ESI Bulletin

ENERGY STUDIES INSTITUTE
National University of Singapore

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University Cultural Centre, National University of Singapore, Singapore, 2006. Photo by User: Sengkang (Permission under Wikimedia Commons).

INTRODUCTION

The theme of this issue is sustainable development through energy system modelling and policy analysis (Part 1 of 2).

To achieve the overarching goal of sustainable development, many countries have launched a basket of policies relating to energy and the environment. These policy packages exert significant influences on the local economy as well as on other countries through trade. The varied experiences of countries which have been implementing such policies for some years provide valuable lessons for countries that are just beginning to grapple with how best to achieve sustainable development.

The Economy-Energy-Environment (E3) modelling framework includes the top-down economy-wide model, bottom-up technology rich model, sectoral energy system model, integrated assessment model, life cycle assessment model, climate impact model, decision-making model, forecasting model, etc. Policy analysis based on these models can provide insights into the inter-relationships among economic development, energy consumption, and the resulting impacts on the environment. In recent years, there has been growing interest in integrating the different models into a comprehensive modelling platform.

The Energy Studies Institute held its

In this issue ...

4th Asian Energy Modelling Workshop on Sustainable Development through Energy System Modelling and Policy Analyses on 19 January 2017, with 10 speakers from mainland China, France, Italy, Japan, Norway, Singapore and Taiwan. The 10 presentation summaries from this event will be shared through the ESI Bulletin over two consecutive issues in April and June 2017. These summaries discuss the new developments in energy system models and their applications to issues relating to sustainable development at the city, national, regional and global levels. The five articles in this issue are the presentation summaries by experts from France, Japan, mainland China, Taiwan and Singapore.

Dr. Raimund MALISCHEK, an Energy Analyst at the International Energy Agency (IEA) in France, presented "Global and Indian Energy Outlook: Urban Energy System Modelling using TIMES". He focused on the TIMES-based energy supply model. The IEA's Energy Technology Perspective (ETP) model is comprised of four interlinked technology-rich models for energy supply, buildings, industry and transport. His analysis demonstrated the vast potential for urban areas to contribute to the decoupling of energy demand growth and carbon emissions from population and GDP growth. In the global 2°C scenario, the power sector is almost completely decarbonised by 2050. The integration of high shares of renewable forms of energy imply deep changes to the existing power system. A case study of the Indian energy system was used to highlight the country specific efforts needed.

Mr. Takashi OTSUKI, Researcher at the Asia Pacific Energy Research Centre (APERC) in Japan, presented "APEC Energy Demand and Supply Outlook, 6th Edition". The Outlook discusses the impact of current trends and policies, as well as alternative scenarios to meet APEC's energy intensity and renewable energy goals. Sectoral energy demand models and energy supply models, including a bottom-up electricity model were used for the projections. With coal remaining the leading fuel in the region, the Outlook implies that the current policies place APEC on an unsustainable path. Current efforts still fall short of achieving the APEC's energy goals, and emissions will remain at a level much higher than the global 2°C trajectory. This is an indication that the APEC energy goals should be intensified to meet the longer term global objectives.

Dr. Fei TENG, Associate Professor at the Institute of Energy, Environment and Economy, Tsinghua University in China, presented "The Air Quality Benefits of China's INDC to Peak Emissions Around 2030". His work was based on the partial equilibrium China-MAPLE model. The scenario analysis showed that: (1) current pollutant control measures are in urgent need of improvement; (2) in the End-of-Pipe Control Scenario, local pollutants will be significantly reduced but not enough; and (3) in the Co-Control Scenario, the emissions of SO_2, NO_X and PM2.5 in 2030 will be reduced by 79 per cent, 78 per cent and 83 per cent, respectively, compared to the 2010 levels. Thus, the intended nationally determined contribution (INDC) of China to peak its emissions around 2030 is fully consistent with its domestic interest to improve its local air quality.

Dr. Chung-Huang HUANG, Vice President of the Taiwan Research Institute (TRI), presented "New Challenges in CGE Modelling: Lessons from TaiSEND in Taiwan". TaiSEND is a dynamic computable general equilibrium (CGE) model which features several mechanisms that describe investment behaviours, retirement of electricity generation technologies, social costs originating from electricity shortages and unemployment. The model development is facing a number of challenges, such as validation of behaviour assumptions, risks involved in the development of renewables, industrial structure changes arising from emerging technologies and industries, significant changes in population and demographic structure, adequate measurement of inter- and intra-generational inequality, etc.

Dr. Brantley LIDDLE, Senior Research Fellow at the ESI, presented "Demographic and Population Density Impacts on Energy/Emissions: Results from National and City-level Data". When considering the levels of disaggregation which approximate life-cycle behaviour, researchers have uncovered relationships that are complex and nonlinear. Urban density is negatively correlated with urban private transport energy consumption. Per capita urban transport-related emissions of CO_2 and NO_x increase and then decline at observed income levels. Passenger-kilometres per capita and car ownership both rise, and the share of public transport in total passenger-kilometres falls monotonically with income. Urbanisation appears to be positively associated with energy consumption and carbon emissions, though the causal direction is ambiguous.

We hope you find these presentation summaries of interest and welcome your views and comments.

Dr. LI Yingzhu, ESI Research Fellow, and Dr. SU Bin,
ESI Senior Fellow
(On behalf of the ESI Bulletin Team)

Aqueduct Leading to the Gaobeidian Reservoir in Chaoyang District, Beijing, China, 2009. Photo by Scott Meltzer (Permission under Wikimedia Commons).

Global and Indian Energy Outlook: Urban Energy System Modelling Using TIMES

Dr. Raimund MALISCHEK, Energy Analyst, International Energy Agency

Kerala Electricity Office Sub-Division College, India, 2011. Photo by നിരക്ഷരൻ Nirakṣaran (Permission under CC BY 3.0).

Dr. Raimund Malischek delivered a presentation focused on the global and Indian energy outlook from the International Energy Agency's *Energy Technology Perspectives 2016* (*ETP 2016*) publication. He began by highlighting the first clear signs of a decoupling of carbon dioxide emissions and gross domestic product (GDP), in conjunction with a record pace of renewable energy installations in 2015. The Paris COP21 climate summit provided a historic push for clean energy, as new goals by all countries were put forward. This went beyond all expectations when the first ETP was published in 2006. Dr. Malischek explained that the *ETP 2016* focused on cities, and that *ETP* 2017 will be released in July 2017.

The *ETP* modelling framework has three main scenarios: a Current Policy Scenario (6DS), a scenario which incorporates COP21 policies (4DS) and a scenario which is aligned with 2°C warming (2DS). All of the scenarios show increasing interdependencies in the world's energy system today. Moving towards 2050, the ETP scenarios show a decrease in fossil fuel use, and a significant role played by electricity. The ETP-TIMES model was chosen to model the supply side of the energy system within the ETP scenarios. Other models like the Mobility Model (MoMo) are used to model the demand side aspects and feed into the supply side model.

The IEA's TIMES model is a technology-rich-least-cost optimisation model developed by the Energy Technology Systems Analysis Program (ETSAP), and its implementation is set up in the General Algebraic Modelling System (GAMS). Two software interfaces – ANSWER-TIMES (a Windows interface to the TIMES family of energy system models) and the Versatile Data Analyst-Back End (VEDA-BE) are used at the back end. The MARKAL-TIMES model is used widely in over 150 institutions in 63 countries. The vibrancy of the modelling community is one of the reasons why the IEA relies on this system in its outlook projections.

At the IEA, enhancing modelling capacity is imperative. Two questions that become increasingly important, and which the ETP model aims at are: (1) where can the use of biomass and hydrogen technologies play an important role in the future and (2) how can they be integrated into existing models. In terms of the methodology, Dr. Malischek noted that the TIMES supply model requires input data such as investment cost data, efficiencies, emissions factors and end-use demand. While data is being fed into the model, constraints are then applied to account for efficiencies, carbon budgets, peaking and quotas for certain technologies. The model then optimises system costs and the result is an energy system. The model will be able to highlight new capacities which generation technologies across different timeframes can fill, as well as prices.

TIMES is a "powerful modelling framework". The IEA typically uses a linear programming framework in its long term scenario analysis; however stochastic extensions and mixed integer programming are also available within TIMES. Reliable and accurate data sourcing constitutes a major part of the work at the IEA, as well as trying to map real world processes into the model. Once the processes are set up, the IEA looks at their cost (variable production cost, fixed operation and maintenance (O&M) costs and levelised investment costs over a certain period). These are then fed into an objective function (total discounted energy system costs over the entire model horizon), and the model will find a least cost optimisation pathway.

Renewable forms of energy, carbon capture and storage (CCS) and energy efficiency in all end-use sectors are required to meet the 2DS in 2050. Such a transition requires

exceptional effort, including radical changes in the world's energy system. To illustrate, Dr. Malischek noted that 68 per cent of global electricity output today is generated from fossil fuels and 22 per cent is generated from renewables. In order to meet the 2DS in 2050, these figures essentially need to be reversed. In particular, electrification of the energy sector will be important, as projects suggest a supply of relatively low carbon sources coming online. Among the challenges is that most fossil fuel electricity generation facilities are not ready for CCS retrofits, leading to the issue of becoming potentially stranded assets in the future.

This summary of Dr. MALISCHEK's presentation was written by ESI Research Fellow, Ms. Melissa LOW.

APEC Energy Demand and Supply Outlook, 6th Edition

Mr. Takashi OTSUKI, Researcher at the Asia Pacific Energy Research Centre, Japan

Bangkok Traffic, Thailand, 2009. Photo by nakhon100 (Permission under CC BY 2.0).

Asia-Pacific Economic Cooperation (APEC) is comprised of 21 economies. It has two energy goals: (1) an energy intensity goal; APEC aspires to reduce aggregate energy intensity by 45 per cent by 2035 (with 2005 as the base year); and (2) a renewable energy (RE) goal; APEC aspires to double the share of renewable forms of energy in APEC's energy mix, including in power generation, from the 2010 level by 2030.

Asia Pacific Energy Research Centre (APERC) supports energy cooperation under the framework of APEC. It was established in 1996 in Tokyo, based on the directive of APEC's Economic Leaders. Its major activities include Research and Study, Policy Cooperative Activities, and APEC Energy Data Management Network and Training. As of January 2017, research staff come from 15 economies. One priority task is *the APEC Energy Demand and Supply Outlook* for the APEC region. The 6th edition was published in May 2016 and introduces scenarios towards 2040, including "Business as Usual" (BAU), "Improved Efficiency" (IE) and "High Renewables" (HR). The BAU scenario is based on existing policies, while IE and HR discuss opportunities and challenges in the APEC energy goals.

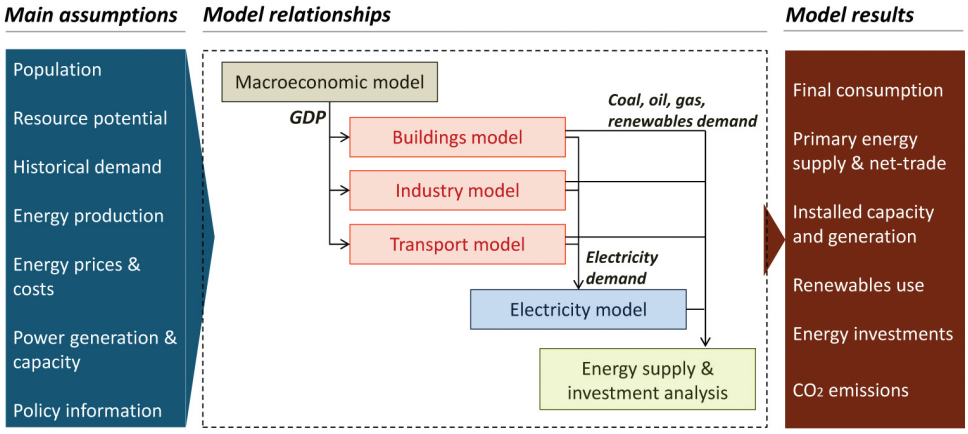
For the Outlook's 6th edition, APERC employed a sectoral approach, consisting of a macroeconomic model, three energy demand models and an electricity model (see Figure 1).

In the BAU scenario, energy demand by 2040 rises 32 per cent from the 2013 level, driven by China and Southeast Asia. Energy intensity largely improves, but only slightly and not enough to achieve the APEC energy intensity goal. Fossil fuels continue to dominate the primary energy supply. The share of fossil fuels remains more than 80 per cent over the projection period. Among the fossil fuels, natural gas shows the highest growth due to projected incremental consumption in the electricity sector. Non-fossil fuels will grow from 14.2 per cent in 2013 to 17.5 per cent in 2040; yet, the BAU scenario would not be environmentally sustainable as CO_2 emissions increase in absolute terms over the period. The "APEC goals" scenarios show the opportunities to curb emissions, while they still remain more than double the estimated emissions needed to achieve the global 2°C goal. The APEC economies need to raise their energy efficiency targets if the global climate goal is to be achieved.

For the electricity sector, APERC uses a bottom-up optimisation type model. This model dispatches generation and storage technologies, considering representative load duration curves in each economy. The temporal characteristics of the load curve as well as of the renewables' output are taken into account in the model. According to APERC's analysis, electricity demand in APEC grows by 70 per cent over the outlook periodin the BAU, showing much faster growth compared with total final energy consumption. On the supply side, although renewables expand, fossil fuels still dominate. The share of renewable capacity expands to 35 per cent by 2040; however, fossil fuels still hold the majority share in generation due to the relatively lower capacity factor of renewables. Doubling the RE's share in terms of generation is not achieved in the electricity sector by 2030 or 2040 in the BAU Scenario.

The projected generation mix significantly varies by region in the BAU, reflecting local resource availability and policy direction. China expands lower-carbon electricity, yet continues to rely on coal. Coal also becomes a main source of generation in Southeast Asia due to its low cost. Emissions thus increase particularly in these two regions, implying that additional low-carbon measures are very important. Another interesting implication of the BAU relates to nuclear power. This scenario suggests that the current reactor lifetime regulations and retirement plans may result in modest nuclear growth. Nuclear is expected to grow in China, Korea and Russia. However, these additions are partially offset by plant retirement plans in other economies,

Figure 1: Sectoral Models for Projections



Source: Takashi OTSUKI's presentation slide.

resulting in a nuclear generation peak around 2030 in the APEC region.

The next edition of *the APEC Energy Demand and Supply Outlook* incorporates some scenario and modelling changes. APERC will discuss three scenarios: the BAU, APEC Energy Goal Scenario, which includes the energy intensity as well as renewables goals, and a 2-Degree Scenario, with the forecast period extended to 2050. In addition to these scenarios, APERC plans to analyse regional integration, such as the ASEAN Power Grid, in a supplemental analysis. Model enhancements include the following elements: incorporating bottom-up elements in the demand models, adding modelled technologies, as well as improving temporal resolution in the electricity model to discuss the grid integration of variable renewables. As for regional integration analysis, APERC has already conducted a study on power grid interconnections in Northeast Asia and plans to create a Southeast Asia model to quantify the costs and benefits.

This summary of Mr. OTSUKI's presentation was written by ESI visiting student, Mr. HAN Lei, from the Beijing Institute of Technology.

The Air Quality Benefits of China's INDC to Peak Emissions Around 2030

Dr. Fei TENG, Associate Professor in the Institute of Energy, Environment and Economy at Tsinghua University, China

Factory on the Yangtze River, China, 2008. Photo by High Contrast (Permission under CC BY 2.0).

In 2015, China submitted an Intended Nationally Determined Contribution (INDC) to the United Nations Framework Convention on Climate Change, with the commitment to peak its carbon emissions by 2030. It has significant benefits in terms of addressing the country's air pollution problem as local emissions are highly related to fossil fuel combustion.

The China Multi-pollutant Abatement Planning and Long-term Benefit Evaluation (MAPLE) Model was developed to answer the following three questions: (1) if China continues to work towards its existing carbon mitigation targets, what will the emission rates of carbon dioxide and other local pollutants be in 2030 and 2050?; (2) can China achieve its air quality target solely through stricter End-of-Pipe Control (EPC) measures? If not, what types of additional measures should be implemented with regard to the energy conservation aspect?; and (3) what share of the co-benefit of local pollutant reduction is due to the carbon mitigation action if the Co-Control (COC) initiative is considered?

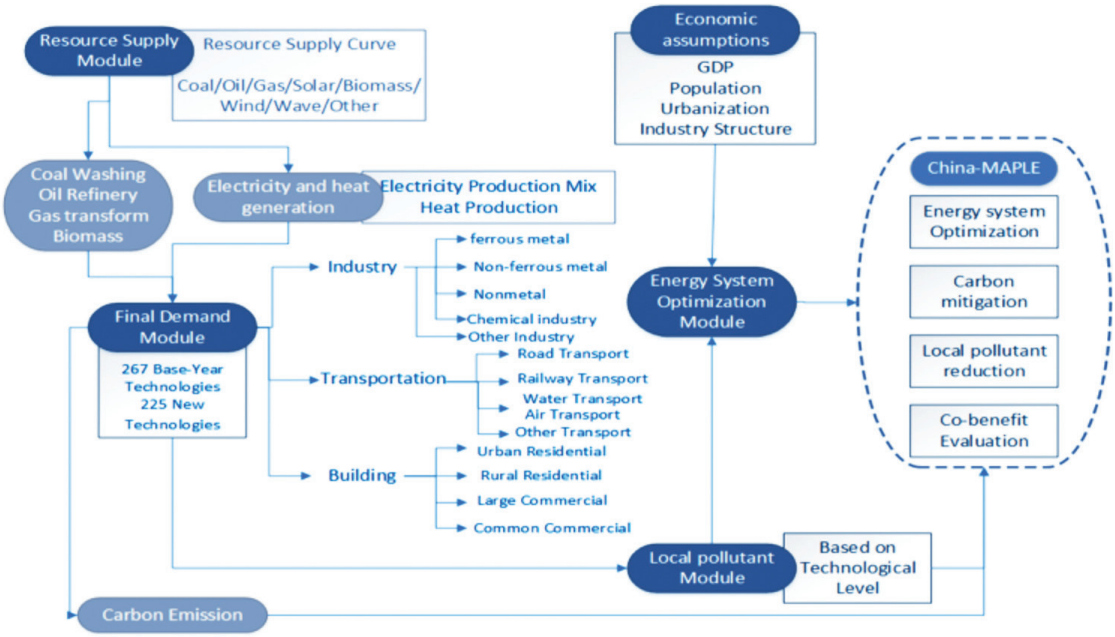
The China-MAPLE Model includes modules on energy supply and conversion, energy demand, energy system planning, local pollutants and co-benefit evaluation (see Figure 1). This model is different from other bottom-up models in three ways: (1) local pollutant control and co-benefit modules are integrated into the energy system framework; (2) the link between local pollutants and the energy module is based on a technological level rather than activity levels; and (3) instead of setting resource costs as fixed or at an increasing rate, it introduces an energy supply curve into the energy supply module.

Different scenarios were developed for analysis and prediction. The results indicate that air quality will continue to deteriorate in the Reference Scenario which is based on the current regulations and implementation status of air pollutants and GHG emissions. Therefore, stringent pollutant emission controls are needed. The End-of-Pipe Control (EPC) Scenario was developed with the assumption that strict enforcement of End-of-Pipe Control and technically feasible control strategies will be fully in force by 2030. The results indicate that the emissions of SO_2, NO_x and $PM_{2.5}$ in 2030 will decrease to 31.9 per cent, 38.7 per cent and 26.6 per cent from the 2010 level, respectively. However, the air quality target of SO_2, NO_x and $PM_{2.5}$ major air pollutants dropping to 80 per cent lower than the 2010 level cannot be achieved. A Co-Control (COC) Scenario was defined as the combination of the effect of peaking carbon emissions by 2030 in the INDC and the enhanced air pollutant reduction measures in the End-of-Pipe Control Scenario. The SO_2, NO_x and $PM_{2.5}$ emissions in the Co-Control (COC) Scenario will decrease to 21.15 per cent, 22.44 per cent and 16.68 per cent, respectively, in 2030 from the 2010 level. Air pollutants can be reduced by approximately 20 per cent from the 2010 level. This reduction roughly meets the target to improve air quality in major Chinese cities by 2030. The co-benefits will be obvious in 2030, reaching reductions of 97.5-169.8 RMB/tCO_2.

The scenario analysis confirms that China faces tremendous pressure in attaining extensive decarbonisation and air quality improvements. The End-of-Pipe Control measures are helpful but inadequate, even with the most stringent penetration rate of the best available technologies in each sub-sector. The air quality target for 2030 will not reached. To meet the upstream mitigation targets, there will be a need to substantially reduce energy consumption. Both the air quality target and carbon emission peaking target can be achieved by 2030 if the co-control measures are implemented.

This summary of Dr. Fei TENG's presentation was written by ESI visiting PhD student, Yunxia LIU, from Tianjin University.

Figure 1: Structure of the China-MAPLE Model



Source: Fei TENG's presentation slide.

New Challenges in CGE Modelling: Lessons from TaiSEND in Taiwan

Dr. Chung-Huang HUANG, Vice President, Taiwan Research Institute

In response to the Kyoto Protocol, Taiwan started the development of a computable general equilibrium (CGE) model in 1998. The development of the first CGE model, TAIGEM (Taiwan General Equilibrium Model), occurred in collaboration with the Centre of Policy Studies in Australia, but its structure has been adapted to Taiwan's industrial structure, technology level, policy targets and social desirability. The agency in charge of Taiwan's energy policy, the Bureau of Energy, provided funding to develop TaiSEND (Taiwan Sustainable Energy Decision model) in 2004. Recognising the contributions of these CGE models to policy analysis, the Ministry of Transportation in 2009 agreed to support the development of the TransCGE model, an extended version of TaiSEND that supports the Energy-Economy-Environment (3E) evaluation of green transportation policy. ISOSEP (Integrated System of Strategic Energy Policy), a newly developed model supported by the Ministry of Science and Technology since 2013, aims to incorporate newly emerging industries, the uncertainties and risks associated with new technologies, and also the uncertainties associated with climate change mitigation and adaptation.

The TAIGEM model was developed primarily to address questions related to climate change. For instance, when the government wanted to introduce a carbon or energy tax, the model was used to evaluate the potential economic impacts, and it found out that the initial rate proposed was too high for the industrial sectors. The model can provide many simulation results, with an emphasis on economic indicators (e.g. GDP and final consumption), energy structure and energy security, environmental indicators (e.g. emissions and emissions intensity), as well as the distributional effect or income inequality. In the 2015 Paris Agreement, intergenerational equality was proposed as one of the 17 new sustainable goals. The target is to reduce intra- as

Kaohsiung MRT Ecological District Station, Taiwan, 2013. Photo by lienyuan lee (Permission under CC BY 3.0).

well as inter-generational inequality. The TAIGEM model is able to provide simulation results that indicate whether or not society is moving towards a more equitable situation.

TaiSEND is a dynamic CGE model focussing on the (3E) effects of energy and climate policies. Unlike many other CGE models, products and services provided by the electricity sector are depicted with a non-differentiable supply function composed of various power generation technologies. A phase-out mechanism is introduced for old technologies so that new technologies can be incorporated. Based on realistic conditions in Taiwan, electricity shortages are permitted via an empirical density function, and unemployment is also allowed by imposing a dual labour market. In addition, a comprehensive module is developed to allocate time to work, leisure, commuting time, as well as health care. For household transportation services, there are six public passenger travel modes, four private passenger travel modes and four freight travel modes. A discrete choice module is integrated into the CGE model to determine household demand for vehicles. The model is expected to further apply discrete choices on other durable goods. TaiSEND has been used since 2004 to evaluate the impacts of numerous issues for the Bureau of Energy, including energy mix, emissions control, oil price volatility, energy efficiency improvement, nuclear phase-out, electricity market deregulation, etc.

Apart from model specifications, certain uncertainties can also significantly influence the validity of simulation results. For example, when analysing optimal energy mix, uncertainties can come from dramatic changes in investment patterns, technology, energy prices and demand, industrial structure, policy, public preference, etc. Therefore, other approaches such as cost-benefit analysis (CBA), analytic hierarchy process (AHP) and political preference are integrated within CGE models to assist Taiwan's policy-makers in decision-making. Besides uncertainties, CGE models also face many new challenges. For example, dramatic demographic changes will induce significant differences in demand behaviour and consequently reshape the industrial structure and other issues such as the social welfare system and fiscal expenditure allocation. However, the population growth rate is made constant in most dynamic CGE models. Emerging technologies and industries arising from the 4th industrial revolution will definitely bring about new goods and services, so the social accounting matrix based on previous data must be updated properly by taking into account the emergence of new products. The risks and uncertainties stemming from renewable energy development, as well as intra- and inter-generational energy justice and inequality are also not usually captured by the existing CGE models. Energy price volatility, industrial transformation and green growth should also be appropriately measured and be consistent with the basic, relevant theories.

In summary, the current CGE modelling is far from perfect in supporting policy-making, and more efforts are necessary to validate the behaviour assumptions. Also regular updating of emerging industries should be done in the existing database, allowing externalities, distortions and disequilibriums in the framework, and paying due attention to uncertainties and risks, etc.

This summary of Dr. HUANG's presentation was written by ESI Research Fellow, Dr. LI Yingzhu.

Demographic and Population Density Impacts on Energy/Emissions: Results from National and City-level Data

Dr. Brantley LIDDLE, ESI Senior Research Fellow

This presentation tied together research on (1) demography and environmental impacts, (2) urban density and transport energy consumption and emissions, and (3) the usefulness of national-level urbanisation for explaining environmental impacts. While larger families use more energy than smaller ones, they use less energy per person; hence, average household size has a negative relationship with road energy use and carbon emissions.

Macro-level studies that have considered age structure have typically used the World Bank definitions/data, i.e., the share of people aged less than 15, between 15 and 64, and over 64. Such studies have generally found those age structure variables to be insignificant. However, when researchers examining the link between age structure and emissions/energy consumption have considered levels of disaggregation that approximate life-cycle behaviour like

Traffic Congestion in Pasir Gudang after 5pm, Mukim Plentong, Johor Bahru District, Johor, Malaysia, 2008. Photo by Emrank ([1]) (Permission under CC BY 2.0).

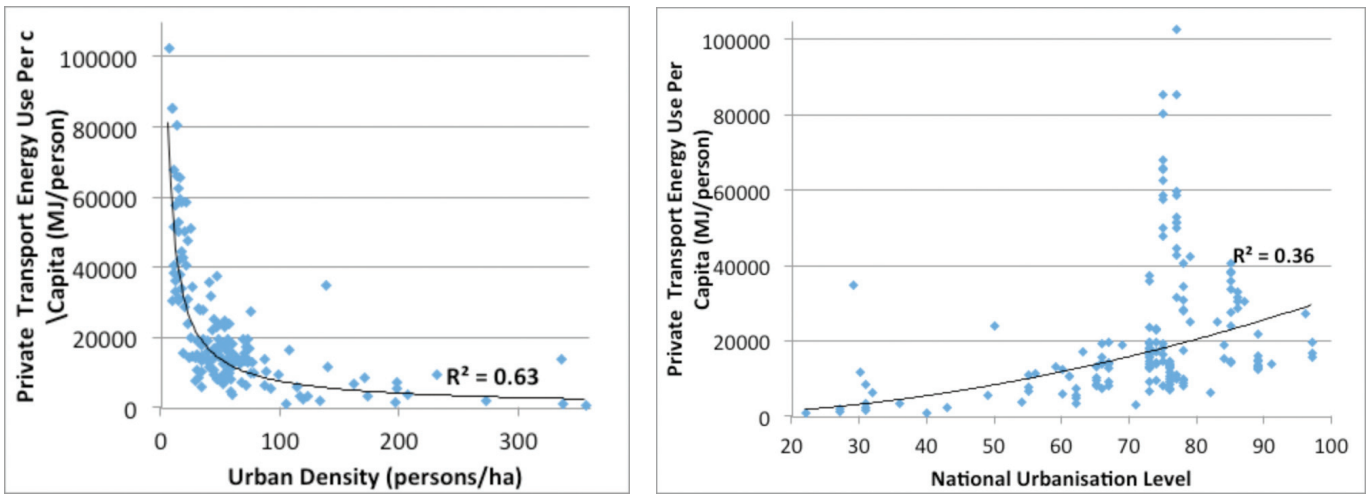
family or household size (e.g., 20-34, 35-49, 50-69 and 70 and older), they have uncovered relationships that are complex and nonlinear. For example, considering transport, young adults were energy intensive, whereas the other cohorts had negative coefficients. For residential electricity consumption, age structure had a U-shaped impact: the youngest and oldest had positive coefficients, while the middle cohorts had negative coefficients. Such a pattern for residential consumption reflects both smaller household size among the youngest and oldest age cohorts, as well as the fact that the oldest age cohorts likely spend more time at home.

While national urbanisation levels are not a good indicator of urban transport demand, there is an established negative relationship between urban density and such demand. Indeed, when examining city-level data, several researchers have established that urban density is negatively correlated with urban private transport energy consumption. However, urban transport energy consumption increases monotonically with income—the estimated turning point from an income-polynomial model was well beyond the sample bounds.

By contrast, per capita urban transport-related emissions of local pollutants CO_2 and NOx increase and then decline at observed income levels—a result driven by a similar inverted-U relationship between income and emissions technology (i.e., emissions per passenger-km). Passenger-kilometres per capita (i.e., mobility demand) and car ownership both rise, and public transport's share of those passenger-kilometres falls monotonically with income. So, income has a push-pull relationship with local transport pollutants: higher income is associated with more emissions-intensive modal choice (i.e., greater motorised mobility demand and a shift away from public to private transport), but higher income is also associated with improved emissions technology. At income levels in OECD-country cities, the improved technology outweighs the more intensive modal structure and local pollution emissions become lower. Yet, there is no evidence that urban density (i.e., more people exposed to emissions) leads to improvements in emissions per passenger-kilometre. Thus, there is a kind of density paradox in terms of transport emissions: higher density is associated with a less energy/emissions-intensive transport system, but higher density means more people are exposed to localised transport pollution.

Lastly, while urbanisation appears positively associated with energy consumption and carbon emissions, the causal direction is ambiguous. Indeed, a Granger-causality analysis uncovered a long-run, causal relationship from several aggregations of electricity consumption (i.e., total electricity consumption, industry electricity consumption and residential electricity consumption) to urbanisation for panels of high, middle and low income countries, as well as for panels of non-OECD countries pooled geographically (i.e., Africa, Asia and Latin America). In other words, the employment and quality of life opportunities that are made possible with access to electricity likely encourage migration to cities, and thus, "cause" urbanisation.

Figure 1: Private Urban Transport Energy and Urban Density



Source: Reprinted from *Journal of Transport Geography*, vol. 28, B. Liddle, "Urban Density and Climate Change: A STIRPAT Analysis Using City-level Data", pp. 22-29, 2013 with permission from Elsevier.

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Skyline of Marina Bay, Singapore. Photo courtesy of the Singapore Tourism Board.

CONFERENCE OVERVIEW

The Energy Studies Institute of the National University of Singapore invites you to participate in the 40th IAEE International Conference, which will be held at the iconic Marina Bay Sands Hotel, Singapore, 18-21 June 2017, with the main theme *Meeting the Energy Demands of Emerging Economies: Implications for Energy and Environmental Markets*.

The ten countries that make up the Association of Southeast Asian Nations (ASEAN) are exerting an increasingly important influence on global energy trends. Underpinned by rapid economic and demographic growth, energy demand in the region has more than doubled in the last 25 years, a trend that is set to continue over the period to 2040. Given Southeast Asia's role as a global growth engine, understanding what is shaping energy markets in this vibrant region and the implications for energy security and the environment is vital for policy makers and anyone with a stake in the energy sector (IEA, *Southeast Asia Energy Outlook, 2015*).

However, this will be a truly international conference, so the focus will be on energy issues interpreted in their broadest global context. Of course, energy policies cannot be addressed in isolation from their local and global environmental impacts, and many conference sessions will address issues relating to this interdependence.

For more information visit www.iaee2017.sg

CONFERENCE VENUE

In addition to its convention facilities, the Marina Bay Sands complex also hosts a hotel, a casino, and a large shopping and dining complex, all in a sweeping garden setting overlooking Marina Bay. The hotel itself has the world's largest rooftop pool, which stretches 150 metres across the hotel and offers breath-taking city-skyline views. A room reservation block has been negotiated with the hotel at a very favourable rate, but this is expected to be filled very quickly. Rooms in nearby hotels around Marina Bay will also be offered, as will less expensive accommodation located elsewhere in the city. The Marina Bay Sands complex has its own MRT (train) station, Bayfront, making it easily accessible to those staying off-site. For further information about the venue please refer to: https:www.marinabaysands.com.

The Energy Studies Institute (ESI) was established in 2007 with the aim of conducting policy-related research in energy issues of regional and global significance, with specific reference to Singapore and the ASEAN region.

Singapore is a thriving global commercial, transport, and financial hub that offers visitors a fascinating insight into an Asian tiger economy. It has a great diversity of attractions to suit all interests, so why not stay a couple of days beyond the conference to experience these in addition to visiting some of the region's leading cultural and vacation sites en route to or from Singapore.

Staff Publications

Internationally Refereed Journal Articles

Shi, X., **Hari M.P.V. and Tao Y.J.,** "Global Impact of Uncertainties in China's Gas Market" *Energy Policy* 104 (2017): 382-94.

Hari M.P.V. and Tao Y.J., "Role of Governance in Creating a Commodity Hub: A Comparative Analysis" *Natural Gas Industry B*, vol. 3(4) (2017): 367-76.

Shi X. and **Hari M.P.V**., "East Asia's Gas-Market Failure and Distinctive Economic: A Case Study of Low Oil Prices", *Applied Energy* 195 (2017): 800-809.

Zhang Zhonghua, Zhao Yuhuan, **Su Bin**, Zhang Youngfeng, Wang Song, Liu Ya, Li Hao, "Embodied Carbon in China's Foreign Trade: An Online SCI-E and SSCI Based Literature Review" *Renewable and Sustainable Energy Reviews* 68 (2017): 492-510.

Wang Hui, Ang B.W. and **Su Bin**, "Multiplicative Structural Decomposition Analysis of Energy and Emission Intensities: Some Methodological Issues" *Energy* 123 (2017): 47-63.

Books and Book Chapters

Melissa Low and Su Bin, "Energy Efficiency Policy for Sustainable Economic Growth in Singapore" in S. M. Khasru (ed.) *Energy Efficiency: Prevalent Practices and Policy Perspectives*, Volume 1, 1st ed. (Dhaka: The Institute for Policy, Advocacy and Governance (IPAG), March 2017).

Other Publications

Melissa Low, "Challenges in Implementing Climate Adaptation Law: the Singapore Approach", Asia-Pacific Center for Environmental Law (APCEL) *Climate Change Adaptation Platform*, 22 March 2017.

Staff Presentations and Moderating

30 March Hari Malamakkavu Padinjare Variam presented "Factors for Development of Benchmark Prices in Crude Oil Markets" at the 27th Annual GIIGNL Commercial Study Group meeting at the Grand, Hyatt, Singapore.

28 March Melissa Low presented "Carbon Pricing Experiences around the World" at the Global Compact Network Singapore Closed Door Dialogue at the Singapore Business Federation Center.

24 March Melissa Low and Ho Juay Choy presented "Singapore´s Low Carbon Emission Policy and Response to Climate Change" at ESI Seminar: ESI-KAS RECAP's Global Emissions Reductions: Motivators, Obstacles and the Role of Germany: Perspectives form China, India, Russia and the US Expert Discussion (See Recent Events in this Bulletin), ESI Conference Room.

23 March Melissa Low presented "Intergovernmental Efforts on Climate Change and Singapore's Mitigation Policies" to the GE4227 *Climate Change: Processes, Impacts and Responses* class in the National University of Singapore's Geography Department.

20 March Allan Loi presented "Modelling Exercise for Emissions Reduction" at the *2nd Economic Research Institute of ASEAN and East Asia (ERIA) Working Group Meeting*, organised by ERIA, Cititel Penang, Malaysia.

5 March Su Bin presented "Overview of Energy Efficiency Policy and Implementation in Singapore", for International Energy Efficiency Day 2017 at The Institute for Policy, Advocacy and Governance, in cooperation with the Ministry of Power, Energy and Mineral Resources, Government of Bangladesh, Dhaka, Bangladesh.

23 February Hari Malamakkavu Padinjare Variam participated as a discussant at the *5th International Energy Agency (IEA) Unconventional Gas Forum*, Brisbane, Australia.

21 February Hari Malamakkavu Padinjare Variam presented "Natural Gas in Maritime Transport and Bunkering" at the *Sustainable Shipping Forum* organised by Energy Carta at NUS Utown.

2 February 2017 Christopher Len presented "Discussion on Arctic Energy Resources including Renewable Energy" at the Nippon Foundation, Japan.

Staff Media Contributions

Gautam Jindal quoted in "Carbon Tax Likely to Have Greater Impact on Large Businesses" by Lee Xin En, *The Straits Times,* 21 March 2017.

Melissa Low interviewed by *The Straits Times* on Singapore's carbon tax consultation, 20 March 2017.

Melissa Low interviewed by *Shin Min Daily* on Singapore's electricity market liberalisation, 14 March 2017.

Philip Andrews-Speed was interviewed by *Nikkei Asian Review* on China's declining oil production, 9 March 2017.

Allan Loi quoted in "Diesel Vehicles May Be on the Way Out" by Christopher Tan, *The Straits Times,* 9 March 2017.

Philip Andrews-Speed was quoted by *ENI's About Oil* on China's renewable energy plans, 2 March 2017.

Gautam Jindal quoted in "Idea of Carbon Tax to Change Mindsets, Hit Large Energy Users Hard: Experts" by Monica Kotwani, *Channel News Asia,* 22 February 2017.

Philip Andrews-Speed was interviewed by *Radio Free Asia* on China's capping of its coal output, 20 February 2017.

Gautam Jindal, "Singapore Looking to Develop Policy Framework for Energy Storage", *Asian Power,* 26 January 2017.

Recent Events

28 March, Global Gas Oversupply and Its Impact on Europe and Asia: Where Will U.S. LNG-Exports Go? (ESI Seminar)

Dr. Frank Umbach, Research Director of the European Centre for Energy and Resource Security (EUCERS) at King's College London and a Senior Associate at the Centre for European Security Strategies (CESS GmbH) at Munich, delivered a

Dr. Frank Umbach. Photo by ESI Staff.

presentation on the global gas glut, the transformation of the gas markets, the reasons behind limited LNG supplies to Europe in 2016, and the next forthcoming LNG wave and its impact on Europe as well as Asia. He suggested that a price war between U.S. LNG exports and Russia's gas pipeline supplies will likely take place in the case of a high LNG price, as U.S. LNG exports to East Asia would be more profitable. But if the LNG price stays low, the U.S. may become more dependent on the European gas market than Europe does on U.S. LNG imports, given its import alternatives such as Russia and other LNG suppliers.

24 March, "Global Emissions Reductions: Motivators, Obstacles and the Role of Germany; Perspectives from China, India, Russia and the US" (ESI Seminar)

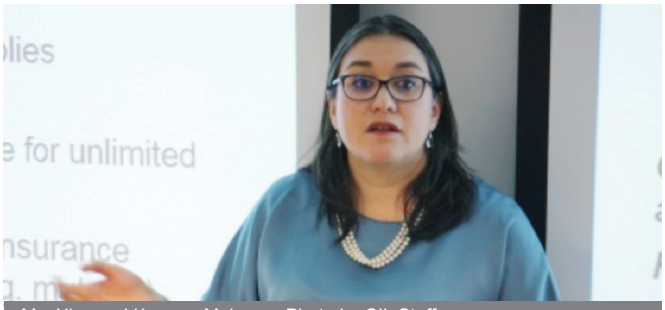

Ms. Grażyna Pulawska, Professor Ho Juay Choy and Ms. Melissa Low (Left to right). Photo by ESI Staff.


Welcome remarks by ESI's Ms. Jacqueline Tao and the Director of KAS RECAP, Dr. Peter Hefele. Photo by ESI Staff.


Mr. Jasper Eitze speaking about the KAS Study. Photo by ESI Staff.

This expert discussion was part of a series of presentations delivered in Beijing, Hong Kong and Singapore of an international Konrad-Adenauer-Stiftung (KAS) Survey. At this discussion, Jasper Eitze, Coordinator Energy, Climate and Environmental Policy at KAS-Berlin presented the major findings of this KAS Regional Project Energy Security and Climate Change Asia-Pacific (RECAP) survey and took a detailed look at the different situations of these four countries which are the world's main producers of emissions. He examined the impact of carbon emission reductions policies ("decarbonisation") on the national development strategies of these jurisdictions, and for Southeast Asia and Singapore. Ms. Grażyna Pulawska, Project Manager, Asia-Europe Environment, Asia-Europe Foundation (ASEF) shared experiences working with Southeast Asian government officials in their attempts to decarbonise their economies. Associate Professor Ho Juay Choy and Ms. Melissa Low from the Energy Studies Institute provided information on Singapore's low carbon emissions policy and response to climate change.

23 March, Nuclear Liability in Practice: The TEPCO Fukushima Daichii NPP Accident (ESI-CIL Joint Seminar)


Ms. Ximena Vásquez-Maignan. Photo by CIL Staff.

Ms. Ximena Vásquez-Maignan, Head of the Office of Legal Counsel at the Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development (OECD) highlighted the importance for countries to be prepared to deal with the legal implications of a nuclear accident. She said that the TEPCO Fukushima Daiichi nuclear power plant accident fully demonstrated that a clear and comprehensive legal framework is necessary to allow the operator of a nuclear installation and, if necessary, its government, to quickly react and adapt to the specific circumstances of events in order to ensure timely and financially adequate compensation to victims. She added that special regimes governing liability for nuclear damage suffered by third parties have been put in place, both at the international level through international conventions, and at the national level through domestic legislations in nuclear power generating countries. However, she also added that these regimes' governing liability have also been adopted by many non-nuclear power generating nations. Using Japan as a case study, she said that legislation on nuclear third party liability, coupled with the innovative mechanisms adopted to supplement such legislation can and will allow for the timely and adequate compensation of victims of a nuclear accident

23 March, Regulatory and Policy Issues Related to Post-Accident Management of Radioactive Waste (ESI-CIL Joint Seminar)


Mr. Patrick Reyners. Photo by CIL Staff.

Mr. Patrick Reyners, former Head of Legal Affairs at the Organisation for Economic Co-operation and Development (OECD) Nuclear Energy Agency (NEA) in Paris delivered a presentation on regulatory and policy issues related to post-accident management of radioactive waste. He noted that existing legislation, albeit applicable, is generic in nature and needs to be supplemented by policy and regulatory measures, as dictated by the particular circumstances of an accident (inventory, removal and storage of contaminated material, extraction of damaged fuel, processing, etc.). He emphasised that the social and economic implications of an accident will inevitably be huge and sensitive, particularly as the ramifications of earlier accidents such as TMI 2 (USA) or Chernobyl (USSR) are still being felt. To make more socially acceptable and efficient decisions, Mr. Reyners said that competent authorities

must seek the best technical expertise available and consult with stakeholders. He closed by underscoring the importance of authorities engaging the affected population, with a view to arrive at informed choices and build confidence.

9 March, Nuclear Governance in the Asia-Pacific (ESI-CIL Joint Workshop)

As part of the ESI-CIL Nuclear Governance Project, Dr Trevor Findlay, a senior research fellow in the School of Social and Political Sciences at the University of Melbourne and an associate of the Project on Managing the Atom at Harvard University's Belfer Center for Science and International Affairs, organised a closed-door workshop on "Nuclear Governance in the Asia-Pacific". The event brought together academics from the Asia-Pacific region to discuss the state of nuclear governance in the region in the areas of nuclear safety, security and safeguards; traditional and non-traditional barriers to strengthening regional governance mechanisms; and ways in which the nuclear governance regime in the region may be strengthened. The meeting was sponsored by the Carnegie Corporation of New York.

1 March, Key Issues in China's Energy and Environmental Strategies: Trends in Natural Gas Pricing; Energy Efficiency and Market Integration along One Belt, One Road Initiative; and China's Green Building Development (ESI Seminar)

In this seminar, three visiting PhD candidates from China shared their research on natural gas pricing; market integration and energy efficiency in the countries under China's One Belt, One Road initiative; and the social and psychological factors behind the development of green buildings in China.

Ms. Shi Min, from the Research Institute of Economics and Management (RIEM) at Southwestern University of Finance and Economics, China shared findings from her research which used a systemic time-series approach to show the extent to which fundamental factors contribute to the variation in gas pricing in the United States, Japan and Germany. Her empirical results showed clear cross-country differences and time-varying patterns and demonstrated that supply and demand factors were less relevant to gas prices than oil prices in Germany and Japan, while they are relatively important in the U.S. market. Through rolling-windows and sub-sample analysis, her findings showed that while the price of oil was important in Germany and Japan, its impact on natural gas pricing has declined significantly in recent years.

Mr. Han Lei, from the School of Management and Economics at the Beijing Institute of Technology (BIT), China shared findings from his analysis of the growth and convergence of energy efficiency policies in view of China's One Belt, One Road (OBOR) Initiative. By comparing China's level of technology and amount of energy reserves with countries in Middle Asia, he noted that trade interdependencies between China and its neighbouring Middle Asian countries can increase market integration by intensifying bilateral trade. In fulfilling the objectives of the OBOR through trade interdependence, he addressed questions on whether energy efficiency converges or not and whether market integration positively affects the growth and/or convergence of energy efficiency among the countries in OBOR.

Ms. Liu Yunxia, from the College of Management and Economics at Tianjin University, China, presented her work on pro-environmental behaviours and how these are integrated with building-related research. Her presentation focused on comparing green building strategies in China and Singapore. She advocated moving beyond the technical aspects of greening buildings, and towards recognising the importance of the human element of green buildings (e.g., public perceptions, attitudes and behaviours) in successfully greening new buildings and retrofitting existing ones. However, she pointed out that there are currently inadequate empirical studies which explore the relationship between psycho-social factors and the promotion of green buildings.

17-18 January, ESI-CIL Nuclear Governance Project's Training Course on Civil Liability for Nuclear Damage 2017

The ESI-CIL Nuclear Governance Project organised a two-day training course for Singapore Government officials on civil liability for nuclear damage. This course is the first of a number of short training courses that the project will run for Singapore's government officials and was attended by close to 20 officials from seven different ministries and agencies. The instructors for the course were Dr. Nathalie Horbach, an international nuclear law expert (and a member of the International Atomic Energy Agency's International Expert Group on Nuclear Liability); Professor Gunther Handl, the Eberhard P. Deutsch Professor of Public International Law at Tulane University Law School as well as CIL Senior Research Fellow Mr. Anthony Wetherall. As part of the course, a compilation of selected documents on civil liability for nuclear damage was prepared.

Contact

- Collaboration as a Partner of ESI (research, events, etc)
- Media Enquiries
- ESI Upcoming Events
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The *ESI Bulletin on Energy Trends and Development* seeks to inform its readers about energy-related issues through articles on current developments. Our contributors come from ESI's pool of researchers, local and overseas research institutes, local government agencies and companies in the private sector. You can download past issues from www.esi.nus.edu.sg.

We welcome your feedback, comments and suggestions. The views expressed in each issue are solely those of the individual contributors.

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