

# Summary Report of the 2<sup>nd</sup> Princeton-China Forum on Energy, Environment & Economic policies

Yuan Xu  
Princeton University

## 1. Introduction

The 2<sup>nd</sup> Princeton-China forum on energy, environment and economic policies was held at Antai College of Economics & Management, Shanghai Jiao Tong University in Shanghai, China on November 3-4, 2009. The forum was in line with the 1<sup>st</sup> one convened at Princeton University on April 18-19, 2008. The participants included faculty, researchers and students from Princeton University and various Chinese institutions as well as international organizations, think tanks, industries, and the Chinese government. The purpose of the forum was to build a platform for the collaboration between Princeton and the Chinese participating units on China's energy, environment and economic policy research, with research findings made available publicly, and helps initiate research projects relevant to policy making and research on China's energy, environment and economic policy issues.

Princeton University and Shanghai Jiao Tong University shared the job of organizing the forum. Two co-organizers were Research Center on Fictitious Economy & Data Science, Chinese Academy of Sciences, and Journal of Environmental Economics and Policy. Financial support came from Gregory and Paula Chow Endowment Fund of the Chinese Economists Society.

The presentations in the forum were organized into six sessions, titled respectively Energy Alternatives, Policies on Carbon Reduction in China, Policy Design of Carbon Reduction, Economic Development and Environmental Regulation (I) and (II), and Environmental Special. The detailed schedule is attached at the end of this summary report. The mixture of talks generated active discussion. To facilitate comparison, this report organizes the presentations a little different from the original structure and puts talks with more similar focus together.

The keynote speech was addressed by Lin Xiao, the vice chairman of Shanghai Municipal Development & Reform Commission. He emphasized the shift of Shanghai to a low-carbon city, particularly in the 12<sup>th</sup> Five-Year Plan (2011-2015). Four aspects would be focused on: adjusting energy structure, energy conservation and pollutant mitigation, alternative energy and energy service, and low-carbon social atmosphere and lifestyle. With the just established Shanghai Environment-Energy Exchange, Shanghai aims to build a platform for carbon trading, especially centering on CDM (Clean Development Mechanism).

This summary report proceeds as the following. Section 2 focuses on presentations addressing technologies for carbon mitigation and scientific research. Section 3 summarizes those on China's environmental challenges. Section 4 covers talks on the projection of China's CO<sub>2</sub> emission trajectories and its mitigation potential. Section 5 presents the participants' insights on how to successfully involve major countries including China into international CO<sub>2</sub> mitigation. Section 6 addresses policies for environmental protection. Section 7 briefly reports a discussion on funding for international cooperation and the information of the 3<sup>rd</sup> forum.

## **2. Technologies for carbon mitigation and science-related research**

### **❖ Energy alternatives**

Session I addressed alternative energy types that could replace conventional fossil fuels. Yiguang Ju, an associate professor at Princeton University, introduced the development of low-carbon alternative fuels and recent progress in combustion research. Both China and the United States relied on import for more than half of their oil consumption. And the world requires significant reduction of CO<sub>2</sub> emissions to prevent unacceptable climate risks. To make the transport sector less carbon intensive and less vulnerable from foreign fuels, two major options are the enhancement of energy efficiency and the development of low-carbon fuels. Princeton is working on synthetic fuel projects, for example, coal-and-biomass to liquids (CBTL) plus CO<sub>2</sub> capture and storage (CCS). The process only requires moderate biomass and can produce large-scale low-carbon synfuels economically. Combustion is responsible for 85% of the world's energy need. Development of kinetic mechanisms and multi-scale modeling tool for synfuel combustion at extreme conditions is the key to increase efficiency and reduce emissions. Collaborative research and development between industry, institution, and government are important for low carbon energy technology.

Zheng Huang, a professor at Shanghai Jiao Tong University, presented the research progress on green energy at Shanghai Jiao Tong University. Three big challenges were recognized for China's energy: energy security, global warming and air pollution. The research of Energy Research Institute at Shanghai Jiao Tong University covers alternative fuels for transportation (particularly DME, bio-ethanol and electrical vehicles), wind and solar power, 4<sup>th</sup> generation nuclear power technology, hydrogen energy and fuel cell, and energy policy and strategy.

As an alternative fuel, coal water slurry could replace oil, a fuel heavily relying on import, with domestically produced coal. Jun Cheng, an associate professor at Zhejiang University, reported the progress of research and demonstration. Coal water slurry comprises 60~70% of pulverized coal, 30~40% water, and less than 1% chemical additives. Since 1980s, the technology had been applied in over 30 power station boilers and over 300 industrial furnaces. The largest project consuming exclusively coal water slurry was a 670 tons/hour boiler (200 MW) in Nanhai power plant coming online in

2005. Over the period of 2006-2008, \$800 million were saved due to the replacement of oil with coal water slurry.

Teddy Zhou, the Chief Scientist at Chint Solar (Zhejiang) Co., Ltd, discussed the recent development and challenges of China's photovoltaic (PV) industry. Heavy subsidy from the European governments triggered the rapid growth of a global PV industry. China in 2007 became the third largest producer to reach 1.8 GW. Suntech alone had a capacity of 1 GW in 2008. A few hundred manufacturers covered the entire industrial chain from raw materials to end products. The mostly applied technology in China was conventional crystalline silicon technology, while a few manufacturers have engaged in thin film technologies to reduce the semiconductor material costs. First Solar in the U.S. market had cut the costs below \$1.00/W<sub>p</sub> with the thin film technology of cadmium telluride. The present worldwide financial crisis disrupted the growth trend of PV industry. Nevertheless, efforts were continued to be made to commercialize the more advanced technologies, with the most promising one of amorphous-microcrystalline silicon tandem junction, an advanced form of silicon-based thin film technology. Chint Solar had produced China's first tandem modules with stabilized conversion efficiency greater than 9%.

#### ❖ CO<sub>2</sub> capture and storage

Another technological focus is on CO<sub>2</sub> capture and storage (CCS) that was addressed in both Session II and Session VI. Michael Celia, a professor at Princeton University, introduced research at Princeton's Carbon Mitigation Initiative and then focused on geological CO<sub>2</sub> storage particularly in deep saline aquifer. Leakage through existing wells was understood via computer models with simplified assumptions to provide more efficient numerical calculations. The simplifications allow for large-scale analysis of leakage in a probabilistic framework while capturing much of the essential physics of the problem. Sensitivity analysis and Monte Carlo simulations can provide insights to help with both regulatory and economic decisions. Essentially CCS decisions become risk management under uncertainty.

Catherine Peters, an associate professor at Princeton University, discussed further Princeton's involvement with geological carbon sequestration (GCS). In the U.S., CCS had become a high priority for research and development. Princeton had established collaboration with Brookhaven National Lab and the University of Minnesota to study GCS leakage risks on a basin-scale and the impact on CCS energy market competitiveness. Another partnership between Princeton and Lawrence Berkeley National Lab focused on DUSEL (Deep Underground Science and Engineering Laboratory) CO<sub>2</sub>. The facility would enable experimental study of CO<sub>2</sub> trapping and vertical migration, on realistic length scales, with unprecedented experimental control and monitoring capabilities. The third major project at Princeton was on the co-sequestration of CO<sub>2</sub> and SO<sub>2</sub>. Results showed that co-injection of a small amount of

SO<sub>2</sub> (1% SO<sub>2</sub> and 99% CO<sub>2</sub>) was not predicted to cause rapid, severe widespread brine acidification. This could be a viable option for future SO<sub>2</sub> mitigation.

Yanqing Wu, a professor at Shanghai Jiao Tong University, presented modeling work on the selection of appropriate CO<sub>2</sub> storage sites. Through comparison with other types, deep and cool sedimentary basins were distinguished as the best choice for storing CO<sub>2</sub>. High permeability of aquifer in sedimentary basins facilitates the migration of CO<sub>2</sub> that leads to greater capacity for CO<sub>2</sub> storage and less pressure on cap formations. Lower porosity indicates larger migration area, smaller storage capacity and higher pressure on cap formations. Potential sedimentary basins were identified in China for future CO<sub>2</sub> storage. Compared with continuous injection, stage injection with different rates at different periods could effectively avoid the generation of excessive pressure and maintain the stability of CO<sub>2</sub> storage.

Zhong Zheng, a Ph.D. candidate at Princeton University, discussed China's low-cost opportunities for near-term demonstration of CCS in plants with nearly pure CO<sub>2</sub> streams. China had established and planned to build plants making ammonia, methanol, and other fuels and chemicals from coal that would eventually emit ~270 million tons of nearly pure CO<sub>2</sub> annually. Due to the low costs associated with the nearly pure CO<sub>2</sub> streams, China is in an advantageous stage to contribute to the development of CCS technologies. 26 facilities – each emitting one million tons of CO<sub>2</sub> per year or more – are within 100 km of prospective deep saline aquifer CO<sub>2</sub> storage sites. The 10-yr net-present values of the CCS costs range from \$89 million to \$1,150 million and 75% of the 26 projects had net-present value of \$200 million or less. For the N<sup>th</sup> plant, the CO<sub>2</sub> removal costs were all below \$21/ton CO<sub>2</sub>.

#### ❖ Science-related talks

Alexander Smits, a professor at Princeton University, introduced the importance of turbulence. Most energy, such as in transportation, are actually consumed to counter the impact of turbulence. Atmospheric boundary layers are created by turbulent air motion near surface. A new experiment was designed to examine the effect of thermal stability on a flat plate turbulent boundary layer, a common feature of atmospheric flows found in the arctic regions. Results were yet to come.

Ping Liu, an assistant professor at Shanghai Jiao Tong University, presented air quality modeling in Shanghai. The U.S. EPA Models-3/Community Multi-scale Air Quality (CMAQ) system was applied to simulate major air pollution in Shanghai in summer 2009 with a 3-km horizontal resolution. Comparison with observations from the routine monitoring network in Shanghai showed acceptable model results for PM<sub>2.5</sub> and PM<sub>10</sub>, but relatively large biases for gaseous pollutants, such as SO<sub>2</sub>, NO<sub>2</sub>, and O<sub>3</sub>. Process analysis – the diagnostic tool embedded in CMAQ – was employed to identify the contribution of major atmospheric processes to the formation and removal of major air pollutants.

### **3. Projection of China's CO<sub>2</sub> emission trajectories and mitigation potential**

China's high CO<sub>2</sub> emissions and expected rapid growth were widely recognized in the forum. Several presentations analyzed China's CO<sub>2</sub> emissions as well as its mitigation potential. Together with his colleagues, Zheng Wang, a professor at the Chinese Academy of Sciences, established the MRICES (Multi-Regional dynamic Integrated model of Climate and Economy with GDP Spillovers) model that incorporated GDP spillover mechanism and endogenous technological progress to simulate climate policies. It was recommended that developed countries should take immediate mitigation measures and cut emissions by 80% in 2050 from the 1990 level. China's CO<sub>2</sub> emissions should peak in 2020 and be reduced by 25% in 2050 from the 2005 level.

As Zheng Huang introduced, in a business-as-usual scenario designed by Energy Research Institute at Shanghai Jiao Tong University, China's CO<sub>2</sub> emissions in 2030 would be over 11 billion tons (Gt) without any peak before the year. In an emission-control scenario, the emissions would peak in 2025 at 9 Gt.

Minjun Shi, a professor at the Chinese Academy of Sciences, reported a research that an energy-environment model, based on the dynamic CGE model, was constructed to simulate Chinese CO<sub>2</sub> emission reductions and economic prospects in 2020 under technology improvement, carbon tax, investment adjustments and mixed scenarios. Though carbon tax and investment adjustments showed effectiveness in controlling greenhouse gases (GHGs) emission growth, the impact on economic growth was negative. On the other hand, technology improvement contributed positively to both GHGs mitigation and the economy, but only minor mitigation goals were attainable. In the business-as-usual scenario, China's CO<sub>2</sub> emissions would reach 11.3 Gt in 2020. With joint efforts of carbon tax, investment adjustment and technology improvement, China could lower its CO<sub>2</sub> emissions in 2020 to 9 Gt, which was suggested as an appropriate cap for China. The optimal path could be led to through high technology improvement and middle carbon tax (~80 RMB/t CO<sub>2</sub>). The corresponding loss of GDP would be about 0.12%~1.09%. The research results were expected to be updated with a more recent version of input-output table.

Liming Du, a post-doctoral researcher at Xiamen University, constructed a dataset of China's provincial CO<sub>2</sub> emissions over the period of 1995-2007. Econometric models were selected to project the emission level in 2020. Most important factors included economic development, energy structure, the share of heavy industries, urbanization, and technological improvement. China's CO<sub>2</sub> emissions were expected to reach 11 Gt and the per capita level at 8 tons in 2020.

Chu Wei, a Ph.D. candidate at Zhejiang Sci-Tech University, presented his study on China's potential to achieve the goals of energy conservation (20% reduction of energy intensity) and pollutant mitigation (10% reduction) in the 11<sup>th</sup> Five-Year Plan (2006-

2010). DEA methodology was applied with provincial data in a three-year period of 2005-2007. The potential of energy conservation in 2006 and 2007 was over one billion tons of coal equivalent each, about 40% of the total energy consumption. The potential of SO<sub>2</sub> mitigation was about 8.5 million tons or 30% of the total emissions. As a result, the research believed that China should be able to achieve the goals in the 11<sup>th</sup> Five-Year Plan. The loss of GDP would be respectively 0.14% and 0.09%.

Ru Guo, an assistant professor at Tongji University, presented an assessment report on carbon emission reduction in Shanghai. Shanghai experienced an average growth rate of 10.2% in its energy consumption over the period of 1990-2005, faster than China's average. On the per capita basis, a resident in Shanghai emitted more than twice CO<sub>2</sub> than an average Chinese. Though energy intensity in Shanghai dropped substantially, the potential for further reduction was limited. For example, the very rapid growth of car ownership pushed upward energy consumption for transportation. Chongming county could be the most likely to witness its CO<sub>2</sub> emissions being offset by its terrestrial carbon sinks.

#### **4. Environmental challenges in China**

Participants in the forum recognized China's multiple environmental challenges and concerns for public policy. Euston Quah, a professor at Nanyang Technological University, identified three areas of public policy concerning environmental management which posed serious challenges to Asian governments as they continued to pursue economic growth. First, environmentally unfriendly facilities, such as nuclear power stations, landfills and incinerators, etc., were needed by a country but the social costs mainly fell on local host residents and neighborhood municipalities. Second, serious problems of waste disposal were generated when Asian economies continued to grow with rising consumption. Third, non-market goods needed to be further understood for pricing, which was necessary for more complete cost-benefit studies.

Minjun Shi quantified the real costs of economic growth for China's 31 provinces from the perspectives of environmental pollution, resource depletion, and ecological degradation. The costs in 2005 were 2.5 trillion RMB or 13.5% of China's GDP, among which resource depletion was responsible for 1.67 trillion RMB, environmental pollution for 0.46 trillion RMB and ecological degradation for 0.33 trillion RMB. Geographically, resource depletion was mainly a problem in central provinces, environmental pollution in east China, and ecological degradation in the west. Genuine saving rates – the net saving rate in a national accounting framework encompassing resource depletion and environmental degradation – tended to be higher in east China than in west China. Particularly, the provinces of Qinghai, Guizhou and Shanxi had negative genuine saving rates, indicating their unsustainable economic growth.

Jiahui Shao, an associate professor at Shanghai Jiao Tong University, addressed water pollution in Shanghai. The urban districts generally had water quality in Category V,

indicating very serious pollution. The suburban districts were only a little better with mainly Category IV water. In the past several years, COD (Chemical Oxygen Demand) and wastewater discharges decreased significantly in industrial sectors, but the achievement was dampened by domestic sectors especially over the period of 2004-2007. Data for 2006 showed that discharge standards were not met in many industries. From 2000 to 2011, Shanghai planned four phases to clean up its environment with total investment of 220 billion RMB, over 3% of its GDP. Membrane technology for water treatment was also introduced. In answering a question from a participant, Professor Shao pointed out that the huge investment, however, did not represent the general case of China with many provinces still trailing in environmental protection efforts.

Shishun Shen, a senior research fellow at China Institute of International Studies, discussed energy cooperation in China's disputed waters. Among China's claimed 3.5 million square kilometers of blue territory, nearly half was disputed with neighboring countries. Recommendations were proposed to peacefully settle the disputes and better promote energy cooperation and development, respectively on the establishment of an appropriate national coordinate leadership, joint development as a temporary marine jurisdiction, step-by-step progress with flexible and diverse cooperation, the promotion of political mutual trust and security framework, and strengthening relevant research. A participant raised the question on why China and Japan chose not to consult international court under the Law of the Sea to solve their dispute in East China Sea. Both countries seemed to be reluctant to do so with their own consideration.

## **5. China's involvement in international CO<sub>2</sub> mitigation**

Dajian Zhu, a professor at Tongji University, overviewed China's economic development in the era of the People's Republic and raised the question on whether the next four decades could lead to a green China. Among the three development models – the U.S. model, the EU model and a leapfrogging model – China should choose the last to achieve high in HDI (Human Development Index) and less in environmental impact. It was noticed that to reach a certain HDI, the empirical CO<sub>2</sub> emissions decreased over time, indicating that China would not necessarily emit more CO<sub>2</sub> to achieve decent HDI.

Yanchun Zhang, a policy specialist at UNDP, argued that a single global discount rate was inappropriate and developed and developing countries did have reasons to select different discount rates. The urge to act, the weight given to the future, the tolerance for risk and other factors that determine how strongly and quickly people want to start addressing climate change would probably vary depending on place of residence and income level. The asymmetries justified higher discount rates particularly for large developing countries than for developed countries. The implications were that developed countries should speed up their mitigation efforts while developing countries should be allowed more time to adjust to a country-specific low-carbon economic path.

Gregory Chow, a professor at Princeton University, proposed to regulate carbon emissions through the United Nations. Recognizing the difficulty of international negotiation on carbon mitigation, an approach was suggested to reach an agreement through a resolution at the United Nations on a global target of CO<sub>2</sub> emissions as well as its distribution among nations. Each member of the United Nations submits a desired goal of world's total CO<sub>2</sub> emissions for a given period (for example, one to three years) and the median one will be adopted. Emission permits are distributed equally to individuals. A carbon-trading scheme then comes to take effects and national governments are held responsible for administering national goals. This proposal could be favorable to less developed countries such as China because of their low per capita emissions. The United States could regain its moral leadership by purchasing emission permits from developing countries. Professor Michael Celia raised a potential problem of asking nations to vote every one to three years.

Yuan Xu, a Ph.D. candidate at Princeton University, presented a framework for allocating a global carbon reduction target among nations, which was developed by researchers at Princeton, Harvard and ECN (Yuan was not a co-author). In the framework, the concept of "common but differentiated responsibilities" referred to the emissions of individuals instead of nations. A simple rule was proposed to derive a universal cap on global individual emissions and find corresponding limits on national aggregate emissions from this cap. All of the world's high CO<sub>2</sub>-emitting individuals are treated the same, regardless of where they live. Any future global emission goal (target and time frame) can be converted into national reduction targets, which are determined by "Business as Usual" projections of national carbon emissions and in-country income distributions. The national emission trajectories generated from this framework were comparable with proposals in China and the United States and thus should be acceptable to them. In 2030, reducing projected global emissions by 13 Gt CO<sub>2</sub> would require the engagement of about 250 million high emitters each in China and the United States as well as another 500 million in the rest of the world. A caveat of this framework is that it does not specify how to achieve the national goals. Countries should enact further mitigation policies.

## **6. China's choices of environmental policies**

China's policies to reduce pollutant emissions are another focus of this forum. As introduced above, Minjun Shi recommended mixed policies of high technology improvement and middle carbon tax. Several other participants also contributed their perspectives.

Xu Zhao, a professor at Shanghai Jiao Tong University, analyzed China's challenges in carbon mitigation. A downward trend of energy intensity and an upward trend of energy consumption coexisted in China. Industries took the lion's share of its energy consumption as well as CO<sub>2</sub> emissions. China's policies for carbon mitigation heavily relied on administrative and legal measures without much flexibility that could be

provided by market-based policies. This study recommended to establish an emission-trading scheme and to reconstruct energy price system with appropriate taxation and subsidies. Carbon offsets could be directed for the implementation of ecological carbon capture.

Yanyun Man, a professor at Peking University, studied China's environmental taxation, particularly in comparison with that of OECD countries. Six types of taxes were recognized, respectively on transportation fuels, heating and process fuels, motor vehicles, natural resources, waste disposal and pollution emissions. In 2007, the environmentally related tax revenue accounted for 2.41% of China's GDP, higher than the average rate in OECD countries. In addition, about 12% of China's total tax revenue in 2007 was environmentally related, much higher than that in OECD countries. On per capita basis, the tax was only about \$50, significantly lower than that in most OECD countries. The research could have instructive implications for China's future direction of environmental tax reform. However, as raised by the forum participants, the environmentally related tax was not specifically for environmental protection.

Yuan Xu focused on how China made SO<sub>2</sub> scrubbers in coal power plants operate in the 11<sup>th</sup> Five-Year Plan. By the end of 2008, China had managed to install 363 GW<sub>e</sub> SO<sub>2</sub> scrubbers at its 601 GW<sub>e</sub> coal power capacity. With first-hand information from visiting China's coal power plants, two decisions facing the managers of coal power plants were analyzed: First, when SO<sub>2</sub> scrubbers can run normally, whether SO<sub>2</sub> scrubbers should be turned on? Second, when SO<sub>2</sub> scrubbers fail, whether coal power plants should be shut down? Though command-and-control policies in the past failed to induce effective operation of SO<sub>2</sub> scrubbers, China in the 11<sup>th</sup> Five-Year Plan relied on two economic-incentive policies and effectively directed the managers to make decisions for the benefit of SO<sub>2</sub> mitigation. Economic-incentive policies were recommended for future reduction of pollutants. A policy scheme was suggested to entitle all power plants with higher electricity prices and simultaneously significantly raise effluent emission charges.

## **7. Discussion**

In discussion, the forum participants exchanged ideas on the potential to establish international research cooperation. Fengting Li, a professor at Tongji University, pointed out the availability of funding in Chinese research grants specifically for international cooperation. In addition, other sources of major funding were also established by the Chinese government to facilitate the communication and collaboration across countries. The funding situation could benefit the American researchers who want more involvement in China.

This 2<sup>nd</sup> forum in the series set up a form of annual meetings between Princeton and Chinese institutions. As announced, the 3<sup>rd</sup> forum was expected to be held in Beijing in early September 2010.

## Appendix: Program of presentations

<b>November 3, Tuesday</b>	
08:30 - 09:00	Registration (Room 209, North Building)
09:00 - 09:30	<b>Welcome</b>
	Chair: <b>Lin Zhou</b> (Dean of School of Economics, Shanghai Jiao Tong University)
	Opening Speech: <b>Yong Shi</b> (Co-Chair of Organizing Committee, Vice Dean of Research Center on Fictitious Economy & Data Science, CAS)
	Welcome Speech: <b>Fanghua Wang</b> (Dean of Antai College of Economics & Management, Shanghai Jiao Tong University)
09:30 - 10:00	Keynote Speech: <b>Lin Xiao</b> (Vice Chairman of Shanghai Municipal Development & Reform Commission)
10:10 - 10:30	Photo Taking
10:30 - 10:45	Coffee Break
10:45 - 12:05	<b>Session I: Energy Alternatives</b> <b>Session Chair: Lifeng Xi (Shanghai Jiao Tong University)</b>
10:45 - 11:05	<b>Yiguang Ju</b> (Princeton University) Development of Low Carbon Alternate Fuels and Recent Progress in Combustion Research
11:05 - 11:25	<b>Zhen Huang</b> (Shanghai Jiao Tong University) Innovative Energy Solution - Green Energy Research at Shanghai Jiao Tong University
11:25 - 11:45	<b>Jun Cheng</b> (Zhejiang University) Development and Application of Coal Water Slurry as an Oil-substituted Fuel
11:45 - 12:05	<b>Teddy Zhou</b> (Astronergy, Inc.) Photovoltaic Industry in China: Recent Development and Challenges
12:05 - 13:30	Lunch (2 <sup>nd</sup> Floor of Campus Canteen)
13:30 - 15:30	<b>Session II: Policies on Carbon Reduction in China</b> <b>Session Chair: Yong Shi (Chinese Academy of Sciences)</b>
13:30 - 13:50	<b>Zheng Wang</b> (Chinese Academy of Sciences) Scheme Analysis for Global Emission Mitigation Based on MRICES Model
13:50- 14:10	<b>Michael A. Celia</b> (Princeton University) Geological Storage as a Carbon Mitigation Option: Modeling and Implementation Challenges
14:10 - 14:30	<b>Xu Zhao</b> (Shanghai Jiao Tong University) China's Choices of Carbon Reduction Policies

14:30 - 14:50	<b>Na Li</b> (Chinese Academy of Sciences) Potential and Policies of Carbon Abatement in China
14:50 - 15:30	<b>Discussion</b>
15:30 - 15:50	Coffee Break
15:50 - 17:50	<b>Session III: Policy Design of Carbon Reduction</b> <b>Session Chair: Gerald Patchell (The Hong Kong University of Science &amp; Technology)</b>
15:50 - 16:10	<b>Yuan Xu</b> (Princeton University) Sharing Global CO <sub>2</sub> Emission Reductions among One Billion High Emitters
16:10 - 16:30	<b>Catherine A. Peters</b> (Princeton University) Geologic Carbon Sequestration: Challenges of Experimental Study
16:30 - 16:50	<b>Yanyun Man</b> (Peking University) Environmental Taxation in China
16:50 - 17:10	<b>Dajian Zhu</b> (Tongji University) Low-carbon Economy and Green Development in China
17:10 - 17:50	Discussion
18:00 - 20:30	<b>Welcome Dinner (Holiday Inn Crowne Plaza Hotel)</b>
<b>November 4, Wednesday</b>	
08:30 - 12:10	<b>Session IV: Economic Development and Environmental Regulation (I)</b> <b>Session Chair: Elizabeth Wilson (University of Minnesota)</b>
08:30 - 08:50	<b>Gregory Chow</b> (Princeton University) Regulating Carbon Emission through the United Nations
08:50 - 09:10	<b>Yanchun Zhang</b> (UNDP) Disaggregate Discounting
09:10 - 09:30	<b>Euston Quah</b> (Nanyang Technological University, Singapore) Economic Growth and Environmental Security: Critical Priorities for Asian Governments
09:30 - 09:50	<b>Ru Guo</b> (Tongji University) Carbon Emissions Reduction in Shanghai
09:50 - 10:10	Coffee Break
10:10 - 12:15	<b>Session IV: Economic Development and Environmental Regulation (II)</b> <b>Session Chair: Fengting Li (UNEP-Tongji Institute of Environment for Sustainable Development)</b>
10:10 - 10:30	<b>Minjun Shi</b> (Chinese Academy of Sciences) How Much Real Cost Has China Paid for its Economic Growth?
10:30 - 10:50	<b>Chu Wei</b> (Zhejiang Sci-Tech University) Are China's Energy-saving and Emission Reduction Targets Feasible?

10:50 - 11:10	<b>Limin Du</b> (Xiamen University) Estimating and Forecasting China's Carbon Dioxide Emissions: Provincial Panel Data Analysis
11:10 - 11:30	<b>Shishun SHEN</b> (China Institute of International Studies) Energy Cooperation in the Disputed Waters and its Solution
11:30 - 12:15	Discussion
12:15 - 13:30	Lunch (2 <sup>nd</sup> Floor of Campus Canteen)
13:30 - 16:55	<b>Session VI: Environmental Special</b> <b>Session Chair: Pascale Maloof Poussart (Princeton University)</b>
13:30 - 13:50	<b>Alexander Smits</b> (Princeton University) Behavior of Turbulent Boundary Layers with Stable Thermal Stratification
13:50 - 14:10	<b>Yanqing Wu</b> (Shanghai Jiao Tong University) CO <sub>2</sub> Geological Storage: Modeling and Challenges
14:10 - 14:30	<b>Zhong Zheng</b> (Princeton University) Low-Cost Opportunities for Near-Term Demonstration of Carbon Capture and Storage in China
14:30 - 14:50	<b>Yuan Xu</b> (Princeton University) SO <sub>2</sub> Scrubbers in Power Plants in China
14:50 - 15:10	Coffee Break
15:10 - 15:30	<b>Ping Liu</b> (Shanghai Jiao Tong University) Air Quality Modeling in Shanghai: Application and Analysis
15:30 - 15:50	<b>Jiahui Shao</b> (Shanghai Jiao Tong University) Situation, Challenges and Measures of Water Environment in Shanghai, China
15:50 - 16:20	Discussion
16:20 - 16:35	Closing Speech: <b>Gregory Chow</b> (Chairman of Organizing Committee, Princeton University)
18:00 - 20:30	Dinner (Holiday Inn Crowne Plaza Hotel)