出國報告（出國類別：其他）

參加第 37 屆 International Association for Energy Economics (IAEE 2014)國際研討會暨參訪麻省理工學院交流出國報告

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派赴國家：美國
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摘 要

第37屆IAEE研討會訂於6月15日至6月19日於美國紐約舉行，內容涵蓋：「ENERGY & THE ECONOMY」、「RENEWABLES, POWER PRICES, AND GRID INTEGRATION」、「ENERGY FINANCING」、「TRANSPORTATION DEVELOPMENTS」「 INTERNATIONAL SHALE DEVELOPMENT: PROSPECTS AND CHALLENGES」等多項重大能源議題，同時 IAEE 大會邀請世界各國能源領域專家學者針對全球能源需求、頁岩氣開採、再生能源發展、運輸部門減碳等議題舉行專家座談，同時涵蓋學術研究、實務理論、政策評估等多項重大全球能源趨勢及技術參訪。

核能研究所目前正積極執行「第二期國家能源型計畫」(NEP-Ⅱ)，包含我國能源配比與各項新及再生能源技術的經濟分析。本次派「能源經濟及策略研究中心」副主任葛復光、副研發師袁正達，自 103 年 06 月 14 日至 26 日赴美國紐約參加「第 37 屆 IAEE 研討會」，並發表「Reconsidering the oil-linked pricing rule based on evidence of unstable cointegrating relations in Asian LNG markets」、「Explaining the causality between Economic growth and carbon emissions in Taiwan: A Multi-sectoral analysis」論文二篇。另外，103 年 06 月 22 日至 23 日公差期間將赴美國劍橋麻省理工學院拜訪 MIT 全球氣候變遷科學與政策聯合專案人員，並針對「能源政策分析」、「能源政策模擬」、「模型建置合作」等相關議題進行討論；藉由此次參訪瞭解該聯合專案的運作經驗，並針對模型運跑、政策擬定與規劃進行經驗交流，以作為本所「能源經濟與策略研究中心」的運作參考，並建立未來雙方在模型建置上進一步合作的基礎。

關鍵字：國際能源經濟研討會、政策評估、可計算一般均衡模型、麻省理工學院

Abstract

The 37th International Association for Energy Economics international conference (IAEE 2014) was held in New York City, United States, during June 15-18, 2014. The concurrent sessions including "Energy and the Economy", "Renewables, Power Prices, and Grid Integration", "Energy Financing", "Transportation Developments", "International Shale Development: Prospects and Challenges" and other important energy issues. The IAEE Conference also invited experts from various research field including energy demand, electricity price, shale gas, renewable technologies, carbon reduction and the advanced development of transportation, while these topics and technical tours are helpful for INER's academic research and policy evaluation skills, and can improve INER's understanding in global energy issues.

INER's Center of Energy Economics and Strategy Research is performing the National Energy Program Phase II (NEP-II) including energy mix and economic analysis for various renewable technologies. INER assigns deputy director Fu-Kuang Ko, and Dr. Cheng-Da Yuan to publish following papers: "Reconsidering the oil-linked pricing rule based on evidence of unstable cointegrating relations in Asian LNG markets" and "Explaining the causality between economic growth and carbon emissions in Taiwan: A multi-sectoral analysis" at the 37th IAEE international conference. In addition, the authors also visited the MIT Joint Program on the Science and Policy of Global Change during June 22-23, 2014. Moreover, INER and MIT have a group meeting for the issues including energy policy analysis, model building and bilateral cooperation. By visiting MIT and sharing experiences of policy analysis, it is helpful for policy formulation and strategy analysis for INER.

Keywords: International Association for Energy Economics (IAEE) international conference, Policies Evaluation, Computable General Equilibrium (CGE) models, Massachusetts Institute of Technology (MIT)

目　次

一、目　的

IAEE 大會為一年一度的涵蓋全球性能源、環境、經濟等國際研討會，並為國際間之重要交流、溝通平台，大會邀請美洲、亞洲、非洲及美國相關的政府代表、環境、資源、經濟等實務與學術機構進行會議討論。會議延攬各國包含金融、運輸、能源、企業、政府等實務界專家、透過專家座談、論文發表等過程來傳達各項最新研究，以解決全球能源、氣候變遷、經濟發展的問題，同時點出各項新及再生能源技術的發展趨勢、全球能源供需與地緣政治等重大能經議題，並討論各國在能源安全與經濟發展等議題之瓶頸與政策，以促進各國專家學者和研究人員擴展交流、合作、研究之機會。本次「第 37 屆 IAEE 研討會」訂於 6 月 15 日於美國紐約舉行，內容涵蓋：「ENERGY & THE ECONOMY」、「RENEWABLES, POWER PRICES, AND GRID INTEGRATION」、「ENERGY FINANCING」、「TRANSPORTATION DEVELOPMENTS」「INTERNATIONAL SHALE DEVELOPMENT: PROSPECTS AND CHALLENGES」等多項重大能源議題，對執行「我國能源科技及產業政策評估能力建置」中央施政計畫與「我國能源配比整合研究探討」科技部專題研究計畫具有助益與參考價值。另外，IAEE 大會 6 月 15 日安排參訪 New Yorker Hotel Power Generating Plant 的 CHP 發電裝置設施；6 月 19 日安排參訪紐約商品期貨交易所（NYMEX），以了解各項能源期貨、商品、交換合約(SWAP)的交易平台等參訪行程，上述技術參訪行程對於提供未來新及再生能源、能源科技的應用、綠色融資等相關產業的發展策略與政策建議具相當之幫助。

目前核能研究所正積極執行「我國能源科技及產業政策評估能力建置」中央施政計畫與「我國能源配比整合研究探討」科技部專題研究計畫，本次派「能源經濟及策略研究中心」副主任葛復光、副研發師袁正達，自 103 年 06 月 14 日至 26 日赴美國紐約參加「第 37 屆 IAEE 研討會」發表「Reconsidering the oil-linked pricing rule

based on evidence of unstable cointegrating relations in Asian Lng markets」、「Explaining the Causality Between Economic Growth and Carbon Emissions in Taiwan: A Multi-sectoral Analysis」論文二篇。透過論文的發表過程與國外學者專家討論分享核能研究所近年來在能源、環境與資源經濟領域的具體研究成果，並藉以掌握各國在相關能源議題、新及再生能源技術的最新進展與對策。

另外，於 IAEE 國際研討會結束之後，安排至全球氣候變遷科學與政策聯合專案研究中心進行參訪，並針對「能源政策分析」、「能源政策模擬」、「模型建置合作」等相關議題與中心共同主持人 John Reilly 博士等人進行討論；藉由此次參訪瞭解該中心的運作經驗，並針對模型運跑、政策擬定之作為與規劃進行經驗交流，以作為本所「能源經濟與策略研究中心」的運作參考，並建立未來雙方在模型建置上進一步合作的基礎。6 月 23 日雙方針對美國環境保護署提出的發電部門 2030 年以前減碳 30%的法案、如何從模型的模擬結果轉成政策建議，以及未來雙邊的合作模式進行交流討論。聯合專案共同主持人 John Reilly 博士表示從模型轉化到政策的過程中，其實並不容易，研究人員需要有清晰的邏輯，並提供符合經濟直覺的合理解釋，才能有助於決策，而相關能源政策在與民眾溝通方面，美國同樣面臨政黨、利益團體的角力難題，並未有任何有效的技巧可以提供給核研所參考，並指出政策的制定過程往往是需要透過多方協商所得的妥協結果。在討論過程中，雙方一致認為台灣企業界對於學術研究或新能源議題的投入較為不足，建議未來可引進台灣的新能源企業例如台達電、台積電等大型企業進行整合，創造學術研究、政策推行與企業研發三贏的局面；另外，研究中心副執行長 Joshua Hodge 博士預計 8 月下旬訪台，葛副主任隨即當面邀請 Joshua Hodge 博士來所內演講以促進雙方交流，並建立雙方未來的合作機會，為此次的參訪交流行程畫下完美句點。

二、過　程

項次	日期	行程		工作重點
		出發	抵達	
1	103 年 6 月 14 日	臺北	紐約	搭機前往美國紐約
2	103 年 6 月 15 日	紐約		報到、大會開幕典禮與技術參訪
3	103 年 6 月 16 日 至 103 年 6 月 19 日	紐約		參加 IAEE 國際研討會，並發表葛復光副主任與袁正達副研發師分別發表一篇論文
4	103 年 6 月 20 日 至 103 年 6 月 21 日	紐約		蒐集整理 IAEE 會議資料、研究心得、修改 MIT 交流會議簡報
5	103 年 6 月 22 日 至 103 年 6 月 23 日	紐約	波士頓	前往 MIT 並進行簡報，進行經驗交流與未來合作事項討論
6	103 年 6 月 24 日	波士頓	紐約	返回紐約搭飛機回台
7	103 年 6 月 25 日 至 103 年 6 月 26 日	紐約	台北	回程

註：

(1) IAEE 研討會相關資訊請參照網址: http://www.usaee.org/usaee2014/

(2)「The MIT Joint Program on the Science and Policy of Global Change」研究中心 http://globalchange.mit.edu/

三、心　得

第 37 屆 IAEE 國際研討會本次於美國紐約舉行，06 月 15 日至 6 月 18 日共四天的會議期間共有超過 350 篇的論文發表。台灣方面此次只有核研所出席並有 2 篇論文發表，而核能研究所由「能源經濟及策略研究中心」葛復光副主任與袁正達副研發師代表出席，發表的二篇論文題目分別為，「Reconsidering the oil-linked pricing rule based on evidence of unstable cointegrating relations in Asian Lng markets」、「Explaining the Causality Between Economic Growth and Carbon Emissions in Taiwan: A Multi-sectoral Analysis」。展現出「能源經濟及策略研究中心」在能源經濟領域的研究已獲得初步的具體成果。另外，於會議上，由袁正達副研發師、葛復光副主任以及柴蕙質副工程師共同完成，由袁正達副研發師代為發表的「Explaining the Causality Between Economic Growth and Carbon Emissions in Taiwan: A Multi-sectoral Analysis」受到了學者的迴響。並於討論時間接受兩位教授的提問， 其中蒙特婁高等商業學院, Pierre O Pineau 教授提問有關為何 2005 年運輸部門的碳排放下降，筆者回答有可能是衡量小貨車與大貨車生產活動的「延噸公里」數下降，此外來自油價上漲所導致的能源服務需求抑低及碳排放減少可能是另一個原因。此外，來自法國巴黎第一大學 「索邦經濟研究中心」的教授 Gaël Giraud 提問筆者是否有考量商品的進、出口貿易或油價上漲等因素對模型中的碳排放所造成的影響?筆者回覆必須視生產哪一種類型的商品而定，因為進出口商品主要以工業部門為主、運輸與服務業的進出口量相對很少，因此影響力道可能較小，但還需要更進一步的數據與實證結果來支持，上述提問點出筆者研究上的限制與疏漏之處，研討會後將針對文章內容進行補強，再進行國外期刊的投稿作業。 另外。加州大學戴維斯分校的 Dr. Sonia Yeh 有關運輸部們的簡報內容，提及民眾的行為與偏好會改變未來的運輸部門碳排放，例如石油公司的獨佔性，缺乏燃料之間的競爭、使用者的行為缺乏彈性(in-elastic)、燃料生產者與汽車製造商之間的聯合勾結等行為皆使得運輸部門的減碳計畫面臨更大挑戰，也提供筆者在運輸部門方面研究結果的解釋基礎，更間接對於相關研究成果有更深入的理解。

另外，由柴蕙質副工程師、袁正達副研發師及葛復光副主任共同完成，葛副主任代為發表的「RECONSIDERING THE OIL-LINKED PRICING RULE -based on evidence of unstable cointegrating relations in Asian LNG markets」亦獲回應，與會者對為何 2008 年前後的整合關係改變原因提出疑問。筆者補充解釋，2008 年期間為全球金融風暴，當時 LNG 的貿易市場受到衝擊，由估計結果來看，全球金融風暴之前，價格變數的係數較大，表示台灣 (或韓國) LNG 進口價格與日本進口價格的連動性較大，當日本進口價格變動一單位時，台灣價格也較敏感; 反之全球金融風暴之後，常數項變大，但價格變數的係數較小，表示台灣的價格對日本價格變動較不敏感。常數項通常被解釋為固定費用(例如運費)，在金融風暴期間，雖然液化天然氣(LNG)需求驟降，但 LNG 大部份仍以長約為主，各進口國在 LNG 供應鏈的調度能力不同，例如日本對船運的調度能力較大，進口商多元，在金融風暴期間可能有較多的機會取得低價的 LNG，相對而言，台灣受限於對船運的調度能力、及儲存設備的因應彈性較低，此時台灣與日本的價格連動性便可能變低。

本次 IAEE 研討會讓筆者印象最為深刻的是能夠與各種能源專業領域的許多學者、學術單位的研究人員進行面對面的交流對話，雖然彼此之間在時間不是很充裕的情形下，也是努力交換研究意見並對相關的能源議題發表一些看法與提問，不僅讓筆者對於國際性研討會議題的多元化感到興趣，也體會到在能源經濟研究領域其實並不孤單，在世界各國都有研究人員針對不同技術、不同的再生能源議題進行研究分析，只是平常的研究與交流都在台灣，缺乏更多的國際交流，也發現一樣的能源議題在不同國家民眾的態度並不一樣，例如在餐敘過程中，跟芬蘭的學者討論到，在芬蘭核能發電是可被接受的，被視為一種可行的發電技術，而芬蘭也是具有核廢料最終處置場的國家；然而，核能發電在亞洲的日本、台灣等地人民的接受度與看法並不那麼一致。

在餐敘的場合與中場的休息時間，有許多機會與各國學者交流，也發現許多國際學者都非常親切，除了研究議題的討論外，筆者感受到 IAEE 國際會議也是一個社交的場合，不同國家、不同領域的研究者，在會議中彼此認識，之後或許有互相合作的機會，許多學者已經是彼此認識了，透過該次的會議也都互相寒暄討論彼此的最新研究議題、方向，同時更重要的是交流一些各國的最新能源政策、技術的發展等，這種半正式的交流我想也是國際研討會非常重要的一環，也使得

整體研討會的功能非常完整。其中西澳大學能源與資源經濟學系 (Energy and Resource Economics)的教授 Peter Hartley 與 Mark Stickells 對於澳洲的電力使用進行討論，Mark Stickells 提及因為人口眾多與商業化的關係，東澳是需要大量電力的地方，因此希望可以有廉價的電力供給；相反地，西澳是產出能源礦藏的地方，因此希望石油、天然氣與煤等礦產能源價格能夠維持高的價格，以增加企業獲利。因此雖然在同一國家澳洲，不同區域所面對的能源問題也是非常值得討論的議題。

結束 IAEE 的會議後，筆者回國後看見台灣首次推行綠電，就對該政策引起興趣，該制度允許民眾購買綠電，並以 100 度電為單位，並於七月一日起公告實施，每度電價為 3.95 元。目前遞件申請者僅有十九家企業及一位個人用戶，申購意願並不高。經濟部能源局表示，綠色電價將試辦三年，再視成效決定是否延長。綠電制度以半年為一期，一百度為一個認購單位，即日起至 2014 年底可銷售的綠色電力總量為三億一千萬度，認購者須由台電提供綠電證明。能源局並指出，自願認購綠電的企業，台電可開立綠電購買證明，廠商的主要市場若是在歐盟，較為注重環保議題，企業可因認購綠電，減少碳足跡，更有競爭力。未來如果購買綠電的人越多，分攤成本的人也越多，未來轉嫁至一般用電戶的附加費就可以降低。相信可以吸引更多民眾投入綠電的使用。以推行綠電制度來說，背後必須有電價成本的計算、再生能源的發展、配合制度面的改革以及民眾對於環保節能的認知，讓筆者理解到一個政策的推行必須有很多方面的研究與制度的結合，期待台灣能更進一步在節能減碳的領域發展，下一次的國際研討會也就能將台灣經驗再帶到國際場合與不同國家的經驗相互交流驗證。國內電力市場自由化，雖然面臨諸多挑戰與困難，但是我國推行綠色能源的腳步一直在前進。因為參加該次 IAEE 國際研討會，也更激發自己在能源經濟研究領域的熱忱，特別是運輸部門碳排放的能源使用以及能源服務需求的預測等議題，與筆者在所內的工作項目十分接近，也期許自己能在運輸部門的研究更加精緻化、合理地去預估未來運輸部門的能源服務需求、估計符合台灣本土的彈性數據已提供給本中心的 Market Allocation Model (MARKAL)模型使用，更期待核研所的模型下次能在國際研討會上發表，並作為國際交流的工具與橋樑。

(一) 發表心得

本次 IAEE 國際研討會於美國紐約 NEW YORKER　HOTEL 舉辦。會議加上技術參訪行程期間為期五天，從 2014 年 06 月 15 日至 19 日。此次會議舉行方式為單一場次 105 分鐘，每人報告時間為 15~20 分鐘，5~10 分鐘討論時間，各項議題皆有足夠的時間與各國與會者進行意見交換及充份交流。本次內容涵蓋：「ENERGY & THE ECONOMY」、「RENEWABLES, POWER PRICES, AND GRID INTEGRATION」、「ENERGY FINANCING」、「TRANSPORTATION DEVELOPMENTS」「INTERNATIONAL SHALE DEVELOPMENT: PROSPECTS AND CHALLENGES」等多項重大能源議題。

由袁正達副研發師代為發表的文章為「Explaining the Causality Between Economic Growth and Carbon Emissions in Taiwan: A Multi-sectoral Analysis」，本文主要以 Autoregressive Distributed Lag (ARDL) model 模型來檢視 1982-2011 年我國經濟成長與碳排放的長期關係，透過 Environmental Kuznets Curve (EKC)的估計並有下列重要實證結果。第一，我國工業、運輸、服務與能源密集產業等部門皆存在倒 U 型態的 EKC 曲線，表示上述部門的碳排放將隨經濟成長而呈現逐步下降的趨勢。第二，上述部門的碳排放具有向長期均衡收斂的性質，且部門間的收斂速度呈現一致，每期平均調整約 24%，約需 4.2 年可重新回到長期均衡。第三，我國 EKC 的估計結果存在 Simpson Paradox 的現象，意即碳排放與經濟成長的長期關係在整體部門不明顯，但顯著存在於運輸與能源密集等部門。最後，我們發現經濟成長與碳排放存在單向的因果關係(Unidirectional causality)，即經濟成長有助於解釋碳排放的增加，而碳排放並無法解釋經濟的成長，其原因可能是運輸部門與能源密集部門的碳排放與 GDP 的長期關係較為明確，其原因可能是運輸工具多是以汽、柴油做為能源，而能源密集部門例如鋼鐵、水泥產業主要使用燃煤與大量的初級能源，因此碳排放與 GDP 的關係較為穩定；而其他部門例如服務業、電子業等部門，其能源使用以電力為主，易受電力排放係數的影響，而電力排放係數與全國的發電結構有關，因此根據部門用電量計算碳排放時，可能導致碳排放與 GDP 的關係不明確。[1]

[1]辛普森悖論（Simpson's Paradox）為英國統計學家（E. H. Simpson）於 1951 年提出的悖論，指出兩組數據分別討論時都會滿足某種性質，可是一旦合併考慮，卻可能導致相反的結論，該現象常發生在社會科學或醫學統計上。例如以各別部門來看，運輸部門與能源密集部門的碳排放與 GDP 明顯存在長期關係，其原因可能是運輸工具與能源密集部門主要使用汽、柴油、燃煤等大量的初級能源，因此碳排放與 GDP 的關係較為穩定；而總體部門除運輸與能源密集產業外，尚包含服

(二) 研討會心得

Transportation Policies and the Future of Low-C Transportation

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此次 IAEE 大會在專家座談中有關 「最新運輸部門發展」的座談議題，特別邀請 Dr. Sonia Yeh 為運輸部門的主講人。Dr. Sonia Yeh 為加州大學戴維斯分校運輸研究所的資深研究員，同時也是運輸科技與政策研究所的研究人員與卡耐基美濃大學工程與公共政策學系的兼任教授. Dr. Sonia Yeh 的主要研究領域為能源市場經濟與模型建置,溫室氣體生命週期分析,生質能源的永續標準, 以及政府政策引導的技術進步等研究議題；同時也是加州政府在 2007 年開始執行的「國家低碳燃料標準」(National Low Carbon Fuel Standard) 計畫中，並擔任加州大學戴維斯分校與柏克萊分校研究團隊的共同主持人。Dr. Sonia Yeh 長期參與政府、非政府組織在運輸部門的政策的制定、運作以及模型評估方面經驗非常豐富專精，對於未來運輸部門的低碳發展做了詳盡的簡報。

講者認為目前運輸部門的減碳措施主要存在以下三個現象；第一、全球運輸部門的燃料使用以及溫室氣體的急遽增加。第二、美國聯邦政府以及各州對於運輸部門的減碳目標相繼提出政策。第三、需要建立更好的模型來預測以及進行政策的模擬評估。根據講者的模型評估結果，在 2050 年最樂觀的情境下，已開發國家的每人年度旅行(Per capita Annual Travel)從 20,000 (Passenger KM Traveled, PKT)上升至 28,000 (PKT)；開發中國家由 6,000 (PKT)上升至 13,000 (PKT)，皆呈現大幅上升的趨勢。而在化石燃料的使用與二氧化碳排放方面，開發中國家更是大

務業、電子業等部門，其能源使用以電力為主，易受電力排放係數的影響，而電力排放係數與全國的發電結構有關，因此根據部門用電量計算碳排放時，可能導致總體部門的碳排放與 GDP 不存在長期關係。

幅上升，因為已開發國家研發更先進、更有效率的汽車技術、且每人對於旅行移動的需求已到達飽和點，因此燃料的使用與碳排放的成長較低；相反地，開發中國家的航空與小貨車運輸的比重增加，公共運輸的比重減少，使得 2050 年來自「旅客移動」(Passenger Travelled)的燃料消費導致的碳排放增加超過 4 (Billion Tones CO_2/year)。目前的運輸仍然主要依賴原油的產品，若沒有氣候政策的實施，未來將需要全球對於原油與其他非傳統能源(氫能、生質能)、效率改善等技術的投資來滿足運輸部門對能源的需求。然而仍可透過嚴格的氣候政策例如先進的汽車低碳技術、低碳燃料、效率的改善來達到運輸部門的低碳化。講者並提到運輸部門之所以面臨減碳的困難是因為市場失靈(研發經費不夠充裕、空氣污染的外部性)，市場特性與障礙(例如石油公司的獨佔性，缺乏燃料之間的競爭、使用者的行為缺乏彈性、燃料生產者與汽車製造商之間的聯合勾結等行為)皆使得運輸部門的減碳計畫面臨重大挑戰。

在運輸部門的減碳政策方面，講者提及目前的政策有提升燃料效率、 改善燃料密集度,例如頒布再生能源燃料標準, 國家低碳燃料標準、先進燃料/零排放汽車計畫、能源基礎建設政策等多項政策來改善運輸部門的碳排放。其中加州的「國家低碳燃料標準」主要由加州空氣資源管理局來執行，政府透過加州大學柏克萊分校、戴維斯分校提供政策藍皮書，「國家低碳燃料標準」將石油供給者、生質能、電力、天然氣與氫燃料的提供者都包含在規範之內。另外，2020 年以前達到降低 10%的碳密集度(gCO_2-eq/MJ；公克二氧化碳當量/百萬焦耳)，碳密集度以生命週期排放來衡量，涵蓋範圍包含各種燃料(含汽油、生質燃料、電、天然氣、氫燃料電池等)，允許信用交易等。加州的，「國家低碳燃料標準」目前已初步可見成效。包含增加低碳、廢棄物燃料的使用數量來替代傳統石化能源，多項生質能燃料的碳密集度(gCO_2-eq/MJ)已經呈現下降，低碳燃料標準的信用交易的數量、價格都呈現增加的趨勢(2012 年\$16/MT CO_2-eq 到 2013 年 11 月上漲到 80\$/MT CO_2-eq，2013 年 12 月下跌到 50~60\$/MT CO_2-eq，目前為 35\$/MT CO_2-eq)。

最後，作者並強調不論是預測運輸部門的能源使用、溫室氣體排放或是政策效果的評估，預測模型都必須進一步強調不同政策之間的互動效果，同時必須考量消費者使用行為的改變與偏好，才能對於未來做更合理的預測與政策評估。

(三) 技術參訪心得

能源經濟學界的年度一大盛會 2014 年 IAEE 國際會議今年於美國紐約舉辦，而舉行地點是一個特別的地方 New Yorker Hotel。該飯店位於曼哈頓的第八大道上，是紐約當地非常具有指標性的飯店，該飯店不僅有豐富歷史並具有一套早期的熱電共生設備。本次參訪的重點即在於這套設備的解說，透過技術參訪介紹人 Joe Kinney 的指引與說明，筆者非常驚訝所面對的是世界一流的電氣工程和一個殘存的 1920 年代的實驗現場-熱和發電的奇妙組合；該熱電共生設備本身就是一個歷史，該飯店於 83 年前營業時，曾經號稱是私人擁有最大的直流發電設備，「電學之父」，尼古拉·特斯拉 (Nikola Tesla) 在世最後的十年就是居住在該飯店，使得發電設施與飯店更添傳奇歷史。由於筆者並非發電技術以及工程領域的專家，但是在導覽員一連串的解說與親眼見識到 1920 年代的技術以及設備、相關工程，還是讓筆者驚訝美國在將近一百年以前就擁有如此堅實深厚的科學基礎，且設備維持到現在還能正常運轉，提供整座飯店的供電與用熱，印象非常深刻。

第 37 屆 IAEE 會議於 6 月 15 日舉行開幕，筆者並與葛副主任一起參加大會的指定參訪行程，由大會代表 Joe Kinney 帶領參加人員導覽飯店的四通八達、難得一見的地下世界，包含飯店的原機械和新的熱電聯產電廠，我們的導覽 Joe Kinney 見證了安裝於上世紀 90 年代中期的熱電共生設備。導覽人員 Joe Kinney 表示該飯店的發電機組提供一個能夠實地考察，且對於能源和技術工程愛好者是一次非常寶貴的參訪經驗。筆者非常驚訝於如此古老的發電設施居然還可以運轉，並且供應整個飯店的發電以及用熱，以往筆者住宿並不會特別去注意旅館的歷史或者是電力、熱水是如何供應。Joe Kinney 引導全體人員進入地下室的發電設備，筆者發現理應十分老舊的機器設備，仍繼續運作，並且保養得十分完善，透過研

討會能參觀這個十分具有意義的設備,真的非常特別;而大大小小的通道、機組、設備、管線、可以看出當初在設計時已經考量得十分周全；此外，在比較高的平台，為了操作方便作業，可使用鏈子用拉的方式來替代手工轉動氣閥的功能，各處細節都可以觀察到當初設計者的巧思,讓整個熱電共生的機器設備可以維持功能不停地運轉,參與該次導覽的專家學者對於各項設備機組、歷史以及 Joe Kinney 幽默的導覽方式都十分印象深刻，筆者在該飯店見證了歷史，見識到機器設備發揮了應有的價值，透過該技術參訪，葛副主任與筆者的收穫十分豐富，也讓筆者深深感受到一個優良的發電技術與工程足以改變全體人類的歷史與生活,同時也為整個 IAEE 國際研討會拉開序幕。

(四) MIT 參訪心得

麻省理工學院設置的全球氣候變遷科學與政策聯合專案(Joint Program on the Science and Policy of Global Change)提供科學化的分析基礎以協助決策者解決未來的能源、氣候變遷等重大議題。該聯合專案的成立宗旨為

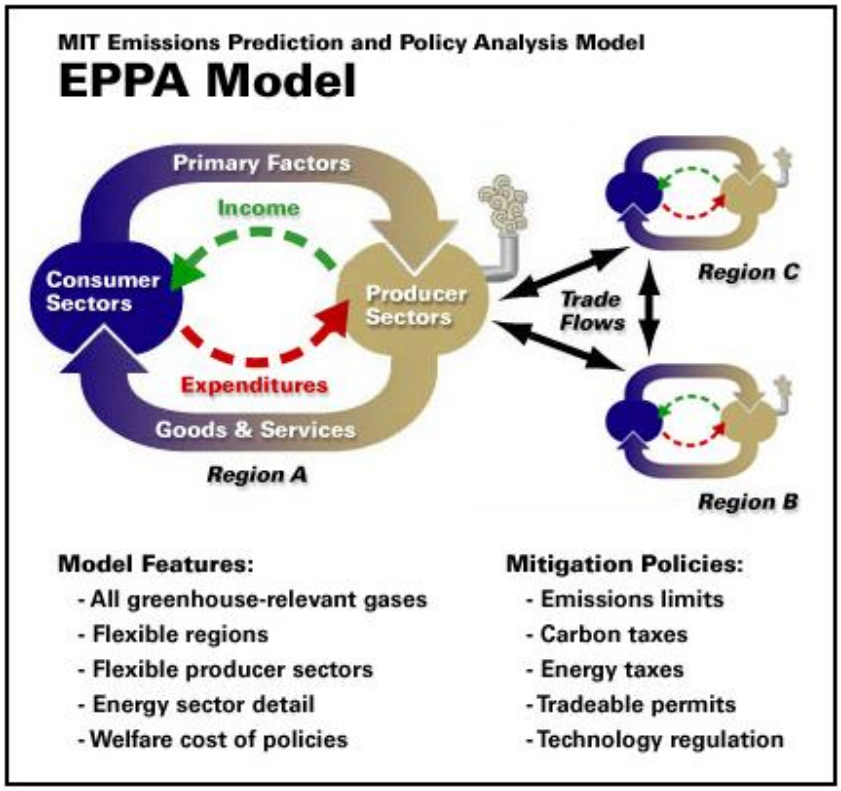
1.以 Integrated Global System Modeling (IGSM)模型架構進行全球氣候變遷的數量分析及其社會、環境的衝擊

2.獨立評估減緩和調適政策對全球氣候變遷的影響

3.促進研究機構、決策團體以及社會大眾的連結與共識

4.培育新一代研究人員的專業能力，以解決未來複雜的全球性挑戰

IGSM 模型架構涵蓋經濟、氣候與陸地生態系統三個子模型；其中經濟模型為 Emissions Predictions and Policy Analysis, EPPA)，EPPA 是一個多行業，多區域可計算一般均衡模型，透過國際貿易的途徑，該模型不僅提供特定減碳政策下的全球經濟成長和碳排放的預測,並可用來評估相關減碳政策的經濟衝擊。



碳排放預測與政策分析模型架構

Emissions Predictions and Policy Analysis Model
http://globalchange.mit.edu/research/IGSM

該聯合專案並積極與各政府、企業部門進行合作。政府部門包含能源部運輸部、環保署、國家科學基金會(NSF)等單位。國際產業合作有日本東京電力公司、BP(英國)、Exxon Mobile(美國)、殼牌石油(荷蘭/英國)；此外，該聯合專案與北京清華大學從 2011 年 10 月正式展開 China Energy & Climate Project (CECP) 五年期計畫，雙方針對能源使用、貿易、氣候、模型建置等議題進行合作。該聯合專案在美國跨部門的合作、國際產業、學術交流及美國減碳政策的評估方面均具有十分重要的地位。

本次 MIT 全球氣候變遷科學與政策聯合專案的參訪行程由葛副主任與 MIT 的 Sergey Paltsev 博士 、Henry Chen 博士等人雙方約定會議討論時間，而該聯合專案的共同召集人 John Reilly 博士亦於當日出席洽談跨國間的模型合作與交流。會議一開始由本所副研發師袁正達先針對核研所目前發展的再生能源技術

與研究方向簡要說明、再針對「能源經濟及策略研究中心」的設置目的、分項執掌進行說明,並闡述目前中心的核心業務與專業能力。再初步說明討論議題如下,以利後續雙方進行討論交流。

1. Hot issue discussion: EPA Power-Plant Proposal Will Seek 30% Carbon Dioxide Emissions Cut by 2030
2. From Model to Policy-Experience sharing
3. Bilateral Collaboration and Perspective

John Reilly 表示目前雖然美國 EPA 有一連串的減碳措施，但各州的減碳目標不同，主要視該州發電結構(generation mix)而定，EPA (Environmental Protection Agency, EPA)允許二氧化碳是可以跨州交易的，是一個動態的交易機制。至於說該法案的影響，就是老舊的燃煤電廠會被自然淘汰，當燃煤的成本提高，就會用相對便宜的 LNG 或核能來替代成本高昂的燃煤發電；此外，經過 EPA 與許多專家、研究單位的複雜計算後，認為 30%的減碳目標是可行，所以新建的燃煤電廠必須符合新的規範，目前對於燃煤電廠的規範，各單位還存有許許多多的意見，並未有一致性的規定與看法，預計明年的此時，會有一個最後的版本。另外，葛副主任提問 EPA 的該法案通過是否跟頁岩氣的開採有關? 如果沒有頁岩氣，是否就不會有該法案的產生? John Reilly 表示目前關於美國頁岩油或頁岩氣的開採，不管是價格或是蘊藏量的估計方面都還有很大的爭議與變數。但是比較便宜的頁岩油確實讓美國未來 30%的減碳目標變得更為可行。

John Reilly 並反問為何我們對於該減碳 30%的議題有興趣?葛副主任回覆是因為核研所有執行國家能源型計畫，台灣對於減碳目標也非常重視，並支持哥本哈根協議並宣示我國 2020 年以前必須至少減量達到基線(Business as Usual, BAU)的 30%為減碳目標。葛副主任並提及 MIT 是否針對 BAU 的設定有特別的定義或說明? John Reilly 表示關於 BAU 設定的問題,事實上各國可選擇自己的 BAU，國際上並沒有正式的文件來規範或是定義。因此，BAU 如果定的高，減碳目標就容易達到；BAU 若是訂得低，減碳目標相對難以達成。而且目前美國雖然大力投入減碳計畫，但是減碳是全球的目標，像歐洲國家、台灣都很努力執行，但有些

國家例如中國、印度等在政策方面並沒有強力的規範或執行；因此全球減碳計畫所累積的效果仍然有限，使得減碳計畫變成各國自願性的行動，對於整體的減碳目標成效有限。[2]另外，各國制定的基線(base line)也有可能是假的，甚至美國在減碳計畫的執行上也面臨許多困境，例如有些學者根本就不承認有氣候變遷這一回事，加上民眾對於政府的不信任、政黨的選舉考量只在乎贏的執政權，由於存在政治上的問題，就算減碳方案是經濟上可行的(Economic applicable)仍然會陷入無法溝通的困局(Fail to communicate)。即便氣候變遷是一個重要的議題，中國、印度如果沒有更具體積極的作為，其他國家不做，只有美國、歐洲國家在做，整體減碳效果仍然非常有限。

至於葛副主任、林師模教授提問關於新的 EPA 能源政策，MIT 是否有參加該政策的制定過程? John Reilly 表示 MIT 的研究中心並沒有接受 EPA 的 Funding，也沒有參加 EPA 的政策制定過程的運作，然而 MIT 的許多學生畢業後在相關政府部門工作，所以 MIT 只是以外圍的角度去分析評估該政策，扮演幫忙如何建置模型，如何評估政策的施行結果的角色。葛副主任並提問 MIT 是否有模型整合的經驗可以提供目前所內建置中的的 MARKAL 模型與可計算一般均衡模型(Computable General Equilibrium model, CGE)模型做為參考?另外，如何將模型的結果轉化成有助於決策的政策?MIT 是否有可供參考的經驗?John Reilly 表示模型的整合方面，MIT 確實有相關的經驗，CGE 是美國模型?，MIT 也有學生做墨西哥模型、全球模型，而與中國北京清華大學合作的模型有包含中國各省分的資料，在模型的衝擊方面，能源部門站整個經濟結構只有約 5%，因此大概 5 到 7 次就可以收斂；MARKAL 模型的架構相對較簡單，給定不同技術的成本下，求取成本的最小化，但 MIT 目前沒有在做 MARKAL 的建置；至於如何將經濟模型轉化成有助於決策者推行的政策，John Reilly 表示在模型如何幫助政策溝通方面，

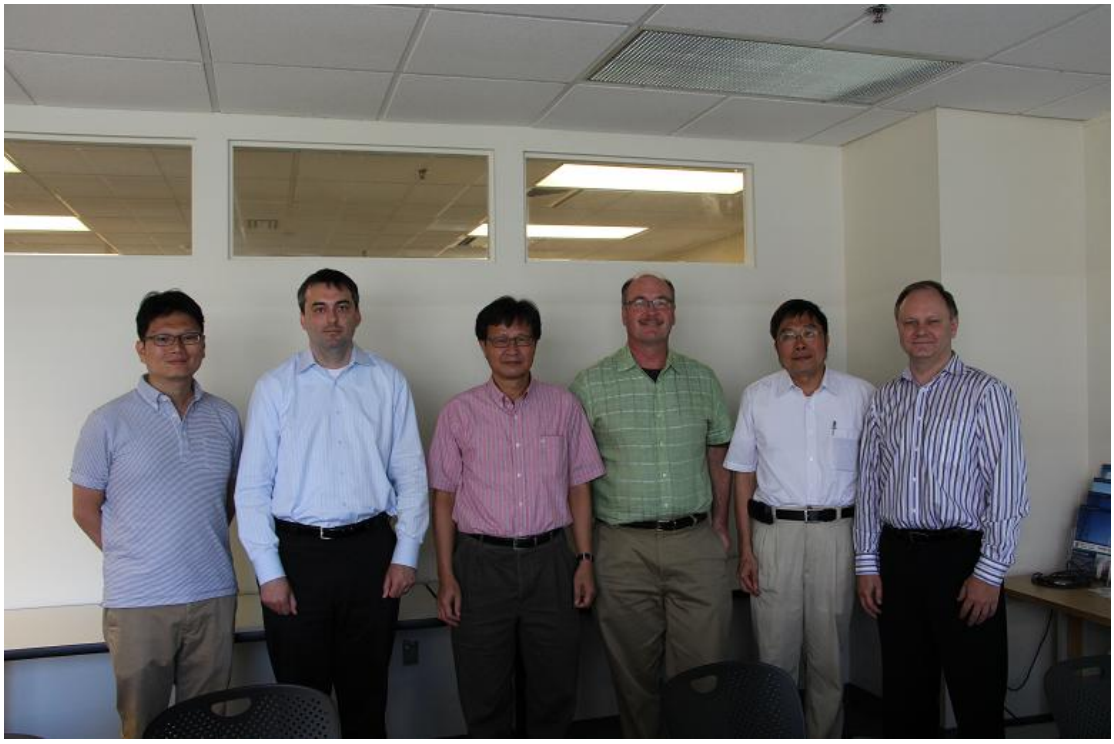
[2]對於不遵約情形所採取之處罰方式，原先京都議定書中所擬定的項目，包括:發出警告、公佈不遵守之行為、增加下一承諾期之減量責任、喪失參與京都機制之資格、停止享有權利或特權、罰款並成立遵約基金等。後來，由於日本強列反對針對違約國家採取具法律效力制裁措施之強制履行機制，認為會與各國國家主權相衝突。日本的堅持終於獲得歐聯的讓步，不再堅持具法律效力制裁措施。

對於決策者來說必須符合經濟直覺(intuition)、並能真實(truthful)的解釋，畢竟全美國的模型太多了。至於 CGE 模型如何透明化?如何跟人民解釋? John Reilly 表示必須深入模型(digging in the model)，要有故事、直覺來解釋模型的現象，一旦違反直覺就非常難以解釋。至於台灣面臨 CGE 模型主要做為政策模擬的工具，但由於參數加設太多、模型架構複雜導致 CGE 模型的預測結果屢屢受到質疑。Sergey Paltsev 則表示 CGE 模型的預測必須看議題，並提供長期的趨勢，而不是預測下個月會發生甚麼事。另外，關於政策溝通方面，老實說 MIT 並沒有任何溝通的秘訣可以提供核研所參考，事實上政策的制定通常也是經過各方協議妥協而來。例如碳稅有人提 30%，有人提 15%，最後可能就是妥協在 20%。

此外，雙方談及未來是否有相關的合作空間與機會? John Reilly 表示台灣已經有非常好的單國模型以及很好的資料，不知道未來合作是指哪一方面?葛副主任表示目前受限研究經費，未來是不是可以與 MIT 合作發展全球模型或台灣的區域模型。John Reilly 表示事實上 Joshua 目前由時代基金會所贊助的計畫預計於 8 月 21 到 23 日到台北進行訪問及會議討論，到時候如果雙方時間允許，可以安排到核研所進行一次簡報交流。林師模教授並提問是否提供給台灣學生的獎學金或博士後研究人才到 MIT 進行研究的機會? John Reilly 表示該中心目前並無這樣的經費來源可以提供給台灣學生作為獎學金，事實上 MIT 的許多研究計畫是由本土或外資企業所贊助的，例如目前與北京清華大學有合作的關係，清華大學每年派 1~2 位學生，到 MIT 學習建置模型，實際來自學校的經費是占少數的。例如東京電力公司也有贊助研究經費派員來 MIT 進行研究，John Reilly 建議透過核研所、MIT、台灣企業的合作模式，是未來台灣可以參考的重要發展方向。未來的相關計畫應將台灣節能，新能源產業的企業納入，不僅可提升企業在國際上的知名度，促進企業形象與社會責任，另外可加深政府與企業間的溝通，並可協助研究單位培育人才，創造三贏的局面。

最後，由葛副主任代表致送本所紀念品給到場學者，並與 Sergey Paltsev,

John Reilly, Henry Chen, Joshua Hodge 等人合影留念。會後並由 Henry Chen 帶我們參訪 MIT 校園，為本次參訪行程畫下完美句點。



赴 MIT 參訪交流，(由右至左分別為 Sergey Paltsev 助理召集人、葛復光副主任、John Reilly 共同召集人、林師模教授、Joshua Hodge 副執行長, 袁正達副研發師

出席討論名單

Joint Program on the Science and Policy of Global Change:

John Reilly Co-Director
Sergey Paltsev Assistant Director
Joshua Hodge Deputy Executive Director
Henry Chen Research Scientist

核能研究所「能源經濟及策略研究中心」

葛復光 副主任
袁正達 副研發師

中原大學應用經濟模型研究中心

林師模 教授

四、建 議 事 項

2014 年的 IAEE 大會於 6 月 15 日於美國紐約舉行，今年度由「能源經濟及策略研究中心」副主任葛復光、副研發師袁正達與中心同仁的共同研究主題「Reconsidering the oil-linked pricing rule based on evidence of unstable cointegrating relations in Asian Lng markets」、「Explaining the Causality Between Economic Growth and Carbon Emissions in Taiwan: A Multi-sectoral Analysis」的兩篇論文很榮幸被 IAEE 大會所接受，並得以代表核研所參加此一國際盛會，特別是在能源經濟專業研究領域、全球重大能源議題的了解與掌握覺得獲益良多，也希望未來所內能積極鼓勵同仁參與國際型的研討會並發表論文，透過實務界與各國的專家學者交流來提升所內的研究能量。IAEE 研討會邀請各國實務界與研究單位的研究人員，幾乎涵蓋所有全球重大能源議題，實務座談與學術發表皆是高水準的學術盛會。透過此次國際研討會，發現各國對於能源議題的重視程度非常之高，投入的各項技術研發經費、政策規劃都非常可觀完整，是國家級的重點發展事業，在此筆者對於未來所內的能源經濟、模型建置、政策評估的議題有以下幾點建議：

（一） 經濟模型龐大且分工精細、建議引進企業贊助

在簡報過程中筆者發現各國的能源使用、減碳路徑、經濟衝擊與政策評估等皆須仰賴模型的支援，然而模型的功能愈多，架構也就愈龐大。例如 UC DAVIS 的運輸模型也是非常龐大的架構，需要仰賴足夠的專業研究人員來進行維護；另外，在 MIT 的參訪過程中，發現 MIT 的模型也有主要的維護人員，同時細部門的模型可以由多位研究生來研發或改進，因為研究生的專業背景不同，必須透過定期舉行討論會議來學習，一方面可以指導新進研究人員進入該領域熟悉模型；另一方面也有互相交流學習的機會。MIT 表示基本上對於有意願來參訪或進行博士後研究的人員都非常歡迎，但是目前並沒有獎學金可以申請，所以必須自行籌措

研究資金，事實上 MIT 的許多研究計畫是由本土或外資企業所贊助的，例如目前與北京清華大學有合作的關係，清華大學每年派 1~2 位學生，到 MIT 學習建置資料與模型，實際來自學校的經費是占少數的。MIT 全球氣候變遷科學與政策聯合專案共同主持人 John Reilly 建議政府相關部門可以加強與台灣企業的合作，由企業提供贊助，而相關研究成果也可以回饋給企業參考，是未來可以發展合作的重要方向。透過將台灣節能，新能源產業的企業納入，不僅可提升企業在國際上的知名度，企業形象，另外加深政府與企業的溝通，並可協助國內研究機構的人才培育，創造雙贏的局面。

（二） 促進與國外學術研究、實務應用的交流，提升企業參與度

IAEE 研討會的參與人員來自世界各國，研究主題、場次與議題之多元化，讓人目不暇給。筆者在聽取簡報的過程，時常遇到跨領域的研究，例如計算電力系統、電動車技術的研究，通常也伴隨著經濟效益、成本以及市場的概念、感覺到融合實務與理論結合的分析與研究，必須整合更多的領域與資訊才能使分析結果更具完整性與可應用性。另外，筆者於研討會的餐敘或者中場休息時間也與許多國家的專家學者交流，發現很多跨領域的學者來參加該研討會獲取靈感，甚至有進行機械研究的學者，也來參與 IAEE 的研討會尋找相關有興趣的議題與人才，希望可以進行跨領域的交流，也遇到來自英國 Portsmouth 大學主修法律的博士，進行環境能源法律的研究，都是進行跨領域研究的例子。建議核研所可以透過國際研討會的交流，不僅能讓同仁多認識各國在能源經濟環境領域的發展現況，也提升同仁對於未來核研所在能源經濟領域的研究能量。此外，有關企業綠色融資，各種能源期貨、契約價格的變化，碳交易等制度，透過企業的角度來思考與觀察，展現出企業與金融市場積極參與新能源技術與促進市場交易的功能。

（三） 建議研究機構與政府政策應更緊密配合

筆者於多場的會議簡報中聽取土耳其、巴西、中國等國家的減碳目標與再生能源的發展政策、甚至運輸部門的能源使用預測、碳排放預測都有相關的經濟模型來進行政策模擬與評估，核研所的「能源經濟及策略研究中心」目前已有 MARKAL 工程模型、亦積極建立 TIMES (The Integrated MARKAL/EFOM System) 模型，同時亦與中原大學應用經濟中心研究團隊合作建立 GEMEET(General Equilibrium Model for Energy, Environment, and Technology Analysis)模型，依據不同的發電特性，區分為基、中尖載等，將各種新及再生能源技術依序納入模型，不僅可成為國內具特色的CGE模型，可用於政策模擬與經濟效益評估，是符合能源經濟領域潮流的做法，也是做為政府、民眾、研究機構之間的溝通橋樑與不可或免的重要工具。相較於各國投入經濟模型的建置、研發與維護，建議所內可以投入更多資源來長期培訓專精的模型運維人才，從一開始的資料建置、模型維護、運跑與政策建議評析，進行一連串的整合，才能維持核研所的專業獨立性，對國內能源經濟模型的建置與相關能源政策的評估具有貢獻，並有效支援經濟及能源部。

（四） 了解中國新興能源產業市場、創造互補互利的空間

此次 IAEE 國際研討會有許多中國的研究機構與人員參加，顯示中國大陸積極培養能源相關領域的人才。會中有與中國科學院能源與環境政策研究中心主任范英、中國科學院數學與系統科學研究院的助理研究員鮑勤、中國石油大學馮達勇教授、中國地質大學博士生孔曉奇等多位中國能源經濟領域的專家學者進行交流。2014 年 IAEE Asian 會議將於九月在北京召開，清華大學與 MIT 共同合作的 CGE 模型的專題報告，能源與環境政策研究中心主任范英於閉幕式發表中國能源政策的演說，都顯示中國在全球能源領域的重要地位，相關研究也非常豐富，而在與 MIT 的交流會議中，MIT 全球氣候變遷科學與政策聯合專案共同主持人 John Reilly 也多次提及中國在全球減碳目標的重要性，顯示中國在未來的能

源發展有重大的潛能，相對的也背負沉重的減碳壓力。建議所內相關研究人員可積極參與中國舉辦的相關研討會，以了解中國未來的能源政策、減碳策略、以及重點發展的節能技術領域，尋求創造互補互利的空間，同時中國也提供廣大的出口市場，將有助於未來台灣的技術輸出與產業規劃的思考方向。

五、附　錄

(一) IAEE 會議相關議程

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SUNDAY, JUNE 15

REGISTRATION
12:00n - 7:00pm • Kips Bay Suite

IAEE COUNCIL MEETING (BY INVITATION)
9:00am - 12:00n • Sutton Place Suite

IAEE/USAEE COUNCIL LUNCH (BY INVITATION)
12:00n - 1:00pm • Gramercy Park Suite

USAEE COUNCIL MEETING (BY INVITATION)
1:00pm - 4:30pm • Sutton Place Suite

SPECIAL PHD SESSION
1:00pm - 5:15pm • Herald Square Suite
Please click here for details.

OPENING RECEPTION
6:00pm - 7:30pm • Crystal Ballroom
Sponsored By: Baker Hughes

STUDENT MENTORING PROGRAM
7:30pm - 10:00pm • Herald Square Suite
This is an informal event for all of our student members. After the opening reception (6:00 – 7:30pm, Sunday June 15 in the Crystal Ballroom) come along to the Herald Square Suite to hear from a dozen energy professionals about their lifetime experiences in different sectors of energy economics. We have invited a diverse group of working professionals to reflect with you on their career paths and lessons learned. They will be meeting with separate groups of students simultaneously but you'll have time during the session to visit with up to six speakers as they will repeat their talks and you can participate in the individual Q&A's and chat one-on-one with the professionals afterwards.

MONDAY, JUNE 16

REGISTRATION
7:00am - 7:00pm • Kips Bay Suite

IAEE AFFILIATE LEADERS MEETING
7:45am - 8:45am • Herald Square Suite

STUDENT BREAKFAST MEETING
7:45am - 8:45am • Sutton Place Suite
Sponsored By: Chevron

CONTINENTAL BREAKFAST
8:00am - 8:45am • Foyer, Mezzanine & Grand Ballroom Balcony
Sponsored By: ConocoPhillips

PRESIDER HUDDLE
8:15am - 8:30am • Mezzanine 2nd Floor

PRESIDENTS' WELCOME AND INTRODUCTION
8:45am - 9:30am • New Yorker Hotel Grand Ballroom

TUESDAY, JUNE 17

REGISTRATION
7:00am - 6:30pm • Kips Bay Suite

2015 PITTSBURGH USAEE/IAEE NORTH AMERICAN CONFERENCE PLANNING MEETING (BY INVITATION)
8:00am - 9:00am • Sutton Place Suite

5TH ELAEE CONFERENCE PLANNING MEETING (BY INVITATION)
8:00am - 9:00am • Gramercy Park Suite

ENERGY JOURNAL BOARD OF EDITORS MEETING (BY INVITATION)
8:00am - 9:00am • Herald Square Suite

CONTINENTAL BREAKFAST
8:15am - 9:00am • Foyer, Mezzanine & Grand Ballroom Balcony

PRESIDER HUDDLE
8:30am - 8:50am • Mezzanine 2nd Floor

DUAL PLENARY SESSION: INTERNATIONAL SHALE DEVELOPMENT: PROSPECTS AND CHALLENGES
9:00am - 10:30am • New Yorker Hotel Grand Ballroom
Top energy economists and environmental specialists will speak to the broad array of challenges facing shale oil and gas development globally, including industry structure, price stability and market mechanisms, as well as physical and environmental concerns over water resources, groundwater and methane leakage. The panel will assume a collaborative, forward-looking posture in focusing on solutions that work, timing, and obstacles that must be faced and resolved.

Benjamin Schlesinger (Presiding)
President, Benjamin Schlesinger & Assoc LLC

Surya Rajan
Director, Strategy, Baker Hughes

Edward Morse
Managing Director and Global Head - Commodities, Citi Research

Daniel Tormey
Principal, ENVIRON Corporation

DUAL PLENARY SESSION: TRANSPORTATION DEVELOPMENTS
9:00am - 10:30am • Crystal Ballroom
High global oil prices have encouraged innovation and conservation in many key use sectors, and environmental drivers are also driving rapid acceptance of new technologies. This trend is now gaining momentum globally in the transportation sector where local and federal government policies are accelerating the pace of penetration of new more efficient vehicles and adoption of alternative fuels. The purpose of this session is to discuss both policy and commercial drivers to these challengers to incumbent fuels and vehicle designs and their ultimate impact on the future of the transportation sector fuel mix.

Amy M. Jaffe (Presiding)
Executive Director, Institute of Transportation Studies, UC Davis

Distinguished Fellow, Logistics Management Institute

Adam E. Sieminski

Administrator, Energy Information Administration

David Hobbs

Head of Research, KAPSARC

Eirik Wærness

Chief Economist, Statoil ASA

COFFEE BREAK

10:30am - 11:00am • Foyer, Mezzanine, Grand Ballroom Balcony & Loews Theater Foyer
Sponsored By: EPRI

CONCURRENT SESSIONS 1 - 10

11:00am - 12:45pm

Click here for concurrent session details

LUNCH AND POSTER SESSION

12:45pm - 2:00pm • Manhattan Center Grand Ballroom

These are not just stand-up buffet lunches - they are also great opportunities for all conference delegates to mingle with - and learn from - students who will be presenting posters of their recent academic work in the room where lunch will be available. At this unique event you will be able to network with students and colleagues around energy topics in which you share a common interest. There will be two sets of posters, one on Monday and another on Tuesday. So don't wait in a long line for food and drink, be first to engage with the students and their posters during these 1¼ hour long breaks from the main conference.

Click here to view poster sessions

DUAL PLENARY SESSION: ENERGY & THE ECONOMY

2:00pm - 3:30pm • New Yorker Hotel Grand Ballroom

The panel will discuss energy prices and US economic activity. The panel will address whether increased US oil and gas production from shale has impacted energy security, the trade balance and the effects of oil price shocks on the economy.

Mine Yucel (Presiding)

Vice President & Sr Economist, Federal Reserve Bank of Dallas

DUAL PLENARY SESSION: RENEWABLES, POWER PRICES, AND GRID INTEGRATION

2:00pm - 3:30pm • Crystal Ballroom

The panel will address key issues associated with increasing amounts of renewables on the critical decisions and impacts for grid operators, utilities and other key stakeholders. The panel will present a breadth of perspectives, and address technical, regulatory, economic, and "business model" implications for the power sector, for different structures from different countries & states.

Douglas Arent (Presiding)

Executive Director JISEA, National Renewable Energy Lab

Karsten Neuhoff

Head of Department, German Institute for Economic Research (DIW Berlin) and Professor Technical University Berlin

Jose Maria Valenzuela

Director de Sustentabilidad Energetica, Secretaria de Energia, Government of Mexico

Everett W. Whitaker

Managing Director, Policy & Planning, Power Economics Energy Consulting, USA, GE Energy Management

COFFEE BREAK

3:30pm - 4:00pm • Foyer, Mezzanine, Grand Ballroom Balcony & Loews Theater Foyer

CONCURRENT SESSIONS 11-20

4:00pm - 5:45pm

Click here for concurrent session details

IAEE AWARDS DINNER

7:00pm - 10:00pm • Manhattan Center Grand Ballroom

IAEE STUDENT HAPPY HOUR

9:30pm - 11:00pm • Stout
Sponsored By: Norwegian School of Economics

Address:
133 West 33rd Street
New York, NY 10001

CONCURRENT SESSIONS 21-30

11:00am - 12:45pm

Click here for concurrent session details

LUNCH AND POSTER SESSION

12:45pm - 2:00pm • Manhattan Center Grand Ballroom

These are not just stand-up buffet lunches—they are also great opportunities for all conference delegates to mingle with – and learn from - students who will be presenting posters of their recent academic work in the room where lunch will be available. At this unique event you will be able to network with students and colleagues around energy topics in which you share a common interest. There will be two sets of posters, one on Monday and another on Tuesday. So don't wait in a long line for food and drink, be first to engage with the students and their posters during these 1¼ hour long breaks from the main conference.

Click here to view poster sessions

DUAL PLENARY SESSION: OIL & GAS RESERVE VALUATION & FINANCING

2:00pm - 3:30pm • New Yorker Hotel Grand Ballroom

This session will focus on resource assessment techniques, the process of a firm's reserve estimation, and the manner in which these issues affect how firms value acreage and ultimately translate their assessments into production. The session will also address the role of uncertainty in estimating resources and reserves and how such uncertainty translates into production outlooks and expected profitability.

Kenneth B. Medlock III (Co-Presiding)

Senior Director, Center for Energy Studies, Baker Institute, Rice University

William Furlow (Co-Presiding)

Senior Manager Business Development, Society of Petroleum Engineers

Sandy Fielden

Director Energy Analytics, RBN Energy

W. John Lee

Professor and Cullen Distinguished University Chair, University of Houston

DUAL PLENARY SESSION: CLIMATE CHANGE AND CARBON POLICIES - INTERNATIONAL LESSONS AND PERSPECTIVES

Professor of Economics, TU Berlin

A. Denny Ellerman

Part-time Professor, European University Institute

Zhang Xiliang

Professor and Executive Director of the Institute of Energy, Environment and Economy, Tsinghua University

Karen Palmer

Senior Researcher, Resources for the Future

COFFEE BREAK

3:30pm - 4:00pm • Foyer, Mezzanine, Grand Ballroom Balcony & Loews Theater Foyer

CONCURRENT SESSIONS 31-40

4:00pm - 5:45pm

Click here for concurrent session details

IAEE GENERAL MEMBERSHIP MEETING

5:45pm - 6:15pm • Sutton Place Suite

CAEE GENERAL MEMBERSHIP MEETING

5:45pm - 6:15pm • Brooklyn Suite

DELEGATES FREE TO ENJOY NEW YORK CITY ON THEIR OWN

WEDNESDAY, JUNE 18

REGISTRATION

7:00am - 5:45pm • Kips Bay Suite

2015 ANTALYA INTERNATIONAL CONFERENCE PLANNING MEETING (BY INVITATION)

8:00am - 9:00am • Sutton Place Suite

EEEP EDITORIAL BOARD MEETING (BY INVITATION)
8:00am - 9:00am • Herald Square Suite

CONTINENTAL BREAKFAST
8:15am - 9:00am • Foyer and Mezzanine

PRESIDER HUDDLE
8:30am - 8:50am • Mezzanine 2nd Floor

DUAL PLENARY SESSION: ENERGY FINANCING
9:00am - 10:30am • New Yorker Hotel Grand Ballroom

The future development of global energy resources requires both the presence of economically producible material and the activity to convert the resources into first extractable reserves and then actual production. For the necessary activity to occur – besides access to the resource – there must be investment. While the issue of resources and reserves has been widely addressed, the path of future activity has gotten less attention. The purpose of this session is to look at the interesting history of how energy activity has traditionally been financed and what the prospects are for future innovation to confront the changing geography and composition of global energy markets; what is currently working and what is not and what the main challenges are moving forward.

David H. Knapp (Presiding)
Managing Director Energy Research Advisor, Energy Inteligence Group

Robert Maguire
Partner, Perella Weinberg Partners

Katherine Spector
Head of Commodities, CIBC World Markets

Robert Levin
Managing Director, CME Group

DUAL PLENARY SESSION: UTILITY BUSINESS MODEL
9:00am - 10:30am • Crystal Ballroom

This session will address profound challenges to its traditional business model faced by the electric utility sector worldwide. Utilities must redefine their business, driven by the proliferation of efficient but potentially disruptive digital technologies; by customers' new options including distributed self-generation, time-of-use price responsiveness, and electricity storage; by entrepreneurial third parties seeking to serve those customers directly; by environmental mandates including planning or hoping to survive or even thrive in the very different electric sector business environment of coming years, and how energy economists can bring their particular skills and expertise to bear in this challenging transition.

John W. Jimison (Presiding)
Managing Director, Energy Future Coalition

Ralph Izzo
Chairman of the Board, President and Chief Operating Officer, Public Service Enterprise Group Incorporated

Jigar Shah
Founder, SunEdison LLC

David M. Newbery
Director, EPRG, University of Cambridge

Michel Derdevet
Secretary General, ERDF

COFFEE BREAK
10:30am - 11:00am • Foyer, Mezzanine, Grand Ballroom Balcony & Loews Theater Foyer

CONCURRENT SESSIONS 41-49
11:00am - 12:45pm
Click here for concurrent session details

WORKSHOP: THE WATER-ENERGY NEXUS: CHALLENGES AND OPPORTUNITIES
10:00am - 1:00pm • Gramercy Park Suite
Sponsored By: Rice University's Baker Institute Center for Energy Studies

For more information, please click here

Separate registration is required.
The Department of Energy is pursuing work in the water-energy nexus because the nexus is integral to both energy security and climate change policy. This workshop will:

- Overview our interconnected water and energy systems
- Examine how climate change and other future trends may affect the relationship between water and energy
- Discuss the patchwork of factors that influence relevant decision-making at

challenges across the nexus

- Describe needs in data, modeling, and analysis to support better understanding and improved decision-making.

Kenneth B. Medlock III (Co-Presiding)

Senior Director, Center for Energy Studies, Baker Institute, Rice University

Christopher A. Smith (Opening Remarks)

Principal Deputy Assistant Secretary For Fossil Energy, U.S. Department of Energy

Fletcher Fields

Economist, Office of Energy Policy and Systems Analysis, U.S. Department of Energy

LUNCH

12:45pm - 2:00pm • Manhattan Center Grand Ballroom

CONCURRENT SESSIONS 50-57

2:00pm - 3:45pm

Click here for concurrent session details

COFFEE BREAK

3:45pm - 4:15pm • Foyer, Mezzanine, Grand Ballroom Balcony & Loews Theater Foyer

CLOSING PLENARY SESSION: GLOBAL ENERGY DEMAND GROWTH AND STUDENT POSTER SESSION AWARD

4:15pm - 5:45pm • New Yorker Hotel Grand Ballroom

Since 2000 global energy demand has grown by more than 30%. Non-OECD economies have displaced OECD economies as the key drivers of global energy demand, but on average non-OECD economies exhibit per-capita energy consumption that is still only a quarter that of OECD economies. What does this say about the amount of energy needed in 20, 30 or 50 years? How will we supply those energy needs? What role will fossil fuels, renewables and nuclear power play? How will environmental constraints factor in? To what extent will local, regional and national energy markets integrate with one another? The closing plenary session of the 2014 NYC conference will feature leading world energy experts who will give their views on what to expect and when to expect it.

Ricardo B. Raineri (Presiding)

Alternate Executive Director - LA, The World Bank Group

Jason Bordoff

Director, Center on Global Energy Policy, SIPA, Columbia University

Mauricio Tolmasquin

President, EPE (Empresa de Pesquisa Energetica), Brazil

Ying Fan

Director, Center for Energy and Environmental Policy Research, IPM, CAS

Frederik R. Janssens

COO Latin America, Origin Energy

Connect with others! #IAEE2014

With Support from: United States Association for Energy Economics

CONCURRENT SESSIONS 11-20
Monday, June 16, 4:00pm - 5:45pm

11. Energy and Economic Growth 2 (Grand Ballroom)

Pierre O Pineau, *Presiding*
Professor
HEC Montreal

A Multiphases Analysis of China's Energy Consumption And Economic Growth Nexus
Xiaoqi Sun
Haizhong An
Xiaoliang Jia
Lijun Wang
China University of Geosciences, Beijing
View Extended Abstract | View Paper

Energy and Chaos: Modelling Energy in a Dynamical Growth Model with Chaotic Bifurcation
Gaël Giraud
Centre d'économie de la Sorbonne
View Abstract

Explaining the Causality between Economic Growth and CO2 Emissions in Taiwan: A Multivariate Sectoral Analysis
Cheng-Da Yuan
Fu-Kuang Ko
Hui-Chih Chai
Institute of Nuclear Energy Research (INER)/Center of Energy Economics and Strategy Research
View Extended Abstract | View Paper

49. Price Linkages (Loews Theater 14)

Matt King, *Presiding*
Strategic Sourcing Specialist
ConocoPhillips

WTI-Brent Spread and the Value of Refining Firms
Amir H Sabet
Richard Heaney
Andrew Caminschi
University of Western Australia
View Extended Abstract

Reconsidering the Oil-Linked Pricing Rule Based on Evidence of Unstable Cointegrating Relations in Asian LNG Markets
Hui Chih Chai
Institute of Nuclear Energy Research, Atomic Energy Council, Executive Yuan
Fu-Kuang Ko
Cheng-Da Yuan

（二）IAEE 會議報告投影片 -1

RECONSIDERING THE OIL-LINKED PRICING RULE -based on evidence of unstable cointegrating relations in Asian LNG markets

New City IAEE Conference
June 2014

Hui-Chih Chai
Cheng-Da Yuan
Fu-Kuang Ko,
Institute of Nuclear Energy Research
Center of Energy Economics and Strategy Research
Deputy Director

Abstract

- Answering a crucial question – does LNG importing price integration and converge in Asian LNG market?
  - LNG price are oil-linked, the pricing rule is less “rational”
  - The answers are necessary for evaluate the current pricing mechanism.
- Applying an appropriate econometric methods for the data
  - The global economic crisis & the characteristics of the LNG trading mechanisms (eg,long run contract) → smooth structural changes.
  - This study uses the smooth transition regression (STR) model and the nonlinear co-integration test。
- Providing policy implications from empirical findings
  - A nonlinear co-integration exists in the Asian LNG market, but do not support the law of one price (LOP).
  - It is lack a single price signals and hard to predict the long-run price → a new pricing mechanism is needed for facilitating information transmission

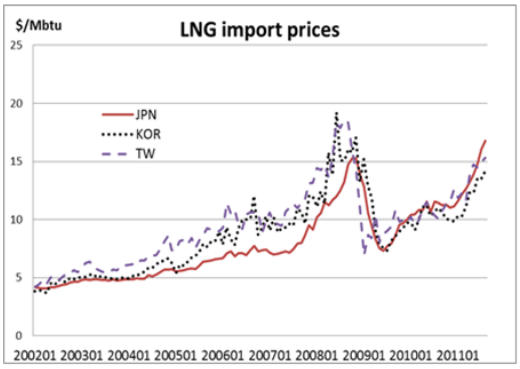
2

Outline

- Backgroud & Motivation
  - Challenges to oil-linked pricing in Asian LNG market
  - The importance of investigating the price integration
- Literatures review
  - NG/LNG price integration
  - Major changes in the LNG market around global economic crisis
- Methods
- Empirical Findings
- Conclusions & Policy Implication

Background

- Asia does not have a common LNG market
- Focusing on three LNG importers in Asian- Japan, South Korea and Taiwan
- LNG import prices are oil-indexed (JCC price)



After the global economic crisis around 2008, The LNG market appears softer than before, and importing prices tend to converge.

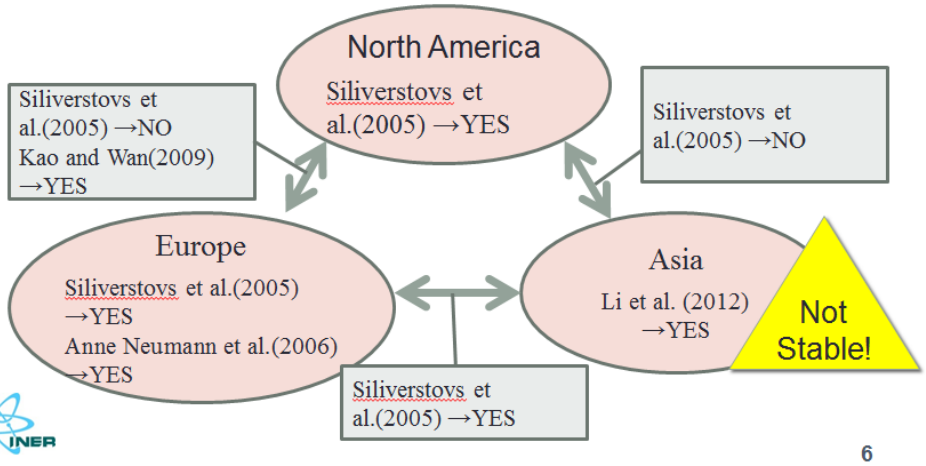
Motivation

- Challenges (problem) to oil-linked pricing LNG
  - The logic behind oil-linked has changed
  - The price signal are NOT based on demand and supply→ renegotiation → transaction cost
  - Bargaining power are vary different → prices diverge
- The importance of investigating the price integration
  - Price fully integration (price converge) → the information are transmission efficiently, and transaction costs are low

5

Literature Review (I)

- At the interregional level, cointegration relationship exists between Japan and Europe market (Siliverstovs et al., 2005)
- the cointegration among Japan, Korea and Taiwan, but the relationship is not stable (Li et al., 2012)



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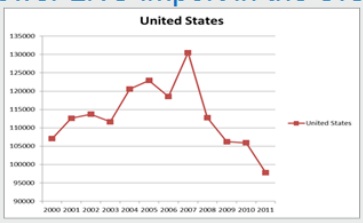
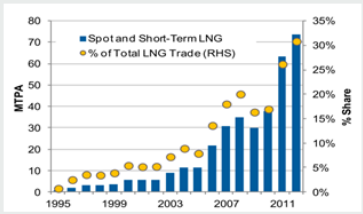
Literature Review (II)

High growth of shale gas and lower LNG import in the U.S.



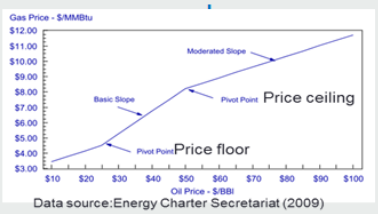
Data source:EIA

More Spot and short-term LNG trading



Data source:IGU, (2013)

More flexible contracts caused by Abandoning the S-curve formula



Data source:Energy Charter Secretariat (2009)

LNG market becomes a softer market

↓

smooth structural changes In the LNG market

INER

7

Purpose & Contribution

- Purpose
  - Answering a crucial question – Does LNG importing price integration in Asian LNG market?
- Contribution
  - Providing policy implications for the current pricing mechanism.
  - Indicating the limitation of linear models and introducing an more appropriate nonlinear model-STR model

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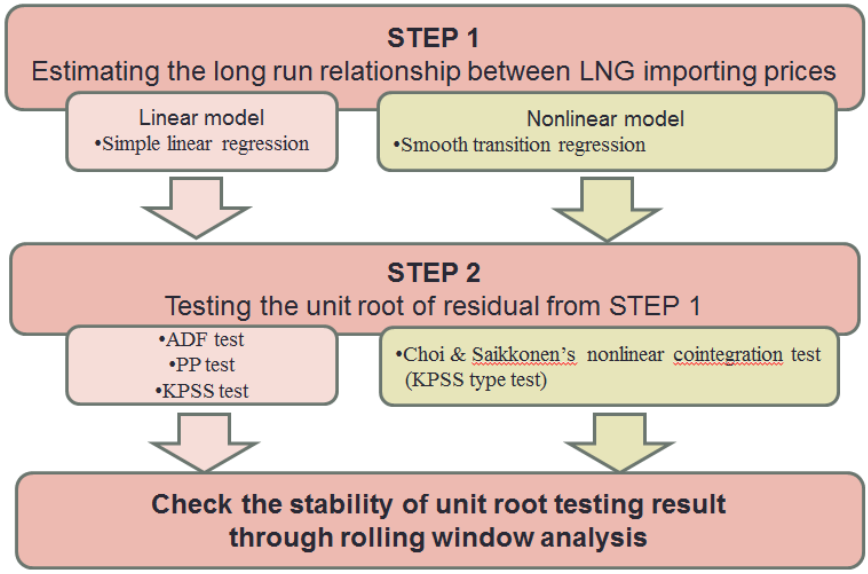
Method (I)

- Two step method (Residual based method or Engle & Granger's cointegration test)



Method (II)

- Linear Model

$$P_t^A = \alpha + \beta P_t^B + \varepsilon_t$$

P_t^A and P_t^B denotes the LNG import price of country A and B respectively;
α and β are parameters, ε denotes the residual

- Nonlinear Model -Smooth Transition Regression (STR) Model

$$P_t^A = \alpha_1 + \beta_1 P_t^B + F(t)[\alpha_2 + \beta_2 P_t^B] + u_t$$

$$F(t;\gamma) = \frac{1}{1+e^{-\gamma(t^k + c_1 t^{k-1} + \ldots + c)}}, \quad \text{where} \quad k = 1, 2 \text{ or } 3$$

F(.) the transition function
t : the transition variable
γ :the speed parameter
c_i :the location parameters

when $F(t) = 0$ $\quad P_t^A = \alpha_1 + \beta_1 P_t^B + u_t$

when $F(t) = 1$ $\quad P_t^A = (\alpha_1 + \alpha_2) + (\beta_1 + \beta_2) P_t^B + u_t$

- the STR model allowed smooth transitions in coefficients, in addition, abrupt change is a special case of the STR model
- the location of breaks c can be treated as an unknown.
- The choice for k can be determined by LM test (Lin and Terasvirta, 1994)

Findings from the linear model (I)

- Step 1. **Estimation results of linear model**

$$P_t^A = \alpha + \beta P_t^B + \varepsilon_t$$

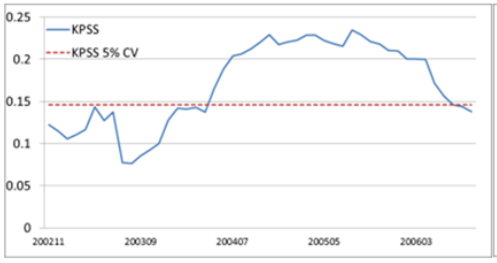
Coef.	KOR	TW
α	1.236	0.126
	(0.001)	(0.793)
β	0.939	0.829
	(0.000)	(0.000)
Adjusted R-squared	0.809	0.725
Log likelihood	-208.269	-224.497
Unit root test on OLS residual		
ADF (H_0: nonstationary)	-1.943*	-3.121***
PP (H_0: nonstationary)	-4.191***	-3.036***
KPSS (H_0: stationary)	0.306	0.257
Wald test		
H0: β=1	-1.433	-2.425**

Residuals from the Linear model "seems" stationary.

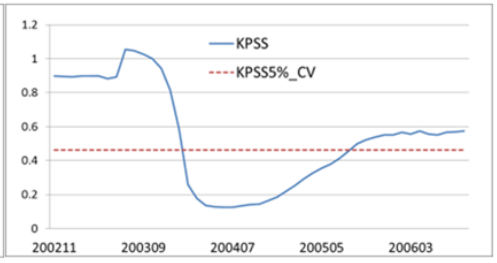
Findings from the linear model (II)

- Step 2. Rolling window analysis of unit root test
  - Residuals from simple linear regression

KOR



TWN



the residual from linear model are not stationary over time
Similar results appears by using other unit root tests (eg, ADF test, PP test) and different window size
→ However, linear co-integration in the Asian LNG market is not stable

Findings from the nonlinear model (I)

- Step 1. Estimation results of the STR model

$$P_t^A = \alpha_1 + \beta_1 P_t^B + F(t)[\alpha_2 + \beta_2 P_t^B] + \varepsilon_t$$

$$F(t;\gamma) = \frac{1}{1+e^{-\gamma(t-c)}}$$

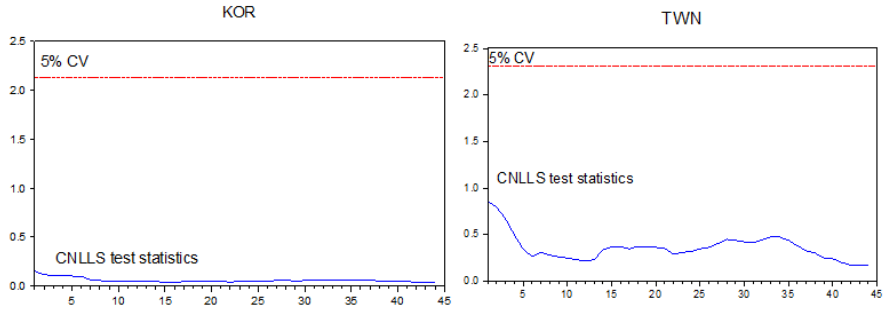
Ceof.	KOR	TWN
α_1	-3.565 (0.000)	-1.148 (0.001)
β_1	1.810 (0.000)	1.524 (0.000)
α_2	5.757 (0.000)	4.597 (0.000)
β_2	-1.099 (0.000)	-0.854 (0.000)
γ (slope parameter)	0.124 (0.001)	1.853 (0.008)
c (location parameter)	77.779 (0.000)	81.347 (0.000)
Log likelihood	-142.960	-152.295
Regime I :F(t)=0		
C_1	-3.565	-1.148
β_1	1.810	1.524
Regime II :F(t)=1		
C_1+C_2	2.192	3.449
$\beta_1+\beta_2$	0.711	0.670
Wald test		
H0: $\beta_1=1$	6.092***	-4.705***
H0: $\beta_1+\beta_2=1$	-4.217***	10.187***

The estimations of location parameters for KOR and TWN are corresponding to May 2008

The estimated coefficient γ is corresponding to the speed parameter. For TWN, γ is relatively large

Empirical Findings from non-linear model (II)

- Step 2. Rolling window analysis of unit root test
  - STR residuals

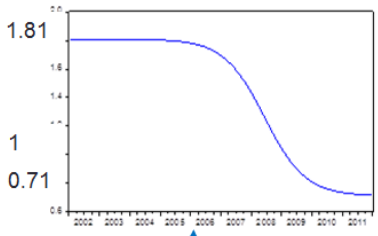


The stationarity of residuals from the STR model (nonlinear model) is much more stable than under the liner regression.
→ Nonlinear cointegration existed in the Asian LNG market

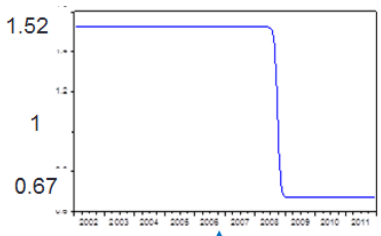
Testing result of Law of one price (LOP)

- Nonlinear Cointegration relationship
  - However, in the cases of either KOR or TWN, the null hypothesis of LOP is rejected by using the Wald test.

β for KOR



β for TWN



Regime I (F=0): $P_t^{KOR} = -3.365 + 1.810 P_t^{JP}$
Regime II (F=1): $P_t^{KOR} = 2.192 + 0.711 P_t^{JP}$

Regime I (F=0): $P_t^{TW} = -1.148 + 1.524 P_t^{JP}$
Regime II (F=1): $P_t^{TW} = 3.449 + 0.670 P_t^{JP}$

Conclusions & Policy Implication

- Nonlinear Cointegration
  - Price relationship changes over time , predicting the LNG price increases in complexity → Upstream integrating shares price risk.
- Smooth transition
  - the LNG market responses slowly → an optimal contract portfolio must be developed for long- and short-term trading, spot trading, and swap trading.
- LOP is not supported
  - It is lack a single price signal → A buyer's alliance or a more rational pricing rule is necessary.

（三）IAEE 會議報告投影片 -2

Explaining the Causality between Economic Growth and Carbon Emissions in Taiwan: A Multivariate Sectoral Analysis

Center of Energy Economics and Strategy Research
Cheng-Da, Yuan
Hui-Chih, Chai
Fu-Kuang, Ko

核研 行政院原子能委員會核能研究所

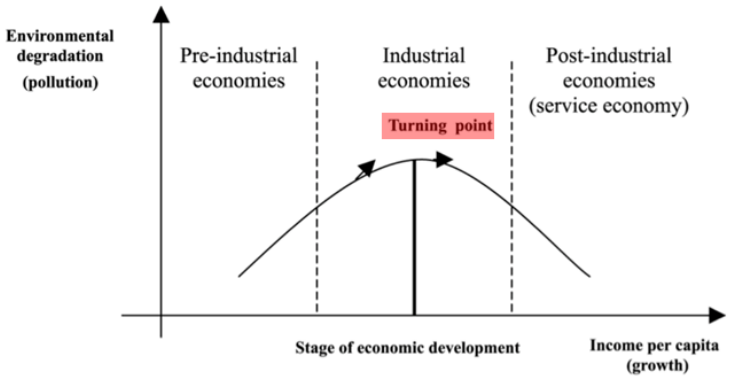
Outlines

- Introduction
- Literature review
- Data and methodology
- Empirical results
- Robustness check: sub-sector analysis
- Conclusions

核研

Introduction- Environmental Kuznets Curve

- Environmental Kuznets Curve (EKC) implies that carbon emissions will decrease with the economic growth



- Neutrial hypothesis, Conservation hypothesis, Emissions hypothesis
- There exists long-run relationship between growth and carbon emissions ?
- Sector specific pattern ?

Environmental Kuznets Curve and functional form

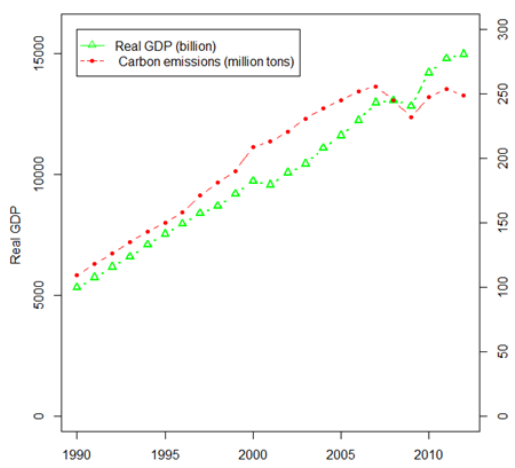
$$\ln(E)_t = \alpha_0 + \alpha_1 \ln Y_t + \alpha_2 (\ln Y_t)^2 + \varepsilon_t \qquad (1)$$

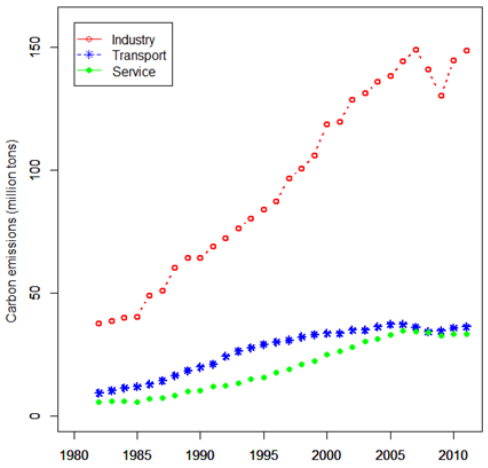
- $\alpha_1 = \alpha_2 = 0$ indicates a level relationship
- $\alpha_1 < 0$ and $\alpha_2 = 0$ monotonically decreasing linear relationship
- $\alpha_1 > 0$ and $\alpha_2 = 0$ monotonically increasing linear relationship
- $\alpha_1 < 0$ and $\alpha_2 > 0$ representing U-shaped relationship
- $\alpha_1 > 0$ and $\alpha_2 < 0$ inverted U-shaped relationship

- The turning point of per capita real income is $Y^* = -\alpha_1 / 2\alpha_2$

If the variable Y is measured in logs then $\exp(Y^*)$ will yield the monetary value representing the peak of the EKC

Fig. 1. Evolution of real GDP and carbon emissions in Taiwan





Source: ENERGY STATISTICS HANDBOOK 2012

Exclude the energy, agricultural and residential sectors

Literature review I

- The causality direction between economic growth and energy consumption was first explored by Kraft and Kraft (1978)
- Narayan and Narayan (2010), Apergis and Payne (2010) use OECD countries cover the period 1985-2005 to investigate the relationship between the renewable energy consumption and economic growth by Panel data approach
- Baranzini et al. (2012) explore the relationship between economic growth and different energy consumption such as electricity and heating oil during 1950-2010 in Switzerland.
- Gross (2012) analyzed the carbon emissions and economic growth relationship in U.S. for industry, services, transport sectors as well as the macro level

Literature review II

$$\left(\frac{E}{L}\right)_{it} = \alpha_1 + \alpha_2\left(\frac{Y}{L}\right)_{it} + \alpha_3\left(\frac{Y}{L}\right)_{it}^2 + \alpha_4\left(\frac{K}{L}\right)_{it} + X_{it}\beta_1 + Z_{it}\beta_2 + \lambda + u_{it}$$

	α2	α3	EKC
Bangladesh	+ (non SIGNIFICANT)	- (non SIGNIFICANT)	NO
Benin	+ (non SIGNIFICANT)	- (non SIGNIFICANT)	NO
Brazil	+ (SIGNIFICANT)	- (SIGNIFICANT)	YES
Costa Rica	+ (SIGNIFICANT)	- (non SIGNIFICANT)	NO
Ecuador	+ (SIGNIFICANT)	- (SIGNIFICANT)	YES
Egypt	+ (non SIGNIFICANT)	- (SIGNIFICANT)	NO
El Salvador	- (non SIGNIFICANT)	+ (non SIGNIFICANT)	NO
Ethiopia	- (SIGNIFICANT)	+ (non SIGNIFICANT)	NO
Guatemala	+ (SIGNIFICANT)	- (SIGNIFICANT)	YES
Guyana	+ (SIGNIFICANT)	- (SIGNIFICANT)	YES
Honduras	- (non SIGNIFICANT)	+ (non SIGNIFICANT)	NO
India	+ (non SIGNIFICANT)	+ (non SIGNIFICANT)	NO
Indonesia	+ (non SIGNIFICANT)	- (non SIGNIFICANT)	NO

Note: Sign and significance (5%) of the EKC coefficients

where i = 1,.., n stands for firm i and t denotes time
E is total energy consumption
Y is output
L is labour
K is physical capital

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna, 2011

7

Data and Methodology I

- Macro, Industry, Transport, Service sectors
  - Industry: energy-intensive, electronics and other industries sub-sectors;
- The carbon emissions is calculated by sectoral approach proposed by Intergovernmental Panel on Climate Change (IPCC).
- The GDP for various sectors are retrieved from AREMOS database
- Our studying period covers from 1982 to 2011.

Note: The energy-intensive industry includes Manufacture of Textiles, Pulp, Paper and Paperboard, Chemical Material, Cement and Cement Product and Basic Metals.

8

Data and Methodology II

- Bound test (Narayan, 2005; Pesaran et al., 2001)

$$\Delta \ln E_{it} = \alpha + \sum_{j=1}^{p} \beta_i \Delta \ln E_{it-j} + \sum_{j=0}^{q} \delta_i \Delta \ln Y_{it-j} + \sum_{j=0}^{r} \gamma_i \Delta \ln Y_{it-j}^2 + \varphi \ln E_{it-1} + \pi \ln Y_{it-1} + \rho \ln Y_{it-1}^2 + \varepsilon_{it}$$

$$\Delta \ln Y_{it} = \alpha + \sum_{j=1}^{p} \beta_i \Delta \ln E_{it-j} + \sum_{j=0}^{q} \delta_i \Delta \ln Y_{it-j} + \sum_{j=0}^{r} \gamma_i \Delta \ln Y_{it-j}^2 + \varphi \ln E_{it-1} + \pi \ln Y_{it-1} + \rho \ln Y_{it-1}^2 + \varepsilon_{it}$$

- Where E is carbon emission and the Y denotes the GDP and it's square term for sector i at time t. and j denotes for lag period.
- The subscribption t denote the time, α, β, δ, γ are parameters need to be estimated.
- The cointegration relationship can be identified by joint test the null hypothesis $\varphi = \pi = \rho = 0$.
- The Δ indicate the first difference.
- The optimal lag length is decided by SBC.

Data and Methodology III

- ARDL (Pesaran et al., 2001)
- The long term model can be defined as

$$\ln E_t = \theta + \sum_{j=1}^{p} \mu_i \ln E_{t-j} + \sum_{j=0}^{q} \sigma_i \ln Y_{t-j} + \sum_{j=0}^{q} \tau_i \ln Y_{t-j}^2 + \nu_t$$

- Where the short term model is defined in log difference form.
- The short term relationship can be estimated by including residuals or ECT obtained from long term relationship above.

$$\Delta \ln E_t = \alpha + \sum_{j=1}^{s} \beta_i \Delta \ln E_{t-j} + \sum_{j=0}^{t} \delta_i \Delta \ln Y_{t-j} + \sum_{j=0}^{u} \gamma_i \Delta \ln Y_{t-j}^2 + \lambda ECT_{t-1} + \xi_t$$

Table 1. Bound test

		Lag 1	Lag 2	Lag 3
Macro	F(lnE|lnY, lnY^2)	3.034[0.05]	1.809[0.18]	4.386[0.02]
	F(lnY|lnE, $ln\ Y^2$)	1.190[0.33]	0.858[0.48]	0.957[0.44]
	F(lnY^2|lnY, lnE)	1.010[0.40]	0.764[0.53]	0.869[0.48]
Industry	F(lnE|lnY, lnY^2)	3.350[0.03]	1.456[0.26]	0.823[0.50]
	F(lnY|lnE, $ln\ Y^2$)	0.487[0.69]	0.163[0.92]	0.352[0.78]
	F(lnY^2|lnY, lnE)	0.431[0.73]	0.113[0.95]	0.366[0.77]
Transport	F(lnE|lnY, lnY^2)	4.556[0.01]	8.631[0.00]	5.223[0.01]
	F(lnY|lnE, $ln\ Y^2$)	0.173[0.91]	0.231[0.87]	2.254[0.13]
	F(lnY^2|lnY, lnE)	0.184[0.90]	0.271[0.84]	2.359[0.11]
Service	F(lnE|lnY, lnY^2)	3.832[0.02]	2.200[0.12]	13.102[0.00]
	F(lnY|lnE, $ln\ Y^2$)	0.566[0.64]	1.243[0.32]	1.458[0.27]
	F(lnY^2|lnY, lnE)	0.622[0.60]	1.343[0.29]	1.561[0.24]

Critical value bound test of the F statistic: intercept and no trend					
90% level		95% level		99% level	
I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
2.915	3.695	3.538	4.428	5.155	6.265

The critical value is from Narayan (2005).
The optimal lag-length is selected by AIC and parsimony criterion, and the value in [ ] is p-value.

Table 2. ARDL long-run estimations

	Macro	Industry	Transport	Service
ln(Y)	15.321** (2.15)	32.247*** (4.29)	33.820*** (6.50)	10.412 (0.96)
$ln(Y)^2$	-1.054* (-2.02)	-2.454*** (-4.14)	-3.166*** (-6.30)	-0.707 (-0.85)
Const.	-47.316* (-1.95)	-97.818*** (-4.11)	-82.743*** (-6.16)	-30.612 (-0.86)
turning point (million)	18,536,450	3,717,863	219,343	23,094,458
Diagnostic test statistics				
Serial Correlation	0.008[.927]	0.762[.383]	0.153[.695]	0.229[.632]
Ramsey's RESET test	9.071[.003]	0.764[.382]	0.015[.901]	9.996[.002]
Normality	3.374[.185]	4.375[.112]	0.613[.736]	0.820[.664]
Heteroscedasticity	4.804[.028]	4.735[.030]	1.608[.205]	5.778[.016]

Note: ARDL model is selected based on Schwarz Bayesian Criterion. The t-statistics are in the parentheses, while the symbols *, **, and *** indicate significance at the 0.1, 0.05, and 0.01 levels, respectively.

Table 3. ARDL short-run estimation

	Macro-ARDL(1,1,0)	Industry-ARDAL(1,1,1)	Transport-ARDAL(1,0,0)	Service-ARDL(1,0,0)
ΔlnY	4.136** (3.22)	0.399 (0.09)	8.161*** (4.13)	2.692* (1.69)
$\Delta(\ln Y)^2$	-0.232** (-2.54)	0.016 (0.04)	-0.764*** (-4.16)	-0.182 (-1.41)
Const.	-10.448** (-2.49)	-24.103*** (-2.65)	-19.966*** (-4.03)	-7.914 (-1.43)
ECT_{t-1}	-0.221* (-1.76)	-0.246** (-2.28)	-0.241*** (-4.03)	-0.258* (-1.79)
R^2	0.61	0.60	0.76	0.47
Adj. R^2	0.55	0.51	0.73	0.41
AIC	78.44	72.62	85.49	67.63
SBC	75.11	68.62	82.82	64.97
DW-statistic	1.96	2.22	1.76	2.11

Note: ARDL model is selected based on Schwarz Bayesian Criterion. The t-statistics are in the parentheses, while the symbols *, **, and *** indicate significance at the 0.1, 0.05, and 0.01 levels, respectively.

Table 4. Bound test for energy intensive, electronics and others industries

		Lag 1	Lag 2	Lag 3
Energy Intensive	$F(\ln CO_2 \mid \ln Y, \ln Y^2)$	12.207[0.00]***	6.631[0.00] ***	8.508[0.00] ***
	$F(\ln Y \mid \ln CO_2, \ln Y^2)$	1.436[0.26]	3.109[0.05]	2.276[0.12]
	$F(\ln Y^2 \mid \ln Y, \ln CO_2)$	1.420[0.26]	3.221[0.04]	2.347[0.12]
Electronics	$F(\ln CO_2 \mid \ln Y, \ln Y^2)$	1.769[0.18]	1.238[0.32]	0.845[0.49]
	$F(\ln Y \mid \ln CO_2, \ln Y^2)$	0.277[0.84]	0.264[0.85]	1.247[0.33]
	$F(\ln Y^2 \mid \ln Y, \ln CO_2)$	0.479[0.70]	0.397[0.75]	1.432[0.27]
Other Industries	$F(\ln CO_2 \mid \ln Y, \ln Y^2)$	3.148[0.04]	1.944[.16]	1.139[0.37]
	$F(\ln Y \mid \ln CO_2, \ln Y^2)$	0.964[0.42]	5.281[0.00]	1.603[0.23]
	$F(\ln Y^2 \mid \ln Y, \ln CO_2)$	0.936[0.44]	5.153[0.01]	1.572[0.24]

Note: The energy-intensive industry includes Manufacture of Textiles, Pulp, Paper and Paperboard, Chemical Material, Cement and Cement Product and Basic Metals.

The critical value is from Narayan (2005).
The optimal lag-length is selected by AIC and parsimony criterion, and the value in [ ] is p-value.

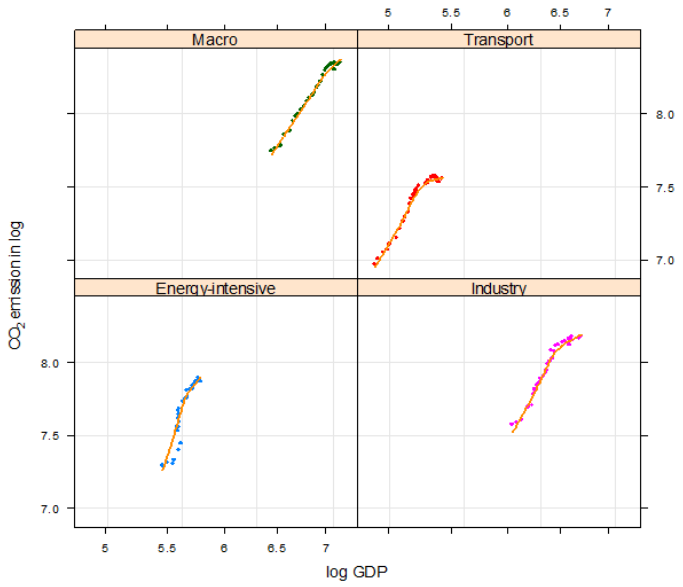
Table 5. Long-run and short-run estimation- energy intensive sector

Long-run estimation						Diagnostic test statistics			
ln(Y)	$ln(Y)^2$	Const.	turning point			Serial Correlation	Ramsey's RESET test	Normality	Hetero-scedasticity
159.37*** (4.47)	-13.97*** (-4.42)	-446.68*** (-4.44)	505876.36			0.021 [0.885]	5.363 [0.021]	0.426 [0.808]	1.897 [0.168]
Short-run estimation						Diagnostic test statistics			
ΔlnY_{t-1}	ΔlnY_{t-2}	$\Delta(lnY)^2_{t-1}$	$\Delta(lnY)^2_{t-2}$	ΔConst.	ECT_{t-1}		adj. R^2	AIC	DW-statistic
7.055 (0.74)	-23.779** (-2.48)	-0.559 (-0.66)	2.091** (2.46)	-115.48*** (-3.99)	-0.258*** (-4.35)		0.59	67.4	1.99

Note: The energy-intensive industry includes Manufacture of Textiles, Pulp, Paper and Paperboard, Chemical Material, Cement and Cement Product and Basic Metals.

Note: ARDL model is selected based on Schwarz Bayesian Criterion. The t-statistics are in the parentheses, while the symbols *, **, and *** indicate significance at the 0.1, 0.05, and 0.01 levels, respectively.

Fig. 2. the relationship between economic growth and carbon emissions by sectors



Conclusions I

- "Simpson paradox"
  - the cointegration tests at macro level hide the evidence we find in sectoral analysis.
- The energy type used in these sectors is different and the carbon emissions depend on the fossil fuel combustion; however, the emission factors are various from energy type.
- The carbon emissions in industry sector can be distinguished by direct and indirect emissions and is more complex than other sectors.

Conclusions II

- A uni-directional causality running from real GDP toward carbon emissions in our analysis, especially for transport and service sectors.
  - "Conservation hypothesis"
- Any carbon emissions deviate from equilibrium system will revert to the long-run equilibrium.
  - the speed of adjustment is similar for these sectors.
- Other factors could influence the carbon emissions in the future

Appendix

Unit-root test

Appendix Table 1. Stationary test

		ADF		Phillips-Perron	
		Levels	Diff	Levels	Diff
$\ln E$	Macro	-0.19	-5.67***	0.22	-6.42***
	Industry	-0.73	-6.21***	-0.56	-7.04***
	Agriculture	-2.06	-5.90***	-2.72	-1.83***
	Transport	-0.64	-3.59***	-0.64	-3.33***
	Service	0.47	-4.57***	0.61	-4.54***
$\ln Y$	Macro	-1.53	-5.71***	-1.61	-6.17***
	Industry	-2.66	-5.98***	-2.66	-6.16***
	Agriculture	-3.56	-4.59***	-3.56	-9.72***
	Transport	-2.34	-5.43***	-3.10	-5.75***
	Service	0.30	-3.44***	0.05	-3.31***
$\ln Y^2$	Macro	-1.48	-5.85***	-1.44	-6.58***
	Industry	-2.39	-6.01***	-2.40	-6.20***
	Agriculture	-3.53	-5.51***	-3.53	-9.22***
	Transport	-2.34	-5.51***	-2.80	-6.23***
	Service	0.46	-3.40***	0.16	-3.24***

The t-statistics are in the parentheses, while the symbols *, **, and *** indicate significance at the 0.1, 0.05, and 0.01 levels, respectively.

(四)MIT 參訪討論議程

INER / MIT Meeting

June 23, 2014

Participators

Joint Program on the Science and Policy of Global Change:

John Reilly Co-Director
Sergey Paltsev Assistant Director
Joshua Hodge Deputy Executive Director
Henry Chen Research Scientist

The Institute of Nuclear Energy Research (INER):

Fu-Kuang, Ko Deputy Director
Cheng-Da, Yuan Associate Research & Development Engineer

Discussion Topics: From Model to Policy

Agenda

10:00 -10:10 AM The MIT Joint Program on the Science and Policy of Global Change

10:10 -10:20 AM

- ☐ Introduction
  - ■ INER's Future Prospects and Sustaining Development for
  - ■ INER's Research
  - ■ Center of Energy Economics and Strategy Research
  - ■ Core Skills-Energy Economics

10:20 - 11:30 AM

- ☐ Discussion Topics
  - ■ Hot issue discussion: EPA Power-Plant Proposal Will Seek 30% Carbon Dioxide Emissions Cut by 2030
  - ■ From Model to Policy-Experience sharing
  - ■ Bilateral Collaboration and Perspective

11:30 AM Ending

（五）MIT 參訪討論議題投影片

From Model to Policy

THE MIT JOINT PROGRAM ON THE SCIENCE AND POLICY OF GLOBAL CHANGE

Center of Energy Economics and Strategy Research, Institute of Nuclear Energy Research (INER)

Fu-Kuang, Ko Deputy Director
Cheng-Da, Yuan Associate Research & Development Engineer

Agenda

- Introduction
  - INER's Future Prospects and Development
  - INER's Research
  - Center of Energy Economics and Strategy Research
  - Core Skills-Energy Economics
- Discussion Topics
  - Hot Issue Discussion: EPA Power-Plant Proposal Will Seek 30% Carbon Dioxide Emissions Cut by 2030
  - From Model to Policy-Experience sharing
  - Potential Bilateral Collaboration and Discussions

Introduction

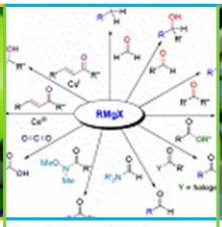
INER's Future Prospects and Development

- **E**nhance research and development on nuclear safety and nuclear technologies that are vital to the establishment of a carbonless nuclear homeland.
- **C**ontribute to the technology development of new energy that promotes the economic development of green energy.
- **S**trengthen atomic energy related healthcare applications and quality that aim to enhance public health.

INER's Research

- Nuclear Safety Technologies

- Nuclear Facilities Decommissioning
- Radioactive Wastes Management



- Biomedical Application of Radiation Technologies

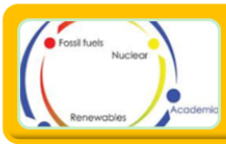
- Renewable and New Energy Technologies
  - SOFC
  - HCPV
  - small/medium wind turbine systems
  - micro grid
  - energy economics and strategy

- Environmental Plasma Technologies
  - Integrated Gasification Combined-Cycle (IGCC)

Center of Energy Economics and Strategy Research

Energy System and Modeling

MARKAL-ED Model
TIMES Model



Energy Economics

Technology Economics Assessment
Computable General Equilibrium Model (CGE Model)
Input-Output Model (I-O Model)

Energy Strategy

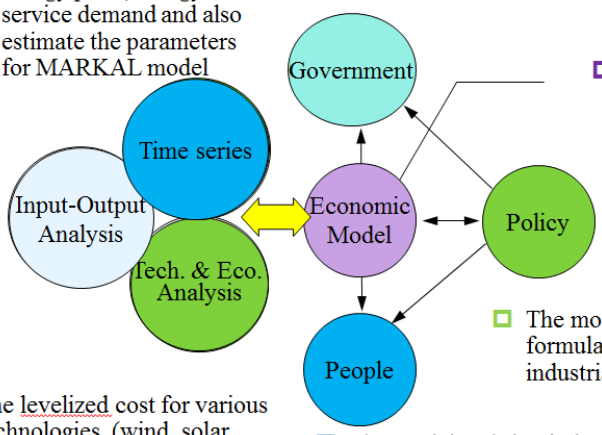
Energy Security
Energy、Economy、Environment (3E Evaluation)

Energy Information and Statistics

Energy Information Platform
Energy and Economics Database

Core Skills-Energy Economics

- The econometrics models are used to forecast energy price, energy service demand and also estimate the parameters for MARKAL model
- The evaluation of economic and environment should be helpful for policy development and decision making
- I-O analysis is an important tool for industrial analysis and is fundamental for building CGE model



- The model and parameters should be adjusted to reflect reality and play a role as bridge to communicate with government and people
- The model is helpful to formulate some guidelines and industrial policy
- The levelized cost for various technologies (wind, solar, biomass, nuclear) are calculated and are compared to international data (DEEC, EIA etc.) and assumptions.
- The model and simulation results should be understand and acceptable by people

Discussion Topics

EPA Power-Plant Proposal Will Seek 30% Carbon Dioxide Emissions Cut by 2030

WASHINGTON—The Environmental Protection Agency will propose a draft rule on Monday seeking a 30% reduction in carbon-dioxide emissions by 2030 from existing power plants based on emission levels from 2005, according to two people who have been briefed on the rule, setting in motion the main piece of President Barack Obama's climate-change agenda.

The rule, scheduled to be completed one year from now, will give flexibility to the states, which must implement the rules and submit compliance plans to EPA by June 2016. States can decide how to meet the reductions, including joining or creating new cap-and-trade programs, deploying more renewable energy or ramping up energy-efficiency technologies.

Smoke rises from the Colstrip Steam Electric Station, a coal burning power plant in in Colstrip, Mont. *Associated Press*

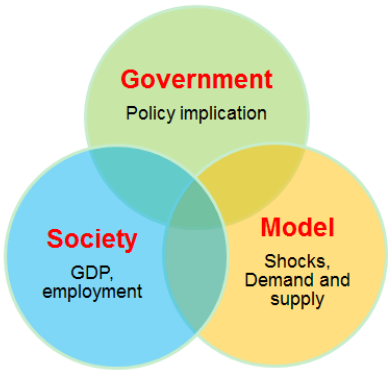
Each state will have different percent reduction standards, and the national average will be 25% by 2020 and 30% by 2030, these people said.

The proposed rule will regulate carbon emissions from hundreds of fossil-fuel power plants across the U.S., including about 600 coal plants, which will be hit hardest by the standard.

"EPA will release its proposed carbon pollution reduction rule on Monday," EPA spokesman Tom Reynolds said. "Until then the agency will not comment on any information that may or may not be in the proposal."

THE WALL STREET JOURNAL. POLITICS AND POLICY, JUNE,1, 2014
By AMY HARDER

- Why EPA proposes this rule ?
- What are the benefits and impacts ?



From Model to Policy-Experience sharing

Energy Policy Analysis	• Experience sharing • How "Business as usual" influence the model ?
Model Strengthen	• How to Integrate MARKAL and CGE model • Compare to other CGE model
Interactive with People	• How to improve public understanding of energy policy and climate issues
Communicate with Government	• How model can improve policy development and implementation • Inter-sectoral communication

Potential Bilateral Collaboration and Discussions

- Potential collaboration and suggestions for INER

Thank you

（六）IAEE 會議與 MIT 參訪主要交流學者名冊

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