ESI Bulletin

ENERGY STUDIES INSTITUTE

an autonomous research institute at

NUS National University of Singapore

ESI Bulletin on Energy Trends and Development (Volume 1 / Issue 2 • October 2008)

MESSAGE FROM ESI EXECUTIVE DIRECTOR

It is with great pleasure that we update you on our activities in this second issue of the *ESI Bulletin*. ESI is looking forward to November when Singapore will be abuzz with an array of energy-related activities tailored for the inaugural International Energy Week (IEW) in Singapore. ESI is pleased to co-organise the IEW with the Energy Market Authority (EMA) to create a platform for international and local policy makers, academics, energy experts and industry players to exchange and catalyse ideas on energy options and strategies for the future.

With its flagship event — the Singapore Energy Conference (SEC) — and a slew of some 30 activities lined up during the week, local and international delegates can be assured of a week that is informative with great opportunities for industry networking. We are grateful to the many government organisations, strategic and media partners, for their support in making this inaugural event possible. ESI and EMA hope that this will be the start of a yearly gathering of movers and shakers in the energy sector.

In the inaugural issue of the *ESI Bulletin*, published in July 2008, ESI featured the National Energy Policy Report prepared by the Ministry of Trade and Industry. In this second issue, we have chosen to focus on Singapore's National Climate Change Strategy proposed by the National Climate Change Committee (N3C) of the Ministry of the Environment and Water Resources (MEWR). Singapore takes climate change very seriously. We must do our share in reducing global CO_2 emissions.

We are very grateful to our contributors for their articles in this issue. Complementing our basic overview of Singapore's National Climate Change Strategy, is a piece by Associate Professor Ho Juay Choy of NUS' Department of Mechanical Engineering and ESI Principal Fellow, which provides more details about Singapore's climate change vulnerabilities and the steps being taken to reduce these. Our colleagues from the Joint Graduate School of Energy and Environment at King Mongkut's University of Technology Thonburi, led by its Director, Professor Bundit Fungtammasan, summarise the climate change strategy of another ASEAN member, Thailand. ESI is indeed keen to foster an open exchange of energy information among the ten ASEAN members and to encourage collaborative efforts aimed at improving energy efficiency, enhancing energy security and mitigating the effects of climate change in the region and beyond. Mr Michael Richardson, Visiting Research Fellow at the Institute of Southeast Asian Studies, looks at the world as a whole. He discusses how changes in how the world generates electricity could potentially contribute to minimising climate change.

In the next issue, we will feature Singapore's efforts to inculcate energy efficiency. We are working closely with MEWR on projects aimed at improving energy efficiency in households, industry, power generation and transportation. We are also heavily involved in a project organised by the International Institute of Strategic Studies (IISS) on nuclear power safety in ASEAN.

ESI's pool of academic, research and administrative staff is growing. Supplementing our recruitment efforts is the global search for three experts to head our three focus areas: energy economics, energy security, and energy and the environment.

As a multi-disciplinary, policy-oriented research institute, we welcome scientific findings, analytical studies and commentaries from all quarters. ESI aims to distil all of this information into timely policy briefs, commentaries and research papers. Our researchers' work will be complemented with the production of our flagship publications: 'Singapore Energy Statistics', 'Regional Energy Outlook' and an internationally refereed journal.

Focus group discussions with academics, the private sector and government bodies will be regularly conducted to obtain direct inputs for important issues in energy policy making. These are important platforms for the exchange of ideas to ensure that ESI's research output is fully engaged in all aspects of the energy landscape with its multiple players and challenging issues.

ESI is privileged to be part of the collaborative efforts aimed at efficiently powering Singapore into the future and participating in the global energy security process.

CHOU Siaw Kiang
Executive Director

In this issue ...

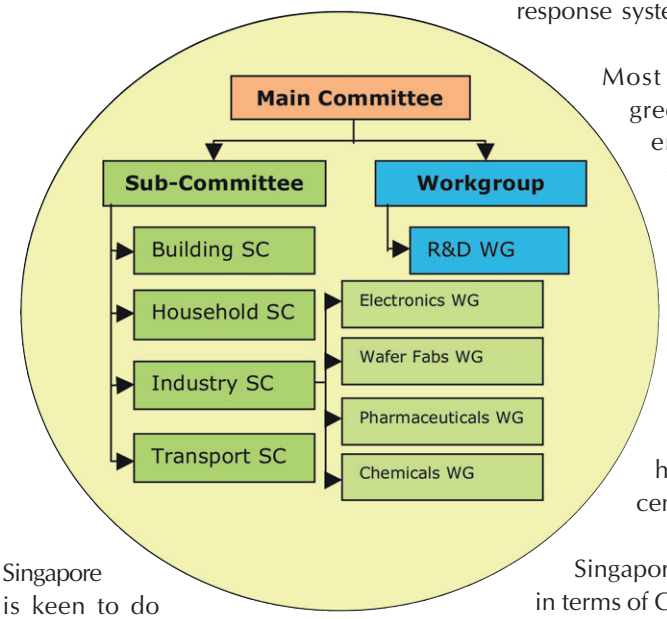
SINGAPORE'S NATIONAL CLIMATE CHANGE STRATEGY*

When Singapore acceded to the Kyoto Protocol in 2006, the National Energy Efficiency Committee (NEEC) was expanded to cover climate change issues and renamed the National Climate Change Committee (NCCC).

The Terms of Reference of the NCCC are to address climate change by:

a) Promoting greater energy efficiency and less carbon-intensive energy in key sectors;
b) Raising awareness amongst the people, private and public sectors on the impacts and opportunities arising from climate change, and the actions they can take;
c) Building competency in Singapore to better respond to climate change such as through promoting research and development of low-carbon technologies;
d) Understanding Singapore's vulnerability to climate change and facilitating the adaptation actions needed.

The NCCC Main Committee is comprised of numerous sub-committees and workgroups:



Singapore is keen to do its part to mitigate climate change by improving the energy efficiency of the power generation, industry, transport, buildings and households sectors. It is participating in the global research effort on climate change and energy technologies.

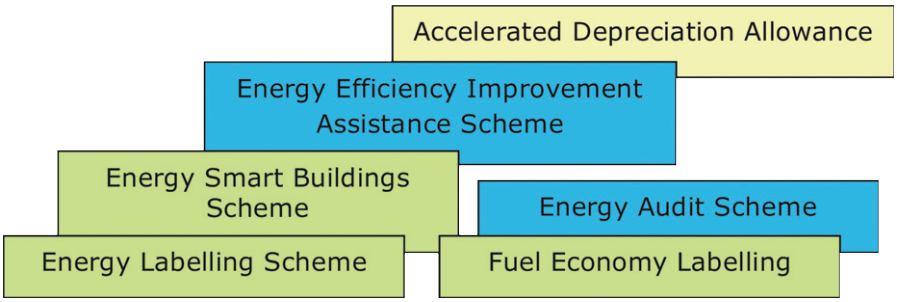
Singapore is vulnerable to climate change due to the fact that considerable land reclamation has occurred around the Island's coastlines. In order to try to estimate the extent of our vulnerability, the National Environment Agency (NEA), in consultation with other government agencies, commissioned a study to analyse the potential effects of changes in temperature, sea level and rainfall patterns in Singapore.

Specifically, Singapore could be faced with increased flooding, coastal land loss, water resource scarcity, resurgence of diseases, heat stress, increased energy demand and impacts on island and marine biodiversity. Plans are being made to monitor all of these potential repercussions and create national response systems.

Most of Singapore's greenhouse gas (GHG) emissions are in the form of carbon dioxide. In 2005, the breakdown by source was: 54 per cent industry, 19 per cent transport, 16 per cent buildings, 9 per cent consumers households and 2per cent others.

Singapore rates relatively well in terms of CO_2 intensity (CO_2 per dollar GDP at 2000 PPP prices). According to the International Energy Agency, it is below the world average. Between 1990 and 2005, our energy intensity improved by 15 per cent, largely due to improvements made in energy efficiency, assiduous adherence to a policy of non-subsidisation of energy prices and the rapid switch from fuel oil to natural gas for power generation. At the same time, our CO_2 intensity dropped 30 per cent between 1990 and 2006. (Natural gas emits 40 per cent less CO_2 than does fuel oil per unit of electricity generated.) As 79 per cent of our electricity is now generated from natural gas using highly efficient combined cycle turbines, the key means for Singapore to reduce GHG emissions is to improve energy consumption efficiencies in the other sectors.

The key NCCC programmes are:



The NEA is taking the lead in this area by chairing the Energy Efficiency Singapore Programme Office (E^2PO) comprised of members from the Energy Market Authority, Economic Development Board, Land Transport Authority, Building and Construction Authority and A*STAR. It has devised a national plan to promote energy efficiency known as Energy Efficient Singapore (E^2 Singapore). E^2 Singapore is geared to:

a) Promoting the adoption of energy efficient technology and measures by addressing the market barriers to energy efficiency;
b) Raising awareness to reach out to the public and businesses so as to stimulate energy efficient behaviour and practices;
c) Building capability to drive and sustain energy efficiency efforts and to develop the local knowledge base and expertise in energy management;
d Promoting research and development to enhance Singapore's capability in energy efficient technologies.

(cont. page 3)

(cont. from page 2 - Singapore's National Climate Change Strategy)

Further details for each sector are provided in the table below.

In the coming years, Singapore's energy demand will increase as both the economy and population expand. However, energy consumption and GHG emissions need not increase greatly if measures to increase energy efficiencies are put in place now. Such measures will have other benefits! The reduced air pollution, not only less CO_2, but also particulate matter and sulphur dioxide, will make Singapore an even more pleasant and healthier place to live. Many new energy-related jobs will be created such as in energy auditing, developing energy solutions and in implementing the Clean Development Mechanism of the Kyoto Protocol. Consuming energy more efficiently means using less energy which translates into lower costs for businesses and households alike. Businesses can look forward to enhancing their competitiveness. Finally, reducing our dependence in imported energy will raise our energy security.

**This summary is based on Singapore's National Climate Change Strategy, a report released by the Singapore Ministry of the Environment and Water Resources in July 2008; the NCCC website <http://www.nccc.gov.sg/main.shtm>; and Ministry of the Environment and Water Resources website http://app.mewr.gov.sg/web/Contents/ContentsNCC.aspx?ContId=452.*

E^2 Singapore's Policies and Measures

	Power Generation	Industry	Buildings	Transport	Households
Promote Adoption of Energy Efficient Technology and Measures	Clean Development Mechanism				
	$10 million EASe Scheme Accelerated depreciation allowance Investment allowance				
	Promote cogeneration and trigeneration via industrial land planning and facility siting	Design for Efficiency scheme Grant for energy efficient technologies	Building regulations Government takes the lead Energy Smart Mandating Green Mark certified $20 million Green Mark Incentive Scheme Grant to upgrade building envelopes Residential building standards	Manage vehicle usage and traffic congestion Improving and promoting the use of public transport Fuel economy labelling Green vehicle rebate Promoting fuel-efficient driving habits	Mandatory labelling Minimum energy performance standards Electricity vending system Electricity consumption tracking device
Research & Development and Capability-Building	Innovation for Environmental Sustainability Fund				
			Green buildings R&D fund		
	Energy service company accreditation scheme Singapore Certified Energy Manager Programme and Training Grant				
Raise Awareness	Energy efficiency seminars and workshops Energy efficiency website 10% Energy Challenge Public Awareness Programme				

Source: Table 3.3 in *Singapore's National Climate Change Strategy*, July 2008, p. 31.

RECENT EVENTS

Norway-Singapore Energy Conference

The inaugural Norway-Singapore Energy Conference, held 25 September 2008 at the Shangri-La Hotel, was well-attended by representatives from the private sector and government agencies, as well as educational and research institutions from both nations.

Opened by H.E. Ambassador Janne Julsrud of the Royal Norwegian Embassy in Singapore and Dr Chin Kin Wah, Deputy Director of the Institute of Southeast Asian Studies, the morning session was devoted to profiling Norway and Singapore's energy roadmaps. Mr. Odd S. Haraldsen from the Royal Norwegian Ministry of Petroleum and Energy and Professor Chou Siaw Kiang from ESI made presentations on the energy strategies of Norway and Singapore, respectively.

Though these nations are very different — Norway is a key non-OPEC petroleum products exporter while Singapore is a pivotal petrochemical refiner — both are making concerted efforts to diversify beyond fossil fuels and are committed to the development of technologies for a sustainable energy future.

Photovoltaics will be part of this future. In his presentation, Professor Joachim Luther, CEO of the Solar Energy Research Institute of Singapore, showcased the main technological routes in photovoltaics. As much of the research in this area is devoted to the attainment of grid parity, it was apt that Mr. Øyvind Hasaas of the Renewable Energy Corporation (REC) and Mr Christophe Inglin of Phoenix Solar, followed up with a private sector perspective on photovoltaics. Via a partnership signing ceremony and live demonstration of REC's solar panels, it was evident that there would be firm commitment for private sector participation in this nascent industry.

The morning session closed with an engaging panel discussion titled "*Are We Facing an Energy Crisis?*" moderated by Mr. Manu Bhaskaran of the Centennial Group. The distinguished panellists agreed that the world is in a "quasi" energy crisis: facing the twin crunch of burgeoning energy demand amid environmental pressures. It would seem that society will have to adapt to continuously increasing energy prices.

The afternoon session focussed on climate friendly development, with presentations on *Powering Development* in emerging Asia (Statkraft Norfund Power Holding), *Clean Development Mechanism* (Det Norske Veritas), *Carbon Capture and Storage Technology* (StatoilHydro), *Trading of Carbon Assets* (Asia Carbon Exchange) and *Becoming Carbon Neutral* (Telenor Asia). Nicely balanced, this session, on the one hand, highlighted the private sector's corporate social responsibility in terms of mitigating climate change at additional cost to themselves, and on the other, how market-based mechanisms, such as CDMs and carbon trading could be revenue generators.

Mr. Goh Chee Kiong, Deputy Director of the Economic Development Board, gave an overview of Singapore's aspirations to become a "Global Clean Energy Hub". It is hoped that clean energy will become a strategic growth area for Singapore. A 2015 target has been set for creation of a vibrant cluster generating S$1.7billion in value-added and employing 7,000. Norway's REC and Norsun are already proudly a part of this project, and Norwegian-Singaporean bonds will surely strengthen further. Norway is indeed already a global forerunner in clean energy technologies, specifically solar, hydroelectric power, carbon capture and storage.

For more information on this event, as well as pdf copies of the speakers' slides, please visit: www.esi.nus.edu.sg; http://www.norway.org.sg/norwaysingapore/The+Norway+Singapore+Energy+Conference.htm; and http://www.innovasjonnorge.no/Internasjonale-markeder/Kontorer-i-utlandet/Singapore/In-English/The-Norway-Singapore-Energy-Conference-2008/.

Panel discussion on "Are We Facing an Energy Crisis?" with moderator (second from right) Mr Manu Bhaskaran (Centennial Group Inc.) and panellists (from left) Ms Eli Aamot (StatoilHydro), Prof Chou Siaw Kiang (ESI), Prof Joachim Luther (SERIS), Mr Odd Sverre Haraldsen (Royal Norwegian Ministry of Petroleum & Energy) and Mr Øyvind Hasaas (REC).

Norway-Singapore Energy Conference Delegates

SEMINARS HELD

1. "The Power to Reduce CO_2 Emissions: EPRI 'PRISM' Analysis" *by Mr Paul Meagher, International Account Executive, Technical Advisory Services Division, Electric Power Research Institute* (held jointly with A*STAR), 23 July 2008.

2. "The Science and Politics of the India-US Nuclear Deal" *by Dr TS Gopi Rethinaraj, Asst Prof, Lee Kuan Yew School of Public Policy*, NUS, 25 August 2008.

3. "Innovative Climate Change Mitigation Technologies and Systems" *by Prof Yan Jinyue, Royal Institute of Technology and Malardalen University, Sweden, Editor-in-Chief of Applied Energy Journal, Distinguished Lecturer, Faculty of Engineering, NUS*, 26 August 2008.

4. "Policy and Regulation Formulation in the European Union on CO_2 Capture and Storage (CCS) and CO_2 Trading through CDM" *by Prof Yan Jinyue*, 27 August 2008.

5. "A Regional Bioenergy System for Increasing Renewable Energy Utilisation and Mitigating Climate Change" *by Prof Yan Jinyue*, 28 August 2008.

Dr Gopi presenting at ESI seminar

Prof Yan (4th from left) and Prof Chou (3rd from left)

Prof Yan presenting his lecture

RESEARCH AND PRESENTATIONS

Recent Publications

ZHOU Peng (P. ZHOU) and ANG Beng Wah (B.W. ANG)
"Linear Programming Models for Measuring Economy-wide Energy Efficiency Performance", *Energy Policy*, vol. 36, no. 8, 2008, 2911-16.

"Indicators for Assessing Sustainability Performance", in *Handbook of Performability Engineering*, ed K.B. Misra, Springer-Verlag, 2008, pp. 905-917.

Recent Presentations

CHOU Siaw Kiang
"Singapore's Energy Roadmap - the Challenges and Opportunities", presented at the Norway-Singapore Energy Conference, Singapore, 25 Sept. 2008.

CHANG Youngho
"Pan-Asian Natural Gas Trade in Competitive Market Frameworks" (co-authored with Terence Pan), presented at the International Energy Workshop 2008, International Energy Agency, Paris, 30 June - 3 July 2008.

(In addition to attending the workshop and making the presentation, Dr Chang held a meeting with Mr Aad van Bohemen, Head, Emergency Planning and Preparations Section, IEA, to discuss possible research collaboration on emergency energy planning and preparations in the region.)

Forthcoming Publications

Elspeth THOMSON
"Energy Security: An ASEAN Perspective" in *ASEAN-Australia-India Security Politics: Comparative Approaches, ed. Chin Kin Wah and William Tow* (Singapore: ISEAS, 2008).

Upcoming Presentations

CHOU Siaw Kiang
"Enhancement of the Envelope Thermal Transfer Value Criterion for Improved Energy Performance of Buildings", an invited presentation at the Joint Symposium 2008 on Shaping our Future Environment, Hong Kong, 18 November 2008.

CHANG Youngho and Benjamin TANG
"Electricity Demand and the Rebound from Generation Efficiency Gains" to be presented at the 2nd Asian Conference of the International Association for Energy Economics, Perth, Australia, 5-7 November 2008.

"Liquefied Natural Gas Terminal and Electricity Market in Singapore" to be presented at the 28th USAEE/IAEE North American Conference, "Unveiling the Future of Energy Frontiers", New Orleans, LA, 3-5 December 2008.

Editorship

Professor CHOU Siaw Kiang has been appointed Associate Editor of *Applied Energy*, an internationally refereed journal published by Elsevier with effect from 1 October 2008.

NEW STAFF

Adjunct Senior Fellow

CHANG Youngho is an Assistant Professor of Economics in the Division of Economics and in the S. Rajaratnam School of International Studies (RSIS) at Nanyang Technological University, Singapore. He is also a member of the R&D Workgroup and Household Subcommittee for the National Climate Change Committee (N3C).

Dr Chang teaches Energy Security to graduate students and Energy Economics to undergraduate students at NTU. Prior to this, he taught Resource and Energy Economics, Environmental Economics, Macroeconomics, Principles of Economics, and Economics of the Environment from 1999 to 2007 at the National University of Singapore. He has conducted courses for government officials from the region and the world at the Singapore Environment Institute (SEI), the Ministry of the Environment and Water Resources (MEWR) and has been invited to speak at numerous energy workshops, conferences and seminars, including the 7th East Asia Summit Energy Cooperation Task Force Meeting in Seoul in June 2008.

Dr Chang specialises in the economics of climate change, the economics of renewable resources, energy and security, oil and economy, and electricity market deregulation. His current research interests are oil price fluctuations and macroeconomic performances, the economics of energy security, the transition of resource use in an economy, the economics of sustainability, energy use and climate change, and the effectiveness of new market structures in deregulated electricity markets. He has published research papers in academic journals such as *Econometric Theory*, *Economics Letters*, *Energy Policy*, *International Journal of Global Energy Issues*, and *International Journal of Electronic Business Management*. He has also carried out consultation projects for the public and private sector including "Analysis of the Effectiveness of New Market Structure in Electricity Industry," "Understanding the Drivers for Ethanol Demand" and "Cost-benefit Analysis of the Kyoto Protocol for Singapore." He has worked for international academic associations such as the International Association for Energy Economics (IAEE) as a member of the organising committee for its annual conferences and a judge for the best student paper competition for the IAEE conferences.

He was a degree fellow at the East-West Center, Hawaii and received his BASc (in Landscape Architecture) from the Seoul National University, MA (in Economics) from the Yonsei University and Ph.D. (in Economics) from the University of Hawaii at Manoa.

Visiting Principal Fellow

Michael QUAH joins ESI on 20 October 2008 as a short-term Visiting Principal Fellow. He is taking leave from his position as Executive Director / Corporate Technology Fellow in Concurrent Technologies Corporation, a non-profit R&D and technical services company in the US.

Dr Quah has a PhD (1980), MPhil and MSc, all in chemical engineering from Yale University, and a BA (magna cum laude) in chemistry and physics, from Harvard.

He worked for the DuPont Company from 1979 to 1999, including stints with DuPont Japan and Singapore (1990-1993). At DuPont, Dr. Quah held positions in R&D, product and business development, and management. His technical work revolved around membrane technologies for reverse osmosis, gas separations, and electrochemical processes, the last area stimulating his interest in alternative energy innovations. When Dr. Quah worked for DuPont in North Carolina (1993-1999), he also served as Adjunct Professor in Chemical Engineering, at North Carolina State University.

After early retirement from DuPont, he held management positions in several companies: Lydall Technical Papers, Ocean Power, and NextEnergy, all in areas related to materials, components and devices for alternative energy systems. In 2003/2004, he worked as an independent consultant and served in the US Army's Research, Development, and Engineering Command, Communications and Electronics Directorate in Fort Belvoir, Virginia.

Admin

May Koh
Manager

Dickson Yeo
Administrative Officer

AWARD

Our congratulations go to Dr ZHOU Peng who was recently awarded the National Semiconductor Gold Medal for publishing the best research paper by a higher degree graduate in the Department of Industrial & Systems Engineering of the Faculty of Engineering at NUS, accepted or published by an international journal.

UPCOMING EVENTS

International Energy Week Singapore

International Energy Week

The inaugural International Energy Week (IEW), jointly organised by the Energy Market Authority (EMA) and ESI will be held from 3 to 7 November 2008 at the Raffles City Convention Centre. Made possible by the efforts of numerous government organisations, strategic and media partners, this convergence of energy-related activities will enable international and local policy makers, academics, energy experts and industry players to exchange and catalyse ideas on energy options and strategies for the future. Mark IEW on your calendar! For more details, visit www.iew.com.sg to register now!

Conferences	7
Workshops, Seminars, Debates & Courses	10
Site Visits	4
Exhibitions	5
Dinners	8
Launches	5

Singapore Energy Conference

This year the Singapore Energy Conference (SEC) will be held from 4 to 5 November 2008 at the Raffles City Convention Centre. The conference brings together policy makers, energy industry players, academics and representatives from research institutes and thinktanks to consider numerous issues. In line with its theme, the SEC will look at climate change policies, sustainable technology, energy efficiency, business risks, opportunities and integrated energy solutions for 'Powering Cities of the Future'. Please visit www.singaporeenergyconference.com to register, and for full details of the programme highlights and distinguished panel of local and international conference speakers, specially brought to you to make this conference an event not to be missed.

Singapore Energy Lecture

The highlight of the Singapore Energy Conference, the Singapore Energy Lecture, will be delivered by Minister Mentor Lee Kuan Yew on 4 November 2008 at the Raffles City Convention Centre. We look forward to listening to his incisive analysis, insights and perspectives on the energy challenges facing Singapore and the world.

Biofuels and Food Security Forum

The Biofuels and Food Security Forum will be held on the morning of 6 November 2008 in the University Hall Auditorium on the NUS campus.

Against the backdrop of soaring oil and food prices in recent months, this Forum will highlight the pros and cons of expanding the use of biofuels as an alternative transport fuel. The positive experience of some biofuel producing countries and regions will be considered against the negative experience of other areas. Will biofuels ever fully, or even partially, replace gasoline and diesel? This Forum will help listeners understand the broad spectrum of issues surrounding the biofuels and food security dilemma, for which at present, there are no immediate or definitive solutions.

This event is brought to you jointly by ESI and the Institute of Southeast Asian Studies as part of the International Energy Week. Registration is through www.iew.com.sg.

ENERGY ECONOMY MODELLING INTEREST GROUP WORKSHOP

Coordinated by Dr Chang Youngho, ESI Adjunct Senior Fellow, the objective of this workshop, to be held from 10 to 13 November 2008, is to build technical capabilities locally and in the ASEAN region. The first of its kind held in Singapore, it is targeted at energy modelling researchers and policy makers. It will use a hands-on approach, applying real data to a modelling software. For enquiries, please contact Ms Jan Lui at 6516 2000 or esilyyj@nus.edu.sg.

CLIMATE CHANGE: VULNERABILITIES, ADAPTATION MEASURES AND GHG MITIGATION FOR SINGAPORE

Ho Juay Choy
Principal Fellow, Energy Studies Institute
Associate Professor, Department of Mechanical Engineering,
National University of Singapore

The International Panel on Climate Change in its Fourth Assessment Report (IPCC AR4) in 2007, projected that by the end of the current century, under the A1B Scenario*, Southeast Asia will face:

- A rise in temperature likely similar to the rise in the global mean temperature, close to the global mean of 1.7 to 4.4 degrees Celsius;
- A rise in sea level likely to be 21 to 48 centimetres; changes in annual precipitation ranging from - 2 to +15 per cent;
- An increase in the frequency of extreme warm and wet seasons and a decrease in the frequency of extreme dry seasons; and
- A likely increase in extreme rainfall and winds associated with tropical cyclones.

While the accuracy of the IPCC's projections for climate change extremes remains unproven and the subject of much debate, the evidence of climate change (temperature increases and melting of ice sheets and glaciers) and its adverse effects on the environment, world economy, human health, food supply and security, natural resources and physical infrastructures are undeniable. Scientific findings indicate that precautionary and prompt action is necessary. The *Stern Review on the Economics of Climate Change* (October 2006), underscored that the cost of non-action could be equivalent to the loss of 5 to 20 per cent of global GDP per year. There is a global consensus that developing countries are more vulnerable to climate change. The IPCC AR4 further noted that "small islands, whether located in the tropics or higher latitudes, have characteristics that make them especially vulnerable to the effects of climate change, sea-level rise and climate extremes".

Rising sea levels are envisaged to be the most challenging among the impacts of climate change for Singapore in view of our small land size and flat topography. Singapore is adopting a number of measures including: key infrastructures to be at least one metre above highest flood levels, land reclamation to be at least 125 centimetres above highest tide levels and construction of revetments to mitigate coastal land loss. R&D efforts are needed in the areas of shore protection and limiting salt water intrusion, protection of coastal biodiversity, and simulation of sea level rises.

Climate change extremes leading to higher air temperatures and rainfall present threats to public health in Singapore. High temperatures would cause heat stress, affecting those already in poor health and the aged. Another effect which has not been infrequent in recent years has been the occurrence of forest fires in neighbouring countries causing adverse air quality in Singapore and respiratory problems among children and the elderly. Vector-borne diseases, such as dengue fever, could become more virulent when the extremes of climate change bring about increased rainfall. Water-borne diseases could also spread rapidly with increased rainfall and occurrence of storms.

Without any significant agricultural land or landfill sites, Singapore has no methane gas emissions. Its greenhouse gas emissions are primarily in the form of carbon dioxide (CO_2) resulting from the use of fossil fuels in power generation and the industrial, commercial and residential sectors (mainly from air-conditioning) and the transport sector.

Prior to acceding to the Kyoto Protocol in 2006, Singapore was committed to becoming carbon dioxide efficient through monitoring and improving its emission levels. The CO_2 emissions in 2004, 2005 and 2006 were 39.6, 40.4 and 41.6 megatonnes, respectively, which is equivalent to less than 0.2 per cent of global CO_2 emissions. The relatively low CO_2 emission growth (5 per cent from 2004 to 2006) compared to the country's economic growth (15 per cent from 2004 to 2006) came about through the use of a less carbon-intensive energy sources for power generation, and a conscious effort to improve energy efficiency. Singapore's carbon intensity (CO_2 emissions per dollar GDP) has improved from 0.28 kt/$m (kilotonnes/million GDP) in 1990, to 0.22 kt/$m in 2004 and to 0.20 kt/$m in 2006, a 30 per cent improvement from the 1990 level. It aims to further improve its carbon intensity by another 8 per cent by 2012 by focusing on both the energy-supply and energy-demand side.

The improvement in the thermal efficiencies and carbon dioxide emission levels of Singapore's power plants is the result of diversification of fuel supply. Prior to 1992, fuel oil was used for power generation. In 1992, an agreement was reached between Singapore and Malaysia for the supply of 150 Mmcfd (million cubic feet per day) of natural gas for power generation at the Senoko power plant. Following this, Singapore and Indonesia signed a gas sales agreement for the supply of natural gas from Indonesia's West Natuna and Sumatra gas fields. The supply of natural

Prof Ho Juay Choy is working on the country report for Singapore on the Regional Review of the Economics of Climate Change for Southeast Asia. The report is being prepared for use by the Asian Development Bank (ADB).

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(cont. from page 11 - Climate Change: Vulnerabilities, Adaptation Measures and GHG Mitigation for Singapore

gas from Indonesia under these two agreements (325 and 350 Mmcfd) commenced in 2001 and 2003, respectively. Singapore's first LNG terminal is to be ready by 2012. This facility will support increased use of natural gas in power generation and in the industrial and commercial sectors, further reducing our carbon dioxide intensity.

In support of the National Energy Policy Framework (2007), the National Environment Agency chairs an Energy Efficiency Programme Office (E^2PO) which has developed a national plan to promote energy efficiency in the industrial, commercial, transport, building and household sectors of the economy. The national plan reinforces existing energy efficiency policies in these sectors. The approach towards improving energy efficiency, and hence reduction of carbon dioxide output, is through financial incentives, policies, regulations and facilitating training in energy management.

**The A1B scenario assumes significant innovations in energy technologies which improve energy efficiency and reduce the cost of energy supply. Such improvements occur across the board and neither favour, nor penalise, particular groups of technologies. A1B assumes, in particular, drastic reductions in power generation costs, through the use of solar, wind and other modern renewable energies, and significant progress in gas exploration, production and transport. This results in a balanced mix of technologies and supply sources with technology improvements and resource assumptions such that no single source of energy is overly dominant.*

THAILAND'S CLIMATE CHANGE POLICY AND RESEARCH

Bundit Fungtammasan
Sirintornthep Towprayoon
Amnat Chidtaisong

The Joint Graduate School of Energy and Environment
King Mongkut's University of Technology Thonburi
Bangkok, Thailand

Being a largely agricultural-based economy with long coastlines, Thailand is particularly vulnerable to climate change. Already, extreme events that could be linked to global warming are being experienced more frequently. A case in point is the recent occurrence of flash floods in the Northern provinces. Unusual weather patterns, such as delayed rainfall and extended drought could jeopardize much of Thailand's agricultural produce, particularly rice. The destruction of this commodity alone could have far reaching repercussions as it is farmed by 3.6 million families. The subsequent supply shortage could affect consumers not only locally, but also internationally, as Thailand is the world's largest exporter of rice. Moreover, if seawater continues to infiltrate the land due to rising sea levels, soil salinity will increase, making coastal farms less productive. Therefore, it is in the interest of Thailand to have in place policies and strategies on climate change prevention/mitigation and adaptation.

GHG Emissions

The major source of greenhouse gas (GHG) emissions in Thailand is the energy sector, which accounted for 56 per cent of the 2003 national total. The burning of fossil fuels in power plants and automobiles and energy usage in industry are the main culprits. In fact, since 1990 the energy-related GHG emissions have increased by more than 150 per cent. The share of emissions from the agricultural sector is ranked second, with 24 per cent of the total; the dominant emissions being methane from livestock and rice cultivation. GHG emissions arising from changing land-use patterns are also significant and are aggravated by the problem of particulate matter and aerosol from forest fires. Emissions from the waste sector have risen from one per cent in 1990 to 8 per cent of the national total in 2003, reflecting growing economic and industrial development. F gases (HFC, PFC and SF6) are reported as negligible and therefore not taken into account in the national GHG inventories. Overall, national total GHG emissions have been increasing at an annual average of 4 per cent. In per capita terms, Thailand's carbon dioxide equivalent emissions have risen from 3.1 tons in 1990 to 5.1 tons in 2003, while the world average has remained relatively stable at 5.6 tons.

International Commitments and Climate Change Policies

Thailand has been a party to the United Nations Framework Convention on Climate Change (UNFCCC) since December 1994. As a Non-Annex I country, Thailand has submitted its first National Communication on GHG emissions to UNFCCC in 2000 and is in the process of developing the second National Communication, aimed for completion by 2009. Thailand ratified the Kyoto Protocol in August 2006 and has put in place the necessary infrastructure for utilizing the Development Mechanism (CDM). As of September 2008, 41 CDM projects, mostly in the biomass and biogas sector, have been approved by the newly established Thai Designated National Agency (DNA) — the Thailand Greenhouse Gas Management Organization (TGO). Two of the projects have been approved by the Executive Board of UNFCCC. These projects will result in a reduction of 2.9 million tons of CO_2-equivalent per year, or 0.8 per cent of the national total in 2003.

A major step towards climate change adaptation and mitigation was taken by the Government in early 2008 when the Cabinet approved a Five-Year (2008 - 2012) National Strategic Plan on Climate

(cont. page 10)

(cont. from page 9 - Thailand's Climate Change Policy and Research)

Change. The vision statement says that Thailand aspires to be a climate-resilient society and will cooperate with the global community to mitigate climate change based on the principle of sustainable development.

The key strategies are these:

1. Building capacity to reduce vulnerability and adapt to climate change impacts.
2. Promoting greenhouse gas mitigation activities based on sustainable development.
3. Supporting R & D to better understand climate change, its impacts, and adaptation and mitigation options.
4. Raising awareness and promoting public participation.
5. Building institutional capacity and establishing a framework for coordination and integration of various efforts by various sectors and agencies, and
6. Supporting international cooperation to achieve the goal of climate change mitigation and sustainable development.

Strategies in the Energy Sector

Although the Thai government has yet to announce a specific energy policy on climate change, recent policies on energy efficiency and alternative energy aimed at bolstering energy security can be expected to contribute in no small measure to the reduction of GHG emissions. In energy efficiency, Thailand aims to drive down the multi-year average energy elasticity from 1.4: 1 prior to 2003 to 1:1 by 2011 through demand side management (particularly the promotion of energy-efficient alliances and light bulbs) and implementation of a building energy code. In renewable energy, a policy target was set in 2003 to increase the share of renewables in final energy consumption from less than one per cent in 2003 to 8 per cent in 2011. One of the more successful measures to attain this goal has been the introduction of relatively attractive "adders" for electricity generated from different types of renewable technologies, particularly those fuelled by biomass residues. Another effective measure is the promotion of alternative fuels for transport: biofuels — bioethanol and biodiesel — as well as compressed natural gas, through various forms of subsidies. However to bring about substantial reduction in GHG emissions, mainstream energy policy makers are of the view that structural changes in the power supply industry and transportation sectors are inevitable. It is against this background that nuclear energy has been factored in the current 15-year power development plan (4 GW to be installed by 2021) and that a modal shift towards rail transport is being planned.

Climate Change Research

In the past few years, there have been advances made in research that assesses the impacts of climate change on Thailand. Such research work is being supported by various funding agencies, including Thailand Research Fund (TRF), the National Research Council of Thailand (NRCT), Global Change System for Analysis, Research and Training (START) - Southeast Asia Regional Research Centre, and the Japan-based Asia-Pacific Network on Climate Study (APN). TRF, for example, launched the Climate Change and Impacts Program in 2006, aimed at carrying out a comprehensive evaluation of the past and present climate change situation in Thailand, and at visualizing the scenarios into the future. In this context, several groups of researchers are investigating climate change scenarios in Thailand using IPCC SRES A2, A1B, and B2, four regional climate models (PRECIS, RegCM 3, GCM - GFDL- R30 and MM5), various GCMs and different downscaling methods. The spatial resolution in these studies ranges from 20x20 km to 50x50 km, covering the entire area of Thailand and some parts of its neighbours such as Laos and Cambodia. The investigations aim to achieve high-resolution climate change scenarios that are adequate for subsequent impact studies at regional or local levels. The programme also includes the application of climate change scenarios in assessing the socioeconomic impacts of climate change in Thailand. Outputs from this programme will be used as a basis for vulnerability assessments, and subsequent formulation of adaptation measures. Future projects include impact studies on agriculture, water resources and management, coastal zones, and forestry, for which some forerunning research works are already ongoing.

One example in this latter category is the forestry sector. Besides being a main carbon dioxide sink, forests also serve as atmospheric methane sinks. Therefore monitoring and trying to understand the response of forests ecosystems to climate change is of particular importance to Thailand. In this regard, the Eddy Covariance technique is being used for real time and continuous observations. Networks for flux measurements (ThaiFLux Network) have been established within Thailand and linked with other flux networks worldwide. These provide an opportunity for data sharing and integrating, leading to a better understanding of and a sound foundation for evaluating the role of global forests in response to global warming and vice versa. Given the importance of forest ecosystems to the Thai economy and society, research on the impacts and vulnerability of forests to climate change will remain one of the focus areas in Thailand for the coming years.

Conclusions

Due to the perceived vulnerability of Thailand to climate change and the sense of shared responsibility in tackling the climate change challenge with the global community, Thailand has recently adopted national policies and taken corresponding measures for the mitigation of climate change. Supporting climate change research that leads to a better understanding of the climate change phenomena, its likely impacts, adaptation and mitigation options, is one of the key strategies. Since any negative effects on Thailand, particularly in the food production sector, would also be felt by other economies in the region, it makes sense for scientists in the region to share data and carry out collaborative research in this vital area.

CONVERTING GLOBAL ELECTRICITY GENERATION TO MINIMIZE CLIMATE CHANGE

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A record amount of money, estimated at between US$100 billion - $150 billion, was invested worldwide in 2007 in new alternative energy capacity, manufacturing plants, and research and development. A number of sectors have been growing so fast that they have captured substantial interest and money from some of the biggest global companies. These developments were driven by concerns about the rising price and looming shortage of oil, and about energy security, air pollution and climate change linked to the burning of fossil fuels.

A United Nations report recently suggested that renewable energy - chiefly wind, solar, hydro, geothermal, wave, tidal, biofuels and biomass - could create at least 20 million additional jobs in the sector by 2030, on top of the 2.3 million that already exist. A study on the status of renewable power published last February documented some impressive global growth.

Renewable electricity generation capacity reached around 240 gigawatts in 2007, a rise of 50 per cent over 2004. Renewables now represent 5 per cent of the world's power capacity and 3.4 per cent of global power supply. (The latter exclude large hydropower projects, which account for 15 per cent of electricity supply.) The biggest renewable contributor in terms of generating capacity is wind power. It grew by 28 per cent last year, to reach an estimated 95 GW. Wind this year passed a global milestone of 100 GW of installed power. But the fastest growing energy technology is grid-connected solar photovoltaics, with 50 per cent annual increases in cumulative installed capacity in both 2006 and 2007, to around 7.7GW. Singapore is investing heavily in solar technology.

"So much has happened in the renewable energy sector during the past five years that our perceptions lag far behind the reality of where the industry is today," said Mohamed El-Ashry, chairman of the Renewable Energy Policy Network for the 21st Century, which marshalled 140 researchers and contributors from both developed and developing nations to produce the report.

Perhaps most encouraging of all, developing countries led by China, India and Brazil have more than 40 per cent of the world's renewable power capacity, more than 70 per cent of solar hot water capacity, and 45 per cent of biofuels production. In China, wind power is the fastest expanding electricity generating technology. China is also a manufacturing powerhouse for solar PV, third only to Japan and Germany. It is the world's largest market for solar hot water, with nearly two-thirds of global capacity. More than 10 per cent of Chinese households rely on the sun to heat their water. When Chinese firms turn to exporting, the lower costs of their units - some seven times less than in Europe - could reshape supply and demand for solar hot water around the world.

However, all these encouraging trends were recorded before a lengthening global economic slowdown sent the oil price tumbling from its record high of over $147 a barrel in early July, to less than half this in October. Now the credit crisis in financial markets is putting a severe brake on lending, raising serious doubts among bankers and investors that sufficient capital will be available to sustain rapid growth in the renewable energy sector. Yvo de Boer, head of UN Climate Change Secretariat, told *Reuters* on 26 September that uncertainty caused by the credit crunch and lack of trust in financial markets were obstacles to developing green energy projects.

Well before the economic slowdown and credit crisis struck this year, the International Energy Agency (IEA) issued a wake-up call about the heavy reliance of the global economy on fossil fuels for continued growth. In its annual *World Energy Outlook* published in November, the IEA said that if government policies remained as they were in mid-2007 and did not do more to increase efficiency and promote renewables, global energy needs would be 55 per cent higher in 2030 than today, with coal, oil and gas meeting 82 per cent of world demand, up from 81 per cent in 2005. In this business-as-usual scenario, non-fossil energy sources would meet just 18 per cent of primary energy demand.

Of these non-fossil sources, nuclear power would account for 5 per cent of demand in 2030, down slightly from 6 per cent in 2005. Hydropower's share would remain at 2 per cent while biomass and waste would dip from 10 to 9 per cent. The share of other renewables - a category that includes wind, solar, geothermal, tidal and wave energy - would rise from less than 1 per cent to about 2 per cent.

With business-as-usual, developing countries would account for 74 per cent of the rise in global energy use. China and India alone would be responsible for 45 per cent of the increase and China would overtake the United States soon after 2010 to become the world's top energy-consuming nation. Yet just three years ago, US demand was more than one-third larger than that of China. The expansion of China, India and other rapidly emerging economies in Asia is based heavily on oil-fuelled transport and on generating electricity from coal, the most polluting of the fossil fuels. As a result, global energy-related emissions of carbon dioxide, the main greenhouse gas blamed for warming the world, would rise by 57 per cent, from 27 billion metric tons in 2005 to 42 billion tons in 2030, contributing to a potentially catastrophic rise in temperature, according to Nobuo Tanaka, the IEA's Executive Director.

Even the IEA's alternative policy scenario,

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in which governments take more resolute action to promote a sustainable energy path, demand for each of the three fossil fuels would continue to grow. They would make up 76 per cent of global primary energy demand in 2030, with the balance of 24 per cent taken by non-fossil energy sources. Energy demand by then would be 11 per cent lower than in the business-as-usual situation, while global energy-related carbon dioxide emissions would be 19 per cent lower - but still 27 per cent higher than in 2005.

In a new study published on 29 September, the IEA estimated that nearly 50 per cent of global electricity supplies would have to come from renewable energy sources to halve global carbon dioxide emission by 2050, so as to minimize significant and irreversible climate change impact. Achieving this energy revolution is a huge challenge. Non-hydro renewable energy currently generates just 2 per cent of the world's electricity, while hydropower accounts for 16 per cent.

The UN report on creating green growth and employment said that the transition to a more sustainable economy could be hastened if more governments implemented and broadened policies to promote renewable energy by putting a realistic price on carbon and capping emissions of greenhouse gases, and by shifting subsidies from fossil fuels and fossil-generated power to alternative energy sources. But as politicians face cost-sensitive voters in recession-hit economies around the world, making these kinds of policy shifts will be unpopular and difficult.

CONTRIBUTIONS WELCOME

The ESI Bulletin is published quarterly. We welcome contributions, comments and suggestions. Please send all correspondence to May at esikamm@nus.edu.sg. The views expressed in each issue are solely those of the individual contributors.

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Published by National University of Singapore