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出國報告（出國類別：其他）

赴新加坡參加第40屆 International Association for Energy Economics (IAEE) 國際研討會

服務機關：核能研究所
姓名職稱：黃揮文　副研究員
派赴國家：新加坡
出國期間：106年6月17日~106年6月22日
報告日期：106年7月12日

摘 要

「第 40 屆國際能源經濟協會(International Association for Energy Economics, IAEE)國際研討會」於 106 年 06 月 18 日至 6 月 21 日於新加坡舉行，由新加坡國立大學(National University of Singapore, NUS)能源研究所(Energy Studies Institute, ESI)主辦，研討會主題為「滿足新興經濟體的能源需求，對能源和環境市場的可能影響」，所涉及議題包括：「新興國家和發展中國家的電力獲取」、「氣候變遷」、「傳輸電網擴張與跨國合作的經驗教訓」、「全球天然氣市場動態」、「東亞天然氣市場轉型」、「能源安全」、「能源市場期貨」，參加會議人數約為 400 人，核能研究所由黃揮文副研究員代表前往新加坡發表「台灣能源安全風險指標計算與分析(Computation and Analysis on Taiwan Index of Energy Security Risk)」論文一篇，並於會議期間與新加坡國立大學能源研究所研究人員以及日本能源研究所(Institute of Energy Economics, Japan, IEEJ)豐田正和理事長與研究人員進行交流。核能研究所正積極進行「能源國家型科技計畫-永續能源技術與策略發展應用計畫」，其中「我國能源風險評估系統化研究能力之建立」工作項目與 IAEE 國際學術研討會之能源安全討論主題具重要相關性，參加本研討會可作為本所能源經濟與策略研究中心針對源風險評估與能源策略評估探討的重要情資，並提升策略建議之可行性。

關鍵字：國際能源經濟協會、氣候變遷、能源安全

Abstract

The 40th International Association for Energy Economics (IAEE) international conference was held in Singapore from June 18 to June 21, 2017, by the Energy Studies Institute (ESI), National University of Singapore (NUS). The theme of conference was "Meeting the Energy Demands of Emerging Economies, Implications for Energy and Environmental Markets," the issues included Electricity Access in Emerging and Developing Countries, Climate Change, Lessons from Transmission Grid Expansion and Cross-Country Co-operation, Global Gas Market Dynamics, East Asian Gas Markets in Transition, Energy Security, and Energy Market Futures.

Around 400 participants attended the conference. Hui-Wen Huang represented the Institute of Nuclear Energy Research(INER) to address a paper entitled "Computing and Analysis on Taiwan Index of Energy Security Risk." During the conference, Hui-Wen Huang also communicated with the researchers of NUS and the chairman of Institute of Energy Economics, Japan (IEEJ) to enhance the cooperation relationships. Participating in this conference can be useful for obtaining important information for Center of Energy Economics and Strategy Research (CEESR) of INER on energy security and energy strategy assessment.

Key words: IAEE, climate change, energy security

目　　次

（頁碼）

一、 目的

「第 40 屆國際能源經濟協會(International Association for Energy Economics, IAEE)國際研討會」於 106 年 06 月 18 日至 6 月 21 日於新加坡舉行，由新加坡國立大學(National University of Singapore, NUS)能源研究所(Energy Studies Institute, ESI)主辦，研討會主題為「滿足新興經濟體的能源需求，對能源和環境市場的可能影響」，所涉及議題包括：「新興國家和發展中國家的電力獲取」、「氣候變遷」、「傳輸電網擴張與跨國合作的經驗教訓」、「全球天然氣市場動態」、「東亞天然氣市場轉型」、「能源安全」、「能源市場期貨」，參加會議人數約為 400 人，共邀請 17 位專家在全體會議中依主題進行專題演講。分組討論共分為 67 個場次，共發表 285 篇論文。國際重要組織與學術單位如：國際能源署、世界銀行集團、日本能源經濟研究所、麻省理工學院、南加州大學、維也納科技大學、印度理工學院、新加坡國立大學，皆有專家參加會議。核能研究所由黃揮文副研究員代表前往新加坡發表「台灣能源安全風險指標計算與分析(Computation and Analysis on Taiwan Index of Energy Security Risk)」論文一篇，並於會議期間與新加坡國立大學能源研究所研究人員以及日本能源研究所(Institute of Energy Economics, Japan, IEEJ)豐田正和理事長與研究人員進行交流。核能研究所正積極進行「能源國家型科技計畫-永續能源技術與策略發展應用計畫」，其中「我國能源風險評估系統化研究能力之建立」工作項目與 IAEE 國際學術研討會之能源安全討論主題具重要相關性，參加本研討會可作為本所能源經濟與策略研究中心針對源風險評估與能源策略評估探討的重要情資，並提升策略建議之可行性。

關鍵字：國際能源經濟協會、氣候變遷、能源安全

二、過程

此次出國含往返旅程共計 6 天。行程如下：

日期	行程	工作重點
6 月 17 日(六)	台北 - 新加坡	去程
6 月 18 日(日)	新加坡	參加「第 40 屆 IAEE 國際研討會」
6 月 19 日(一)	新加坡	參加「第 40 屆 IAEE 國際研討會」
6 月 20 日(二)	新加坡	參加「第 40 屆 IAEE 國際研討會」
6 月 21 日(三)	新加坡	參加「第 40 屆 IAEE 國際研討會」
6 月 22 日(四)	新加坡 - 台北	回程

註：第 40 屆 IAEE 國際研討會相關資訊請參照網址：http://iaee2017.sg/

本次第 40 屆 IAEE 國際研討會由新加坡國立大學(National University of Singapore, NUS)能源研究所(Energy Studies Institute, ESI)主辦，核能研究所由黃揮文副研究員代表前往新加坡發表「Computation and Analysis on Taiwan Index of Energy Security Risk」論文一篇。第 40 屆 IAEE 國際研討會議程如附件 1，

此外，本次國際研討會中也有其他台灣代表與會，例如：中央大學梁啟源教授與財團法人中技社劉致峻先生發表「The Effect of Speculation in Futures Market on Oil Price」，淡江大學廖惠珠教授發表「The Relationship between US Rig Count and BRENT WTI Spread」，中原大學國際經營與貿易學系林晉勛副教授與張桂鳳博士候選人發表「Taiwan's Economic Responses to Different Carbon Trajectories of China and Taiwan」，藉由上述幾篇關於台灣能源現況之介紹與研究， 均有助於提高台灣在能源研究方面之國際能見度。

本研討會贊助廠商如下：

1. 法國電網分配(Enedis)公司(法國電力公司(EDF)之附屬公司)
2. 石油輸出國組織國際開發基金(The OPEC fund for International Development)
3. MAGICSOFT(IT 方案服務公司)

三、心得

會議活動分為開幕致辭(Welcome and opening remarks)、全體會議(Plenary session)與分組會議(Concurrent sessions)，分別說明如下：

(一) 開幕致辭(Welcome and opening remarks)

第 40 屆 IAEE 國際研討會由新加坡國立大學(National University of Singapore, NUS)能源研究所(Energy Studies Institute, ESI) Siaw Kiang CHOU 教授與新加坡南洋理工大學 Euston Quah 教授共同擔任會議聯合主席。會議開始由 Siaw Kiang CHOU 教授代表致辭(如圖 1)歡迎參與第 40 屆 IAEE 國際研討會的來賓，預祝大會成功，希望與會來賓皆能獲得豐碩的收穫，開幕大會現場如圖 2。

圖 1 Siaw Kiang CHOU 教授代表開幕致辭

圖 2 開幕大會現場

開幕演講由國際能源署能源市場與安全部(Energy Markets And Security, International Energy Agency) Keisuke Sadamori 主任擔任，說明世界能源趨勢。由於技術改進與成本降低，美國頁岩油產量增加，導致油價下跌(如圖 3)。然而但如果新的上游投資計畫不能盡快執行，剩餘產能將逐步減少，預測世界石油市場從 2020 年將開始趨緊縮。近期電動汽車數量突破紀錄，然而政策支持仍然至關重要。2016 年，全球電動汽車達到二百萬輛，但銷售增長率從 2015 年的 70%降低到 2016 年的 40%，顯示風險增加。由澳大利亞和美國領導的新一波液化天然氣(Liquefied Natural Gas, LNG)供應，將提高對潛在需求變化的反應能力。

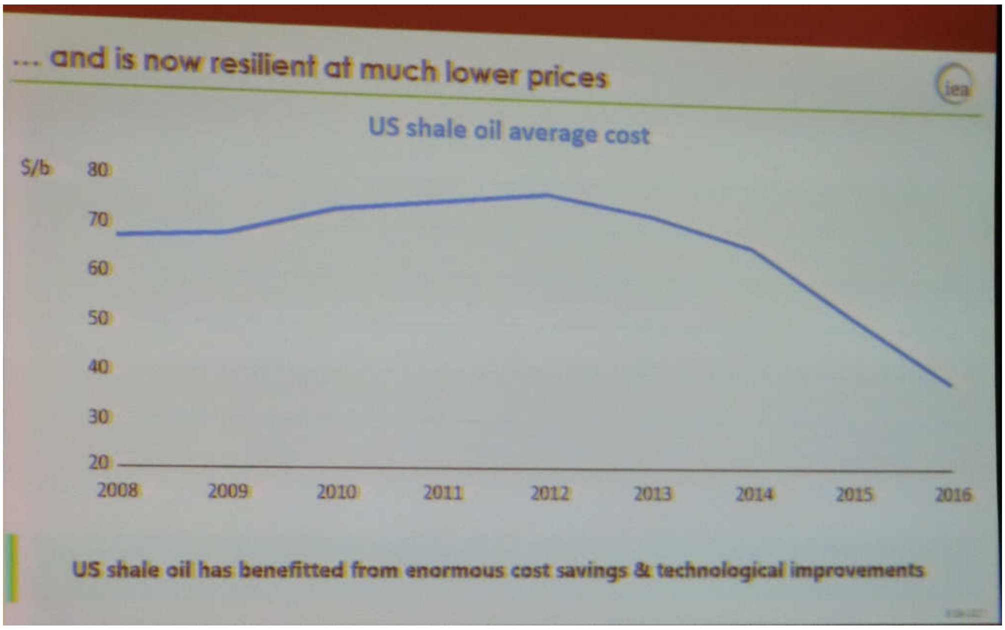


圖 3 美國頁岩油成本降低

(二) 全體會議(Plenary session)

全體會議中邀請專家演講，整理重要演講如下：

1. 氣候變遷概述(Climate Change Overview)

演講者：世界銀行集團(World Bank Group)資深財務專家(Senior Financial Specialist), Weijen Leow 先生

說明世界銀行集團在氣候變遷所扮演的角色。世界銀行集團包括以下機構：國際復興開發銀行(International Bank for Reconstruction and Development, IBRD)、國際開發協會(International Development Association, IDA)、國際金融公司(International Finance Corporation, IFC)、多邊投資擔保機構(Multilateral Investment Guarantee Agency, MIGA)與國際投資爭端解決中心(International Centre for

Settlement to Investment Dispute, ICSID)，向開發中國家提供長期貸款和技術協助以脫離貧窮。

為了減緩氣候變遷對全球的影響，世界銀行集團進行以下工作：(1) 綠色債券(Greens Bonds)：125 個國際復興開發銀行(IBRD)以 18 種貨幣發行的綠色債券總計 91 億美元，其中 57 億美元在 2016 年 6 月 30 日前發行。(2)符合條件綠色債券計畫(Eligible Green Bond Projects)：90 個符合條件綠色債券計畫，承諾金額達 159 億美元。在 24 個國家的 84 個綠色合資計畫已經開始付款，總額達 141 億美元。綠色債券收益共計 66 億美元，用於支援這些計畫的支出融資。這些工作預計對 10 個再生能源計畫的 24 億美元承諾，預期達到 2,359 MW 再生能源產能 - 相當於 2014 年拉脫維亞的總產能。世界銀行集團已承諾投入 39 億美元，以改善新興國家的公共交通。在 13 個計畫中，國際復興開發銀行的承諾總額達 23 億美元，公共交通乘客每天將增加 230 萬人次。

碳定價在全球內得到了越來越多的關注，許多國家已開始建立碳稅(carbon tax)與碳排放交易系統(Emissions Trading System, ETS)制度，中國將在 2017 年引入世界上最大的碳價定價(carbon pricing)計畫，幾乎可以將定價機制所涵蓋的排放比例從 13%提高到 20-25%(如圖 4)，世界銀行將持續關注其發展，並與全球一起努力因應氣候變遷。

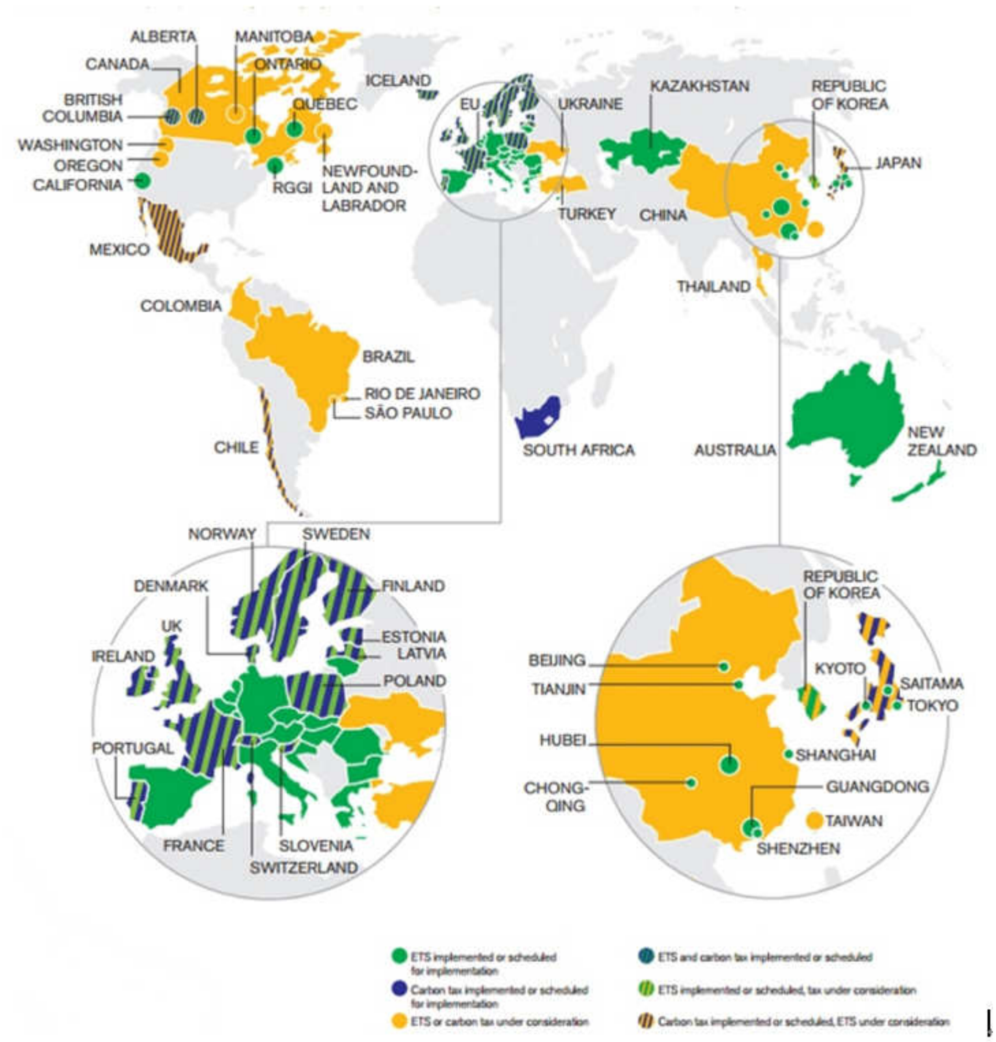


圖 4 世界各國建立碳稅與碳排放交易系統制度分布圖

2. 發展南亞區域電力市場：市場設計選擇 (Developing a Regional Power Market in South Asia: Option for Market Design)

演講者：印度理工學院坎普爾校區(Indian Institute of Technology Kanpur) Anoop Singh 副教授

南亞國家包括印度、孟加拉、不丹、尼泊爾、巴基斯坦、斯里蘭卡，面臨電力供應不足(如圖 5)、能源短缺以及能源安全問題等挑戰，主要發電量的可用性在該地區各不相同，而協同運營的潛力為南亞地區的跨境電力貿易合作提供了空間。南亞地區電力市場發展的選擇從謹慎到積極可分為以下階段(如圖 6)：(1)以電力網路節點代理為基礎的市場結構(Nodal Agency Based Market Structure)、(2)被授權的交易執照持有人的參與(Participation of Deemed Trading Licensees)、(3)交易許可證持有人的參與(Participation of Trading Licensees)與(4)所有符合條件的消費者(All eligible consumers)。市場設計選擇包括：(1)南亞區域電力交易所(South

Asian Regional Power Exchange, SARPX)或南亞電力交易所(South Asian Power Exchange, SAPX)、(2)印度電力交易所的區域合同、(3)印度電力交易所的新市場與(4)跨越南亞的所有電力交易。發展南亞電力市場的先決條件包括：(1)容易取得的能源資源和容易通過的許可、(2)電力傳輸互聯、(3)共同貨幣、(4)進出口稅和過境稅的處理與(5)調和的管制和政策架構。

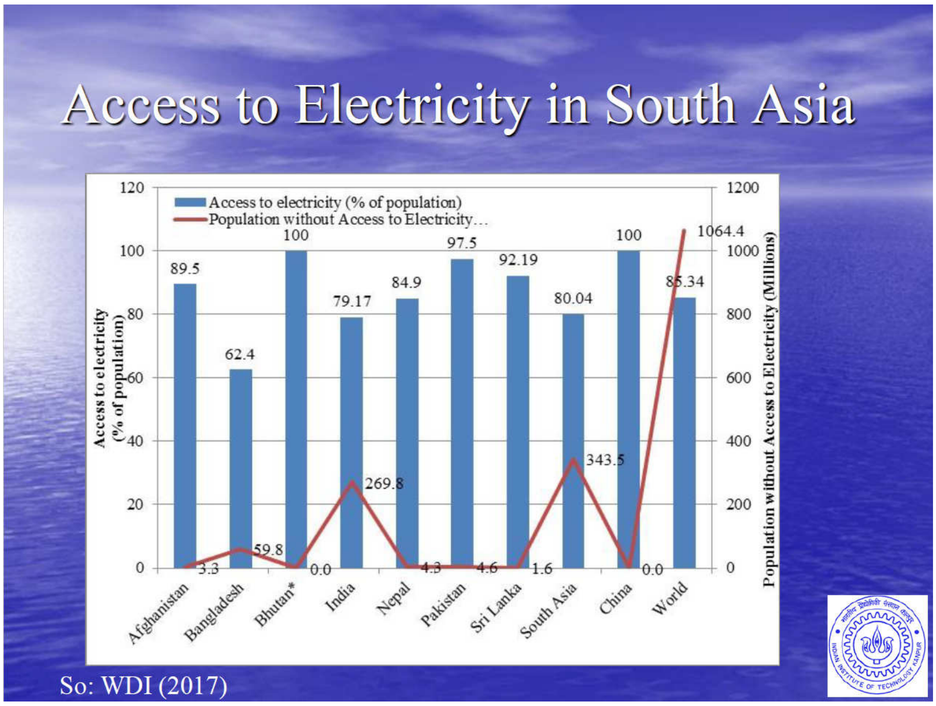


圖 5 南亞各國電力供應比較

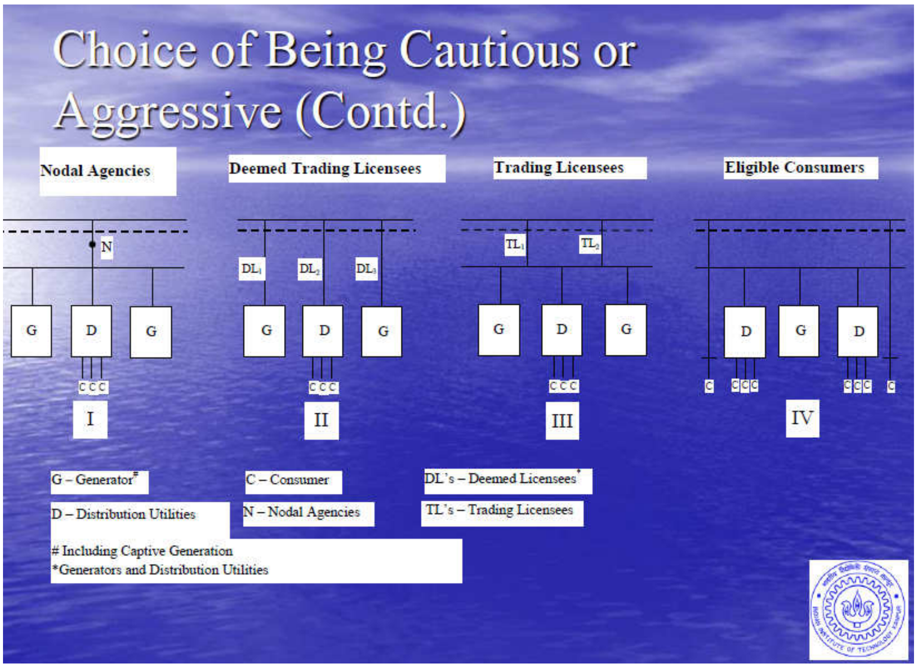


圖 6 南亞地區電力市場發展的選擇

3. 電力網路與電池：南澳大利亞州的案例 (Interconnectors versus batteries: the case of South Australia)

演講者：澳洲 Carbon Market Economics 公司總裁, Bruce Mountain 先生

南澳大利亞州為澳洲六個州的其中一州，以交流電力網路(interconnector)和直流電力網路與鄰近的州傳輸電力。近年來南澳大利亞州已朝脫碳(decarbonization)發電技術發展，分散式式太陽光電迅速擴張(如圖 7)，再生能源的興起與燃煤發電的沒落導致需更加依賴電力網路。澳洲液化天然氣(Liquefied Natural Gas, LNG)出口的增長使得天然氣價格已經加倍，此外電力網路也變得非常昂貴。

在再生能源不斷增加，而化石燃料發電衰退的情況下，衍生電力系統安全問題，需要儲能或替代備用發電技術，因此南澳大利亞州進行以下措施：(1)州政府向 Tesla 公司採購 100MW 鋰離子電池、(2)國家政府干預市場以開發天然氣發電、(3)政府資助電力網路擴張研究。

電池儲能可以作為電力傳輸的替代和後備電力來源，電力傳輸公司如果擁有電池儲能設備，可加強電力穩定度，然而由於電池儲能價格仍然很高，電力傳輸公司目前並無誘因納入電池儲能設施。南澳大利亞州使用脫碳發電技術在澳洲居於領先地位。再生能源與電池儲能的快速發展，與電力傳輸整合將可增加競爭力。

我國目前規劃於 2025 年再生能源發電量為 20%，建置對應之電池儲能設備有其必要性，由南澳大利亞州之案例可知，鋰離子電池為電池儲能選項之一。此外智慧電網也應及早布建，以因應分散於各地之太陽光電電力穩定傳輸。

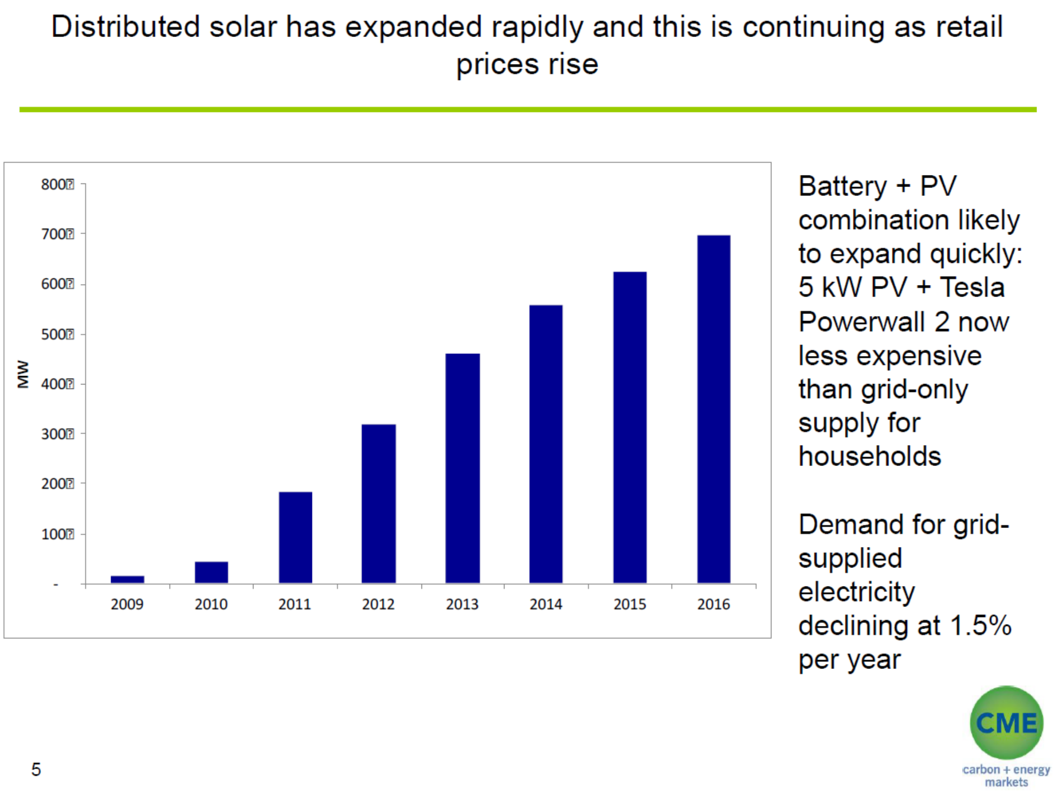


圖 7 南澳大利亞州分散式式太陽光電迅速擴張

4. 兩個部門的故事：管制結構和對美國天然氣和電力傳輸投資的影響 (A Tale of Two Sectors: Regulatory Structures and Impacts on Investment in US Gas and Electric Transmission)

演講者：美國 Charles River Associates 公司副總裁, Seabron Adamson 先生

美國近年來頁岩氣供應對天然氣運輸的需求急劇增加(如圖 8)，許多新建的州際天然氣管路投入使用。另一方面美國的輸電網路逐漸老化，而電力傳輸投資增長幅度不大(如圖 9)，將造成美國境內輸電網路障礙。天然氣管路投資的經濟管制議題包括：(1)沒有國家管理之天然氣管網路系統，造成管線營運公司與管路開發公司之競爭；(2)美國聯邦能源管理委員會(Federal Energy Regulatory Commission, FERC) 管制價格和許可新管路。電力傳輸投資的經濟管制議題包括：(1)電力傳輸系統由個別公用事業經營；(2)電力傳輸規劃由獨立調度中心(Independent System Operator, ISO)或區域集團負責；(3)區域電網採開放獲取模式(Open access mode)；(4)電網新建成本轉化為傳輸費率基準；(5)美國聯邦能源管理委員會以政策鼓勵電力傳輸投資：(a)2005 年發布能源政策法(Energy Policy Act)、(b) FERC 2011 年發布之 Order No. 1000。

天然氣管道部門投資與電力傳輸部門投資之比較：天然氣管道-(1)新管道分散合約模式；(2) 合約利益和成本高度一致；(3)對其他用戶成本影響最小或沒有成本；(4)競爭從最初就開始。電力傳輸-(1)區域集中規劃；(2)區域成本分配議題；(3)用戶費率都可能受到影響。

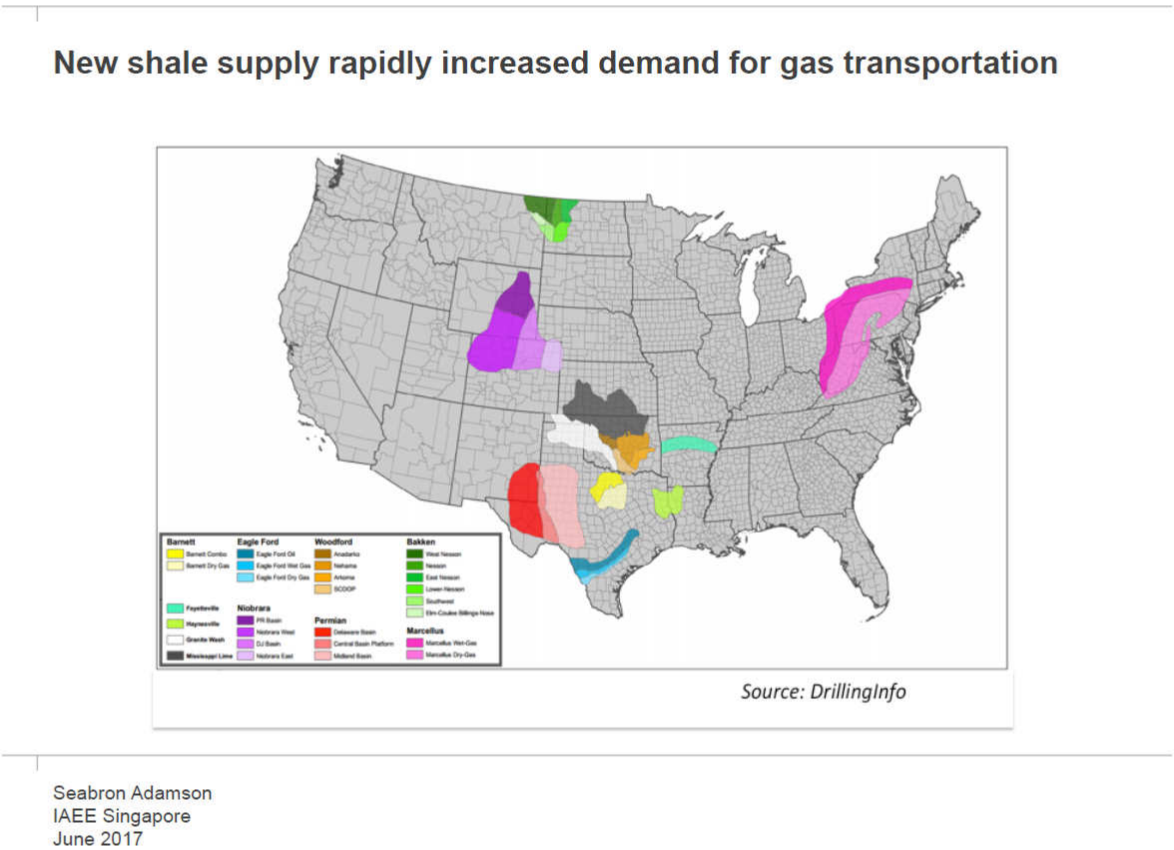


圖 8 天然氣運輸的需求急劇增加

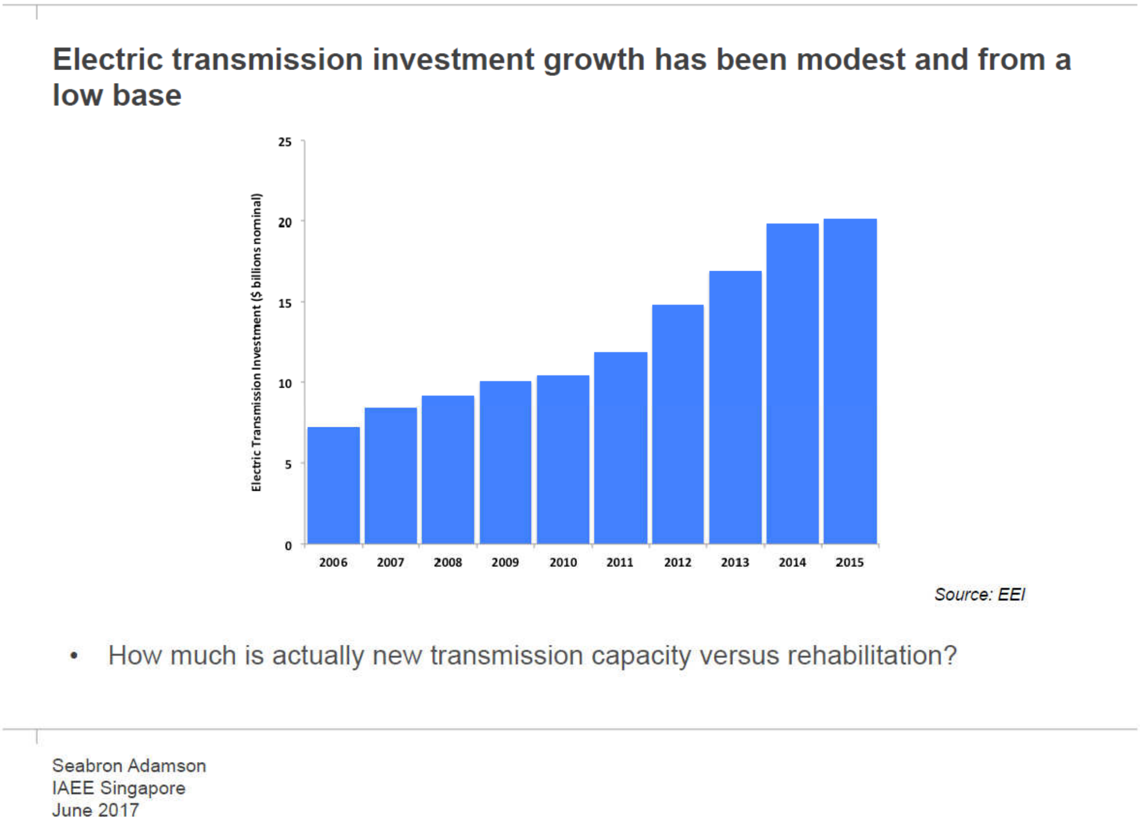


圖 9 美國電力傳輸投資增長幅度趨緩

5. 能源安全：奈及利亞的挑戰與前景(Energy Security: Challenges & Prospects in Nigeria)

演講者：奈及利亞 Port Harcourt 大學，Omowumi Iledare 教授

能源安全組成包括(如圖 10)：可用性(Availability)、可負擔性(Affordability)、可獲取性(Accessibility)與永續性(Sustainability)。能源可用性：(1)需要大量投資、(2)能源多元化、(3)地緣政治和能源貿易政策、(4)相對於需求的充足、(5)無論意外因素如何干擾皆能維持能量流的持久性。能源可負擔性：(1)價格對最終用戶的重要性、(2)市場結構、(3)公共政策工具、(4)管制機構和治理結構。能源可獲取性：(1) 在能量流的安全性方面必須滿足能源需求、(2)社會發展在經濟產出擴張和生活品質提高方面、(3)能源定價為可獲取性的關鍵。能源永續性：(1)環境可接受性、(2)能源不間斷地流向最終用戶。奈及利亞的基本能源安全問題為：(1)奈及利亞的人均用電量是世界上最低的，遠低於許多其他非洲國家。(2)奈及利亞的人均用電量僅為巴西的 7%，僅為南非的 3%。(3)巴西擁有 2.01 億人口，擁有 100GW 發電能力。(4)南非人口達 5000 萬人，擁有 40 GW 發電能力。(5)正在處

理能源貧困問題，需要大量投資，使得在短期和長期階段都可獲得持續的能源。(6)非洲特別是奈及利亞的能源獲取，對於實現全球能源安全至關重要。在奈及利亞，能源獲取受到電力網路不足和間歇性電力的限制。(7)供應路線的轉變和低油價正在改變國際石油市場的地緣政治動態。

奈及利亞的基本能源安全挑戰：(1)依賴石油與天然氣，但多年來一直沒有完整可行的天然氣政策架構。(2)將能源資源作為收入來源，未能利用能源資源發展經濟。(3)以能源部門改革為前提的能源多樣化規劃，似乎將由於能源部門治理缺乏政策一致性和透明度而注定失敗。(4)從短期能源安全的角度來看，由於發電廠與輸配電基礎設施老化和維護不力，對供需平衡的能力很低。奈及利亞的能源安全前景包括：(1)化石能源資源和儲量潛力很大、(2)非化石燃料能源的估算潛力很大、(3)青年勞動力是能源的資產、(4) 隨著世界能源永續發展的趨勢，預計將帶來需求性投資。圖 11 奈及利亞與美國 2014 年能源配比比較，圖 12 顯示奈及利亞的電力需求預測。

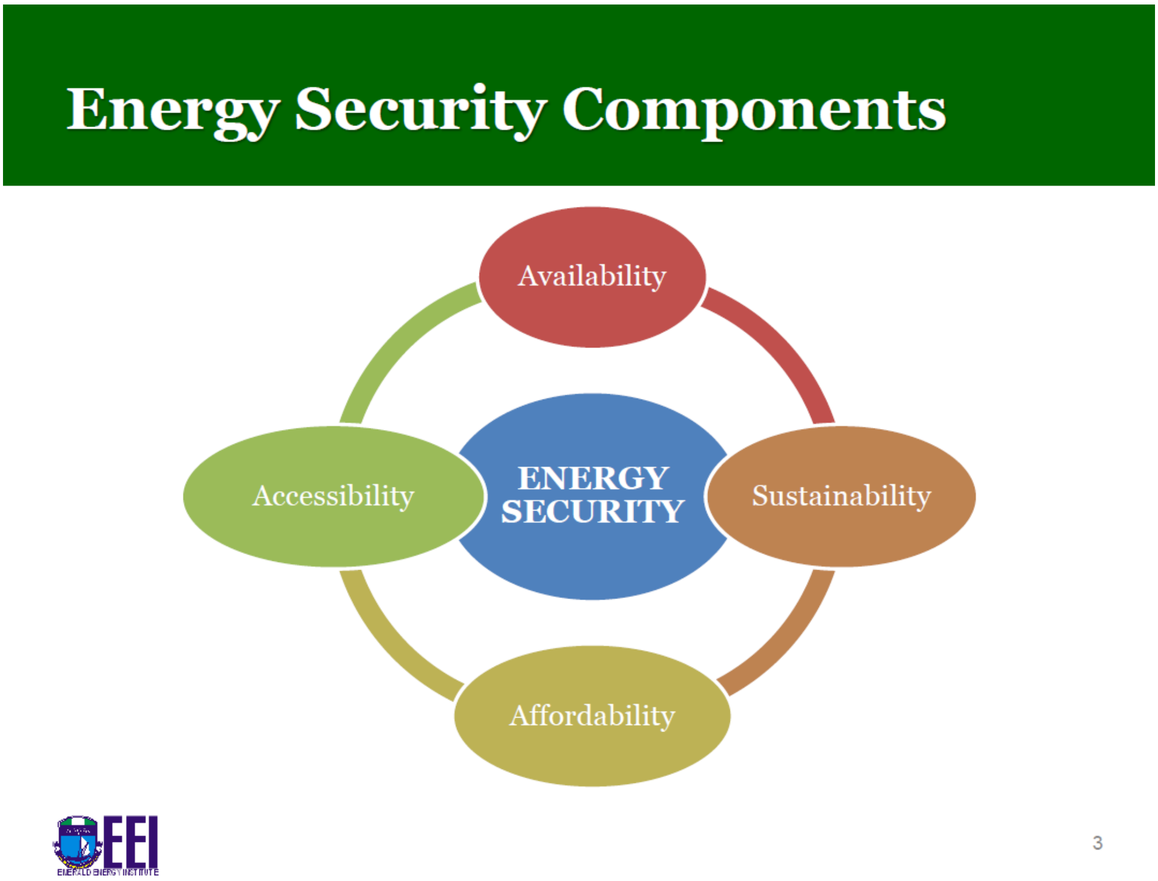


圖 10 能源安全組成

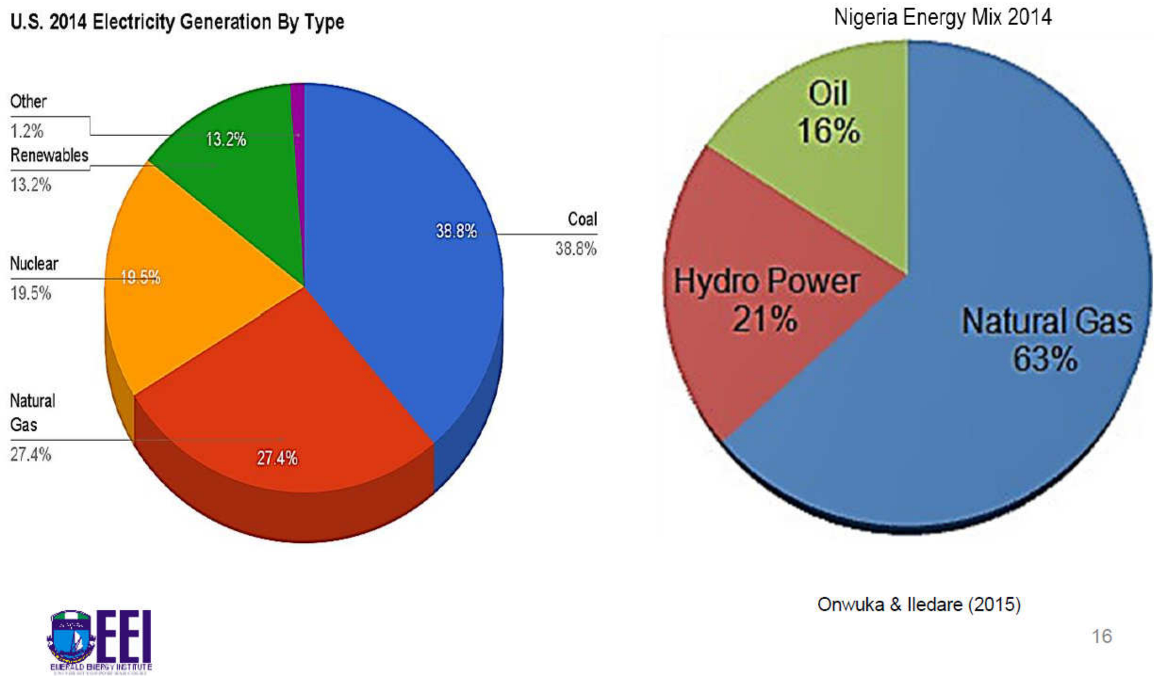


圖 11 奈及利亞與美國 2014 年能源配比比較

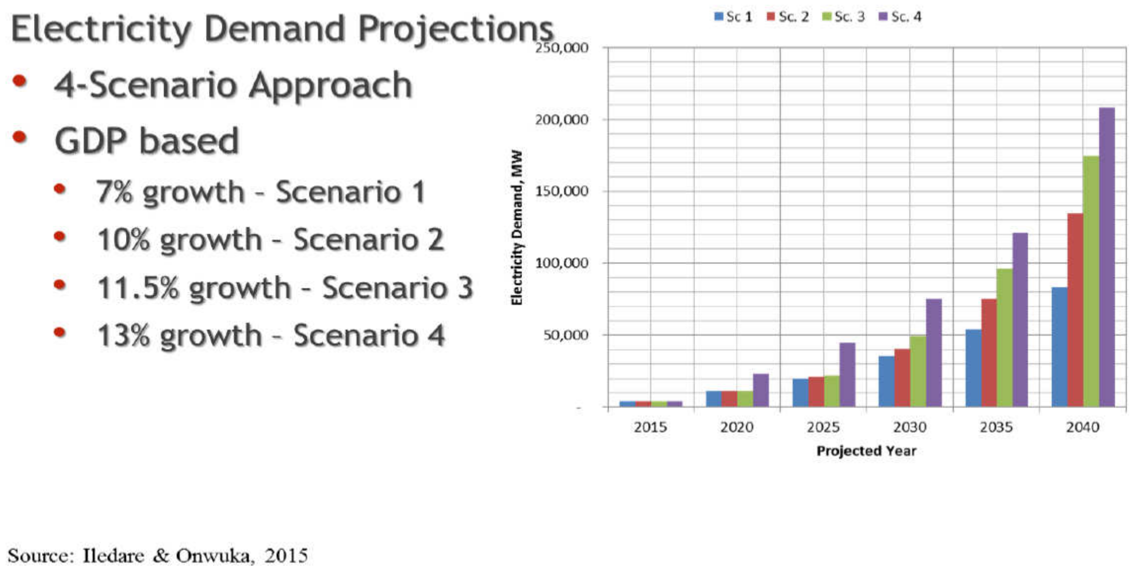


圖 12 奈及利亞的電力需求預測

(三) 分組會議(Concurrent session)

分體會議中由投稿作者進行簡報，第 40 屆 IAEE 國際研討會分組會議論文清單如附件 2，整理重要簡報如下：

1. 台灣能源安全風險指標計算與分析(Computation and Analysis on Taiwan Index of Energy Security Risk)

演講者：核能研究所 副研究員 黃揮文

本文作者包括本所能源經濟策略中心黃揮文副研究員、韓佳佑副工程師與葛復光副主任，發表論文全文如附件 3，發表論文簡報如附件 4。分組會議主席新加坡國立大學為 Philip Andrews-Speed 博士。

本研究引用了美國商會(U.S. Chamber of Commerce, USCC)所設計的國際能源安全風險指標，並使用台灣國內數據，完成台灣本土化歷史年能源安全風險分析。結果顯示自 2012 年起整體能源安全風險下降，重要原因為受到近年來全球性原油價格下跌及原油價格波動趨緩都影響。此外，台灣過去一直過度集中在特定國家進口天然氣，而導致能源進口曝險(Exposure of Energy Import)在特定期間過高，此議題已經由增加和分散進口國家充分緩解。為了以不同情境預測未來台灣能源安全風險，本研究整合了三項工具：USCC 的國際能源安全風險指標、TIMES 模型和 GEMEET 模型。所提出之情境包括：基準情境(Business As Usual, BAU)、樂觀情境(Optimistic Scenario)與保守情境(Moderate Scenario)。為了遵循政府減碳政策：我國國家自主決定預期貢獻(Intended Nationally Determined Contribution, INDC)與溫室氣體減量法 (Greenhouse Gas Reduction Act)，樂觀情境與保守情境皆使用大量再生能源，並配合使用燃氣發電與具有碳捕獲及封存(Carbon Capture and Storage, CCS)功能之燃煤電廠方式以降低二氧化碳排放，此外並降低用電需求達到減碳目標。此二情境之主要差異在樂觀情境假設將再生能源設施建置極大化，而保守情境假設無法建置足夠之再生能源設施，因此需使用較多的燃氣發電與具有碳捕獲及封存功能之燃煤電廠，並且降低更多用電需求。因此樂觀情境與保守情境之二氧化碳排放逐年持續降低。而基準情境不控制二氧化碳排放，在不使用核能發電的條件下，大量使用化石燃料電廠。因此樂觀情境與保守情境之 CO_2 相關風險指標分數顯著低於基準情境。

簡報後與會者提問如下：

(1) 美國 Energy Business and Finance Collins College of Business School of Energy Economics 之 Ron Ripple 教授提問：能源進口曝險不應該只侷限於考慮進口國家多樣性，應再考慮國際政治局勢，以及與進口國家之政治、經濟穩定度。黃員回覆：由於本項研究考慮將台灣之能源風險與國際重要國家之能源風險進行比較，因此對外研究需考量能源風險指標之一致性。

此外「國際政治局勢，以及與進口國家之政治、經濟穩定度」較難直接量化，本研究將考慮內部另行進行質化分析。

(2)日本亞太能源研究中心(Asia Pacific Energy Research Center, APERC)之 General Manager 入江一友(Kazutomo IRIE)博士表示：台灣為亞洲太平洋經濟合作組織(Asia-Pacific Economic Cooperation, APEC)之會員，APERC 為執行 APEC 相關計畫之單位，能源風險為 APERC 工作之一，有機會核能研究所可與 APERC 進行交流。黃員回覆：核能研究所與 APERC 的上位單位日本能源經濟研究所(The Institute of Energy Economics, Japan, IEEJ)已簽訂合作備忘錄，雙方可再這項基礎上進行交流合作。

2. 我們如何達到巴黎協議的目標？一個整合建模方法(How can we meet the Paris agreement target？- An integrated modeling approach)

演講者：日本東京工業大學(Tokyo Institute of Technology)，Koji Tokimatsu 副教授

採用簡化氣候模型 RICE 2010(架構如圖 13)進行研究，假設以下三個零碳排放情境，以氣溫升高幅度需控制在攝氏 2 °C 以內作為目標，並以無氣候政策介入之條件作為基準情境(Business As Usual, BAU)。第一個情境“2100 zero”，前期維持原排碳量，2090 年後大量降低排碳，在 2100 年排碳達到 0，並持續至 2150 年。第二個情境“350 ppm 0”，其 21 世紀後半世紀的排放軌跡為零，累積排放符合 2010 年至 2050 年的 Wigley-Richels- Edmonds (WRE) 350 的限制。第三個情境“net zero”，從 2010 年到 2150 年的累積排放為 0，前期可為正排放，而 21 世紀後半世紀採用生質能源與碳捕獲和儲存(biomass energy with carbon capture and storage, BECCS)與化石能源與碳捕獲和儲存(fossil energy with carbon capture and storage, FECCS)技術達到負排放，使累積排放為 0。結果顯示，可以在“淨零”情景下達成 2 °C 目標，而“350 ppm 0” 情境氣溫升高將達 2.4 °C。“2100 zero”情境氣溫升高將達 4.l °C，而 BAU 約為 5.2 °C。即使“net zero”不能達到 1.5 °C 目標，意味著需要採用積極的技術來達到目標。“net zero”情境下，碳影子價格(shadow price)大幅上漲，2100 年達到數百美元/噸二氧化碳當量。不同情境下之二氧化碳平衡圖 14，不同情境下之全球平均溫度上升如圖 15。

由於生質能源被視為是碳中性的能源，而使用生質能源與碳捕獲和儲存(BECCS)可達到負碳排放的效果，我國可納入此一技術，較容易達成國家減碳政策目標。

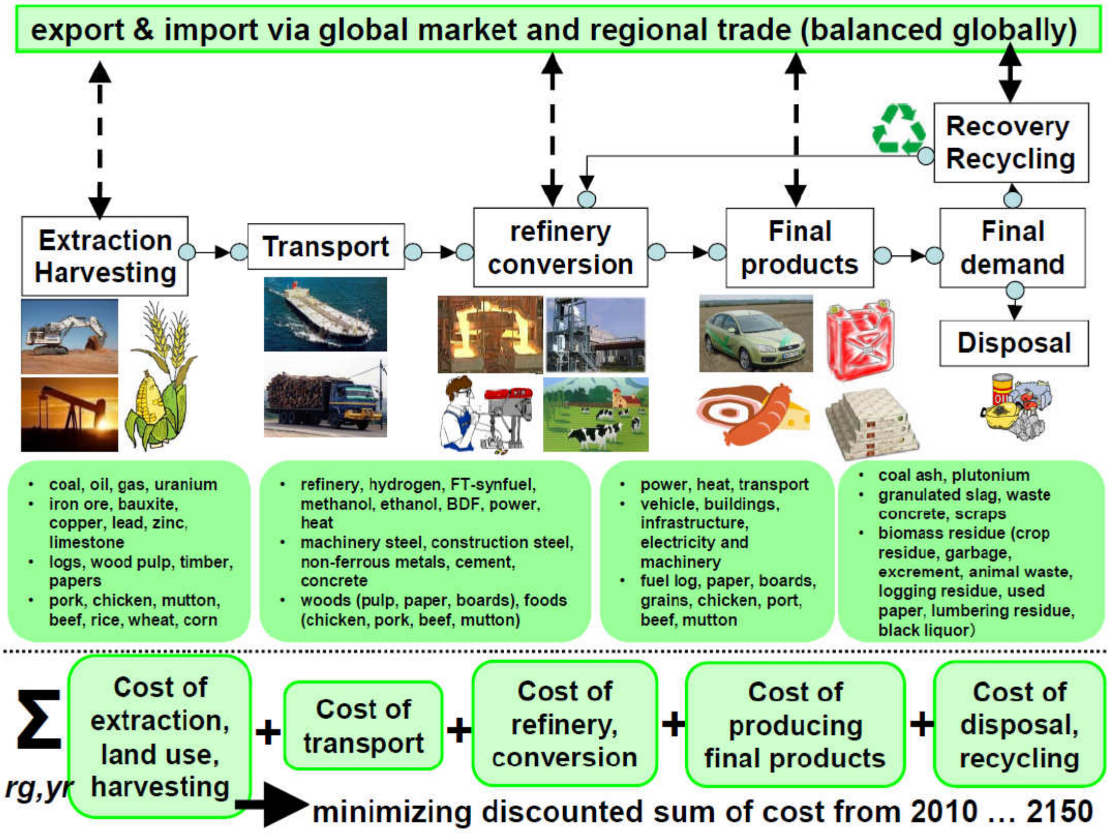
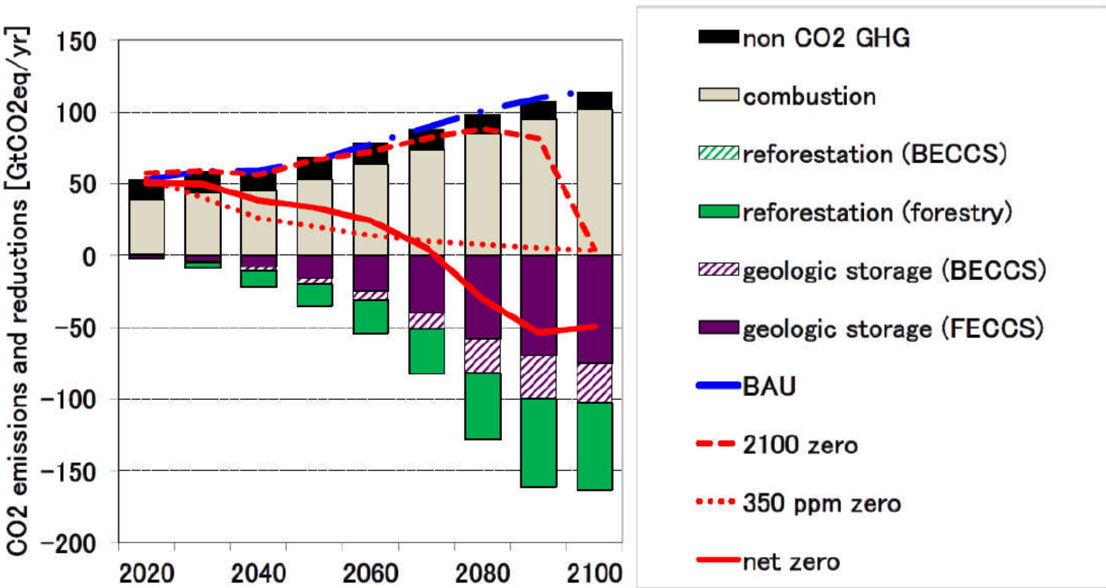


圖 13 簡化氣候模型 RICE 2010 架構



BECCS: 生質能源與碳捕獲和儲存(biomass energy with carbon capture and storage)
FECCS: 化石能源與碳捕獲和儲存(fossil energy with carbon capture and storage)

圖 14 不同情境下之二氧化碳平衡

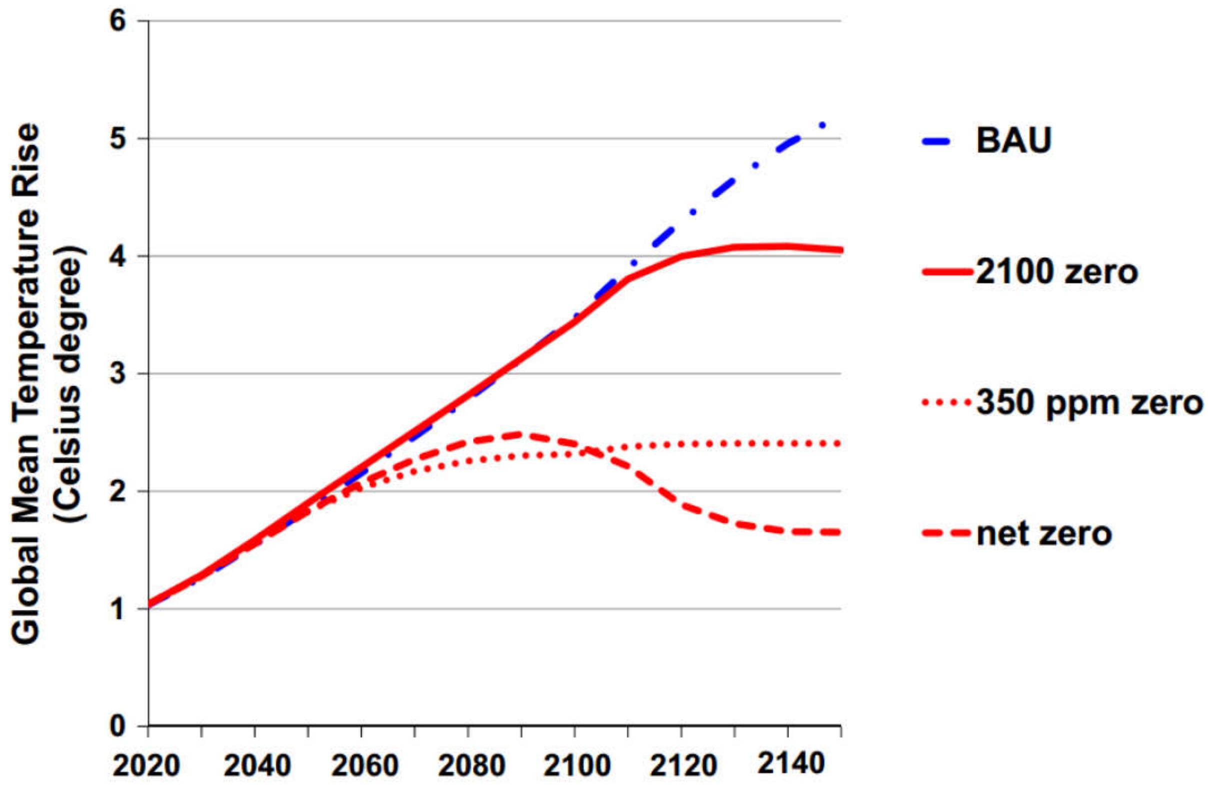


圖 15 不同情境下之全球平均溫度上升

3. 建模運輸能源需求和排放：開發全球客運模型，並結合可計算的一般均衡模型 (Modelling Transport Energy Demand and Emissions: Development of A Global Passenger Transport Model Coupled with Computable General Equilibrium Model)

演講者：日本國立環境研究所(National Institute for Environmental Studies)社會與環境系統研究中心(Center for Social and Environmental Systems Research), Research Associate, Runsen Zhang

此研究整合發展客運運模式、亞太整合模式(Asia-pacific Integrated Model, AIM)/運輸，結合客運的選擇模式和運輸技術細節。該 AIM /運輸與 AIM /可計算總平衡(AIM/Computable General Equilibrium (AIM/CGE))相結合，以掌握運輸部門、能源、溫室氣體排放和巨觀經濟(macro-economy)之間的互動機制。再以 AIM/CGE 和 AIM/Transport 的整合與迭代，求出收斂解(如圖 16)。並建立基準情境(business as usual, BAU)和緩解情境(mitigation scenario)作為案例分析，緩解情境模擬實行碳稅之情形。圖 17 顯示全球基準情境之能源使用與碳排放預測。圖 18 顯示緩解情境對應基準情境之影響。模擬結果顯示：汽車和石油仍然主導能源消耗和溫室氣體排放。碳稅將對技術和燃料選擇產生重大影響，有助於減少排放並減輕全球暖化。

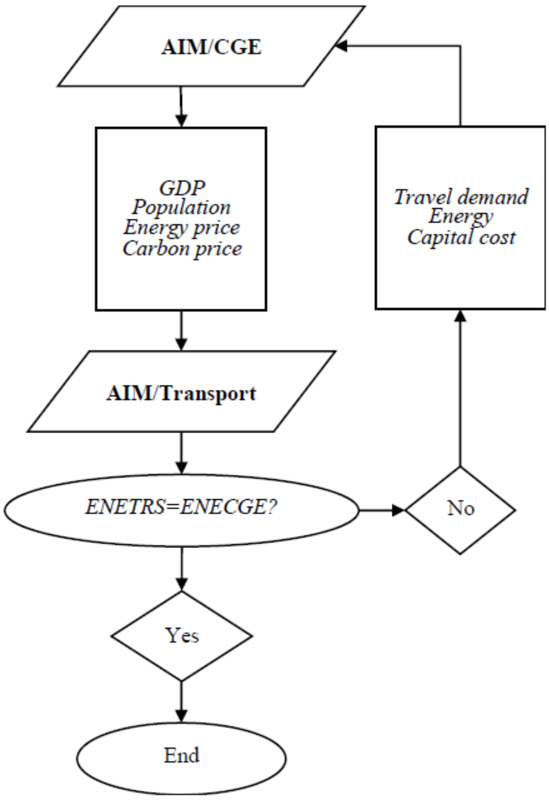


圖16 結合AIM/CGE和AIM/運輸的迭代運算法

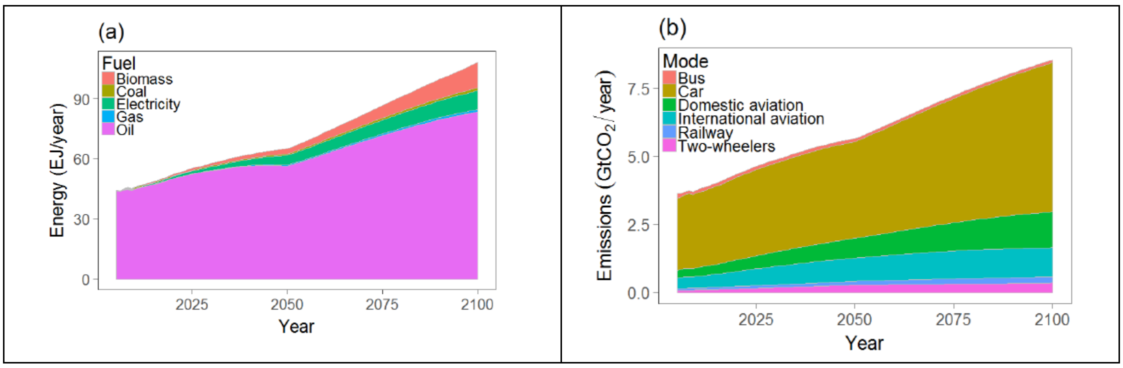
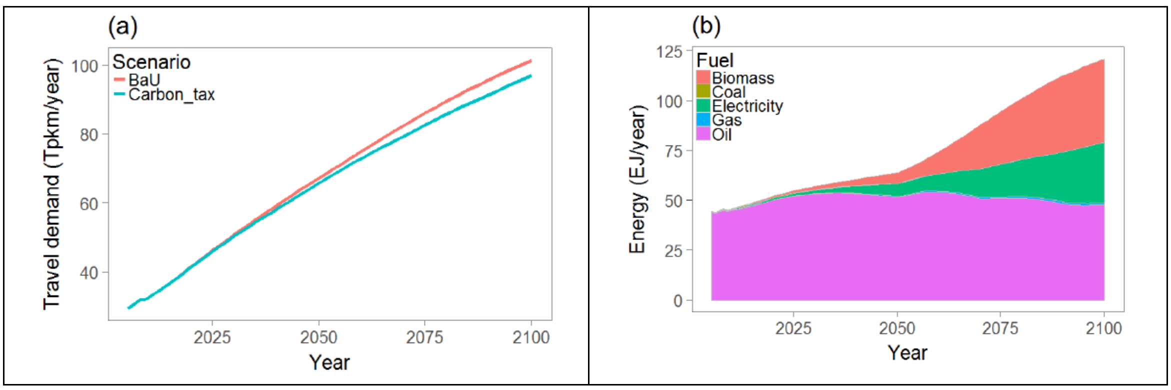


圖17 全球基準情境之能源使用與碳排放預測



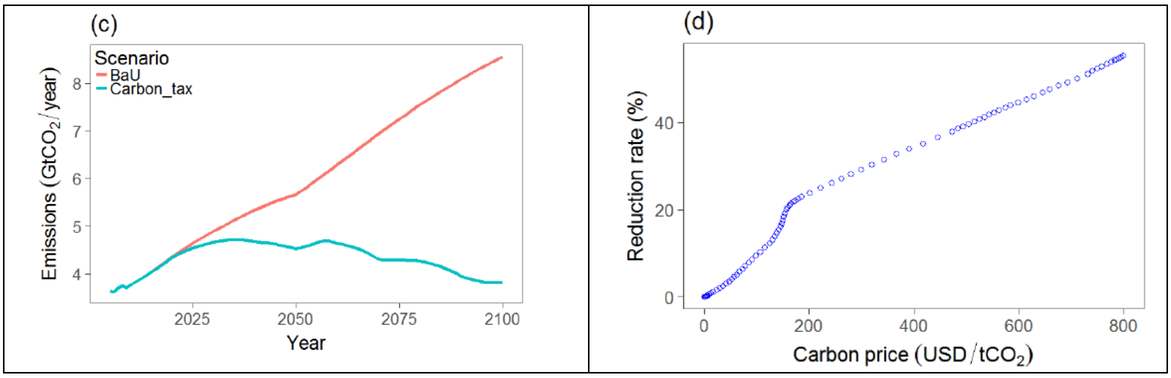


圖18 碳稅的影響：(a) 客運需求、(b)能源、(c)排放量、(d)溫室氣體(GHG)減排率

4. 能源安全概念與亞洲太平洋經濟合作組織能源合作的演變(The Evolution of the Energy Security Concept and APEC Energy Cooperation)

演講者：日本亞太能源研究中心(Asia Pacific Energy Research Center, APERC)之部長(General Manager)入江一友(Kazutomo IRIE)博士

能源安全最初被認為是穩定的能源供應(主要是石油作為最重要的能源)，以因應地緣政治風險，如國家之間或國家之間的衝突。二十一世紀初以來，三大事件改變了能源安全的觀念，包括新的威脅和能源來源受到保護：一是 2001 年 9-11 攻擊事件；其次為，2005 - 2006 年期間俄羅斯與烏克蘭的天然氣爭端；第三次為 2005 年的卡崔娜颶風。

現在，隨著暴力非國家行為者(Violent non-state actor, VNSA)的加入和自然災害，人為災害和網路攻擊的威脅，能源安全的概念也在擴大。

該概念還將天然氣和其他能源基礎設施更廣泛地用作需要增強保護的實體。為了達到目前更廣泛的能源安全觀，能源專家(政策制定者、企業領袖和政策研究人員)應該熟悉這些新出現的能源安全因素。為了確保天然氣、電力和石油的穩定供應，這種熟悉是必要的。亞洲太平洋經濟合作組織(APEC)進行了油氣安全演習(Oil and Gas Security Exercises, OGSE)，假設發生網路攻擊、地震或颱風等自然災害以及船舶碰撞等人為災害等恐怖襲擊事件。預計這些做法將啟發 APEC 能源政策制定者對新的更廣泛的能源安全概念。

例如屬於第三次 OGSE 的菲律賓演習於 2015 年 12 月 7-9 日舉行，第一階段：假想貨船與油輪的碰撞導致貨船下沉並損壞馬爾帕那(Malampaya)水下天然氣管道(如圖 19)，考慮到天然氣供應造成人為災害；第二階段：假想強烈的颱風對煉油廠造成損害(如圖 20)，考慮到自然災害的風險；第三階段：假想菲律賓強勁的颱風繼續向北移動，襲擊菲律賓石油產品主要出口國之一的台灣。颱風在台灣登

陸，造成兩座煉油廠的損壞，導致其出口菲律賓的石油產品減少，考慮到外國領土的自然災害可能會對經濟的能源安全構成威脅 (如圖 21)。

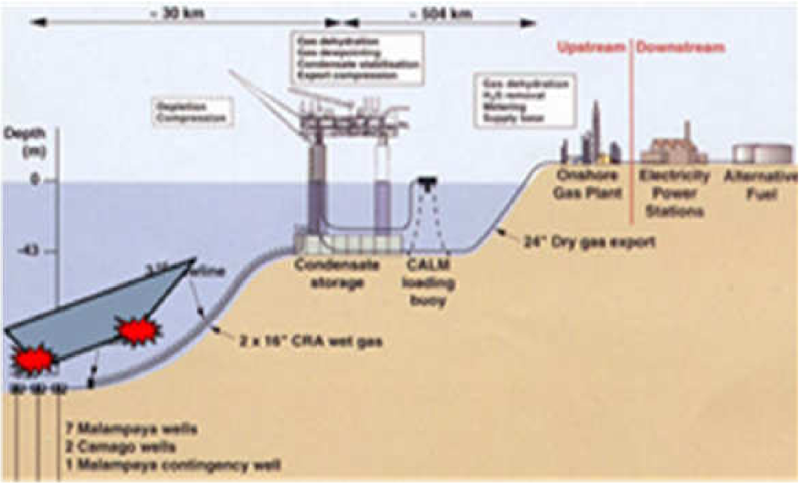


圖 19 第一階段菲律賓演練示意圖

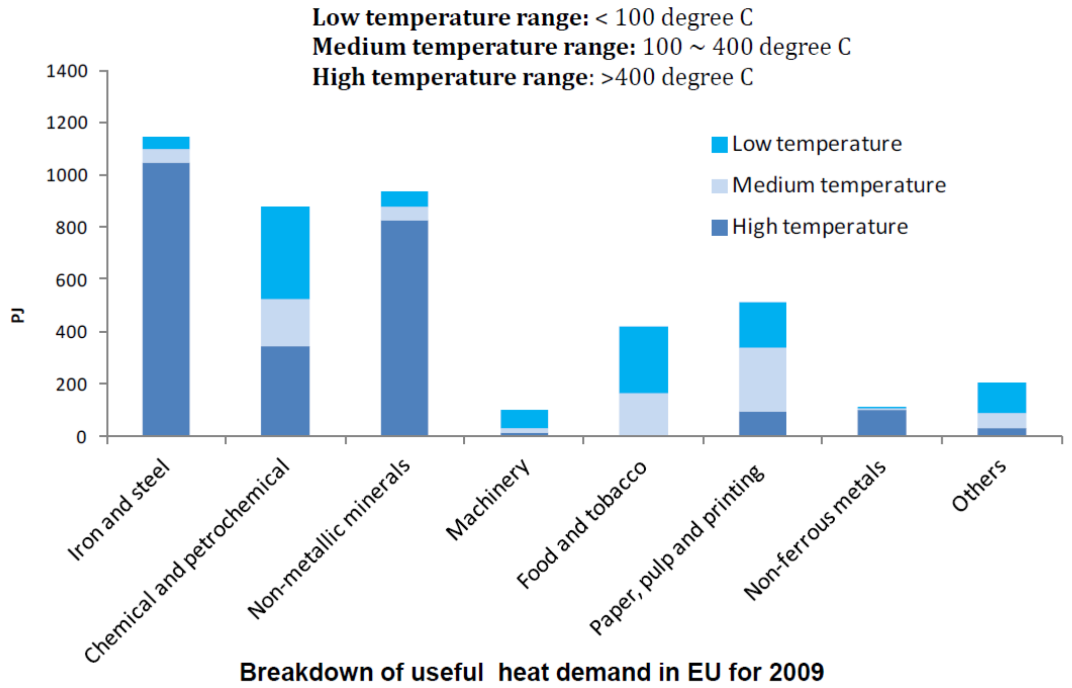
圖 20 第二階段菲律賓演練示意圖

圖 21 第三階段菲律賓演練示意圖

5. 再生能源在工業部門加熱應用的潛力-APEC 指定案例研究(Potential for Renewable Energies' Application for Heating in the Industrial Sector – A Case Study of Selected APEC Economies)

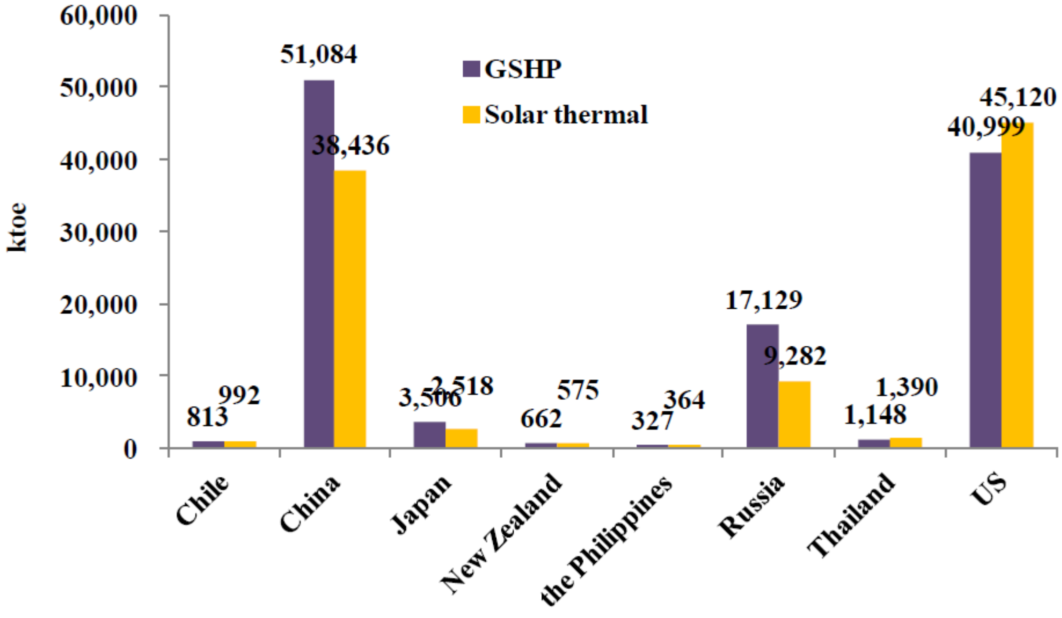
演講者：日本能源經濟研究所(The Institute of Energy Economics, Japan, IEEJ), 研究員, 闞思超(**Sichao Kan)**

本文為日本能源經濟研究所(IEEJ)與日本亞太能源研究中心(APERC)共同研究。直接使用再生能源進行供熱應用是減少工業部門溫室氣體排放的一個選擇。本研究為亞太能源研究中心(APERC) 亞洲太平洋經濟合作組織(APEC)能源需求和供應展望第七版的研究之一，本研究估計了再生能源在八個 APEC 經濟體成員中對工業部門應用熱能的潛力。通過比較每個經濟中每個選定行業子部門的有用熱需求曲線和再生能源選擇的供應潛力，同時考慮到所產生的能源成本，確定其潛力。初步分析顯示，造紙、紙漿和印刷以及食品和煙草子部門將具有長期使用再生熱能發展的潛力。儘管化工和石油化工部門直接使用再生能源的潛力預計將來是未來最高的。在經濟方面，由於其巨大的工業能源需求，中國的再生能源發電潛力最大。然而，目前美國是再生能源消費最大的經濟體，未來再生能源的應用潛力預計將會很高。生質能是行業中最常用的再生能源，未來其利用的潛力將是所有再生能源選擇中最高的。2009 年歐盟不同行業的可使用熱量需求情況圖 22，八個 APEC 成員經濟體地源熱泵和太陽能熱供應潛力如圖 23，作者推估 2040 年再生能源和能源消耗總量潛勢如圖 24。



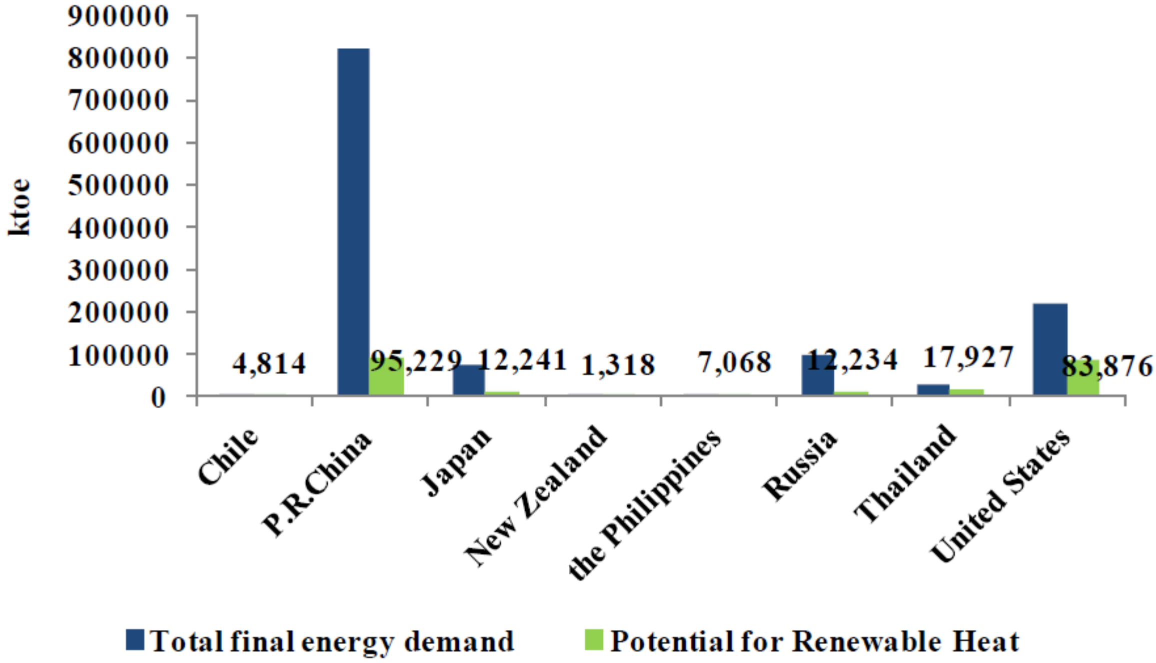
Data source: N. Pardo, K. Vatopoulos, A. Krook-Riekkola, J.A. Moya, and A. Perez (2012): "Heat and cooling demand market and perspective", EU Joint Research Center Scientific and Policy Report.

圖 22 2009 年歐盟不同行業的可使用熱量需求情況



GSHP: ground-source heat pump 地源熱泵

圖 23 八個 APEC 成員經濟體地源熱泵和太陽能熱供應潛力



Potential for renewable heat and total energy consumption in selected industries by economy (2040)

圖 24 推估 2040 年再生能源加熱和能源消耗總量潛勢

6. 發展亞洲太平洋經濟合作組織低碳城鎮指標系統(Development of APEC low-carbon town indicator (LCT-I) system)

演講者：日本亞太能源研究中心(Asia Pacific Energy Research Center, APERC), 研究員**,** 田中裕子(**Yuko Tanaka)**

日本亞太能源研究中心一直擔任亞洲太平洋經濟合作組織(APEC)低碳示範城(Low-Carbon Model Town, LCMT)計畫的秘書處。LCMT 計畫於 2011 年啟動，以響應 2010 年 6 月 19 日在日本福井舉行的第九屆 APEC 能源部長級會議(Energy Ministers Meeting, EMM)的聲明，部長們通過合作能源解決方案討論了能源安全的低碳途徑，以實現永續發展 APEC 各經濟體以及發展策略。在城市規劃中引入低碳技術，以提高能源效率和減少化石能源使用，對於管理亞太地區城市能源快速增長至關重要。

LCMT 項目包括三個主要活動：(1) APEC 專家制定和完善“APEC 低碳城市概念”；(2)對每個案例城鎮進行低碳發展進行可行性研究；(3)APEC 織專家對每個案例小鎮的低碳發展政策進行審查。

APEC 低碳城鎮指標(Low-Carbon Town-I, LCT-I)系統自 2013 年開始開發。LCT-I 系統是評估和監測每個低碳城鎮進度的自我評估工具。在 2013 年進行基礎調查之後，LCT-I 系統的試用評估是在這些 LCMT 案例小鎮的幫助下於 2015 年進行的。 LCT-I 系統指南第一版及其評估表於 2016 年 11 月發布。圖 25 顯示低碳城鎮指標在各階段參與概念評估、可行性研究、政策審查的城鎮，其中台灣澎湖參與第二階段概念評估。到目前為止，已有六個案例城市進行了可行性研究和政策審查：中國的于家堡、泰國的蘇梅島、越南的峴港、秘魯的聖博爾哈(San Borja)，印度尼西亞的比通(Bitung)和菲律賓的曼達維(Mandaue)。俄羅斯克拉斯諾亞爾斯克(Krasnoyarsk)於 2017 年被選為下一個案例小鎮。

LCT-I 系統被設計為盡可能簡單，方便用戶使用。 LCT-I 系統的評估區域是全面的，並使用五等分評估(1-5 分)。使用者可以輕鬆進行各種規模、特點和進度階段的低碳城鎮建設計畫評估。由於“概念”所涉及的低碳措施最初是從能源角度出發，它們首先分為兩個主要方面：與能源使用直接相關的措施，並採取措施“間接相關”的能源使用。在直接相關的措施中，有關需求和供應兩個方面都列為第一項。在間接相關措施中，包括“環境與資源(Environment & Resources)”和“治理(Governance)”兩個方面。雖然這兩個間接相關的一級計畫的措施並不涉及能源的使用，但它們是開發 LCT 的重要因素。評估目標由 5 個主要項目(一級)和 14 項中級項目(二級)組成。三級項目中有 35 個定量和定性指標。

LCT-I 系統的特點為：(1)評估和監測每個 LCT 發展計畫進展情況的自我評估工具；(2)設計盡可能簡單，方便用戶使用；(3)LCT-I 系統的評估範圍是全面的，原則上採用五點評估；(4)建議計算二氧化碳排放量。圖 26 顯示 LCT-I 系統評估架構，圖 27 顯示 LCT-I 系統評估結果表單。

LCMT 研討會規劃於 2017 年 9 月在印尼首都雅加達舉行，目的為(1)傳播 APEC 低碳城鎮；(2)推動 LCT-I 系統的使用和認可，作為在 APEC 地區傳播 LCT 的工具；(3)探討利用 LCT-I 系統在 APEC 發展中國家開展銀行業低碳發展項目的可能性;；(3)收集專家和 LCT 項目代表對 LCT-I 系統改進的回饋意見；(4)分享世界先進低碳城鎮項目的資訊，包括 APEC 地區以前的 LCMT 案例城鎮。

簡報後黃員詢問：參與評估的城鎮之間是否進行低碳績效比較或排序。田中裕子研究員回覆：參與評估的城鎮之間不作比較，但是 APERC 會對個別城市觀察其長期發展。

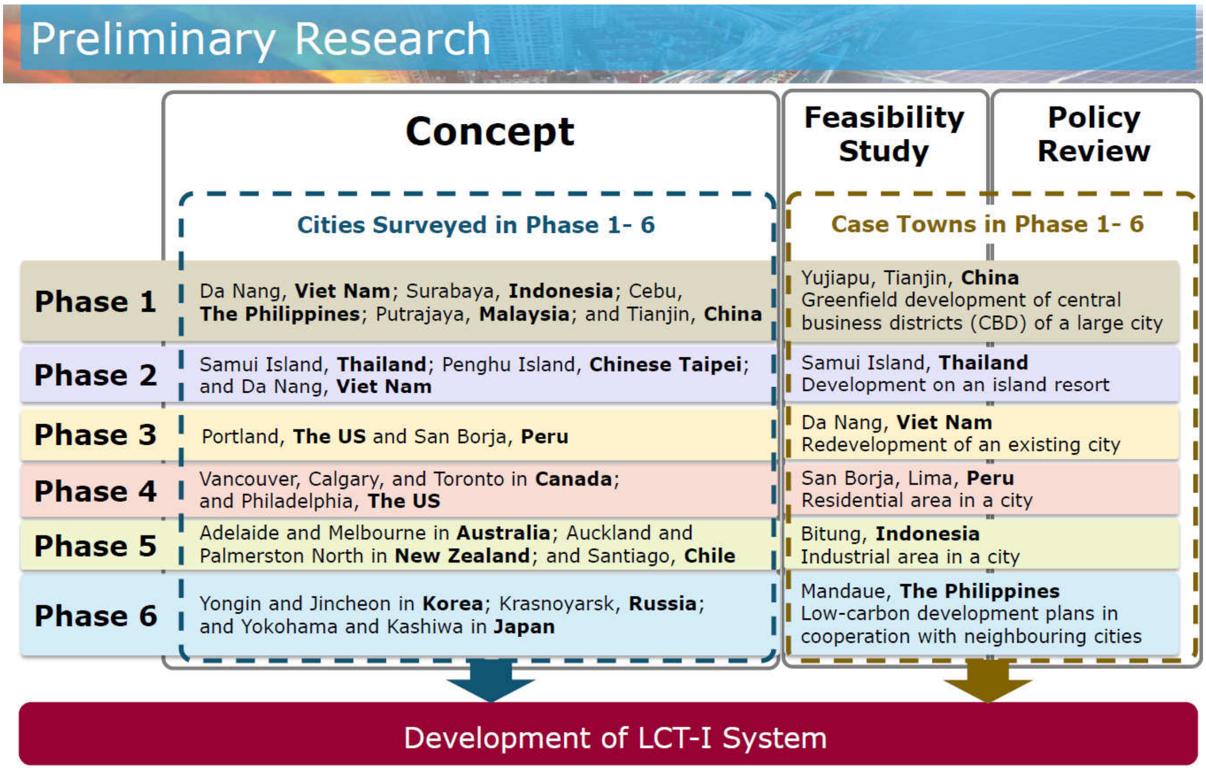


圖 25 低碳城鎮指標在各階段參與概念評估、可行性研究、政策審查的城鎮

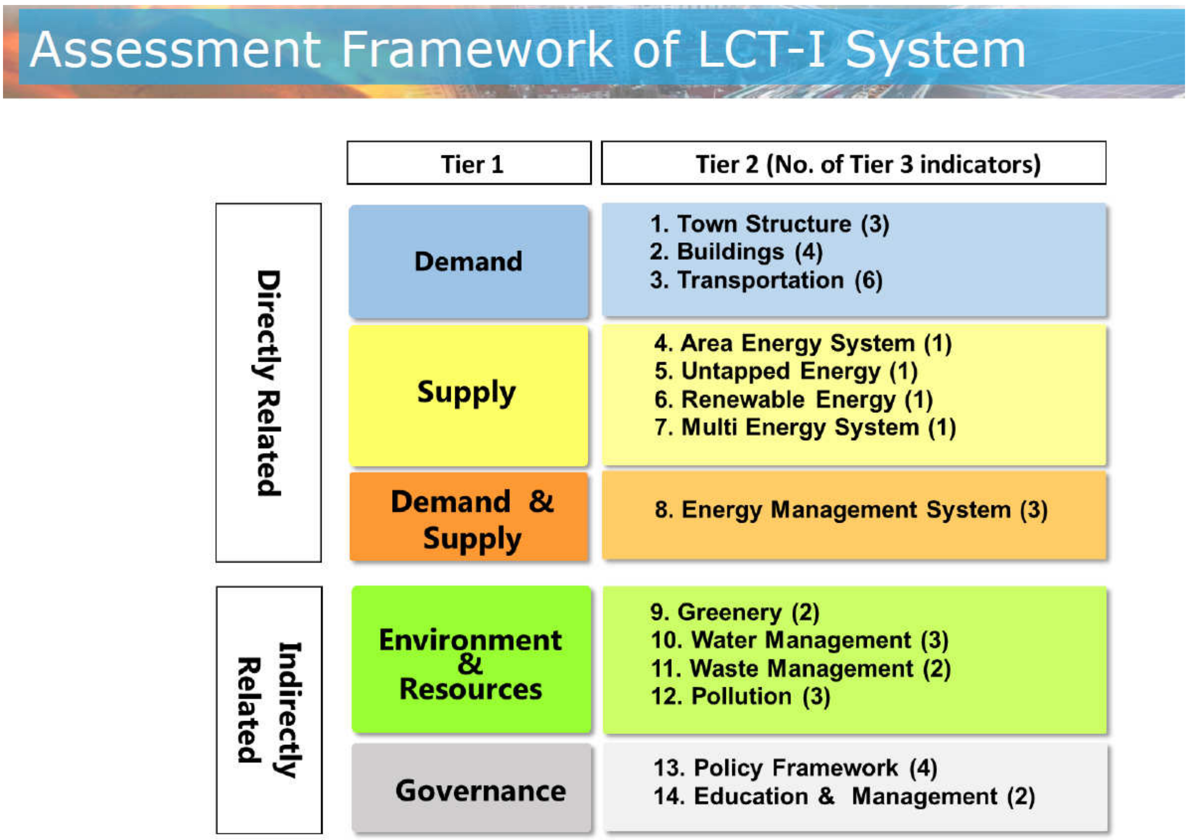


圖 26 LCT-I 系統評估架構

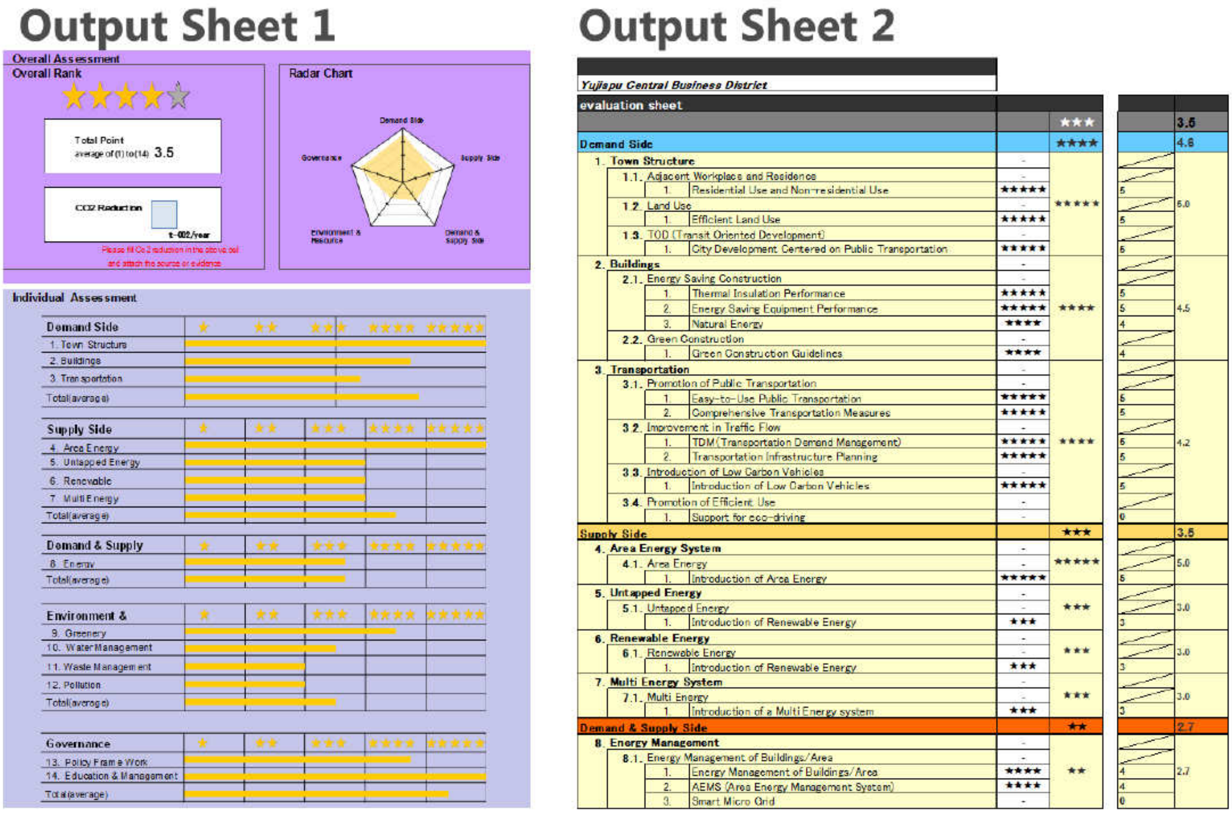


圖 27 LCT-I 系統評估結果表單

7. 美國油井數量與布蘭特原油對西德州中級原油價差之間的關係(The Relationship between US Rig Count and BRENT WTI Spread)

演講者：淡江大學廖惠珠教授

西德州中級原油價格(West Texas Intermediate Crude Oil, WTI)已成為世界基準價格。許多商業貿易商使用 WTI 來對沖石油價格風險。然而，由於與其他兩個主要基準價格(即布蘭特原油(BRENT)和杜拜原油(DUBAI))的明顯價格偏離，WTI 從 2012 年開始失去了世界領先的價格作用。雖然 BRENT 自 2012 年以來將 WTI 取代為新的主導基準價格，但許多市場參與者仍然傾向於通過交易 WTI 期貨進行套期保值。這種交易可能會帶來一些風險。首先，如果 BRENT 和 WTI 之間的差距更加波動，那麼套期保值者可能無法避免風險。其次，在更不佳的情況下，套期保值者甚至可能會虧損更多的錢。因此，值得澄清影響因素及其對 BRENT 與 WTI 之間差距波動的影響。最近，北美的油井數量被認為是影響差距波動的重要因素。

油井數量的大小用於判斷上游石油公司的活動。通常，如果油價上漲，油井數量增加，然後加起來生產油量。因此，一些文獻使用油價和油井數量作為兩個重要的自變量來解釋石油生產並發現重大影響。然而，本研究所認為關聯(油價上升→油井數量增加→石油生產增加)可能適合於解釋過去的歷史，但不適合世界現況。事實上，本研究在最近的數據中發現了更為複雜的聯動，而不是上面的積極聯動(油價上升→油井數量增加)。與過去的分析相反，今天的油井數量變量是解釋油價走勢的重要變量(油井數量增加→石油生產增加→油價下跌)。圖 28 顯示美國油井數量、布蘭特原油對西德州中級原油價差與西德州中級原油價格之關係。

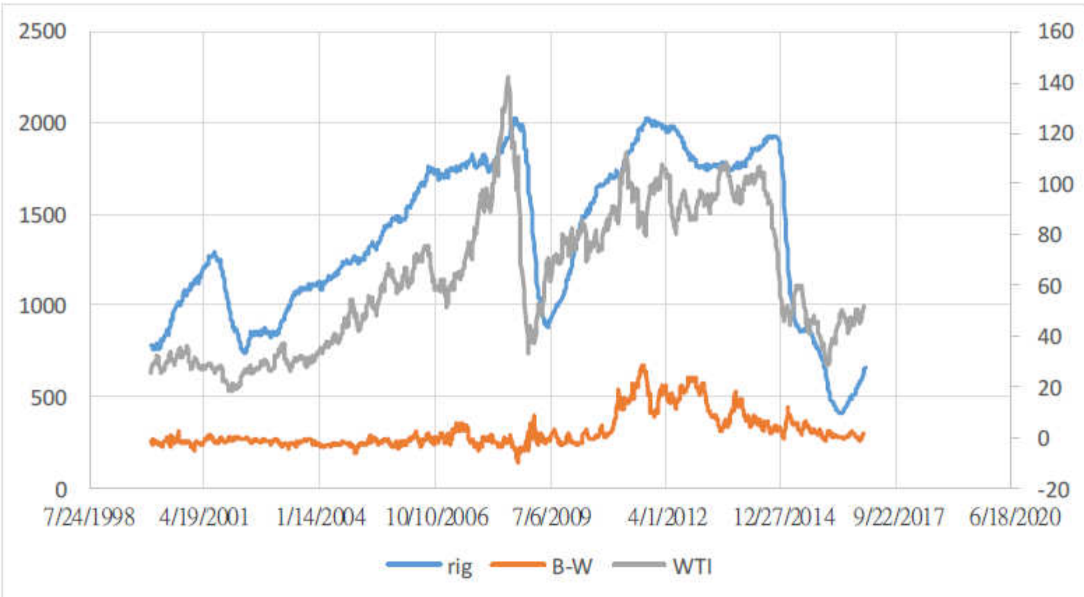


圖 28 美國油井數量(rig)、布蘭特原油對西德州中級原油價差(B-W)與西德州中級原油價格(WTI) 之關係

8. 期貨市場投機行為對油價的影響(The Effect of Speculation in Futures Market on Oil Price)

演講者：財團法人中技社劉致峻先生

本研究由中央大學梁啟源教授指導。在 2004 - 2016 年期間，原油市場出現巨大的價格波動，僅供需分析就無法充分解釋。例如，期貨市場的投機行為成為導致油價波動的另一個合理因素。作者提出非商業交易者在 NYMEX 的輕質原油淨多頭位置作為代替期貨市場的投機行為，並採用符合限制的 SFAVAR 模型來評

估投機對油價的影響變化。結論認為，在油價變動分析中考慮到投機是相關的，將有利於油價的預測。

本研究的目的是檢查2004年至2016年期間期貨市場的投機行為是否影響原油價格， SFAVAR 模型評估顯示：(1)非商業交易者的投機行為增加對原油價格變動瞬間表現出顯著正面影響，其累積效應至少在 6 個月內不會消失；(2)供應方面的因素，庫存變化對油價變化產生了直接的負面影響，而後期則出現了石油生產變化的負面累積影響；(3)實際經濟活動、通貨膨脹、貨幣金融等需求因素的衝擊一般對油價產生積極影響，累計積極影響持續 6-12 個月。而且研究也發現，雖然過去十年油價的演變是由不同時期的不同因素決定的，但在 2004-2007 年、2011 - 2013 年和 2015 年期間，期貨市場的投機行為遠遠超過其他因素。圖 29 顯示石油價格變動之歷史分解。

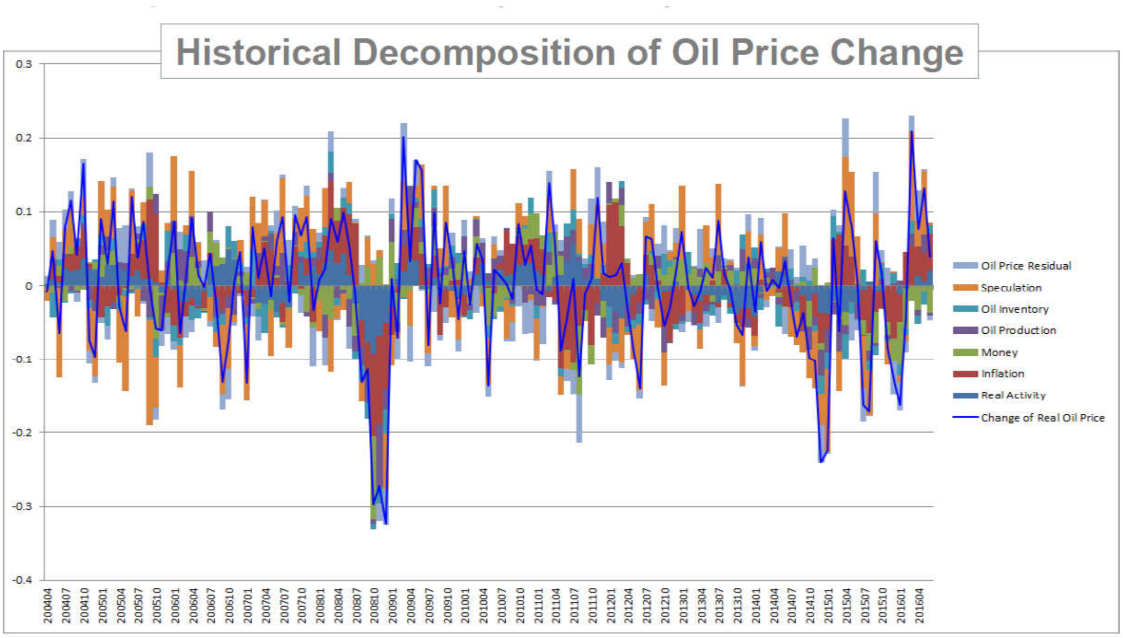


圖 29 石油價格變動之歷史分解

四、建議事項

「第 40 屆 International Association for Energy Economics (IAEE)國際研討會」於 106 年 06 月 18 日至 6 月 21 日於新加坡舉行，研討會主題為「滿足新興經濟體的能源需求，對能源和環境市場的可能影響」，所涉及議題包括：「新興國家和發展中國家的電力獲取」、「氣候變遷」、「傳輸電網擴張與跨國合作的經驗教訓」、「全球天然氣市場動態」、「東亞天然氣市場轉型」、「能源安全」、「能源市場期貨」，參加會議人數約為 400 人，核能研究所由黃揮文副研究員代表前往新加坡發表「Computation and Analysis on Taiwan Index of Energy Security Risk」論文一篇。IAEE 研討會邀請各國研究單位的研究人員與業界相關人員，透過此次國際研討會，可掌握全球重要能源議題，在此有以下幾點建議：

(一) 建議持續派員參 IAEE 國際研討會

IAEE 為國際重要能源經濟研討會，歷次會議重要議題涵蓋：能源安全、氣候變遷、能源市場、能源政策、再生能源、能源模型等，國際重要組織與學術單位如：國際能源署、世界銀行集團、日本能源經濟研究所、麻省理工學院、南加州大學、維也納科技大學、印度理工學院、新加坡國立大學，皆有專家參加會議。本所派員參加 IAEE 國際研討會，可掌握國際能源經濟議題最新趨勢。

(二) 建議加強與新加坡國立大學(NUS)能源研究所(ESI)之合作關係

新加坡國立大學能源研究所為第 40 屆 IAEE 國際研討會之主辦單位，因此黃員在會議期間與 NUS-ESI 之研究人員多所交流。其中 Philip Andrews-Speed 博士為黃員發表論文之分組會議主席(Energy Security 場次)，為 ESI 能源安全組組長。此外李瑩珠研究員表示 ESI 正自行開發可計算的一般均衡(Computable General Equilibrium, CGE)經濟模型，規劃與 MARKAL 工程模型進行軟連結，與本所能源經濟與策略研究中心將 GEMEET 經濟模型與 TIMES 工程模型進行軟連結作法相似，本所目前已與 NUS-ESI 進行技術交流，未來可在軟連結發展過程中再交換心得。此外新加坡國立大學接受新加坡政府委託之能源政策相關計畫，由於新加坡國家規模較小，並未設立能源經濟政策相關國家實驗室，因此新加坡國立大

學為能源經濟政策之重要智庫，與 NUS-ESI 加強交流可了解新加坡能源經濟政策方向與政策形成之機制。

(三) 建議加強與日本能源研究所(IEEJ)及下屬單位亞太能源研究中心(APERC)之合作關係

IEEJ 之組織架構如圖 30，目前人數為 198 人(包含 APERC 成員)，其研究所本部包括：(1)企劃事業單位、(2)戰略與研究單位、(3)化石能源與電力單位、(4)新能源與國際協力支援單位、(5)計量分析單位、(6)地球環境單位、(7)中東研究中心，另設附屬機關包括：(1)石油情報中心、(2) 亞太能源研究中心(APERC)、(3)綠能認證中心(Green Energy Certification Center)。

核能研究所能源經濟與策略研究中心與 IEEJ 之組織架構與組織功能相似，而 IEEJ 之工作範圍更廣。IEEJ 除了承接日本政府(包括經濟產業省)的委託工作外，也執行 APEC 之指定工作，加強與 IEEJ 及下屬單位 APERC 之合作關係，可了解日本能源經濟政策方向與其能源經濟分析技術。

核能研究所與 IEEJ 於 2015 年簽訂合作備忘錄，卻一直未能有機會進行較深入之交流。黃員於 2015 年參與第 11 屆臺日能源合作研討會期間與 IEEJ 豐田正和理事長曾經進行技術性討論，本次會議黃員主動交談。豐田正和理事長邀約黃員參加 APEC 能源議題(APEC Energy Issues)場次，黃員前往聆聽 APERC 入江一友(Kazutomo IRIE)部長發表之「能源安全概念與亞洲太平洋經濟合作組織能源合作的演變」、IEEJ 闞思超(Sichao Kan)研究員發表之「再生能源在工業部門加熱應用的潛力-亞洲太平洋經濟合作組織經濟體指定案例研究」與 APERC 田中裕子研究員發表之「發展亞洲太平洋經濟合作組織低碳城鎮指標系統」。場次結束後，黃員與豐田正和理事長、入江一友部長與其他研究人員進行交流，黃員認為核能研究所能源經濟與策略研究中心與 IEEJ 未來應該在合作備忘錄架構下多進行技術交流。豐田正和理事長表示 IEEJ 研究內容以務實為原則，研究結論提供日本經濟產業省作為能源經濟之策略建議。黃員說明核能研究所規劃於 2018 年辦理能源系統經濟策略相關研討會，屆時將邀請豐田理事長進行演講。

(四)　建議建立以國際政經濟關係為基礎質化分析能源進口曝險之能力

黃員於分組會議發表台灣能源安全風險指標計算與分析(Computation and Analysis on Taiwan Index of Energy Security Risk)論文時，美國 Ron Ripple 教授提問：能源進口曝險不應該只侷限於考慮進口國家多樣性，應再考慮國際政治局勢，以及與進口國家之政治、經濟穩定度。黃員回覆：由於本項研究考慮將台灣之能源風險與國際重要國家之能源風險進行比較，因此對外研究需考量能源風險指標之一致性。此外「國際政治局勢，以及與進口國家之政治、經濟穩定度」較難直接量化，核能研究所將考慮內部另行進行質化分析。

黃員進行分析時，石油進口曝險長年偏高，原因為分析石油、天然氣、煤炭等化石燃料進口曝險時，考慮多樣性與自由度。而我國長期高比例向單一中東國家進口石油，而依據國際性的非政府組織自由之家(Freedom House)之評估，中東國家自由度皆不佳，使石油進口曝險估算長年偏高。然而數十年來我國進口石油相當穩定，原因為我國與該石油進口國長期關係良好，而該國政治情勢持續穩定，使得能源安全風險指標與實際現象偏離。因此以質化方式討論石化能源進口國與我國的政治、經濟關係，以分析石化能源進口曝險有其必要性。

(五)　建議關切新興國家之能源發展，以發掘我國未來潛在機會

本次研討會主題為「滿足新興經濟體的能源需求，對能源和環境市場的可能影響」，新興國家如南亞國家、非洲國家皆參與研討會，目前能源供應看似困難，然而有相當的國家具有豐富之天然資源，以及充沛之青壯人力，隱然可感受其發展潛力。關切這些新興國家之能源發展，可發掘其中我國未來潛在機會。

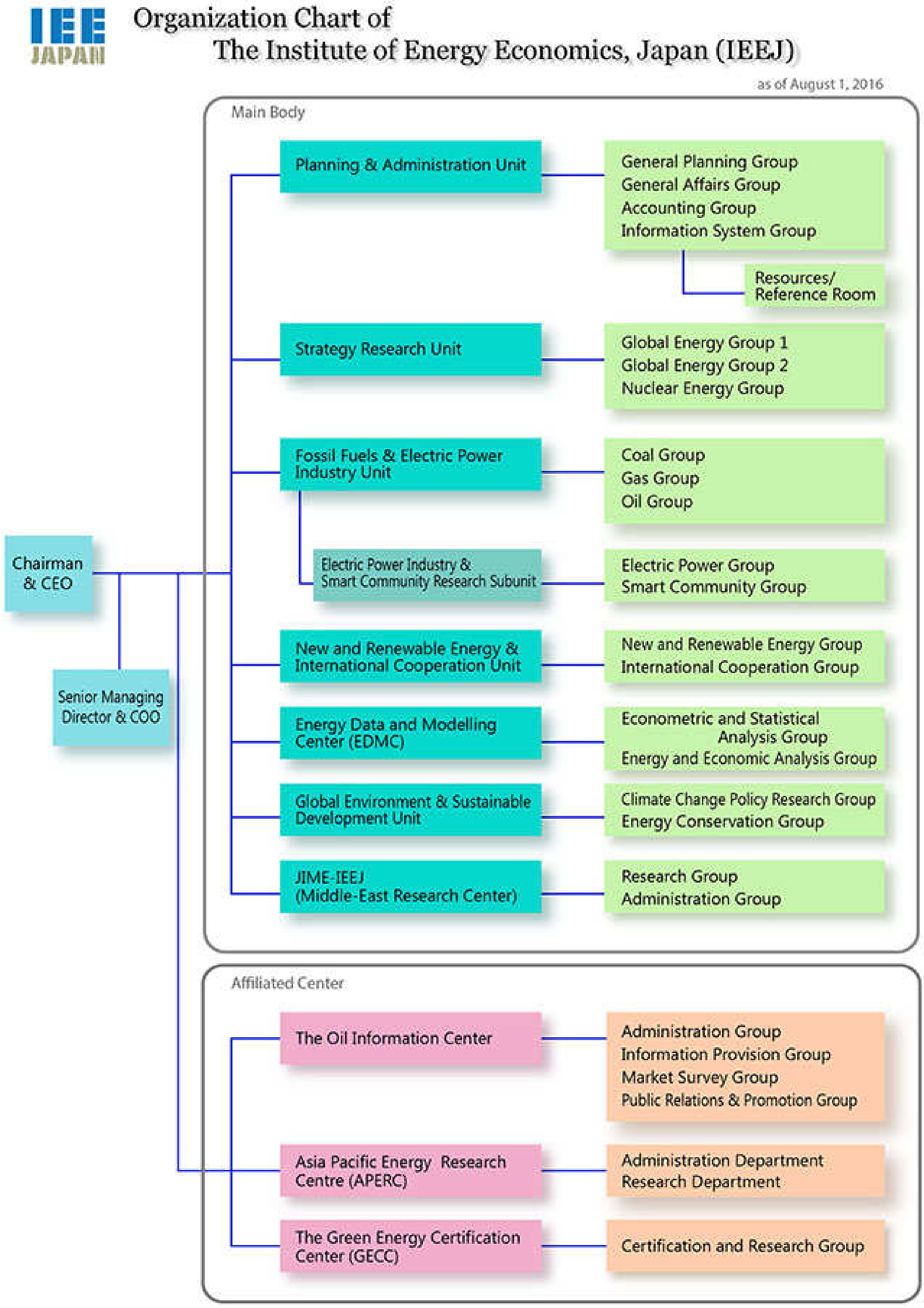


圖 31 日本能源研究所組織架構

五、資料蒐集

1. 40th IAEE International Conference Program (已送本所圖書館登錄)
2. The Energy Journal, Volume 38, Number 3, May 2017 (已送本所圖書館登錄)
3. Economics of Energy & Environmental Policy, Volume 5, Issu2, September 2016 (已送本所圖書館登錄)
4. IAEE Energy Forum, Second Quarter, 2017 (已送本所圖書館登錄)
5. ESI Bulletin, Volume 10, Issue 3, June 2017 (已送本所圖書館登錄)

註：本次會議未提供光碟，會議論文可由以下網址下載：

http://www.iaee.org/iaee2017/program_concurrent.aspx

附件 **1**
第 **40** 屆 **IAEE** 國際研討會議程

Programme overview

Sunday 18 June

Time	Activity	Venue
12:00 p.m. – 7:00 p.m.	Registration	Level 4 Foyer
9:00 a.m. – 2:00 p.m.	IAEE Council Meeting (by invitation only)	Lotus 4D
2:00 p.m. – 5:30 p.m.	Tour of Singapore (free and easy)	
6:30 p.m. – 8:00 p.m.	Welcome Reception	Bay View Foyer Area
7:30 p.m. – 9:30 p.m.	Council Dinner (by invitation only)	
8:30 p.m. – 10:30 p.m.	Student Happy Hour	Bay View Foyer Area

Monday 19 June

Time	Activity	Venue
7:30 a.m. – 7:00 p.m.	Registration	Level 4 Foyer
8:00 a.m. – 9:00 a.m.	Student Breakfast Meeting	Lotus 4D & 4E
8:00 a.m. – 9:00 a.m.	IAEE Affiliate Leaders Meeting	Lotus 4A
9:00 a.m. – 9:30 a.m.	Welcome and Opening Remarks Professor SK Chou, Executive Director, Energy Studies Institute, NUS Ricardo Raineri Bernain, Professor and President, IAEE Mr. Masagos Zulkifli, Minister for Ministry of the Environment and Water Resources	See Page 8 - Orchid Pink
9:30 a.m. – 10:00 a.m.	Opening Address: Keisuke Sadamori, Director, Energy Markets and Security, International Energy Agency, Paris, France	
10:00 a.m. – 11:00 a.m.	Keynote Session: Oil & Gas Markets: Global Actions and Regional Consequences	
11:00 a.m. – 11:15 a.m.	Coffee break	Orchid Green
11:15 a.m. – 12:30 p.m.	Dual Plenary Session 1: Electricity Access in Emerging and Developing Countries	See Page 8 - Orchid Pink
11:15 a.m. – 12:30 p.m.	Dual Plenary Session 2: Climate Change	See Page 8 - Orchid Orange
12:30 p.m. – 2:00 p.m.	Awards Luncheon	Peony Blue
2:00 p.m. – 3:30 p.m.	Concurrent sessions (1-10)	See Pages 10 - 11
3:30 p.m. – 4:00 p.m.	Coffee break	Orchid Green
4:00 p.m. – 5:30 p.m.	Concurrent sessions (11-20)	See Pages 11 - 13
7:00 p.m. – 10:00 p.m.	Conference Banquet	Capella Hotel, Sentosa

		Island Coach transfer (both ways) from MBS

Tuesday 20 June

Time	Activity	Venue
7:30 a.m. – 6:30 p.m.	Registration	Level 4 Foyer
8:00 a.m. – 9:00 a.m.	Asian Affiliate Leaders Meeting	Lotus 4A
8:00 a.m. – 9:00 a.m.	EJ Board of Editors Meeting	Lotus 4E
9:00 a.m. – 10:30 a.m.	Dual Plenary Session 3: Lessons from Transmission Grid Expansion and Cross-Country Co-operation	See Page 8 - Orchid Pink
9:00 a.m. – 10:30 a.m.	Dual Plenary Session 4: Global Gas Market Dynamics	See Page 8 - Orchid Orange
10:30 a.m. – 11:00 a.m.	Coffee break	Orchid Green
11:00 a.m. – 12:30 p.m.	Concurrent Sessions (21-30)	See Pages 13 - 15
12:30 p.m. – 2:00 p.m.	Lunch (buffet)	Peony Blue
2:00 p.m. – 3:30 p.m.	Tri Plenary Session 5: The Economic Future of Nuclear Power	See Page 8 - Orchid Pink
2:00 p.m. – 3:30 p.m.	Tri Plenary Session 6: East Asian Gas Markets in Transition	See Page 8 - Orchid Orange
2:00 p.m. – 3:30 p.m.	Tri Plenary Session 7: Energy Security	See Page 8 - Melati Yellow
3:30 p.m. – 4:00 p.m.	Coffee break	Orchid Green
4:00 p.m. – 5:30 p.m.	Concurrent Sessions (31-40)	See Pages 15 - 17
5:30 p.m. – 6:00 p.m.	IAEE General Membership Meeting	Lotus 4D
Evening	Free to experience Singapore’s various cuisines	

Wednesday 21 June

Time	Activity	Venue
7:30 a.m. – 6:00 p.m.	Registration	Level 4 Foyer
8:00 a.m. – 9:00 a.m.	2018 International Conference Planning Meeting	Lotus 4A
8:00 a.m – 9:00 a.m.	EEEP Editors Meeting	Lotus 4E
9:00 a.m. – 10:30 a.m.	Concurrent Sessions (41-50)	See Pages 17 - 19
10:30 a.m. – 11:00 a.m.	Coffee break	Orchid Green
11:00 a.m. – 12:30 p.m.	Concurrent Sessions (51-60)	See Pages 19 - 21
12:30 p.m. – 2:00 p.m.	Lunch (buffet)	Peony Blue
2:00 p.m. – 3:30 p.m.	Concurrent Sessions (61-67)	See Pages 21 - 22

3:30 p.m. – 4:00 p.m.	Coffee break	Orchid Green
4:00 p.m. – 5:30 p.m.	Concluding Plenary Session 8 : Energy Market Futures	See Pages 6 - Orchid Pink
5:30 p.m. - 6:00 p.m.	Farewell remarks and closure	

附件 **2**

第 **40** 屆 **IAEE** 國際研討會分組會議論文清單

CONCURRENT SESSIONS 1 - 10 Monday 19 June, 2:00 p.m. - 3:30 p.m.

1. Management of Electricity Markets
(Orchid: 4201AB-3 & 4301AB-3)

Carlo Andrea Bollino, *Presiding*
Professor Department of Economics
University of Perugia

Operating Reserve Demand Curve, Scarcity Pricing and Intermittent Generation: Lessons from the Texas ERCOT Experience
Raul Bajo-Buenestado
Department of Economics, University of Navarra

Design of a Decentralized Market with Locational Marginal Pricing for Efficient Congestion Management in Distribution Grids
Hans Schermeyer
Wolf Fichtner
Armin Ardone
Karlsruhe Institute of Technology (KIT)

Equilibrium Capacity Reserves in a Multinational Electricity Market
Thomas P Tangerås
Research Institute of Industrial Economics

Smart Demand Side Management: Storing Energy or Storing Consumption – It Is Not The Same!
Joachim Geske
Richard Green
Imperial College London
Chen Quixin
Tsinghua University

2. OPEC and Saudi Arabia
(Orchid: 4211-2 & 4311-2)

Carol Dahl, *Presiding*
Senior Fellow
Colorado School of Mines

OPEC Cartel Behavior: What Is Their Objective and What May Happen Now?
Peter N Volkmar
PhD Student, Rice University

Higher Retail Energy Prices in Saudi Arabia and Their Aggregate Impact on Welfare Across Generations
Frédéric Gonand
University Paris-Dauphine
Lester HUNT
Fakhri Hasanov
KAPSARC

Oil Price: Saudi Arabia vs Shale Oil
Jean-Pierre Favennec
Consultant, WD Cooperation

OPEC Spare Capacity and Price Volatility
Yaser Faquih
Rice University

3. Consumer Aspects of Energy Use
(Orchid: 4206 & 4306)

Brantley Liddle, *Presiding*
Senior Fellow
Energy Studies Institute, NUS

Human Capital and Energy in Economic Growth - Evidence from Chinese Provincial Data
Zheng Fang
SIM University
Yang Chen
Xi'an Jiaotong-Liverpool University

Electricity Consumption, Education Expenditure and Economic Growth in Chinese Cities
Fang Zheng
Singapore Institute of Management
Chen Yang
Xi'an Jiaotong-Liverpool University

The Demographic Factor of Energy Consumption in Saudi Arabia
Fakhri Hasanov
Xun Xu
King Abdullah Petroleum Studies and Research Center

Demographic Change and the Rising Oil Demand in OPEC
Fakhri Hasanov
Xun Xu
King Abdullah Petroleum Studies and Research Center

4. The Rebound Effect
(Melati: 4001AB & 4101AB)

Lester Hunt, *Presiding*
Professor of Energy Economics
KAPSARC

The Impact of Gasoline Prices on Driving Behaviors of NYC Taxi Drivers
Sang Uk Nam
University of Arizona

How Much Do Environmental Attributes Affect Electricity Savings? Sample Results from a Natural Experiment in Singapore
Tian Sheng, Allan Loi
Research Associate, Energy Studies Institute

The Solar Rebound, Household Income, and Subsidization of Residential Photovoltaic Systems
Matthew E Oliver
Juan Moreno-Cruz
Georgia Institute of Technology

Rebound Effect for UK Residential Sector
Mona Chitnis
University of Surrey
Roger Fouquet
London School of Economics and Political Science
Steve Sorrell
University of Sussex

Household Responses to Transitory Income Shocks: Evidence from Weather Induced Utility Bill and Mortgage Payment Activity
Gregory B Upton
Louisiana State University Center for Energy Studies
Meagan McCollum
Baruch College CUNY

5. Energy Sector Modelling
(Melati: 4002)

Gabrial Anandarajah, *Presiding*
Sr Research Associate
UCL Energy Institute

How to Build an Energy Market Modelling System
Robert E Brooks
President, RBAC, Inc.

Study on Energy Supply Curves in China's Bottom-up Energy Model up to 2030
Xiaoqian Xi
Xi Yang
China University of Petroleum

Assessment of Economic Impact of Emission Trading Schemes in China—Based on a Single Country CGE Model
Liu Yu
Institute of Science and Development, Chinese Academy of Sciences (CASISD)

Analysis of the Turkish Energy Sector with the BUEMS Energy Modelling Framework
Gurkan Kumbaroglu
Mine Isik
Ilhan Or
Bogazici University

6. Student Best Paper Session
(Melati: 4003)

Anthony D Owen, *Presiding*
Professor
Energy Studies Institute, National University of Singapore

Quality of Life Modelling in Terms of Energy Consumption
Reza Nadimi
Tokyo Institute of Technology

Trend Contagion in WTI and Brent Crude Oil Spot and Futures Prices - A Spread and Correlation Analysis
Tony Klein
Technische Universitaet Dresden

The Impact of Securing Alternative Energy Sources on Russian-European Natural Gas Pricing
Nathalie Hinchey
Rice University

The Impact of Wind Power Support Schemes on Technology Choices
Nils May
DIW Berlin

7. Road Transport
(Melati 4004)

Paul Kishimoto, *Presiding*
Research Associate
MIT

Correlated Emission Reduction Measures Selection under Uncertainty
Jun Yuan
Energy Studies Institute

Can Deregulation of CNG Reverse the Outcome of Regulation? Evidence from Thailand`s Transport Sector
Thanicha Ruangmas
Corbett Grainger
Department of Agricultural and Applied Economics, UW-Madison

Vehicle and Road Taxing Schemes in the United States and its Effects on Greenhouse Gas Emission
Jerome Dumortier
Cali Curley
Indiana University - Purdue University Indianapolis

Oil Refining in a CO2 Constrained World: Implications for Transport Policymaking
Amir F.N. Abdul-Manan
Saudi Aramco

The Purchase Intention of Electric Vehicles: Rational Choice, Behavioral Habit and Policy Intervention
Bin-Bin Peng
Jin-Hua Xu
Chinese Academy of Sciences
Ying Fan
Beihang University

8. Energy Access and Energy Subsidies (Melati 4102)

Omowumi Iledare, *Presiding*
Professor & Director
Emerald Energy Institute UNIPORT

Residential Energy Demand and Behaviour: its Implication for Climate Mitigation Policies and Energy Subsidy Reform in Thailand
Supawan Saelim
National Institute of Development Administration

Equilibrium Strategy for Gasoline Subsidy Policy Removal
Muhammad I
Akimaya Carol Dahl
Colorado School of Mines

A Road Map for Energy Access and Development: Lessons Learned in Chile for Developing Countries
Ricardo Raineri Bernain
Pontifical Catholic University of Chile
Cristian E Cardenas-Lailhacar
University of Florida

Competitiveness and Systemic Value of Different Power Technologies - Lessons from and for the Brazilian Case
Diogo Romeiro
GEE-IE/UFRJ
Edmar Almeida
Energy Economics Group, IE-UFRJ
Luciano D Losekann
GEE / UFF

9. Gas Market Integration (Melati 4103)

Ronald Ripple, *Presiding*
Professor of Energy Bus and Fin
The University of Tulsa

Raising Rivals' Costs: Vertical Market Power in New England's Wholesale Natural Gas and Electricity Markets
Levi Marks
University of California, Santa Barbara
Matthew Zaragoza-Watkins
Kristina Mohlin
Environmental Defense Fund
Charles Mason
University of Wyoming

How 'Integrated' is an Integrated Oil and Gas Company (IOC)? Understanding How and Why IOCs Pursue Alternative Business Models
Chi-Kong Chyong
David Reiner
EPRG, University of Cambridge

The Profitability of Transnational Energy Infrastructure: A Comparative Analysis of the Greenstream and Galsi Gas Pipelines
Roberto Cardinale
University College London

Estimation of the Efficiency of Policy Measures Targeting a More Integrated Gas Market
Ekaterina Dukhanina
Chair on the Economics of Natural Gas
Olivier Massol
IFP School
François Lévêque
Mines ParisTech

10. Aspects of Investment in Renewables (Melati 4104)

Prudence Dato, *Presiding*
Student
Savoie Mont Blanc University

The Role of Multilateral Development Banks in Enabling or Constraining New Power Generation Technologies in Emerging Economies
Bjarne Steffen
Tobias S. Schmidt
ETH Zurich - Swiss Federal Institute of Technology

The Relationship Between Finance and Industrial Policy in the Promotion of Renewable Technology: The Challenges to Promote Photovoltaic in Brazil
Gustavo O Andreão
Miguel Vazquez
Michelle Hallack
PPGE-UFF

Rural Electrification Trajectories
Anjali Nursimulu
Ecole Polytechnique Federale de Lausanne

Is 'Being Green' Rewarded in the Market?: An Empirical Investigation of Decarbonization Risk and Stock Returns
Soh Young In
Stanford University
Ki Young Park
Associate Professor in Economics, Yonsei University
Ashby Monk
Executive and Research Director, Stanford Gl

CONCURRENT SESSIONS 11 - 20
Monday 19 June, 4:00 p.m. - 5:30 p.m.

11. Electricity Market: Forward Pricing and Risks (Orchid: 4201AB-3 & 4301AB-3)

Adonis Yatchew, *Presiding*
Professor Department of Economics
University of Toronto

Electricity Price Forecasting Using Sale and Purchase Curves: The X-Model
Florian Ziel
University Duisburg-Essen
Rick Steinert
European University Viadrina

Dynamic Environmental Efficiency Analysis on China's Generation Corporations, a Game Cross Malmquist Approach
Bai-Chen
Xie Jie Gao
Tianjin University

Optimising Market Structure using Market Power Mitigation and Forward Contract in Electricity Market Restructuring
Dzikri F Hakam Rafael
E Macatangay
University of Dundee

Liquidity and Risk Premia in Electricity Futures
Ivan Diaz-Rainey
Fergus Bevin-McCrimmon
University of Otago
Greg Sise
Energy Link Ltd.

Price Forecast Accuracy of Trading Agents in Electricity Markets: The Role of Market Informedness, Risk Aversion, and Trading Behaviour
Ezgi Avci Surucu
Eric Van Heck
Wolfgang Ketter
Erasmus University-RSM

12. Electricity Network Issues (Orchid: 4211-2 & 4311-2)

Richard Green, *Presiding*
Professor Business School
Imperial College

Optimal Regulation of Network Expansion
Willems Bert
Tilburg University
Gijsbert Zwart
Groningen University

Cost Reflective Network Pricing - Some Lessons from the Australian Experience
Iain F MacGill
Anna Bruce
UNSW Australia

Network Tariff Challenge: Who Pays the Piper?
Johannes Reichl
Andrea Kolmann
Valeriya Azarova
Johannes Kepler University Linz
Cornelia Ferner
Dominik Engel
Salzburg University

Connecting the Heat and Electricity Market to Accomodate Renewable Energy
Philipp Riegebauer
Researcher & Consultant, Centre of Innovative Energy Systems (ZIES)

The Effects of Clean Electricity Certificates on the Value of Transmission Rights
Olvar Bergland
Norwegian U of Life Sciences

13. Energy Market Modelling
(Orchid: 4206 & 4306)

Robert Brooks, *Presiding*
President
RBAC Inc

Modelling Long-term Impacts of Renewable Electricity Support Designs on Social Welfare
Kaveri K Iychettira
Rudi A Hakvoort
Delft University of Technology
Pedro Linares
Comillas Pontifical Unversity, Madrid

Dynamic Investments in Flexibility Services for Electricity Distribution with Multi-Utility Synergies
Jesus Nieto-Martin
Mark A Savill
Cranfield University
Derek W Bunn
London Business School

Modelling Time-of-Use Demand Response in a Long-Term Whole Energy System Model, UK TIMES
Pei-Hao Li
Steve Pye
UCL Energy Institute

Decomposition of The Factors Influencing Export Fluctuation in China's New Energy Industry Based on A Constant Market Share Model
Zhengxin Wang
Honghao Zheng
Tong Jin
Lingling Pei
Yiqin Hu
Zhejiang University of Finance & Economics

Impact of Emission Trading Market Linkage on the Carbon Price: Findings of the GTAP-E Model
Jiang Mengfei
Xi Liang
University of Edinburgh Business School

14. Regional Power Market Cooperation
(Melati: 4001AB & 4101AB)

Thomas Tangeras, *Presiding*
Research Fellow
Research Institute of Industrial Economics

Inter-regional Power Grid Planning up to 2030 in China Considering Renewable Energy Development and Regional Pollutant Control: A Multi-region Bottom-up Optimization Model
Jia Jun-Jun
School of Management, University of Science and Technology of China
Yi Bo-Wen
Xu Jin-Hua
Center for Energy and Environmental Policy Research, Institute of Policy and Management, Chinese Academy of Sciences
Fan Ying
School of Economics & Management, Beihang University

Role of Renewables in the Future Energy Mix Potentials of the Southeast Asian Nations (ASEAN-10)
Emmanuel O Falobi
Olugbenga A Falode
Adeola F Adenikinju
CPEEL. University of Ibadan

Regional Cooperation in Renewable Energy Trade: Prospects and Constraints in Meeting the Paris Agreement
Venkatchalam Anbumozhi
ERIA
Kaliappa Kalirajan
Australian National University

Evaluating the Impact of Cross Border Interconnections on Security of Supply
Agha Salman Muhammad
Khan Laurens J. De Vries
Delft University of Technology

15. Distributed Generation and Climate Policy
(Melati: 4002)

Richard Hochstetler, *Presiding*
Instituto Acende Brasil

Policy Implications in a World with Renewables, Limited Dispatchability, and Fixed Prices
Mathias Mier
University of Oldenburg
Klaus Eisenack
Humboldt-University of Berlin

The Impact of Increasing Renewable Generation on the Operational Cost in the British Electricity Transmission System
Manuel Ruppert
Wolf Fichtner
Viktor Slednev
Karlsruhe Institute of Technology
Sara Lupo
the University of Edinburgh

Combined Effects of Electricity Market Liberalization and Climate Policy: Lessons from Europe
Bianka Shoai-Tehrani
Yasuhide Nakagami
Keigo Akimoto
Systems Analysis Group, Research Institute of Innovative Technology for the Earth
Pascal Da Costa
Laboratoire Genie Industriel, CentraleSupélec, Université Paris-Saclay

Distributed Generation in Brazil: Assessing the Institutional and Market Design Barriers Preventing Renewables Small-scale Generation Deployment
Clarice C Ferraz
Professor, Federal University of Rio de Janeiro

16. Energy Access
(Melati: 4003)

Mattia Baldini, *Presiding*
Technical University of Denmark

China's Energy Efficiency: Re-estimation Incorporating Human Capital and the Analysis of Its Distribution Dynamics
Lingdi Zhao
Jian Feng
Ocean University of China

Capacity Subscription Mechanism for Community Microgrids
Emi Gui
UNSW

Mapping Residential Thermal Comfort Gap at Very High Resolution Spatial Scale: Implications for Energy Efficiency Policy Design
Joao P Gouveia
Pedro Palma Júlia
Seixas Sofia
Simoes
CENSE, FCT/NOVA University

Can the U.S. Keep the PACE? A Natural Experiment in Accelerating the Growth of Solar Electricity
Nadia Ameli
UCL
Mauro Pisu
OECD
Daniel M Kammen
UC Berkeley

17. Energy Security Issues (Melati: 4004)

C Philip Andrews Speed, *Presiding*
Principal Fellow
Energy Studies Institute

How Costly is China's Oil Import? Welfare Loss Estimation of Foreign Oil Dependence 2001–2015
Zhan-Ming Chen
Shipei Zeng
Xiaohua Xia
Renmin University of China
Leo Lester
Lantou Group
Lin-Ting Zhang
University of British Columbia

Computation and Analysis on Taiwan Index of Energy Security Risk
Hui-Wen Huang
Fu-Kuang Ko
Chia-Yu Han
Institute of Nuclear Energy Research

Assessing The Economic Implication Of Energy Insecurity In Nigeria
Susan SAF Fubara
Israel Onyije
Omowunmi Iledare
Emerald Energy Institute

Multinational Oil Companies and Energy Security in The Emerging Economies
Yayan Satyakti
Department Of Economics University of Padjadjaran

18. Uncertainty in Power Markets (Melati: 4102)

Pierre O. Pineau, *Presiding*
Professor
HEC Montreal

The Spatial Analysis of Wind Generation on Nodal Prices: Evidence from New Zealand
Le Wen
Basil Sharp
Energy Centre, Business School, University of Auckland

Impact of Wind Farms Aggregation on Large System Scheduling Cost under Frequency Linked Deviation Settlement Mechanism
Parul Mathuria
Anoop Singh
Department of Industrial and Management Engineering, Indian Institute of Technology Kanpur

Impact of Geographical Diversification of Wind Plants on Generation Adequacy – A German Case Study
Michael Bucksteeg
University of Duisburg-Essen

Inefficiencies in Zonal Market Coupling Due to Uncertainties in Generation Shift Keys
Björn Felten
Christoph Weber
Tim Felling
University of Duisburg-Essen

Expansion Governance Simulation for the Northern Seas Offshore Grid
Joao Gorenstein Dedecca
Rudi Hakvoort
Paulien Herder
Delft University of Technology
Andres Ramos
Sara Lumbreras
Universidad Pontificia Comillas

19. Analysis of Climate Change Mitigation Options (Melati: 4103)

Machiel Mulder, *Presiding*
Professor
University of Groningen

Global Climate Change Mitigation: Roel of BECCS
Gabrial Anandarajah
Olivier Dessens
UCL Energy Institute

The Global Impact of International Trade on Embodied Carbon Emission: Evidence from An Input-Output Analysis
Meicong Liang
Xin Wang
Fei Teng
Tsinghua University

Input-Output and Structural Decomposition Analy-sis of Singapore's Carbon Emissions
Bin Su
Energy Studies Institute, National University of Singapore

Structural Path Analysis Applied to India's Carbon Emissions
Yingzhu
Li Bin Su
Energy Studies Institute, National University of Singapore
Shyamasree Dasgupta
Indian Institute of Technology Mandi

20. Perspectives on Emission Trading (Melati: 4104)

Christian von Hirschhausen, *Presiding*
Professor
TU Berlin

The Importance of Consumption-based Accounting in a Potential Trade-Carbon Emissions Nexus Literature
Brantley Liddle
Energy Studies Institute, National University Singapore

Understanding the Fairness of Countries' INDCs Under the Paris Agreement Goals
Xunzhang Pan
Academy of Chinese Energy Strategy, China University of Petroleum-Beijing
Lining Wang
CNPC Economics & Technology Research Institute

A New Perspective on Global Carbon Emission Inequality: Insights from Global Interpersonal Carbon Gini-Index
Wang Tianpeng
Gao Haidi Teng
Fei
Song Shuangshuang
Tsinghua University

Mute Carbon Price? How to Restore Economic Incentives in Emission Trading
Vera Zipperer
Karsten Neuhoff
DIW Berlin
Misato Sato
Grantham Research Institute on Climate Change and the Environment LSE

CONCURRENT SESSIONS 21 - 30 Tuesday 20 June, 11:00 a.m. - 12:30 p.m.

21. Energy Storage (Orchid: 4201AB-3 & 4301AB-3)

Olayinka Williams, *Presiding*
Business School
Imperial College

Economic Case for Battery Energy Storage Systems (BESS) for Frequency Regulation in Singapore
Gautam Jindal
Energy Studies Institute, National University of Singapore

Intermittent Electricity Generation and Storage in the Reunion Island: A long-term Economic Analysis Using a Detailed Power System TIMES Model.
Ricardo Delgado
Angela Cadena
Universidad de los Andes
Stéphane Tchung-Ming
European Commission

Cost Mechanism for Deploying Energy Storage in the Smart Grid Environment
Wooyoung Jeon
Chonnam National University

Steering the Adoption of Battery Storage Through Electricity Tariff Design
Kevin Milis
Steven Van Passel
Herbert Peremans
Unversity of Antwerp

Electricity Storage, Emissions Taxes and the Dynamic Value of Variable Renewable Energy
Miguel A Castro
Agricultural Food and Resource Economics. Michigan State University

22. Liberalized Power Markets (Orchid: 4211-2 & 4311-2)

Ricardo Raineri Bernain, *Presiding*
Professor
Pontificia Univ Catolica de Chile

Too Big to Fail in the Electricity Sector
Sebastian Osorio
Ann van Ackere
HEC Lausanne – University of Lausanne
Erik R Larsen
Aarhus University

Deregulation and Utility Innovation: The Case of Japanese Electric Sector
Nan Wang
Research Institute of Innovation Technology for the Earth (RITE)
Gento Mogi
University of Tokyo

Regulatory Reform in the Japanese Electricity Industry: An Event Study Analysis
Koichiro Tezuka
Nihon University
Masahiro Ishii
Sophia University
Satoru Hashimoto
Teikyo University

Electricity Market Liberalization and Institutional Arrangement : An Agent-Based Model of Singapore and Nigeria
Saheed L Bello
CPEEL/University of Ibadan

Will the Liberalized Market be Sufficiently Competitive?
Richard L Hochstetler
Insitituto Acende Brasil

23. Energy Outlook: Asia (Orchid: 4206 & 4306)

Yukari Yamashita, *Presiding*
Board Member Director
Institute of Energy Economics

Energy Outlook and Energy Saving Potential in East Asia Region
Phoumin Han
Energy Economist, Economic Research Institute for ASEAN and East Asia (ERIA)

The Impact of International Oil Price on Asian Natural Gas Premium Based on Dynamic Autoregressive Model
Xinlei Yang
Liwen Ning
Xiucheng Dong
China University of Petroleum

Understanding the Value of Gas Infrastructure in Supporting Southeast Asia's Mid-Merit Power Sector
Mike Thomas
Liutong Zhang
Leo Lester
The Lantau Group

Appropriate Electricity Modeling Approaches for Emerging Economies: The Case of Laos and Kenya
Nkiruka I Avila
University of California, Berkeley

24. Support for Expanding Renewables (Melati: 4001AB & 4101AB)

Iain MacGill, *Presiding*
Associate Professor
University of NSW

A Comparative Analysis on Three Different Supporting Methods to Expand Renewable Energies in Japan
Yoshiki Ogawa
Professor, Toyo University

Activity Patterns in the Australian Green Certificate Market
Regina Betz
Zurich University of Applied Sciences
Iain MacGill
CEEM / UNSW Australia
Beatrice Petrovich
University of St. Gallen
Johanna Cludius
ZHAW/ EPAG

Willingness to Pay for Green Electricity Based on Contingent Valuation Method: Case Study of Tianjin, China
Bai-Chen Xie
Li-Qiu Liu Wei
Zhao
Tianjin University

Development Pathways for Green Bonds: A Comparative Case Study
Jacqueline Tao
Melissa Low
Energy Studies Institute, National University of Singapore

25. Natural Gas: Pricing and Prospects (Melati: 4002)

Peter Hartley, *Presiding*
Mitchell Professor of Economics
Rice University

Prospects for Renewable Energy Developments and Role of Natural Gas
Hamdani Sid Ahmed
GECF

The Economics of Rate-of-return Regulation in the Natural Gas Pipeline Industry
Olivier Massol
IFP School
Florian Perrotton
IFP Énergies Nouvelles

What Drives Natural Gas Pricing? A Cross Country Study
Dayong Zhang
Min Shi
Southwestern University of Finance and Economics
Xunpeng Shi
University of Technology Sydney

The Actual Impact of Shale Gas Revolution on the U.S. Manufacturing Sector
Yassine Kirat
University of Paris 1, Paris School of Economics

A Real Option Model for Investment Strategy on Underground Gas Storage Facilities Considering Market Reform in China
Zhang Qi
Chen Siyuan
Wang Ge
Li Yan
China University of Petroleum, Beijing

26. Energy Efficiency Policies (Melati: 4003)

Inga Konstantinaviciute, *Presiding*
Sr Research Associate
Lithuanian Energy Institute

Energy Efficiency Policy: A Review of Instruments and Potential Interaction Effects
Catharina Wiese
Lise-Lotte Pade
Technical University of Denmark
Anders Larsen
Roskilde University

Designing Better Energy Efficiency Policies: A Science of Improvement Perspective
Kah Hin Chai
Yuli Samantha
National University of Singapore

Reluctance to Adopt Energy Efficiency Renovation in Chinese Households – A Behavioural Perspective
Jiefang Ma
Kun Song
Tianjin University
Henk J Visscher
Queena K Qian
Delft University of Technology

Consistent Cost Curves for Identification of Optimal Energy Savings
Henrik Klinge Jacobsen
Mattia Baldini
Technical University of Denmark

27. Energy Modelling: Methodologies (Melati: 4004)

Su Bin, *Presiding*
Energy Studies Institute NUS

Creation of an Electricity Satellite Account Abstract
Kevin Connolly
Stuart McIntyre
Grant Allan
University of Strathclyde

Dynamic Demand Functions and Underlying Demand Trends: A Horse Race Between Rolling Regression and Structural Time Series Models
David Broadstock
Hong Kong Polytechnic University
Dong Wang
Xiaoqi Chen
Southwestern University of Finance & Economics, China

Gaining Better Insights in Respect to Energy Transition Processes - The Concept of Context Scenarios
Witold-Roger Poganietz
Karlsruhe Institute of Technology (KIT)

28. Experiences with Emission Trading Systems (Melati: 4102)

Hari M P Variam, *Presiding*
Research Associate
ESI NUS

The Impact of the EU Emissions Trading Scheme (EU ETS) on Firms' Performance and Energy Efficiency
Georgia Makridou Kostas
Andriosopoulos
ESCP Europe Business School
Iordanis Kalaitzoglou
Audencia Business School
Michael Doumpos
Spiros Papaefthimiou
Technical University of Crete

The Behaviour-price Dynamics in the EU ETS
Yinpeng Liu
Jianfeng Guo
Chinese Academy of Sciences
Ying Fan
Beihang University
Jiqiang Wang
Tianjin University

Explore Financial Innovation for Linkage EU ETS and China ETSand China ETS
Lan Wang
Xi Liang
University of Edinburgh

Assessment of Carbon Leakage Through Channels: The Hubei Pilot ETS Perspective
Xiujie Tan
Jingbo Cui
Wuhan University
Yu Liu
Chinese Academy of Sciences
Bin Su
Energy Studies Institute

29. Energy Security and the Environment (Melati: 4103)

Anne Neumann, *Presiding*
Chair for Economic Policy
Universitat Potsdam

Peer Review on Energy Efficiency in the Philippines: A Follow-up
Elvira T Gelindon
Asia Pacific Energy Research Centre
Naomi Wynn
Department of Industry Australia

The Opportunity Cost of Climate Mitigation Policy by Promoting Renewable Power Generation in the Philippines
Angga Pradesha
International Food Policy Research Institute
Sherman Robinson
Rowena
Valmonte-Santos Alam
Mondal
Mark Rosegrant
IFPRI

Evaluation of Market Liberalization in Developing Countries in the Case of the ASEAN and the Philippines in Particular
Koji Jaeger
Yuk Li
Stefan Scharl
Aaron Praktiknjo
RWTH Aachen University

Choosing the Green Energy Option: Willingness to Pay of Metro Manila Residents for Solar Energy
Paolo R. Magnata
Ateneo de Manila University

30. Market-based Prices and Renewables (Melati: 4104)

Paul Burke, *Presiding*
Australian National University

Derivatives as a Commitment Device : on the Use of Swaps in Electricity Markets
Chloe Le Coq
Stockholm School of Economics (SITE)
Sebastian Schwenen
Technische Univ. Munchen & DIW

Adequacy of Renewable Energy Policies: A Preliminary Assessment
Muyi Yang
Suwin Sandu
Deepak Sharma
Centre for Energy Policy, University of Technology Sydney

The Interaction Effect of Bidding Mechanism and Renewable Portfolio Standards on Renewable Energy Projects
Zhang Qi
Wang Ge
Li Yan
Chen Siyuan
China University of Petroleum, Beijing

Carbon Pass-through Rates on Spot Prices in Australian Electricity Markets
Fatemeh Nazifi
Stefan Trück
Macquarie University

CONCURRENT SESSIONS 31 - 40 Tuesday 20 June, 4:00 p.m. - 5:30 p.m.

31. Restructuring Energy Markets: International Experience (Orchid: 4201AB-3 & 4301AB-3)

Brantley Liddle, *Presiding*
Senior Fellow
Energy Studies Institute NUS

The Impact of Electricity on Economic Development: A Macroeconomic Perspective
David I Stern
Paul J Burke
The Australian National University
Stephan B Bruns
University of Göttingen

Electricity Subsidy Reform in Indonesia: Demand-Side Effects on Electricity Use
Paul J Burke Sandra
Kurniawati
Australian National University

Electricity Sector Reform and The Impact of Demand Side Management in Sri Lanka
Minoli D Amarasinghe
John Foster
Colin Brown
The University of Queensland
Liam Wagner
Griffith University

Technology Choices in the U.S. Electricity Industry Before and After Market Restructuring
Zsuzsanna Csereklyei
David I Stern
Australian National University

32. Power Grid Flexibility (Orchid: 4211-2 & 4311-2)

Lars Bergman, *Presiding*
Former President and Professor
Stockholm School of Economics

The Impact of the Publication of Unplanned Power Plant Non-usabilities on Intraday Electricity Erices: Empirical Evidence for Germany and Austria
Niyaz Valitov
University of Wuppertal
Andreas Maier
QUADRA Energy GmbH

Efficiently Coordinating Grid Flexibility - Via Energy Markets or Network Charges
Christine Brandstätt
Jacobs University Bremen

Situation Depending Dimensioning of Balancing Reserves in Interconnected Transmission Networks
Jens D. Sprey
Albert Moser Patrick
Schultheis
Institute for Power Systems and Power Economics (IAEW), RWTH Aachen University

Proactive Network Planning in Medium Voltage Level
Marius Sieberichs
Albert Moser Jens
Sprey
Institute for Power Systems and Power Economics (IAEW), RWTH Aachen University

Techno-economic Analysis of Reactive Power Provision in Decentralizing Energy Systems
Fabian Hinz
Dominik Möst
Chair of Energy Economic, TU Dresden

33. Energy and Water
(Orchid: 4206 & 4306)

Emmanuel Falobi, *Presiding*
CEO
PetroKnowledge Energy Consulting

Water Transfer Through Interprovincial Trade within China: From the Perspective of Value Chain
Xi Liu Zengkai
Zhang Guozhu
Mao Huibin Du
Tianjin University
Juan Moreno-Cruz
John Crittenden
Georgia Institute of Technology

Regional Electricity and Renewable Integration: Benefits of Hydropower Reservoirs
Pierre-Olivier Pineau
Sebastien Debia
Leonard Langlois
Sylvain Perron
HEC Montreal

Backing Out Expectations from Hydropower Release Time Series
Stein-Erik Fleten
Alois Pichler
Maren Boger
Einar M Vestbøstad
Norwegian University of Science and Technology
Jussi Keppo
NUS Business School

34. Business Opportunities in the Power Sector
(Melati: 4001AB & 4101AB)

Yujia Jacqueline Tao, *Presiding*
Research Associate
University of Singapore

Improving the Business Case for Consumer-level Energy Storage in the UK
Giorgio Castagneto Gissey
UCL Energy Institute, University College London

The Economics of Prosumage: Quantification of Business Opportunities in Germany, California, Australia, India, and South Africa
Charlotte Rochell
Ralf Ott
Maximilian Eissler
Philipp Zorn
TU Berlin
Clemens Gerbaulet
TU Berlin and DIW Berlin

The Welfare Effects of Strategic Storage Use in Deregulated Energy Markets
Olayinka o Williams
Richard J Green
Imperial College Business School

35. Fossil Fuels and Emission Abatement
(Melati: 4002)

Alberto Lamadrid, *Presiding*
Assistant Professor
Lehigh University

Optimal Timing of Phasing out Fossil Fuel Producer Subsidies
Xu Zhao
China University of Petroleum, Beijing

Total-factor Energy Efficiency with CO2 Emission: A Study Based on Pollution Generation and Abatement Process
Fei Wu
Dequn Zhou
Peng Zhou
Nanjing University of Aeronautics and Astronautics

The Effects of Energy Related Environmental Regulation on Exporters' Exiting Behavior: The Evidence from China
Dongmei Tu
Shaoxin
Wang Yao Li
University of Electronic Science and Technology of China

International Coal and Renewables Financing and Climate Change
Han Chen
Natural Resources Defense Council

36. Promoting Emission Reduction
(Melati: 4003)

Valerie Karplus, *Presiding*
Asst Prof MIT Sloan School of Mgt
Dir MIT Tsinghua China Energy

Exploring the Changes of Industrial CO2 Intensity in China: An Integrated Decomposition Approach
Qunwei Wang
Nanjing University of Aeronautics and Astronautics
Hang Ye
Soochow University

How to Promote Green Purchase: A Behaviour Experiment Analysis Based on Game Theory
Jing Wei Jia
Wan Zou Li
Xiao Zhao
China University of Petroleum (Beijing)

An Interprovincial Cooperative Game Model for Power-saving and Carbon-reducing in China
Zeng Lijun
Zhao Laijun
Shanghai Jiaotong University

Does the Co-existence of Carbon Emission Trading and White Certificate Make Sense? The Case of China
Lei Zhu
Beihang University

37. Energy Modelling of Emission Reduction Pathways
(Melati: 4004)

Albert Hiesl, *Presiding*
Student
Vienna University of Technology

How Can We Meet the Paris Agreement Target? - An Integrated Modelling Approach
Koji Tokimatsu
Tokyo Institute of Technology
Masahiro Nishio
National Institute of Advanced Industrial Science and Technology
Rieko Yasuoka
Systems Research Center, Co. Ltd

Modeling a Global Energy System based on 100% Renewables
Konstantin Löffler
Pao-Yu Oei
DIW Berlin / TU Berlin
Karlo Hainsch
Thorsten Burandt
TU Berlin

Decarbonizing the Indian Energy System until 2050
Karlo Hainsch
Thorsten Burandt
Konstantin Löffler
TU Berlin
Christian von Hirschhausen
Pao-Yu Oei
TU Berlin, DIW Berlin

Taiwan's Economic Responses to Different Carbon Trajectories of China and Taiwan
Shih-Mo Lin
Kuei-Feng Chang
Jin-Xu Lin
Chung Yuan Christian University
Yen-Heng Chen
Massuchusas Institute of Technology

Long-Term Decarbonisation Energy Pathways for Malaysia Using a Hybrid Demand-Supply Model
Kumar Maragatham
University College London
Strachan Neil
UCL Energy Institute

38. Mitigating Carbon Emissions fron Coal
(Melati: 4102)

Casimir Lorenz, *Presiding*
Student
TU Berlin

Two Scenarios for Carboncapture and Storage in Vietnam
Minh Ha-Duong
CIRED, CNRS
Hoang Anh Trinh Nguyen
USTH

Mitigating Carbon Lavishness by Multiple Carbon Re-Use
Stefan Petters
Carbotopia Syndicate
Kalvin Tse Klaus
Mauthner
Carbotopia Team Member

Rethinking the Way to Decarbonize the Energy System: Prospective Study of Hydrogen Markets Attractiveness
Olfa Tlili
Yannick Perez
RITM, University Paris-Sud and Laboratoire Génie Industriel, CentraleSupélec, Université Paris-Saclay
Claude Heller
Jean André
Air Liquide R&D
Camille Cany
Christine Mansilla
Alain Le Digou
I-tésé, CEA, Université Paris Saclay

A Global Coal-Phase-Out and the International Coal Market: A Focus on Demand-side and Supply-side Policies in China and India
Roman Mendelevitch
Humboldt-Universität zu Berlin
Franziska Holz
DIW Berlin
Pao-Yu Oei
Casimir Lorenz
TU Berlin / DIW Berlin

Analyzing the Consequences of a Shifting Steam Coal Demand to Asia: Insights from the World Steam Coal Market Model COALMOD
Ivo Valentin Kafemann
Franziska Holz
Tim Scherwath
German Institute for Economic Research (DIW)
Roman Mendelevitch
Humboldt-Universität zu Berlin

39. Oil Prices (Melati: 4103)

Fabian Moisl, *Presiding*
Vienna University of Technology

The Impact of Fluctuation of US Dollar Index on Crude Oil Prices: Fast Fourier Transform Approach
Lin Li
Jinhua Cheng
Feng Zeng
Wenqi Zhu
China University of Geosciences (Wuhan)

Buffer vs. Speculation: A Review on the Role of Crude Oil Inventory
Soohyeon Kim
Eunnyeong Heo
Seoul National University

Actual or Numerical? A Discussion on Crude Oil Prices and Exports
Zhu Wenqi Zhu
Yongguang Xu
Deyi Cheng
Jinhua Hu Peiqi

Li Lin
China University of Geosciences

The Effect of Speculation in Futures Market on Oil Price
Chih-Chun Liu
CTCI Foundation
Liang Chi-*Yuan*
National Central University

40. Transportation Pollution Issues (Melati: 4104)

Jerome Dumortier, *Presiding*
Assistant Professor
IUPUI

Effectiveness and Equity Comparison of Personal Carbon Trading and Carbon Tax in Private Transport: Based on Driving Decision Model and Case Study in China
Lele Zou
Yingzi Wang
Chinese Academy of Sciences

Effects of Container Ship Speed on Supply Chains' CO2 Emission
Nguyen Khoi Tran
Jasmine Siu Lee Lam
Nanyang Technological Univeristy

What Drives the Decrease in Average CO2 Emissions from New Passenger Cars in Finland or is it all Just Scam?
Xun Zhou
Timo Kuosmanen
Aalto University School of Business

CONCURRENT SESSIONS 41 - 50 Wednesday 21 June, 9:00 a.m. - 10:30 a.m.

41. LNG Markets and Trade (Orchid: 4201AB-3 & 4301AB-3)

James Smith, *Presiding*
Professor of Finance
Southern Methodist University

Integrated Gas-to-Liquefied Natural Gas Projects: Government Revenues in Australia and Industry Concerns
Diane Kraal
Senior Lecturer, Monash University

Natural Gas Transits and Market Power - The Case of Turkey
Florian Weiser
Simon Schulte
ewi Energy Research & Scenarios gGmbH

A Reference Framework for Formulating Gas Hub Prices: A Case Study of East Asia
Xunpeng Shi
UTS
Hari Mp
Energy Studies Institute, NUS

Comparative Study of the Evolution of Natural Gas Spot Prices in Asia and North America
Hari Malamakkavu Padinjare
Variam Allan Tian Sheng Loi
Energy Studies Institute

LNG Tipping Points in the GMT+8 Time Zone
Mark Stickells
Andrew Pickford
University of Western Australia

42. Solar Energy (Orchid: 4211-2 & 4311-2)

Gautam Jindal, *Presiding*
Research Associate
ESI NUS

A Systemic Approach to Evaluate PV Economics and PV Policy Strategies
Hyun Jin Julie Yu
CEA Saclay/DAS/ I-tese

Prospects of Solar CSP Integration in the Oil & Gas Industry in the Middle East for Process Heating
Saqib Sajjad
Energy Efficiency Section Head, Abu Dhabi Gas Industries Ltd.

Modelling Potential Sites for Solar PV Plants in Northwest Nigeria Using Geoinformation Tools
Saheed A Raji
Federal University of Petroleum Resources

The Impacts of Photovoltaic Electricity Self-consumption on Value Transfers Between Private and Public Stakeholders in France
Jonathan Richard Ludovic Roulot
Ecole Centrale de Nantes and Pontificia Universidad Católica de Chile
Ricardo Raineri Bernain
Pontificia Universidad Católica de Chile

The Opportunity of Local Network Credits for Households with PV Systems and Efficient Air Conditioner Equipment
Sebastian Oliva H.
Doctor, Energy Centre, University of Chile

43. Urbanisation and Energy (Orchid: 4206 & 4306)

Jiefang Ma, *Presiding*
Tianjin University

Residential Electricity Consumption and Time-use Measured Lifestyle: Quantifying the Impacts of Urbanization in China
Pui Ting Wong
Yuan Xu
The Chinese University of Hong Kong

Effects of China's Urban Form on Urban Energy Consumption
Caiyun Bian
Qi Zhang Lu
Lin
Academy of Chinese Energy Strategy, China University of Petroleum-Beijing

The Relationship Between Urban Characteristics and Transport Expenditures of Chinese Households
Paul N Kishimoto
Massachusetts Institute of Technology

Urban Agglomeration Economies and Industrial Energy Efficiency: An Empirical Analysis Based on Dynamic Spatial Durbin Model
Feng Han
Institute of Politics and Economics, Nanjing Audit University
Jiayu Fang
Rui Xie
School of Economics and Trade, Hunan University

44. Evolving Gas Markets (Melati: 4001AB & 4101AB)

Anne Sophie Corbeau, *Presiding*
KAPSARC

Arguments For and Against LNG as a Base for Russian Gas Exports to Asia
William K P Kucera
Centre for Energy, Petroleum and Mineral Law and Policy, University of Dundee

A Strategy of LNG Exporting Countries for Trading in the Northeast Asian Region: Price Competition, Leadership or Collusion?
Gobong Choi
Eunnyeong Heo
Seoul National University

Long-term Gas Contracts Evolution in the Changing Industry Environment
Shohrat Niyazmuradov
Eunnyeong Heo
Seoul National University

NUMBYISM: Public Risk Perception and Attitude Toward Shale Gas Development-evidence from China
Tan Huimin
Southwestern University of Finance and Economics
Gabrielle Wong-Parodi
Carnegie Mellon University
Xu Jianhua
Peking University

LNG Consumption: Prospects of World and Asian Demand in the Face of Nuclear Energy Evolution
William Clavijo
Renato Queiroz
Edmar Almeida
Federal University of Rio de Janeiro
Niagara Rodrigues
Federal Fluminense University

45. Perspectives on Nuclear Power (Melati: 4002)

Michel Berthelemy, *Presiding*
Economist
CEA

Fostering Nuclear Safety Through Local Monitoring: Evidence from Incident Data in the French Fleet
Romain Bizet
Petyo Bonev
François Lévêque
Mines ParisTech

Would there be a Clear Winner Between Renewables and Nuclear Energy in the Climate Debate?
Victor Nian
Research Fellow, Energy Studies Institute, National University of Singapore

Scenarios for Decarbonizing the European Electricity Sector without Nuclear Power
Clemens Gerbaulet
Casimir Lorenz
Christian von Hirschhausen
Pao-Yu Oei
TU Berlin and DIW Berlin
Claudia Kemfert
DIW Berlin

Decommissioning of Nuclear Power Plants and Storage of Nuclear Waste in Western Europe and the U.S. - Lessons Learned and Perspectives for Asian Nuclear Countries
Ben Wealer
Christian von Hirschhausen Jan
Paul Seidel
Berlin Institute of Technology

46. Energy Emission Reduction Initiatives in China (Melati: 4003)

Lixia Yao, *Presiding*
Research Fellow
ESI NUS

Transition Pathway Towards China's Low-carbon Energy Economy
Yuyan Weng
Xiliang Zhang
Tsinghua University
Tianyu Qi
The Boston Consulting Group

The Impact of Stricter Standards on CO2 Emission Across Industries
Zhizhan Duan
Chuang Xu
Dongwen Tian
Beihang Univerisity

Research on the Effect of Export Tax Rebate Rate Adjustment on Industrial Emission in China
Shengling Bai
Chaofan Yang
Beihang University

Estimation on Costs and Potentials of Carbon Emission Reduction of Beijing- A Modified Multi-Objective Programming Approach
Yigang Wei
Beihang University
Yan Li
Shandong Normal University

47. Impacts on Households of Decarbonization (Melati: 4004)

Lei Zhu, *Presiding*
Associate Professor
China/BUAA

Minimising Customer Bill Increases in a Decarbonising and Decentralising Electricity System
Paul W Graham
Thomas Brinsmead
CSIRO

Persistence of the Effects of Providing Feedback Alongside Smart Metering Devices on Household Electricity Demand
Joachim Schleich
Corinne Faure
Grenoble Ecole de Management
Marian Klobasa
Fraunhofer ISI

Leveraging Customer Perceived Value within Transformation of Electric Utilities: The Case of New Brunswick
Tugcan Sahin Yuri
Yevdokimov
Dhirendra Shukla
Viktor Getalo Chris
Diduch
University of New Brunswick

Energy-Intensive Adaptation to Particulate Matter Pollution: The Case of Electricity Consumption by Korean Households
Euikon Jeong
Jiyong Eom
Jaewoong Lee
KAIST College of Business

How Real Time Pricing Modifies Chinese Households' Electricity Consumption?
Hongxia Wang
Xueying Yu
Hong Fang
Beihang University

48. Carbon Pricing in China (Melati: 4102)

Yingzhu Li, *Presiding*
Research Fellow
Energy Studies Institute NUS

Social Awareness And Household Carbon Emission In China
Li Jun
Zhang Da Yong
Southwestern University of Finance and Economics

Interaction Between Electricity Market Reform and Carbon Pricing: Insights from a Strengthened Scrutiny for Carbon Leakage in China
Xin Wang
Meicong Liang
Fangyuan Qian
Fei Teng
Tsinghua University

Pricing Carbon and China's Industrial Energy Consumption: Exploring the Sectoral Heterogeneity
Banban Wang
Jie Wei
School of Economics, Huazhong University of Science and Technology

The Environmental Potentials of China`s Electricity Reform
Yang Yu
Stanford University
Jianxiao Wang
Tsinghua University

Dynamic Development of Regional Social Economy-Energy-Environment in China
Fang Hong
Li Jing
Beihang University

49. Oil Infrastructure
(Melati: 4103)

John Jimison, *Presiding*
Senior Advisor
Energy Future Coalition

Technical and Economic Viability of Producing Marginal Oil Fields In The Niger-Delta Using Water Injection
Rita U Onolemhemhen
Sunday O Isehunwa
Akin P Iwayemi
Adeola F Adenikinju
CPEEL, University of Ibadan

The Relationship Between US Rig Count and BRENT WTI Spread
Huei-Chu R Liao
TamKang University
Shu-Chuan Lin
Chinese Petroleum Corporation

Enhanced Oil Recovery as a Stepping Stone to Carbon Capture and Sequestration
Dana M Abdulbaqi
Mohammed AlShaikh
Saudi Aramco
Carol Dahl
Colorado School of Mines and Luleo Technical University

Investment Management of Petroleum Fund on Exploration and EIOR Activities in Indonesia
Christine L Wowor
Institute of Technology Bandung
Luky A Yusgiantoro
Atma Jaya Catholic University
Wahyusaputro S Bernardus

Economic Implications of Oil and Gas Supply Infrastructure Disruption in Nigeria
Onuoha I Nnachi
Omowumi J Iledare
Israel J Onyije
Emerald Energy Institute, University of Port Harcourt

50. Power Market Reform around the World
(Melati: 4104)

Bruce Mountain, *Presiding*
Director
Carbon Market Economics

Market Power and Policy in Deregulated Electricity Market with Penetration of Renewable Energy in China
Dequn Zhou
Peng Zhou
Zhaotian Chong
College of Economic and Management, Nanjing University of Aeronautics and Astronautics

Avoiding Pitfalls in China's Electricity Reforms
Michael Davidson
Ignacio Pérez-Arriaga
Massachusetts Institute of Technology

An Empirical Study of Capacity Remuneration in Electricity Markets: Impact on Power Industrial Prices
Charlotte Scouflaire
Université Paris Dauphine

Agent-Based Analysis of Cross-Border Effects for Switzerland by Introducing a Decentralized Capacity Market in France and a Strategic Reserve in Germany
Florian Zimmermann
Wolf Fichtner Dogan
Keles
Chair of Energy Economics at Karlsruhe Institute of Technology (KIT)

Understanding the Response to Disruptions in the Electricity System
Alberto J. Lamadrid
Assistant Professor, Lehigh University

CONCURRENT SESSIONS 51 - 60 Wednesday 21 June, 11:00 a.m. - 12:30 p.m.

51. The Political Economy of Oil Supply
(Orchid: 4201AB-3 & 4301AB-3)

Aaron Praktiknjo, *Presiding*
Assistant Professor
RWTH Aachen University

Enhancing Sustainable Development from Oil, Gas, Mining: From an 'All of Government' Approach to Partnerships for Development
Kathryn M McPhail
Independent Adviser, Volta Associates

Balancing Upstream Investment Performance and Government Take: Empirical Evidence of the Mechanics and Impact of Petroleum Fiscal Terms
Oyebimpe Adeogun
Omowumi O Iledare
Emerald Energy Institute, University of Port Harcourt

A Network Game Theoretic Approach for Northeast Asian Pipeline Options
Hanee Ryu
Hanyang University

Assessment of Oil Supply Risk: The Case of South Asia
Mohsin Muhammad
Peng Zhou
University of Aeronautics and Astronautics

52. The Growth of Solar Power
(Orchid: 4211-2 & 4311-2)

Jonathan Roulot, *Presiding*
Ecole Centrale Nantes

The Price-Concentration Relationship in Early Residential Solar Third Party Markets
Jacquelyn Pless
University of Oxford
Ria Langheim
Center for Sustainable Energy
Ben Sigrin
National Renewable Energy Laboratory

Solar Securitization: Challenges, Financial Arrangements and Policy Implications
Jacqueline Yujia Tao
Yujie Lu
Anton Finenko
Rubenrajoo S Rengarajoo
National University of Singapore

Sharing Decentralized Photovoltaic Systems: Technical and Economical Effects of Collaboration Concepts
Albert Hiesl
Reinhard Haas
Michael Hartner
TU Wien, EEG

53. Modelling Electricity Demand
(Orchid: 4206 & 4306)

David Broadstock, *Presiding*
Deputy Director CESEF
Hong Kong Polytechnic University

The Social Value Of Demand Response and its Integration in Capacity Mechanisms
Xavier Lambin
TSE -- ENGIE

Long-term Forecast of Industrial Electricity Demand. A DSO Vision: Scale Really Matters!
Mathieu Bordigoni
Enedis

Modeling Demand-Price Curve: A Clustering Approach to Derive Dynamic Elasticity for Demand Response Programs
Ioannis p Panapakidis
Technological Educational Institute of Thessaly
Athanasios S Dagoumas
University of Piraeus

Estimating the Resource Adequacy Value of Demand Response in the German Energy-only Market
Hamid Aghaie
AIT Austrian Institute of Technology

German Continuous Intraday Market: Orders Book's Behavior Over the Trading Session
Clara Balardy
EPEX Spot/ Université Paris-Dauphine

54. International Dimensions of Climate Change Policies
(Melati: 4001AB & 4101AB)

Regina Betz, *Presiding*
Zurich Univ of Applied Sciences

Welfare Implications of EU Effort Sharing Decision and Possible Impact of a Hard Brexit
Marc Vielle
EPFL (LEURE)
Frédéric Babonneau
EPFL-ORDECYSY
Alain Haurie
ORDECSYS

Global Climate Change Mitigation: Strategic Interactions or Unilateral Gains?
Sigit Perdana
Rod Tyers
University of Western Australia

Latitudinal Effect on Energy Savings from Daylight Saving Time
Olvar Bergland
Norwegian U of Life Sciences
Faisal M Mirza
University of Gujrat

Trade Sanctions and the Stability of International Environmental Agreements
Jan Schneider
University of Oldenburg
Achim Hagen
Humboldt-Universität zu Berlin

55. Outlook for Transport Fuels (Melati: 4002)

Nguyen Khoi Tran, *Presiding*
Research Fellow
Nanyang Technological University

Does Design Affect Utilization? An Empirical Study of the Market for Offshore Support Vessels
Roar Adland
Alexander Sterud
Morten V. Tvedte
Norwegian School of Economics (NHH)

Information Asymmetry in Quasi Public Good Crowdfunding: A Case From China's EV Charging Pile Market
Li Yan
Zhang Qi
Zhu Lijing
Chen Siyuan
Wang Ge
China University of Petroleum, Beijing

Automotive Fuel Demand in Brazil: Consumer Choice and Asymmetric Response to Price and Income
Luciano D Losekann
Niagara Rodrigues
Universidade Federal Fluminense
Getulio Borges
UFRJ

Modelling Transport Energy Demand and Emissions: Development of a Global Passenger Transport Model Coupled with Computable General Equilibrium Model
Runsen Zhang
Tatsuya Hanaoka
Shinichiro Fujimori
NIES
Hancheng Dai
Peking University

56. Energy and China's Economy (Melati: 4003)

Lei Zhu, *Presiding*
Associate Professor
China/BUAA

Estimating Oil/Natural Gas Trade Competitiveness and Cooperation Potential of Main OROB Countries: Perspective of Industry Chains
Sun Zesheng
Zhejiang University of Science & Technology

The Threshold Effect Analysis of Urbanization and Energy Consumption: A Case Study of 29 Provinces in China
Qi Sun
Li Jiang Feng
Qiao Sheng Wu
Si Yao Li
Jun Shen
Na Zhou
China University of Geosciences (Wuhan)

Energy Depletion, Carbon Damage and Genuine Productivity of China's Provinces: A Multiregional Input–Output Accounting
Yuning Gao
Yufeng Lu
Miao Yu
Angang Hu
Tsinghua University

Effect of Preferential Trade Agreements on Energy Imports from Chinese and Exporters' Perspective
Carlo Andrea Bollino
Univ of Perugia
Phillipp Galkin
Tarek Atalla
KAPSARC

57. Consumer Attitudes towards Energy and the Environment (Melati: 4004)

Paul Graham, *Presiding*
Chief Economist Energy Flagship
CSIRO

The Relevance of Social Reference Points for Energy Saving Behavior: Evidence from a Field Experiment in Singapore
Renate Schubert
ETH Zurich & FRS/SEC Singapore
Jan Schmitz
ETH Zurich
Zhengyi Jiang
FRS/SEC Singapore

Environmental Motivations Behind Individual's Energy Efficiency Investments and Daily Energy Saving Behaviour: Evidence from Germany, the Netherlands and Belgium
Vladimir Udalov
University of Wuppertal
Jens Perret
EIIW
Veronique Vasseur
Maastricht University

Choosing not to Choose: Learnings about Consumers' Preferences and Switching Behaviour of Electricity Contracts for Emerging Economies
Fabian Grabicki
Roland Menges
TU Clausthal

Heterogeneous Preferences and the Individual Change to Alternative Electricity Tariffs
Andreas Ziegler
University of Kassel

58. Energy Efficiency Issues: Asia (Melati: 4102)

Allan Loi, *Presiding*
Energy Analyst
Energy Studies Institute

On the Equivalence of Energy Consumption Efficiency Estimates from Consumer and Producer Based Empirical Perspectives
David Broadstock
The Hong Kong Polytechnic University
Xiaoqi Chen
Southwestern University of Finance & Economics

Scaling Compliance with Coverage? Firm-level Performance in China's Industrial Energy Conservation Program
Valerie J. Karplus
Da Zhang Xingyao
Shen
MIT

Impact of Standards and Labelling Program on Consumer Discount Rate - An Experimental Study in India
Manisha Jain
Anand Rao
Indian Institute of Technology Bombay
Anand Patwardhan
University of Maryland

No Subsidy Like Information: The Effect of Energy Information On Energy Efficiency Behavior
Gloria JinaKim
Jiyong Eom
KAIST College of Business

Household Preference for Electricity Service Plans: the Role of Enabling Technology and Risk Preference
Jaewoong Lee
Jiyong Eom
Soyoung Yoo
KAIST College of Business

59. Modelling Energy Markets (Melati: 4103)

Victor Nian, *Presiding*
Energy Studies Institute
National University of Singapore

Interval Tests for Structural Breaks in the Dependence: Empirical Evidence of Oil and Gold Markets
Qiang Ji
Center for Energy & Environmental Policy Research, Institutes of Science and Development, Chinese Academy of Sciences
Bingyue Liu
Department of Statistics and Finance, University of Science and Technology of China

Does Oil Price Plunge Affect Alternative Energy Growth? Evidence from Dynamic Panel Model
Ishaya T Tambari
University of Portsmouth

Understanding Natural Gas Prices: Bubbles, Oil Indexation and Structural Breaks
Dayong Zhang
Professor, Southwestern University of Finance and Economics

Price Rate Analysis of Gasoline, Ethanol and Sugar Between 2001 and 2015 in Brazil
Igor G Cesca
Virginia Parente
Fernando AS Postali
University of São Paulo

60. Renewable Energy Policies (Melati: 4104)

Fatemeh Nazifi, *Presiding*
Lecturer
Macquarie University

Innovation of Renewable Energy Generation Technologies at a Regional Level in China: A Study Based on Patent Data Analysis
Nan Yu
University of Wuppertal

Impact of the Unbundling on Renewable Electricity: Evidence from Kenya
Le Dong
Akihisa Mori
Kyoto University

Renewable Energy Policy
Chen Wei-Ying
National Chengchi University
Yeh Fang-yu
Science & Technology Policy Research and Information Center

Regional Distribution of Small Scale Photovoltaic Installations in Germany and its Drivers: A Spatial Econometric Approach
Jan Paul Baginski
Christoph Weber
Kevin Kuske
University of Duisburg-Essen

Investment in Energy Efficiency, Adoption of Renewable Energy and Household Behaviour: Evidence from OECD Countries
Prudence Dato
IREGE/ Savoie Mont Blanc University

CONCURRENT SESSIONS 61 - 67
Wednesday 21 June, 2:00 p.m. - 3:30 p.m.

61. APEC Energy Issues (Orchid: 4201AB-3 / 4301AB-3)

Venkatachalam Anbumozhi, *Presiding*
Econ Res Inst for ASEAN

The Evolution of the Energy Security Concept and APEC Energy Cooperation
Irie Kazutomo
General Manager, Asia Pacific Energy Research Centre

Future Perspective of Nuclear Power Development in the APEC Region: A Modelling Study
Hao Jia
Kazutomo Irie
Takashi Otsuki
Asia Pacific Energy Research Centre, IEEJ, Japan

Development of APEC Low-Carbon Town Indicator System
Yuko Tanaka
Kazutomo Irie
Asia Pacific Energy Research Centre, The Institute of Energy Economics, Japan

Potential for Renewable Energies' Application for Heating in the Industrial Sector – A Case Study of Selected APEC Economies
Sichao Kan
Yoshiaki Shibata
The Institute of Energy Economics, Japan
Cecilia Tam Alexey
Kabalinskiy
Asia Pacific Energy Research Center

62. Economic Growth and the Environment (Orchid: 4211-2 / 4311-2)

Ira Drupady, *Presiding*
Research Associate
ESI NUS

Economic Growth and Air Pollution in the Persian Gulf Oil Exporting States
Masao Tsujimoto
Associate Professor, Hiroshima Shudo University

Adaptation Plan for the Energy Sector: Participative Methods for Developing Countries
Santiago Arango-Aramburo
Diana C Ríos-Echeverri Gloria
P Jaramillo-Álvarez
Universidad Nacional de Colombia

Do Energy-environmental Kuznets Curve Hypothesis Sustain in the Asian Region?
Kentaka Aruga
Saitama University

Effects of Economic Greenhouse Gases Emissions on Economic Growth: Evidence from Nigeria and South Africa
Ikechukwu Sebastine Asogwa
Justin C Alugbuo
Charles N Anumudu
Michael Okpara University of Agriculture, Umudike

63. Energy Modelling: Low Carbon Options (Orchid: 4206 & 4306)

Roman Mendelevitch, *Presiding*
Research Associate
Humboldt Universitat zu Berlin

Emissions Trading in a Policy Stew: a Case Study on China's Wind CDM Projects
Yuan Xu
Aitong Li
The Chinese University of Hong Kong
Bing Zhang
Xiuru Zhou
Nanjing University

Clean Development Pathways for India: Evaluating Feasibility and Modeling Impact of Policy Options
Arun Singh Valerie
J Karplus Niven
Winchester
Massachusetts Institute of Technology

Does the Low-carbon Pilot City Program Affect China's Carbon Intensity -A Difference-in-difference Analysis
Du HuiBin
Tianjin University

Interactions Between Market Reform and a Carbon Price in China's Power Sector
Fei Teng
Xin Wang
Tsinghua University
Frank Jotzo
Crawford School of Public Policy, The Australian National University

64. Experience with Emission Trading Policies (Melati: 4001AB & 4101AB)

Melissa Low, *Presiding*
Research Associate
National University of Singapore

Current Status and Issues of the Korean Emission Trading Scheme
Seonghee Kim
Senior researcher, Institute of Energy Economics, Japan

Methodical Guidelines for Preparation of Lithuanian GHG Emissions Projections
Inga Konstantinaviciute
Arvydas Galinis Vaclovas
Miskinis Vidas Lekavicius
Viktorija Bobinaite
Lithuanian Energy Institute

Review of Emission Accounting Models in the Maritime Industry
Yuwei Yin
Nguyen Khoi Tran
Jasmine Siu Lee Lam
Nanyang Technological University

Emission Permits Allocation, Market Power and Cost-effectiveness of ETS - A Theoretical Analysis
Mei Wang
Peng Zhou
Nanjing University of Aeronautics and Astronautics

65. Energy Efficiency in Buildings (Melati: 4002)

Catharina Wiese, *Presiding*
Technical University of Denmark

Consumer's Attitude Towards Investments in Residential Energy Efficient Appliances: How End-user Choices Contribute to Change Future Energy Systems
Mattia Baldini
Jordan Wente
Alessio Trivella
Technical University of Denmark

Social Psychological Determinants for the Adoption of Green Residential Building
Yunxia Liu
Zaisheng Hong
Peng Liu
Tianjin University
Tian Sheng Allan Loi
Energy Studies Institute, National University of Singapore

An Empirical Study of Tokyo Emission Trading Scheme: An Expost Analysis of Emissions from Commercial and University Buildings
Toshi H Arimura
Tatsuya Abe
Waseda University

Cooling Infrastructure for the Commons: Energy-economic Assessment of Neighbourhood-Scale Cooling System in the Tropics
Marcel Bruelisauer
FRS / ETH Zurich
Renate Schubert
ETH Zurich

Potential of Waste Heat and Waste Cold Energy Recovery in Singapore for District Cooling Applications: Impacts on Energy System
Dominik Franjo Dominkovic
Alessandro Romagnoli
Tim Fox
Allan Schrøder Pedersen
Nanyang Technological University

66. Energy Modelling (Melati: 4003)

Muyi Yang, *Presiding*
PostDoc Associate
University of Technology Sydney

Impacts of Supply and Demand Factors During Oil Price Falls
Myung Suk Kim
Sogang University

The Pattern of Inter-fuel Substitution in Energy Intensive Manufacturing Industries in India During 2000-01 – 2011-12
Shyamasree Dasgupta
Prateek Gauba Shivam
Satija
Indian Institute of Technology

Estimating Energy Rationing Costs on General Equilibrium Environment with Compensating Variation
Edson Goncalves
FGV

The Role of Natural Gas in Global Energy Balance for the Period Till 2040
Dmitry Sokolov
Head of Department, EEFD, Gas Exporting Countries Forum (GECF)

67. Industrial Aspects of Energy Use (Melati: 4004)

Nur Azha Putra, *Presiding*
Energy Studies Institute, NUS

Technology Transition or Firms' Relocation? A Multi-country Study of the Steel Industry
Giulia Valacchi
Graduate Institute Geneva

Why do Manufacturing Industries Invest in Energy R&D?
Jose Garcia-Quevedo
Maria-Teresa Costa-Campi
University of Barcelona

Mining Modernity: Energy Limitations and Efficiency Opportunities in Vietnam's Aluminum Industry
Cecilia Springer
University of California, Berkeley

Market Structure and Performance of Downstream Oil Industry: A Case Study of Indian National Oil Companies
Deepak Sharma
Haripriya Gundimeda
Indian Institute of Technology Bombay

附件 **3**

發表論文全文

Computation and Analysis on Taiwan Index of Energy Security Risk

Computation and Analysis on Taiwan Index of Energy Security Risk

by

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Abstract

This study adopted the International Index of Energy Security Risk developed by U.S. Chamber of Commerce (USCC) and the Taiwan's domestic data to complete the localized energy security risk analysis for the past years. The result shows that, since 2012, the overall risk of energy security has declined, mainly due to the recent reduction of global crude oil prices and slowdown in crude oil prices volatility. In addition, Taiwan has been over-concentrated in a particular country for natural gas import in the past years, which induced high risk of exposure of energy import for a specific period of time. The issue has been adequately mitigated by means of increasing the importing countries to enhance diversity and to reduce the risk exposure.

In order to predict the future Taiwan's energy security risks under three proposed scenarios, this study integrates three tools: USCC International Energy Security Risk Index, TIMES Model and GEMEET Model.

The proposed scenarios include: Business As Usual (BAU), Optimistic Scenario and Moderate Scenario. In compliance with the government's carbon reduction policy, for Optimistic Scenario and Moderate Scenario, large scale renewable energy, gas-fired power generation, coal-fired power plants with carbon capture and storage (CCS) are used, ans electricity demand is suppressed. The main differences between the two scenarios are: in Optimistic Scenario, the construction of renewable energy facilities is maximized. However, in Moderate Scenario, it is assumed that sufficient renewable energy facilities cannot be built. As a result, more gas-fired power generation and coal-fired power plants with CCS are used, and more electricity demand is suppressed to achieve the same carbon reduction requirement. Under these scenarios, the carbon dioxide emission continued to decline year by year. In BAU, carbon dioxide emission is not controlled. The fossil fuel power plants are massively used to replace the nuclear power generation. As a result, the scores of CO_2 related risk index of Optimistic Scenario and Moderate Scenario are significantly lower than those of BAU.

However, in Optimistic Scenario and Moderate Scenario, a large amount of fossil fuel is still need to be imported, and the fossil fuel prices will continue to rise. Therefore, the negative impact of importing fossil fuel combined with price rising has offset the positive impact of reducing carbon dioxide emissions. Therefore, for Optimistic Scenario and Moderate Scenario, the overall energy security risks of in 2050 are even higher than that in 2015.

Introduction

Taiwan is lack of self-produced energy. About 98 percent of energy is imported, including coal, natural gas and nuclear power. In recent years, Taiwan governmen proposed a very challenging goal: Intended Nationally Determined Contribution (INDC) and Greenhouse Gas Reduction Act. For this reason, a set of Taiwan index of enrgy security is crucial to indicate the critical poitnts for reaching the goal.

Since this international energy security risk index covers a wide range of aspects, this study uses this tool to conduct a comprehensive localized data to analyze energy security risks in the past. In addition, the energy security risk index, energy model-TIMES and economic model-GEMEET were integrated to predict the energy security risks in 2050. The cases studies include Business As Usual (BAU), Optimistic Scenario, Moderate Scenario.

The Institute of Nuclear Energy (INER) initiated energy model research with MARKAL model in 2006. Ko, F.K. et al. adopted MARKAL model to perform the study of "Taiwan's power sector long-term carbon dioxide emission reduction targets and scenarios" [1]. In 2015, Chen, J. S. et al. combined with the MARKAL model and International Energy Security Risk Index to perform energy security risk analysis [2]. In 2016, in order to improve the fixed time interval issue, INER introduced the TIMES model with the advantages of Time Slice. In 2017, Huang, YC uses the TIMES model to perform "Grid-Level Taiwan Analog Energy Storage System Analysis "[3] study.

The General Equilibrium Model for Energy, Environment and Technology analysis (GEMEET) model used in this paper is developed jointly by INER and Center for Applied Economic Modeling in Chung Yuan Christian University since 2007. The related jointed researches were performed on "Technological Change and the Rate of Feed-in Tariff" (2012) [4] and "Assessing Taiwan's Energy Security under Climate Change" (2015) [5].

Localization of Input Data for Taiwan's Index of Energy Security Risk

In the USCC International Index of Energy Security Risk, the individual energy security measures selected were organized around eight broad categories, which include global fuels, fuel imports, energy expenditures, price and market volatility, energy use intensity, electric power sector, transportation sector, and environmental. Table 1 shows the categories and implication of international index of energy security risk of USCC.

Based on the eight categories, 29 individual metrics (shown as Figure 1) were developed covering a wide range of energy supplies, energy end uses, generating capacity, operations, and emissions. The major input data sources for USCC[6][7] are from U.S. Energy Information Administration (EIA), International Energy Agency (IEA), and World Bank. Each year, USCC analyze top energy consumers in the world, including Taiwan. In the past few years, USCC did not adopt the input data directly published by Taiwan government. As a result, the analyzed indicators did not correctly reflect Taiwan's energy security risks.

In recent years, the staff of Institute of Nuclear Energy Research (INER) has continued to communicate with USCC research team to understand how to calculate metrics. The INER staff used the information published by Bureau of Energy and Directorate General of Budget, Accounting and Statistics, Taiwan [8][9] as input data for the analysis of energy safety risk indexes. Hence, the results can correctly reflect the Taiwan energy security risk.

The USCC research team also obtained information from the website of Bureau of Energy, Taiwan, and revised information on Taiwan's input over the years. Currently, the energy security risk analysis results analyzed by the USCC research team and the INER staff have been closer (shown as Figure 2). It is also shown that the energy security risk result of the Organization for Economic Co-operation and Development (OECD) average-country, analyzed by USCC, is lower than that of Taiwan over the years.

Since 2012, the overall risk of energy security has declined; mainly due to the recent decline in global crude oil prices and slowdown in global crude oil prices volatility were affected. In addition, the economic turmoil in 2008 also induced energy demand reduction in 2009, making crude oil prices decrease, and makes the overall energy security risk a short term decline in 2009 (shown as Figure 3).

Table 1 Category and implication of international index of energy security risk of USCC [1]

Category	Implication
Global Fuels (14%)	Measuring the reliability and diversity of global reserves and supplies of oil, natural gas, and coal. Higher reliability and diversity mean a lower risk to energy security.
Fuel Imports (17%)	Measuring the exposure of the national economies to unreliable and concentrated supplies of oil, natural gas, and coal. Higher supply reliability and diversity and lower import levels mean a lower risk to energy security.
Energy Expenditures (20%)	Measuring the magnitude of energy costs to national economies and the exposure of consumers to price shocks. Lower costs and exposure mean a lower risk to energy security.
Price and Market Volatility (15%)	Measuring the susceptibility of national economies to large swings in energy prices. Lower volatility means a lower risk to energy security.
Energy Use Intensity (14%)	Measuring energy use in relation to population and economic output. Lower use of energy by industry to produce goods and services means a lower risk to energy security.
Electric Power Sector (7%)	Measuring indirectly the reliability of electricity generating capacity. Higher diversity means a lower risk to energy security.
Transportation Sector (7%)	Measuring efficiency of energy use in the transport sector per unit of GDP and population. Greater efficiency means a lower risk to energy security.
Environmental (6%)	Measuring the exposure of national economies to national and international greenhouse gas emission reduction mandates. Lower emissions of carbon dioxide from energy mean a lower risk to energy security.

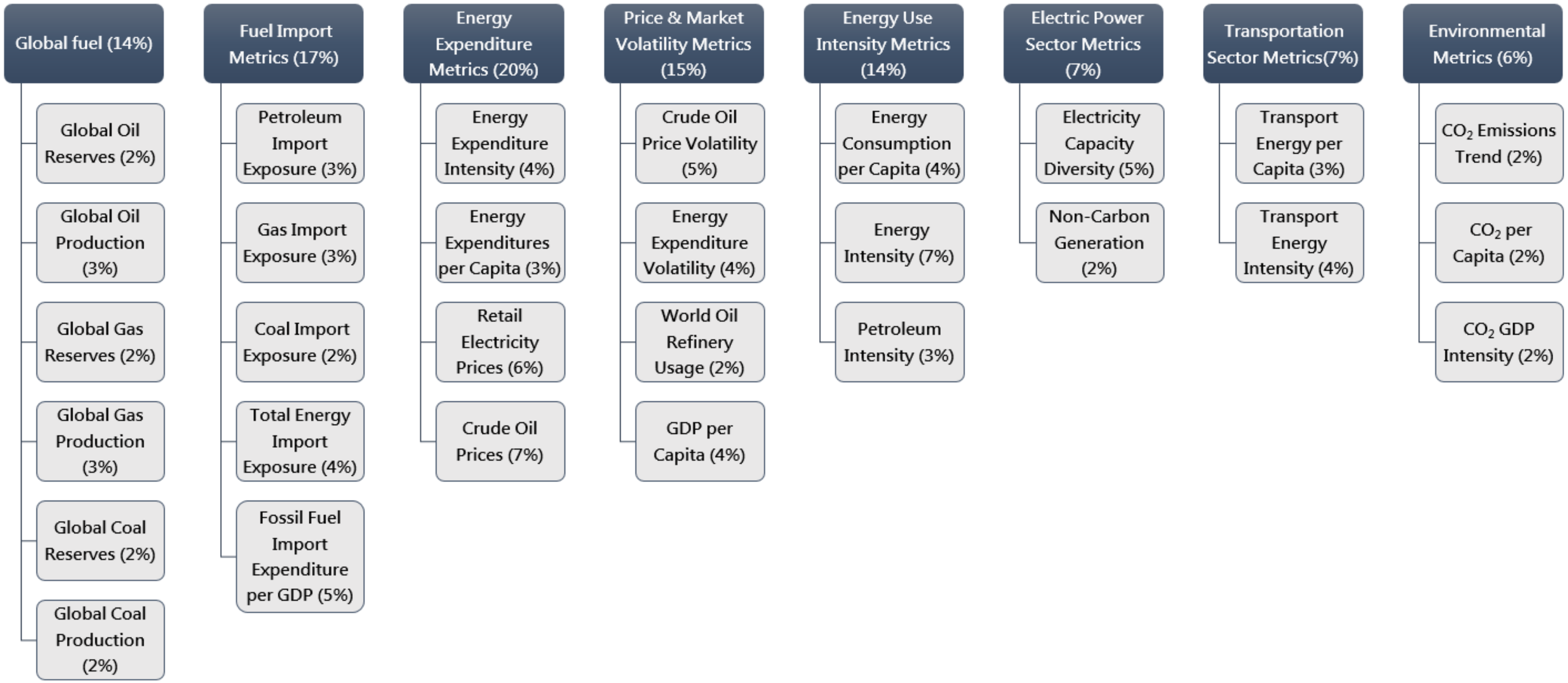


Figure 1 Structure of international index of energy security risk of USCC

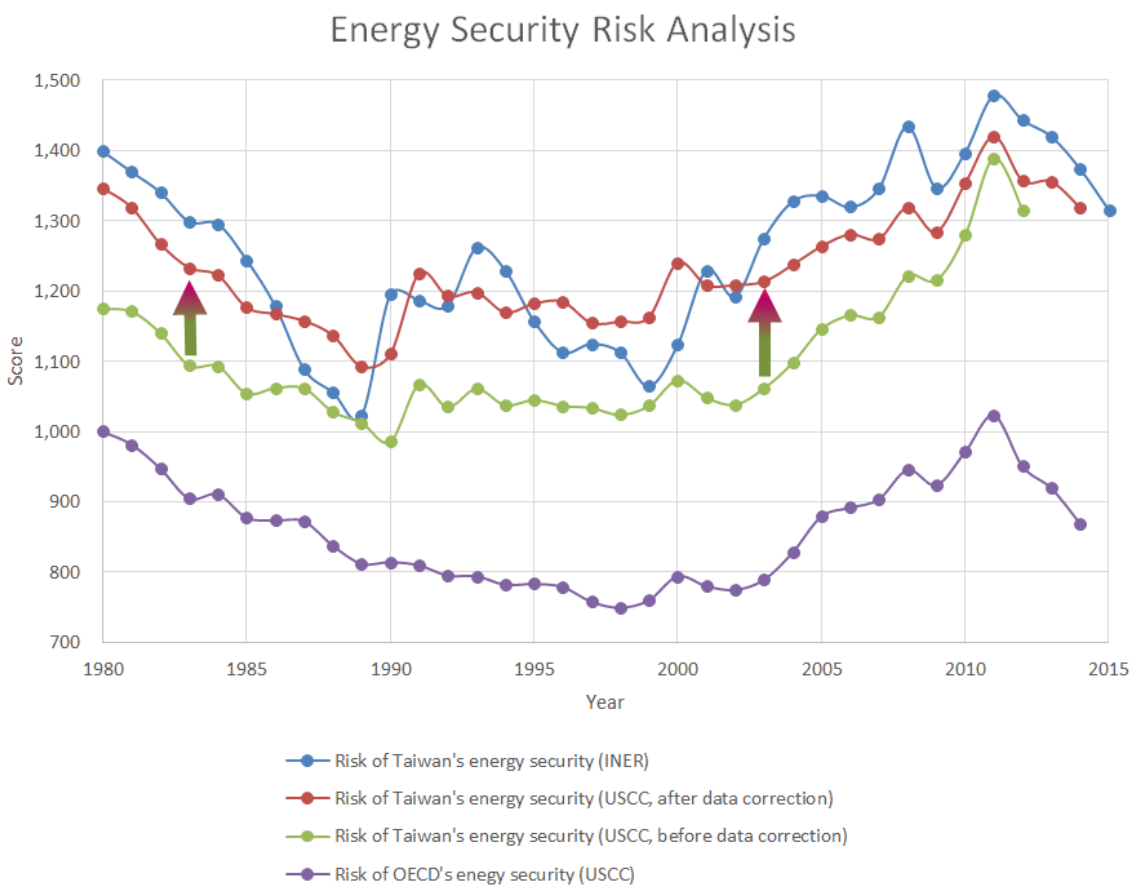


Figure 2 Comparison of Taiwan's energy security risk index results

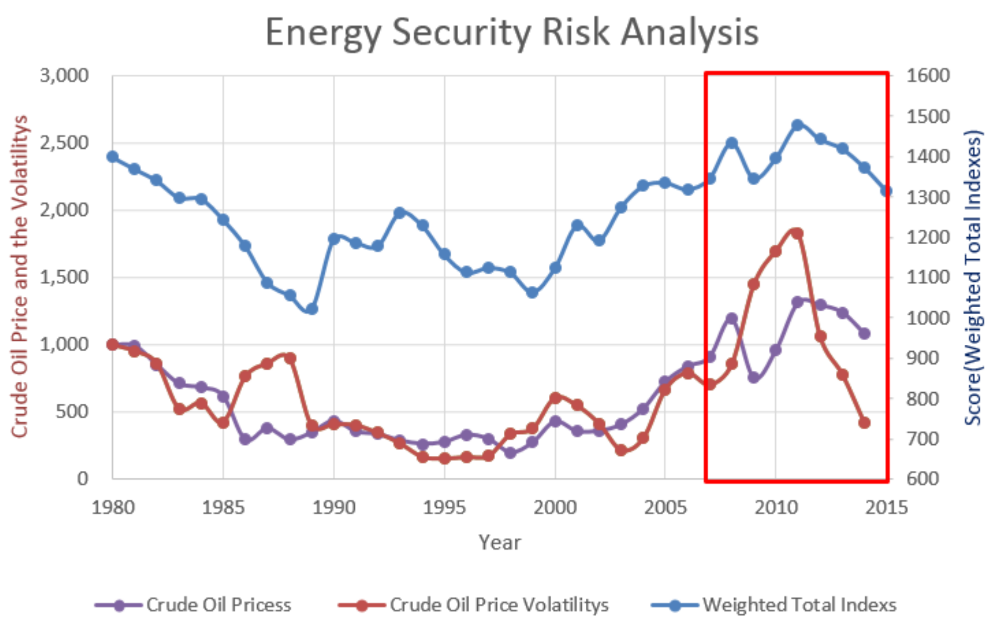


Figure 3 Comparison of the global crude oil prices, global crude oil price volatility, and Taiwan's weighted total energy security risk index

Exposure of Energy Import

Taiwan is lack of self-produced fossil fuels, including oil, coal and natural gas. All these resources are relied on imports. As a result, Exposure of Energy Import appears to be relatively important in the of energy security risk indexes analysis. Energy import exposure is considered for (1) degree of freedom, (2) diversity and (3) Net imports accounted for the proportion of total domestic supply of primary energy (oil, coal or natural gas) from imported countries. The following example shows the detailed description of the relevant calculation steps of natural gas import exposure.

Freedom Weighting (FW):

$$\mathrm{FW} = \sum_{i=1}^{N} \left(\frac{X_i F_i}{X_T} \right)^2 \tag{1}$$

In Eqs.(1), where:

N is the number of natural gas importing countries,

X_i is the total amount of natural gas imported from the i^{th} country(metric tons);

F_i is the freedom of the ith country;

X_T is the total import volume of natural gas (metric tons).

Diversity of Supply (DS):

$$\mathrm{DS} = \sum_{i=1}^{N} \left(\frac{X_i}{X_T} \right)^2 \tag{2}$$

$$\mathrm{HHI} = 10{,}000 \times \mathrm{DS} \tag{3}$$

Consider Eqs.(1) and Eqs.(3), the country's natural gas import exposure for the year:

$$\text{Natural Gas Import Exposure} = \left(\mathrm{FW}^2 \times \sqrt{\mathrm{HHI}} \right) \times \mathrm{NI} \tag{4}$$

NI is the ratio of net imports of natural gas to total domestic natural gas (%).

In Eqs.(4), in order to reflect the influence of the change of the degree of freedom of the importing country on the risk of the index, the calculation result of Eqs.(1) is taken square, So the change in weight of 2 times the degree of freedom will change the risk of 4 times.

In terms of energy supply diversity, Using the calculation of market share: Herfindahl – Hirschman Index (HHI). Because the HHI index is very sensitive to changes in market share, the result of Eqs.(3) is given to the range of 1 to 100.

Figure 4 shows gas import exposure results. Taiwan started to import gas in 1991. Gas import focused on a specific country during 1991 – 1995, which induce high gas import exposure. Followed by increasing the import countries, the import exposure risk gradually decreased. Since 2011, natural gas demand has increased, with new imports of natural gas concentrated in a specific new country. Hence, gas import exposure increased slightly in recent years. Figure 5 shows coal import exposure results. Coal imports were concentrated in a specific country during the period 2001-2005, induced high coal import exposure in this period.

In the calculation of "crude oil, coal, natural gas import exposure", the INER staff has contacted the Vice President of the US Institute for 21st Century Energy, Stephen Eule, to discuss the calculation of INER's domestic data (Eqs.(1) to Eqs.(4)). However, the USCC also calculates the "crude oil, coal and natural gas import exposure" of the world's top 75 energy consuming countries. In order to reduce the calculation time, USCC adopted the degrees of freedom (FW) of global fuel exporters in Eqs. (1) and Eqs. (2). However, INER adopted the data of Taiwan related fuel exporters. The difference between USCC and INER analysis is shown in Fig 6. Figure 7 shows that the changes average of petroleum, gas, and coal import exposure is relatively large in some periods, and also affects the weighted total index during these periods. Note that the overall energy security risks during 2007-2015 were dominated by crude oil prices and crude oil price volatility.

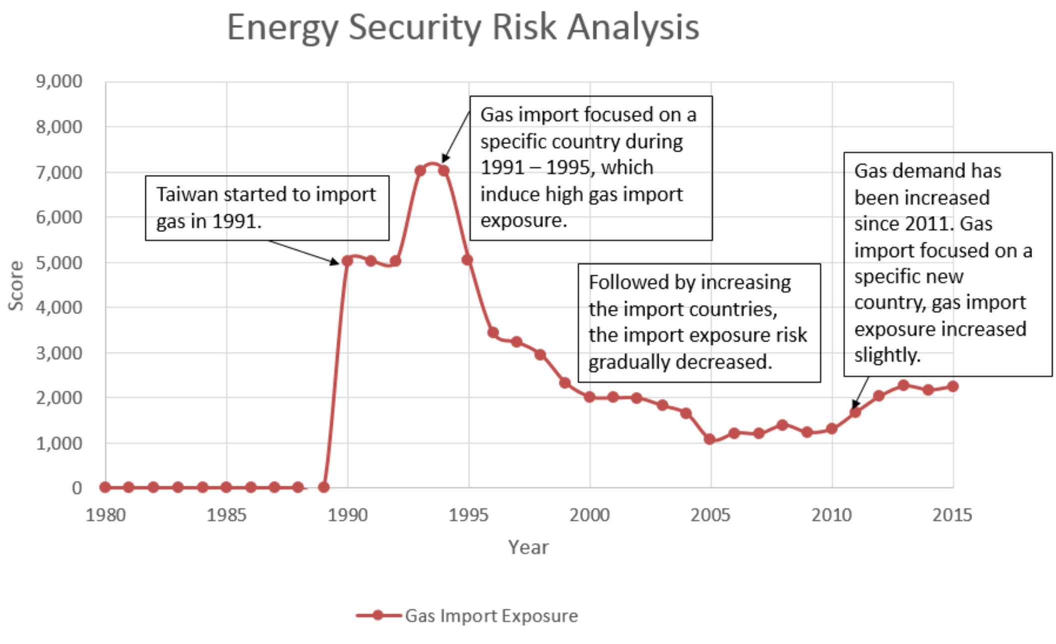


Figure 4 Gas Import Exposure results analyzed by INER

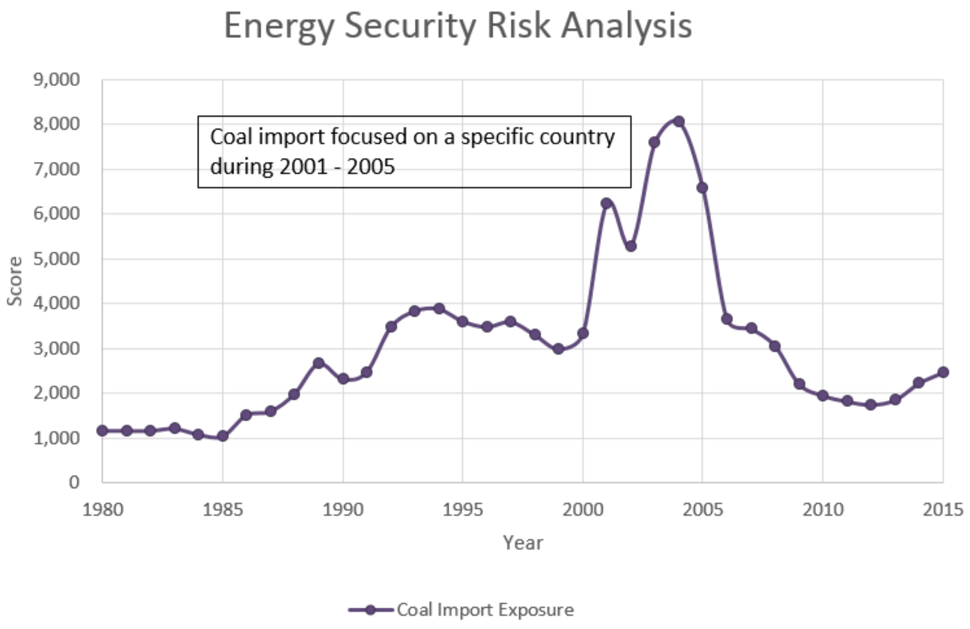


Figure 5 Coal import exposure results analyzed by INER

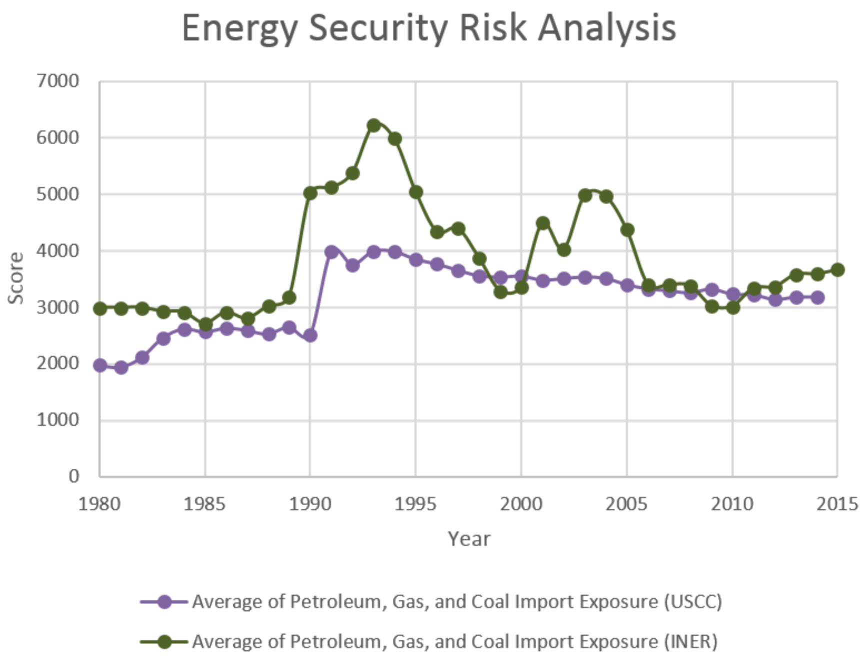


Figure 6 Comparison of average of petroleum, gas, and coal import exposure results analyzed by USCC and INER

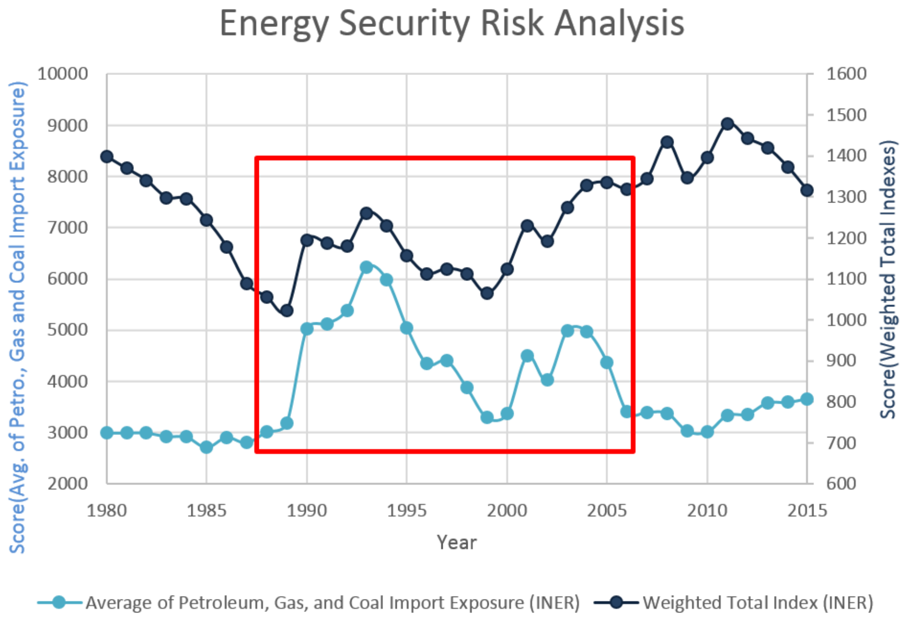


Figure 7 Comparison of average of petroleum, gas, and coal import exposure and weighted total index analyzed by INER

Method – TIMES Model

This study combines two models: TIMES (The Integrated MARKAL-EFOM System) and USCC's international index of energy security risk to evaluate the future energy security. The procedure adopted in the paper is shown in Figure 8. First, based on the definition of each index listed in Figure 1, raw data collection was executed, and also the historical energy security from 1980 to 2015 was studied (see Figure 2 – Figure 7). Then, in the scenario studies, three scenarios considering the target of carbon reduction and different potential of renewable energy respectively were planned. In each scenario, energy portfolios, energy imports as well as consumptions etc. are correspondingly produced by TIMES model, and moreover by another model, namely General Equilibrium Model for Energy, Environment and Technology Analysis (GEMEET), the total energy demand such as Gross Domestic Product (GDP) is obtained. The detailed descriptions associated with these scenarios will be illustrated in the next section. Finally, based on the results of TIMES and GEMEET model, the risk associated with indexes in the future year can be evaluated.

TIMES model was supported by Energy Technology Systems Analysis Program (ETSAP) that was established by International Energy Agency (IEA) in 1976, and the associated developments were performed in 1978. TIMES is a 3E (Energy, Economy and Environment) model; it was the combination of MARKAL (market allocation) model and EFOM (Energy Flow Optimization Model) and thus the absences of MARKAL model were improved.

TIMES is a quite mature energy system planning model and widely adopted. Up to now, it had been adopted by 250 research institutes in the 70 countries, in which the function of optimization of energy system is mainly used to obtain an energy portfolio with the lowest cost for world, areas or single country. The energy portfolios with the lowest cost produced by TIMES model takes the energy demand, energy supply and technology limitations into account; besides, the most suitable time point of each new technology commercializing or old technology decommissioning can be decided. Therefore, the energy policy simulation by TIMES model could achieve exactly assessment of energy system for a country. The investor can also perform the investment of energy technology timely to avoid the energy loss or waste due to excessive energy produce or import. The overall scheme of TIMES model is depicted in Figure 9.

Comparing with the MARKAL model, the TIMES model increases and modify many functions, and by which the analysis will better fit the actual situation. The new functions are briefly described as below:

(1) The Settings of Flexible Simulation Period

The simulation period in TIMES model can be adjusted flexibly such as: one year simulation period for short term or many years as one simulation period for long term. The function makes not only easily verify the historical results, but also the flexible adjustment for future simulation period. For that, the dynamic energy supply and demand in the future is more completely revealed. Besides, the settings of time slice in TIMES model includes season, month, week and hour (see Figure 10) that results in a more flexible simulation comparing with MARKAL model.

(2) The flexible settings of time slices and energy storage technology

In MARKAL model, only the electricity and heat are defined with the function of time slices; however, in TIMES model all commodities and technologies can be with the time slices settings according to their characteristics. Besides, in MARKAL model the energy storage technology is only set as discharge in the night and charge in the day, but in TIMES model it can discharge or charge at any moment according the users' settings. The function of time slices results in the flexible application of energy storage in simulation.

(3) The flexible input and output of technology

The proportion of commodity input and commodity output for certain technology must be fix in MARKAL model, and that gives rise to the inflexible simulation in the input and output mechanism. However, it is not the case in TIMES model, for which the settings of complex energy technology structure are much easier, such as multi-import and poly-generation, and is quite flexible, such as the petroleum refinery technology.

(4) The required time and cost for construction, decommissioning of power plant

In TIMES model, the user is permitted to define the required time and cost for a power plant's construction and decommissioning. The technological life and economic life can be considered individually. However, in MARKAL model the technological life is equal to the economic life.

(5) The vintage mechanism of technology

The vintage mechanism in TIMES model makes the newer parameter for newer technologies be used in a certain moment during the simulation based on the users' setting; the parameters for older technologies do not change correspondingly. However, in MARKAL model once the newer parameters for a technology are used, the older ones are also revised correspondingly.

(6) The precise and actual investment cost

In MARKAL model, the investment cost of a technology is amortization at the instant of operation. However, in TIMES model the investment cost is amortization before the commercially operation (that is during the construction). The discount rate is a constant during the simulation in MARKAL model, but it is can be adjusted flexibly.

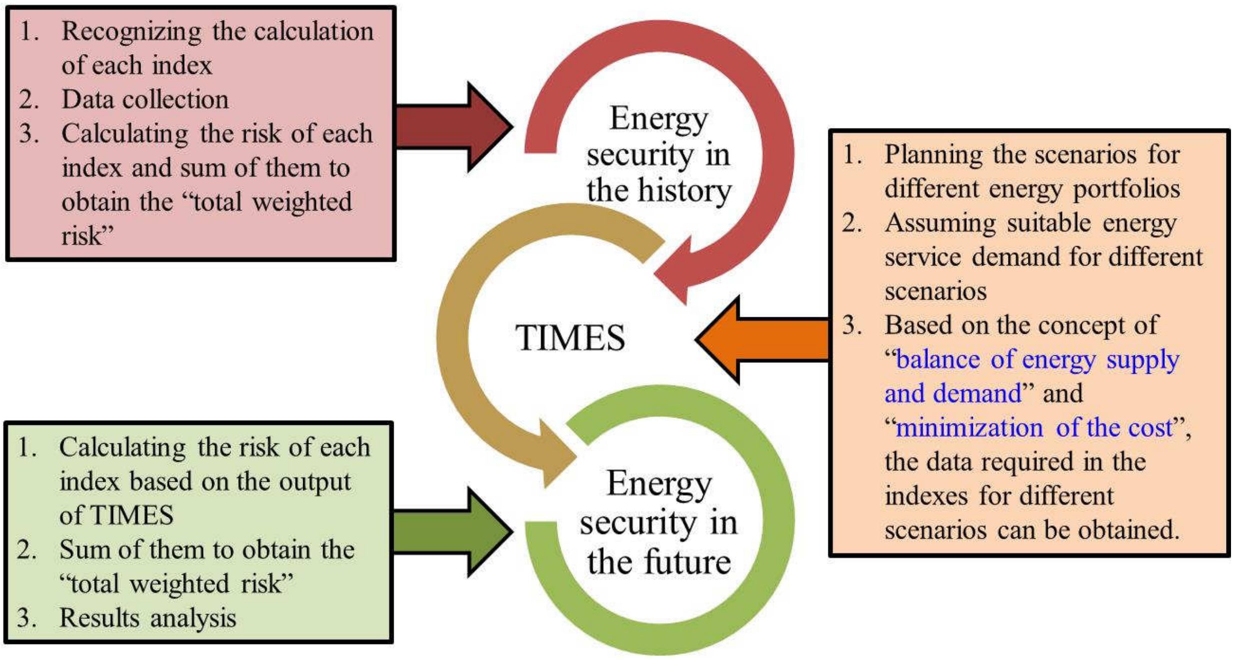


Figure 8 Combining the USCC energy security indexes with TIMES model

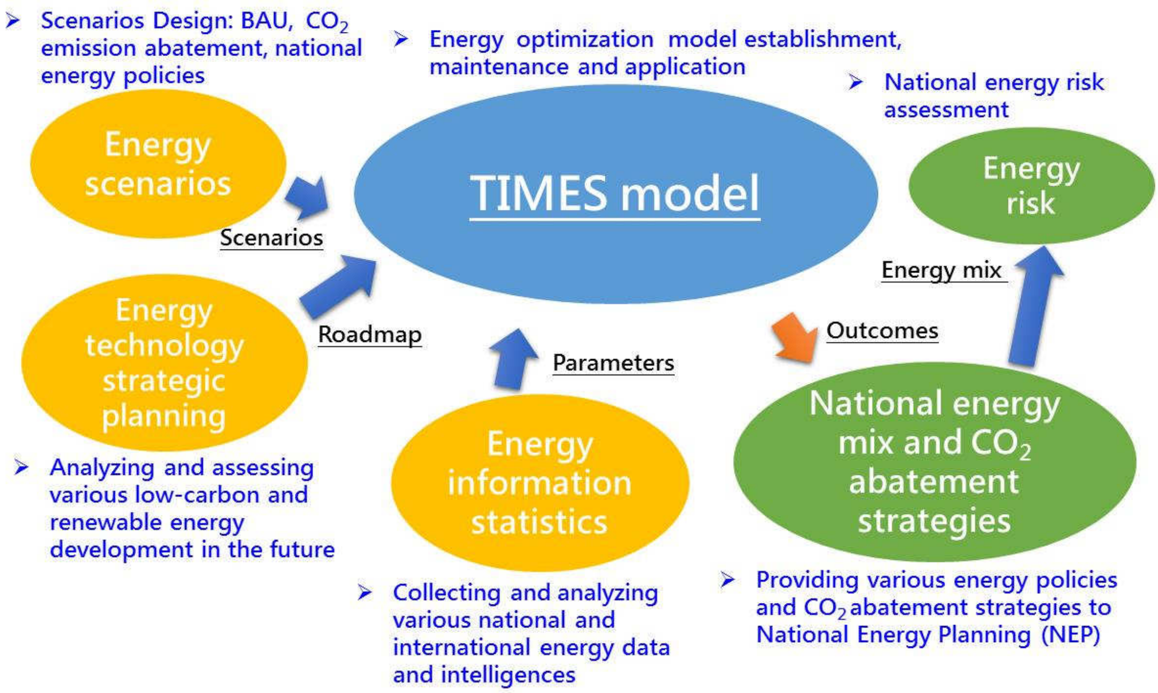
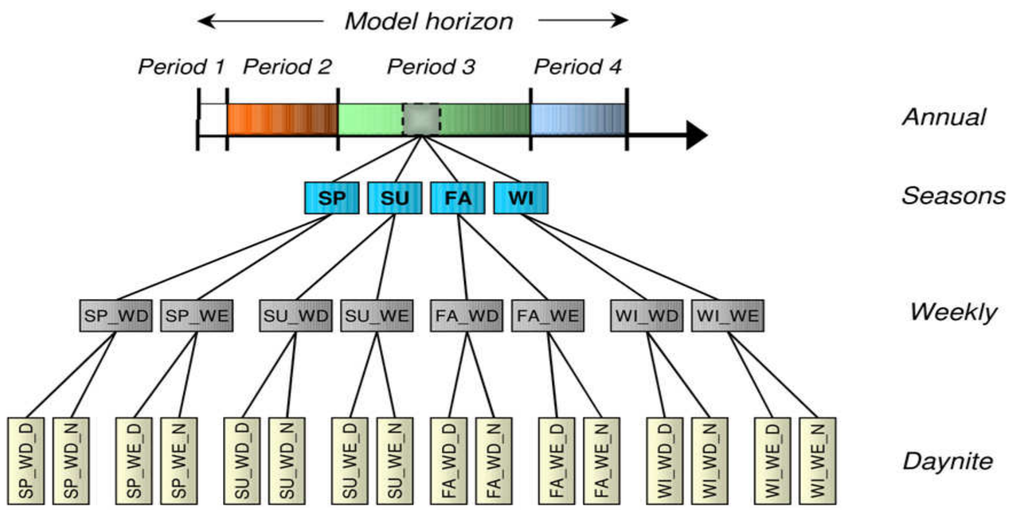


Figure 9 The scheme diagram of TIMES model



Data source: ETSAP, 2005

Figure 10 The settings of time slice in TIMES model

Prediction for the Future Years

Scenario Assumptions

This study proposes three scenarios: Business As Usual (BAU), Optimistic Scenario and Moderate Scenario in terms of the potential of PV and offshore wind as well as the Intended Nationally Determined Contribution (INDC) as listed in Table 2. In optimistic scenario, the accumulated installed capacity of PV and offshore wind by 2050 is estimated to 44GW and

15GW respectively; however, in moderate scenario they are estimated as 30GW and 9GW respectively as listed in Table 3.

Table 2 Scenario assumptions

Scenario	BAU	optimistic	moderate
Coal	Upper limit of installed capacity for 2016 – 2027 is based on the “Taipower's electric power development for long-term (10505)”, and 2.3% average annual growth rate is for 2028 – 2050.		
Natural gas	Upper limit of installed capacity for 2016 – 2027 is based on the “Taipower's electric power development for long-term (10505)”, and 5.4% average annual growth rate is for 2028 – 2050.		
Oil	Upper limit of installed capacity for 2016 – 2027 is based on the “Taipower's electric power development for long-term (10505)”. The installed capacity decreases to 295MW in 2027 and is assumed to be without notable growth after 2028.		
CCS	User defined form 2035 – 2050*		
Renewables	Upper limit of installed capacity is based on the target of government plan for 2016 – 2030 as listed in Table 2		
	Upper limit of installed capacity of PV and offshore wind for 2030 – 2050 is based on the larger one in Table 2		Upper limit of installed capacity of PV and offshore wind for 2030 – 2050 is based on the smaller one in Table 2
Nuclear	Without life-extension/mothballed		
Co-generation	Upper limit of installed capacity referred to the statistics of Bureau of Energy		
Carbon reduction target	N/A	Achieving the carbon reduction goal in INDC from 2020 to 2030, and Greenhouse Gas Reduction Act from 2030 to 2050	

Note: * 2035 (0.3GW), 2040 (2.6GW), 2045 (4.6GW) and 2050 (7.6GW)

Table 3 Upper limit of renewables estimation (MW)

Technology	2015	2020	2025	2030	2035	2040	2045	2050
Offshore wind	0	520	3,000	5,200	6,150 7,650	7,100 10,100	8,050 12,550	9,000 15,000
PV	842	6,500	20,000	22,003 28,390	24,006 35,290	26,010 40,330	28,013 43,500	30,016 44,800
Enhanced geothermal	0	0	0	0	367	734	1,101	1,835
Onshore wind	647	1,200	1,200	1,200	1,200	1,200	1,200	1,200
Hydro	2,089	2,100	2,150	2,200	2,200	2,200	2,200	2,200
Shallow geothermal	0	150	200	200	315	315	315	315
Waste	741	768	813	950	1,354	1,496	2,004	2,488
Wave	0	0	0	50	170	320	520	720
Ocean current	0	0	0	20	150	300	600	1,050

Note: the numbers in gray area represent the historical data;, the ones in red area represent the target of gonvernment policy, and the ones in blue area represent the estimation of the study.

Results of the Prediction for the Future Years

The three important greenhouse gas emissions reduction policies in Taiwan include: (1) Intended Nationally Determined Contribution (INDC) - in 2030, greenhouse gas emissions are to be 50 % lower than their projected level (BAU); (2) Greenhouse Gas Reduction Act - in 2050, greenhouse gas emissions are to be 50 % lower than greenhouse gas emissions in 2005; (3) 2025 nuclear-free homeland policy objectives –power generation portfolio: coal 30%, gas 50%, renewable energy 20%.

In Optimistic Scenario and Moderate Scenario, the following carbon reduction policies are followed to set carbon reduction conditions for TIMES model: (1) during 2015 to 2030: based on Intended Nationally Determined Contribution (INDC) of Taiwan, (2) during 2030 to 2050: based on Greenhouse Gas Reduction Act. In Optimistic Scenario, a large number of renewable energy facilities are installed to achieve carbon reduction requirement.

In these scenarios, large scale renewable energy, gas-fired power generation, coal-fired power plants with carbon capture and storage (CCS) are used, electricity demand is suppressed to achieve carbon reduction requirement. The main differences between the two scenarios are: in the Optimistic Scenario, the construction of renewable energy facilities is maximized. However, in Moderate Scenario, it is assumed that sufficient renewable energy facilities cannot be built. As a result, more gas-fired power generation and coal-fired power plants with CCS are used, and more electricity demand is suppressed. Under these scenarios, the carbon dioxide emission continues to decline year by year. In BAU scenario, carbon dioxide emission is not controlled. The fossil fuel power plants are massively used to replace the nuclear power generation. As a result, carbon dioxide emission continues to rise year by year. Figure 11-13 shows the power generation by the various power generation measures for BAU, Optimistic Scenario, and the Moderate Scenario.

In this study, the power generation portfolio of Optimistic Scenario is 27.1 % of coal, 54.3% of gas and 13.1% of renewable energy, and the power generation portfolio of Moderate Scenario is 27.6 % of coal, 53.7 %of gas and13.1% of renewable energy in 2025, which are close to that of 2025 nuclear-free homeland policy. Under the power generation portfolio, the issues of gas-fired power generation include: (1) The unloading capacity of Liquid Natural Gas (LNG) terminal is limited; (2) The risk exposure for offshore gas pipeline transportation is high under rough sea condition, and the onshore pipeline construction could cause social protests; (3) the spare storage period is only 7 ~ 10 days; (4) The risk exposure would increase with the international natural gas price volatility. The issues of coal-fired power generation include: (1) Without nuclear power generation, base load would only rely on coal-fired power generation, and become insufficient; (2) Social intentions are opposed to coal-fired power generation, that makes new power plant contruction become difficult. The issues of coal-fired power generation include: (1) Renewable energy power generation is intermittent, thus power quality is deteriorated; (2) Smart grid is needed to integrate regional power systems; (3) The power generation cost for renewable energy is high.

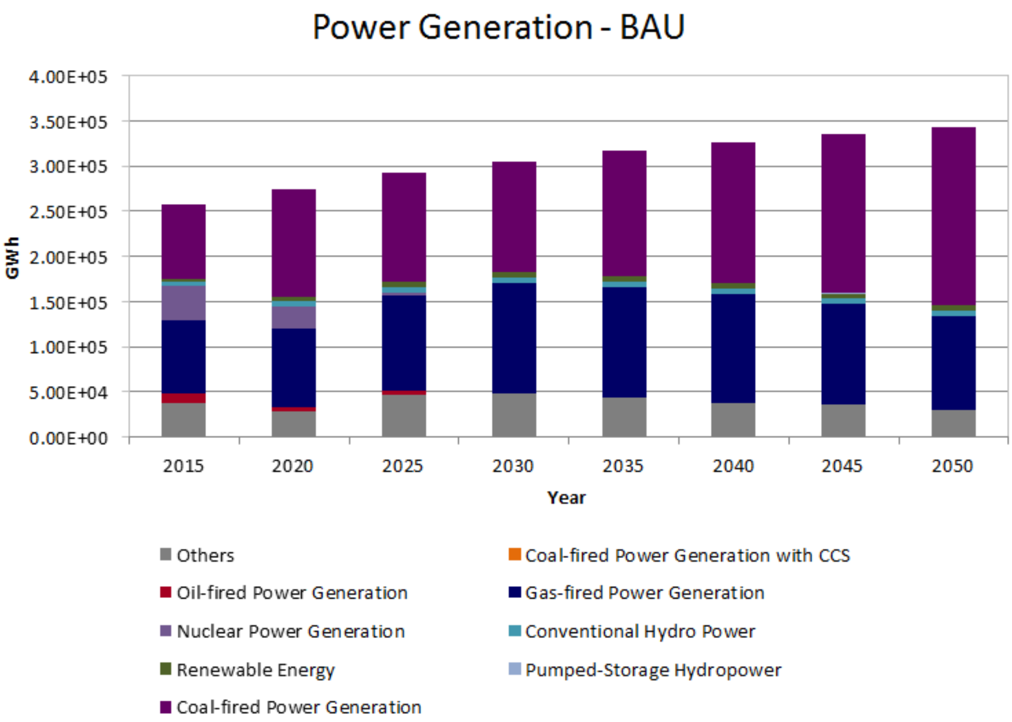


Figure 11 Power generation for BAU

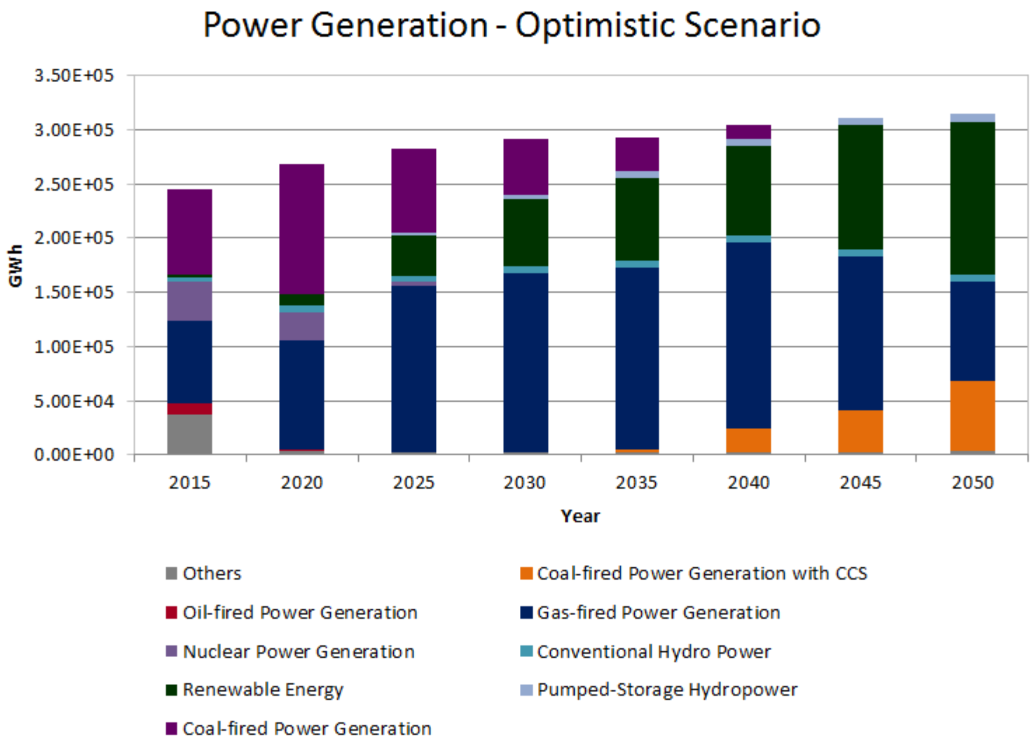


Figure 12 Power generation for Optimistic Scenario

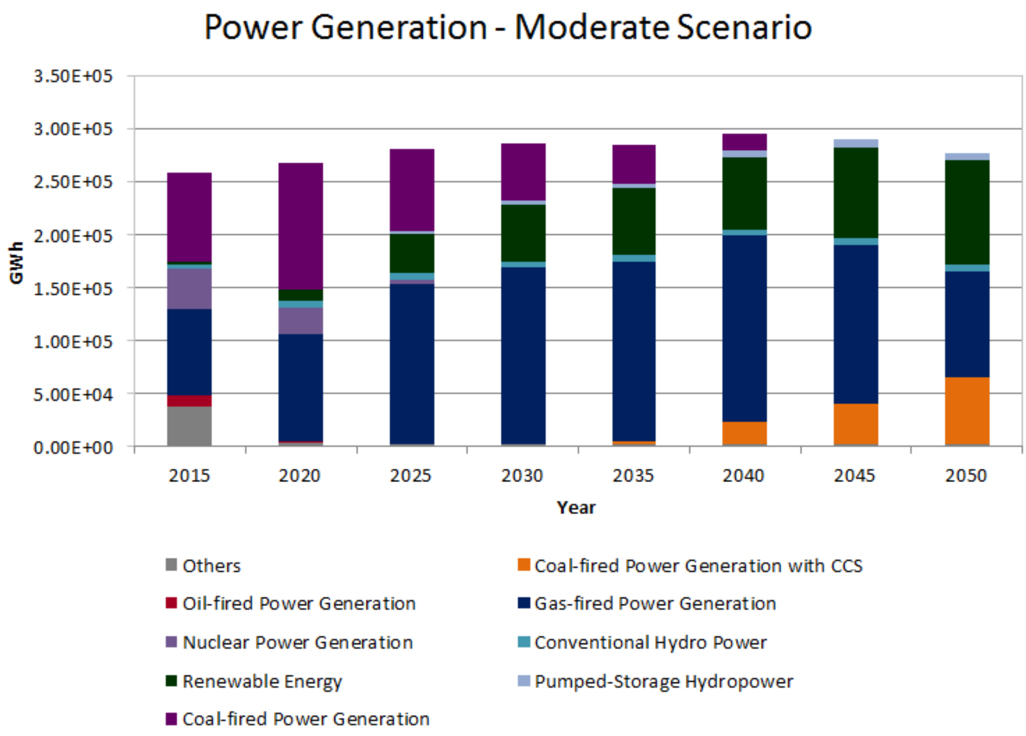


Figure 13 Power generation for Moderate Scenario

The GEMEET model uses the power generation of the three scenarios (Figure 14), which are analyzed by the TIMES model, to estimate GDP per capita of the future years (Figure 15). Due to suppression of electricity demand, GDP per capita of Optimistic Scenario and Moderate

Scenario are lower than that of BAU. For Moderate Scenario, GDP per capita even declines after year 2040, due to more electricity demand is suppressed. Figure 16 shows Risk of GDP per capita, the score rankings from high to low are Moderate Scenario, Optimistic Scenario and BAU. It shows that suppressing electricity demand induces negative impact on GDP.

Carbon dioxide emissions are significantly reduced by the use of renewable energy and the related auxiliary measures in Optimistic Scenario and Moderate Scenario. Their scores of CO_2 related risk indexes are significantly lower than those of BAU, which include: non-carbon generations (Figure 17), CO_2 emission trend (Figure 18), CO_2 per capita (Figure 19) and CO_2 GDP intensity (Figure 20).

Figure 21 shows the imported fossil fuel price projections predicted by INER. From 2020 to 2040, which are based on the projection of low oil price scenario in International Energy Agency (IEA)/World Energy Outlook (WEO) (2015 Edition) [10]. For 2045 and 2050, the growth rate of prices is as the average growth rate during the period between 2020 and 2040. The estimated results show that prices including crude oil price, steam coal price, coking coal price and natural gas price will continue to rise from 2015 to 2050.

In Optimistic Scenario and Moderate Scenario , large scale renewable energy, gas-fired power generation and coal-fired power plants with carbon capture and storage (CCS) are used to reduce CO_2 emissions.

In 2050, fossil fuel prices will continue to rise, Taiwan still need to import large amount of fossil fuel under this situation. It makes the energy expenditure-related indexes of the risk value increase significantly. Figure 22 shows a comparison of energy expenditure per capita, Figure 23 shows a comparison of imports of fossil fuels per GDP. Figure 24 shows a comparison of energy expenditure intensity. These figures show that energy expenditure is highly influenced by high fossil fuel prices in 2050.

Figure 25 shows the Comparison of BAU, Optimistic Scenario and Moderate Scenario on energy security risk analysis for future years. Since Greenhouse Gas Reduction Act and Taiwan's INDC have strict carbon dioxide emission requirements, Moderate Scenario assumes that sufficient renewable energy facilities cannot be built as that of Optimistic Scenario. Hence, the electricity demand is reduced to fulfill the carbon dioxide emission requirement, which results in a decline of GDP per capita. After 2045, a widening gap of overall energy security risk appears between Optimistic Scenario and Moderate Scenario. The negative impact of rising fossil fuel prices has offset the negative impact of reducing carbon dioxide emissions, and the overall energy security risks of Optimistic Scenario and Moderate Scenario in 2050 are even higher than the overall energy security risk 2015.

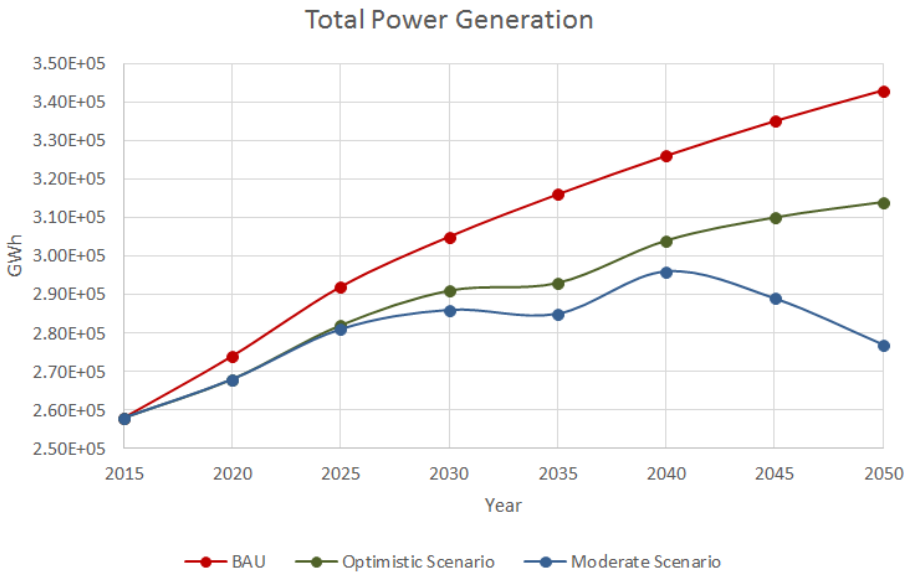


Figure 14 Comparison of BAU, Optimistic Scenario and Moderate Scenario on total power generation for future years

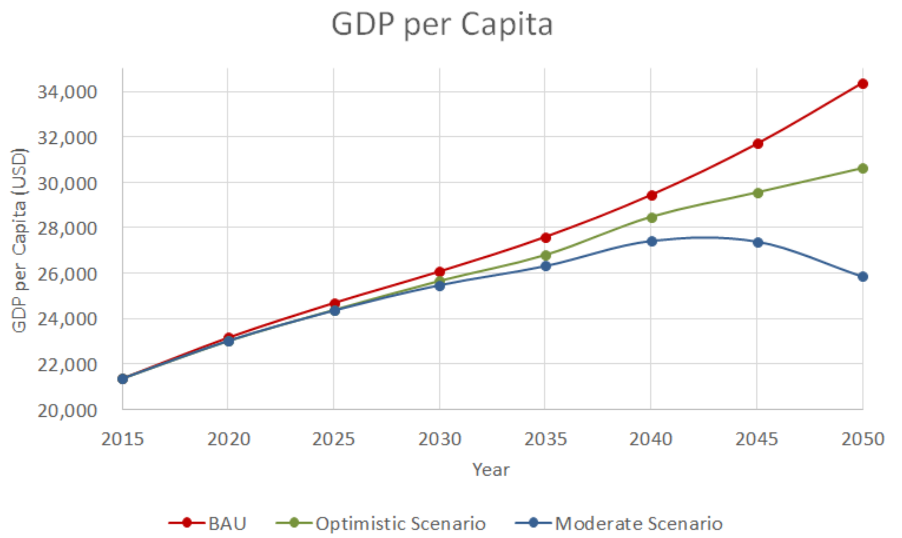


Figure 15 Comparison of BAU, Optimistic Scenario and Moderate Scenario on GDP per Capita for future years

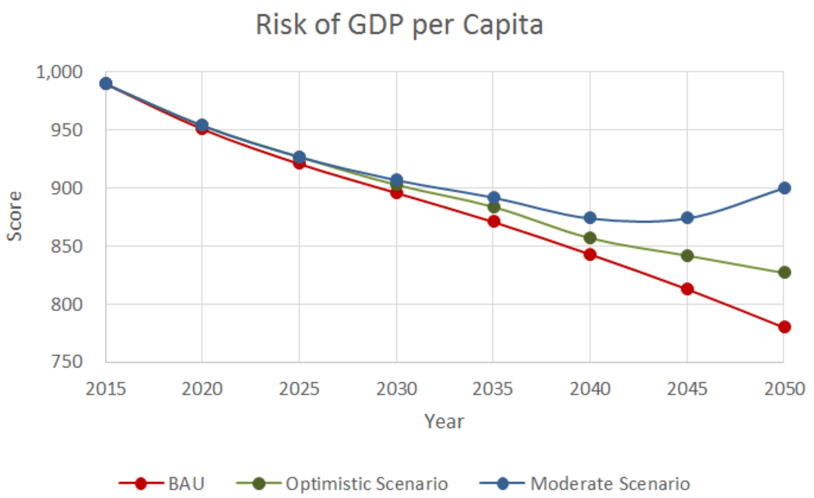


Figure 16 Comparison of BAU, Optimistic Scenario and Moderate Scenario on the Risk of GDP per Capita for future years

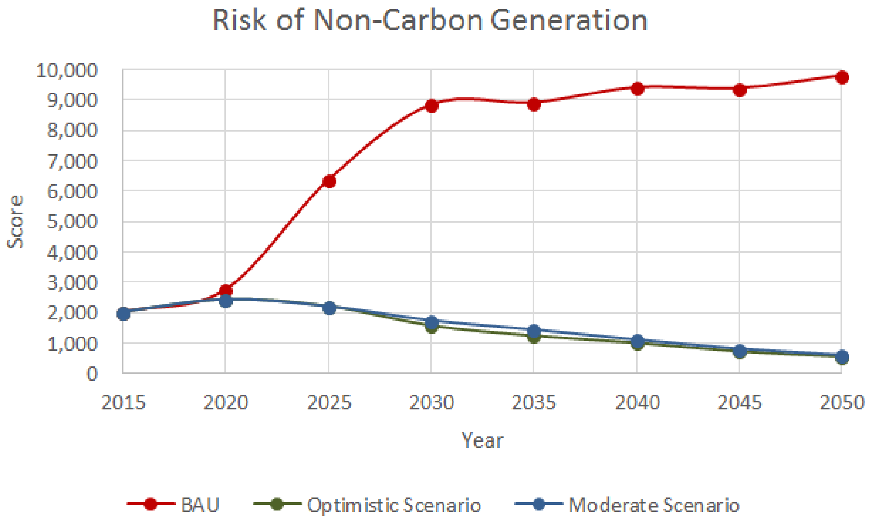


Figure 17 Comparison of BAU, Optimistic Scenario and Moderate Scenario on the Risk of Non-Carbon Generation for future years

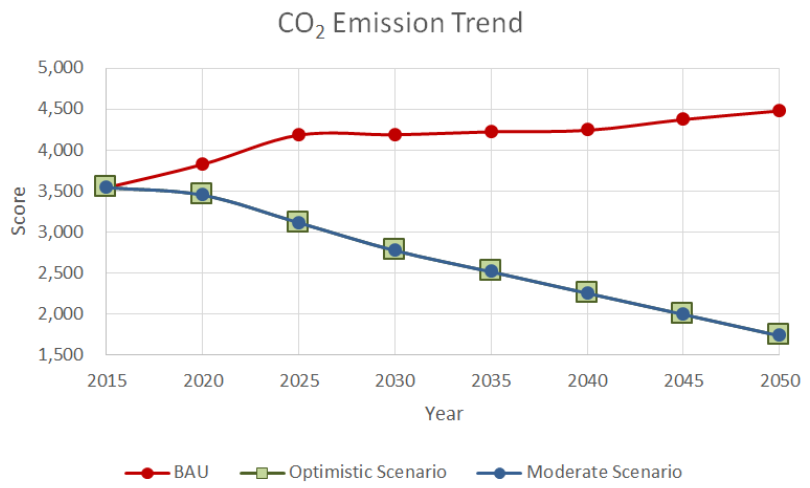


Figure 18 Comparison of BAU, Optimistic Scenario and Moderate Scenario on the Risk of CO_2 Emissions Trend for future years

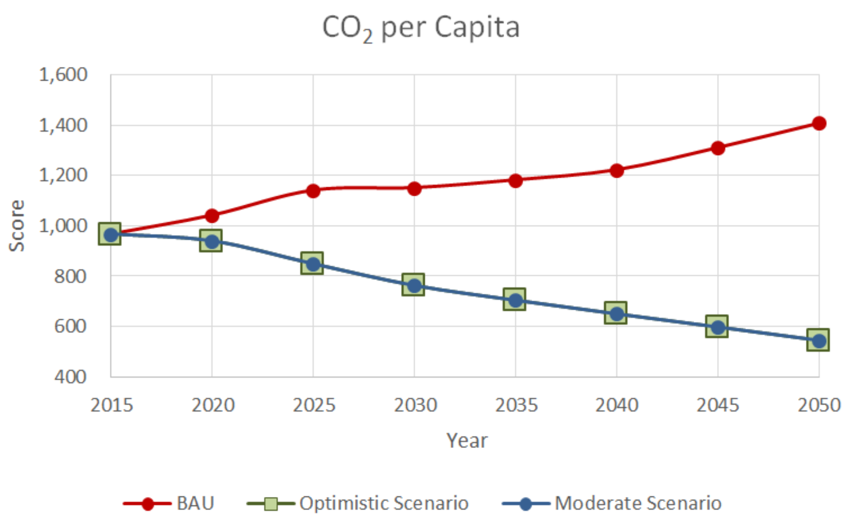


Figure 19 Comparison of BAU, Optimistic Scenario and Moderate Scenario on the Risk of CO_2 per Capita Trend for future years

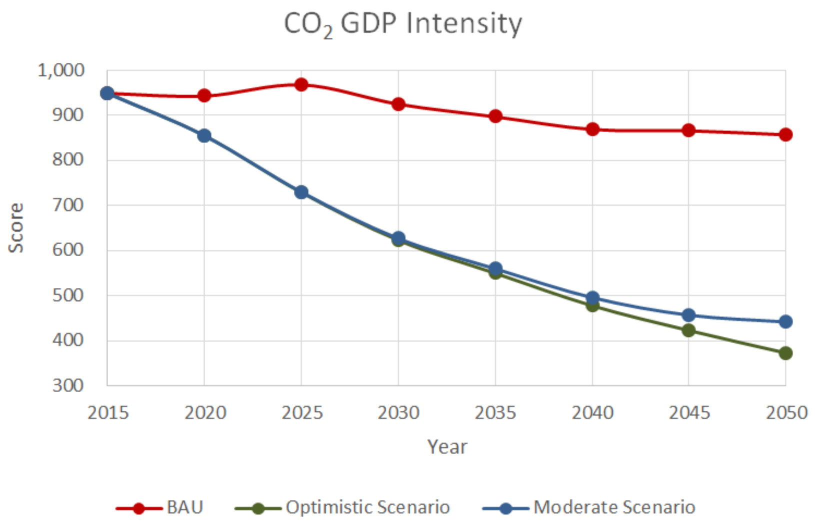


Figure 20 Comparison of BAU, Optimistic Scenario and Moderate Scenario on the risk of CO_2 GDP intensity for future years

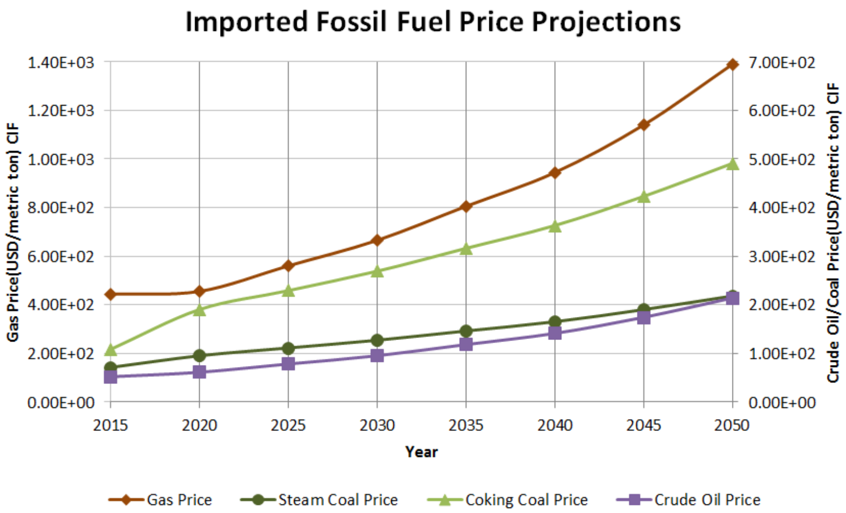


Figure 21 Imported fossil fuel price projections

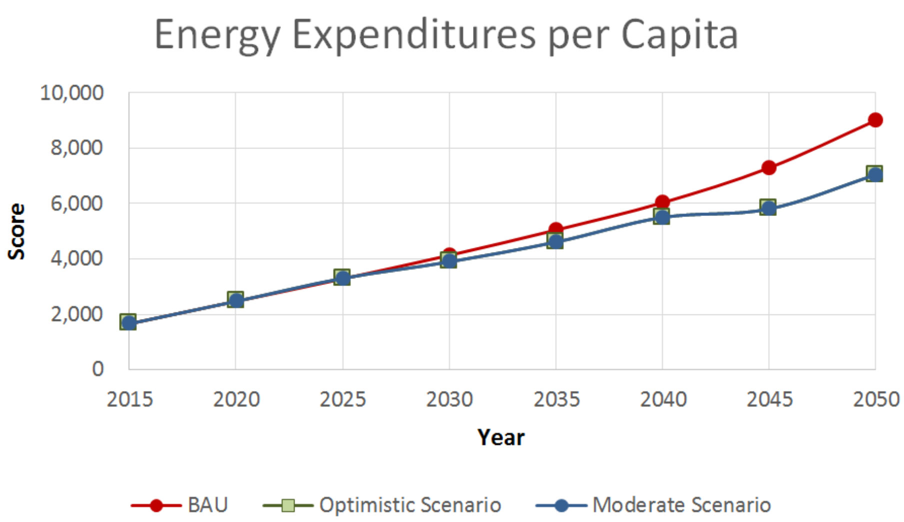


Figure 22 Comparison of BAU, Optimistic Scenario and Moderate Scenario on the risk of Energy expenditures per capita for future years

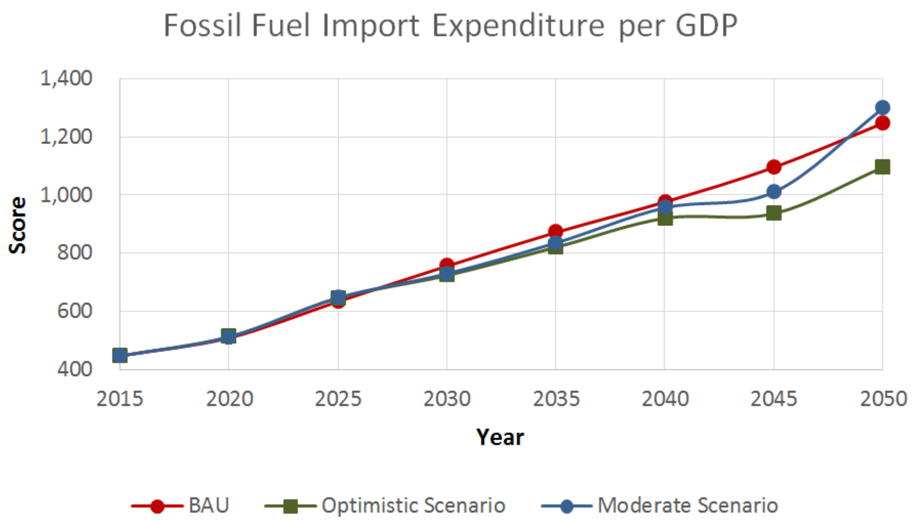


Figure 23 Comparison of BAU, Optimistic Scenario and Moderate Scenario on the risk of fossil fuel import expenditure per GDP for future years

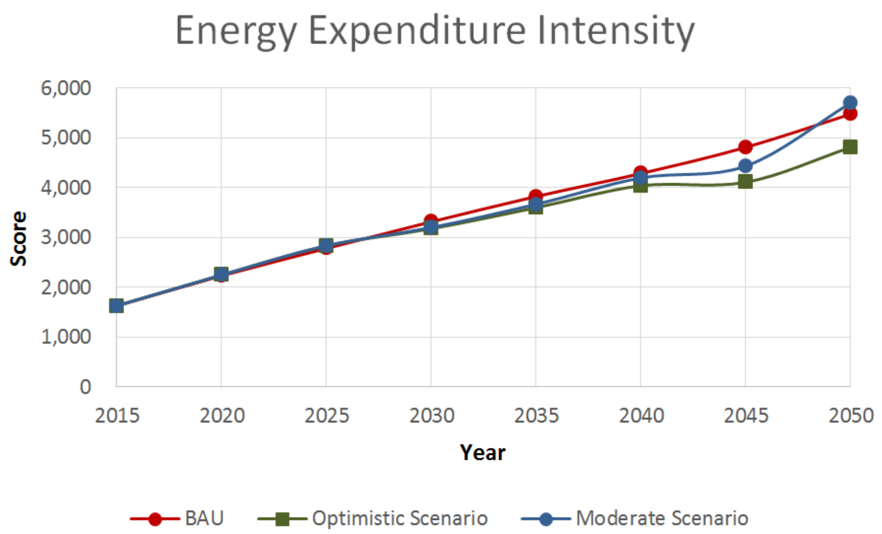


Figure 24 Comparison of BAU, Optimistic Scenario and Moderate Scenario on the risk of energy expenditure intensity for future years

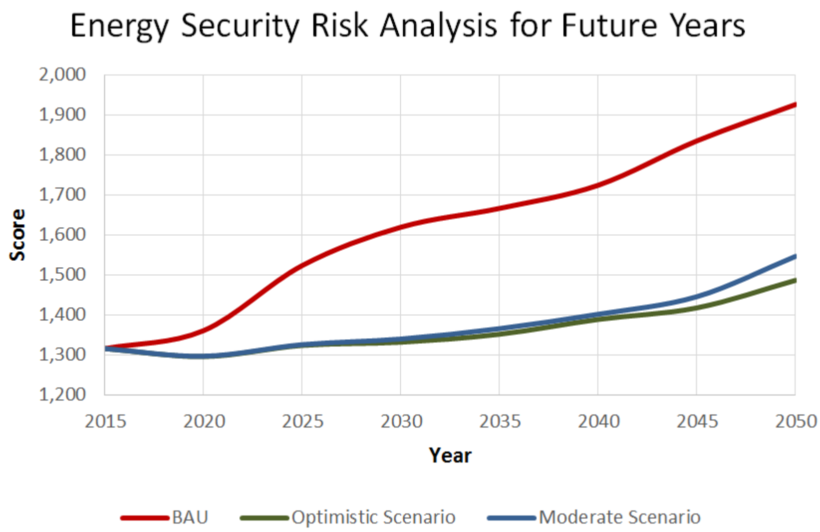


Figure 25 Comparison of BAU, Optimistic Scenario and Moderate Scenario on energy security risk analysis for future years

Conclusions

This study adopted the International Index of Energy Security Risk which was developed by U.S. Chamber of Commerce (USCC). 29 indexes belong to eight categories individually, which include global fuels, fuel imports, energy expenditures, price and market volatility, energy use intensity, electric power sector, transportation sector, and environmental. In order to perform the localization for these energy security risk analysis, the research team contacted with USCC to obtain the details of the computation for each index, and then the Taiwan's domestic data were prepared to complete energy security risk analysis for the past years.

The analysis shows that, since 2012, the overall risk of energy security has declined, mainly due to the recent decline in global crude oil prices and slowdown in crude oil prices volatility were affected. In addition, the economic turmoil in 2008 also affected energy demand in 2009, making crude oil prices fell, and makes the overall energy security risk a short term decline in 2009.

Exposure of energy import is important in the of energy security risk indexes analysis for Taiwan. Energy import exposure is considered for (1) degree of freedom, (2) diversity and (3) net imports accounted for the proportion of total domestic supply of primary energy from imported countries.

The analysis result shows that Taiwan has been over-concentrated in a particular country in the past, which induced high risk of exposure of energy import for a specific period of time. The issue has been adequately mitigated by means of increasing the importing countries to enhance diversity and to reduce the risk exposure.

In order to predict future Taiwan's energy security risks under proposed scenarios, this study integrates three tools: USCC International Energy Security Risk Index, TIMES Model and GEMEET Model. The TIMES model predicts the basic data of the scenarios, and the GEMEET model calculates GDP based on the electricity demand from TIMES model. The resulting data is used to analyze the energy security risks of Taiwan's domestic energy security risks by USCC International Energy Security Risk Index.

This study proposes three scenarios: BAU, Optimistic Scenario and Moderate Scenario. In compliance with INDC and Greenhouse Gas Reduction Act, for Optimistic Scenario and Moderate Scenario, a large scale of renewable energy, gas-fired power generation, coal-fired power plants with CCS are used, and electricity demand is also suppressed to achieve carbon reduction requirement.

The main differences between the two scenarios are: in the Optimistic Scenario, the construction of renewable energy facilities is maximized. However, in Moderate Scenario, it is assumed that sufficient renewable energy facilities cannot be built. As a result, more gas-fired power generation and coal-fired power plants with CCS are used, and more electricity demand is suppressed. Under these scenarios, the carbon dioxide emission continued to decline year by year.

In BAU scenario, carbon dioxide emission is not controlled. Under the condition of no nuclear power generation and low renewable energy, fossil fuel power plants are massively used. Therefore, carbon dioxide emissions continue to rise year by year.

Due to this difference, the scores of CO_2 related risk indexes of Optimistic Scenario and Moderate Scenario are significantly lower than those of BAU, which include: non-carbon generations, CO_2 emission trend, CO_2 per capita and CO_2 GDP intensity. For the same reason, the overall energy security risk score for Optimistic Scenario and Moderate Scenario is also lower than that of BAU.

In Optimistic Scenario and Moderate Scenario , in addition to using large scale renewable energy, gas-fired power generation and coal-fired power plants with carbon capture and storage (CCS) are still need to use to achieve CO_2 emission requirement. In 2050, fossil fuel prices will continue to rise, and Taiwan still need to import large amount of fossil fuel, making the energy expenditure-related indexes of the risk value increased significantly.

Optimistic Scenario and Moderate Scenario comply with the carbon dioxide emissions requirements of Taiwan’s Greenhouse Gas Reduction Act Taiwan’s INDC. Hence, the overall energy security risks are far lower than that of BAU. Moderate Scenario assumes that sufficient renewable energy facilities cannot be built as that of Optimistic Scenario. Hence, the electricity demand is reduced to fulfill the carbon dioxide emission requirement, which results in a decline of GDP per capita. After 2045, a widening gap of overall energy security risk appears between Optimistic Scenario and Moderate Scenario. In addition, the negative impact of rising fossil fuel prices has offset the negative impact of reducing carbon dioxide emissions, and the overall energy security risks of Optimistic Scenario and Moderate Scenario in 2050 are even higher than the overall energy security risk 2015.

At present, the Taiwan government has decided to perform 2025 nuclear-free homeland policy objectives, which means the power generation portfolio by 2025 will be: coal 30%, gas 50%, renewable energy 20%. With this power generation portfolio, nuclear energy is excluded, coal-fired power generation is reduced, gas-fired power generation and renewable energy are widely used. However, from the energy security point of view, heavily relying on a particular power generation will worsen the energy import risk exposure, which has been in serious condition. Massively using gas-fired power generation will induce short spare storage period and international natural gas price volatility issues. Excluding nuclear power and reducing coal-fired power generation will cause base load power shortage issues. Massively increasing renewable energy will cause deterioration of power quality and high electricity price issues. Based on the preliminary results, the suggestion can be proposed: the energy policy with diversity consideration should be taken into account.

Acknowledgment

The authors are very thankful for the assistance of Stephen Eule, Vice President for Climate & Technology, Institute for 21st Century Energy, USCC, and the assistance of TIMES research team and GEMEET research team of Center of Energy Economics and Strategy Research, INER.

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附件 **4**

發表論文簡報

Computation and Analysis on Taiwan Index of Energy Security Risk

Institute of Nuclear Energy Research (INER)

The 40th Annual IAEE International Conference

Computation and Analysis on Taiwan Index of Energy Security Risk

Hui-Wen Huang
19 June, 2017

核能研究所
能源經濟及策略研究中心
Center of Energy Economics and Strategy Research

Outline

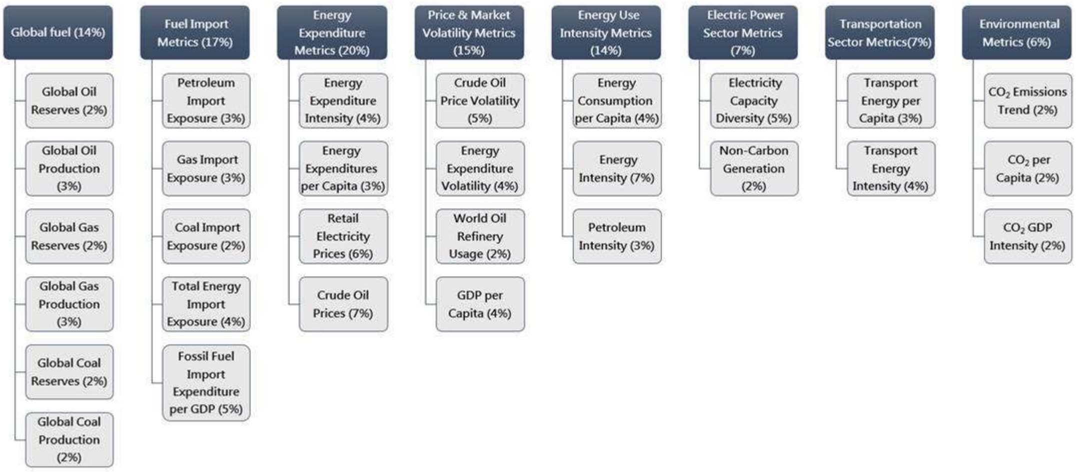
- Introduction
- Exposure of Energy Import
- Prediction for the Future Years
- Conclusions
- Suggestion

2

Introduction

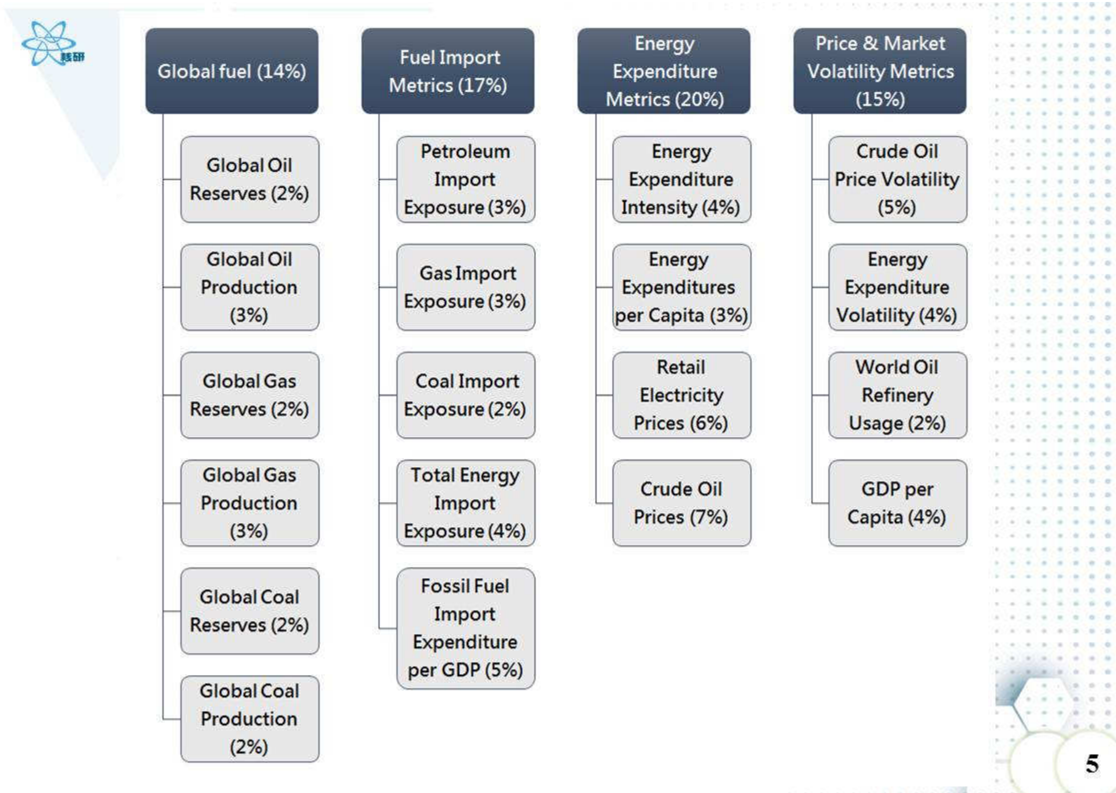
- The International Index of Energy Security Risk - by U.S. Chamber of Commerce (USCC).
- 29 indexes belong to eight categories
- Localization for these energy security risk analysis
- Taiwan's domestic data were used to perform energy security risk analysis

3

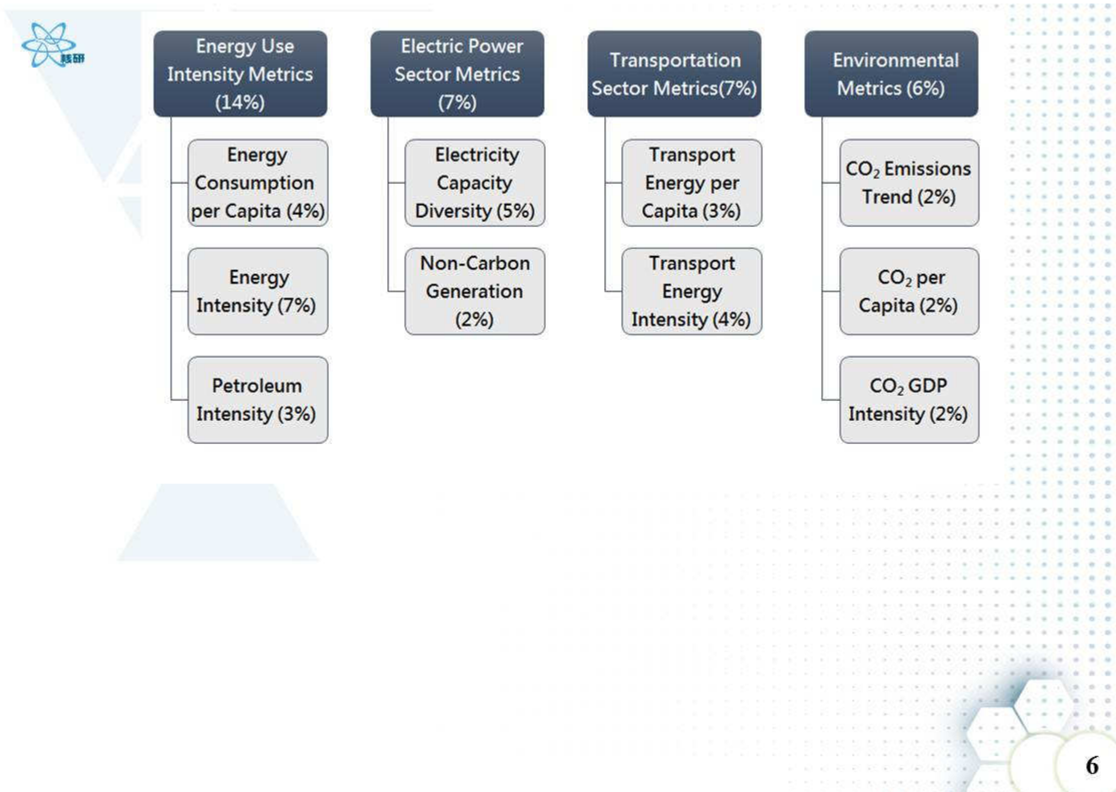


Structure of international index of energy security risk of USCC

4

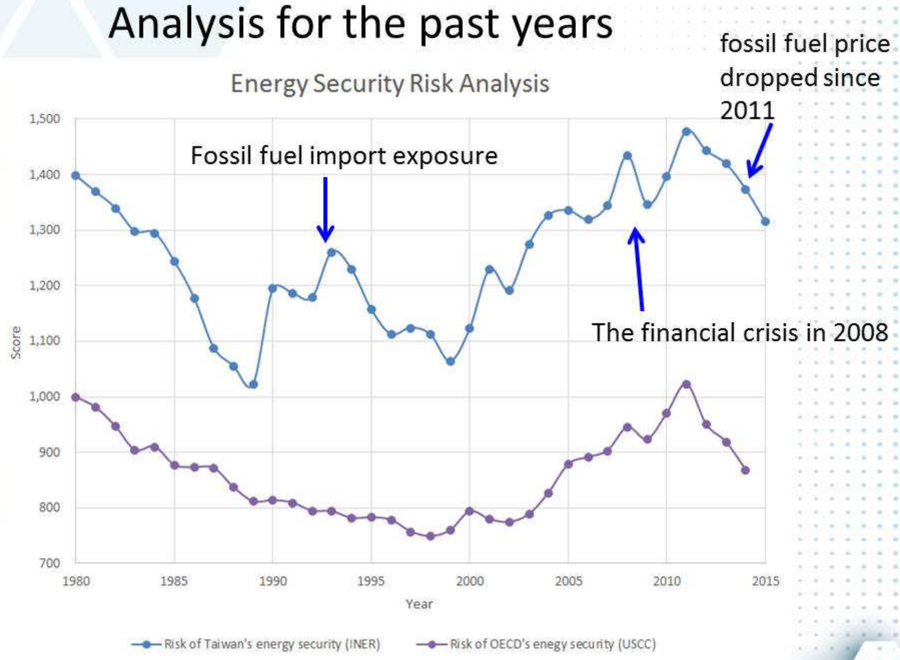


Global fuel (14%)
Global Oil Reserves (2%)
Global Oil Production (3%)
Global Gas Reserves (2%)
Global Gas Production (3%)
Global Coal Reserves (2%)
Global Coal Production (2%)
Fuel Import Metrics (17%)
Petroleum Import Exposure (3%)
Gas Import Exposure (3%)
Coal Import Exposure (2%)
Total Energy Import Exposure (4%)
Fossil Fuel Import Expenditure per GDP (5%)
Energy Expenditure Metrics (20%)
Energy Expenditure Intensity (4%)
Energy Expenditures per Capita (3%)
Retail Electricity Prices (6%)
Crude Oil Prices (7%)
Price & Market Volatility Metrics (15%)
Crude Oil Price Volatility (5%)
Energy Expenditure Volatility (4%)
World Oil Refinery Usage (2%)
GDP per Capita (4%)
5



Energy Use Intensity Metrics (14%)
Energy Consumption per Capita (4%)
Energy Intensity (7%)
Petroleum Intensity (3%)
Electric Power Sector Metrics (7%)
Electricity Capacity Diversity (5%)
Non-Carbon Generation (2%)
Transportation Sector Metrics(7%)
Transport Energy per Capita (3%)
Transport Energy Intensity (4%)
Environmental Metrics (6%)
CO_2 Emissions Trend (2%)
CO_2 per Capita (2%)
CO_2 GDP Intensity (2%)
6

Analysis for the past years



Comparison of Taiwan's energy security risk and OECD energy security risk

7

Risk Exposure of Energy Import

- Taking Diversity of Supply into account on gas, coal, and oil import
- Taiwan has been over-concentrated in a particular country in the past,
  - induced high risk of exposure of energy import for a specific period of time.
- The issue has been adequately mitigated by increasing the importing countries to enhance diversity and to reduce the risk exposure.

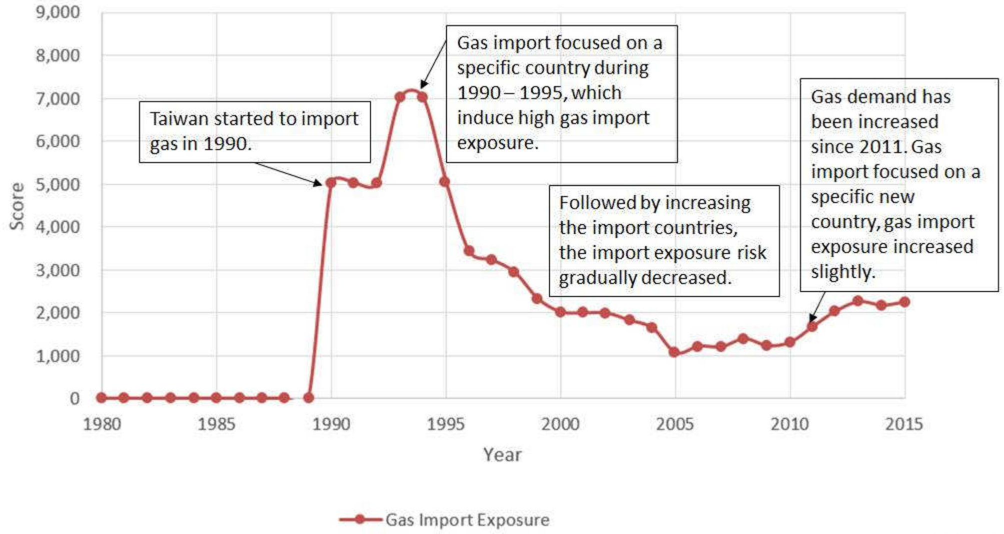
Petroleum Import Exposure (3%)

Gas Import Exposure (3%)

Coal Import Exposure (2%)

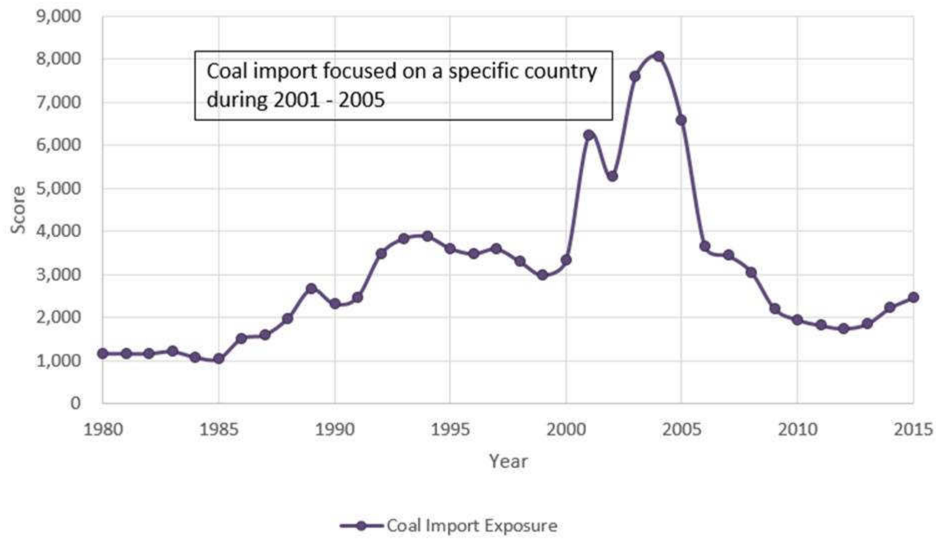
8

Energy Security Risk Analysis



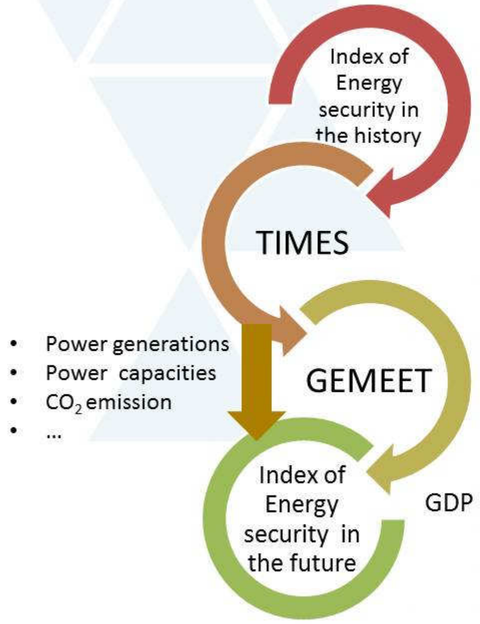
Gas Import Exposure results analyzed by INER

Energy Security Risk Analysis



Coal import exposure results analyzed by INER

Prediction for the Future Years



- **TIMES model** predicts the basic data of the scenarios
- **GEMEET model** calculates GDP based on the electricity demand from TIMES model.
- Analyzing the energy security risks of Taiwan's domestic energy security risks indexes for the future years

Combining the USCC energy security indexes with TIMES and GEMEET model

11

Prediction for the Future Years

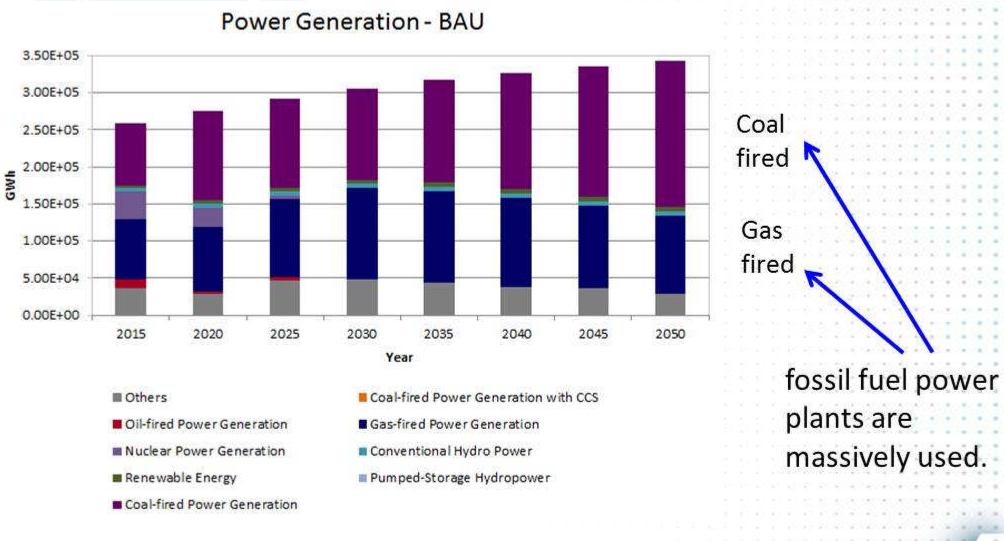
- Scenarios:
  - Business as usual (BAU)
  - Optimistic Scenario
  - Moderate Scenario
- Optimistic Scenario and Moderate Scenario - in compliance with
  - Intended Nationally Determined Contribution (INDC)
  - Greenhouse Gas (GHG) Reduction Act

12

Prediction for the Future Years

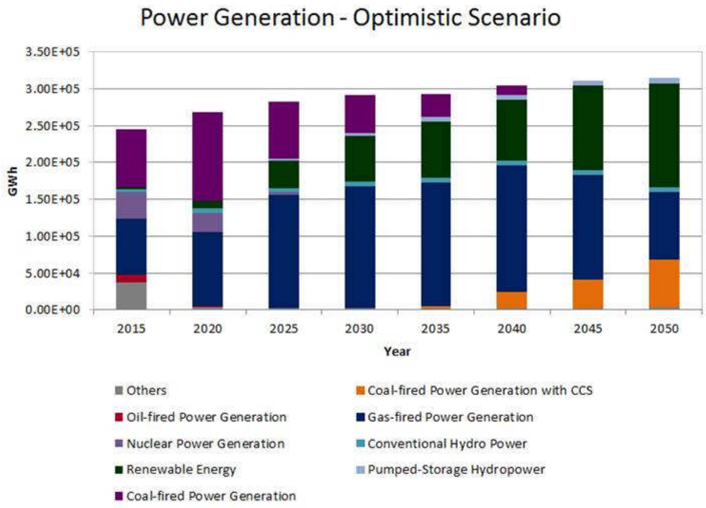
- Greenhouse gas emissions reduction policies in Taiwan
  - Intended Nationally Determined Contribution (INDC)
    - in 2030, greenhouse gas emissions are to be 50 % lower than their projected level (BAU)
  - Greenhouse Gas (GHG) Reduction Act
    - in 2050, greenhouse gas emissions are to be 50 % lower than greenhouse gas emissions in 2005

13



Power generation for BAU

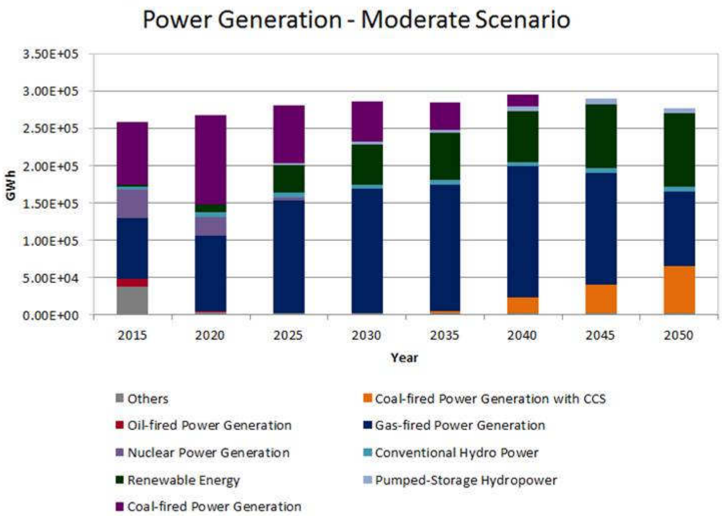
14



Power generation for Optimistic Scenario

- Maximized renewable energy
  - By 2050, PV 44 GW , offshore wind power 15 GW
- Gas-fired power generation
- Coal-fired power plants with carbon capture and storage (CCS)
- Reduce power demand
- to achieve CO_2 emission reduction policy

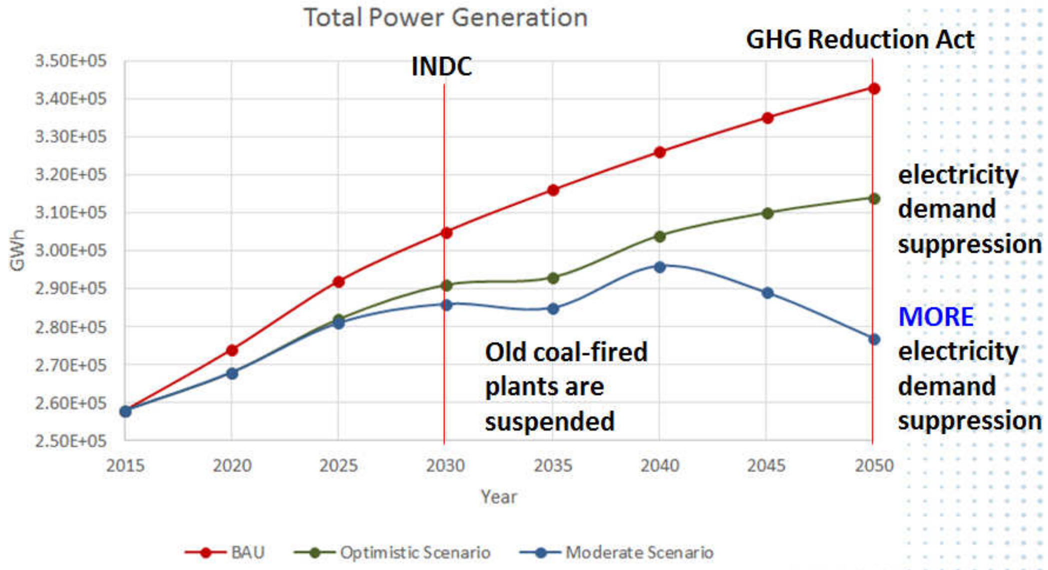
15



Power generation for Moderate Scenario

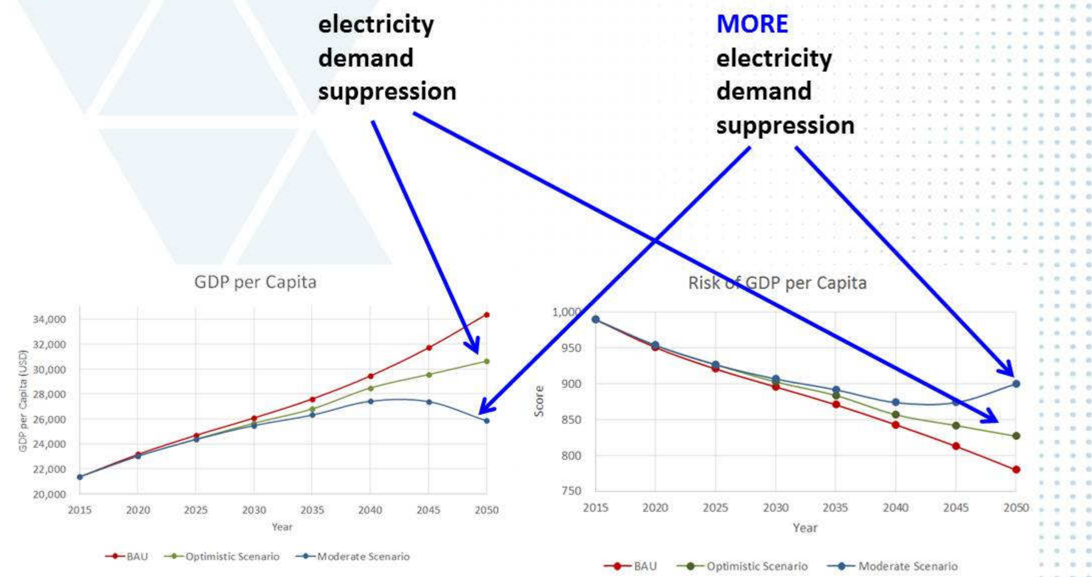
- Limited renewable energy
  - By 2050, PV 30 GW , offshore wind power 9 GW
- Gas-fired power generation
- Coal-fired power plants with carbon capture and storage (CCS)
- Reduce MORE power demand
- to achieve CO_2 emission reduction policy

16



Comparison of BAU, Optimistic Scenario and Moderate Scenario on total power generation for future years

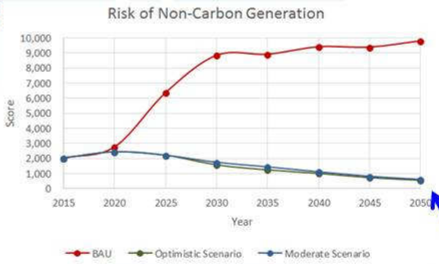
17



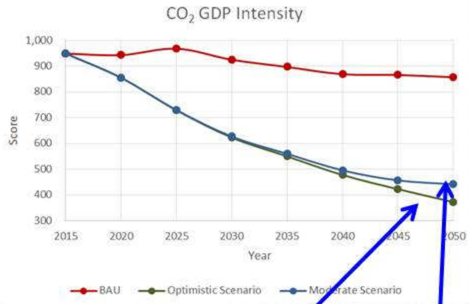
Comparison of BAU, Optimistic Scenario and Moderate Scenario on GDP per Capita for future years

Comparison of BAU, Optimistic Scenario and Moderate Scenario on the Risk of GDP per Capita for future years

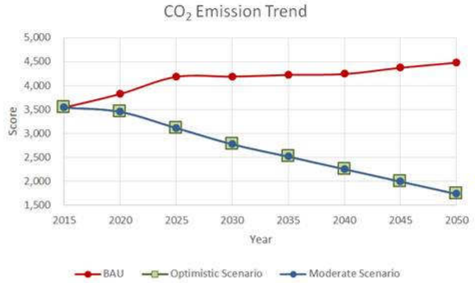
18



Comparison of BAU, Optimistic Scenario and Moderate Scenario on the Risk of Non-Carbon Generation for future years



Comparison of BAU, Optimistic Scenario and Moderate Scenario on the risk of CO_2 GDP intensity for future years



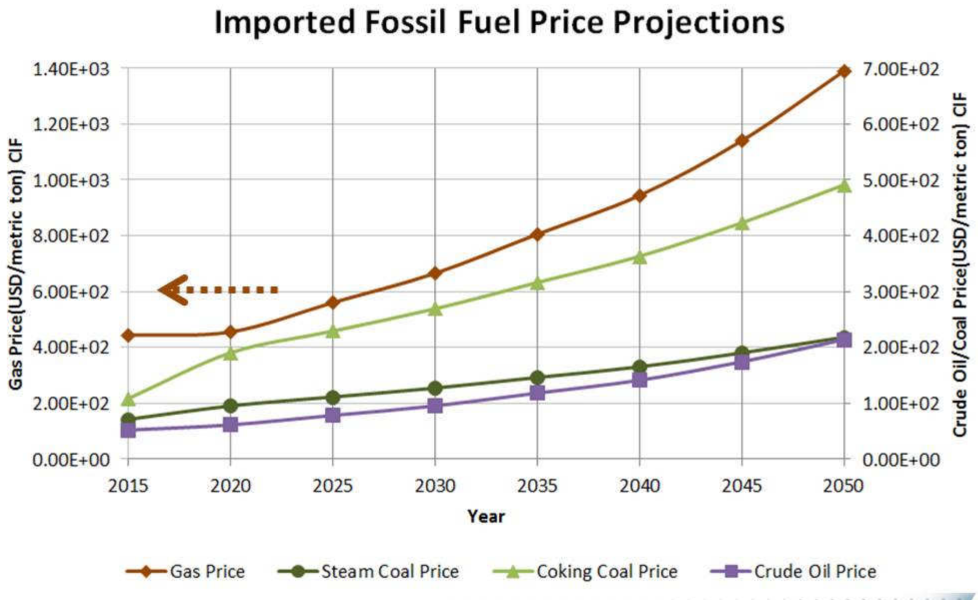
Comparison of BAU, Optimistic Scenario and Moderate Scenario on the Risk of CO_2 Emissions Trend for future years

To fulfill GHG reduction act

Moderate Scenario-

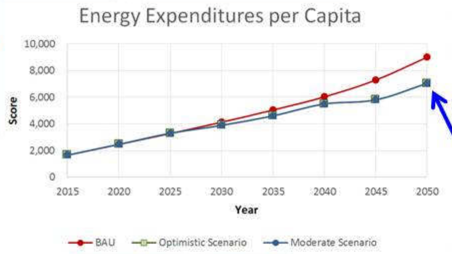
- **electricity demand suppression**
- **Lower GDP**

19

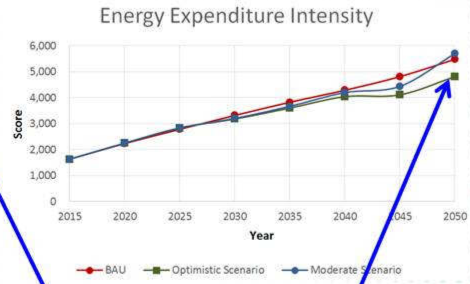


Imported fossil fuel price projections

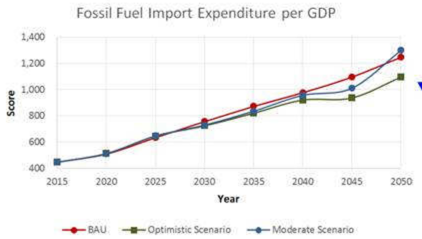
20



Comparison of BAU, Optimistic Scenario and Moderate Scenario on the risk of Energy expenditures per capita for future years



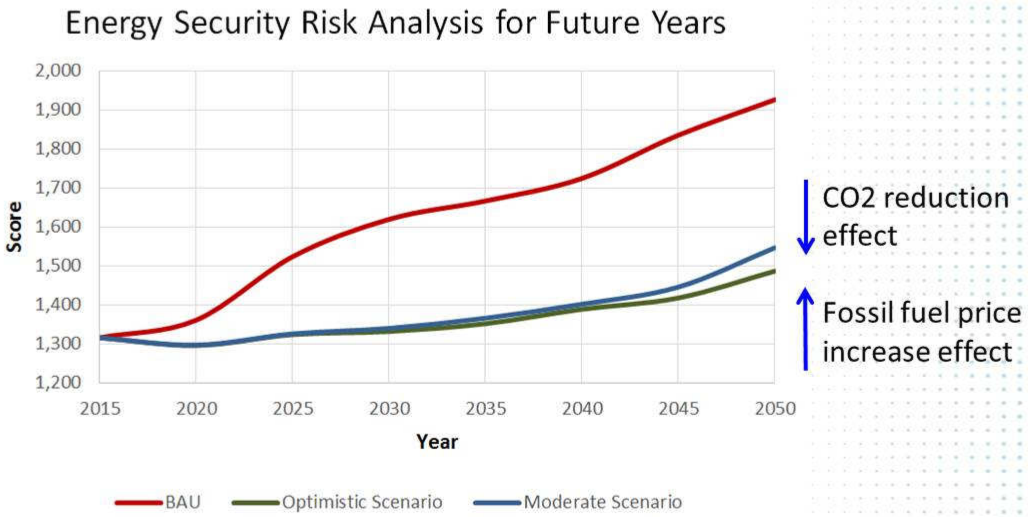
Comparison of BAU, Optimistic Scenario and Moderate Scenario on the risk of energy expenditure intensity for future years



Comparison of BAU, Optimistic Scenario and Moderate Scenario on the risk of fossil fuel import expenditure per GDP for future years

The effect of fossil fuel price increase

21



Comparison of BAU, Optimistic Scenario and Moderate Scenario on energy security risk analysis for future years

22

Conclusions

- Heavily relying on a particular power generation will **worsen the energy import risk exposure.**
- Massively increasing renewable energy will cause **deterioration of power quality** and **high electricity price issues.**
- Using **renewable energy** requires **gas fired power plant** to compensate the instability.

23

Conclusions

- Massively using gas-fired power generation will induce **short spare storage** issue.
- **Fossil fuel price** will rise in decades which will induce economic issue.
- Excluding **nuclear power** and reducing **coal-fired** power generation will cause **base load power shortage issues**.

24

Suggestion

- The energy policy with **diversity** consideration should be taken into account.

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