacific should become more vigilant because nuclear dangers remain persistent in the region.

Finally, Dr Huisken suggested that the international community should strive for a mechanism through which all fissile materials are produced under international arrangements rather than through unilateral fuel production. The immediate priorities, he concluded, should be the security of nuclear materials, persuasion of countries about the disutility of nuclear weapons, and finally to avoid the rise of suspicions on any perceived hidden agenda of individual states to acquire nuclear weapons capabilities, particularly in the context of Southeast Asia.

The Security Aspects of Nuclear Energy – Discussion

A question was raised on why there has been more focus on nuclear terrorism even though terrorists have traditionally used conventional weapons. Mr Pomper pointed out that although the likelihood of nuclear terrorism is fairly low, the consequences can have serious and far-reaching ramifications. As such, the international community has to take steps to prevent it from happening.

Prof. Choi agreed, noting that the commercialisation of uranium enrichment technology and prevailing political priorities of a country influence international dynamics on nuclear security. The main problem surrounding the expansion of nuclear energy use pertains to spent fuel processes, which could be resolved via the retrieval of spent fuel from states. Though difficult to implement, he suggested that a global partnership could overcome the barriers to achieve an international consensus regarding this solution.

On the risk of nuclear proliferation among states, Dr Huisken pointed out that nuclear weapon states are certainly not careless when safeguarding their inventory of nuclear arms and fissile materials. He argued that if the world fails

to stop a nation from nuclear weaponisation, more efforts should be made to secure the nuclear arsenals and prevent such materials from falling into the hands of terrorists, in particular.

The issue regarding private sector involvement in nuclear energy and its role in international nuclear security was raised during the discussion. Mr Pomper noted that private sector involvement would have little impact in enhancing nuclear security since it depends more on the prevailing nuclear regulatory framework. In this respect, Prof. Choi argued that the main security issue regarding nuclear energy lies in the nuclear fuel cycle, especially ensuring the security of spent fuel.

The discussion concluded with a final note that it is important to decouple nuclear energy from nuclear weapons. The mere possession of fissile materials by terrorists is sufficient to cause social panic. However, the management of spent nuclear fuel – a crucial aspect of nuclear weaponisation – remains dependent on political will in exercising national self-restraint and in facilitating interstate cooperation. The politicisation of nuclear fuel cycles therefore carries significant ramifications on prospects for a robust international mechanism to secure its inventory against errant use.



Session 4: Nuclear Energy and the Role of Civil Society Organisations

Chairperson:

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CSOs and Nuclear Energy in Southeast Asia: Cases of Engagement from Indonesia and the Philippines

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On the role of CSOs in the context of nuclear energy development, Prof. Mely Caballero-Anthony remarked at the onset of the presentation that the key question that needs to be addressed is: to what extent has CSO engagement made an impact on nuclear policymaking? She pointed out that, while questions raised by nuclear technical experts are important, issues raised from 'the ground' (i.e. the public and non-governmental organisations) are equally crucial but these aspects are often overlooked by nuclear energy planners.

Though nascent to speak of, CSOs have in recent years experienced exponential growth in Southeast Asia. Notwithstanding their different agendas, CSOs share a few common features despite their diversity: 1) provision of basic needs not forthcoming from the State, 2) protection of human rights, and 3) advocacy for institutional reforms to improve governance.

Taking the case of Indonesia and the Philippines, a few tentative observations were made by Prof. Caballero-Anthony and her co-writers in the area of CSOs' role in nuclear energy development. First, there is a growing

and vibrant CSO community in Southeast Asia, and these groups are increasingly better organised and strategic in intra- and interstate interactions with counterpart institutions. For example, strategies adopted by CSOs in Indonesia and the Philippines are relatively similar, and they interact not just within national boundaries but beyond to form transnational linkages.

Second, though not all CSOs oppose nuclear energy, they commonly strive to provide alternative viewpoints and independent sources of information to the public. Moreover, CSOs no longer merely convey knowledge but also serve as credible alternative actors that propose alternative policy ideas and frameworks. In the case of Indonesia, it is interesting to note that nuclear proponents comprise former civil servants who might have been involved in energy policymaking before, and thus possess the advantage of prior policymaking experience and insights to share with the public.

Lastly, CSOs also facilitate capacity building for 'bottom-up' energy policy planning and endeavour to enhance governance through persuasion and/or advocacy. In the case of the Philippines, Mr Kevin Punzalan highlighted, 21 CSOs grouped together to form an alliance against the revival of the defunct Bataan NPP in the wake of Manila's decision to reactivate the facility. These CSOs, he pointed out, not only canvassed for public support but also participated in government discussions with the objective of presenting vital information to persuade policymakers.

Nuclear Energy and the Role of Civil Society Organisations – Commentary

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Dr Teresita Cruz-del Rosario

Dr Teresita Cruz-del Rosario proposed that one needs to address the question of whether CSOs enhance the governance of energy security. She added that in doing so, one needs not only to deal with the facts but also the issue of value judgment that is influenced by social meanings, values and norms – intangible aspects policymakers have often overlooked. This shortfall, however, has been increasingly filled by CSOs that are beginning to grasp the meaning of value judgment and hence are able to contribute meaningfully to this area of policy thinking.

The role of CSOs in nuclear energy development require deeper scrutiny by first defining CSOs themselves, according to Dr Cruz-del Rosario. The definition of CSOs has been contested due to certain complexities, such as the difficulty in distinguishing those co-opted, initiated or operated by governments and industrial sectors from those essentially not affiliated to any at all. The questions of what constitutes legitimacy and who confers this legitimacy, she added, remain to be answered and need

to be addressed in order to satisfactorily posit the role of CSOs in energy governance.

The following question was also deemed important to be addressed, according to Dr Cruz-del Rosario: while countries that have an open political culture enjoy a stronger foundation of CSO engagement, what about those that do not? She opined that the political culture of nuclear energy policymaking has often been neglected in favour of technical aspects in the nuclear debate. Even in countries with closed political cultures, so-called CSOs also exist for the purpose of giving a display of openness in order to encourage foreign investments rather than stimulating true public participation. The debate about the role of CSOs in energy governance should thus take this factor into consideration.

Lastly, Dr Cruz-del Rosario proposed a need to find means to balance between 'processes' and 'results' in energy policymaking. There may be strong CSO representation and activity, she highlighted, but there might be no solutions at all for perennial energy problems. Therefore, CSOs in energy governance face a number of challenges. First, they need to manage policy content in order to ensure their consistency with competing social values and meanings beyond the mere technical and operational aspects of energy governance. Second, while it is true that contemporary CSOs are able to forge intrastate and transnational linkages with fellow organisations, many of them remain unable to manage coalition dynamics in order to push for a coherent agenda. This is an area many CSOs need to improve upon in order to enhance, and not hinder, energy governance. Otherwise, competing dynamics among CSOs might lead to social unrest leading Dr Cruz-Del Rosario to quote that 'today's CSOs can potentially become tomorrow's mob'.

The interesting dynamics of CSOs in energy governance and the challenges they face in their quest to enhance energy governance, she concluded in her commentary, are pertinent areas that require more research attention in order to better CSOs' role in nuclear energy development.

Nuclear Energy and the Role of Civil Society Organisations – Discussion

One participant commented that, instead of engaging in colourful rhetoric and attempting to romanticise nuclear issues, CSOs should examine renewable energy sources and help deliver them directly to the people since the ultimate aim of energy governance is to provide sustainable power to every individual. Responding to this comment, Prof. Caballero-Anthony pointed out that some CSOs in Southeast Asia have already begun playing an active role in enhancing rural electrification through the initiation of micro-energy projects.

Nonetheless, she added, the advocacy role of CSOs remains essential even if such efforts may not yield results. At the very least, CSOs can help to place pertinent issues of concern in the public domain for scrutiny when policymakers have failed to address them. Prof. Caballero-Anthony concluded that though CSOs appear controversial, there is still widespread recognition that they exist as a distinct, unique group that can potentially shape the outcomes of nuclear policies through the framing of pertinent issues.

The role of CSOs constitutes arguably the most difficult issue to resolve in the area of nuclear policymaking. One participant pointed out instances in which CSOs were misguided and misled by unsubstantiated information, thus creating unintended consequences for energy governance. Another participant suggested that besides energy governance, CSOs' engagement in the realm of energy policymaking should also include 'risk governance' in view of the range of risk issues pertinent in nuclear energy development.

The discussion about the role of CSOs in energy governance shifted from national- to regional-level issues, with some participants wondering why CSOs have not managed to place the nuclear debate on the ASEAN platform. One of the participants remarked that CSOs in the ASEAN region have tried to do so but have not been successful. Besides nuclear issues, CSOs in the region have not managed to bring non-nuclear issues onto the ASEAN platform as well. Clearly, this is an area that CSOs need to explore and improve upon if their advocacy role pertaining to nuclear development in the region is to yield results.





*Front row: Mr Miles Pomper, Dr Teresita Cruz-del Rosario, Prof. Mely Caballero-Anthony, Prof. Kazuaki Matsui and Dr Mark Diesendorf
Middle row: Mr Yang Razali Kassim, Dr Michael Quay, Dr Chang Youngho and Dr Rajesh Basrar
Back row: Dr Guy Hentsch, Dr T S Gopi Rebhinraj, Dr Alevin Chew and Prof. Jor-Shan Choi
Absent from photo: Prof. Simon Tey*

Closing Remarks

Dr Rajesh Basrur

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Dr Rajesh Basrur

In bringing the workshop to a close, Dr Rajesh Basrur briefly summarised the pertinent points raised in the course of the day's discussions. He stressed the salience of nuclear energy and the debates over its associated critical issues in the current context of a potential expansion in nuclear energy use in the Asia-Pacific. Dr Basrur suggested that future platforms such as this workshop discuss pertinent issues revolving around nuclear energy in order to explore further prospects for research in this critical area of concern that bears significantly on energy security in the region.



Programme

| | | |
|---------------|--|---|
| 09:15 – 09:50 | Registration | Associate Professor Simon Tay Chairman, Singapore Institute of International Affairs (SIIA), Singapore |
| 10:00 – 10:15 | Welcome Remarks Associate Professor Mely Caballero-Anthony Head, Centre for Non-Traditional Security (NTS) Studies; and Secretary-General, Consortium of Non-Traditional Security Studies in Asia (NTS-Asia) S. Rajaratnam School of International Studies (RSIS) Nanyang Technological University Singapore | Commentator: Dr Michael Quah Principal Fellow, Energy Studies Institute (ESI), National University of Singapore Singapore |
| 10:15 – 11:45 | Session 1: The Environmental Aspects of Nuclear Energy Chairperson: Associate Professor Mely Caballero-Anthony Head, Centre for Non-Traditional Security (NTS) Studies; and Secretary-General, Consortium of Non- Traditional Security Studies in Asia (NTS-Asia) S. Rajaratnam School of International Studies (RSIS) Nanyang Technological University Singapore Presenters: Dr T S Gopi Rethinaraj Assistant Professor, Lee Kuan Yew School of Public Policy (LKYSPP), National University of Singapore Singapore | 11:45 – 12:00 Group Photo-taking 11:45 – 13:15 Lunch 13:15 – 14:45 Session 2: The Economic Aspects of Nuclear Energy Chairperson: Dr Michael Quah Principal Fellow, Energy Studies Institute (ESI) National University of Singapore Singapore Presenters: Professor Kazuaki Matsui Executive Director, Institute of Applied Energy Japan Dr Mark Diesendorf Deputy Director, Institute of Environmental Studies, University of New South Wales Australia |

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Joint paper with

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14:45 – 15:00 **Break**

Commentator:

Dr Ron Huisken
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15:00 – 16:30 **Session 3:
The Security Aspects of
Nuclear Energy**

16:30 – 16:45 **Break**

Chairperson:

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Associate Fellow,
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16:45 – 17:50 **Session 4:
Nuclear Energy and the
Role of Civil Society Organisations**

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17:50 – 18:00 **Closing Remarks**

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End of Workshop

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About the RSIS Centre for Non-Traditional Security (NTS) Studies

The **RSIS Centre for Non-Traditional Security (NTS) Studies** conducts research and produces policy-relevant analyses aimed at furthering awareness and building capacity to address NTS issues and challenges in the Asia-Pacific region and beyond.

To fulfil this mission, the Centre aims to:

- Advance the understanding of NTS issues and challenges in the Asia-Pacific by highlighting gaps in knowledge and policy, and identifying best practices among state and non-state actors in responding to these challenges
- Provide a platform for scholars and policymakers within and outside Asia to discuss and analyse NTS issues in the region
- Network with institutions and organisations worldwide to exchange information, insights and experiences in the area of NTS
- Engage policymakers on the importance of NTS in guiding political responses to NTS emergencies and develop strategies to mitigate the risks to state and human security
- Contribute to building the institutional capacity of governments, and regional and international organisations to respond to NTS challenges

Our Research

The key programmes at the **RSIS Centre for NTS Studies** include:

- 1) Internal and Cross-Border Conflict Programme
 - Dynamics of Internal Conflicts
 - Multi-level and Multilateral Approaches to Internal Conflict
 - Responsibility to Protect (RtoP) in Asia
 - Peacebuilding
- 2) Climate Change, Environmental Security and Natural Disasters Programme
 - Mitigation and Adaptation Policy Studies
 - The Politics and Diplomacy of Climate Change
- 3) Energy and Human Security Programme
 - Security and Safety of Energy Infrastructure
 - Stability of Energy Markets
 - Energy Sustainability
 - Nuclear Energy and Security
- 4) Health and Human Security Programme
 - Health and Human Security
 - Global Health Governance
 - Pandemic Preparedness and Global Response Networks

The first three programmes received a boost from the John D. and Catherine T. MacArthur Foundation when the RSIS Centre for NTS Studies was selected as one of three core institutions leading the MacArthur Asia Security Initiative* in 2009.

Our Output

Policy Relevant Publications

The **RSIS Centre for NTS Studies** produces a range of output such as research reports, books, monographs, policy briefs and conference proceedings.

Training

Based in RSIS, which has an excellent record of post-graduate teaching, an international faculty, and an extensive network of policy institutes worldwide, the Centre is well-placed to develop robust research capabilities, conduct training courses and facilitate advanced education on NTS. These are aimed at, but not limited to, academics, analysts, policymakers and non-governmental organisations (NGOs).

Networking and Outreach

The Centre serves as a networking hub for researchers, policy analysts, policymakers, NGOs and media from across Asia and farther afield interested in NTS issues and challenges.

The **RSIS Centre for NTS Studies** is also the Secretariat of the Consortium of Non-Traditional Security Studies in Asia (NTS-Asia), which brings together 20 research institutes and think tanks from across Asia, and strives to develop the process of networking, consolidate existing research on NTS-related issues, and mainstream NTS studies in Asia.

More information on our Centre is available at www.rsis.edu.sg/nts

** The Asia Security Initiative was launched by the John D. and Catherine T. MacArthur Foundation in January 2009, through which approximately US\$68 million in grants will be made to policy research institutions over seven years to help raise the effectiveness of international cooperation in preventing conflict and promoting peace and security in Asia.*

About the S. Rajaratnam School of International Studies, Nanyang Technological University

The **S. Rajaratnam School of International Studies (RSIS)** was established in January 2007 as an autonomous School within the Nanyang Technological University (NTU). RSIS' mission is to be a leading research and graduate teaching institution in strategic and international affairs in the Asia-Pacific.

To accomplish this mission, **RSIS** will:

- Provide a rigorous professional graduate education in international affairs with a strong practical and area emphasis
- Conduct policy-relevant research in national security, defence and strategic studies, diplomacy and international relations
- Collaborate with like-minded schools of international affairs to form a global network of excellence

Graduate Training in International Affairs

RSIS offers an exacting graduate education in international affairs, taught by an international faculty of leading thinkers and practitioners. The teaching programme consists of the Master of Science (MSc) degrees in Strategic Studies, International Relations, International Political Economy and Asian Studies. Through partnerships with the University of Warwick and NTU's Nanyang Business School, RSIS also offers the NTU-Warwick Double Masters Programme as well as The Nanyang MBA (International Studies). The graduate teaching is distinguished by their focus on the Asia-Pacific region, the professional practice of international affairs and the cultivation of academic depth. Over 200 students, the majority from abroad, are enrolled with the School. A small

and select Ph.D. programme caters to students whose interests match those of specific faculty members.

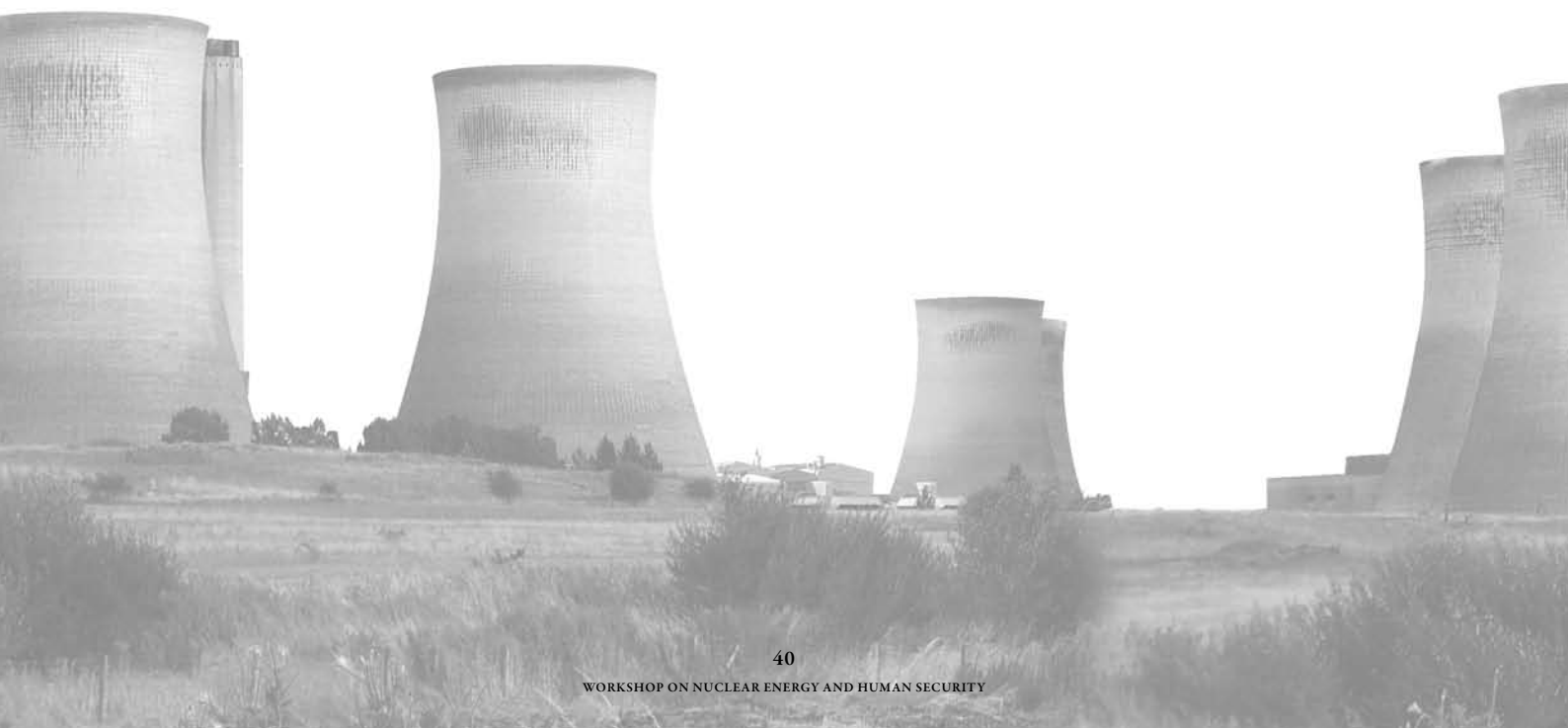
Research

Research at **RSIS** is conducted by five constituent Institutes and Centres: the Institute of Defence and Strategic Studies (IDSS), the International Centre for Political Violence and Terrorism Research (ICPVTR), the Centre of Excellence for National Security (CENS), the Centre for Non-Traditional Security (NTS) Studies, and the Temasek Foundation Centre for Trade & Negotiations (TFCTN). The focus of research is on issues relating to the security and stability of the Asia-Pacific region and their implications for Singapore and other countries in the region. The School has three professorships that bring distinguished scholars and practitioners to teach and do research at the School. They are the S. Rajaratnam Professorship in Strategic Studies, the Ngee Ann Kongsi Professorship in International Relations, and the NTUC Professorship in International Economic Relations.

International Collaboration

Collaboration with other Professional Schools of international affairs to form a global network of excellence is a **RSIS** priority. **RSIS** will initiate links with other like-minded schools so as to enrich its research and teaching activities as well as adopt the best practices of successful schools.

For more information on the School, visit www.rsis.edu.sg



CENTRE FOR
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