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Road Traffic in Hanoi, Vietnam, 2011. Photo by Franzfoto

INTRODUCTION

The theme of this issue is modelling and analysis of carbon markets and carbon pricing strategies.

The increase in global temperatures, rise in sea levels and change in weather patterns have garnered worldwide attention since the 1990s. Scientists attribute these phenomena to the steadily increasing greenhouse gas (GHG) emissions resulting from human activities. Obviously, the ensuing accelerated biodiversity loss, aggravated coastal erosion, and more frequent extreme weather events, etc., will have significant impacts on mankind. In order to prevent climate change from accelerating, many countries/regions have launched comprehensive policy packages to mitigate emissions. Carbon pricing in the form of a tax, emissions trading, border-tax-adjustments, etc., along with investment in emission mitigation activities such as energy efficiency improvements, low-carbon technology RD&D, and the promotion of renewable energy, are some of the major types of policy instruments used. Nevertheless, uncertainty is inevitable throughout the process of designing and implementing policies.

Since the early 1990s, modelling has been widely used in the policy analysis of energy and environmental issues at local, national, regional and global levels, providing quantitative insights into energy RD&D and investment strategies, climate mitigation and adaptation pathways, as well as the associated potential impact on economic development, social welfare, and ecosystem sustainability. In addition, simulating and comparing different scenarios enables us to explore innovative policy designs that could effectively constrain the impact of uncertainty or uncover the potential of existing policy instruments and integration with other instruments.

In this issue of the Bulletin, we offer a compilation of some of the presentations made at ESI's *3rd Asian Energy Modelling Workshop on Carbon Pricing and Investment towards Low Emissions: Uncertainties and Potential*,

In this issue ...

held 25-26 February 2016, to which 12 speakers were invited from Australia, China, Germany, Japan, Norway, Singapore, South Korea and the Philippines. This issue focuses on the modelling and analysis of carbon markets and carbon pricing policies around the world and their implications for Asian countries. The previous issue provided summaries of papers from this event relating to the modelling and analysis of low-carbon technologies and investment strategies.

Ms. Mo Lingshui, a low-carbon development expert at the Asian Development Bank (ADB) in the Philippines, presented "Carbon Pricing Mechanisms and Carbon Market Linkage in Asia and the Pacific". Carbon pricing mechanisms play an important role in incentivising emission reductions and enabling ambitious climate change mitigation programmes. The Paris Agreement established a voluntary mechanism to support the use of internationally transferred mitigation outcomes towards nationally determined contributions, and to promote sustainable development. Carbon pricing mechanisms are increasingly prevalent around the world. The countries with carbon mechanisms constitute 40 per cent of global GDP, and both Asia and the Pacific region have seen rapid development in the carbon market. Assuming that regional linking is indeed possible in Asia and the Pacific, Ms. Mo provided an overview of global carbon market development trends, discussed current carbon market development in Asia and the Pacific, and analysed the pre-requisites for linking carbon markets. She also outlined the key design elements necessary for a linking agreement and explored strategies for countries in the region that are initiating the design process.

Dr. Nico Bauer, research group leader at the Potsdam Institute for Climate Research (PIK) in Germany, presented "Carbon Pricing, the 2°C Target and International Climate Policies: Main Insights from the Global Integrated Assessment Model REMIND-MAgPIE". The Paris Agreement signed in December 2015 was a breakthrough because it reconfirmed the objective of keeping the increase in global average temperature to below 2°C above pre-industrial levels and called for a truly global climate change policy. However, it did not provide a clear, long-term strategy on how this objective can be achieved. The policy instrument of international carbon pricing is an alternative with many advantages, but also shortcomings. The REMIND-MAgPIE model for integrated assessment of global long-term climate change mitigation in the energy and land-use sectors has been used to analyse many issues. Dr. Bauer focused on three main ones: (a) the effectiveness of carbon pricing regimes to trigger the transformations; (b) the effect of delaying carbon pricing until 2030; and (c) carbon pricing of land-use emissions and the interaction with the energy sector and economic value of land.

Dr. Zhou Peng, Professor and Vice Dean of the College of Economics and Management at the Nanjing University of Aeronautics and Astronautics (NUAA) in China, presented "Carbon Emissions Trading in China: Modelling Allowance Allocation". China launched pilot emissions trading schemes in seven provinces/cities in 2013-14, and is planning to establish a national emissions trading scheme in 2017. Professor Zhou began with a brief discussion of the carbon prices in the seven pilot carbon markets, and then discussed the allocation of emission allowances. The evolution of the main carbon emissions allocation methods used in earlier studies can be classified into four approaches, namely, indicator, optimisation, game theory and hybrid. It is observed that the fairness principle dominates the CO_2 emissions allocation method, while the efficiency principle has gradually received attention in recent years. Of the four approaches, the indicator approach is the most commonly used. The others seem to be more encompassing, but tend to reduce the transparency of the allocation results. Professor Zhou explained the modelling results by examining how the choice of allowance allocation method affects the carbon cost pass-through.

Dr. Zhou Xin, Principal Policy Researcher at the Institute for Global Environmental Strategies (IGES) in Japan, presented "Carbon Pricing and Border Carbon Adjustment: Implications for Industrial Competitiveness, Carbon Leakage and International Trade". There have been many proposals to address the competitiveness and carbon leakage concerns arising from the asymmetric international arrangement for mitigating the global GHG emissions under the Kyoto Protocol. Carbon adjustment at the border has received special attention. The objective of the border carbon adjustment (BCA) is to level the playing field between domestic regulated industries and foreign unregulated industries. Dr. Zhou discussed two practical issues relating to the policy design of BCA: (a) how to determine the carbon content of imports/exports, and (b) the hidden inequality in accounting for trade-related emissions in the national GHG inventory when the BCA is implemented. A multi-region computable general equilibrium (CGE) model was applied to assess the economic and environmental impacts of a carbon tax on fossil fuels and BCA in Japan. Their impacts on industrial competitiveness, carbon leakage and trade were assessed based on various scenarios of policy design.

Dr. Cho Yongsung, Professor and Vice President for Development and External Affairs, at Korea University in South Korea, presented "Prospects for Korea's Carbon Emissions Trading: Linking and Offsets". Korea intends to reduce its GHG emissions by 37 per cent below the BAU scenario by 2030, equivalent to a 22 per cent emissions reduction compared to the 2012 level. Part of the reduction goal may be achieved through an emissions trading scheme (ETS). Korea launched a national ETS in January 2015. It was the first nationwide cap-and-trade scheme in operation in Asia. However, Korea's ETS faces several challenges, such as the dominance of a relatively small number of players in the market, and the limitation for many covered entities to access CDM credits which were expected to cover much of the shortfall. In addition, the carbon price seems to reflect the government's intention to allow prices to remain around KRW 10,000 (EUR 7) for market stability, rather than the economics of abatement. To overcome these difficulties, linking the ETS' among Korea, Japan and other countries has been considered. The role of voluntary carbon offsets in Korea's ETS should be strengthened.

Dr. Liu Yu, Associate Professor at the Institute of Policy and Management at the Chinese Academy of Sciences (IPM-CAS) in China, presented "Assessment of the Impacts of Hubei's ETS in China-based or Multi-regional CGE Analysis". Among the seven pilot ETS' in China, the one in Hubei Province is a good representative in terms of its effects on its economy and society; its pilot emissions trading is also very influential. The multiregional CGE model (TermCO_2) was used to simulate the economic and environmental impacts of the pilot ETS on the whole province. The results show that Hubei's pilot ETS has brought about noticeable emissions reduction with relatively limited negative effects on its economy. Hubei's carbon emissions in 2014 were reduced by 1 per cent (6.98 Mt CO_2) and the average carbon price was 34.31 RMB/t-CO_2; the provincial GDP declined slightly by 0.06 per cent (1.48 billion RMB) and the average GDP loss was 212.09 RMB/t-CO_2. Meanwhile, Hubei's economic structure adjusted, and provincial employment and investment decreased by 0.09 per cent and 0.33 per cent, respectively.

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

Dr. Su Bin, Senior Fellow
(On behalf of the ESI Bulletin Team)

Carbon Pricing Mechanisms and Carbon Market Linkage in Asia and the Pacific

Ms. Mo Lingshui, Low-carbon Development Expert in the Asian Development Bank, The Philippines

Thai Airways International Airbus A300-622R, 2011. Photo by Aero Icarus (Permission under CC BY-SA 2.0).

Many governments have adopted or at least debated the merits of the carbon pricing mechanism. By 2015, 39 national and 23 sub-national jurisdictions in five continents had launched or were preparing to price carbon through a carbon tax and/or emissions trading scheme (ETS) based on domestic circumstances and political needs. Generally speaking, more and more countries or regions are choosing emissions trading as their major pricing instrument.

Currently, a low carbon price exists in carbon markets globally due to an oversupply of emission quotas which are caused by compounding factors. It is noted that a cap fails to deliver long-term demand for carbon emissions reduction (i.e., loose cap). Using credits from programmes such as the Clean Development Mechanism and Joint Implementation intensifies the market surplus when emission allowances are over-supplied. Existing banking rules also enable the banking of "hot air", adding further pressure on the market. However, existing systems lack flexibility to adjust market supply and demand. There are also no measures to correct the systematic mistakes in existing emissions trading systems. Experience and lessons from existing emissions trading systems provide the implications for future development of new ones. There is the need for a long-term emission cap against long-term mitigation targets to create long-term mitigation demand as well as a more flexible framework against unexpected changes. Apart from that, strict criteria are needed to define long-term use of emissions reduction credits.

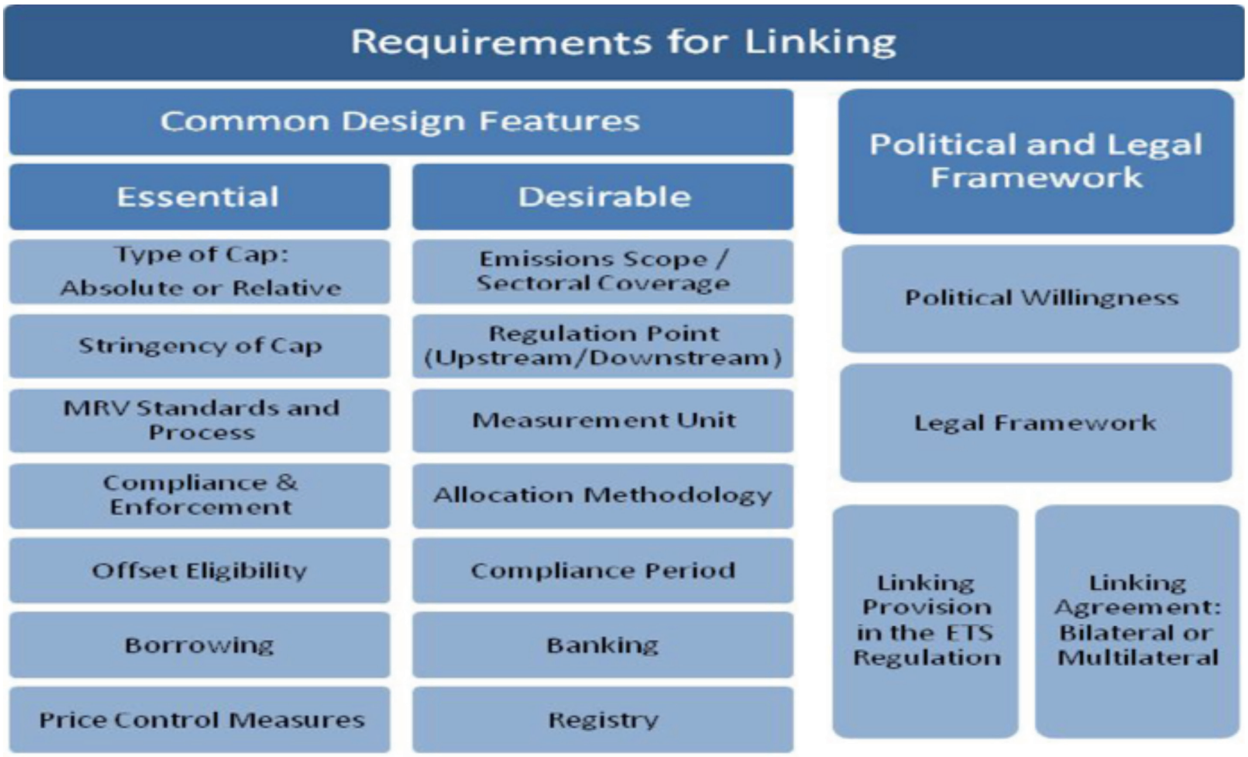
In recent years, many ETS' have emerged in Asia and the Pacific, such as in New Zealand and Australia (repealed) in 2008, Tokyo in 2010, Kazakhstan in 2013, seven Chinese pilot ETS' in 2013-14 and South Korea in 2015. Other countries, such as Thailand, Vietnam, and Indonesia are preparing for carbon trading programmes. Most of these emerging or proposed carbon trading systems have included or considered a component for linking with international markets or other carbon markets in their legislation. Theoretically, linking carbon markets can increase market size, reduce price volatility, reduce the cost of meeting collective mitigation targets and improve the integrity of the environment. This trend of building market linkages around the world will catalyse the creation of an integrated global carbon market.

The 2016 Paris Agreement built a legal foundation for a global carbon market through the linkage of different carbon markets. It also demonstrated that governments around the world are quite positive about contributing to emissions reduction. However, carbon market linkages face several challenges in practice. The linking of different carbon markets requires a similar design among market systems. Figure 1 summarises the requirements for a well-performing linkage framework, and highlights the essential and desirable design elements.

Existing systems are designed differently in terms of key design elements such as stringency of the emissions cap; standards of monitoring, reporting and verification (MRV) and capacity for the implementation of MRV; compliance and enforcement rules; eligibility of credit and banking; price control measures; etc. In addition, the political priority of climate change mitigation differs across countries and this leads to different designs of new systems. There may also be domestic legal issues relating to market linkages.

To reduce the barriers that can hinder the linkage of different market systems in the future, it is suggested that the foundations for linkages be laid early in the research and design processes. It is necessary to apply international standards to MRV and to build capacity for

Figure 1: Requirements for Linking



Source: Mo Lingshui presentation slide.

MRV implementation, implement progressive offset rules, allow flexible and dynamic cost containment measures, and establish robust legal frameworks that clearly describe the emission allowances and credits as financial assets in legal terms.

The development and linking of carbon markets could follow the progressive path of pilots at the regional, national and global levels. The short-term target (before 2020) could be the linking of carbon markets within a country and the long-term target (beyond 2020) could be the linking of ETS' among countries.

For example, take the case of China's plans to link its pilot schemes. Currently, seven pilot ETS' are operating independently in China, and the Chinese government is seeking an effective and suitable approach to building a nation-wide ETS, which is scheduled to commence in 2017. Basically, to comply with the national strategy, the seven pilots have many similarities in design. For example, the caps are absolute but in line with the national carbon intensity reduction target. Each pilot has broad sectoral coverage and a large number of participants. Most allowances are allocated free with ex-post adjustments, and China Certified Emission Reductions (CCER) can be used as offset credits. Borrowing is prohibited but banking between years is allowed in all but the Hubei ETS. Even the compliance period is identical across the pilots.

Not surprisingly, differences also exist in the details. For example, different baselines are chosen for free allocation, slightly different approaches are used in allocation and different methodologies are adopted in the MRV procedures. Eligibility of offset credits (e.g., generated within the province or across China), limits on the use of offset credits, compliance and enforcement frameworks, price management measures, etc., are generally different from one another. In addition to the designs, regulator capacity for compliance and enforcement are different across the pilots in practice.

The assessment shows that there are great economic benefits, a solid political foundation and inherent similarities in the scheme designs which could facilitate the establishing of linkages among the pilots. However, the lack of an ETS legal framework at the provincial level, as well as design differences are key obstacles in linking them up. Therefore, harmonising the key design features of the pilots is necessary before the scheduled linking can take place.

This summary of Ms. Mo's presentation was written by ESI Research Fellow, Dr. Li Yingzhu.

Carbon Pricing, the 2°C Target and International Climate Policies: Main Insights from the Global Integrated Assessment Model REMIND-MAgPIE

Dr. Nico Bauer, Research Group Leader at the Potsdam Institute for Climate Impact Research, Germany

Since the 1970s, CO_2 and other greenhouse gas (GHG) emissions have steadily increased, especially CO_2 emissions from the use of fossil fuels from 2000 to 2010. The financial crisis did not have much impact because it was only a short-term economic downturn rather than structural change.

The key questions are how far we can reach out with the cumulative CO_2 emissions and temperature anomaly, which has a fairly linear relationship, and what are the implications for an economy when emissions caps are used?

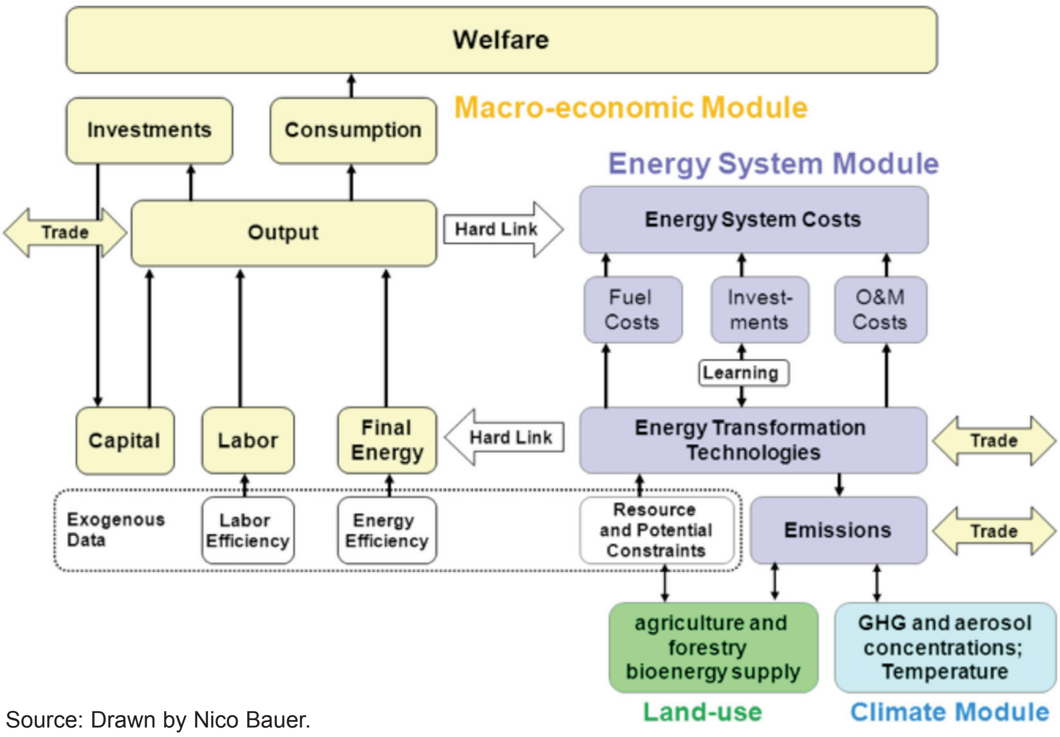
Makati Skyline, Manila, Philippines, 2008. Photo by j_0_n (Permission under CC BY 2.0).

There are several sources of CO_2 emissions, including those in the atmosphere, those resulting from the use of fossil fuels, those from land use, and others. According to the IPCC Working Group III AR5 report, the electricity sector in the baseline scenario would experience very large increases over the century. When looking at the 450 ppm (or achieving the 2°C target) scenario, reduced emissions from electricity are quite significant through bioenergy and carbon capture and storage.

The REMIND (Regional Model of Investments and Development) Model is a global multi-regional model incorporating the economy, the climate system and a detailed representation of the energy sector. It allows for the analysis of technology options and policy proposals for climate mitigation. Figure 1 depicts the structure of the REMIND Model. It combines a macro-economic model with a bottom-up engineering model over a time horizon extending to year 2100. It solves for an inter-temporal Pareto optimum in economic and energy investments in the model regions, fully accounting for interregional trade in goods, energy, carriers and emission allowances.

Putting a cap on fossil fuel usage results in a lower price for the supply side and a higher price for the demand side. At the same time, it reduces the consumer rent but produces the carbon rent (tax revenue and/or auctioning value of a carbon trade system). If applying global uniform

Figure 1: Structure of the REMIND Model



Source: Drawn by Nico Bauer.

Table 1: Emissions of CO_2 Deviations from BAU in 2030

Carbon Price (USD/t- CO_2)	Coal (USD/GJ)	Oil (USD/GJ)	Gas (USD/GJ)
150	16	23	13
50	6.8	15.7	7.8
20	3.9	13.5	6.1
0	2	12	5

carbon prices, the impacts on fossil fuel prices are different as shown in Table 1. For example, the largest impact is on the price of coal, which can change from USD 2/GJ (with no carbon price) to USD 3.9/GJ (with USD 20/t-CO_2), USD 6.8/GJ (with USD 50/t-CO_2) and USD 16/GJ (with USD 150/t-CO_2).

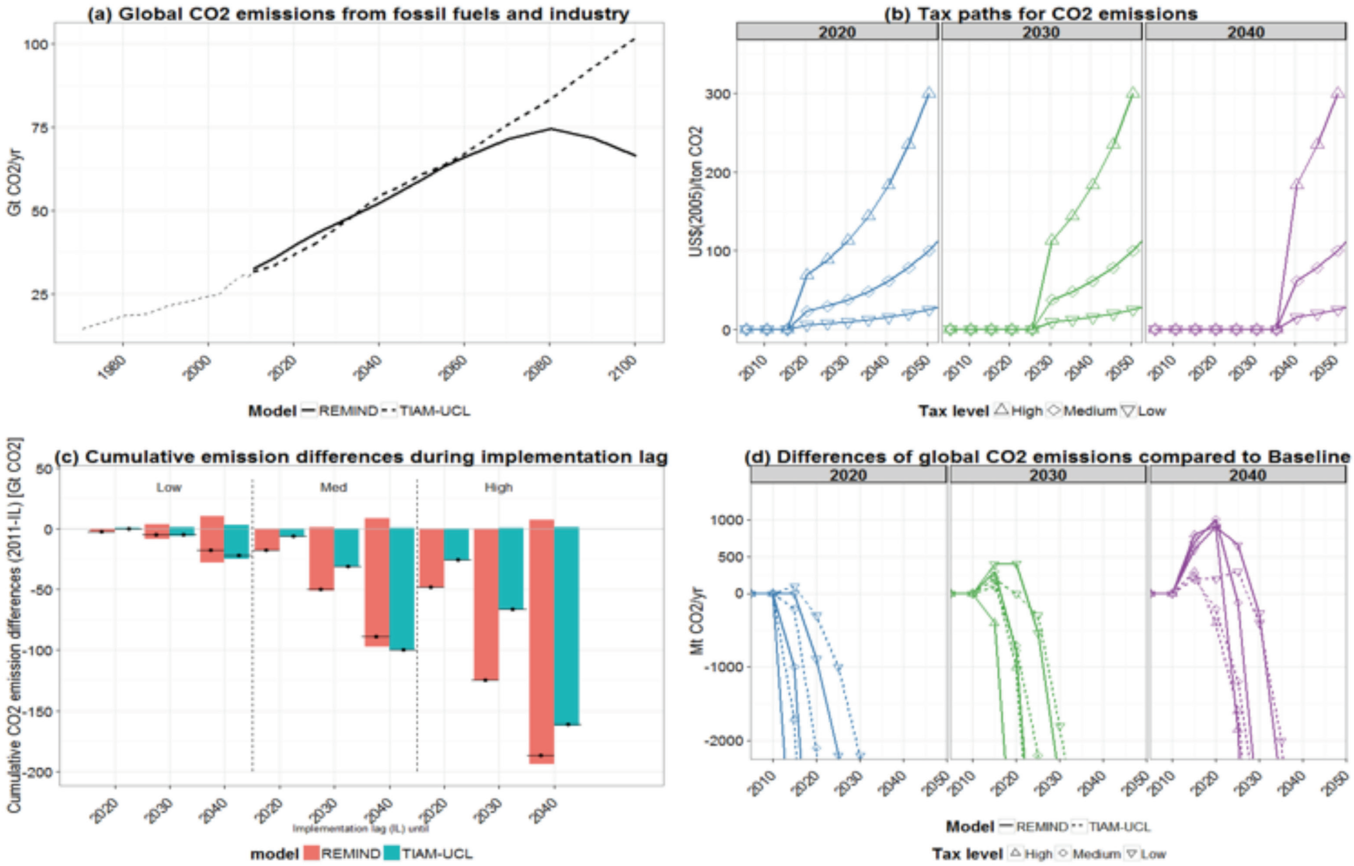
There are contradicting effects from both the supply and demand sides. With the REMIND Model, we can simultaneously assess both sides with a global uniform carbon price. Different tax paths are used for CO_2 emissions, and these are given in Figure 2. For example, the medium-case of tax path starts from 2030 with USD 38/t-CO_2. After imposing these carbon prices, we can see a small supply-side effect. In the medium-case, the cumulative CO_2 that can be saved increases from 20 Gt (starting carbon pricing from 2020) to 50 Gt (starting from 2030) and 95 Gt (starting from 2050). At the same time, we will get a higher electricity price compared with the baseline. Investment in coal power plants would be reduced, and the high carbon price would incentivise low-carbon generation technologies, such as solar and wind.

What is the role of bioenergy and land-use change emissions? If land-use emissions are not priced, more bioenergy will be used to substitute for fossil fuels in the non-electric sectors. Bioenergy leads to increasing pressure on agricultural land, especially pasture lands that are converted into bioenergy cropland. More emissions will be offset by using bioenergy with carbon capture and storage. Carbon pricing can protect forests and lead to land-use intensification. Thus, inclusion of the land-use sector via the Model of Agricultural Production and its Impact on the Environment (MAgPIE) makes a difference as to how the mitigation target is achieved as there is a considerable leakage effect from the land use sector to the fossil fuel sectors.

In summary, global warming is caused by emissions from the energy and land-use sectors. Thus, immediate global pricing of all GHG emissions would be a significant transformative trigger. In the energy sector, it would reduce near term coal use and the power sector's emissions, as well as deforestation. The use of oil and gas would fall after 2030. Delayed carbon pricing would have an adverse effect due to carbon lock-in, but a strong policy announcement would have far-reaching effects. Although there is no carbon price, the signal to investors could have a significant effect on their investments. In the land-use sector, the emissions are also substantial. Carbon pricing reduces deforestation and non-CO_2 emissions, but bioenergy demand can potentially lead to extensive deforestation.

This summary of Dr. Bauer's presentation was written by ESI Senior Fellow, Dr. Su Bin.

Figure 2: Global Uniform Carbon Pricing Impact: Simulation Results



Source: Drawn by Nico Bauer.

Carbon Emissions Trading in China: Modelling Allowance Allocation

Dr. Zhou Peng, Professor at Nanjing University of Aeronautics and Astronautics, China

Wuhan from Yellow Crane Tower, China, 2006. Photo by Yu Hui (Permission under CC BY-SA 2.0).

China adopted carbon emissions trading (CET) schemes in order to reduce CO_2 emissions intensity by 65 per cent from 2005 to 2030, and to reach the CO_2 emissions peak around 2030. The CET pilot scheme first started in Shenzhen in June 2013, followed by Shanghai, Beijing, Guangzhou, Tianjin, Hubei and Chongqing by June 2014. These pilot schemes foreshadowed the implementation of a national policy on CET in 2017. However, the emissions trading scheme (ETS) market has seen significant fluctuations in carbon prices and low liquidity in the market where only two per cent of the entire allocated allowances were traded. The initial allocation of allowances could be one major reason for causing the low liquidity in trading.

Even though the principles governing emissions allocation are controversial, they are generally placed in terms of fairness and efficiency. Allocation methods range from macro-level theoretical studies to real-world application at the micro level. The indicator approach, optimisation approach, game theoretic approach and hybrid approach are devised at the macro level, while implementation, grandfathering, auctioning and benchmarking are devised at the micro level. The single indicator approach allocates emissions reduction targets proportional to key indicators such as population, total emissions, GDP per capita and emissions intensity. The composite indicator considers different sectors together in a multi-criteria decision analysis. In the optimisation approach, linear programming and non-linear programming models are used. The game theoretic approach can be considered at the firm and country level. In the hybrid approach, allowances for a gradual increase in the number of participating regions and level of reductions are made according to the participation threshold and allocation rules. The indicator approach has the advantage of simplicity and ease of use, but the approach is not universally accepted. Other approaches are more encompassing but less transparent.

Analysis of past studies on emissions allocation indicates that in almost all cases, emission permits/reductions were used as the targeting indicator for allocation. A few studies made emission intensity reductions the targeting indicator. It was found that 67 per cent of the studies followed the fairness principle, while 28 per cent followed the efficiency principle to examine emissions allocation, while five per cent followed both. Similarly, for allocation methods, 73 per cent of the papers used the indicator approach with the single indicator approach being more popular than the multi-indicator approach. The share of studies using the optimisation approach was 11 per cent, followed by the hybrid approach at 10 per cent and the game theoretic approach at seven per cent. The indicator approach shows that allocation methods based on equal per capita emissions and equal per capita cumulative emissions have received consideration at the country level, while grandfathering has been extensively examined at the regional level.

Allocation principles at the regional level depend on the perspective of policy-makers. If the fairness principle is considered, the indicator and hybrid approaches seem to be suitable. When the efficiency principle is considered, the optimisation approach is preferred. If interactions between participants are considered, then the game theoretic approach is preferred. For allocation of emission reduction targets at the firm level, grandfathering is the most popular way followed by benchmarking and auctioning. From the perspective of efficiency, auctioning is the most efficient approach followed by benchmarking and grandfathering.

As for emission permit allocation affecting CO_2 cost pass-through, defined as the impact of the CO_2 emission permit price on the product price due to the implementation of a CET scheme measured by CO_2 cost pass-through rate, there are three types: higher, average, and lower. A higher rate of CO_2 cost pass-through indicates consumers bear most of the CO_2 cost, which tends to affect low income groups disproportionately but reduces product consumption to a certain degree. A lower rate shows that the CO_2 cost would be mainly undertaken by the manufacturers, subsequently encouraging the investment of carbon efficient technologies but possibly putting domestic carbon intensive industries at a disadvantage.

A survey of the literature on CO_2 cost pass-through shows that most studies examine the CO_2 cost in the context of power markets in the European Union's ETS, while a few examine other oligopolistic industries such as the cement and petroleum industries. Theoretical analysis of CO_2 pass-through modelling includes the Cournot–Nash Model, Oligopoly Market Model, Cournot Competition Model, COMPETES Model, TIMES, linear programming, autoregressive distributed lag model, vector error correction model, Multivariate GARCH Model and regression model.

To summarise, the CO_2 emission permit allocation method plays an important role in understanding the degree of the CO_2 cost pass-through rate. The degree of the CO_2 cost pass-through rate is dependent on the product market structure. Under constant production costs and linear demand assumptions, the more competitive the industry is, the greater the CO_2 cost pass-through rate becomes. The CO_2 cost pass-through rate is also dependent on carbon intensity and definition. High carbon intensity gives rise to a production price under whatever allocation methods when the CO_2 cost pass-through rate refers to the proportion of the CO_2 emission permit price that is passed through to the product price. The CO_2 cost pass-through rate is also dependent on carbon intensity and definition. The implementation of a CET system has a negative impact on the industry's total output whatever the allocation method is used, and the optimal emissions reduction is determined only by the marginal abatement cost coefficient of the firm and CO_2 emission permit price of the carbon market. It can therefore be concluded that the benchmarking rule is a better choice in the early stages of carbon emissions trading, while the auctioning rule is quite suitable when the CET is well developed.

This summary of Dr. Zhou's presentation was written by ESI Research Associate, Mr. M.P. Hari.

Carbon Pricing and Border Carbon Adjustment: Implications for Industrial Competitiveness, Carbon Leakage and International Trade

Dr. Zhou Xin, Principal Policy Researcher at the Institute for Global Environmental Strategies, Japan

Mumbai, India, 2015. Photo by Aleksandr Zykov (Permission under CC BY-SA 2.0).

In December 1997, the Kyoto Protocol was adopted as a legally binding international treaty. It required a five per cent reduction of greenhouse gas (GHG) emissions by developed countries collectively (eight per cent reduction for Europe, seven per cent for the US and six per cent for Japan) from the 1990 levels over the 2008 to 2012 period. Developing countries were not required to do so, and this made for asymmetric conditions between the developed and developing countries in implementing their domestic climate policies.

This leakage in the international arrangement also had major

Table 1: Scenario Settings in the Simulation

Scenarios	Direct Emissions Criteria	Embodied Emissions Criteria	Remarks
BAU	√		
CTax	√		
BTA1	IM_Dir	IM_Emb	Imports only
BTA2	EX_Dir	EX_Emb	Exports only
BTA3	IMEX_Dir	IMEX_Emb	Both imports and exports
NIAfT	√		

implications for international trade and competitiveness. Developed countries have typically adopted carbon pricing policies in the form of a carbon tax or through emissions trading. The business sectors have had many concerns about these carbon pricing policies as they have increased production costs and terms of trade, thus adversely impacting industrial competitiveness. Of particular concern have been the energy intensive and trade exposed (EITE) sectors, such as iron and steel, cement, aluminium, pulp and paper, and chemicals.

Domestic carbon policy implementation can also impact the carbon leakage. Leakage can occur through three channels (a) production channel: short-term competitiveness due to the carbon-constrained industries losing international market share; (b) investment channel: relocation of capital to countries with less stringent climate policies due to differences in the returns to capital investment; and (c) energy channel: reduced energy demand in countries with a climate policy causes reduction in global energy prices and triggers higher energy consumption and increased CO_2 emissions in non-binding countries.

To address the issues of industrial competitiveness and carbon leakage, a border carbon adjustment (BCA) can be employed. The rationale is to use trade measures to level the playing field by applying similar costs to competing countries through the treatment of traded goods (either imports or exports) at the border. There are different ways to carry out the adjustments depending on the domestic carbon pricing policies implemented. Under the carbon tax system, a border tax adjustment (BTA) can be used, which levies an import carbon tax or provides an export rebate; under a cap-and-trade system, the BCA can require importers to surrender allowances corresponding to the emissions embodied in their goods.

There are also various practical issues relating to the policy design of a BCA, such as imports/exports only or a combination of both, sector coverage and criteria for carbon intensity (inclusion of indirect emissions from electricity). One of them is the criteria for determining the carbon coverage. The structure of the carbon emissions and costs includes (a) direct carbon emissions; (b) indirect carbon emissions from electricity use; and (c) indirect emissions embodied in upstream production. An effective and fair BCA should ensure that the carbon coverage of the subject imports/exports is the same as the carbon coverage defined by the domestic carbon pricing policy. Two criteria for carbon coverage are direct emissions (based on producer responsibility) and embodied emissions (based on consumer responsibility).

In this paper, a case study of Japan was carried out to assess the impacts of domestic carbon pricing policy and the BCA. To achieve the Kyoto Protocol's six per cent reduction target, the Japanese government promulgated a law to cope with global warming in 1998, and a target achievement plan in 2005. Ambitious targets were set: a 25 per cent reduction in GHG emissions compared to the 1990 levels by 2020, and an 80 per cent reduction by 2050. More recently, from 2012, Japan implemented a carbon tax on top of the current Petroleum and Coal Tax: Phase-wise by charging JPY 95/t-CO_2 (2012-2014), JPY 190/t-CO_2 (2014-2016) and JPY 289/t-CO_2 (2016 onward).

A multi-region computable general equilibrium (CGE) model, named GTAP6inGAMS, was used in the simulation analysis. The data (the GTAP and GTAP-E database) covers Japan and its major trading partners: China, Korea, India, USA, ASEAN and the rest of the world (RoW), and 39 sectors for each country (including six EITE sectors). The analysis sought to (a) examine the impacts of using direct versus embodied emissions criteria on the effectiveness of BTA measures; and (b) assess the impacts of the carbon tax policy in Japan and the introduction of the BCA and National Inventory Adjustment for Trade (NIAfT).

There were six scenario settings in the simulation as shown in Table 1. Three are BTA scenarios: the BTA-1 Scenario applies the adjustment only on imports; the BTA-2 Scenario applies only the export rebate; and the BTA-3 Scenario applies both imports and exports adjustments. The main results on environmental effectiveness and industry competitiveness are summarised in Table 2.

Table 2: Summary of the Results

Policy scenarios	Environmental effectiveness				Competitiveness	
	Domestic reductions	Reductions in ROW	Global reductions	Carbon leakage	EITE sectors	Economy-wide effects
CTax	+	−	−	+	−	−
IM_Dir	−	+	+	−	+	−
EX_Dir	−	+	+	−	+	+
IMEX_Dir	−	+	+	−	+	−
IM_Emb	−	+	+	−	+	−
EX_Emb	−	+	+	−	+	+
IMEX_Emb	−	+	+	−	+	+
NIAfT	−	+	+	−	+	−

A carbon tax can reduce domestic emissions, trigger a carbon leakage and have negative impacts on the EITE sectors. There are also economy-wide effects. Different border carbon adjustment measures all increase the emissions in Japan, decrease the emissions in the RoW, contribute to global emissions reductions and can improve the competitiveness of the EITE sectors in Japan. Notably, the BTA scenario with an export rebate can improve both the competitiveness of EITE sectors and economy-wide effects. Since the BCA measure is a very strong trade measure, it will be challenged by World Trade Organisation (WTO) rules.

In summary, the international climate change treaty has profound implications for trade, international competitiveness and carbon leakage. Carbon tax policies in Japan can reduce domestic emissions but at the same time trigger carbon leakage. However, both effects are quite small because the carbon tax implemented in Japan is very low. Carbon tax policies in Japan will impact the competitiveness of domestic industries adversely, including the EITE sectors and the whole economy. However, the impacts are very small.

The three BTAs can effectively address the competitive issues. BTA2 (with an export rebate) has effects on both the EITE sectors and the economy as a whole. The three BTAs are effective in addressing the emissions out of the border and thus also the leakage. BTA3 (with both imports and exports adjustment) is the most effective. However, due to the negative carbon leakage from Japan to the RoW, they might be challenged by WTO rules. For using direct versus embodied emissions criteria, embodied emissions-based BTAs can be more effective in addressing the two concerns (competitiveness and carbon leakage) than direct emission criteria-based BTAs.

This summary of Dr. Zhou's presentation was written by ESI Senior Fellow, Dr. Su Bin.

Prospects for Korea's Carbon Emissions Trading Scheme: Linking and Offsets

Dr. Cho Yongsung, Professor at Korea University, South Korea

Busan Harbour, South Korea, 2008. Photo by Henri Bergius (Permission under CC BY-SA 2.0).

South Korea's GHG emissions have grown rapidly since the 1990s. By the year 2010, CO_2 emissions from fuel combustion amounted to 563 million tonnes, of which nearly 50 per cent came from coal. In all, more than 90 per cent of the emissions were from fossil fuels. In terms of sector, almost 70 per cent were from the energy sector. By 2013, Korea accounted for 1.78 per cent of total global CO_2 emissions, ranking seventh in the world. Between 1990 and 2011, Korea's GHG emissions grew over two-fold, from 296 million tonnes to 698 million tonnes, with more than 80 per cent coming from the energy sector. Despite these high volumes of GHG emissions, Korea's efforts to reduce GHG intensity, emissions per unit of GDP and energy intensity have shown some success (see Figure 1). However, Korea's energy intensity was 0.19 tonnes of oil equivalent (toe) per USD 1,000 in 2010, while the average of the IEA countries was 0.15 toe per USD 1,000. This difference shows that Korea still needs to devote more effort to reducing its energy intensity.

National Target for GHG Abatement

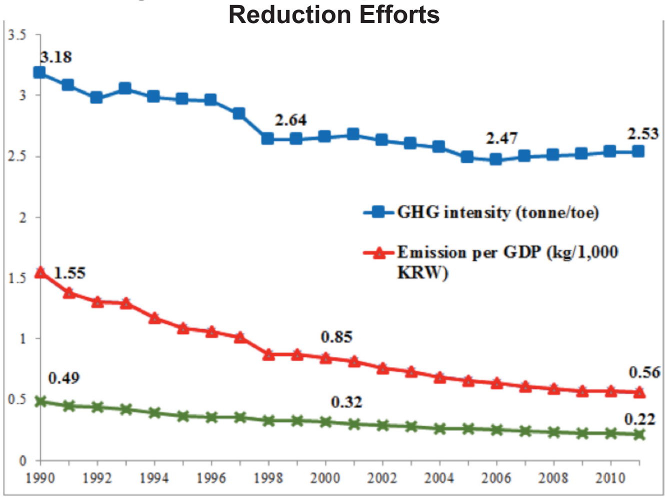
The national target for GHG abatement is to reduce GHG emissions by 30 per cent compared to the BAU case by 2020, and by 37 per cent compared to the BAU case by 2030. These are somewhat ambitious targets. However, they are only relative as the BAU may also change as time passes. To achieve them, several mitigation actions have been implemented, including: purchasing international credits, establishing an emissions trading scheme (ETS) and GHG and energy target management systems (TMS), setting obligations for renewable energy and setting energy efficiency standards in the building and transport sectors. The TMS was launched in 2010 and implemented in 2012; it covers 68 per cent of the total GHG emissions. By 2014, 560 entities were involved in the scheme with most from the power and industrial sectors. Table 1 shows the CO_2 reduction targets under the TMS in 2014 relative to the fact that the CO_2 emissions in 2013 were 626 million tonnes.

TMS' are similar to ETS' in terms of their measurement, reporting and verification (MRV) process and the cap-setting process. However, under the TMS, there are no tradable emission permits, and banking and financing are also not flexible. There is no proportional penalty under the TMS, whereas only a fixed penalty of USD 10,000 would be imposed on the offenders. Korea's ETS, launched in 2015, covers 525 entities. During the first compliance period (2015-2017), 1,687 million tonnes of CO_2 emissions were allocated, with the power and energy sector, along with the steel, petrochemical and cement sectors together accounting for nearly 80 per cent of the total emissions.

Strategy to Reduce GHG Emissions

An important strategy to accomplish Korea's carbon reduction targets is the use of forest sinks, as forest projects are regarded as one option for carbon offsets in the voluntary and compliance markets. The role of forest owners is important in forest carbon offset projects because private forests account for about 68 per cent of Korea's total forests. Therefore, incentives for forest owners are needed for their active participation. Several projects are promulgated under the forest sink strategy, including: forest development projects, forest management projects, revegetation projects, wood product utilisation projects, etc. Among them, the revegetation projects, forest development projects and forest management projects number 53 in total, of which 17 can sell credits in the market and 33 are of non-transaction

Figure 1: Positive Aspects of Korea's Reduction Efforts



Note: Using GHG emissions (excluding sinks), nominal GDP, and primary energy consumption.

Source: Drawn by Cho Yongsung.

Table 1: TMS Targets in 2014

Government	MOTIE		MAFRA		MOLIT		MOE	Total
Sector	Power	Industry	Food	Wood	Building	Transport	Waste	
Entity (company)	37	389	28	7	51	15	33	**560**
Expected emissions ($MtCO_2$)	274.5	308.7	3.1	0.45	5.4	4.7	9.2	**606.1**
Target (Mt CO_2)	262.2	305.5	3.1	0.44	4.9	4.6	8.3	**589.1**
Abatement Rate (%)	**4.48**	**1.05**	**1.05**	**1.22**	**8.34**	**2.07**	**9.19**	**2.80**

Note: Ministry of Trade, Industry and Energy (MOTIE), Ministry of Agriculture, Food and Rural Affairs (MAFRA), Ministry of Land, Infrastructure and Transport (MOLIT), Ministry of Environment (MOE).

Source: Korea Ministry of Environment press release (23 October 2013).

type, i.e., merely for the purpose of exercising. It is found that Korean companies would pay USD 5.45/tCO_2 and USD 7.77/tCO_2 for forest carbon credits, in domestic and overseas forest carbon projects, respectively.

Mutual Impacts on the Economy and Environment from GHG Reduction in Japan and Korea

A multi-sector, computable general equilibrium model was used to analyse the impacts of the ambitious low-carbon strategy on the Korean and Japanese economies. To do this, three scenarios were drawn. In Scenario 1, each country meets its own target independently, without an international ETS. In Scenario 2, Korea and Japan link each domestic ETS together and allow permit trading, but other countries reduce their GHG emissions independently. In Scenario 3, Japan, South Korea and Annex B countries allow CO_2 emissions trade, but other countries reduce GHG emissions independently.

It is found that Scenario 2 is the best option for Korea as it costs the least for permit trading. Therefore, important future policy issues need to include policy cooperation and coordinated policy implementation. Collaboration between Japan and Korea in the design of global warming policy and a coordinated establishment of emissions markets would stimulate the creation of new emissions trading markets and related businesses in Asia and also foster the transition of Asian countries to low-carbon economies. Japan and Korea are responsible for making appropriate levels of international contributions with respect to global warming issues but must actively address issues such as border tax adjustments by bearing carbon costs.

This summary of Dr. Cho's presentation was written by ESI Research Fellow, Dr. Lixia Yao.

Assessment of the Impact of Hubei's ETS in a China-Based or Multi-Regional CGE Analysis

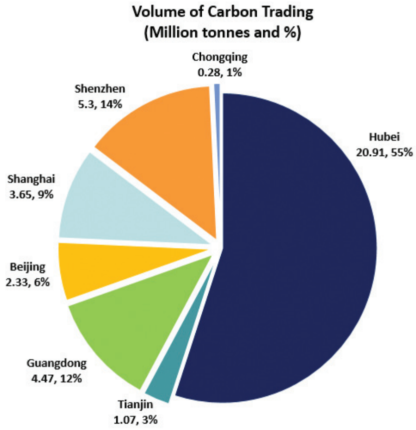
Dr. Liu Yu, Associate Professor at the Institute of Policy and Management, Chinese Academy of Sciences, China

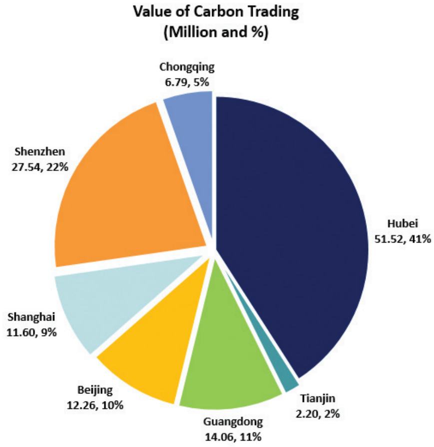
China has been actively involved in controlling GHG emissions and improving its ability to adapt to climate change. In the short run, China formulated the "1617" target by which energy intensity must decrease by 16 per cent, and carbon intensity must drop by 17 per cent during the 12th Five-Year Plan (2015). In the medium term, China also put forward the "4045" target, whereby emissions per unit of GDP would fall by 40 to 45 per cent in 2020, compared to their levels in 2005. In the long run, China plans to peak its carbon dioxide emissions by around 2030, while emissions per unit of GDP are to fall by 60 to 65 per cent (Intended Nationally Determined Contribution). In order to achieve the target at least cost, market-based mechanisms can play significant roles as they allow more flexibility with respect to where GHG emissions are to be reduced. They can also build countries' abilities to invest in more cost-effective mitigation options and create continuous incentives for improvement.

In 2011, China announced the launch of pilot ETS' in seven municipalities and provinces (Beijing, Chongqing, Shenzhen, Guangdong, Hubei, Tianjin, and Shanghai). During 2013 and 2014, these seven pilots were operated cumulatively, covering about 1.2 billion tonnes of GHG and becoming the second largest carbon trading market after the Europe Union Emissions Trading Scheme (EU ETS). It is therefore useful to make a quantitative estimation of the pilot ETS', especially for their economic and environmental effects, which will provide a basis for the scientific decisions necessary to implement a nationwide ETS.

Xiaogan, Hubei Province, China, 2011. Photo by Brian Dell (Permission under CCO 1.0).

Figure 1: The Largest Carbon Trading Market: Hubei Province





Source: Drawn by Liu Yu.

The Typical Pilot: Hubei Province

Compared to the others, the Hubei Pilot ETS has distinctive characteristics in terms of its socio-economic and energy contexts. Hubei is the only pilot in central China with a heavy industrial structure, and also the only one to base its coverage entirely on energy consumption. At present, Hubei is still in the process of rapid industrialisation. Its GDP per capita is only slightly higher than China's national average (RMB 42,539 in Hubei compared to RMB 41,805 in China as a whole). The industrial sector is the major source of economic growth and carbon dioxide emissions in Hubei, and is the most comparable to China's national industrial structure. Like China, Hubei relies heavily on coal as its primary energy source. Hubei's pilot ETS has been operating for over a year and has been a pioneer among all the pilots for its stable operating system, constant innovation in carbon finance and various top ranking trading indexes nationwide. Consequently, assessing the impacts of the Hubei Pilot ETS on the economy and environment not only contributes to a better understanding of its own functioning, but also has important implications vis-à-vis establishing a nationwide ETS.

Methodology and Data

The literature survey, including one on multi(inter)-regional CGE (Computable General Equilibrium) models, CASISD-R (Institutes of Science and Development of CAS-Region) models, IRIO (Inter-regional Input Output) models, MRIO (Multi-Regional Input Output) models, etc., provides a detailed description of the ETS Module which introduced sectors into the CGE model. In order to estimate the economic and environmental impacts of Hubei's Pilot ETS, the Chinese multi-regional general equilibrium model (TermCO_2) was used, while setting a scenario based on the institutional factors of Hubei's Pilot ETS. Simulations were then performed on the economic and environmental impacts of the pilot ETS on the whole province.

Data comes from the 2007 Provincial Input-Output Tables of China published by the National Bureau of Statistics. It contains 30 provinces and 42 industries. Provincial trade and tariff data were collected from China Customs. The simulation software was from Gempack (General Equilibrium Modelling PACKage) developed by CoPS (Centre of Policy Studies).

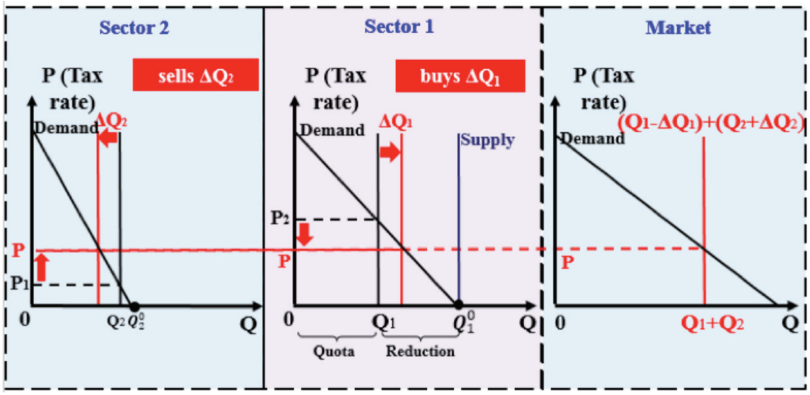
Conclusions and Policy Implications

After applying a Chinese multi-regional general equilibrium model (TermCO_2) to Hubei Province's data, the following conclusions were reached: (a) Hubei's carbon emissions were reduced by 1.00 per cent (6.98 million tonnes) and the provincial GDP declined by 0.06 per cent (1.48 billion yuan) in 2014; (b) The elasticity of GDP to carbon reduction in Hubei was 0.06, and the average GDP loss was 212.09 yuan per tonne; (c) The provincial employment and investment rates decreased by 0.09 per cent and 0.33 per cent, respectively.

The policy implications are: (a) Market-based measures should play an important role in emissions reduction; the authorities should support the carbon trading system because it can sharply reduce the cost of emissions reduction. (b) The other effects should be taken into account, as not all parties can benefit from the carbon trading; it is therefore necessary to build a compensation system which ensures enthusiasm on the part of all the parties participating in the trading. (c) The selection of the region needs to be carefully determined; it is better to choose developed provinces because developing regions will suffer losses and existing regional disparities could worsen. (d) It is helpful to adjust the economic structure; promoting ETS will improve the structure of domestic demand and transform the pattern of economic development.

This summary of Dr. Liu's presentation was written by ESI Visiting PhD student, Ms. Zaijing Gong, from the Harbin Institute of Technology.

Figure 2: ETS Module: Between Sectors from Non-trading to Trading



Source: Drawn by Liu Yu.

Staff Publications

Internationally Refereed Journals

Philip Andrews-Speed, Qiu Mingda and **Christopher Len**, "Chinese Engagement in Southeast Asian Energy and Mineral Resources: Motivations and Outlook", *Eurasian Geography and Economics* 57 (2016): 316-42.

Laura Allison and **Monique Taylor**, "ASEAN's 'People-oriented' Aspirations: Civil Society Influences on Non-traditional Security Governance", *Australian Journal of International Affairs* 71 (2016): 24-41.

Jacqueline Tao and Anton Finenko, "Moving beyond LCOE: Impact of Various Financing Methods on PV Profitability for SIDS", *Energy Policy* 98 (2016): 749-58.

Allan Loi and Soh Leng Loo, "The Impact of Singapore's Residential Electricity Conservation Efforts and the Way Forward: Insights from the Bounds Testing Approach", *Energy Policy* 98 (2016): 735-43.

Meng Yanyi, **Su Bin**, Elspeth Thomson, Zhou Dequn and Zhou Peng, "Measuring China's Regional Energy and Carbon Emission Efficiency with DEA Models: A Survey", *Applied Energy* 183 (2016), 1-21.

Victor Nian, "Impacts of Changing Design Considerations on the Life Cycle Carbon Emissions of Solar Photovoltaic Systems", *Applied Energy* 183 (2016), 1471-87.

Victor Nian, "The Carbon Neutrality of Electricity Generation from Woody Biomass and Coal, a Critical Comparative Evaluation", *Applied Energy* 179 (2016), 1069-80.

Ju Keyi, **Su Bin**, Zhou Dequn, Wu Junmin and Liu Lifan, "Macroeconomic Performance of Oil Price Shocks: Outlier Evidence from Nineteen Major Oil-related Countries/ Regions", *Energy Economics* 60 (2016), 325-32.

Ang B.W., **Su Bin** and Wang Hui, "A Spatial-temporal Decomposition Approach to Performance Assessment in Energy and Emissions", *Energy Economics* 60 (2016), 112-21.

Books and Book Chapters

S.K. Chou and M.P. Hari, "Lessons from International Experience for Energy Market Reform in Bangladesh" (Ch.8) in *International Best Practices in Power and Energy Sector: Lessons for South Asia and Bangladesh*, Institute for Policy Advocacy and Governance, Dhaka, Bangladesh, 2016.

Policy Briefs

Melissa Low and Rajesh Rangarajan, "Post-Paris COP21: 'Facilitative Sharing of Views', Transparency and Climate Action in Southeast Asia", *ESI Policy Brief* 14, 22 September 2016.

ESI Reports

Energy Studies Institute, *Perspectives on China's Rise as a Maritime Power and its Quest for Energy Security, 27-28 August 2015*, Meeting Summary (Singapore: ESI, 2016).

Energy Studies Institute, *Energy Transitions and a Globalised Arctic: The Role of Science, Technology and Governance, 17-19 August 2016*, Event Report (Singapore: ESI, 2016).

Staff Presentations and Moderating

15 December Brantley Liddle presented, "The Urbanisation, Development, Environment, and Inequality Nexus: Stylised Facts and Empirical Relationships" at the *Workshop on Urbanisation in Asia: Economics and Social Consequences,* organised by the Asian Development Bank Institute and Sogang University, Seoul.

2 December Gautam Jindal presented, "Frequency Balancing for PV Integration in Small Isolated Electricity Markets: Singapore", at the *Third Asia-Pacific Solar Research Conference*, Canberra, Australia.

29 November Christopher Len presented, "The Significance of the Indian Ocean and the Role of China" at the Institute of South Asian Studies, National University of Singapore.

25 November Anthony D. Owen presented, "Benefits of Interconnected Markets" at the *Interconnecting ASEAN Electricity Markets Workshop* organised by the Konrad Adenauer Stiftung (KAS) in Singapore.

25 November Anton Finenko presented, "LTMS Interconnection: Lessons from International Experiences" at the *Interconnecting ASEAN Electricity Markets Workshop* organised by the Konrad Adenauer Stiftung (KAS) in Singapore.

15 November Melissa Low presented, "Singapore's Approach to Energy Efficiency, Security and Climate Change", at COP22 Korean Pavilion, Marrakech, Morocco.

12 November Christopher Len presented, "Energy Security" at *Rising Experts' Roundtable Discussion, 7th Xiangshan Forum*, Beijing.

10 November Victor Nian moderated at ESI's *Singapore-China Energy Forum 2016: Energy and Environmental Strategies in China's 13th Five-Year Plan and Beyond*, Hotel Jen Tanglin, Singapore.

10 November Jacqueline Tao moderated at *ESI's Singapore-China Energy Forum 2016*: *Energy and Environmental Strategies in China's 13th Five-Year Plan and Beyond*, Hotel Jen Tanglin, Singapore.

10 November Melissa Low presented, "Challenges for Implementing Climate Adaptation Law in Singapore", at *Attaining the Sustainable Development Goals Conference*, organised by the NUS Law School's Asia-Pacific Centre for Environmental Law et al., Shaw Foundation Alumni House, NUS.

1 November Melissa Low, presented, "Paris Agreement: A New Era in Climate Change Governance?", for GL2103 Global Governance, U-Town, NUS.

31 October Melissa Low presented, "Key Legal and Procedural Issues from the Paris Climate Change Agreement" for LX5103 Environmental Law, NUS.

28 October Philip Andrews-Speed moderated a roundtable, "Cybersecurity Strategies in Power Generation: Defence or Resilience?" organised by ESI for the *Singapore International Energy Week 2016* at Marina Bay Sands Expo and Convention Centre.

27 October Philip Andrews-Speed moderated a roundtable, "China Energy Security and Connectivity" organised by the Chinese Academy of Social Sciences and Institute for the Analysis of Global Security for the *Singapore International Energy Week 2016* at Marina Bay Sands Expo and Convention Centre.

25 October Allan Loi presented, "Analysing Elasticity Trends for Singapore Household Electricity Demand: Implications for Policy Making and the Rebound Effect", at the *United States Association for Energy Economics (USAEE/IAEE) Conference* organised by the IAEE Association, Tulsa, Oklahoma, USA.

21 October Melissa Low presented, "Singapore's Experience in Addressing Climate Change", at the *2nd Green School International Conference*, Jeju Island, South Korea.

13 October Su Bin presented, "Multi-region Comparisons of Emission Performance: The Structure Decomposition Analysis Approach", at Fudan University, Shanghai, China.

12 October Melissa Low presented, "The Emergence of the Sharing Economy and Implications on Singapore", at the *7th Leaders in Urban Governance Programme* (LUGP), Ministry of National Development, Singapore.

12 October Su Bin presented, "Multi-region Comparisons of Emission Performance: The Structure Decomposition Analysis Approach", at Southwestern University of Finance and Economics, Chengdu, China.

11 October Su Bin presented, "Multi-region Comparisons of Emission Performance: The Structure Decomposition Analysis Approach", at the Development Research Centre of the State Council, Beijing, China.

10 October Su Bin presented, "Multi-region Comparisons of Emission Performance: The Structure Decomposition Analysis Approach", at China University of Mining and Technology, Xuzhou, China.

10 October Li Yingzhu presented, "Economic, Social and Environmental Impacts of Energy Subsidies: Case Study of Malaysia", at the *8th International Conference on Applied Energy*, Beijing, China.

10 October Victor Nian presented, "Incentivising the Adoption of Nuclear and Renewable Energy in Southeast Asia" at the *International Conference on Applied Energy 2016*, Beijing, China.

9 October Su Bin presented, "Multi-region Comparisons of Emission Performance: The Structure Decomposition Analysis Approach", at the Institute of Geographical Science and Natural Resources Research, Chinese Academy of Sciences, Beijing, China.

7 October Jacqueline Tao presented, "Energy Issues in ASEAN: Current Progress and Future Developments", at the *2nd International Symposium on Engineering and Society in Energy Science 2016*, organised by the Graduate School of Energy Science, Kyoto University, Japan.

28 September Su Bin presented, "Singapore Electricity Market Reform and Recent Developments", at *International Conference on China's Power Sector Reform*, Renmin University, Beijing, China.

Staff Media Contributions

Philip Andrews-Speed was interviewed by *Argus Media* on US shale gas coming to Asia, 24 November.

Victor Nian was quoted in "Vietnam's Nuclear Implosion", *Nuclear Forum Asia*, 23 November.

Victor Nian quoted in "Vietnam's Nuclear Implosion: Is the Final Decision a Giant Leap Backwards?", *Asian Power*, 22 November.

Philip Andrews-Speed was interviewed by *New York Times* on China's coal pricing policy, 14 November.

Philip Andrews-Speed was interviewed by *Thomson Reuters* on Tillerson as US Secretary of State: energy implications for Asia, 13 November 2016.

Melissa Low quoted in "What Can Singapore Expect from COP22 in Marrakesh?" by Vaidehi Shah, *National Climate Change Secretariat News*, 11 November.

Philip Andrews-Speed was interviewed by *Radio Free Asia* on China's coal pricing policy, 7 November.

Allan Loi quoted in "Singaporeans Using Less Electricity, Water", *The Straits Times*, 6 November.

Melissa Low, "Progress of Sustainable Development Goal 13 – Climate Action", *UNDP Responsible Business SDG Centre*, 3 November.

Gautam Jindal and Melissa Low, "Commentary: Challenges Ahead in Phasing Down Use of HFCs", *Channel NewsAsia*, 27 October.

Philip Andrews-Speed was interviewed by *China Oil & Gas Monitor* on China's shipbuilding, 27 September.

Melissa Low, "Why the Paris Agreement's Early Entry into Force is Crucial", *Today Newspaper*, 27 September.

Melissa Low quoted in "Paris Climate Deal Poised to Come into Force" by Albert Wai, *Today Newspaper*, 22 September.

Philip Andrews-Speed was interviewed *by Wall Street Journal* on China's national oil company reforms, 14 September.

Philip Andrews-Speed was interviewed by *China Oil & Gas Monitor* on China's oil stocks, 7 September.

Recent Events

16 November, Unleashing the Nuclear Watchdog: Strengthening and Reform of the IAEA (ESI Seminar)

Dr. Trevor Findlay, Senior Research Fellow at the School of Social and Political Sciences at the University of Melbourne and Associate of the Project on Managing the Atom at Harvard University's Belfer Center for Science and International Affairs delivered a presentation on strengthening and reform of the International Atomic Energy Agency (IAEA). He began by providing an overview of the purpose and history of the IAEA before explaining the United Nation's mandates.

Dr. Trevor Findlay (Photo by ESI).

Dr. Findlay noted the safeguards which were included and later strengthened following the 1992 revelations about Iraq's secret weapons programme. He added that safeguards under the IAEA are strengthened by studying the measures under existing legal authority before coming up with additional protocol to increase the reach of inspection powers and information gathering. Although there are already 127 IAEA safeguards with gold standard in force, he noted that application is currently not universal. International cooperation is thus needed to overcome challenges, and he added that the immediate focus should be keeping the momentum going, starting from the IAEA International Conference on Nuclear Security: Commitments and Actions to be held in Vienna, Austria from 5-9 December 2016.

10 November, Singapore-China Energy Forum 2016: Energy and Environmental Strategies in China's 13th Five-Year Plan (ESI Conference/ Workshop)

This forum was convened to examine the Chinese government's new initiatives pertaining to energy that were introduced in the 13th Five-Year Plan (2016-2020). Under the overarching goal of building a moderately prosperous society by 2020, this Plan calls for an "energy revolution" by replacing fossil fuels with cleaner resources and designing proposals to reform the electricity, oil, and gas industries to increase market efficiency. To become a low carbon economy, energy-intensive industries will be subjected to strict regulations of carbon emission standards while the adoption of a "greener" lifestyle will be encouraged. The Plan also reveals commitments to environmental management and protection, proposing to establish a nationwide real-time online environmental monitoring system, and an emissions permit system for static industrial pollution sources.

At this event, some of the speakers delivered presentations on a variety of issues, including energy structural change, energy efficiency pathways, the role of financial markets, coal investments abroad, expansion of natural gas markets and sectoral developments related to climate policies. Others took a macro approach to examine China's "One-Belt-One-Road" strategy, analysed global trade policies under pressure from climate change, and compared regional low-carbon strategies with China's.

Participants at the Singapore-China Energy Forum 2016 (Photo by ESI).

3 November, Easing the Traffic: The Effects of Indonesia's Fuel Subsidy Reforms on Toll Road Travel (ESI Seminar)

Dr. Paul Burke (Photo by ESI).

Dr. Paul Burke, an Economist at the Australian National University shared findings from his study of fuel subsidy reforms in Indonesia. Using data from 19 Indonesian toll roads from 2008 to 2015, he calculated the effects of Indonesia's recent fuel subsidy reforms on motor vehicle travel. The timing of the reforms was determined by budgetary and political factors, providing a suitable setting for estimating a causal effect. Estimates using monthly data suggest an immediate fuel price elasticity of motor vehicle flows on the roads of –0.1, increasing to –0.2 when responses over a year were considered. By the end of 2015, the study estimated that Indonesia's fuel subsidy reforms of 2013 and 2014 had reduced traffic pressure on these 19 toll roads by around 10 per cent relative to the counterfactual without reform. His main conclusion was that a move by the Indonesian government towards an adequate fuel excise system could contribute to more free-flowing traffic while generating revenue for infrastructure and other investment.

28 October, Cybersecurity Strategies in Power Generation: Defence or Resilience? (ESI Roundtable at SIEW)

(Left to right) Dr. Philip Andrew-Speed, Mr. Lim Thian Chin, Mr. Ngai Chee Ban, Mr. Madan Oberoi and Mr. Akhlesh Kaushiva (Photo by ESI).

In view of the surge in cybercrime and cyber-attacks on essential services such as power and banking services around the world, ESI organised a Think-Tank Roundtable at the Singapore International Energy Week (SIEW 2016) on cybersecurity strategies in power generation. The speakers included Mr. Akhlesh Kaushiva, Programme Manager, United States Department of Energy; Mr. Matt Wittenstein, Energy Analyst (Power), International Energy Agency; Mr. Lim Thian Chin, Deputy Director, Head of Critical Information Infrastructure Protection, Cyber Security Agency of Singapore; Mr. Ngai Chee Ban, Operations Leader for Asia Pacific, Honeywell Process Solutions; and Dr. Madan Oberoi, Director of Cybercrime, Interpol Global Complex for Innovation. Dr. Philip Andrews-Speed, Senior Principal Fellow and Head of the Energy Security Division at ESI moderated the panel discussion.

The speakers gave a grim overview of the current cybersecurity landscape in power generation, citing how legacy systems' co-existence with new open systems are a "recipe for disaster". They underscored the need for energy delivery control systems to be able to survive cyber incidents while sustaining critical functions and noted that despite advancements in recent years, an ecosystem of cyber threats exists both up and downstream. Overall, the speakers called for more conviction by power companies to protect their systems against cybercrime and for more awareness among consumers, prosumers and all market participants.

12 October, A Journey of Resilience: Meeting Singapore's Carbon Intensity Targets by 2030 (ESI Seminar)


Mr. Vinod Kesava (Photo by ESI).

Mr. Vinod Kesava, Principal Founder and CEO of Climate Resources Exchange (CRX) gave a presentation on Singapore's journey of resilience in meeting its carbon intensity targets by 2030. To illustrate that energy savings do lead to cost savings, he shared details of several projects aimed at improving industrial energy efficiency in Singapore. A key feature of the projects was the use of an integrative design process through workshops and charrettes in order to address inefficiencies by viewing the parts within the overall industrial system. He added that government grants such as the Design for Efficiency (DfE) Grant help companies offset the costs of organising the workshops and charrettes that led to the identification of inefficient plant processes. Mr. Kesava touched briefly on carbon credit standards and their potential for business value creation. With respect to Singapore's new climate pledges, he underscored the importance of carbon credit standards, given that the Paris Agreement effectively endorsed cooperative international market and non-market approaches and the use of internationally transferred mitigation outcomes (ITMOs) in the future.

New Staff

Brantley LIDDLE, PhD

Dr. Brantley Liddle joined ESI in November 2016 as a Senior Research Fellow. Most recently, he was Vice President/Chief of Research/Special Advisor at the Asia Pacific Energy Research Centre in Tokyo. Prior to that posting, he led the energy/environment-economic modelling research program at the Centre for Strategic Economic Studies at Victoria University in Melbourne, Australia as a senior research fellow. Earlier, he had a postdoctoral fellowship in the population-environment-economy research group at the Max Planck Institute for Demographic Research in Rostock, Germany; he also served as an interdisciplinary economist at the US Department of Energy, where he worked on the National Energy Modelling System.

Dr. Liddle's areas of research interest/expertise include population change and the macro environment; energy and the macro economy; and transport and energy consumption. He earned an interdisciplinary PhD from the Massachusetts Institute of Technology's Sloan School of Management and Department of Civil and Environmental Engineering. He was among the first both to write a sustainability-focused dissertation and effectively complete a PhD in systems engineering at MIT. Dr. Liddle received a combined bachelor of science and arts in civil engineering and political science from Brown University.

Contact

- Collaboration as a Partner of ESI (research, events, etc)
- Media Enquiries
- ESI Upcoming Events
- ESI Mailing List

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