

出國報告（出國類別：其他）

應邀赴韓國參加 AFORE 2015 與發表 邀請演講出國報告

服務機關：核能研究所

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派赴國家：韓國

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摘 要

本次公差主要係應韓國能源研究所 (KIER) 邀請，赴韓國濟州參加 AFORE 2015 (The 5th Asia-Pacific Forum on Renewable Energy) 研討會，擔任 Clean Coal Technology (CCT) & Carbon Capture and Storage (CCS) 場次之特邀請者 (Invited Speaker)，並發表專題演講。

AFORE 2015 由韓國新及再生能源學會 (KSNRE) 主辦，主題領域涵蓋太陽能、風能、智慧電網、氫能、淨煤及二氧化碳捕捉與封存等。本案之心得及建議簡要說明如下：AFORE 大會從技術與經濟研究結果、政策、策略及商業角度進行報告及討論，其議題涵蓋核研所科專計畫的主要內容，具備未來性與競爭力；顯示本所能源技術開發計畫符合國際主流趨勢，值得持續推動。韓國能源研究所為韓國能源科技研究之主要推動機構，而大會籌備委員會主席強調該所之領域與本所淨碳計畫相當契合，建議未來或可形成國際合作之重點技術研究團隊。

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一、目的

為推動國家減碳政策，政府積極建構低碳能源發展藍圖；同時，透過國際共同研發，引進淨煤技術及發展碳捕捉與封存，降低國內能源系統的碳排放。核能研究所（以下稱本所）目前亦積極進行能源國家型科技計畫領域之「淨碳技術發展」研究計畫，並配合能源局能專計畫項下之「潔淨低碳多元應用暨氣體處理技術發展」計畫，冀望從永續發展觀點推動自主性潔淨能源技術之建立。有鑑於為有效掌握國際潔淨能源議題，本次公差主要係應韓國能源研究所 (Korea Institute of Energy Research, KIER) 邀請，赴韓國濟州 (JEJU) 參加 AFORE 2015 (The 5th Asia-Pacific Forum on Renewable Energy) 研討會，擔任 Clean Coal Technology (CCT) & Carbon Capture and Storage (CCS) 場次之特邀講者 (Invited Speaker)，並發表專題演講。

AFORE 是亞太地區新及再生能源技術領域之年度國際盛會，第五屆大會由韓國新及再生能源學會 (Korean Society for New and Renewable Energy, KSNRE) 主辦；於 2015 年 11 月 4 日至 7 日於韓國濟州 (JEJU) 舉行；會議主題是關於再生能源面對能源價格激進變化的時代，從技術與經濟研究結果、政策、策略及商業角度進行報告及討論。本次會議主題涵蓋太陽能、風能、智慧電網、氫能、淨煤及二氧化碳捕捉與封存等議題，為掌握低碳能源發展最新研發現況之重要場合。今年 AFORE 與 KSNRE 秋季年會同地舉行，議程互有重疊；依據大會資料，參與大會共計有來自 21 國家在低碳潔淨能源、新及再生能源技術等重點研究領域之學者、專家超過 500 人，顯見會議之國際參與性。

本所目前正積極進行「淨碳技術發展」相關研究計畫，計畫成果績效已逐漸受到國際學者專家之認可與肯定。本年度 AFORE 大會之 CCT & CCS 場次由 KIER 負責籌備，該場次之主席 Dr. Ho-Jung RYU 邀請筆者擔任特邀講者，並就國內有關淨煤及二氧化碳捕捉與封存等領域之發表專題演講。故本所派員參與會議，筆者便以 “Status Quo for the Development of Carbon Capture Storage and Utilization Technologies in Taiwan” 為題發表邀請演講，並與國際學者專家討論、分享核研所近年來在淨碳技術的研究成果。藉此專業技術交流場合，得以掌握國際間新及再生能源技術未來面臨之挑戰、熱能儲存之發展與趨勢、長程之能源展望等，拓展與國際學者專家之關係及國際合作。

其次，大會亦邀請與會的 VIP 貴賓共聚一堂，提供相互認識與交流之場合。另外，經由與相關研究人員交流，可望拓展與亞洲能源學者專家之人脈及國際合作。故本所此

次派員赴韓國公差乃為拓展國際人脈、推動國際合作及實務驗證專業工程技術之甚佳機會。

二、過 程

(一) 公差行程

本次公差自民國 104 年 11 月 03 日至 11 月 06 日止，共計 4 天 (圖 II-0)。

- 11 月 03 日(星期二) 自台灣桃園機場 (TPE) 出發，抵達韓國濟州 (CJU) 國際機場，轉乘機場運航巴士，抵達會議場所
- 11 月 04 日(星期三) ~ 11 月 05 日(星期四) 停留濟州
辦理會議註冊，出席 AFORE 2015 (The 5th Asia-Pacific Forum on Renewable Energy) 國際會議，發表邀請演講
- 11 月 06 日(星期五) 濟州 (CJU) 國際機場搭機，返回台灣桃園 (TPE) 國際機場，返抵台北

(二) 第五屆亞太再生能源論壇 (The 5th Asia-Pacific Forum on Renewable Energy, AFORE 2015)

AFORE 是由韓國新及再生能源學會 (KSNRE) 發起主辦，為亞太地區新及再生能源技術領域之年度國際盛會；第五屆大會於 2015 年 11 月 4 日至 7 日於韓國濟州 (JEJU) 舉行 (圖 II-1 ~ II-2)，會議主題涵蓋太陽能、風能、智慧電網、氫能、淨煤及二氧化碳捕捉與封存等議題。今年 AFORE 與 KSNRE 秋季年會聯合大會共計有來自 21 國家在相關重點研究領域之學者、專家、研究生等超過 500 人參與。

AFORE 2015 之議程如表 II-1 所示，會議自 11 月 4 日 (星期三) 開始註冊，並於當天開始 KSNRE 秋季年會。星期四早上開始進行 AFORE 之會議議程，安排上、下午各分為兩個時段，同時各有八個平行場次之口頭論文發表。壁報論文則分為兩個時段，於星期四、五在會場大廳展示，從上午 11:00 開始 12:00 作者須在現場解說。而在星期六當天則安排技術參訪行程。大會之會議議程有別於一般研討會，全體會議 (Plenary Session) 在第一天下午舉行，安排三場 Keynote 演講；而開幕典禮則安排在傍晚，隨後晚上舉行大會歡迎晚宴。

大會涵蓋的領域列舉如下：

1. Photovoltaics
2. Solar Thermal
3. Wind Energy
4. Bioenergy
5. Marine Energy
6. Geothermal Energy
7. Small Hydro Power
8. Waste Energy & Utilization
9. Hydrogen & Fuel Cell
10. Low Carbon Technology
11. Policy, Strategy & New Business
12. Energy Storage System
13. Smart Grid
14. CCT & CCS

筆者在韓國的公差行程於 11 月 5 日告一段落，次日（星期五）即自濟州 (CJU) 國際機場搭機，返回台灣桃園 (TPE) 國際機場，結束本次公差行程。

§II 有關 2015 KR 公差行程之圖表

表 II-1 : AFORE 2015 之議程

>> Forum Schedule

November 4(Wed.)								
Time	Crystalball room I	Crystalball room II	Crystalball room III	Emerald	Charlottee	Pearl	Jade	Ruby
9:00~18:00	Annual Fall Meeting of The Korean Society for New & Renewable Energy 2015							
November 5(Thur.)								
Time	Crystalball room I	Crystalball room II	Crystalball room III	Emerald	Charlottee	Pearl	Jade	Ruby
8:30~	Annual Fall Meeting of The Korean Society for New & Renewable Energy & AFORE2015 Registration							
9:00~11:00	Wind Energy I (Dr. Hyun-Goo KIM)	CCT/CCS /Low Carbon (Dr. Ho-Jung RYU/ Prof. Kwang Bok YI)	Speical Session I 'International Joint Workshop on Super Grid in Northeast Asia'				Smart Grid I (Dr. Suyong CHAE)	
11:00~12:00	POSTER DISCUSSION-1							
12:00~13:00	Lunch							
13:00~15:00	Plenary Sessions (Crystalball room) (Chair : Prof. Eunnyeong Heo)							
15:00~15:15	Break time							
15:15~17:00			Geothermal Energy I (Prof. Jong Min CHOI)	Hydrogen & Fuel Cell (Dr. Seok-Hee PARK)	Marine Energy I (Prof. Domenico COIRO)	Wasted Eenergy & Utilization I (Prof. Weilin ZHUGE/Dr. Yeon Seok CHOI)	Bio Energy I (Dr. Kyubock LEE)	
17:30~18:30	Opening Ceremony (Crystalball room) (Chair : Dr. Heon Jung)							
18:30~20:30	Banquet (Crystalball room)							

November 6(Fri.)

Time	Crystalball room I	Crystalball room II	Crystalball room III	Emerald	Charlottee	Pearl	Jade	Ruby
08:30~	AFORE2015 Registration							
09:00~10:30	Speical Session II 'New & Renewable Energy Hybrid system'	Policy, Strategy & New Business	Speical Session III 'Earth Abundant & Non-toxic Solar cell Materials and Devices'	Smart Grid II (Prof. Jee Hoon JUNG)	Hydrogen & Fuel Cell II (Prof. Kyoungyoun KIM)	Marine Energy II (Prof. Changjo YANG)	Wasted Eenergy & Utilization II (Dr. Yeon Seok CHOI)	Speical Session IV 'The Future of Mcroalgae Biorefinery'
10:30~11:00							ESS (Dr. Sun-Hwa YEON)	
11:00-12:00	POSTER DISCUSSION-2							
12:00~13:00	Lunch							
13:00~15:00	Hydro Power (Prof. Young-Do CHOI)	Wind Energy II (Prof. Bum Suk Kim)	CCT/CCS /Low Caron II (Dr. Jong-Ho MOON/Dr. Jeom-In BAEK)	Geothermal Energy II (Dr. Young-Jin BAIK)	Hydrogen & Fuel Cell III (Prof. Kyoungyoun KIM)	Marine Energy III (Prof. Changjo YANG)	Solar Thermal /Photovolt aics (Prof. Jin Hyeok Kim)	Speical Session V 'Biotechno logy for Fuels and Chemicals'
15:00~15:15	Break time							
15:15~15:40	Closing ceremony (Crystalball room I) (Chair : Dr. Heon Jung)							Bio Energy II (Dr. You-Kwan OH)

November 7(Sat.)

09:00~	Technical Tour							
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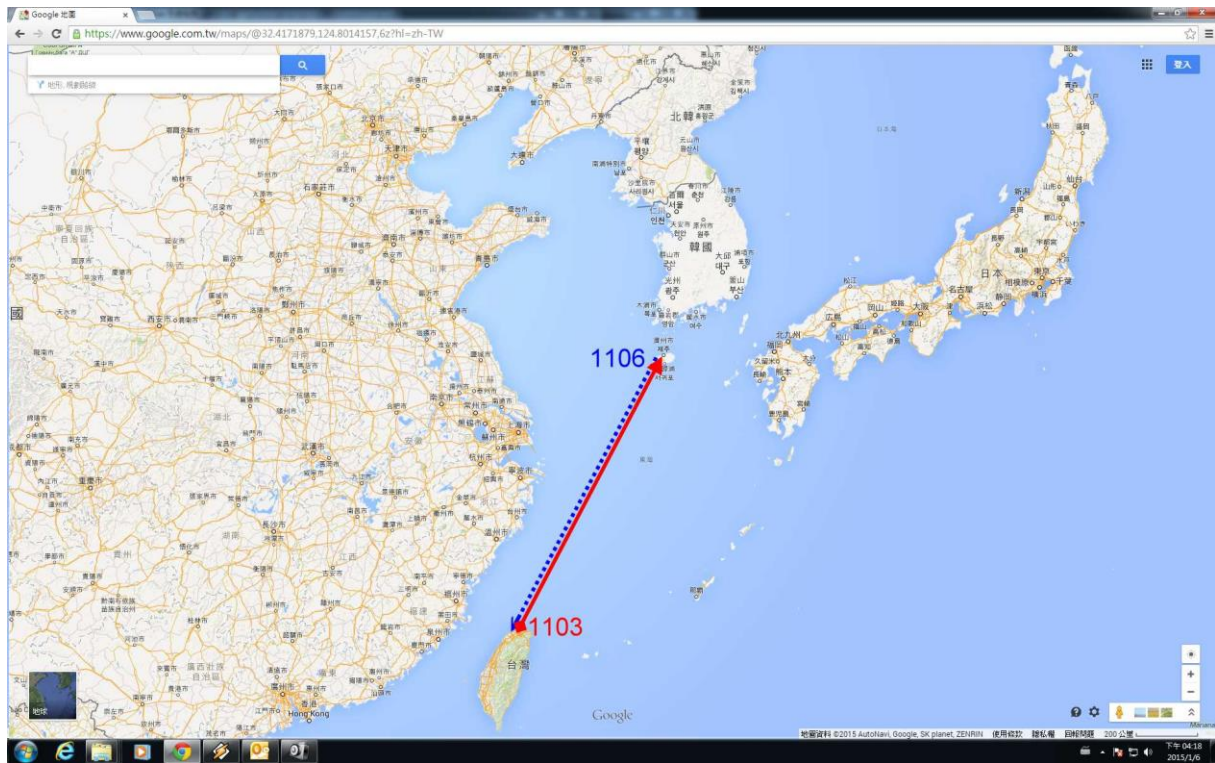


圖 II-0： 公差行程 (2015.11. 03. ~ 06.) 示意圖 (底圖取自 <https://maps.google.com.tw/>)



圖 II-1： AFORE 2015 舉辦地點旅館



圖 II-2： AFORE 2015 會場

三、心得

本次公差主要係應韓國能源研究所邀請，前往韓國濟州參加第五屆亞太再生能源論壇 (The 5th Asia-Pacific Forum on Renewable Energy, AFORE 2015)，擔任 CCT & CCS 場次之特邀講者，發表專題演講。在參與會議期間，順便聆聽會議與會者之論文發表，並與作者就相關技術等議題進行交流。本報告將依序分別選擇重點摘要於下文中。

(一) AFORE 2015 大會議程

第五屆亞太再生能源論壇 (AFORE 2015) 於 2015 年 11 月 4 日至 7 日在韓國濟州 (JEJU) 舉行 (圖 III-1 ~ III-3)，由韓國新及再生能源學會 (KSNRE) 主辦；並聯合數個亞洲與國際相關學會協助舉辦，包含 World Renewable Energy Network (WREN)、Japan Renewable Energy Council (JREC)、China Renewable Energy Society (CRES)、Chinese Society of Engineering Thermo-physics (CSET)、Guangzhou Institute of Energy Conversion (GIEC) 等。這個聯合活動的目的是提供工程師、研究人員、教授、學生和其他人的平台，展示他們的最新成果、交換想法、建立新的聯繫、建立新的合作關係等。大會議題涵蓋新及再生能源領域的技術和工程實務，包括目前的發展趨勢和未來的規畫與需求。

AFORE 2015 會議排程自 11 月 4 日 (星期三) 揭開序幕，與會者於當天開始報到 (圖 III-4)；並於當天開始 KSNRE 秋季年會，而 AFORE 之會議議程則自星期四早上開始進行。大會的開幕典禮於 11 月 5 日 (星期四) 傍晚舉行，首先由大會主席致詞歡迎各國與會嘉賓 (圖 III-5 ~ III-6)；隨後，數位貴賓輪流上台致詞，並由主辦單位進行學會頒獎活動 (圖 III-7 ~ III-12)。其次，下屆大會預定於明年移師中國廣州舉辦 (圖 III-13)。

本屆大會的技術議程自 11 月 5 日 (星期四) 早上開始舉行，分為全體會議 (Plenary Session)、論文口頭發表、及壁報論文展示三部分，將分章節依序描述於本報告中。

1. Plenary Sessions

大會的全體會議 (Plenary Session) 在星期四下午舉行 (圖 III.1.1-1 ~ III.1.1-2)，共安排三場 Keynote 演講；各應邀講員之資料與講題列舉如下：

Plenary Sessions (Chair: Prof. Eunnyeong Heo)

P1- DEEP DECARBONATION - THE MOST PRESSING CHALLENGE OF THE '2030 AGENDA'

Dr. Soogil Young

Research Professor of Green Growth and Sustainable Development KDI School of Public Policy Management; Director, Sustainable Development Solutions Network (SDSN), Korea

P2- LONG TERM ENERGY OUTLOOK OF JAPAN

Prof. Gento Mogi

University of Tokyo, Japan

P3- RECENT ADVANCES IN THERMAL ENERGY STORAGE USING PHASE CHANGE MATERIALS

Prof. Yogi Goswami

University of South Florida / Editor-in-Chief of Solar Energy, USA

本報告將選擇較屬策略性、概觀性之演講依序分別摘要重點於下文中。

(1) DEEP DECARBONATION - THE MOST PRESSING CHALLENGE OF THE '2030 AGENDA' (圖 III.1.1-3 ; 圖 III.1.1-4 ~ III.1.1-26)

十一月五日下午大會演講 (Plenary lecture) 的首位演講者 Prof. Soogil Young 為韓國 Sustainable Development Solutions Network (SDSN) 的 Director (圖 III.1.1-3)。該演講之內容主要係闡述在變動的大環境下聯合國推動「2030 議程」之發展，尤其深度減碳將是最迫切的挑戰，其重要資料摘要如圖 III.1.1-4 ~ III.1.1-26 所示，而重點主要涵蓋下列議題：

- A. Title of presentation (圖 III.1.1-4) ;
- B. UN '2030 AGENDA' (圖 III.1.1-5 ~ III.1.1-7) ;
- C. The 2°C challenge (圖 III.1.1-8 ~ III.1.1-10) ;
- D. DDPs (圖 III.1.1-11 ~ III.1.1-14) ;
- E. An illustrative exploration of DDPs in Korea (圖 III.1.1-15 ~ III.1.1-22) ;
 - a. Prospect (圖 III.1.1-15) ;
 - b. Mission and target (圖 III.1.1-16) ;

- c. Solutions (圖 III.1.1-17) ;
- d. Emissions (圖 III.1.1-18 ~ III.1.1-22)
- F. Three scenarios (圖 III.1.1-23 ~ III.1.1-25) ;
- G. Utilize DDP analysis (圖 III.1.1-26).

聯合國自 2014 年起推動「2030 議程」，揭諸了 17 項「永續發展目標 (SDGs, Sustainable Development Goals)」，其主旨係要終結貧窮、轉化生活方式、與保護地球 (Source: <https://sustainabledevelopment.un.org/post2015/transformingourworld>)。在全體 SDGs 中，公認最迫切的挑戰乃是深度減碳 (Deep Decarbonization) 議題；因此，目前許多國家正積極進行永續發展的專案 DDPP (Deep Decarbonization Pathways Project)。該演講闡述了 DDPP 之主要內容，並以韓國的探索實例加以說明。總結再摘要整理如何運用 DDP 分析之措施。此議題對我國落實「溫室氣體減量法」之目標具有指標性參考價值，值得吾人深思。

(2) LONG TERM ENERGY OUTLOOK OF JAPAN (圖 III.1.1-27 ; 圖 III.1.1-28 ~ III.1.1-44)

大會演講的第二位演講者 Prof. Gento Mogi，任職於日本 University of Tokyo (圖 III.1.1-27)。該演講之內容主要係闡述日本的長程能源展望，其重要資料摘要如圖 III.1.1-28 ~ III.1.1-44 所示，而重點主要涵蓋下列議題：

- A. Title of presentation (圖 III.1.1-28) ;
- B. Strategic energy plans (圖 III.1.1-29 ~ III.1.1-31) ;
- C. Issues changed since 2014 (圖 III.1.1-32 ~ III.1.1-35) ;
- D. Basic viewpoints of energy policy (圖 III.1.1-36 ~ III.1.1-40) ;
 - a. Energy demand in 2030 (圖 III.1.1-37) ;
 - b. Primary energy supply in 2030 (圖 III.1.1-38) ;
 - c. Primary energy mix in 2030 (圖 III.1.1-39) ;
 - d. Constitute of renewable energy in 2030 (圖 III.1.1-40) ;
- G. Wind and solar PV outlook (圖 III.1.1-41 ~ III.1.1-43) ;
 - a. Land category (圖 III.1.1-42).
 - b. Potential of wind and PV (圖 III.1.1-43).

H. Scheduled decommissioning of existing reactors (圖 III.1.1-44).

日本在本世紀初即制訂了能源策略規畫 (Strategic Energy Plan)，並定期修正；而自 311 福島事件後，主、客觀環境都面臨急遽的變化。該演講闡述了日本的長程能源展望之主要內容，而其基本觀點是實踐「3E + S」能源政策；更明確言之，能源安全乃為主要前提。另外，講者最後附帶提及日本現役核能反應爐之除役規畫時程。本演講所揭諸之理念與措施頗具參考價值，值得國內制訂者深思。

(3) RECENT ADVANCES IN THERMAL ENERGY STORAGE USING PHASE CHANGE MATERIALS (圖 III.1.1-45；圖 III.1.1-46~ III.1.1-70)

大會演講的第三位演講者 Prof. Yogi Goswami 任職於美國 University of South Florida，為 J. of Solar Energy 的主編 (圖 III.1.1-45)。該演講之內容主要係闡述在熱能儲存技術之發展，其重要資料摘要如圖 III.1.1-46~ III.1.1-70 所示，而重點主要涵蓋下列議題：

- A. Title of presentation (圖 III.1.1-46)；
- B. Energy storage options (圖 III.1.1-47 ~ III.1.1-48)；
- C. CSP (concentrated solar power) technologies (圖 III.1.1-49)；
- D. Cost issues (圖 III.1.1-50 ~ III.1.1-51)；
- E. Thermal Energy Storage (圖 III.1.1-52 ~ III.1.1-55)；
 - a. Sensible heat storage (圖 III.1.1-53)；
 - b. Latent heat TES (圖 III.1.1-54 ~ III.1.1-55)；
- F. Recent developments of PCMs (圖 III.1.1-56 ~ III.1.1-66)；
 - a. PCMs (phase change materials) properties (圖 III.1.1-57 ~ III.1.1-58).
 - b. Encapsulation of PCM pellets (圖 III.1.1-59 ~ III.1.1-62).
 - c. Cyclic performance (圖 III.1.1-63).
 - d. High-temperature PCMs (圖 III.1.1-64 ~ III.1.1-65).
 - e. Lab-scale test system (圖 III.1.1-66)；
- G. Geothermal energy: storage and transportation (圖 III.1.1-67 ~ III.1.1-68)；
- H. Summary & conclusions (圖 III.1.1-69).

鑑於再生能源的間歇性缺點，能源儲存技術乃為再生能源普及發展之關鍵因素。該演講之內容主要係闡述相變化材料 (phase change materials, PCMs) 在熱能儲存技術之最新發展，預期可將熱能儲存 (Thermal Energy Storage, TES) 系統之成本大幅降低至現值之 40% 以下。其次，該類材料亦可應用於其他傳統產業中，未來潛勢可期。

2. Oral Paper Sessions

AFORE 議程每天上、下午各分為兩個時段，分別安排口頭論文發表與壁報論文展示；前者同時各有數個平行場次，各排定至多八場專題演講 (Lecture)。由於 KSNRE 秋季年會在 11 月 5 日 (星期四) 仍分享會場 (圖 III.1.2-1)，故上、下午各安排有 4、5 個平行場次；而在 11 月 6 日 (星期五)，則於上、下午各安排有 8 個平行場次 (表 II-1)。技術議題涵蓋前述十四項領域，其口頭論文篇數超過 150 篇。基於篇幅考量，本報告中摘錄了數場相關的代表性論文加以陳述之。

(1) 本所在此次 AFORE 大會中發表之邀請演講 (圖 III.1.2-2；圖 III.1.2-3 ~ III.1.2-26)

本次 AFORE 大會議程 (11 月 4 日至 7 日) 與在國內舉辦的化工年會暨台日韓三國聯合化工會議 (11 月 5 日至 7 日) 衝堂，而筆者必須於 11 月 7 日 (星期六) 在後者之 NEP-II 淨煤主軸成果發表會上演講，故行程之安排頗費周章。經與大會協調後，籌備委員會乃將 CCT & CCS 的第一場次安排在 11 月 5 日 (星期四) 上午，並由筆者擔任首位演講者 (圖 III.1.2-2)，場地則在口頭論文發表會場之主要演講廳 (Crystalball room III)。筆者演講內容之重要資料摘要如圖 III.1.2-3 ~ III.1.2-26 所示。

筆者之簡報亦獲得在場韓國與會者之熱烈回應討論。大會籌備委員會主席鄭憲博士 (Dr. Heon Jung, Principal Researcher, KIER) 表示，自筆者之簡報獲悉 INER 之研發領域與 KIER 之工作具有高度協合性，希望未來兩單位能有機會合作；他亦誠摯邀請筆者前往參訪，以進一步交流。

(2) 此次 AFORE 大會中發表之相關的代表性論文

論文 # IN-CCT&CCS-2：本論文由 Pacific Northwest National Lab. (PNNL) [USA] 的研究人員發表 (圖 III.1.1-27)，演講主題為 “**INNOVATION IN CATALYSIS AND REACTION ENGINEERING FOR THE CONVERSION OF**

BIOMASS INTERMEDIATES TO FUELS”，屬於生質物轉化為燃料領域。演講內容摘要如圖 III.1.1-28 ~ III.1.1-50 所示。

論文 # O-CCT&CCS-1：本論文由 Korea Institute of Industrial Technology, [Korea] 的研究人員發表，演講主題為 **“PERFORMANCE EVALUATION OF AN CCS-DEDICATED POWER GENERATION SYSTEM - PRESSURIZED OXYFUEL COMBUSTION”**，屬於 Oxyfuel 領域。演講內容摘要如圖 III.1.1-51 ~ III.1.1-62 所示。

論文 # O-CCT&CCS-2：本論文由 Sungkyunkwan University [Korea] 的研究人員發表，演講主題為 **“CFD SIMULATIONS ON COMBUSTION, HEAT TRANSFER AND NO_x EMISSIONS IN 100 MWe OXY-COAL FURNACE”**，屬於 Oxyfuel 領域。演講內容摘要如圖 III.1.1-63 ~ III.1.1-80 所示。

論文 # O-CCT&CCS-3：本論文由 Chungnam National University [Korea] 的研究人員發表，演講主題為 **“CO₂ SORPTION MECHANISM OF A K-MG-BASED SORBENT AT HIGH PRESSURE FOR SEWGS CO₂ CAPTURE”**，屬於 CO₂ CAPTURE 領域。演講內容摘要如圖 III.1.1-81 ~ III.1.1-98 所示。

3. Poster Session

大會壁報論文發表議程安排在 11 月 5 日（星期四）與 11 月 6 日（星期五），兩天各有不同之場次（圖 III.1.3-1）；每天展示到傍晚，而討論解說時段則為上午 11:00 ~ 12:00，現場盛況如圖 III.1.3-2 ~ III.1.3-5 所示。在本屆 AFORE 大會中，壁報論文總數約 180 篇，幾乎與口頭發表論文分庭抗禮。大會壁報論文所屬的領域與篇數列舉如下：

- (1) PV: 30 篇;
- (2) ST: 8 篇;
- (3) WE: 17 篇;
- (4) BE: 24 篇;
- (5) ESS: 8 篇;
- (6) PN: 5 篇 + 13 篇;
- (7) GE: 7 篇;

- (8) HP: 3 篇;
- (9) WU: 7 篇.
- (10) HF: 35 篇;
- (11) LC: 10 篇;
- (12) SG: 12 篇;
- (13) CCT&CCS: 11 篇.

其中前六領域安排在 11 月 5 日（星期四）展示，其他則為第二天。筆者抽空參閱了壁報論文發表，以瞭解彼等在未來之研發努力及現況成果。本報告中摘錄了在第一天數篇與本組計畫較具相關性的論文展示於後（圖 III.1.3-6 ~ III.1.3-7）。

4. Technical Tours

今年 AFORE 大會於論文發表研討議程結束後，在 11 月 7 日（星期六）當天則安排技術參訪行程。筆者由於當天在臺另有行程，故未克參與。

（二）技術交流與國際學者專家人脈拓展

本所目前正積極進行「淨碳技術發展」相關研究計畫，計畫成果績效已逐漸受到國際學者專家之認可與肯定。筆者此行應 KIER 邀請為本年度 AFORE 大會之貴賓 (VIP)，擔任 CCT & CCS 場次特邀講者；就國內有關淨煤及二氧化碳捕捉與封存等領域之發表專題演講，並分享核研所近年來在淨碳技術的研究成果。在參與 AFORE 2015 會議過程中，筆者藉此專業技術交流場合，與國際學者專家討論，得以掌握國際間新及再生能源技術未來面臨之挑戰與長程之能源發展趨勢；其次，和大會邀請與會的 VIP 貴賓共聚一堂，相互認識與交流，拓展與國際學者專家之關係及國際合作。

另外，經由與相關研究人員交流，可望拓展與亞洲能源學者專家之人脈（表 III-1），有助於未來推動國際合作及實務驗證專業工程技術之機會。

§III 有關 2015 KR 公差 AFORE 之列表

表 III-1 : AFORE 2015 之學者專家

Name	Position	Affiliation	Expertise
Hyungkee YOON, Ph. D.	President	Korean Society for New and Renewable Energy (KSNRE)	Energy Policy
Heon JUNG, Ph. D.	Principal Researcher	Korea Institute of Energy Research (KIER)	Clean Energy
Ho-Jung RYU, Ph. D.	Senior Researcher	Korea Institute of Energy Research (KIER)	CCT
Seong-Ryong PARK, Ph. D.	Principal Researcher	Korea Institute of Energy Research (KIER)	Energy Efficiency
Gento MOGI, Ph. D.	Associate Professor	The University of Tokyo	Energy Policy
Heejip KIM	Visiting Professor	Seoul National University	Energy Policy
Soogab LEE, Ph. D.	Professor and Chair	Seoul National University, Dept. Mechanical & Aerospace Engr.	Mechanical Engr.
Young-Ho LEE, Ph. D.	Professor	Korea Maritime and Ocean University	Flow Informatics
Min Sung PARK, Ph. D.	Deputy Director	Korea Advanced Institute of Science and Technology (KAIST)	Biomass Energy
Jang-Ho LEE, Ph. D.	Director	KunSan National University, Center for Urban Wind Energy Sys.	Wind Energy

Won YANG, Ph. D.	Principal Researcher	Korea Institute of Industrial Technology (KITECH)	Thermochemical Energy System
Jeong Bae KIM, Ph. D.	Dept. Chair	Korea National University of Transportation	Energy System
Changkook RYU, Ph. D.	Associate Professor	Sung Kyun Kwan University	Energy Engineering
Chae Whan RIM, Ph. D.	Head	Korea Institute of Machinery & Materials (KIMM)	Technology Commercialization
Yeon-Seok CHOI, Ph. D.	Principal Researcher	Korea Institute of Machinery & Materials (KIMM)	Energy System

§III.1 有關 2015 KR 公差 AFORE 之圖像

Registration

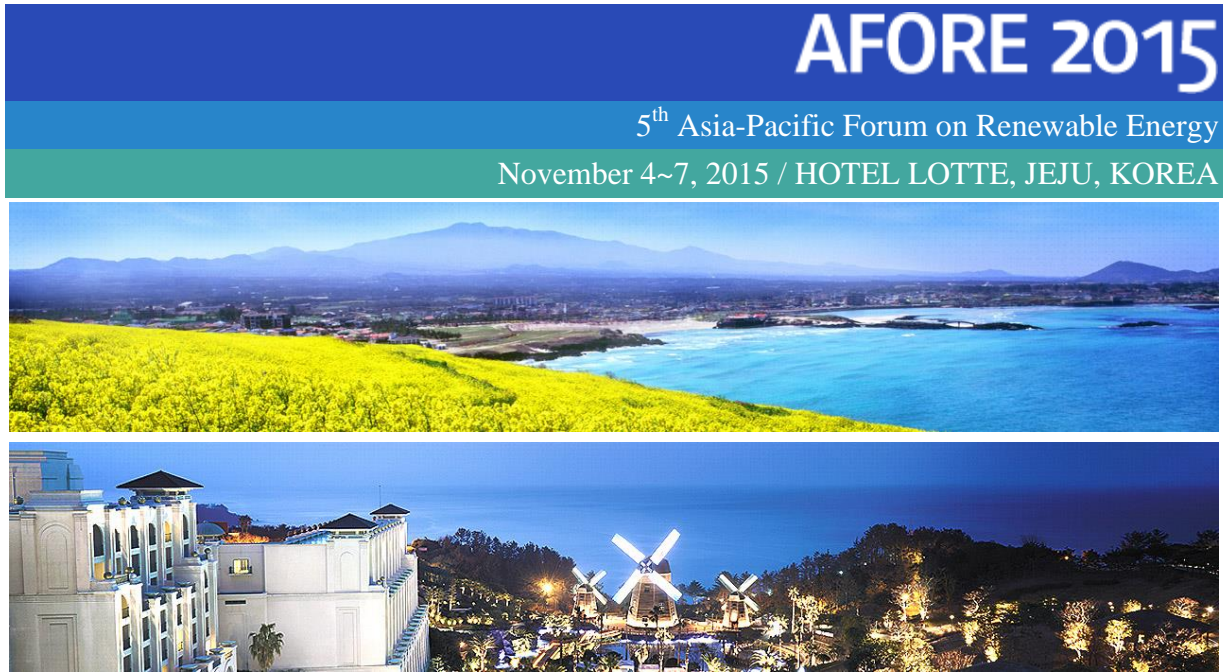


圖 III-1 AFORE 2015 大會的網頁橫幅



圖 III-2 AFORE 2015 大會會場的當地圖騰



圖 III-3 筆者攝於 AFOPRE 2015 大會會場



圖 III-4 AFOPRE 2015 大會的報到櫃臺

AFORE 2015 Opening Ceremony



圖 III-5 開幕典禮



圖 III-6 大會主席開幕致詞



圖 III-7 大會貴賓之一輪流上台致詞



圖 III-8 大會貴賓之一



圖 III-9 大會貴賓之二輪流上台致詞



圖 III-10 大會貴賓之二



圖 III-11 大會貴賓之三輪流上台致詞



圖 III-12 大會貴賓之三



圖 III-13 下屆大會舉辦資訊

1. Plenary Sessions



圖 II.1.1-1 AFORE 2015 全體會議會場景象之一



圖 II.1.1-2 AFORE 2015 全體會議會場景象之二

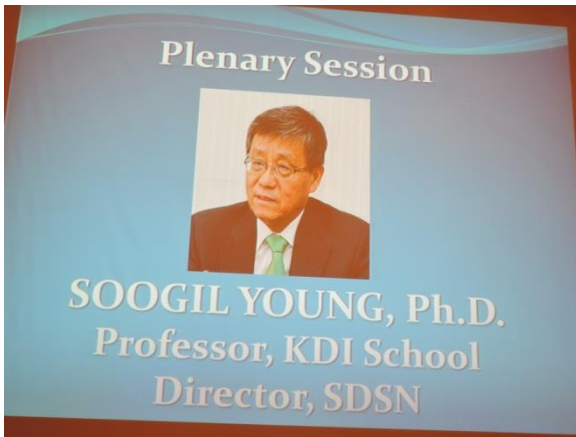


圖 III.1.1-3

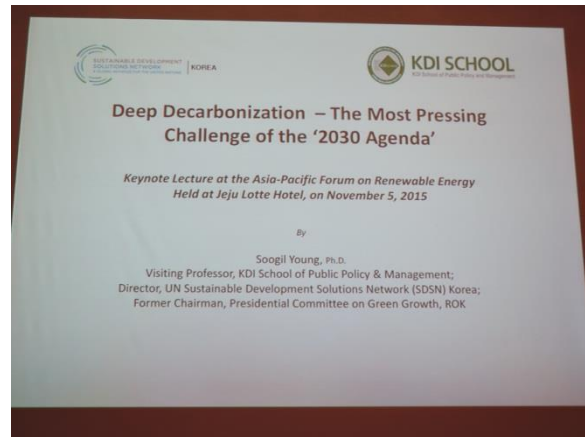


圖 III.1.1-4



圖 III.1.1-5

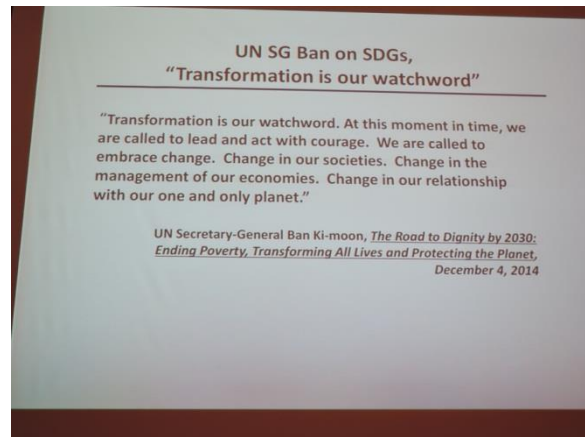


圖 III.1.1-6



圖 III.1.1-7

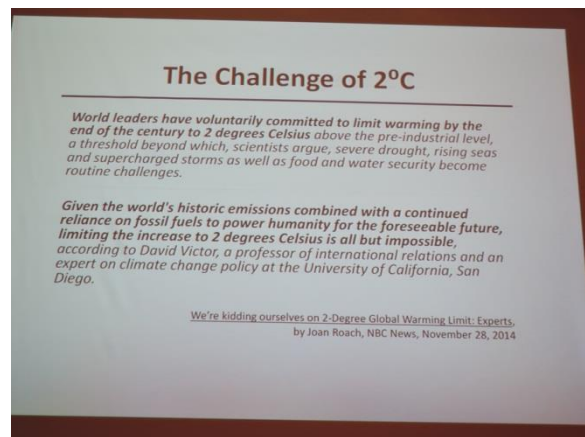


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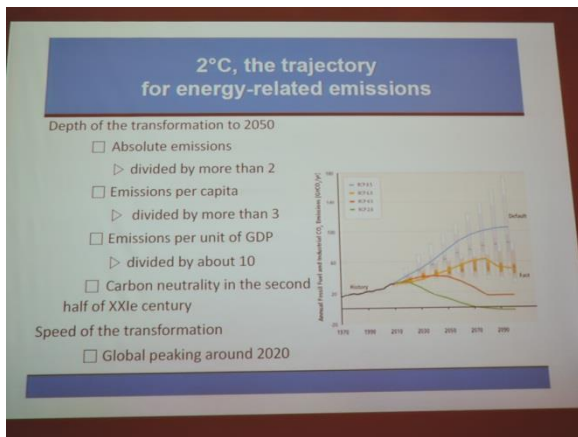


圖 III.1.1-9



圖 III.1.1-10

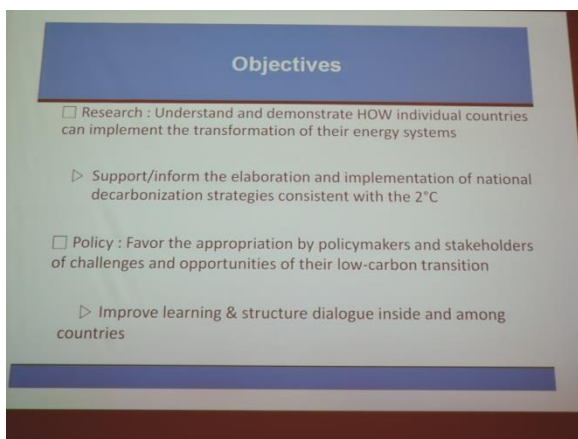


圖 III.1.1-11

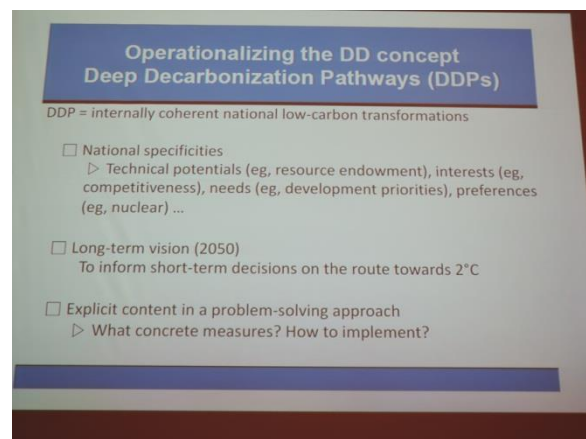


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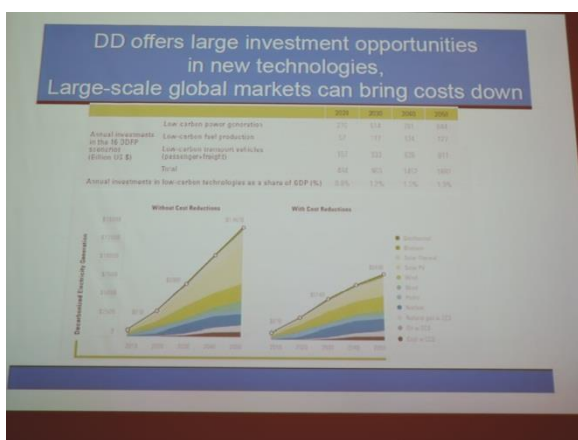


圖 III.1.1-13



圖 III.1.1-14

Prospect of Economic & Social Developments

Indicator	Unit	2010	2050
Population	Million person	49	48
GDP	SBillion (in 2005 prices)	1,015	2,754
GDP per capita	US\$/person (in 2005 prices)	20,538	57,234
Industrial value added	US\$Billion (in 2005 prices)	437	1,170
Residential floor area	Million square meters	1,173	1,017
Commercial floor area	Million square meters	694	1,510
Passenger transport	Billion kilometers traveled	485	451
Freight transport	Billion ton-kilometers	0.8	1.2

圖 III.1.1-15

Mission & Target

- How to get “an **86.3% reduction** of CO₂ emission from **fuel combustion**, falling from 556 MtCO₂ in 2010 to **76 MtCO₂ in 2050.**”
 - Key words: backcast, technology, economic growth

圖 III.1.1-16

Solutions : 3 pillar

- Energy efficiency
- Low-carbon electricity or decarbonization of electricity
- Fuel switching
 - switching of final energy to decarbonized electricity

圖 III.1.1-17

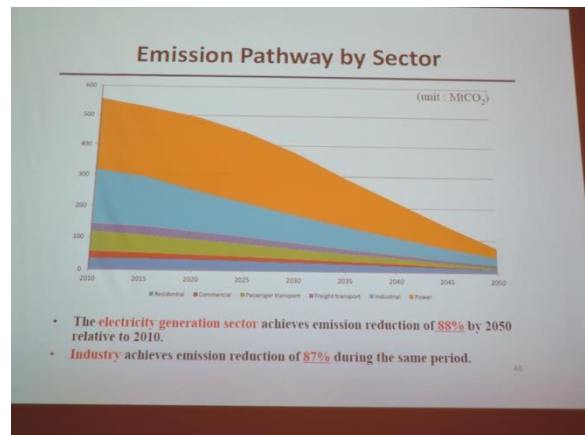


圖 III.1.1-18

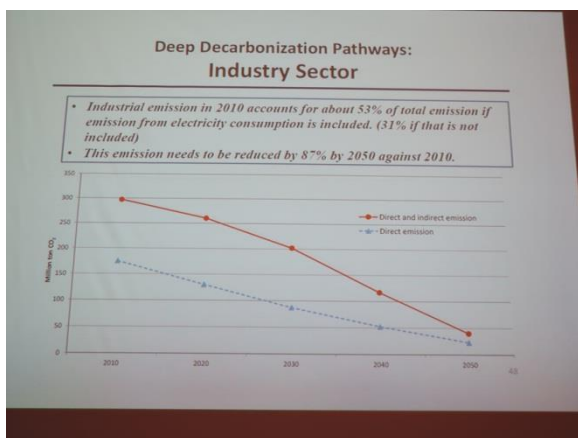


圖 III.1.1-19

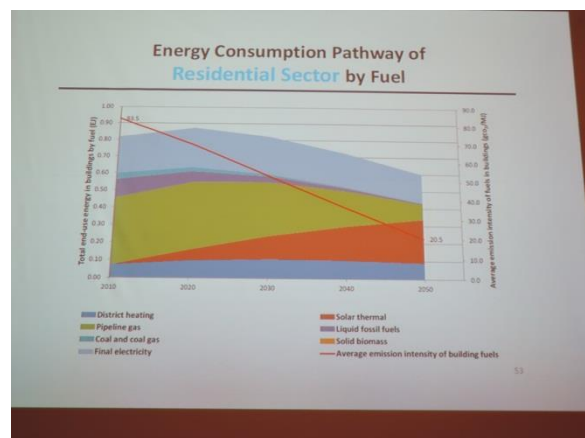


圖 III.1.1-20

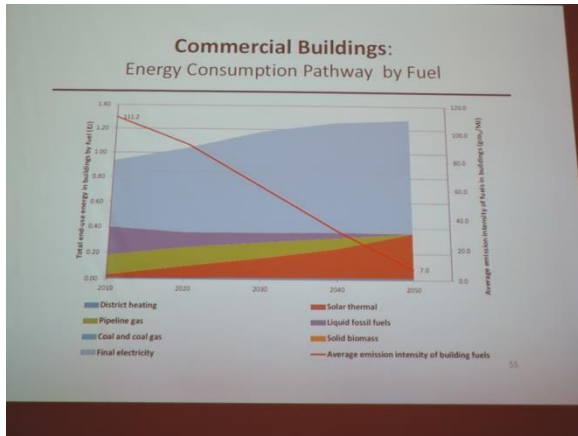


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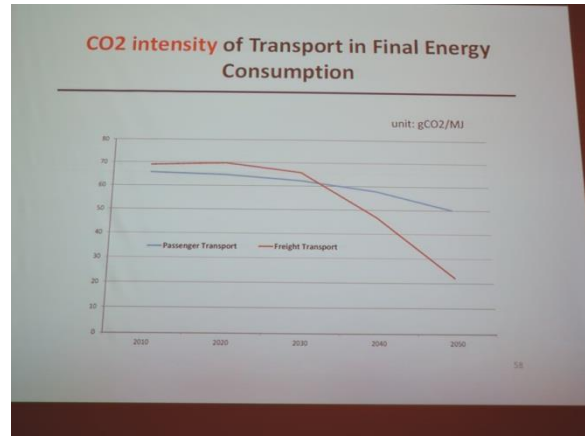


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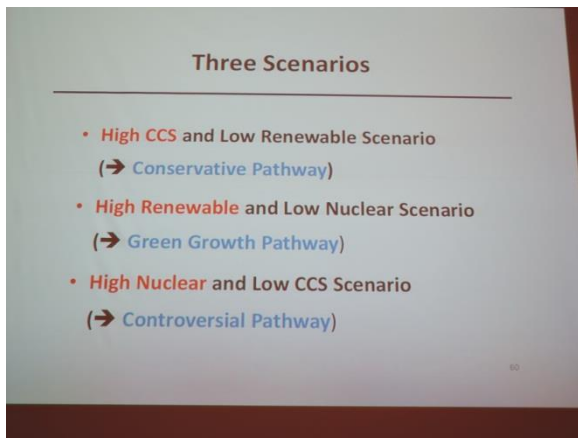


圖 III.1.1-23

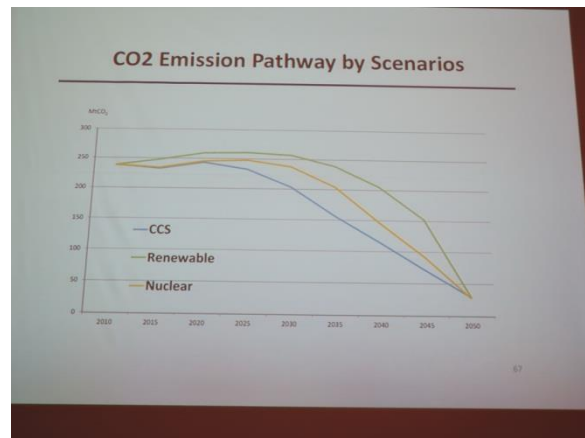


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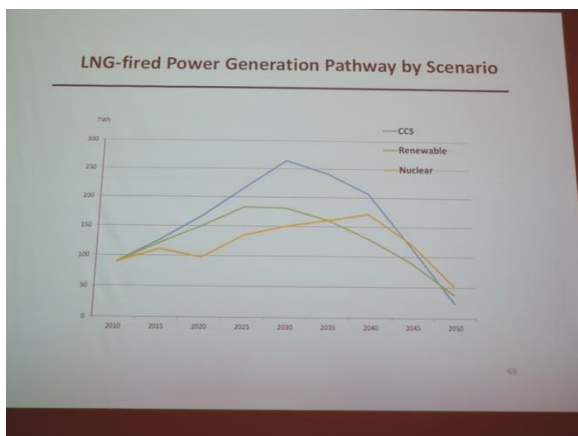


圖 III.1.1-25

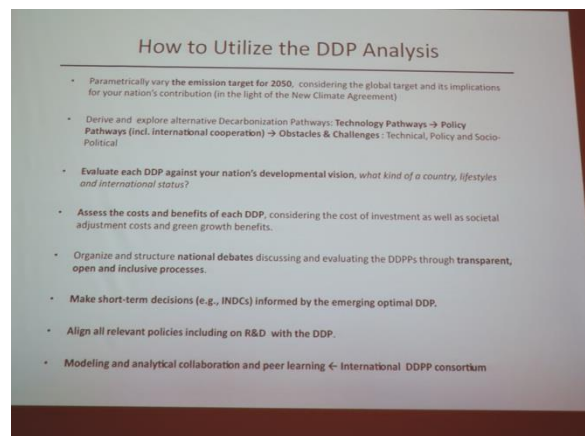


圖 III.1.1-26

P2

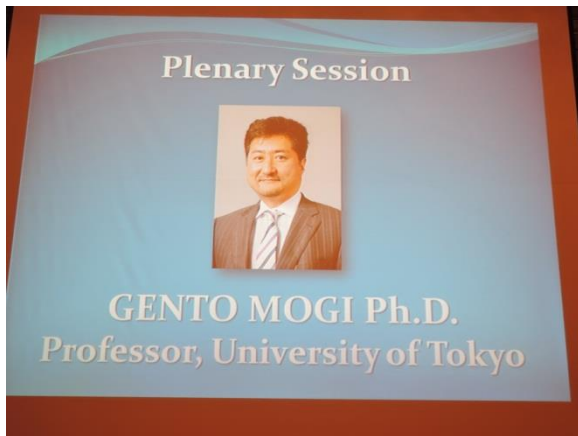


圖 III.1.1-27

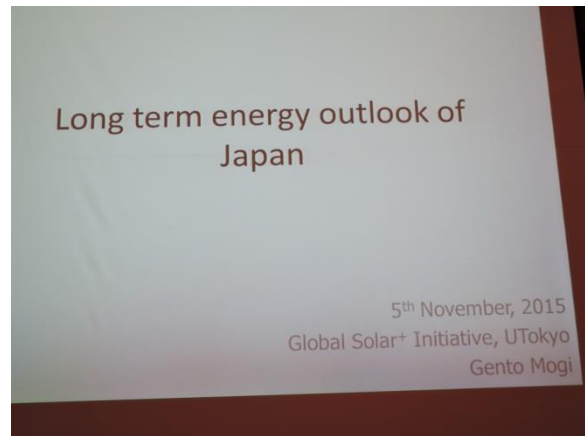


圖 III.1.1-28



圖 III.1.1-29

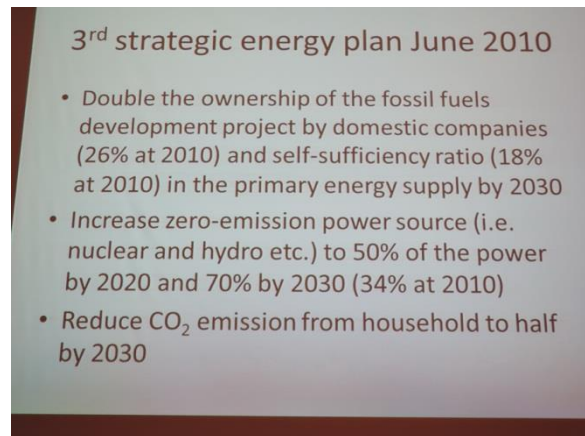


圖 III.1.1-30



圖 III.1.1-31

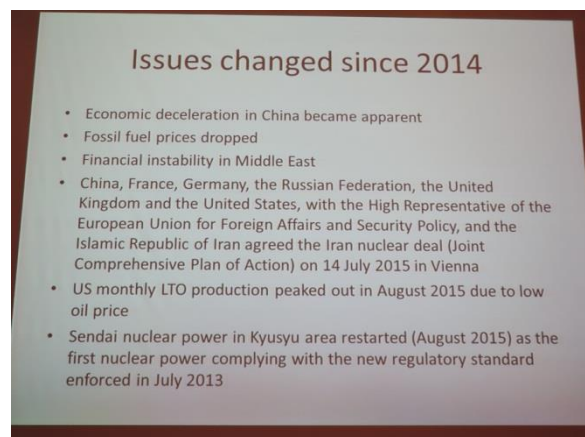


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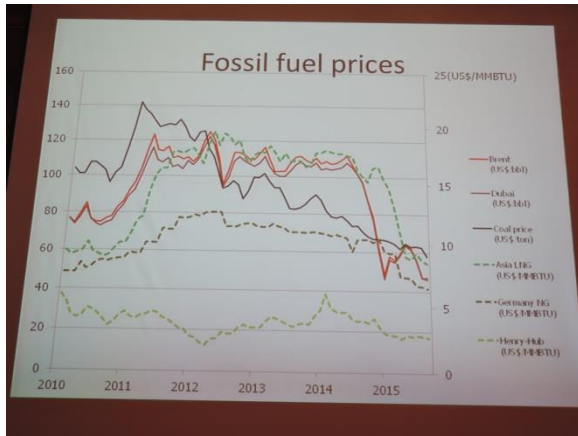


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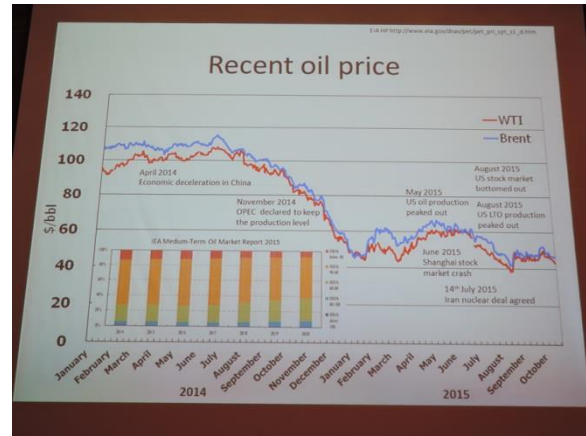


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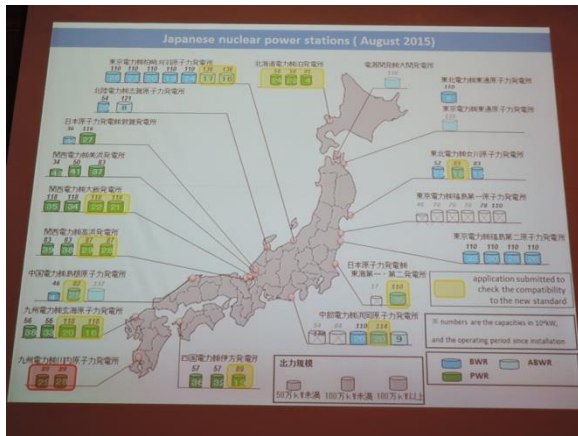


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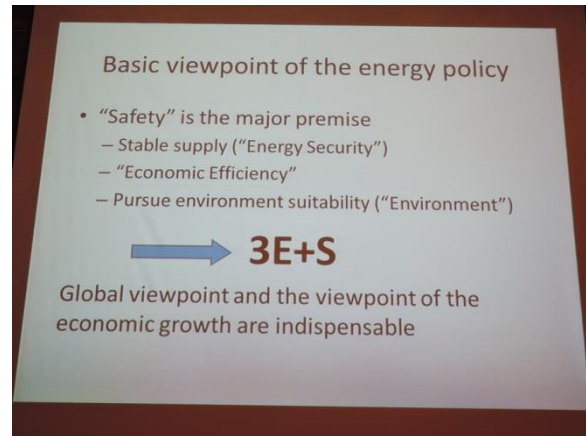


圖 III.1.1-36

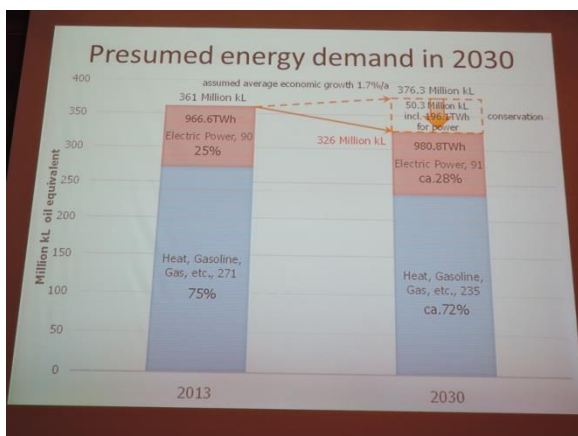


圖 III.1.1-37

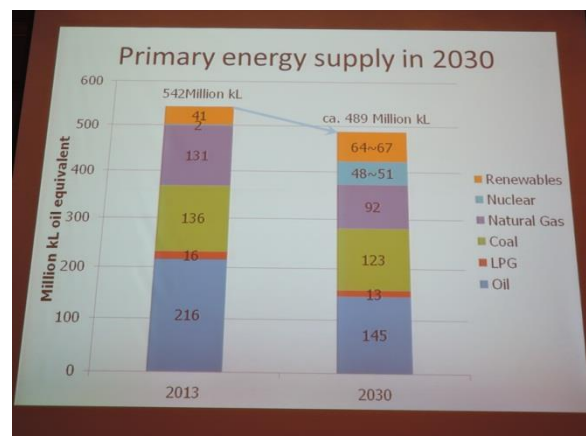


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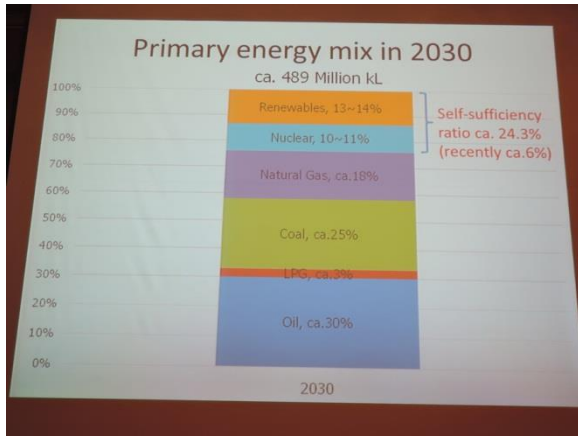


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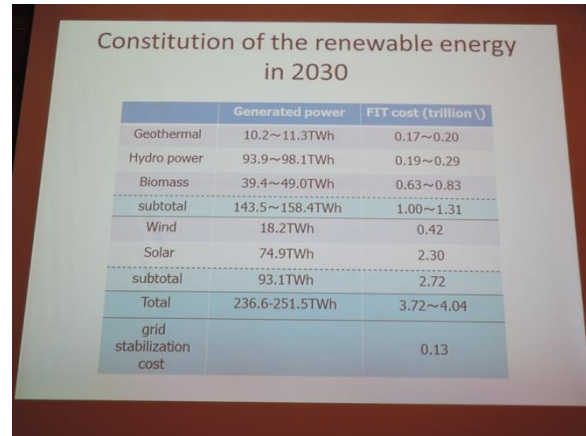


圖 III.1.1-40

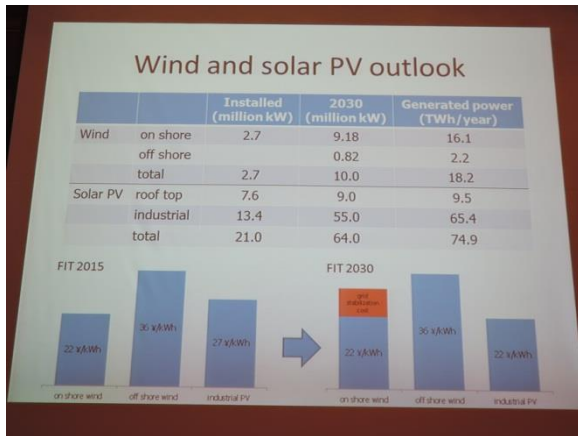


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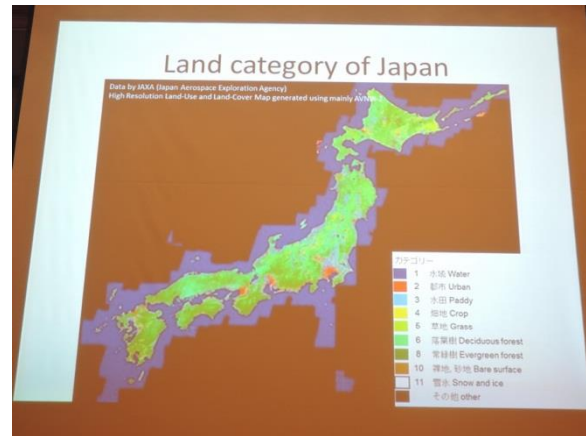


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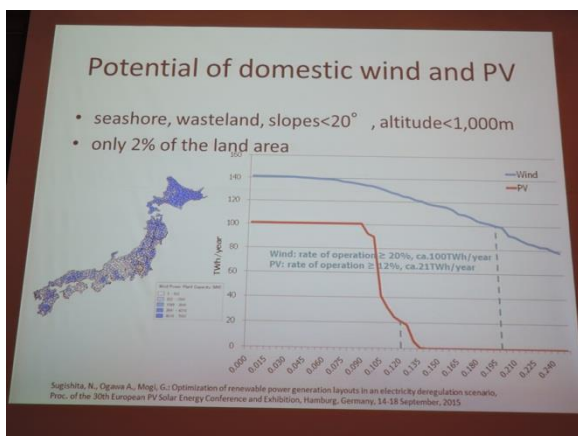


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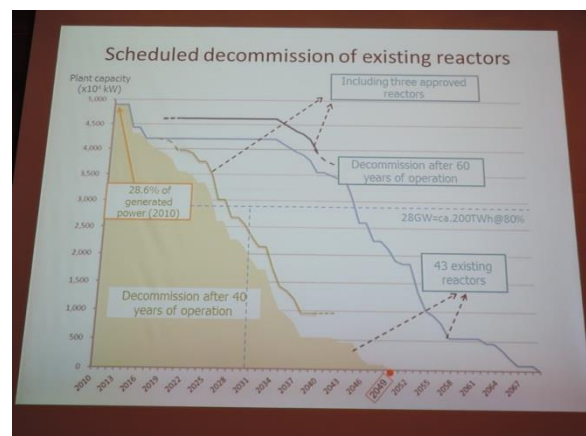


圖 III.1.1-44

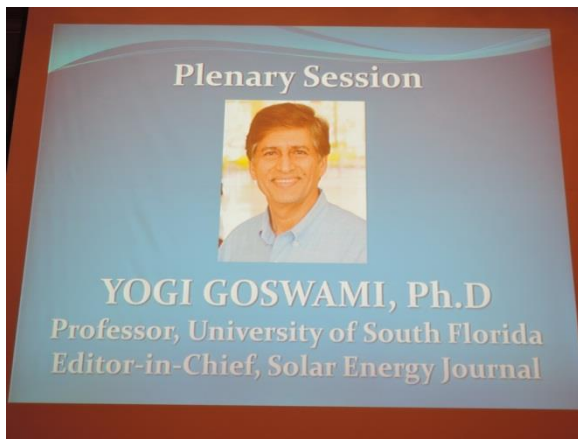


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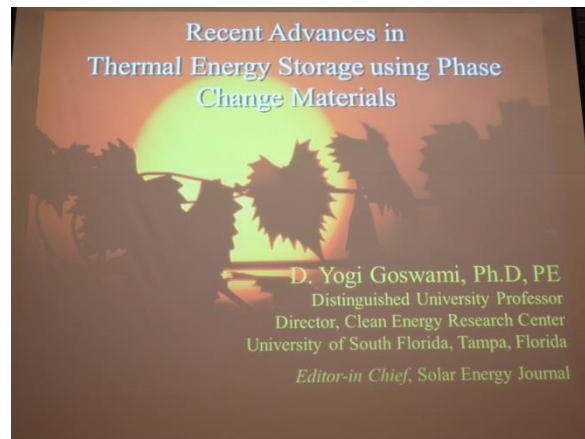


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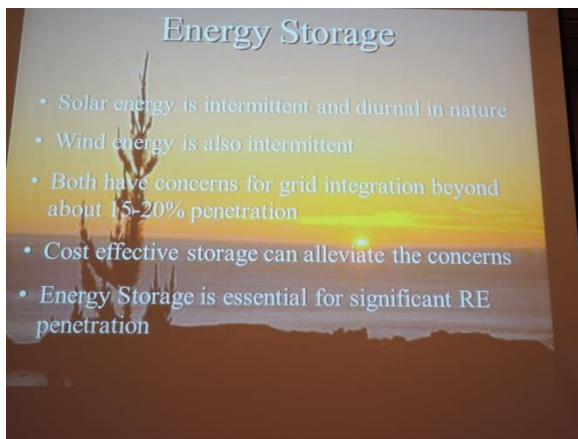


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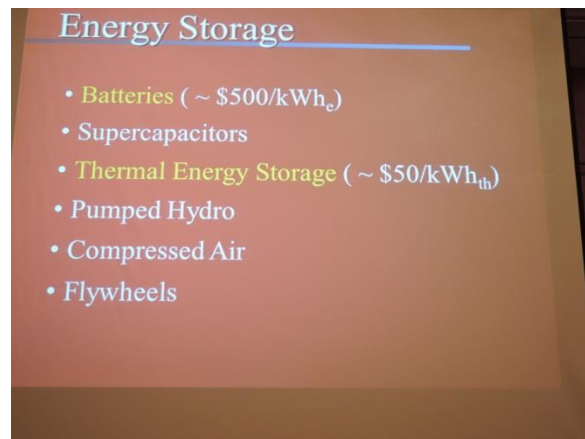


圖 III.1.1-48



圖 III.1.1-49

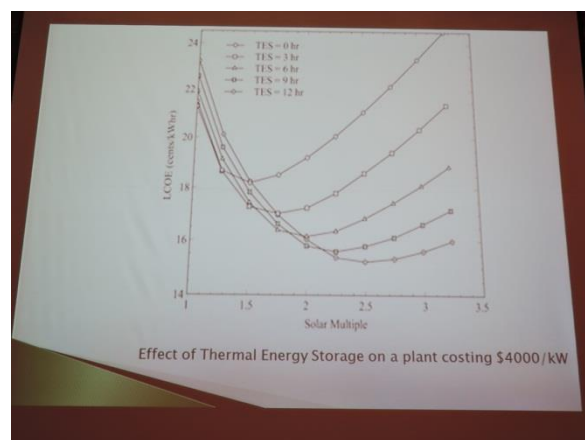


圖 III.1.1-50

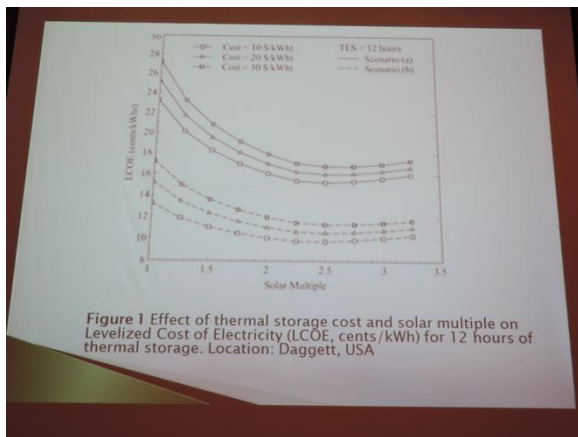


圖 III.1.1-51

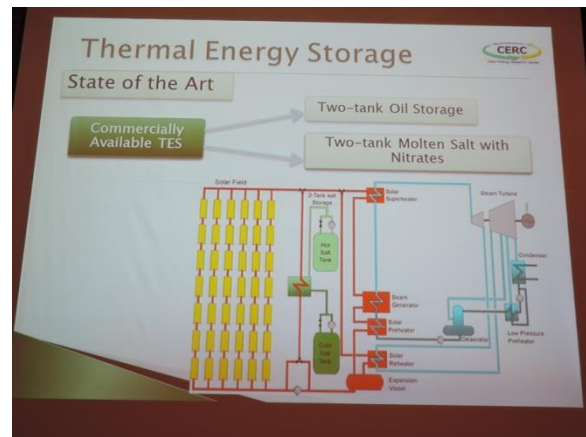


圖 III.1.1-52

Sensible Heat Storage

Two-Tank High Temp TES

- Synthetic oil storage has temperature limitation and high cost
- Molten salt systems have corrosion issues and require expensive piping, pumps and tanks
- Both have low energy density and high cost

圖 III.1.1-53

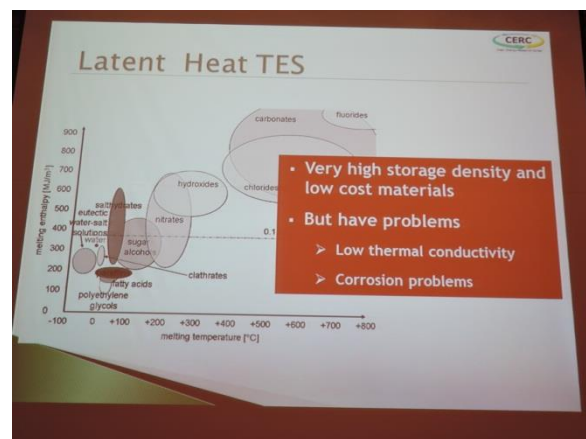


圖 III.1.1-54

Example Research Initiatives in Latent Heat TES

- Project: Finned tubes with embedded PCM
Facility: DLR, Germany
- Project: Salt/graphite composite PCM
Facility: DLR, Germany
- Project: PCM with embedded heat pipes.
Facility: Univ. of Connecticut, USA

圖 III.1.1-55

Recent Developments

- Encapsulate PCMs for use in packed bed systems to overcome heat transfer and corrosion problems
- Use low cost materials and industrially scalable encapsulation methods
- Reduce TES system costs from the present \$40 - \$80/kWh_{th} to < \$15/kWh_{th}

圖 III.1.1-56

Properties of some phase change materials of interest

PCM	Melting point (°C)	Latent Heat (kJ/kg)
NaNO ₂	308	172*
KCl(22)-50MgCl ₂ -30NaCl	396	291
NaCl(56.2)-43.8MgCl ₂	442	325
CaCl ₂ (52.8)-47.2NaCl	500	239
KCl(45)-55KF	605	407
NaCl(50)-50KCl	657	338*
K ₂ CO ₃ (51)-49Na ₂ CO ₃	710	163
NaCl	801	510*

* Experimental measured values.
All salt concentrations are in mole percent.

圖 III.1.1-57

Properties of some phase change materials of interest

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* Experimental measured values.
All salt concentrations are in mole percent.

Our Recent paper gives an in-depth review of TES for CSP
"Thermal Energy Storage Technologies and Systems for Concentrating Solar Power Plants"
Progress in Energy and Combustion Science, March 2013.

圖 III.1.1-58

Encapsulation of PCM pellets

Major issues in encapsulation of PCMs:

- > Large volumetric expansion of PCM on melting.
- > Pressure buildup due to expansion on heating

An innovative solution to these problems:
A coating which is both flexible and selectively permeable in nature was conceived and developed

圖 III.1.1-59

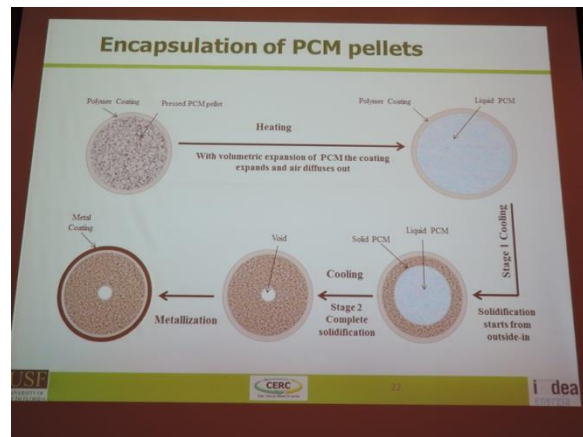


圖 III.1.1-60

Encapsulation of PCM pellets

Second Innovation:
Electroless metalization of polymer coating

Polymer Coated Capsules to 350°C

Metalized Capsules to 450°C

圖 III.1.1-61

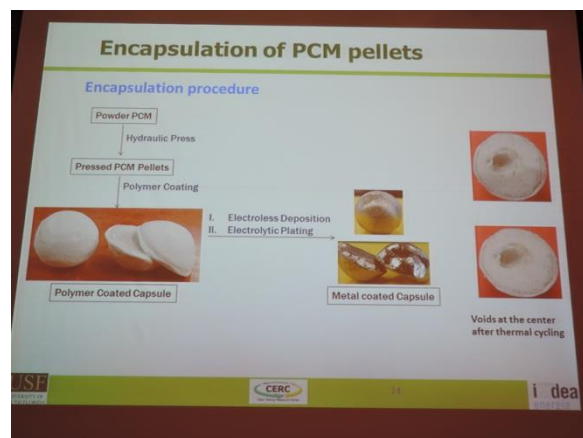


圖 III.1.1-62

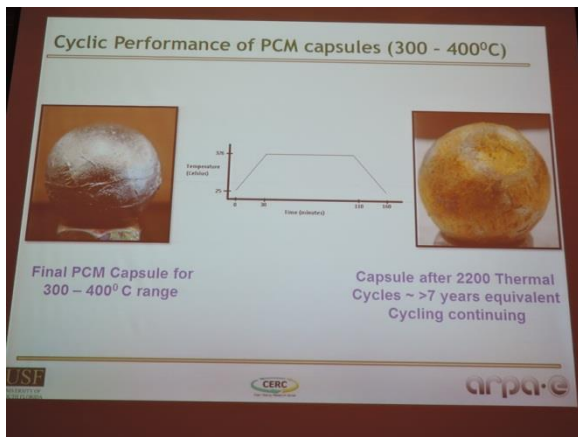


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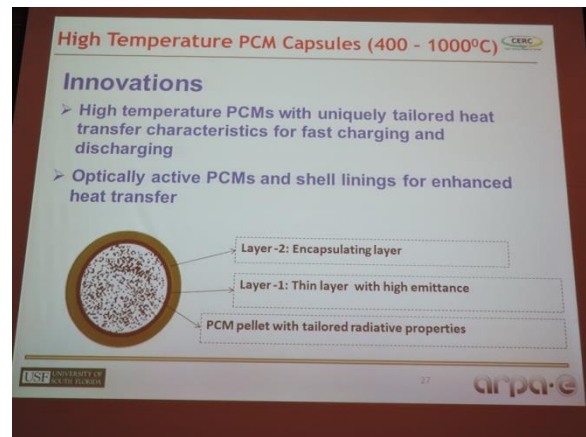


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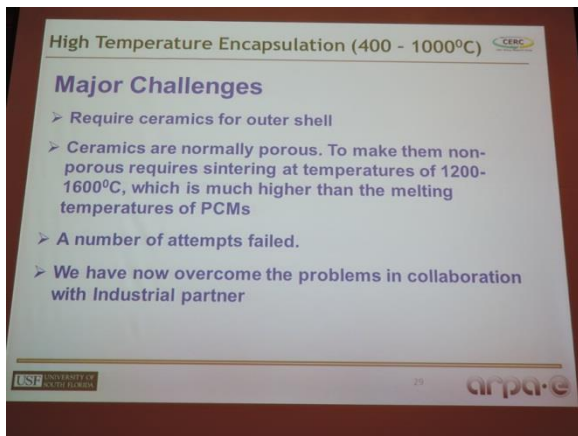


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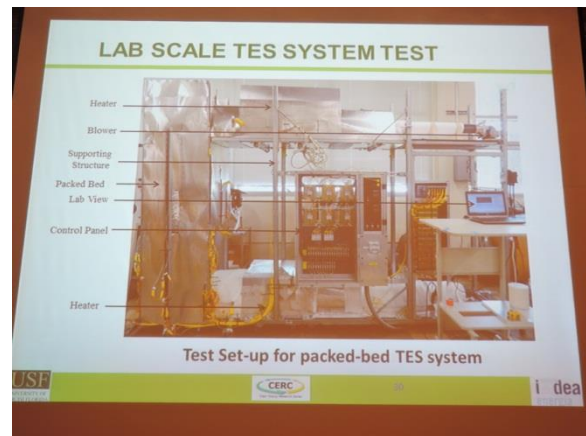


圖 III.1.1-66



圖 III.1.1-67

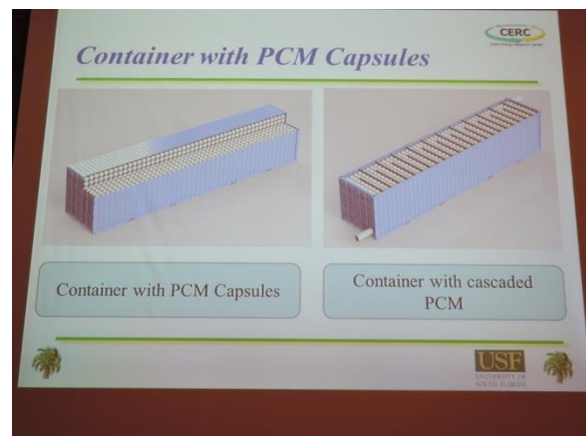


圖 III.1.1-68

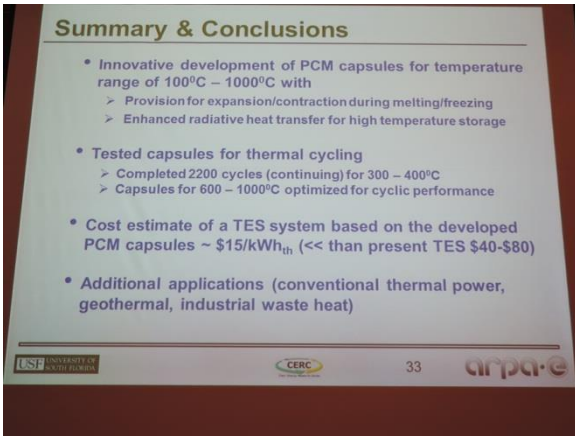


圖 III.1.1-69



圖 III.1.1-70

2. Oral Paper Sessions



圖 III.1.2-1 口頭論文發表會場之中廊

CCT&CCS / LC : Low Carbon Technology

■ 0-CCT&CCS/LC-I

November 5 [Thur.], 09:00~11:00 [Crystalball room III]

Chair : Dr. Ho-Jung RYU (*Korea Institute of Energy Research, Korea*)
Prof. Kwang Bok YI (*Chungnam National University, Korea*)

IN-CCT&CCS-1

09:00~09:30

STATUS QUO FOR THE DEVELOPMENT OF CARBON CAPTURE, STORAGE AND UTILIZATION TECHNOLOGIES IN TAIWAN

Yau-Pin Chyou*

Institute of Nuclear Energy Research (INER), Taiwan

*corresponding author (ypchyou@iner.gov.tw)

IN-CCT&CCS-2

09:30~10:00

INNOVATION IN CATALYSIS AND REACTION ENGINEERING FOR THE CONVERSION OF BIOMASS INTERMEDIATES TO FUELS

Dr. Yong Wang*

PNNL

*corresponding author (yong.wang@pml.gov)

0-CCT&CCS-1

10:00~10:20

PERFORMANCE EVALUATION OF AN CCS-DEDICATED POWER GENERATION SYSTEM – PRESSURIZED OXYFUEL COMBUSTION

Tefera Zelalem TUMSA^{1,2}, Dong-hee KIM^{1,2}, Tae Young Mun¹, Young Jae LEE¹, Uendo LEE¹, Won YANG^{1,2*}

¹*Thermochemical Energy System Group, Korea Institute of Industrial Technology, South Korea*

²*Department of Green Process and System Engineering, University of Science and Technology (UST), South Korea*

*corresponding author (yangwon@kitech.re.kr)

0-CCT&CCS-2

10:20~10:40

CFD SIMULATIONS ON COMBUSTION, HEAT TRANSFER AND NO_x EMISSIONS IN 100 MWe OXY-COAL FURNACE

Changkook RYU^{1*}, Jeung-Eun A. KIM¹, Won YANG² and Yong Ju KIM³

¹*School of Mechanical Engineering, Sungkyunkwan University, Suwon, Korea*

²*Thermochemical Energy System Group, Korea Institute of Industrial Technology, Cheonan, Korea*

³*Power Generation Lab., KEPCO Research Institute, Daejeon, Korea*

*corresponding author (cryu@me.skku.ac.kr)

圖 III.1.2-2 CCT & CCS 第一場次的議程剪影

IN-CCT&CCS-1: INER 發表邀請演講之口頭簡報摘錄

The 5th Asia-Pacific Forum on Renewable Energy, AFORE 2015, November 4-7, JEJU, KOREA

Status Quo for the Development of Carbon Capture, Storage and Utilization Technologies in Taiwan




Yau-Pin Chyou, Ph. D.
2015/11/05

Institute of Nuclear Energy Research

圖 III.1.2-3

Contents

- Background
- Perspective
- R&D activities
 - Clean utilization technologies
 - Carbon capture technologies
 - Carbon storage and utilization technologies
- Summary
- Appendix



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圖 III.1.2-4

R&D activities of CCSU @ Taiwan

- (WG 1) Clean utilization technologies of carbonaceous fuel:**
 - gasification-based energy system,
 - high-efficiency, low-emission (HELE) technologies,
 - gas clean-up processes,
 - system design and plant performance evaluation practice, etc.
- (WG 2) Carbon capture technologies:**
 - pre-, post-, and oxy-combustion capture technologies,
 - advanced gas separation processes,
 - solid sorbent synthesis and characterization, etc.
- (WG 3) Carbon storage and utilization technologies:**
 - monitoring, verification and accounting (MVA) technologies,
 - conversion of carbon sources, etc.

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圖 III.1.2-5

Summary of CCSU activities @ Taiwan

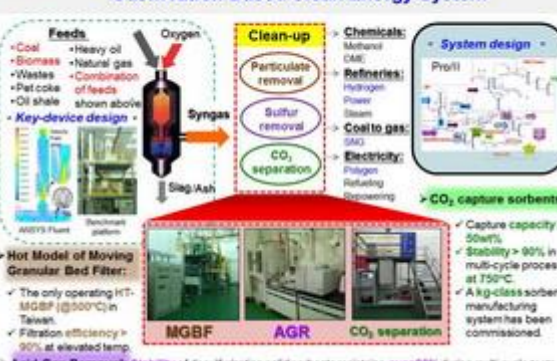
	WG1	WG2	WG3
INER	✓	✓	
ITRI	✓	✓	✓
NEP-II	✓	✓	✓
CSC		✓	✓
TPC		✓	✓
CPC			✓

INER: Institute of Nuclear Energy Research
ITRI: Industrial Technology Research Institute
NEP-II: National Energy Program, Phase II
CSC: China Steel Corporation
TPC: Taiwan Power Company
CPC: China Petroleum Corporation

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圖 III.1.2-6

Overview of R&D activities @ INER Gasification-Based Clean Energy System



Feeds: Coal, Biomass, Wastes, Petroleum coke, Oil shale, Heavy oil, Natural gas, Combination of feeds.

Clean-up: Particulate removal, Sulfur removal, CO₂ separation.

Chemicals: Methanol, DME, Refineries, Hydrogen, Power, Steam.

Coal to gas: SAG, Electricity: Pyrolysis, Refining, Reforming.

System design: Pro/II

CO₂ capture sorbents: Capture capacity > 50wt%, Stability > 90% in multi-cycle process at 150°C, A kg-class sorbent manufacturing system has been commissioned.

Hot Model of Moving Granular Bed Filter: The only operating HT-MGBF (@500°C) in Taiwan, Filtration efficiency > 90% at elevated temp.

Acid Gas Removal: Stability of desulfurization solid sorbents maintains over 90% during multi-cycle tests.

Labels: MGBF, AGR, CO₂ separation.

圖 III.1.2-7

CCS Technology Approach-ITRI



Pre & Oxyfuel Combustion CO₂ Capture

- Chemical Looping Process for CO₂ Capture and H₂ Generation
 - Setup a 30 MW Chemical Looping System
 - Counter-current moving bed for oxygen carrier
- Gasification
 - Coal and biomass co-gasification
 - Integrated CO₂ Capture to zero emission

Post Combustion CO₂ Capture

- Calcium Looping CO₂ Capture Technology
 - Cooperation with the Taiwan Cement Company, has installed a 1.8MW pilot plant at Ho-Shing cement plant
 - Calcium looping integrating hydration and cascade cyclones under development

CO₂ Storage

- Site characterization and baseline data collection of a potential storage site
- International Collaboration with NETL on Geological Storage
 - HTC and stable isotope tracers
 - Fiber optics for leakage monitoring
 - Risk Assessment

Labels: Lianyungang, Lianyungang, Lianyungang.

圖 III.1.2-8



圖 III.1.2-9

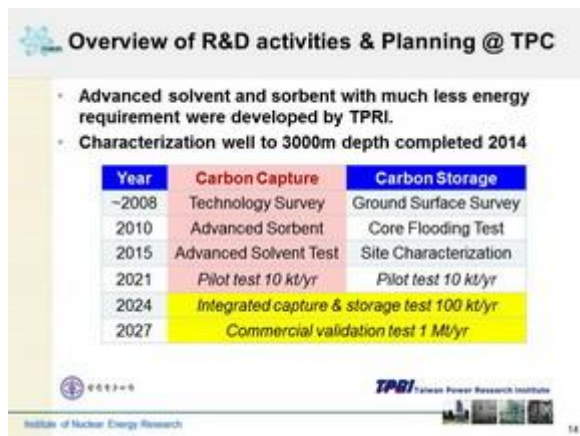


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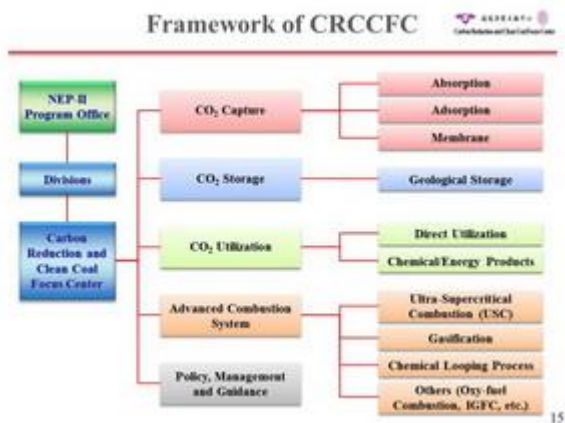


圖 III.1.2-11



圖 III.1.2-12



圖 III.1.2-13



圖 III.1.2-14

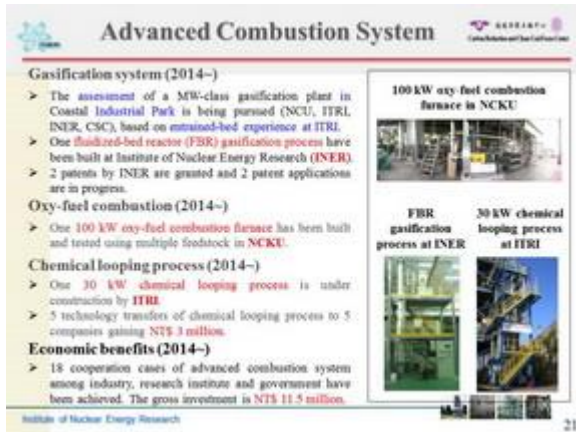


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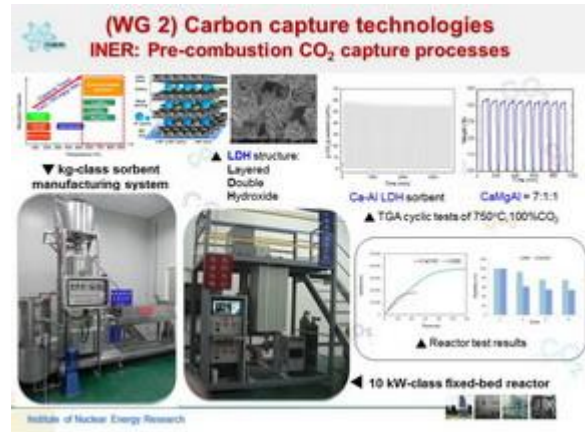


圖 III.1.2-16



圖 III.1.2-17



圖 III.1.2-18



圖 III.1.2-19

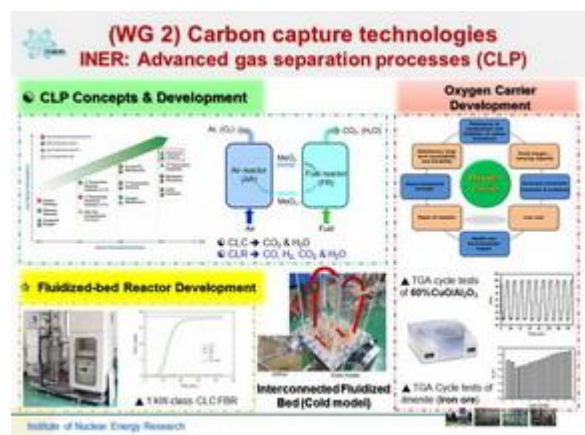


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圖 III.1.2-21

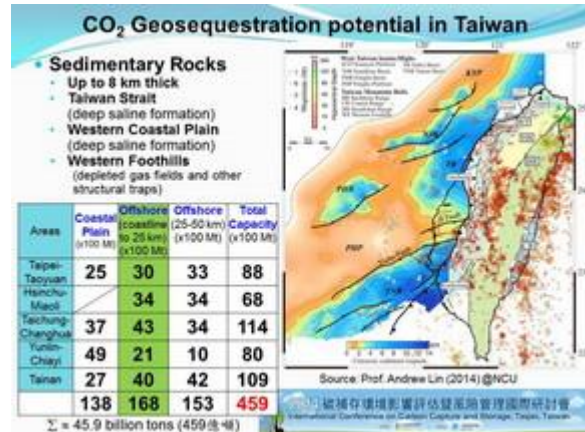


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圖 III.1.2-23

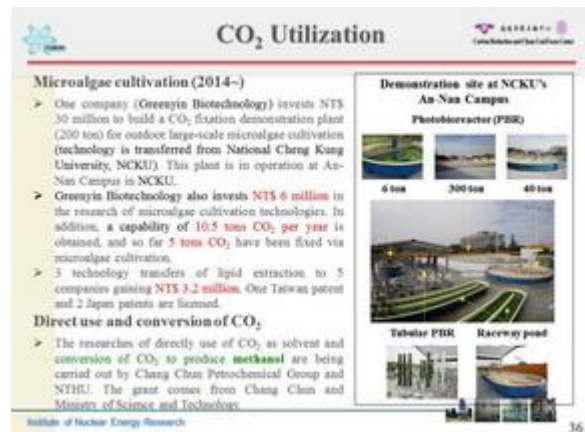


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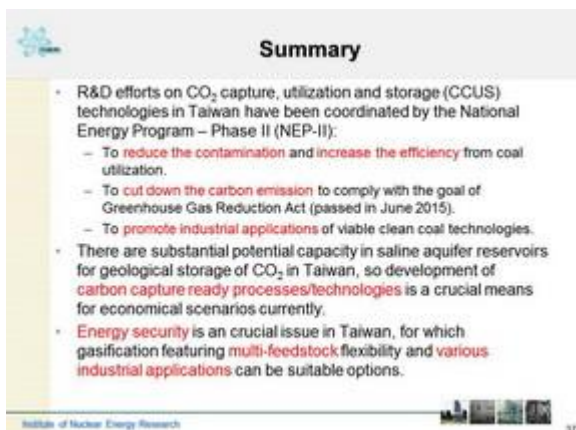


圖 III.1.2-25



圖 III.1.2-26

IN-CCT&CCS-2:



圖 III.1.2-27



圖 III.1.2-28

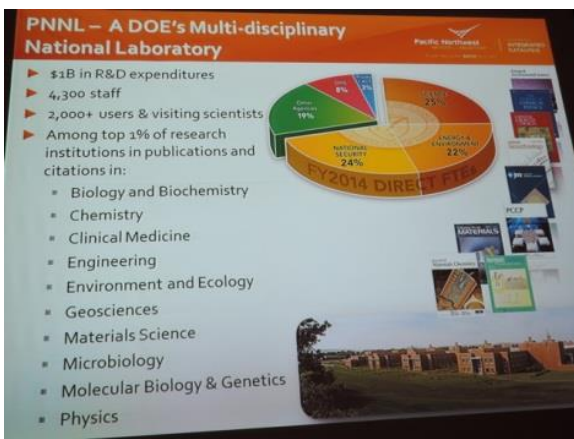


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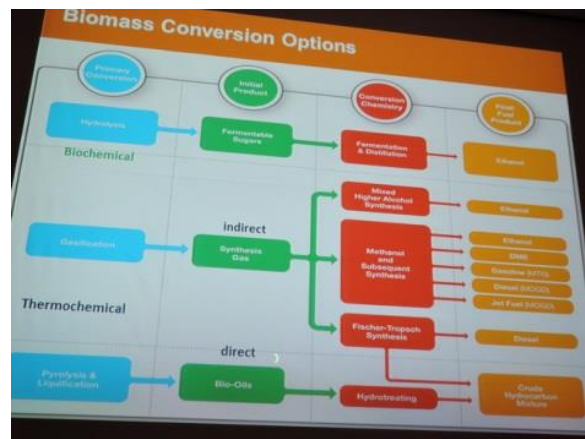


圖 III.1.2-30

Technology	Advantages	Disadvantages
Biochemical	<ul style="list-style-type: none"> Selectivity Mature for grain based feedstock 	<ul style="list-style-type: none"> Mainly ethanol Inefficient microorganisms and enzymes for the pretreatment and conversion
Thermochemical		
Indirect	<ul style="list-style-type: none"> Mature technologies 	<ul style="list-style-type: none"> Economy of scale
Direct	<ul style="list-style-type: none"> Simple process Effective in densification 	<ul style="list-style-type: none"> Storage and upgrading of pyrolysis oils

圖 III.1.2-31

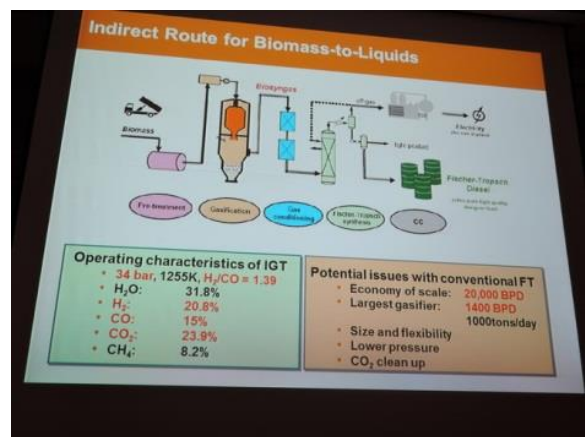


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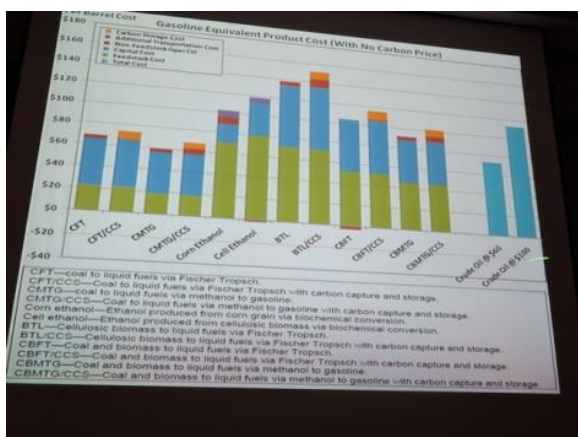


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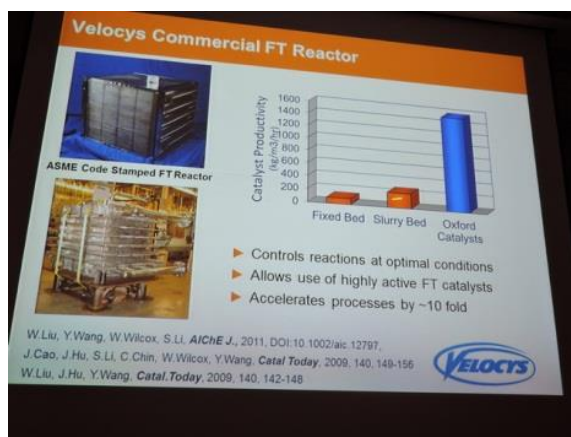


圖 III.1.2-34



圖 III.1.2-35

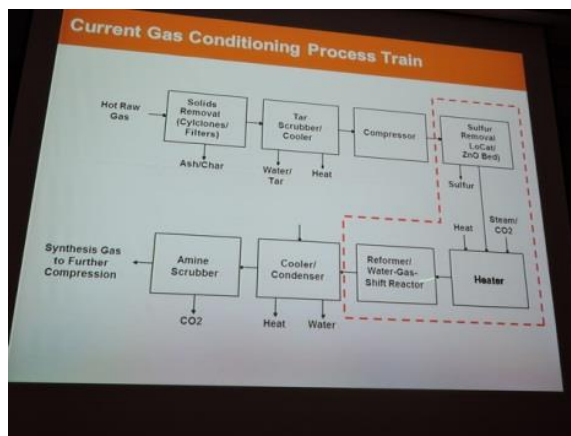


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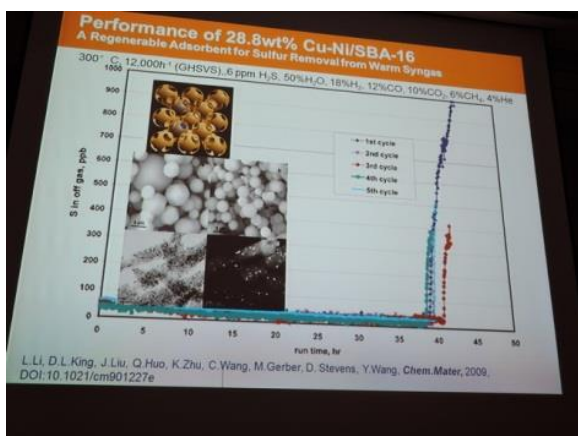


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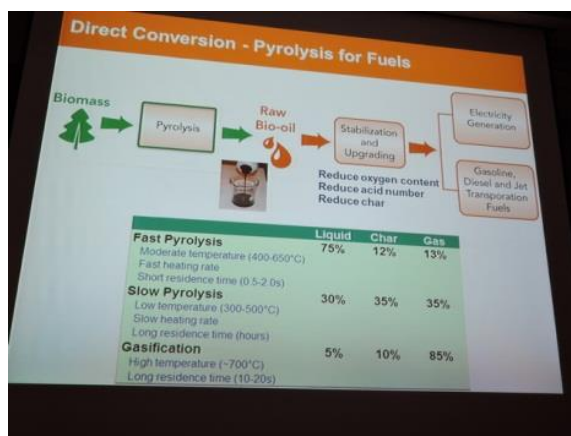


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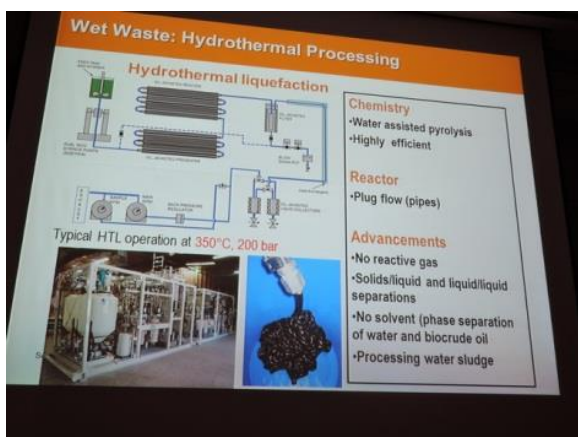


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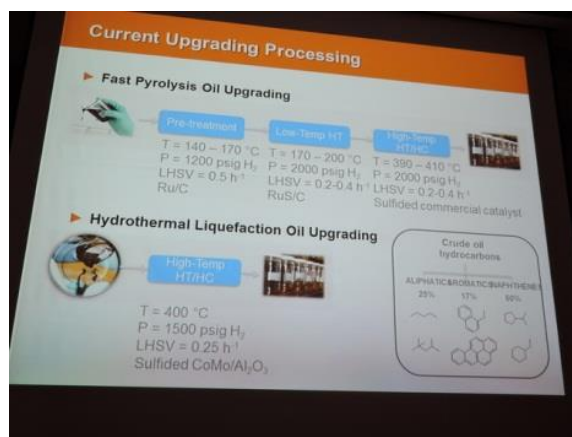


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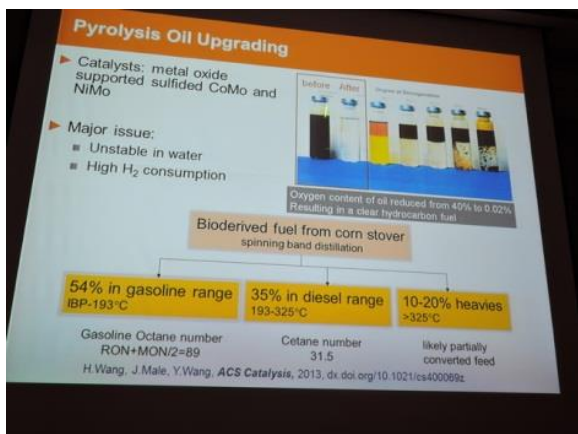


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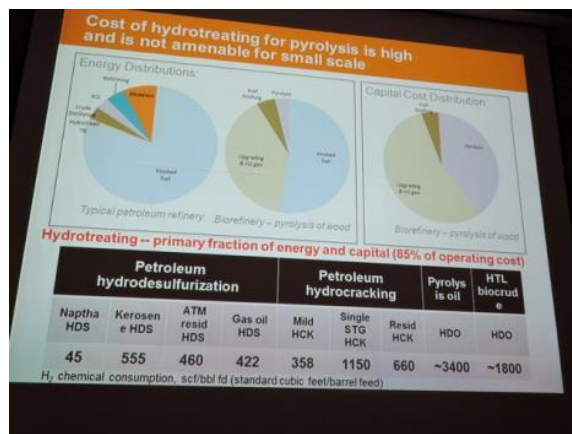


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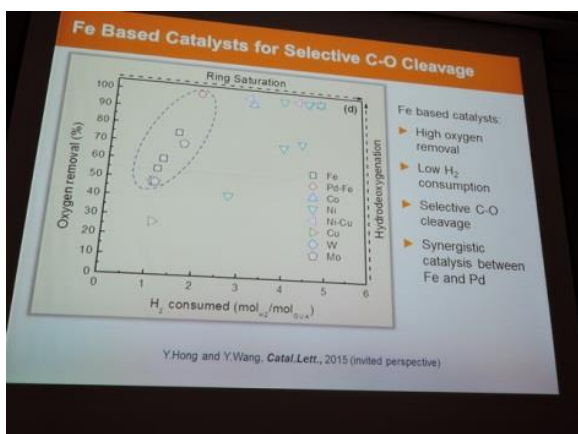


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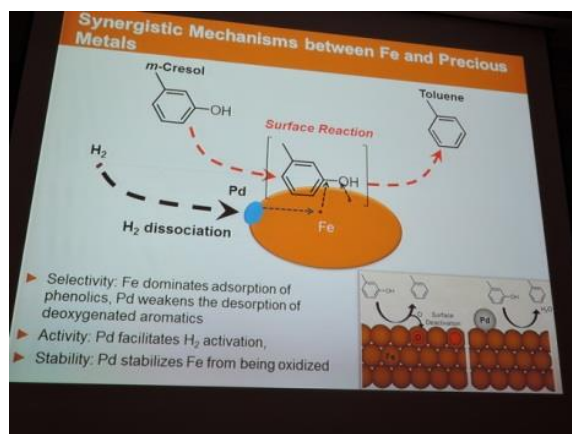


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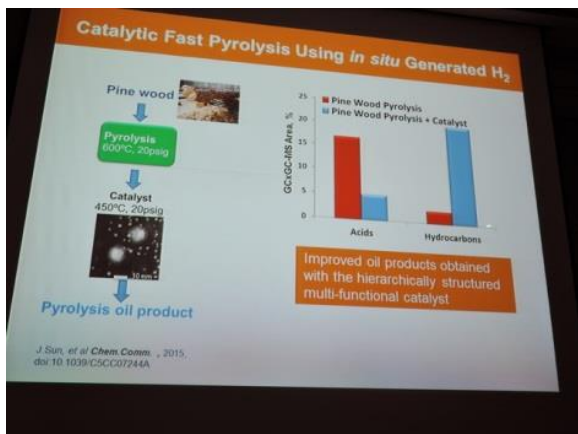


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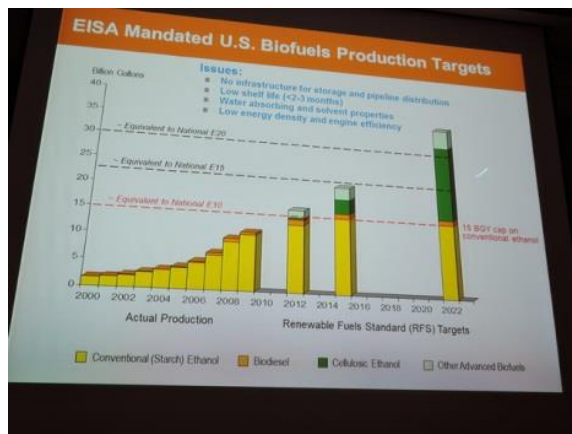


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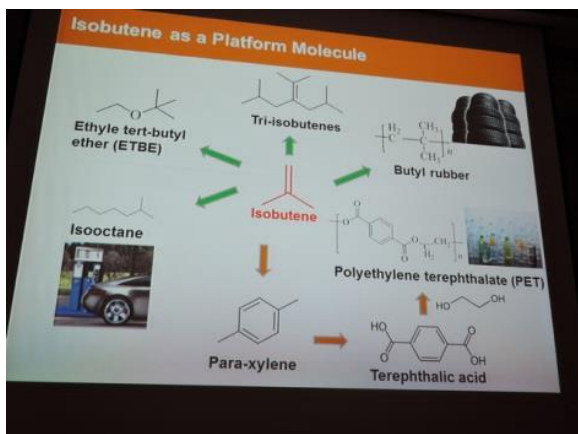


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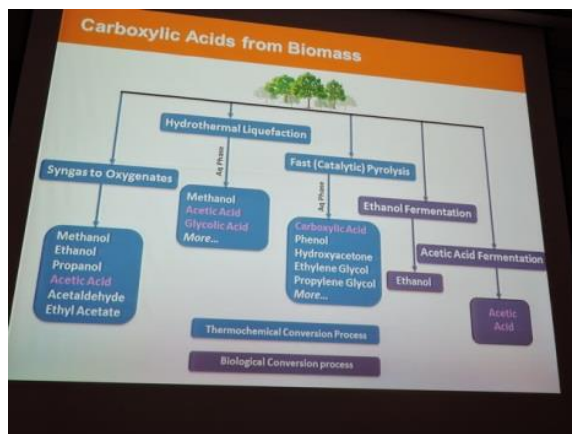


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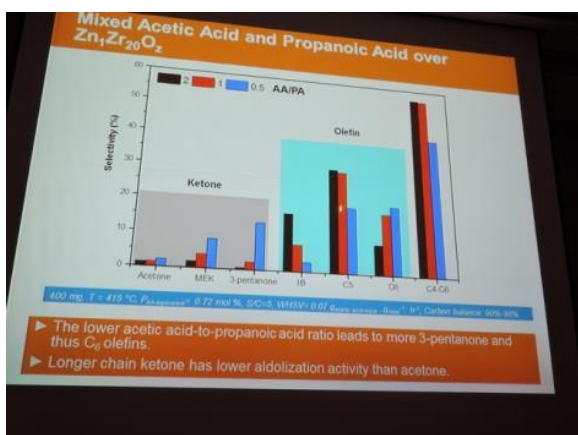


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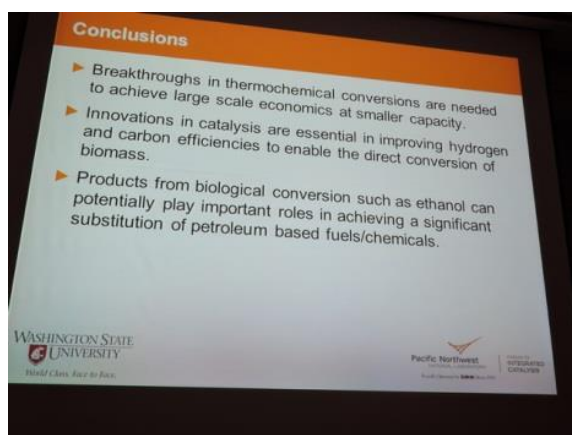


圖 III.1.2-50

O-CCT&CCS-1:



圖 III.1.2-51

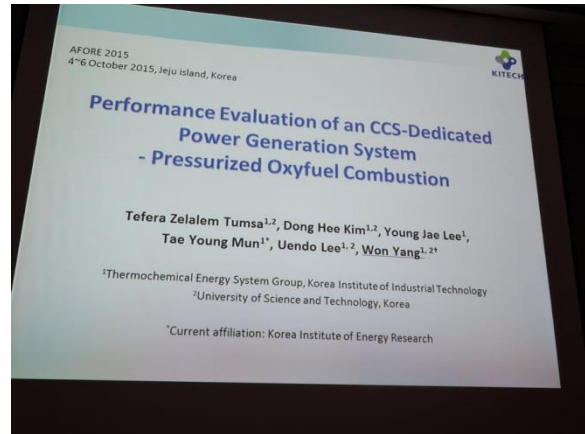


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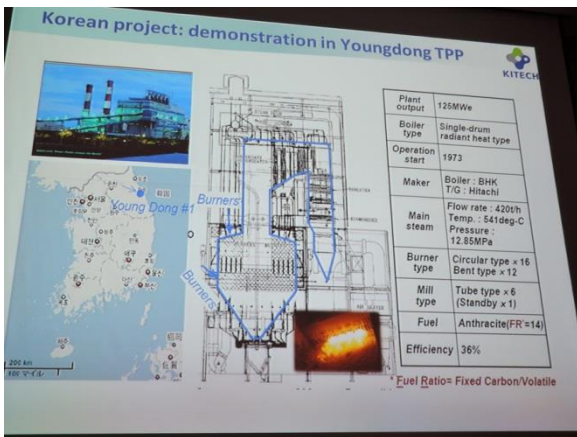


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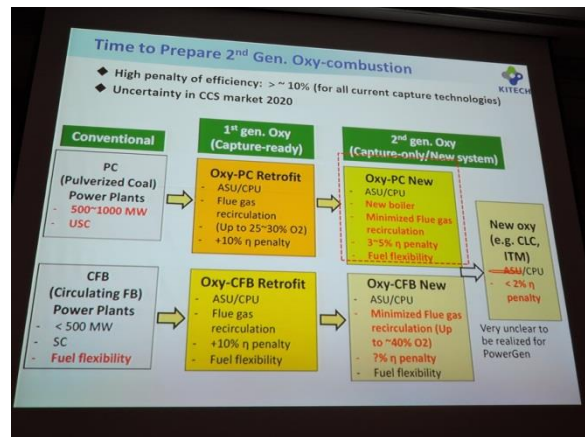


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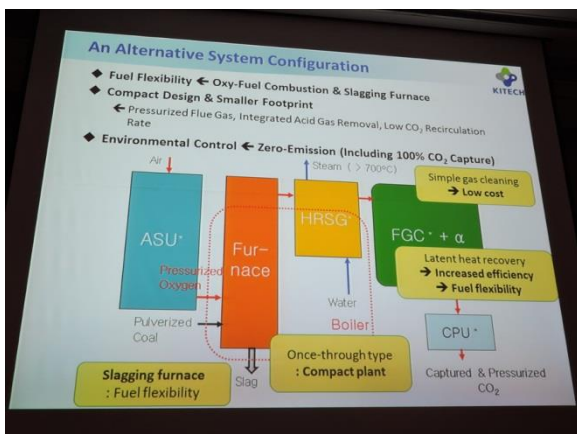


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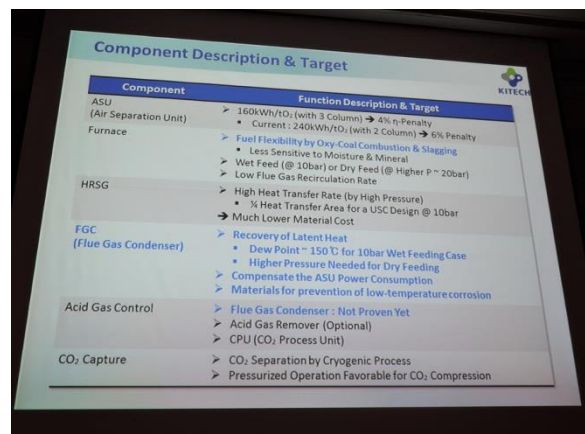


圖 III.1.2-56

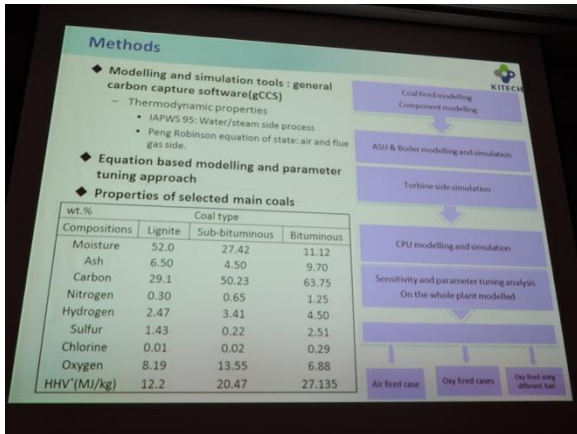


圖 III.1.2-57

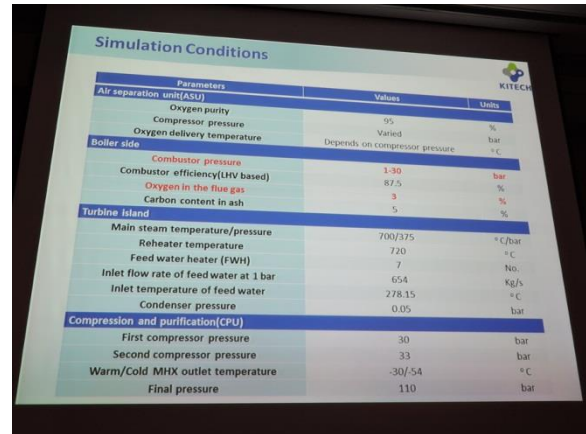


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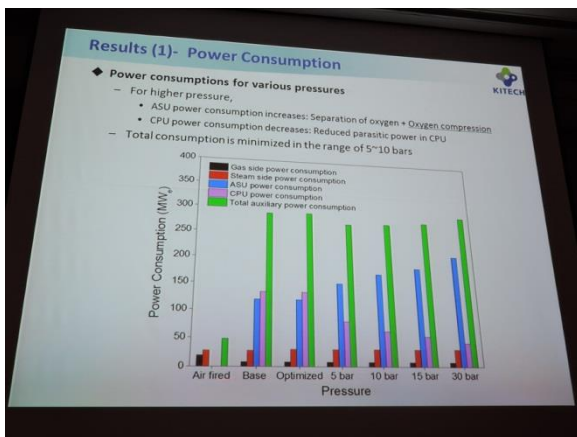


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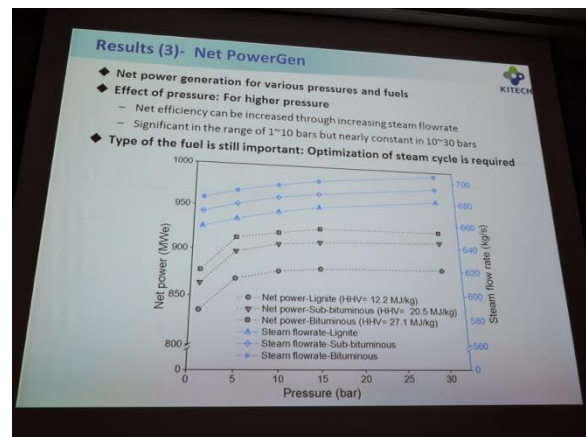


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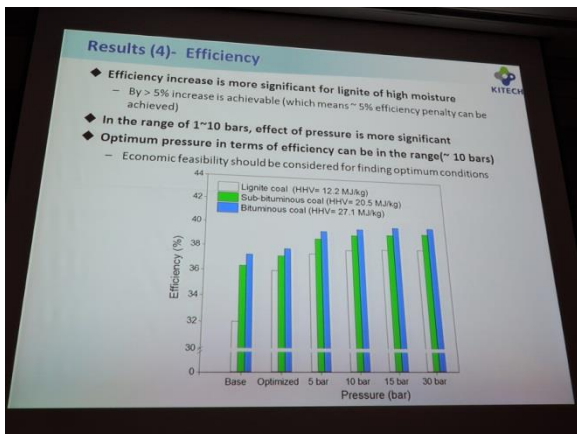


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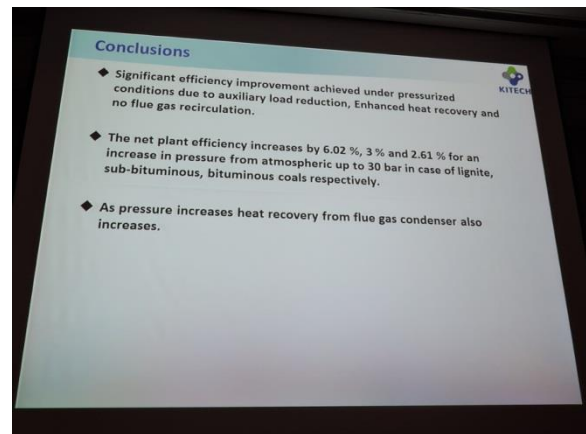


圖 III.1.2-62

O-CCT&CCS-2:



圖 III.1.2-63

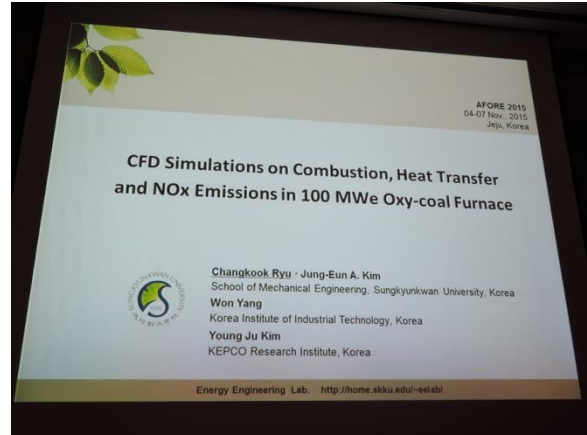


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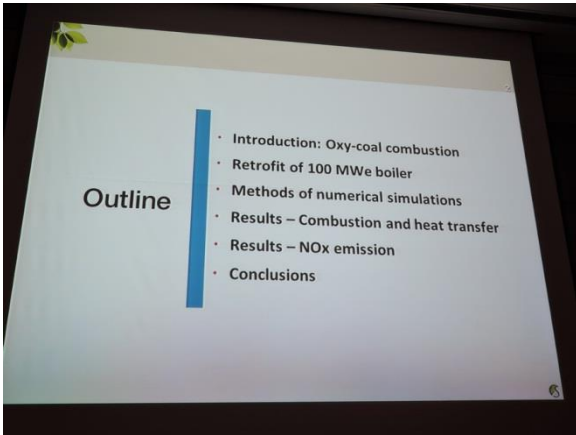


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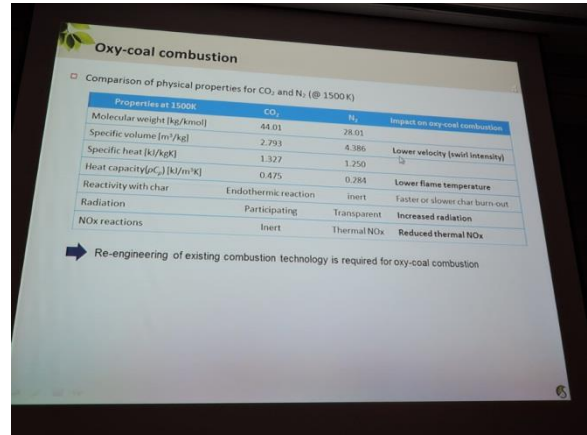


圖 III.1.2-66



圖 III.1.2-67

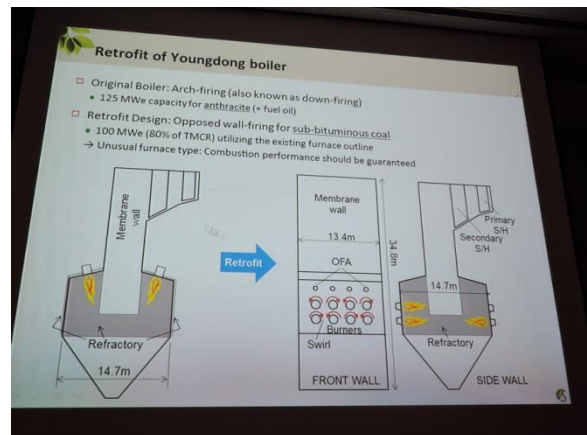


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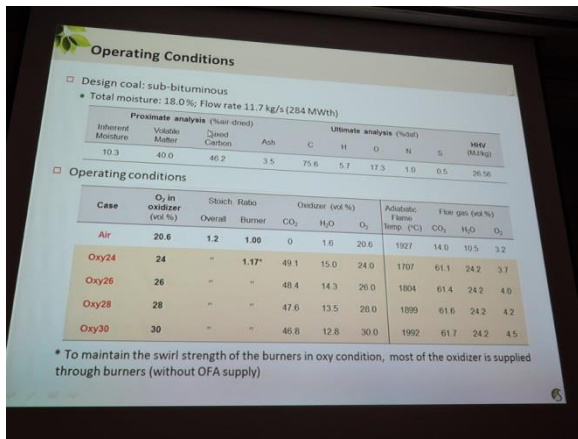


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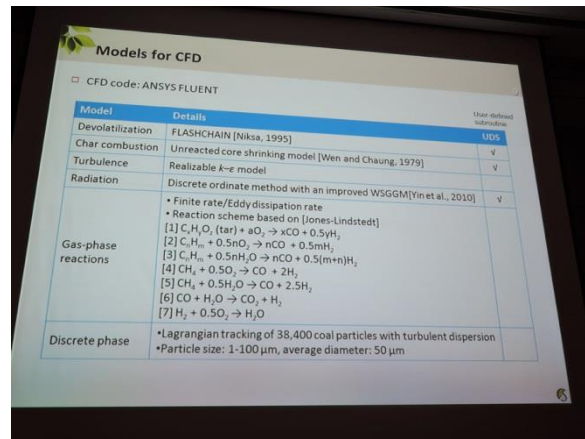


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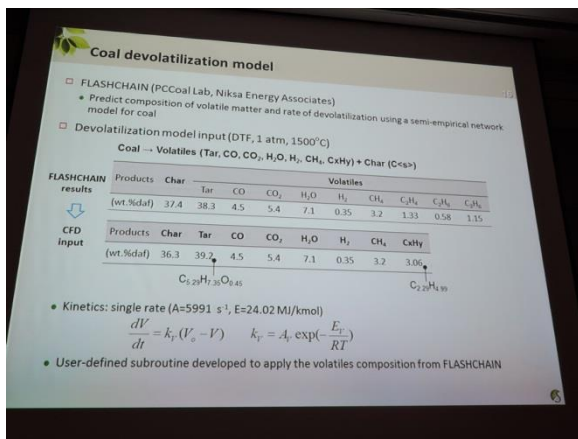


圖 III.1.2-71

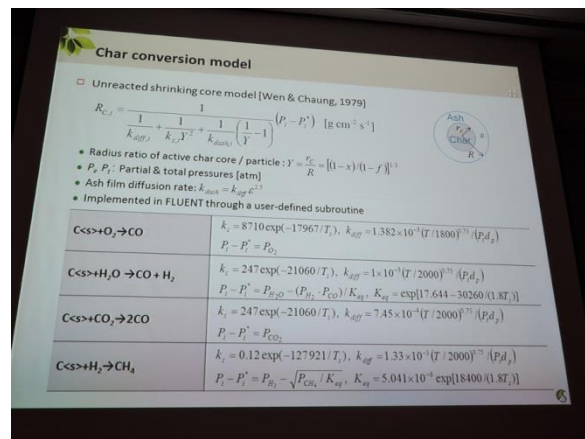


圖 III.1.2-72

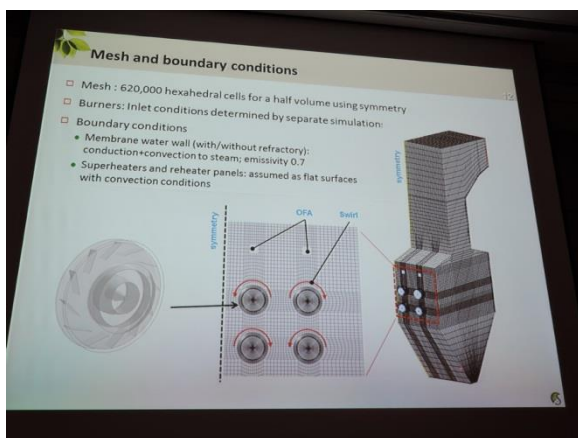


圖 III.1.2-73

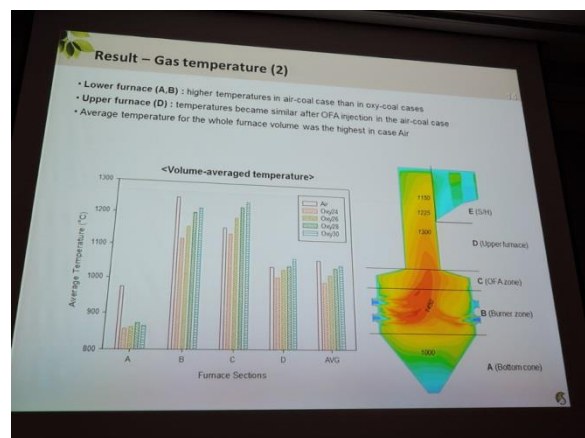


圖 III.1.2-74

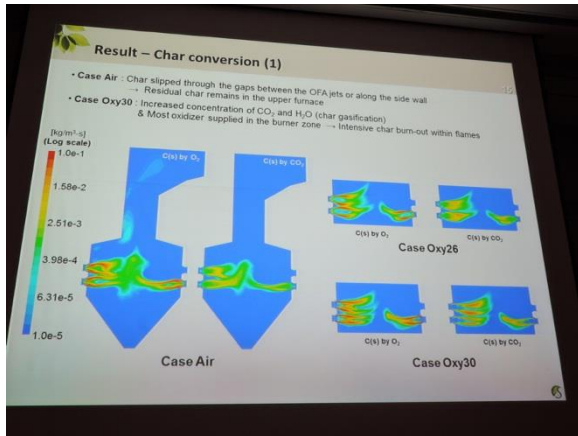


圖 III.1.2-75

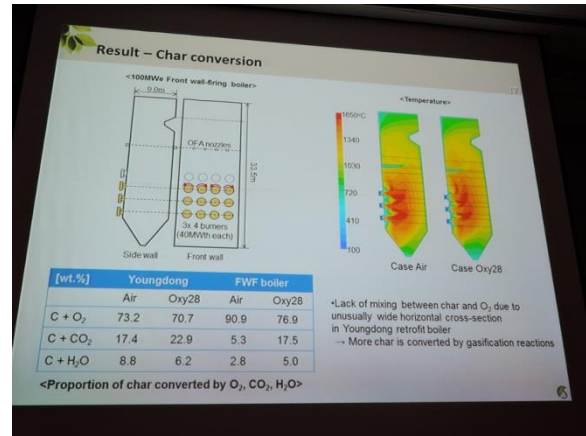


圖 III.1.2-76

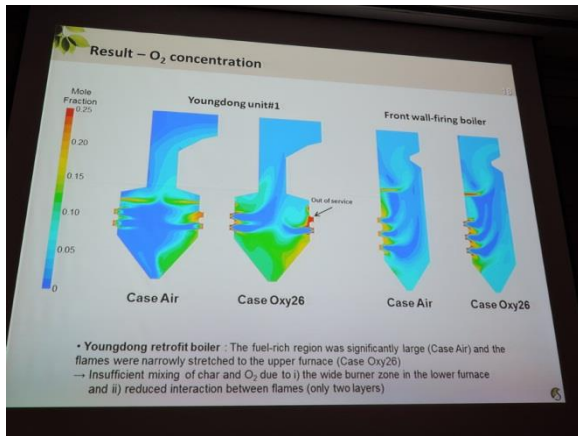


圖 III.1.2-77

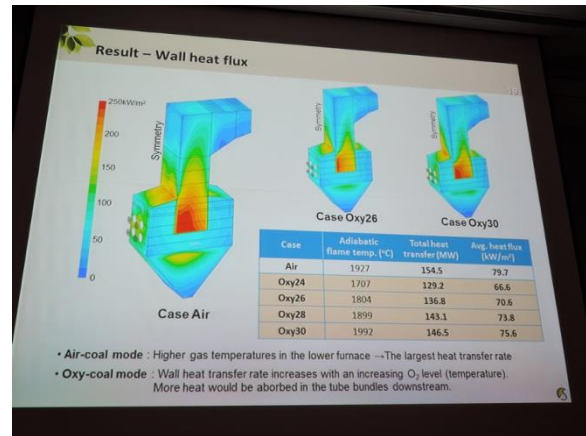


圖 III.1.2-78

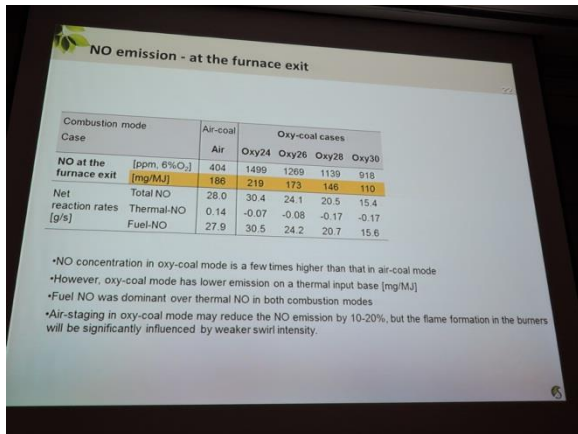


圖 III.1.2-79

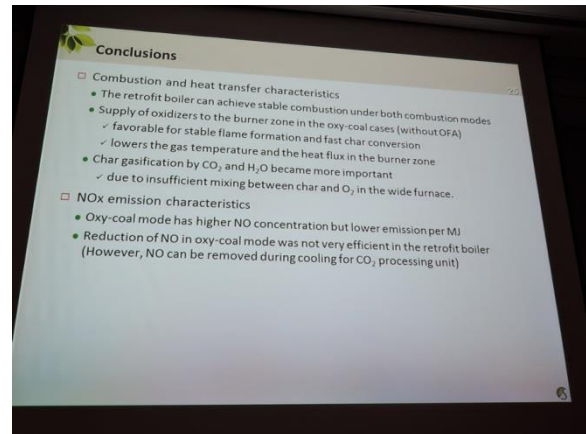


圖 III.1.2-80

O-CCT&CCS-3:



圖 III.1.2-81

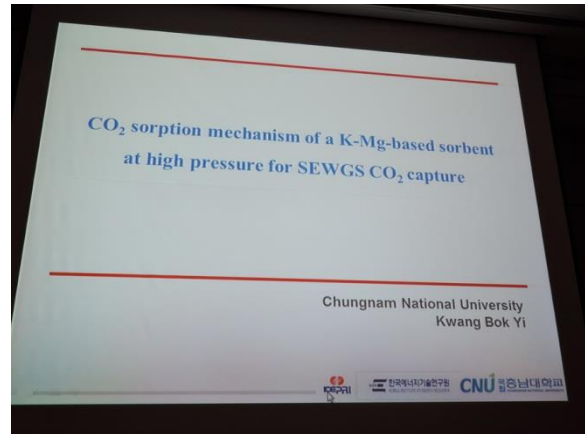


圖 III.1.2-82

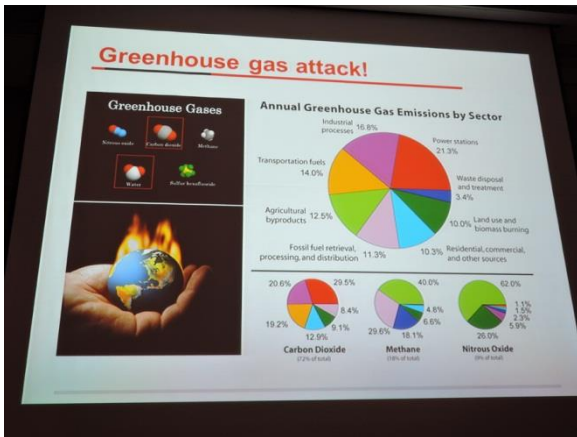


圖 III.1.2-83

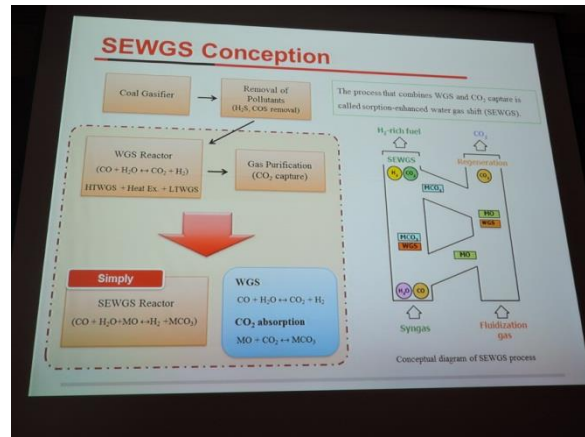


圖 III.1.2-84

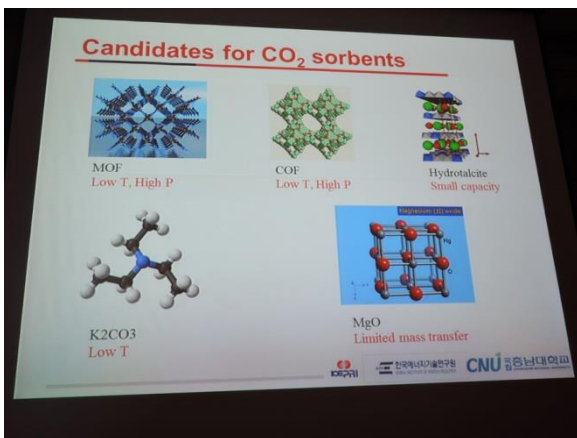


圖 III.1.2-85

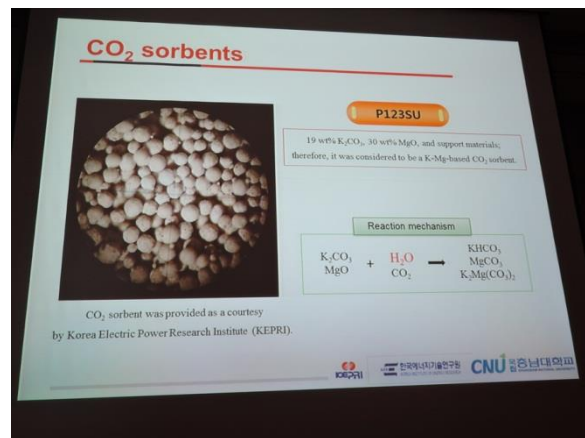


圖 III.1.2-86

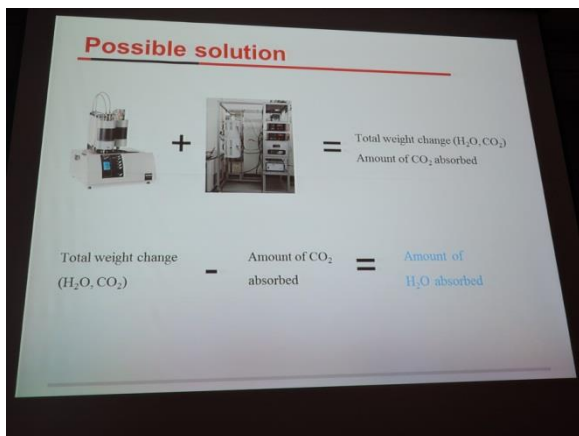


圖 III.1.2-87

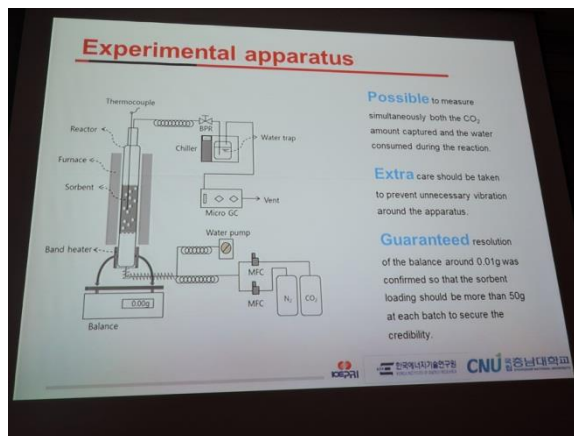


圖 III.1.2-88

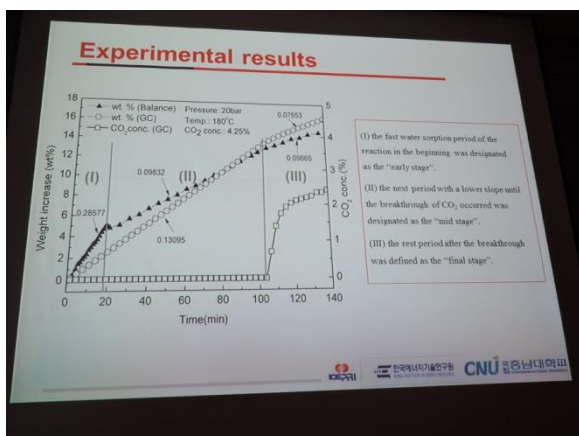


圖 III.1.2-89

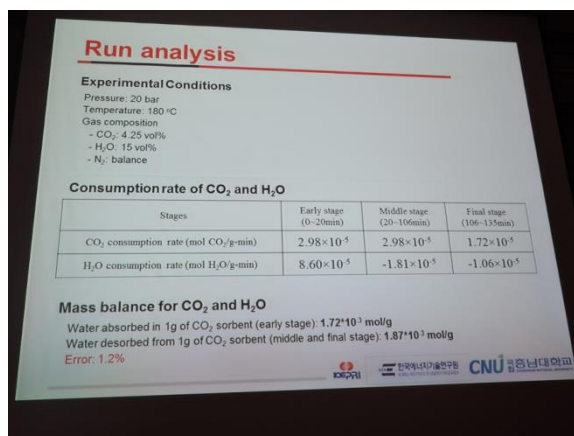


圖 III.1.2-90

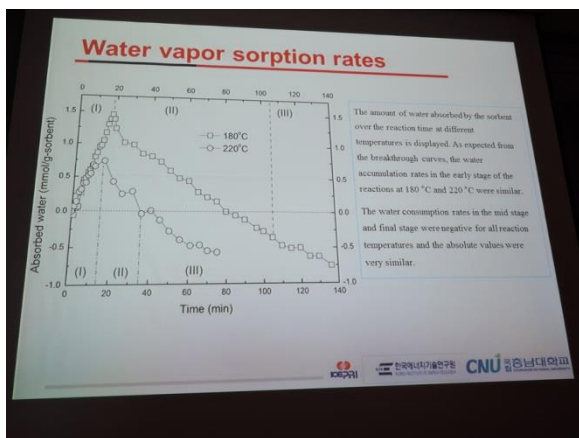


圖 III.1.2-91

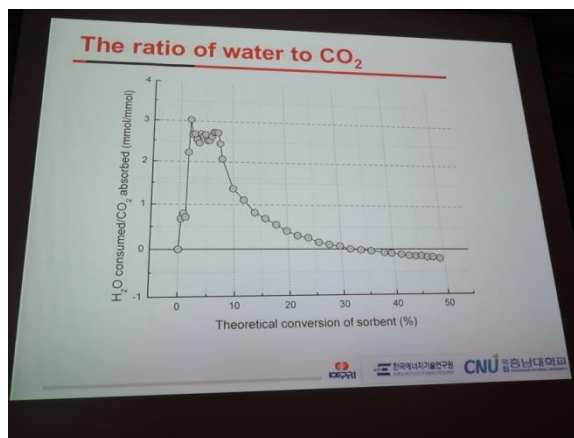


圖 III.1.2-92

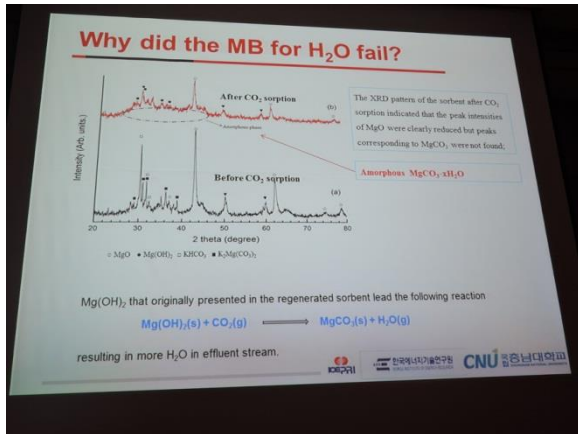


圖 III.1.2-93

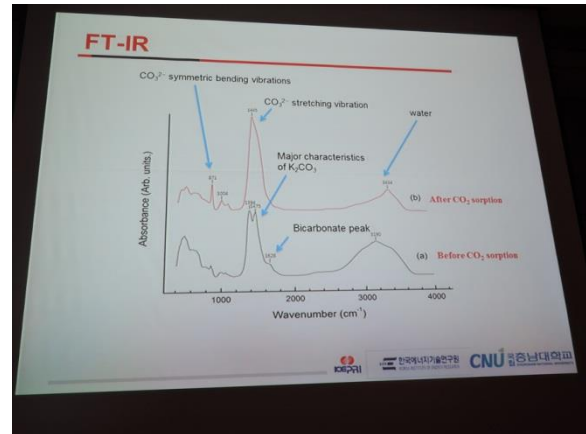


圖 III.1.2-94

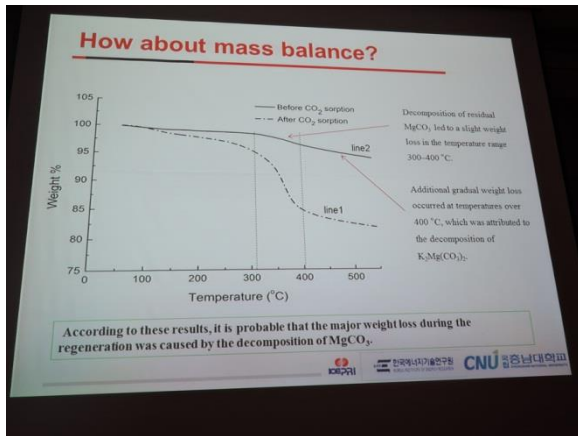


圖 III.1.2-95

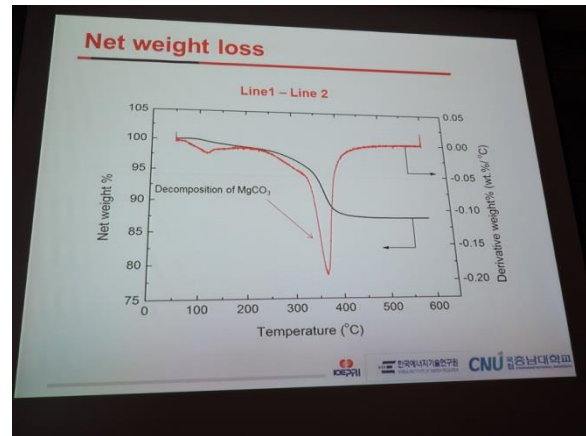


圖 III.1.2-96

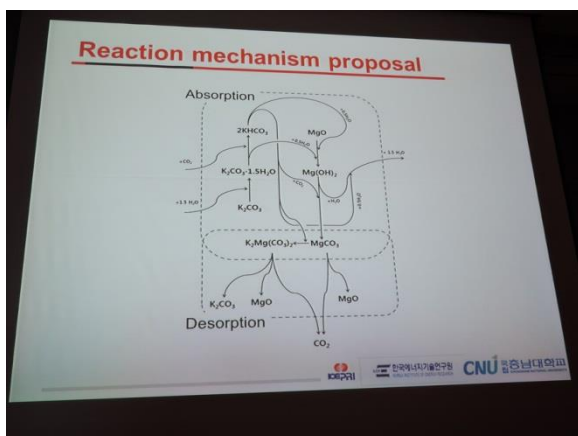


圖 III.1.2-97

- ### Conclusions
- Custom designed thermogravimetric analyzer coupled with GC provided information about water absorption rate and amount during the CO₂ sorption reaction.
 - From the amount of water absorbed, K₂CO₃ was not the main active material to absorb CO₂. Instead, K₂CO₃ behaved as a carrying medium for water and CO₂ by the reversible reaction between K₂CO₃ and KHCO₃. This reaction helped water vapor and CO₂ to penetrate the dense MgCO₃ layer and enhanced the CO₂ sorption rate and capacity.
 - XRD analysis revealed that K₂Mg(CO₃)₂ can be formed as the final product of the reaction. However, the formed K₂Mg(CO₃)₂ is believed not to participate in further cyclic CO₂ sorption and regeneration reactions because of its high decomposition temperature.
 - MgO is believed to be the main active material for CO₂ sorption with forming amorphous MgCO₃.

圖 III.1.2-98

3. Poster Session



圖 III.1.3-1 :



圖 III.1.3-2 :

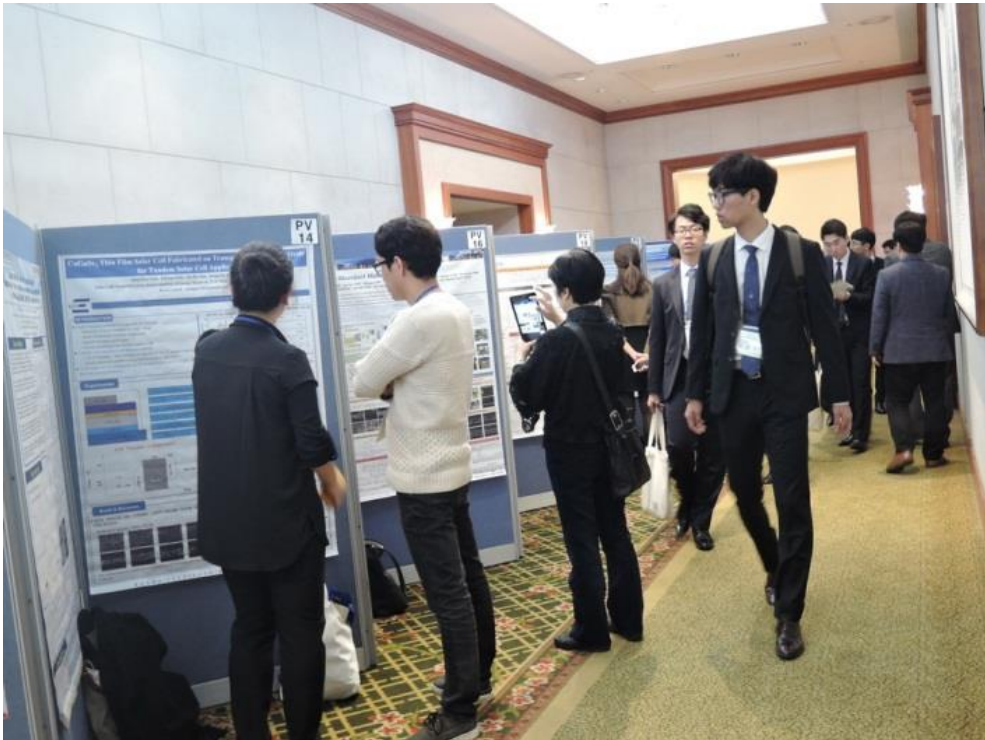


圖 III.1.3-3 :



圖 III.1.3-4 :

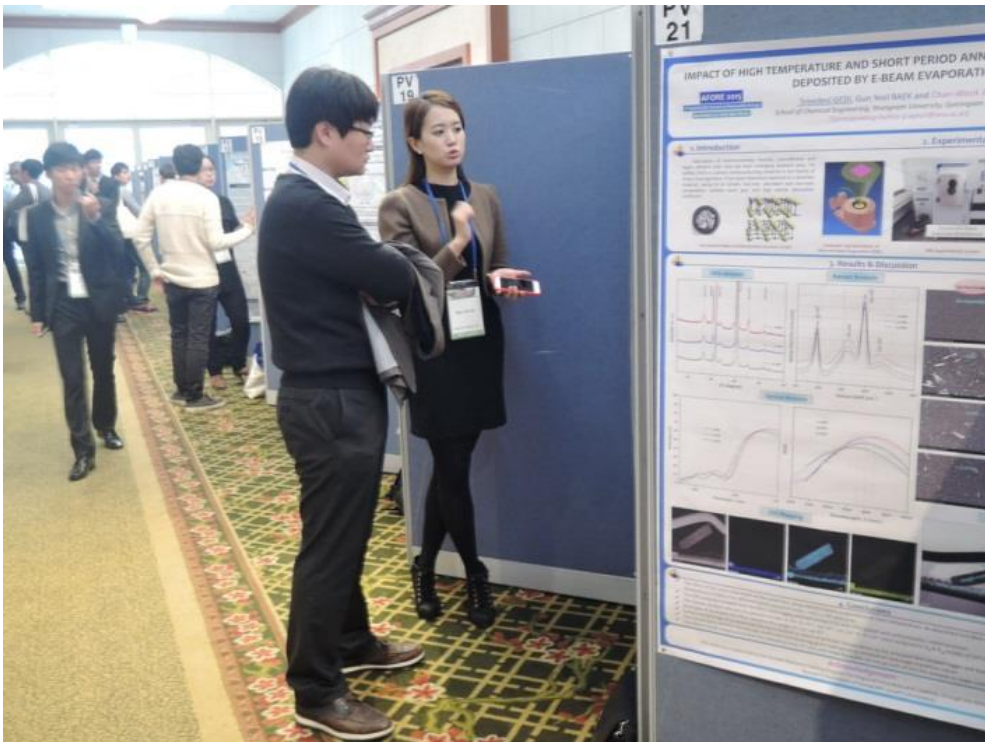


圖 III.1.3-5 :

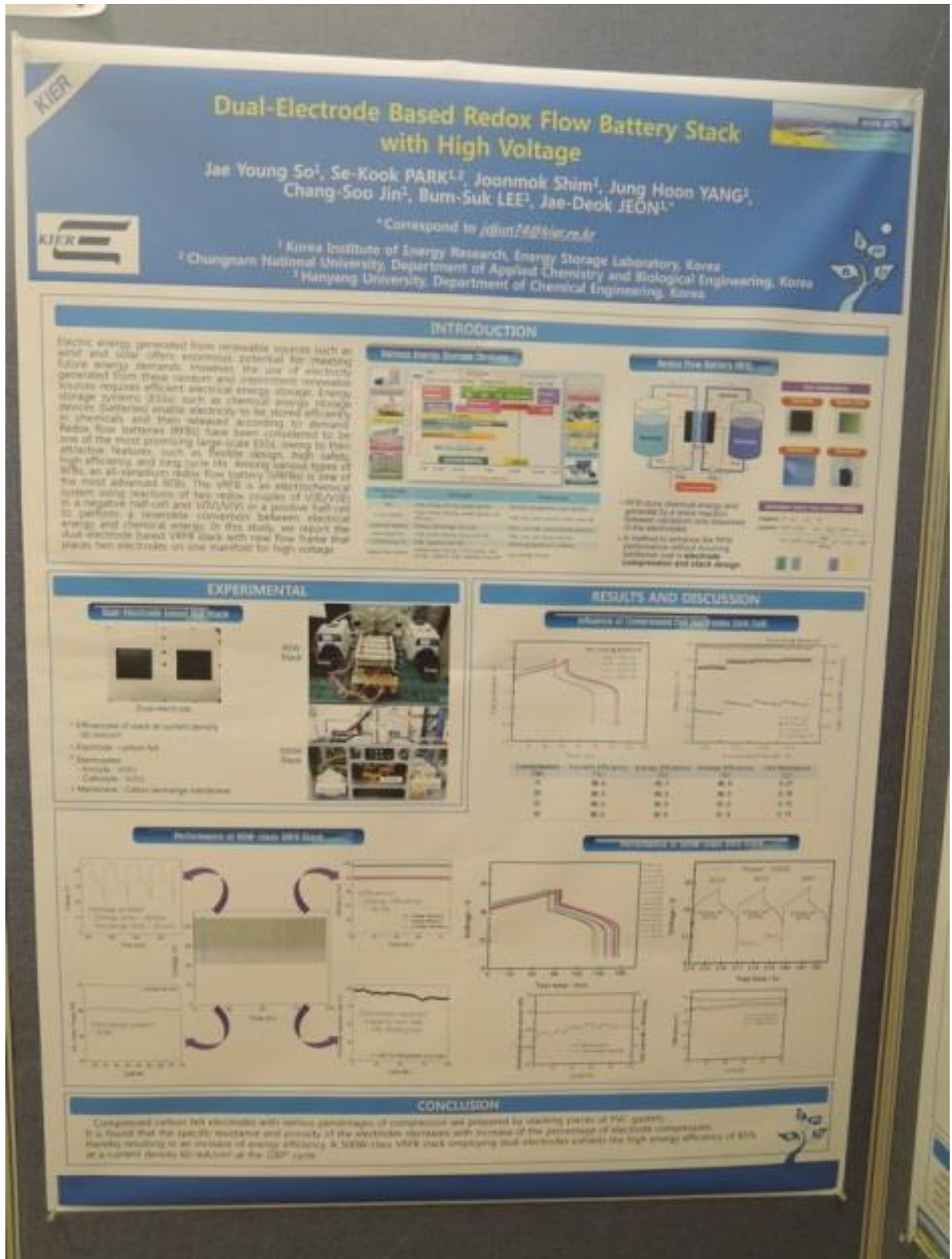


圖 III.1.3-6 :

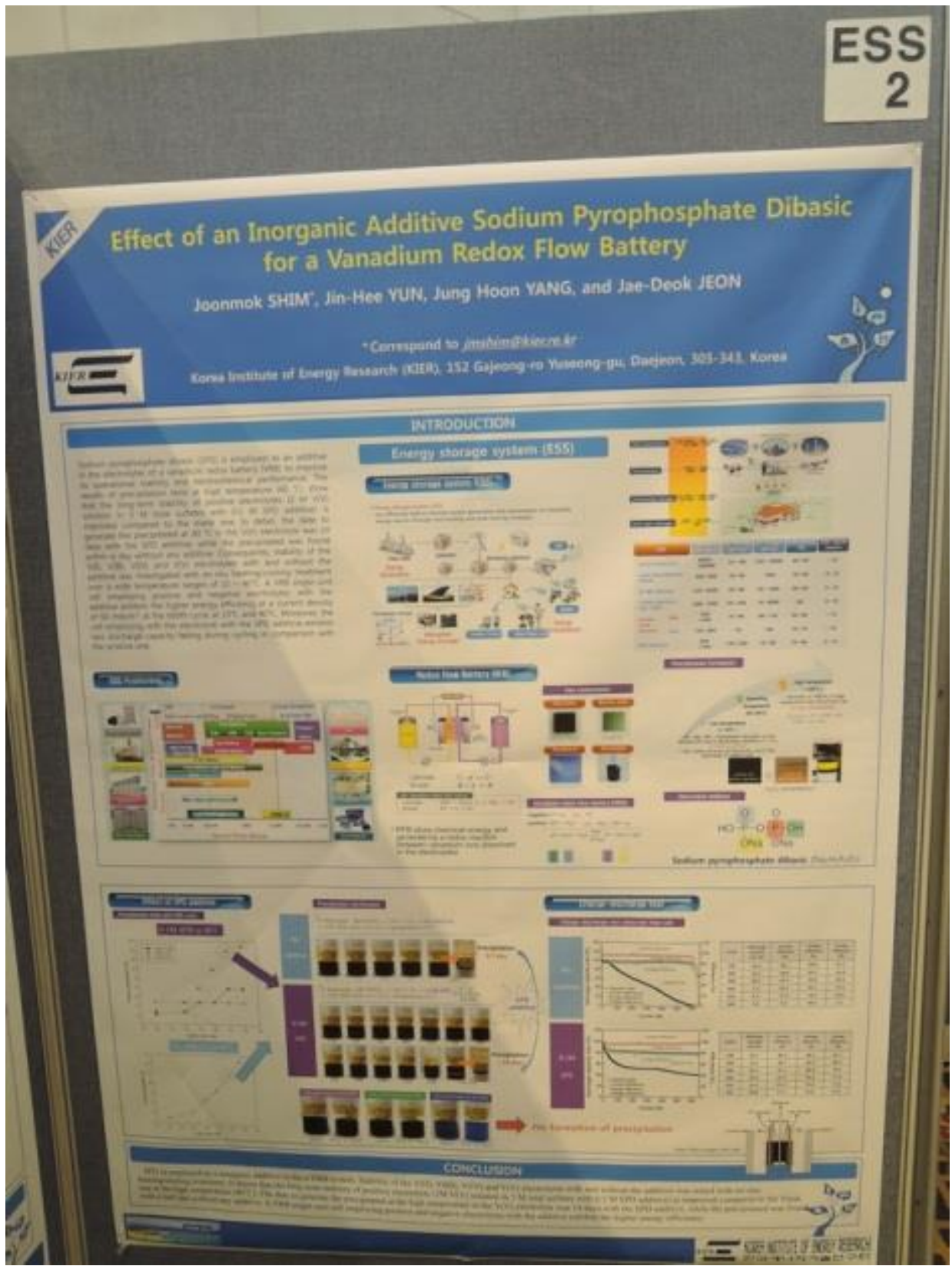


圖 III.1.3-7 :

四、建議事項

為推動國家減碳政策，政府自 2008 年發佈「永續能源政策綱領」以來積極建構低碳能源發展藍圖；因此，核能研究所積極進行**能源國家型科技計畫**領域之「淨碳技術發展」研究計畫，冀望能為我國減碳情景略盡綿薄之力。此外，該計畫亦從永續發展觀點推動**自主性潔淨能源技術之建立**，研發淨煤、多元氣化與應用、碳捕捉與分離等技術，藉以**提升能源自主性、降低國內的碳排放**。我國於 2015 年已正式通過「溫室氣體減量及管理法」，條文中明確規範我國溫室氣體長期減量目標為 2050 年的溫室氣體排放量要降為 2005 年的 50% 以下；另於 COP21 提交之 NDC，規劃 2030 年溫室氣體排放減量之階段性目標，顯示減碳策略與措施將是國家重要政策。聯合國 IPCC 之 AR5 已自 2013 年底起開始逐步發佈，持續警示氣候變遷之相關影響，為減緩全球氣候變化，政府必須儘速明確揭櫫策略方向，投資於科技知識來支持人類活動全方位的必要改變，以確保邁向一個永續之未來。

此次公差行程之建議事項可分為數個面向分述如下：

(一) 技術研發領域

1. 世界各國致力於發展新及再生能源、低碳排放潔淨技術，皆為國際抑低溫室氣體排放之潮流；顯示**本所能源技術開發計畫符合國際主流趨勢**，值得持續推動。
2. AFORE 大會從技術與經濟研究結果、政策、策略及商業角度進行報告及討論，其議題涵蓋**核研所科專計畫的主要內容**，具備未來性與競爭力，對實現永續發展將發揮著重要作用。

(二) 國際交流合作領域

1. 本次公差應邀請赴韓國，擔任研討會低碳排放潔淨技術場次之特邀講者，並發表專題演講，顯示本所之研發實力已受到關注，未來在**國際合作之重點團隊可扮演關鍵性支持角色**。
2. 韓國能源研究所為韓國能源科技研究之主要推動機構，而大會籌備委員會主席強調該所之領域與本所淨碳計畫相當契合，建議未來或可**形成國際合作之重點技術研究團隊**。

五、附 錄

- (一) 第五屆亞太再生能源論壇 (The 5th Asia-Pacific Forum on Renewable Energy, AFORE 2015) 之 Program at a Glance

Program at a Glance - AFORE 2015

November 4(Wed.)

Time	Crystalball room I	Crystalball room II	Crystalball room III	Emerald	Charlottee	Pearl	Jade	Ruby
2015 추계학술대회 & AFORE2015 Registration								
09:00~								
10:00-12:00		연료전지 1 (이준식 박사)	태양광 (윤재호 박사)	풍력 (임채욱 교수) [풍력 기획-KETEP]	지열 (이상돈 박사)	해양_파력 (안경관 교수)	폐기물 (상병인 박사) [폐기물 기획-KETEP]	해양_온도차 (오철 교수)
12:00~13:00	Lunch							
13:00~13:30	정기총회 (Crystalball room I)							
13:30~14:30	2015 추계학술대회 개회식 & 기조강연 (Crystalball room I) (사회자 : 정현 박사) - 개회사 : 윤형기 한국신재생에너지학회장 - 축사 : 황진택 한국에너지기술평가원장 - 기조강연 : 노건기 산업통상자원부 신재생에너지과장 안남성 한양대학교 교수(전 KETEP 원장) 김희집 에너지신산업추진협의회 위원장(서울대학교 객원 교수)							
14:30~16:30	환경 및 저탄소 /에너지저장 1 (양원 박사)	연료전지 2 (수소연료전지 기획) (박석희 박사) [수소연료전지 기획-KETEP]	[태양광 기획-KETEP I]	특별세션 '국내 해상풍력 보급현황 및 전망'	수력(소수력) 1 장태현 처장(한국수자원공사)	해양_염분차 (정남조 박사)	녹색에너지정책 전략 (홍성준 박사)	가스하이드레이트 (류병재 박사)

16:30~17:30 포스터 발표 (Lobby)

November 5(Thur.)

Time	Crystalball room I	Crystalball room II	Crystalball room III	Emerald	Charlottee	Pearl	Jade	Ruby
08:30~	2015 추계학술대회 & AFORE2015 Registration							
09:00~11:00	환경 및 저탄소 에너지저장 2 (천동현 박사)	Wind Energy I (Dr. Hyun-Goo KIM)	CCT/CCS /Low Carbon I (Dr. Ho-Jung RYU/Prof. Kwang Bok YI)	Special Session I 'International Joint Workshop on Super Grid in Northeast Asia'	수력 (소수력) 2 장태현 처장(한국수자원공사)	해양_조류 (황태규 박사)	Smart Grid I (Dr. Suyong CHAE)	바이오 (이규복 박사) [바이오 기획-KETEP]
11:00~12:00	POSTER DISCUSSION-1							
12:00~13:00	Lunch							
13:00~15:00	Plenary Sessions (Crystalball room) (Chair : Prof. Eunnyeong Heo) - Dr. Soogil Young(Research Professor of Green Growth and Sustainable Development KDI School of Public Policy Management; Director, Sustainable Development Solutions Network (SDSN), Korea) - Prof. Yogi Goswami (University of South Florida / Editor-in-Chief of Solar Energy, USA) - Prof. Chunde Yao (Deputy President of Chinese Society of Engineering Thermo-physics(CSET), China) - Prof. Gento Mogi(University of Tokyo, Japan)							
15:00~15:15	Break time							
15:15~17:00				Geothermal Energy I (Prof. Jong Min CHOI)	Hydrogen & Fuel Cell I (Dr. Seok-Hee PARK)	Marine Energy I (Prof. Domenico)	Wasted Energy & Utilization I (Prof. Weilin ZHUGE/Dr.	Bio Energy I (Dr. Kyubock LEE)

COIRO)
Yeon Seok
CHOI)

Opening Ceremony (Crystalball room) (Chair : Dr. Heon Jung)

- Opening address : Dr. Hyungkee Yoon(President of Korean Society for New and Renewable Energy(KSNRE), Korea)

- Welcoming Speech :

Mr. HeeRyong Won (Governor of Jeju Special Self-Governing Province, Korea)

17:30~18:30 Mr. Chung, Yangho (Deputy Minister of Ministry of Trade, Industry and Energy, Korea)

0 - Congratulatory message :

Mr. Changil Kang (Member of National Assembly, Korea)

Prof. Hongguang Jin (President of Chinese Society of Engineering Thermo-physics(CSET), China)

Mr. Byamba JIGJID (President of Mongolian Society of Asia Super Grid(MSASG), Mogolia)

Mr. Li Bao shan (president of China Renewable Energy Society(CRES), China)

18:30~20:30

0 **Banquet (Crystalball room)**

November 6(Fri.)

Time	Crystalball room I	Crystalball room II	Crystalball room III	Emerald	Charlottee	Pearl	Jade	Ruby
08:30~	AFORE2015 Registration							
09:00~10:30	Special Session II 'New & Renewable Energy Hybrid system'	Policy, Strategy & New Business (Dr. Nyun-Bae PARK)	Special Session III 'Earth Abundant & Non-toxic Solar cell Materials and Devices'	Smart Grid II (Prof. Jee Hoon JUNG)	Hydrogen & Fuel Cell II (Prof. Kyoungyoun KIM)	Marine Energy II (Prof. Changjo YANG)	Wasted Enerngy & Utilization II (Dr. Yeon Seok CHOI)	Special Session IV 'The Future of Mocroalgae Biorefinery'
10:30~11:00							ESS (Dr. Sun-Hwa YEON)	
11:00~12:00	POSTER DISCUSSION-2							

12:00~13:00
0 **Lunch**

13:00~15:00 0	Hydro Power (Prof. Young-Do CHOI)	Wind Energy II (Prof. Bum Suk Kim)	CCT/CCS /Low Caron II (Dr. Jong-Ho MOON/Dr. Jeom-In BAEK)	Geothermal Energy II (Dr. Young-Jin BAIK)	Hydrogen & Fuel Cell III (Prof. Kyoungyoun KIM)	Marine Energy III (Prof. Changjo YANG)	Solar Thermal /Photovoltaics (Prof. Jin Hyeok Kim)	Special Session V 'Biotechnology for Fuels and Chemicals'
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15:00~15:15
5 **Break time**

Closing ceremony (Crystalball room I) (Chair : Dr. Heon Jung)

15:15~15:40
0 Prof. Ma Longlong (President of Guangzhou Institute of Energy Conversion(GIEC), China)
CSET, China, Introduction of AFORE2016(venue, date)
AFORE2015 Excellent Paper Award

Bio Energy II
(Dr. You-Kwan OH)

November 7(Sat.)

09:00~ **Technical Tour**