出國報告（出國類別：實習）

赴美研習專業工程模擬模型建置技術及實務驗證

服務機關：核能研究所
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出國期間：98 年 9 月 19 日~98 年 10 月 3 日
報告日期：98 年 11 月 11 日

摘　要

爲推動國家減碳政策，政府積極建構低碳能源發展藍圖，電力部門應發展低碳潔淨能源，而核能與燃煤發電皆爲國內重要的基載電力，也將是必要的低碳能源選項。有鑑於爲有效掌握國際潔淨能源議題，本次公差主要係出席 International Pittsburgh Coal Conference (IPCC) 及前往 University of New Orleans 研習，推動重要學習及交流溝通平台。

IPCC 是國際潔淨能源技術領域之年度盛會，議題涵蓋環境永續性、碳管理、淨煤等重要領域，爲掌握低碳能源發展最新研發現況之重要場合。美國紐奧良大學能源轉換及節約研究中心爲潔淨能源技術領域之國際知名重鎮，該中心主任王亭教授非常歡迎本所派員前往研習，並建立雙方長期合作關係。故本所此次派員赴美公差乃爲拓展國際人脈、推動國際合作及實務驗證專業工程技術之甚佳機會。

目　　次

摘　要

一、目　的

爲推動國家減碳政策，政府積極建構低碳能源發展藍圖，電力部門應發展低碳潔淨能源，而核能與燃煤發電皆爲國內重要的基載電力，也將是必要的低碳能源選項。因此，在能源供應面的「淨源」方面，須推動能源結構改造與效率提升，加速訂定電廠整體效率提升計畫；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，降低發電系統的碳排放。

我國核電廠運轉均已超過 20 年，爲增加電廠出力，本所接受台電公司委託執行「核三廠一號機二號機小幅度功率提昇技術服務案」，研究評估機組運轉參數以提升效率，亦可爲我國減碳情景略盡綿薄之力。此外，本所目前亦積極進行能源國家型科技計畫領域之「永續淨煤整合系統關鍵技術開發」及「減碳政策評估與淨碳技術發展」研究計畫，冀望從永續發展觀點推動自主性潔淨能源技術之建立。有鑑於爲有效掌握國際潔淨能源議題，本次公差主要係出席 International Pittsburgh Coal Conference (IPCC) 及前往 University of New Orleans 研習，推動重要學習及交流溝通平台。

IPCC 係國際潔淨能源技術領域之年度盛會，第 26 屆年會於 2009 年 9 月 20 – 23 日在美國賓州匹茲堡舉行，議題涵蓋環境永續性、碳管理、淨煤、碳衍生產品等重要領域，爲掌握低碳能源發展最新研發現況之重要場合。包含 NETL, EPRI, TU Freiberg (Germany), GE, PNNL, RTI, TDA Research, MIT, Air Products, Siemens, ExxonMobil, OSU, ECN (Netherlands), GTI, Alstom 等世界各先進國家在低碳潔淨能源技術等研究重點之專家多人與會，故本所派員出席會議將爲實務驗證專業工程技術之甚佳機會。

其次，美國紐奧良大學能源轉換及節約研究中心爲潔淨能源技術領域之國際知名重鎮，該中心主任王亭教授爲該校講座教授，從事能源技術研究逾 30 年；目前是潔淨能源技術領域國際知名學者，亦爲歐、美、大陸等國家在低碳能源技術發展之重要顧問。王教授非常歡迎本所派員前往紐奧良大學研究中心研習專業工程模擬模型建置技術及實務驗證，並建立雙方長期合作關係。

王教授在 IPCC 大會發表研究成果論文，亦強烈建議本所研習人員出席該會議；藉此機會，可強化研習專業工程模擬模型建置技術及實務驗證效果、深入瞭解目前國際上之技術研究重點及最新發展趨勢。王教授並表示可替本所研習人員引介與會各相關領域專家，拓展與國際能源學者專家之關係及國際合作。故本所此次派員赴美公差乃爲拓展國際人脈、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 98 年 9 月 19 日至 10 月 3 日止，共計 15 天。

9 月 19 日(星期六)　自桃園機場出發，抵達美國 Newark，在當地過夜
9 月 20 日(星期日)　轉機抵達美國賓州匹茲堡，辦理 IPCC 會議註冊
9 月 21 日(星期一) ～ 9 月 23 日(星期三)
出席第 26 屆 IPCC 會議(International Pittsburgh Coal Conference)
9 月 24 日(星期四)　搭機赴 New Orleans
9 月 25 日(星期五) ～ 10 月 1 日(星期四)
在 University of New Orleans (UNO)研習
10 月 1 日(星期四) ～ 10 月 2 日(星期五)
自 New Orleans 搭機赴西岸 Los Angeles，轉機返回台灣
10 月 3 日(星期六)　返抵台北

（二）第 26 屆匹茲堡淨煤國際會議(International Pittsburgh Coal Conference, **IPCC**)

International Pittsburgh Coal Conference (IPCC) 爲國際淨煤技術領域之年度盛會，第 26 屆年會於 2009 年 9 月 20 – 23 日在美國賓州匹茲堡舉行，議題涵蓋環境永續性、碳管理、淨煤等重要領域，如 Gasification, Combustion/Chemical Looping, Coal-Derived Products, … etc.。本次大會共有來自世界各先進國家，包含 NETL, EPRI, TU Freiberg (Germany), GE, PNNL, RTI, TDA Research, MIT, Air Products, Siemens, ExxonMobil, OSU, ECN (Netherlands), GTI, Alstom 等在低碳潔淨能源、淨煤、氣化技術等研究重點之專家計超過四百人參與盛會。

IPCC 之議程如表 II-1 所示。在每天早上的全體會議 (Plenary Session) 中，各安排三場 keynote 演講。隨後，則分爲三個時段，同時各有六個平行場次之口頭論文發表。壁報論文場次則安排在 9 月 22 日（星期二）的晚間。

在 IPCC 論文發表議程之外，USDOE/NETL 特別於 9 月 23 日（星期三）安排了一場 Gasification Fundamentals Workshop，邀請與會的學者專家討論關鍵的技術挑戰。而

NETL 未來將組成國際性的跨領域技術交流平台，更希望能獲得 DOE 經費支持，成立相關研究計畫，推動各界合作。

本次大會之議程依六大領域依次舉行研討場次，各領域之主題摘要如下：

2009 Sessions and Topics

1. Combustion

Chairs - John Wheeldon and Evan Granite

- Industrial Applications, Economics, and Environmental Issues
- Advance Pulverized Coal Combustion Technologies (Supercritical, Fluidized Bed, Etc.)
- Novel Technologies (Oxyfuel, Chemical Looping, Etc)
- Flue Gas Clean Up
- Science And Modeling
- Materials, Instrumentation, and Controls
- Turbines (Steams)

2. Gasification

Chairs - Gary Stiegel , Johan Van Dyk , Julio Friedmann and Ke Liu

- Industrial Applications, Economics, and Environmental Issues
- Underground Coal Gasification (UCG)
- Synthesis Gas Cleanup
- Gasification Science and Modeling
- Novel Gasification Technologies and Concepts
- Co-Gasification of Coal and Biomass

3. Sustainability and Environment

Chairs - Frank Kranik and Massood Ramezan

- Energy Production and Water Use - Conservation and Recycle

- Life Cycle Analysis (LCA) of Energy Production Systems
- Energy Production Impact on the Environment
- Energy Sustainability - Efficiency and Conversion to Reduce GHG
- GHG: Inventory Protocol, Legal and Regulatory Considerations, Credits

4. Carbon Management

Chairs - Bob Miller and Leslie Ruppert

- Pre-Combustion Capture
- Post-Combustion Capture
- CO_2 Sequestration (Monitoring, Mitigation, and Verification; Storage: Depleted Oil/Gas Reservoirs, Aquifers, Basalt, Coal Bed Methane)
- Transportation Infrastructure and Issues
- Legal and Regulatory Issues
- Carbon Footprint Comparison: CTX (DCL/ICL), Petroleum

5. Coal-Derived Products

Chairs - Chunshan Song, Sam Tam, Bryan Morreale and Rachid Oukaci

- Coal-To-Liquids, CTL (Direct Liquefaction, Fischer-Tropsch, Methanol-To-Gasoline, Etc.)
- Substitute Natural Gas (SNG)
- Hydrogen Production
- Syngas Utilization (Gas Turbines, Fuel Cells)
- Chemicals/Materials
- Coal Utilization By-Products (Ash, Fertilizers, Etc.)
- Jet Fuel

6. Coal Science

Chairs - Jim Hower, B.K. Parekh, and Frans Waanders

- Chemistry
- Geoscience/Coal Resources

- Trace Elements/Emission
- Processing
- Coal Preparation

（三）赴 University of New Orleans (UNO) 研習

美國紐奧良大學 (University of New Orleans, UNO) 隸屬於路易斯安那州 (Louisiana State) 州立大學系統，校園位於紐奧良市區北邊之湖濱區，如圖 II-1 所示。該校之能源轉換及節約研究中心 (Energy Conversion & Conservation Center, ECCC) 成立於 1999 年，其任務是促進潔淨能源研究與教育、加強區域性經濟成長、以及發展國家級與跨國型能源計畫，運用改善節能及效率來達成環境友善性與永續性。王亭教授 (Professor Ting Wang) 原爲美國 South Carolina 州克林姆遜 (Clemson) 大學機械工程系教授及渦輪機實驗室主任，負責主導能源部 (DOE) 的先進渦輪機系統 (Advanced Turbine System, ATS) 計畫。當年，紐奧良大學特別重金禮聘王教授爲 Jack & Reba Matthey 研究基金首席講座教授，並擔任 ECCC 的創始主任；同時，路易斯安那州長 “Mike” Foster 亦任命他爲綜合能源政策顧問委員會委員

筆者於 9 月 24 日（星期四）自匹茲堡搭機飛抵紐奧良，次日起即拜訪紐奧良大學能源轉換及節約研究中心，進行研習行程。此次研習行程安排如表 II-2 所示，涵蓋了相當廣泛之技術領域。在此期間，筆者亦應邀發表一場專題演講「Clean Carbon Research at INER in Taiwan」，介紹核研所對台灣永續潔淨能源之觀點與規劃以及近年來在淨碳技術領域之研發工作；會後並與部分研究人員合影留念，如圖 II-2、 II-3 所示。其次，在王教授引薦下筆者於 9 月 28 日（星期一）拜會了 UNO 主管研發事務的副校長兼研究院院長 (Vice Chancellor for Research & Dean of Graduate School) Prof. Scott Whittenburg（請參見圖 II-4）；Prof. Whittenburg 對 UNO 與核研所建立合作關係感到非常欣慰，亦期望未來能有進一步更密切之合作。

筆者在 UNO 的研習行程於 10 月 1 日告一段落，當天即自 New Orleans 搭機赴美國西岸大城 Los Angeles，轉機返回台灣；最後，於 10 月 3 日(星期六)返抵台北，結束本次公差行程。

§II　有關 2009 US 公差行程之圖表

表 II-1：IPCC-26 之議程

PRELIMINARY PROGRAM SCHEDULE

Sunday, September 20, 2009						
8:00-16:00	UCG Tutorial – Westmoreland Room					
15:00-19:00	Registration – Butler Room (2nd Level)					
18:30-20:30	Reception – Pennsylvania Room (2nd Level)					
Monday, September 21, 2009						
13:00-17:45	Technical Tour – Westin Hotel Lobby					
7:00-17:00	Registration – Butler Room (2nd Level)					
8:00-8:20	Opening Ceremony – Allegheny Ballroom 2 & 3 (3rd Level)					
8:20-10:05	Plenary Session – Allegheny Ballroom 2 & 3 (3rd Level)					
10:05-10:20	**Break – Lobby (3rd Level)**					
ROOM	**Westmoreland (West and Central)**	**Cambria**	**Westmoreland (East)**	**Fayette**	**Washington**	**Somerset**
	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6
10:20-12:00	Gasification: General Session – 1	Sustainability and Environment: Policy	Carbon Management: Pre-Combustion – 1	Combustion: Oxy-Combustion – 1	Coal-Derived Products: Chemicals and Materials from Coal	Coal-Derived Products: Coal-to-Liquids: Technology – 1
12:00-13:30	**Conference Luncheon – Penn City and the Pennsylvania Room (2nd Level)**					
	Session 7	Session 8	Session 9	Session 10	Session 11	Session 12
13:30-15:10	Gasification: General Session – 2	Sustainability and Environment: GHG/GWP	Carbon Management: Pre-Combustion – 2	Combustion – 1	Coal Science: Coal Beneficiation – 1	Coal-Derived Products: Coal-to-Liquids: Catalysts
15:10-15:25	**Break – Lobby (2nd Level)**					
	Session 13	Session 14	Session 15	Session 16	Session 17	Session 18
15:25-17:25	Gasification: Underground Coal Gasification – 1	Gasification: Fundamentals – 1	Carbon Management	Combustion: Chemical Looping – 1	Coal Science: Coal Beneficiation – 2	Coal-Derived Products: Coal-to-Liquids: Technology – 2
18:00-21:00	**Gateway Clipper Dinner Cruise**					
Tuesday, September 22, 2009						
7:00-17:00	Registration – Butler Room (2nd Level)					
8:20-10:05	Plenary Session – Allegheny Ballroom 2 & 3 (3rd Level)					
10:05-10:20	**Break – Lobby (3rd Level)**					
ROOM	**Westmoreland (West and Central)**	**Cambria**	**Westmoreland (East)**	**Fayette**	**Washington**	**Somerset**
	Session 19	Session 20	Session 21	Session 22	Session 23	Session 24
10:20-12:00	Gasification: Underground Coal Gasification – 2	Gasification: Fundamentals – 2	Carbon Management: Post-Combustion – 1	Combustion: Oxy-Combustion – 2	Coal Science: Coal Chemistry – 1	Coal-Derived Products: Carbon Management for Coal Conversion
12:00-13:30	**Conference Luncheon – Allegheny Ballroom 2 & 3 (3rd Level)**					
	Session 25	Session 26	Session 27	Session 28	Session 29	Session 30
13:30-15:10	Gasification: Underground Coal Gasification – 3	Gasification: Fundamentals – 3	Carbon Management: Post-Combustion – 2	Combustion: Chemical Looping – 2	Coal Science: Coal Geoscience – 1: Coal Fires	Coal-Derived Products: Substitute Natural Gas (SNG)
15:10-15:25	**Break – Lobby (2nd Level)**					
	Session 31	Session 32	Session 33	Session 34	Session 35	Session 36
15:25-17:25	Gasification: Synthesis Gas Cleaning – 1	Gasification: Fundamentals – 4	Carbon Management: Sequestration – 1	Combustion: Mercury	Coal Science: Coal Chemistry – 2	Coal–Derived Products: Hydrogen Production – 1
18:00-21:00	**Poster Presentations – Pennsylvania Room (2nd Level)**					
Wednesday, September 23, 2009						
7:00-17:00	Registration – Butler Room (2nd Level)					
8:20-10:05	Plenary Session – Allegheny Ballroom 2 & 3 (3rd Level)					
10:05-10:20	**Break – Lobby (3rd Level)**					
10:20-17:00	**Gasification Fundamentals Workshop – Crawford Room (3rd Level)**					
ROOM	**Westmoreland (West and Central)**	**Cambria**	**Westmoreland (East)**	**Fayette**	**Washington**	**Somerset**
	Session 37	Session 38	Session 39	Session 40	Session 41	Session 42
10:20-12:00	Gasification: Synthesis Gas Cleaning – 2	Gasification: Advanced Technologies – 1	Carbon Management: Sequestration – 2	Combustion: Oxy-Combustion – 3	Coal Science: Coal Geoscience – 2	Coal-Derived Products: Hydrogen Production – 2
12:00-13:30	**Awards Luncheon – Allegheny Ballroom 2 & 3 (3rd Level)**					
	Session 43	Session 44	Session 45	Session 46	Session 47	Session 48
13:30-15:10	Gasification: Co-Gasification and Low-Rank Coal – 1	Gasification: Advanced Technologies – 2	Sustainability and Environment: General – 1	Combustion – 2	Coal Science: Coal Geoscience – 3	Coal-Derived Products: Syngas Utilization (Gas Turbines, Fuel Cells)
15:10-15:25	**Break – Lobby (2nd Level)**					
	Session 49	Session 50	Session 51	Session 52	Session 53	Session 54
15:25-17:25	Gasification: Co-Gasification and Low-Rank Coal – 2	Gasification: Advanced Technologies – 3	Sustainability and Environment: General – 2	Combustion: Flue Gas Clean Up	Coal Science: Coal Geoscience – 4	Coal-Derived Products: Coal Co-Conversion with Other Feedstocks
18:00-20:00	**Advisory Board Meeting**					

表 II-2：在 University of New Orleans (UNO) 研習之行程

Itinerary of Dr. Yau-Pin Chyou at ECCC
(September 24 – October 1, 2009)

Dr. Yau-Pin Chyou
Institute of Nuclear Energy Research (INER)
Taiwan (R.O.C.)

Sept. 24 (Thursday) Arrive at New Orleans

Sept. 25 (Friday)
10:00 am Armin Silaen (Gasification simulation)
11:00 am Dr. T. S. Dhanasekaran (Mist-Air film cooling on gas turbine cooling)
Noon Lunch (Dr. T. S. Dhanasekaran)
1:30 pm Proposal preparation
4:00 pm Presentation "Clean Carbon Research at INER in Taiwan"

Sept. 26 (Saturday)
10:00 am Experiencing impact of hazard climate on the social/eco-system in New Orleans
7:30 pm Dinner at Mat & Naddie's Restaurant (Dr. Ting Wang)

Sept. 27 (Sunday) Revise proposal of the joint NEP project of NCU, INER and UNO

Sept. 28 (Monday)
10:00 am Dr. T. S. Dhanasekaran (Thermoflow, IGCC-Wei Li's work, and MaGIC)
11:45 am Lunch (Liang Wang)
1:00 pm Liang Wang (Reverse-flow combustor, CFD and Experiment)
2:00 pm Jason Kent (TurboPiston Pump, Car drag wind tunnel test)
3:00 pm Dr. J. Khan (Gas Turbine Inlet fogging and wet compression)
4:00 pm Monayam Mazumder and Dr. Khan (Mild gasifier simulation)
6:00 pm Dinner at Okinagu Restaurant (Dr. J. Khan)

Sept. 29 (Tuesday)
10:00 am Dr. T. S. Dhanasekaran (Mist/steam cooling CFD and experiment)
11:00 am Lei Zhao (Mist air film cooling CFD and experiment)
Noon Lunch (Lei Zhao)
1:30 pm Lei Zhao (Petcoke calcination, kiln brick heat transfer, and Pyroscrubber)

3:00 pm Open information exchange

Sept. 30 (Wednesday)
10:00 am Visit NASA/Stennis Space Center
7:30 pm Dinner (Dr. Ting Wang)

October 1 (Thursday) Departure

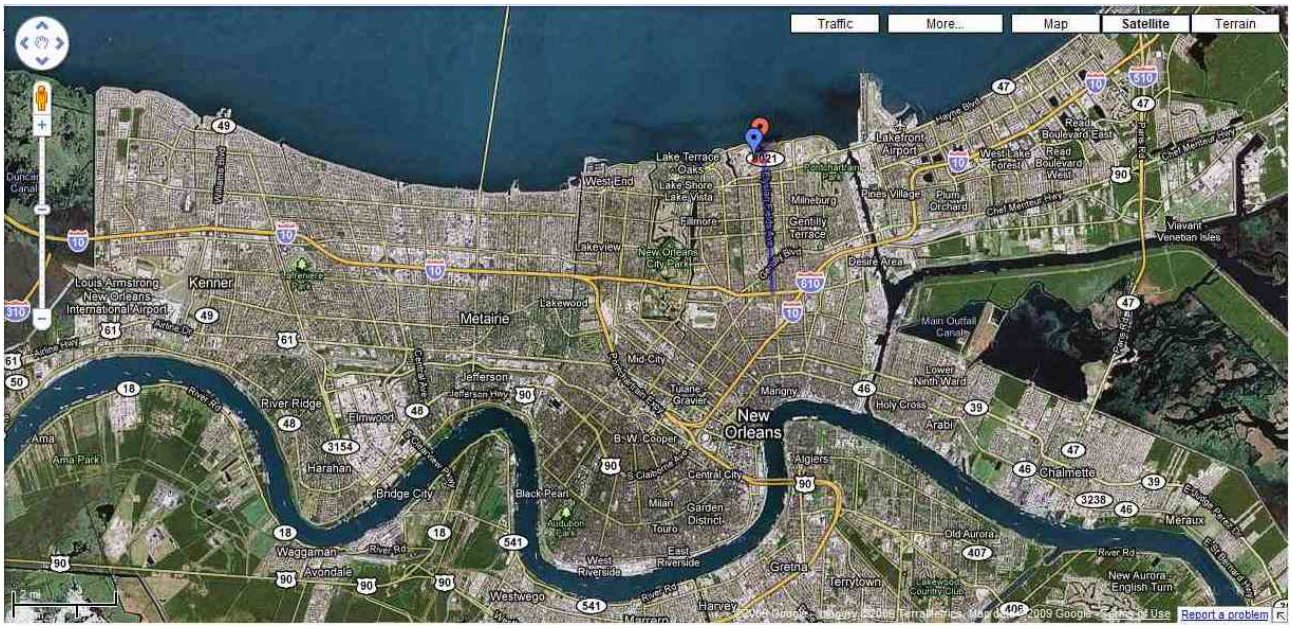


圖 II-1： 紐奧良市區週邊之衛星影像，圖中上方北邊 Pontchartrain 湖濱區之藍、紅色標記分別爲 UNO 與 ECCC 的地點位置，而圖中下方則爲蜿蜒之 Mississippi River

圖 II-2： 筆者與王亭教授合影於 UNO 校園 (2009.09.25)

圖 II-3： 筆者與 ECCC 部分研究人員合影留念 (2009.09.25)

圖 II-4： 筆者拜會 UNO 副校長 Prof. Scott Whittenburg (2009.09.28)

三、心　得

本次公差主要係出席 International Pittsburgh Coal Conference (IPCC) 及前往 University of New Orleans 研習，本報告將依序分別選擇重點摘要於下文中。

（一）第 26 屆 International Pittsburgh Coal Conference (IPCC) 議程

第 26 屆 IPCC 於 2009 年 9 月 20 ～ 23 日在在美國賓州匹茲堡召開 (圖 III.1.1-1 ~ III.1.1-6)，其議程分爲全體會議 (Plenary Session) 、論文發表、及 Workshop 三部分。

1. Plenary Sessions

在每天早上的全體會議 (Plenary Session) 中，大會各安排三場 keynote 演講。今 (2009) 年各應邀講員之資料與講題列舉如下：

Plenary Presentations

2009 Plenary Speakers

Monday, September 21 - Energy Production / Policy Speakers

Granger Morgan

Head, Department of Engineering and Public Policy

Carnegie Mellon University, USA

"Making Clean Coal a Reality"

Al Whitehouse

Director, International Program

U.S. Department of Interior, USA

"International Cooperation to Combat Climate Change and the Role of Coal"

Ben Yamagata

Coal Utilization Research Council, USA

"Coal with Carbon Capture and Storage in an Era of Rising Energy Demand and Regulation of CO_2"

Tuesday, September 22 -International Issues

Selahaddin Anac

General Manager

Turkish Coal Enterprise (TKI), TURKEY

" Present Situation of Coal in Energy Policy of Turkey and Turkish Coal Industry"

Harko Mulder

Manager Process Development

Sasol Technologies, SOUTH AFRICA

"Coal-to-Liquids: Can CO_2 Emissions be Significantly Reduced?"

Zhongxue Gan

Vice President and CTO

ENN Group, P.R. CHINA

"ENN's Clean Energy Road Map"

Wednesday, September 23 - Environmental Issues

Frank Princiotta

U.S. Environmental Protection Agency, USA

"Global Climate Change and Other Air Pollution Challenges"

Gregory Gillette

GE Energy, USA

"Sustainable Development of Coal Gasification Technology"

Robert Beck

Executive Vice President and Chief Operating Officer

The National Coal Council, Inc.

"The Urgency of Sustainable Coal"

(1) Energy Production/Policy (圖 III.1.1-7 ~ III.1.1-12；圖 III.1.1-13 ~ III.1.1-18)

九月二十一日早上的研討議題爲「能源生產與政策 (Energy Production/Policy)」，排定三場大會演講 (Plenary lecture)；講者分別來自學術單位、政府機構、與產業研究聯盟，從不同立場與角度就能源、研發策略等領域加以闡述。

首位演講者 Prof. M.G. Morgan 是 Carnegie Mellon Univ.工程與公共政策學系系主任，講題爲“Making Much Cleaner Coal A Reality”(圖 III.1.1-7)，其內容主要涵蓋造成 CO_2 氣候問題之原因、爲何 CCS 是解決問題必要的選項、如何發展一套有效的管理架構、消除燃煤排放是“淨”煤的一部份工作等 (圖 III.1.1-8)。二氧化碳異於其他空污物，可存在於大氣中超過 100 年；因此，若要穩定大氣中的 CO_2 濃度，全球必須減排約 80%。目前全球每年排放約 7GT CO_2，而地球/大氣層/海洋可循環之數量約 4GT，因此其對環境之衝擊可用圖 III.1.1-9 淺顯比喻之。溫室氣體不僅造成全球暖化，亦引發了一些氣候變遷，而大部分現存於大氣中之 CO_2 遲早將溶解於海洋中，目前其酸度已較工業革命前增加了 30% (圖 III.1.1-10)。爲解決此一複雜問題，並無簡單且具魔力的解決辦法 (亦即“no silver bullets”)；因此，我們將需要一套技術與策略的組合。例如，EPRI 最近之研究結果如圖 III.1.1-11 所示，而 CCS 爲其中必要之一部分。最後，講者總結認爲我們必須停止“坐而言”，必須“起而行”；開始建造商業級處置廠，否則將無法達成減量目標(圖 III.1.1-12)。

另一場值得在此加以著墨著者亦與 CCS 相關，如圖 III.1.1-13 所示，講者爲煤利用研究協會 (CURC) 的 Executive Director, Ben Yamagata。其討論議題如圖 III.1.1-14 所示，包含煤在能源供應之角色、提議中 CO_2 規章之衝擊、美國氣候變遷法案之前景、CURC 的 Coal w/CCS 計畫等。圖 III.1.1-15 顯示，再生能源是成長最快速的電力能源，但至 2030 年化石燃料 (煤與 NG) 仍佔有全球約三分之二的發電燃料。圖 III.1.1-16 展示高成本案例至 2050 年之發電技術組合，再生能源將持續快速成長 (達約 1,500 TWh @ 2050)，核能維持穩定比率 (~ 1,000 TWh)，而燃煤廠將轉爲配置 CCS (~ 1,800 TWh)。然而，對低成本案例而言，發電技術組合卻截然不同；再生能源成長大幅度減緩 (< 500 TWh @ 2050)，核能反而急遽擴充 (> 2,000

TWh)，而燃煤(w/CCS)則維持穩定。因此，多位國際政壇領袖大聲疾呼，強調 CCS 之必要性，如圖 III.1.1-17 所示。最後，CURC 的 Coal w/CCS 計畫如圖 III.1.1-18 所示，包含之五大重點，而目前應積極推動者當屬先驅型計畫與 CCS R&D。

(2) International Issues (圖 III.1.1-19 ~ III.1.1-24；圖 III.1.1-25 ~ III.1.1-30)

九月二十二日早上的研討議題爲「國際議題 (International Issues)」，排定三場大會演講(Plenary lecture)；講者分別來自 TURKEY、SOUTH AFRICA、與 CHINA，就該國能源、研發策略等領域加以闡述。

在南非，利用燃煤轉化液態燃料 (CTL) 已有多年之歷史；其製程係將煤氣化，經淨化後，再利用 F-T 程序生產液態燃料。SASOL 公司應邀在大會演講 CTL 製程 CO_2 減量之議題 (圖 III.1.1-19)，包含製程效率提昇、無碳電源、替代的 H_2 生產、CCS 等 (圖 III.1.1-20)。圖 III.1.1-21 簡述了 CTL 製程之碳足跡，亦即 1.3kmol 煤碳產生 0.67kmol 碳基衍生產品與 0.63kmol CO_2，而最大理論碳效率爲 52%。因此，其 CO_2 減量之機會如圖 III.1.1-22 所示；例如，在無碳電源與水解產氫選項中，核能皆可扮演相當程度之角色，其流程圖如圖 III.1.1-23 所示。總結而言，CTL 製程中發電設備 (如鍋爐) 所產生之 CO_2 可藉由替代性電源而大幅減少；核能可容易地整合其中而提供電力，亦有可能提供蒸汽 (w. PWR)，而主要障礙則是聯線的可用率 (圖 III.1.1-24)。另外，製程產生的 CO_2 則可經由替代性的 H_2 生產 (如水分解) 與 CCS 來減量。

接下來，中國大陸的新奧集團 (ENN) 提出了一種抑制 CO_2 排放的新方法，稱之爲 CAU (圖 III.1.1-25、III.1.1-26)。基本上，CAU 爲衍生自碳循環的自然法則，結合生物碳固定、化學製程、觸媒氣化 (CCG) 等程序，並善用太陽能。例如，圖 III.1.1-27 顯示低溫觸媒氣化可提升能源轉換效率，並降低 CO_2 排放，而圖 III.1.1-28 則爲整合微藻利用、產氫等製程之方塊圖。新奧集團正積極推動 CAU，並規劃煤基清潔能源生產零排放之示範單元流程 (圖 III.1.1-29)。總結而言，ENN 認爲 CCG 結合 CAU 將可加速相關產業之發展，成爲對付氣候變遷挑戰之另類選擇 (圖 III.1.1-30)

(3) Environmental Issues (圖 III.1.1-31 ~ III.1.1-36；圖 III.1.1-37 ~ III.1.1-42)

九月二十三日早上的研討議題爲「環境議題 (Environmental Issues)」，排定三

場大會演講(Plenary lecture)；講者分別來自政府機構、產業代表、與非營利委員會，從不同立場與角度就能源、研發策略等領域加以闡述。

全球氣候變遷與空氣污染議題無疑是環境議題的嚴峻挑戰。前者對長程永續性之挑戰與技術角色間之關係如圖 III.1.1-31 所示。自 2000 年以來，全球 CO_2 排放年成長率達 3.5%，而預期 2005-2030 年間全球新增碳排放之 60%將來自中國與印度，其所造成之環境衝擊不容忽視。在圖 III.1.1-33 與圖 III.1.1-34 中，IEA 列舉了發電部門之關鍵技術、至 2050 年對 CO_2 之衝擊、及其 R&D 需求。太陽光電雖然最具有 CO_2 減排潛能，但其價格卻居高不下；其次，再生能源皆有間歇性、來源不均等問題須加以考量。反觀基載電力 (含核能、燃煤＋CCS、生質物氣化等) 則各有其對 CO_2 減排之貢獻。整體而言，這些關鍵技術對 R&D 之需求均相當高。就以新增裝置容量而言，核能 (1000 MW/y)、燃煤與燃氣加裝 CCS (各 500MW/y) 仍爲主流(圖 III.1.1-35)。總結而言，面對氣候變遷挑戰，CCS、核能、與低排放車輛爲尤其重要之關鍵技術；然而，此議題並無具魔法的解答，所有具潛勢之技術均須加以追求 (圖 III.1.1-36)。

在技術領域，煤氣化技術的永續發展爲一項關鍵議題 (圖 III.1.1-37)。圖 III.1.1-38 顯示，IGCC 的排放性能已逼近 NGCC 之水準，遠優於 SCPC；而其進料彈性亦較佳，包含石油焦、高灰份高含硫煤，且對氯的容許度亦較高。圖 III.1.1-39 則表列了各類技術每年減少十億噸 CO_2 之建廠/場需求比較。降低碳捕捉成本之途徑除了成熟之核心技術外，更須仰賴先進技術，如製程改善、高溫薄膜、先進渦輪機組等 (圖 III.1.1-40)。未來，低品位煤將爲進料之大宗，故相關之技術，如輸送設備、整合儀控等，都是發展重點(圖 III.1.1-41、III.1.1-42)。

2. Technical Paper Sessions

IPCC 之論文發表議程每天各分爲三個時段，同時各有六個平行舉行之口頭論文發表場次，各排定四至六場專題演講。技術議題則概分爲六項次領域：(1) Combustion、(2) Gasification、(3) Sustainability and Environment、(4) Carbon Management、(5) Coal-Derived Products、及(6) Coal Science。在這些平行場次中，不乏時間相互衝突之重要演講；然而，在無法兼顧之情況下，筆者只能擇要參與。

(1) Combustion (圖 III.1.2-1 ~ III.1.2-6；圖 III.1.2-7 ~ III.1.2-12)

在 Combustion session，Oxy-Combustion 及 Chemical Looping Process (CLP)

等議題已成爲重要的顯學；其中後者亦是核研所計畫中所規劃的主要內容之一，故筆者擇要參與聆聽了數場論文發表，以瞭解彼等在未來之研發努力及現況成果。

總部位於法國的 Alstom 公司可謂是開發 Chemical Looping Process (CLP) 的產業先驅，圖 III.1.2-1 顯示，應用 CLP 概念可結合 CO_2 捕捉，仍維持低 COE。而可能之選項與應用則如圖 III.1.2-2 所示，包含舊有 PC/CFB 廠更新加裝碳捕捉、整合碳捕捉/CTL/CO_2 分離與產氫等；其特色爲低成本之 CO_2 捕捉選項，而無論是否整合碳捕捉皆具競爭力。圖 III.1.2-3 進一步分析 CLP 新容量之經濟效益，在分析案例中 CLP 氣化結合碳捕捉最具成本優勢，而 CO_2 避免成本約爲每噸 $11-13。Alstom 公司自 2000 年左右起發展 CLP 技術，其研發至商業化時程分爲數個不同階段，時間長達 20 年 (圖 III.1.2-4)。目前已完成 Phase 3 先導廠 (65kWt) 測試 (圖 III.1.2-5)，正進行 Phase IVA 原型 3 MWt 設施之建置 (圖 III.1.2-6)。

在 CLP 應用中，載氧體之性能扮演了重要的角色，也是國際間重要的研究項目之一 (圖 III.1.2-7)。圖 III.1.2-8 進一步展示 CLP 概念與預期性能，如降低 NO_X、無能量耗損之 CO_2 分離、高 CO_2 捕捉率 (>99%)、高整廠淨效率 (>52%) 等。圖 III.1.2-9 則列舉常見且具有潛力之載氧體，如 Ni-、Cu-、Fe-基氧化物，其 TGA 高溫性能測試數據則如圖 III.1.2-10 所示，而圖 III.1.2-11 則顯示 H_2S 雜質會降低 NiO/TiO_2 之還原比率。最後，圖 III.1.2-12 比較了 NiO 在不同載體上之性能；基本上，其氧氣傳輸能力皆在 10 wt%以上，但成本則有高、低價格之差別。

(2) Gasification (圖 III.1.2-13 ~ III.1.2-18；圖 III.1.2-19 ~ III.1.2-24)

氣化議題可謂是大會的重點項目，全程有 16 場次的論文發表，筆者選擇重點參與了多場演講。基於篇幅考量，本報告中摘錄了兩場代表性的論文加以陳述之。

圖 III.1.2-13 爲韓國第一座 300 MW IGCC 廠的簡要資料，預計自 2010-2012 年間建廠，由 DOOSAN 重工主導，包含 FEED、主要設備、EPC 等。爲執行計畫，DOOSAN 開發了一套智慧型設計工具 DIGITs，其架構如圖 III.1.2-14 所示。圖 III.1.2-15 則展示了氣化爐性能模擬結果，就合成氣組成之預測而言，其自行開發程式之計算結果與 EPRI 數據及商用軟體計算結果間的一致性相當吻合。另外，DIGITs 的另一項特色則是針對氣化爐熔渣流之整體熱傳模擬 (圖 III.1.2-16)，

藉此可決定最低運轉溫度 (MOT)；進一步更可進行運轉條件之優化分析，圖 III.1.2-17 顯示其最佳冷煤氣效率可達 83%。總結而言，藉由 DIGITs 之分析，可獲得該 IGCC 廠之最佳運轉範圍，而部分負載特性分析則可決定相關之重要參數(圖 III.1.2-18)。

氣化爐內之化學反應相當複雜，至今仍無完整之理論可精確描述，因此，CFD 結合化學反應之模擬爲進一步瞭解此複雜問題之必要手段。美國 UNO 研究團隊對此議題已進行多年研究，本次大會則發表反應速率影響之論文 (圖 III.1.2-19)。圖 III.1.2-20 列舉了氣化爐內簡化的整體反應式，而有限速率燃燒模式之相關數據則表列於圖 III.1.2-21。模擬結果顯示，該模式與慣用之瞬間反應模式計算所得之氣體溫度差異不大(2D)，但碳轉化率、合成氣組成、熱值等卻呈現明顯落差(圖 III.1.2-22、III.1.2-23)。總結而言，前述研究方法可提供氣化爐性能參數之相對變化，但對局部氣化程序之掌握仍未臻完善，尚有精進改善空間(圖 III.1.2-24)。

(3) Sustainability and Environment

幾乎所有產業在今日的市場上都面臨碳、水、及環境等“足跡”之監督。任何商業、策略或管理決策之基本要件都必須依據對自身“足跡”之瞭解。換言之，在一個碳排放急速增加的社會中，碳足跡將成爲衡量吾人認知、管理與成長之依據。此類瞭解需要許多對產業部門的新思維，而上述的監督對能源市場的發電及燃料供應業者尤其嚴格。目前市場上仍存在著不確定性，其原因來自缺乏法規、對新訂且較嚴苛規定之懼怕與期望。國際社會團體(如 ISO, CSA, UNFUC)等正嚐試彙整現存法規以提供一致性的應用規範，協助產業界掌握機會規劃並推動新思維決策，以免於對突然改變之恐懼。簡而言之，即早規劃進行溫室氣體盤查可加速永續性的配比組合。

在技術發展方面，生質物與煤混燒有助於降低碳排放。由於生質物之化學與物理特性，傳統燃煤設施對生質進料有所限制，例如木材混燒比率通常得在 15% 以下。爲提升其相容性，業界正發展一些生質基的衍生燃料；例如，生質碳係由木質纖維生質物經加熱碳化而成，而其碳化條件可彈性調整，以符合應用端之燃燒反應性及熱釋放效率。將原始生質物轉化成生質碳之主要優點爲其可在微幅改裝或現有之燃燒設施上直接作爲燃料，具有經濟效益優勢。另一類具減碳效益之衍生燃料爲 RDF (Refuse Derived Fuel)，來源取自於都會廢棄物 (MSW)。此類燃

料爲一種再生燃料，若適當地應用於燃燒鍋爐中，可符合即將實施的再生配比標準 (Renewable Portfolio Standards, RPS)。

(4) Carbon Management (圖 III.1.2-25 ~ III.1.2-36)

面對氣侯變遷現象，碳管理已成爲舉世矚目的優先研究議題。在今年 IPCC 大會中，NETL 的 Director，Anthony Cugini 應邀親自發表一場主題演講 (圖 III.1.2-25)。圖 III.1.2-26 顯示能源需求之配比，至 2030 年全球能源需求將較 2006 年增加 45%，而 CO_2 排放增加 51%；值得注意者，化石燃料仍佔總需求之八成以上。碳管理的選項如圖 III.1.2-27 所示，包含提升效率、節約能源、降低對碳基燃料之依賴 (再生能源、核能)、碳封存與再利用。碳捕捉之解決辦法正開始逐漸浮現，各類解答之成本優勢與商業化時程則如圖 III.1.2-28 所示。研發工作之投入與進展是推動科技進化之動力，例如圖 III.1.2-29 所示之計算篩選方法，而 CLP 可視爲與生俱來的 CO_2 捕捉方法 (圖 III.1.2-30)。

其次，CO_2 再利用領域可視爲創造永續碳循環的選項 (圖 III.1.2-31)；而碳封存之需求則應符合環境可接受、安全、可驗證、經濟可行等條件。預測封存場址之行爲必須考慮大尺度工程與微觀自然系統，從 10^4 m (封存場址尺度)至 10^{-10} m (分子動力學尺度)，如圖 III.1.2-32 所示。其相關研發工作具有跨領域之特性，而許多現有技術皆可提供一些另類的應用；例如，CT 數據可引導精確預測模式之開發以探討流體在多孔隙/裂縫媒介中之行爲 (圖 III.1.2-33)，地震量測數據則可作爲 CO_2 定量追踪之用 (圖 III.1.2-34)，而圖 III.1.2-35 則展示一種創新的 CO_2 顯跡物。最後。此議題之研究可借鏡自國家風險評估計畫，整合全國目標與場址特定需求，並結合區域性夥伴與核心 R&D 等 (圖 III.1.2-36)。

(5) Coal-Derived Products (圖 III.1.2-37 ~ III.1.2-42)

在此領域，特別引起筆者注意之論文爲 CLP 應用於強化 CTL 技術之研究 (圖 III.1.2-37)，其目標係希望提升 C1-C4 轉化效率，如圖 III.1.2-38 所示。此研究係結合氣化爐、鈣環路程序、及 FT 合成製程 (圖 III.1.2-39)，而在 OSU 所進行之實驗設置與測試條件則如圖 III.1.2-40 所示。典型的鈣環路輔助 CH_4 重組之結果如圖 III.1.2-41 所示。總結而言，CLP 整合重組器、水氣轉化器、捕碳與除硫器等成爲一單階段反應器，可降低 CTL 含 CCS 程序之碳足跡，將 H_2 純度自 75%

提升至 >95%，增加液態燃料之產出，降低重組溫度自 >950℃至 650℃，減少能源消耗等 (圖 III.1.2-42)。

(6) Coal Science

此領域屬較偏基礎性之碳基科學研究，包含碳化學、碳地質學、碳萃取製程等。這些專業與目前核研所進行中之計畫較無直接關聯性，再加上分身乏術之因素，因此只能選擇割愛。

3. Gasification Fundamentals Workshop (圖 III.1.3-1 ~ III.1.3-6)

由 USDOE/NETL 特別安排的 Gasification Fundamentals Workshop 於 9 月 23 日（星期三）舉行，邀請與會的學者專家討論關鍵的技術挑戰。其在大會議程資料中所提供的 Statements 如下所述：

There is a paucity of information on the very fundamental aspects of gasification. The design of today's gasifiers have been more empirical rather than based on first principles and a solid understanding of the chemistry and thermodynamics. This lack of information prevents the optimum design and operation of a gasifier from being achieved. The National Energy Technology Laboratory (NETL) desires to identify needed research on gasification fundamentals. The workshop will focus on four areas: 1) Feed Preparation and metering, 2) Gasification kinetics for variable feedstock, 3) Slag and flyash behavior and material interactions, and 4) Modeling – CFD and process. Based upon participants' feedback, a workshop report will be prepared documenting what has already been established regarding gasification fundamentals and what are the critical needs to develop fuel-flexible gasification from which a subset of the most pressing issues will be identified.

當天 Workshop 中所討論的關鍵議題再細分爲 (1) Feed Preparation and Metering、(2) Slag/flyash Behavior and Material Interactions、及 (3) Numerical Modeling Capabilities 等次領域；考量核研所目前研發工作項目之優先次序，筆者選擇參與第三領域之討論場次。經過上、下午兩場熱烈的討論，與會者達成原則性共識，而 NETL 將彙整內容後再寄送與會者修訂增補；未來將組成國際性的跨領域技術交流平台，更希望能獲得 DOE 經費支持，成立相關研究計畫，推動各界合作。

在氣化爐模擬技術領域，前述歷經國際學者專家腦力激盪所認同的關鍵技術挑

戰與核研所計畫所規劃之內容有許多契合之處；諸如，heterogeneous chemical kinetics at relevant conditions, transport time scales for turbulent reactive flow, gas/solid flow interactions (pyrolysis, volatilization, swelling, slag formation, surface deposition, fouling, etc.)。上述情形可佐證核研所計畫研發項目規劃之前瞻性與適當性，若能獲得充足研發資源積極推動，未來績效應有機會與國際同步，甚或取得領先地位。

（二）在 UNO 研習之行程

1. 與 ECCC 研究人員技術交流

筆者於 9 月 25 日(星期五)起拜訪紐奧良大學 (University of New Orleans, UNO) 位於湖濱區校園之能源轉換及節約研究中心 (Energy Conversion & Conservation Center, ECCC)，進行一系列之研習行程。ECCC 的研發領域概分爲三大群組：亦即氣體動力與熱輸送 (Aero-thermal)、能源轉換 (Energy Conversion)、及能源節約 (Energy Conservation)，其核心技術能力與設施如下所述：

Special Capabilities and Facilities: ECCC laboratories consist of three primary groups: Aerothermal Laboratory, Energy Conversion Laboratory, and Energy Conservation Laboratory. ECCC labs are capable of providing measurements and tests in thermal-fluid and power systems including air/steam pressure, flow rates, temperatures, two-phase flow characteristics, flow structures, energy component efficiency, combustion, emissions, HVAC, wind tunnel testing, Particle Image Velocimetry (PIV), inverse liquid crystal thermography, and infrared thermal imaging. Three wind tunnels are available for aerothermal research for providing a wind speed up to 100 mph. The temperature of one wind tunnel can be cooled to 10 o C (50 o F) and heated up to 60 o C (140 o F). The measurement systems include two 3-D automatic traversing systems, a four-channel hot wire anemometer, a 96-channel thermocouple acquisition system, a 288-channel pressure scanning system, a laser Doppler anemometer (LDA) and a phase Doppler particle analyzer (PDPA).

筆者此次之研習行程安排如表 II-2 所示，密集地涵蓋了相當廣泛之技術領域。下文中就能源氣化、熱傳、流體動力等研發領域分別加以闡述。

(1) Gasification Related Issues

如前所述，氣化程序包含了相當複雜的系列化學反應，如熱裂解、異相/均相

氣化、水氣轉移等。在燃料煤的成份中，揮發物佔了相當大的比例，經熱裂解反應釋出，爲氣化程序的重要中間產物。藉由煤種的工業分析與元素分析資料，設定揮發物之通用化學式 CH_xO_y，計算燃料的質量與能量 (熱值) 平衡；如此，可得出該煤種的總量揮發物化學式，進而建構有限速率的反應模式。

在動力系統模擬領域，UNO 團隊目前採用 Thermoflow 軟體，其具有完整的燃氣渦輪機組資料庫，可針對現有商用機組進行詳細之系統流程設計分析。至於其他化工製程，Thermoflow 則以簡化模型來建立相關之操作單元。他們曾利用上述模型進行案例分析，包含乾式/濕式進料，含或不含碳捕捉單元等。另外一項創新研究則是溫和型氣化程序 (MaGIC®) 的開發，其原理是利用熱裂解過程將揮發物自固態煤進料中釋放出來，再結合中高溫淨化程序；因此，MaGIC 產生之合成氣其熱值與密度遠高於目前氣化程序之產物，整體系統之效率可大幅提升，而設備成本與尺寸亦可顯著降低。目前 UNO 團隊正利用 Thermoflow 建立基礎模型，以系統化探討相關參數之效應。筆者在研習過程中，則提出核研所構建整合分析平台 (IVIED Platform) 之規畫，未來雙方可在此領域進一步推動合作研究。

(2) Heat Transfer Related Issues

從熱力學觀點而言，熱工系統之熱效率取決於操作溫度與環境背景之溫差。因此，許多先進型系統皆致力於將操作溫度推向高溫極限；然而，伴隨而來面臨的挑戰則是增強冷却效率之需求。噴霧/蒸汽冷却之效用遠優於傳統的空氣冷却，然而，由於相關物理機制之複雜性，一般在實驗上僅落實至 2% ~ 5.5%的噴霧比率。目前進行中之研究則將霧汽比大幅提升至約 10%，探討其可能造成之影響。

在數值模擬上，可將蒸汽狀況視爲離散相液滴，並利用隨機模式來描述紊流中的無規則運動。當液滴沈積於固體表面時，可能會反彈或崩解，而造成蔓延或黏著現象。研究發現，上述現象可由一無因次參數，$We=\rho d_d V_d^2/\sigma$，來界定之；換言之，由 We 數值之大小，吾人即可研判液滴的行爲狀態，其次，Fluent 數值分析結果亦顯示，隨機模式的時間常數遠小於該軟體之隱含值。

在噴霧空氣膜冷却之實驗研究方面，Phase Doppler Particle Anemometry (PDPA) 爲常用的光學量測儀具；其可同時量測液滴尺寸與粒子速度，爲透視二相流流場參數的利器。目前 UNO 正建立相關之量測實驗，未來其數據將與上述數值模擬結果相互驗證。

(3) Fluid Dynamics Related Issues

在一般燃氣渦輪機的設計中，基於軸長尺寸之限制與組件冷卻需求，從壓縮機出口至燃燒室入口之氣流通道常採用逆向流方式設計。此類設計對流場之均勻性造成相當嚴峻的挑戰。在 UNO 的 Aerothermal Lab. 中，已完成了一套全尺寸的逆向流燃燒室模型，置放於風洞中，將進行全區域之壓力分布量測，進而可換算成速度分布。其次，則利用 CFD 來探討燃燒室襯裡與外筒鞘套對流場之影響。

另外一項重點研究項目則是渦輪活塞泵之開發。一般泵的特性曲線顯示，其運轉特性可選用高揚程或大流量，但兩者不可兼得。換言之，吾人常須串聯數級的泵陣列以獲得所需之流量與揚程。前述的渦輪活塞泵爲一種創新的設計，可同時滿足兩種參數之需求；若能順利開發產品上市，對工業增壓需求、排洪、電廠安全維護等應用將極具潛能與市場。

整體而言，紐奧良大學成立能源轉換及節約研究中心 (ECCC) 係高瞻遠矚之策略，其任務是促進潔淨能源研究與教育、加強區域性經濟成長、以及發展國家級與跨國型能源計畫，運用改善節能及效率來達成環境友善性與永續性。其目標設定的專業領域則如下所述：

Areas of Expertise:

- Conduct innovative research and development (R&D) in energy conversion and conservation with special interests in (a) improving energy efficiency of gas turbine systems, internal combustion engines, power plants, industrial plants, and buildings, (b) producing clean energy by employing gasification technology using coal, petroleum coke, and biomass as feedstock, and (c) reducing emissions in prime movers and boilers.
- Promotes interaction between academia, industry, and government to collaborate in energy R&D and education. ECCC is a founding member of the Clean Power and Energy Research Consortium (CPERC) which is a named National Center of Excellence for Clean Energy and Power Research in the U.S. Energy Bill.
- Provides services (workshops, short courses, energy audits, infrared thermography analysis) to advocate clean energy and energy conservation.

2. 見證極端氣候對社會與生態系統之衝擊 (圖 III.2.2-1 ~ III.2.2-6)

在紐奧良市的發展歷程中，「卡崔娜颶風 (Hurricane Katrina)」對當地社會與生

態系統之衝擊無疑是近年來頗受矚目之議題。筆者利用此次公差之便，亦有機會見證此極端氣候肆虐所遺留之痕跡。

紐奧良市位於密西西比河出海口附近的沖積扇區域，大部分地區位於海平面以下；因此，在市區北邊的 Pontchartrain 湖濱及南方蜿蜒而過的密西西比河岸皆築有堤岸，以隔離水面與陸地，而在其間則開鑿數條運河貫穿市區 (圖 II-1)。這些運河主要是供排水之用途，當密西西比河高水位時能將河水快速地宣洩至北方的大湖中，再排放至墨西哥灣。在這些運河的堤防牆邊亦配備大型抽水機，以便必要時可將市區積水抽排至運河中 (圖 III-2.2-1)。此次 Katrina 造成 New Orleans 市區大淹水長達數月之久的元兇，是運河擋水牆潰決所致；圖 III-2.2-2 所示右邊白色新砌的牆堤便是當年潰堤所在之處。

圖 III-2.2-3 展示了 Katrina 的軌跡，她於 2005 年 8 月 23 日在巴哈馬群島附近形成熱帶低壓，兩天後侵襲 Florida 州南端時還只是個一級颶風；而隨後幾天在墨西哥灣的濕暖水氣挹注之下，快速增強爲五級颶風 (圖 III-2.2-4)，並於 8 月 29 日在密西西比河出海口附近再次登陸，終釀成世紀大水患。圖 III-2.2-5 展示了墨西哥灣沿岸受 Katrina 侵襲前後衛星照片之比對，由此可體會到損害之嚴重性；圖 III-2.2-6 則是密西西比州南部 Biloxi 城之 close-up 衛星影像。

值得一提者，在 Pontchartrain 湖邊與密西西比河岸之堤防皆採用親水堤岸方式建造，甚至與堤防道路相結合，其縱深/厚度遠大於運河之擋水牆 (約 30 cm 厚)。前者通過了此次極端氣候之嚴峻考驗，後者則潰敗而釀成大患；無可諱言者，國內之堤防工程限於腹地，多採用後者之設計，尤以都會區爲甚，其風險似值得加以深入評估。所謂「前車之鑑，後事之師」、「他山之石，可以攻錯」，Katrina 的教訓或許值得吾人深思！

3. 參訪 NASA/Stennis Space Center (圖 III.2.3-1 ~ III.2.3-16)

美國航太總署 (NASA) 在密西西比州南部，距紐奧良約一小時車程之處，設立一個 Engineering Technology Test Center，其任務是負責測試火箭推進器與太空梭主引擎 (SSME)，以及相關之感測、控制元件。在 1982 年，雷根總統簽署行政命令，將該中心改名爲 NASA/Stennis Space Center (SSC)，以表彰該州聯邦參議員 John Stennis 對推動太空科技研究的支持 (圖 III.2.3-1 ~ III.2.3-6)。SSC 是全美僅次於Florida州Kennedy Space Center (KSC) 幅員第二大的太空科技測試園區 (圖 III.2.3-5)。測試平台如圖 III.2.3-4 所示，燃料與助燃劑分別爲液態氫與純氧；

因此，其燃燒反應之產物爲水蒸汽。據該中心人員告知，每次進行 SSME 測試便有如製造人造雨；故測試流程結束後，密州南部就得連續下“雨”數日。

圖 III.2.3-7 展示了 SSME 的主要性能參數，及其在測試平台上進行實驗之狀況。引擎測試是非常複雜的熱流實驗流程，需要量測、控制與分析之數據範圍廣泛且數量龐大;因此,基於任務需求,SSC 開發了許多感測與控制元件 (圖 III.2.3-8 ~ III.2.3-11)。SSME 的整體推進劑流程如圖 III.2.3-12 所示，而圖 III.2.3-13 則展示另一型測試的熱機實體。前述感測技術亦衍生不少的民生應用產品，如圖 III.2.3-14 所示的熱感測儀、氫氣火焰感測設備等。尤其值得一提者是後者對消防安全防護之貢獻，氫氣火焰係人眼所無法直接辨識之熱源，時常造成救火人員之傷亡；因此，此類產品可謂是太空尖端科技研究應用至民生之範例。

今(2009)年是人類登陸月球四十週年紀念，NASA 在七月份曾舉行了大型慶祝活動，且在各研發園區設置明顯看板 (圖 III.2.3-1)，在 SSC 內亦有相關的文物展示 (圖 III.2.3-15、III.2.3-16)。

§III.1　有關 2009 US 公差 IPCC 之圖像

1. Plenary Sessions

圖 III.1.1-1

圖 III.1.1-2

圖 III.1.1-3

圖 III.1.1-4

圖 III.1.1-5

圖 III.1.1-6

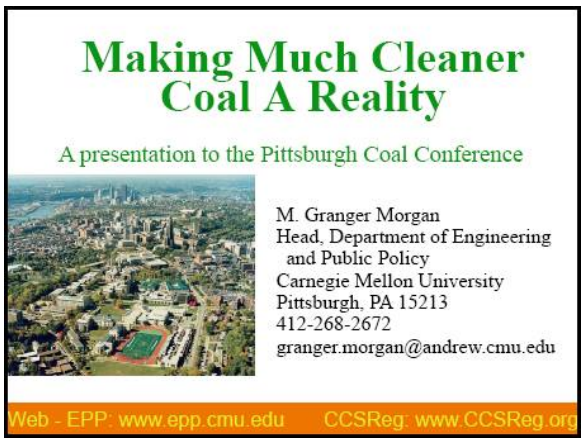


圖 III.1.1-7

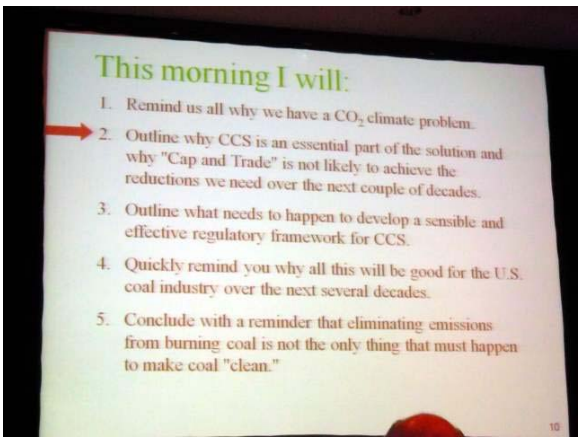


圖 III.1.1-8

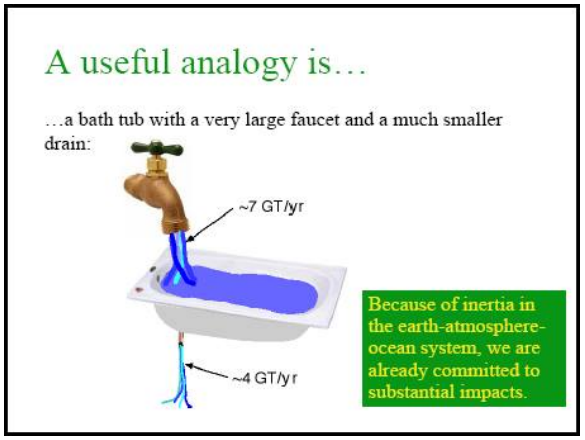


圖 III.1.1-9

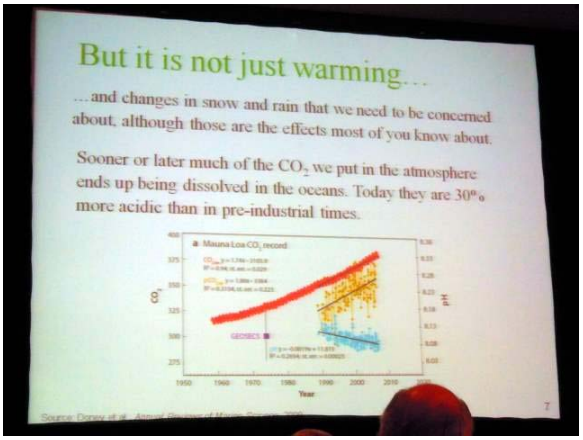


圖 III.1.1-10

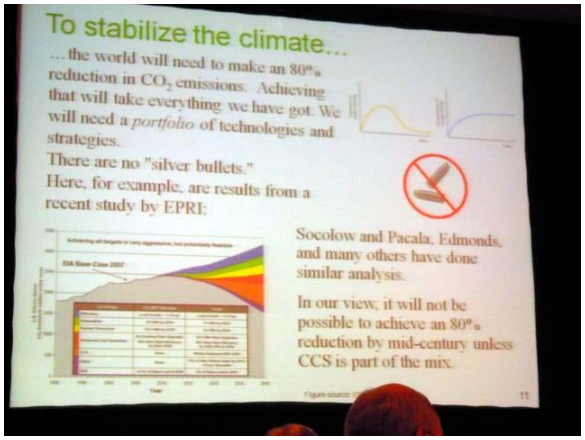


圖 III.1.1-11

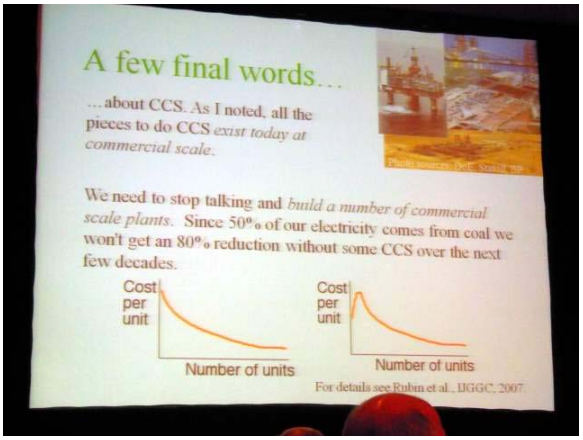


圖 III.1.1-12

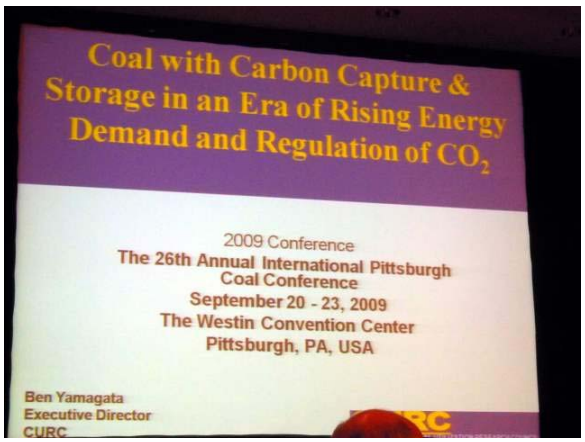
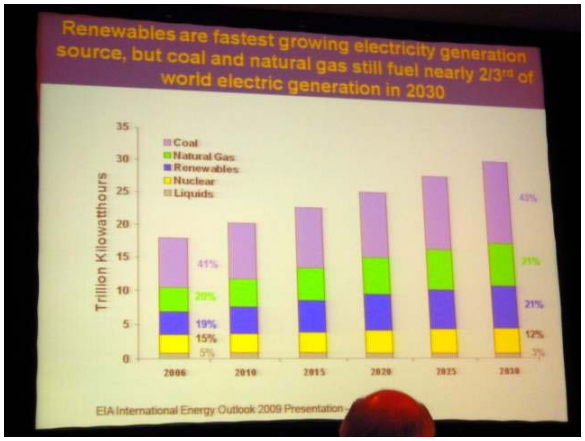


圖 III.1.1-13

圖 III.1.1-14



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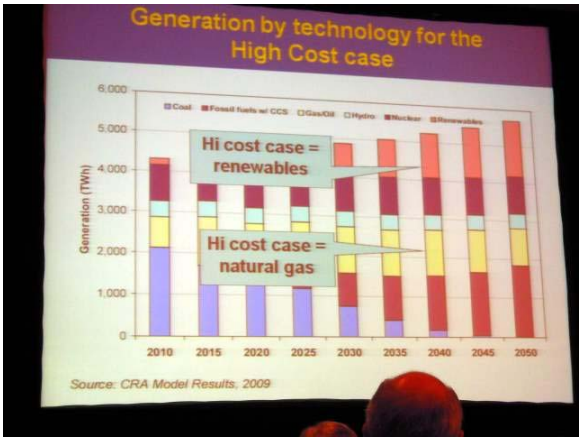

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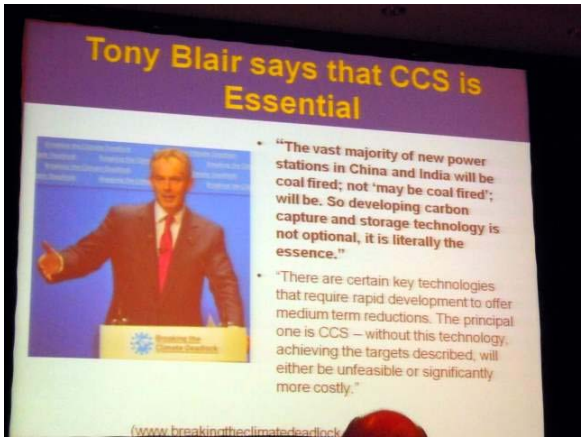

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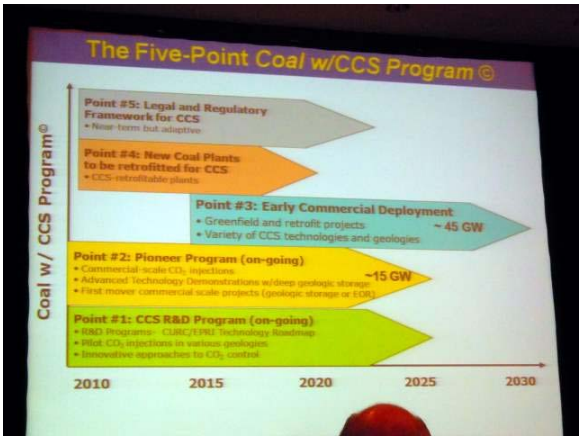

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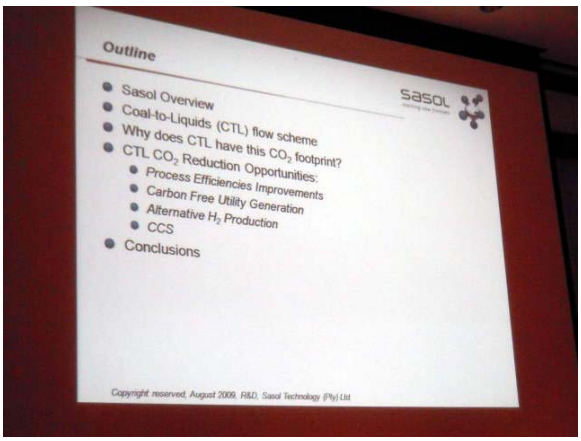

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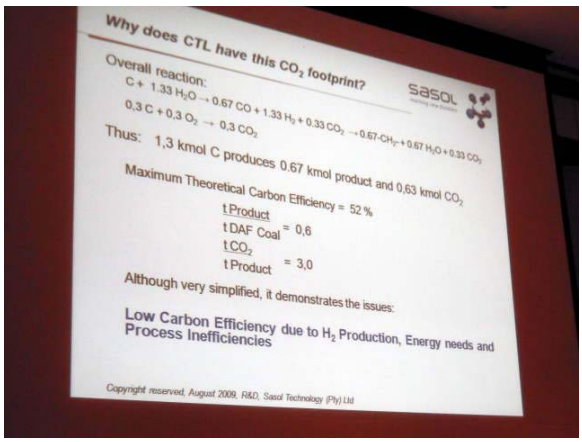

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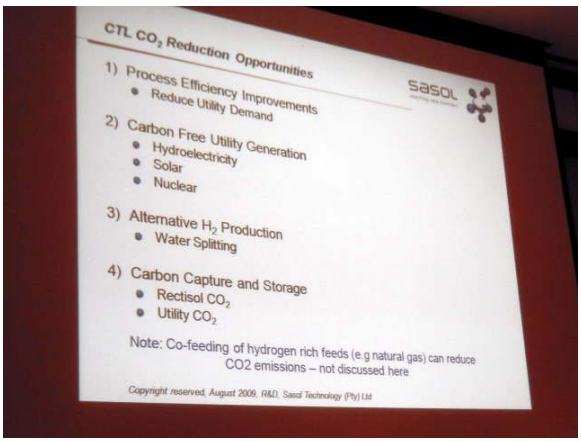

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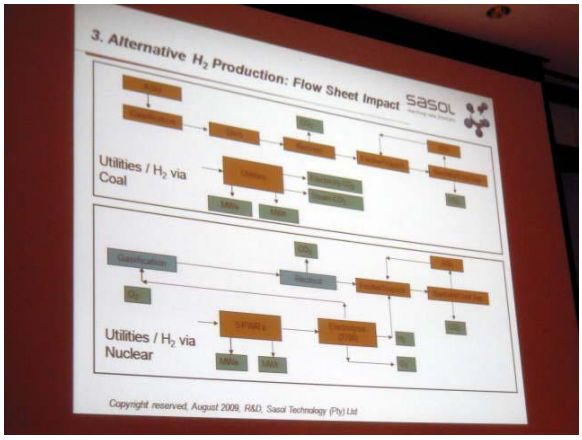

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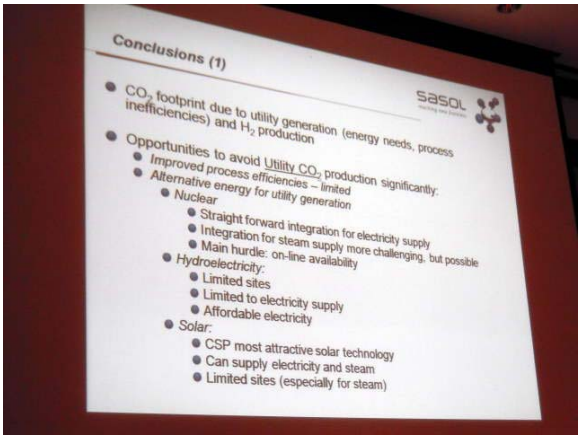

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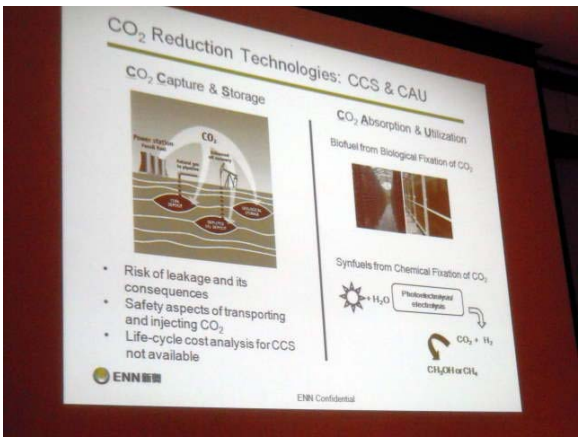
圖 III.1.1-25



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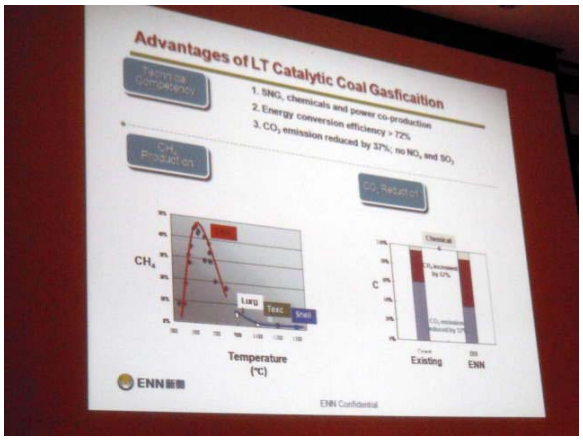

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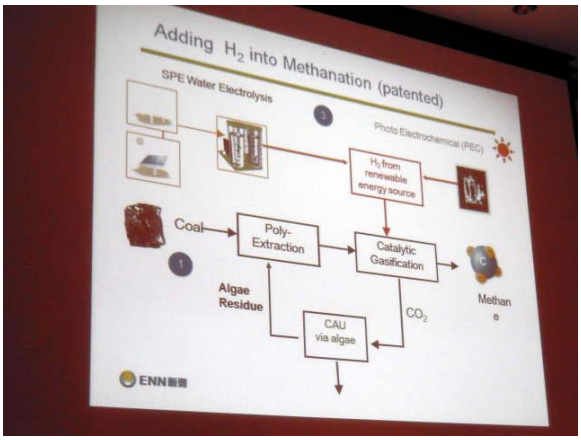

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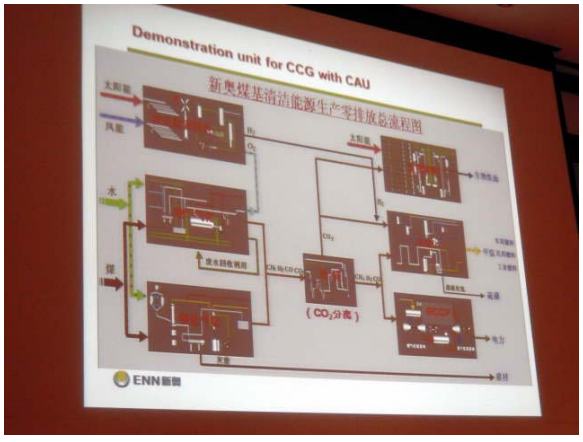

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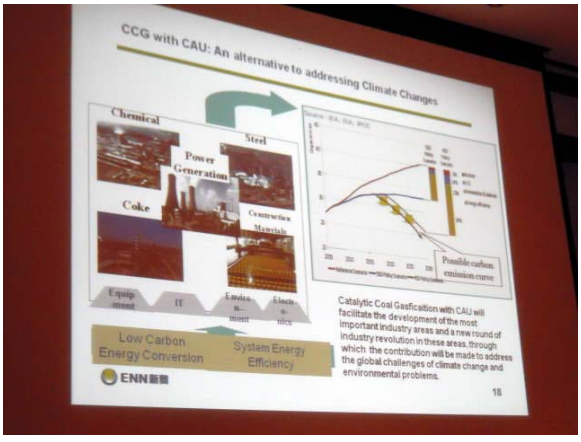

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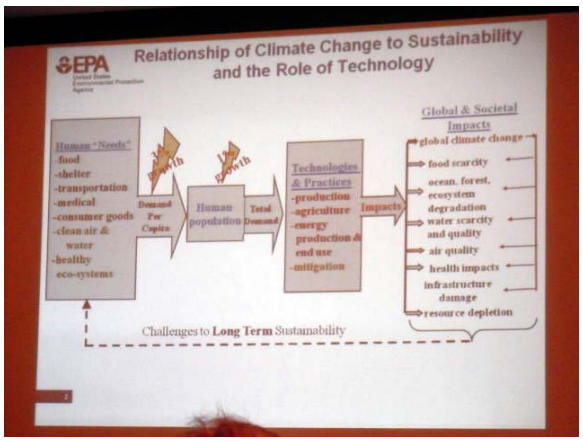

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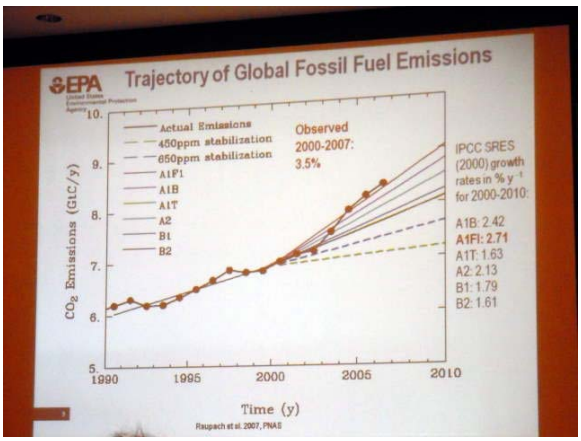

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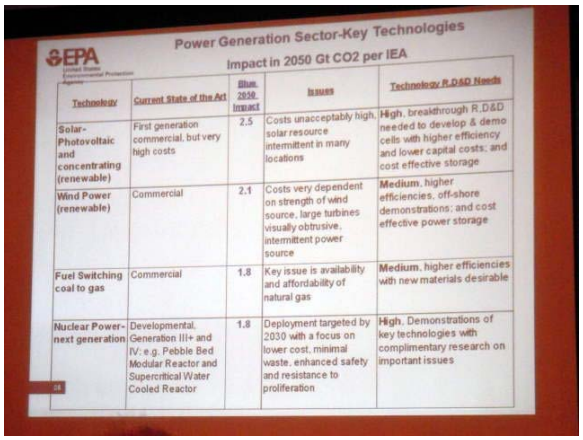
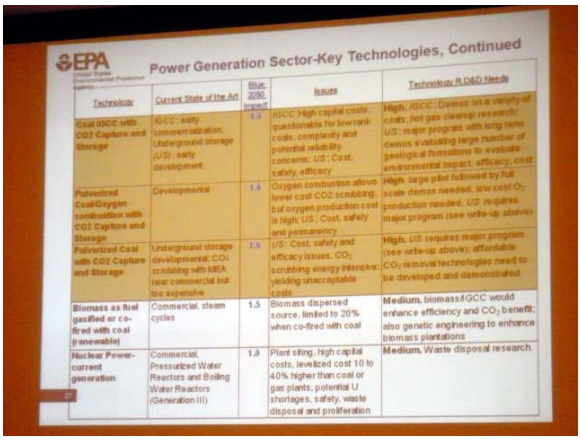


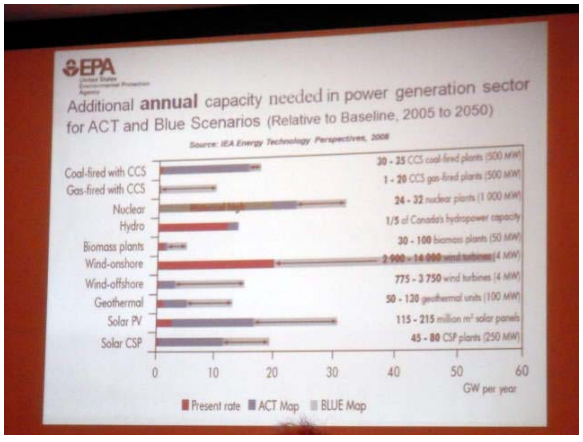
Technology	Current State of the Art	Blue 2050 Impact	Issues	Technology R,D&D Needs
Solar-Photovoltaic and concentrating (renewable)	First generation commercial, but very high costs	2.5	Costs unacceptably high, solar resource intermittent in many locations	High, breakthrough R,D&D needed to develop & demo cells with higher efficiency and lower capital costs; and cost effective storage
Wind Power (renewable)	Commercial	2.1	Costs very dependent on strength of wind source, large turbines visually obtrusive, intermittent power source	Medium, higher efficiencies, off-shore demonstrations; and cost effective power storage
Fuel Switching coal to gas	Commercial	1.8	Key issue is availability and affordability of natural gas	Medium, higher efficiencies with new materials desirable
Nuclear Power-next generation	Developmental, Generation III+ and IV; e.g. Pebble Bed Modular Reactor and Supercritical Water Cooled Reactor	1.8	Deployment targeted by 2030 with a focus on lower cost, minimal waste, enhanced safety and resistance to proliferation	High, Demonstrations of key technologies with complimentary research on important issues

圖 III.1.1-33



Technology	Current State of the Art	Blue 2050 Impact	Issues	Technology R,D&D Needs
Coal IGCC with CO2 Capture and Storage	IGCC: early commercialization; Underground storage (US): early development	1.6	IGCC: High capital costs, questionable for low rank coals, complexity and potential reliability concerns; US: Cost, safety, efficacy	High, IGCC: Demos on a variety of coals, hot gas cleanup research; US: major program with long term demos evaluating large number of geological formations to evaluate environmental impact, efficacy, cost
Pulverized Coal/Oxygen combustion with CO2 Capture and Storage	Developmental	1.6	Oxygen combustion allows lower cost CO2 scrubbing, but oxygen production cost is high; US: Cost, safety and permanency	High, large pilot followed by full scale demos needed, low cost O_2 production needed, US: requires major program (see write-up above)
Pulverized Coal with CO2 Capture and Storage	Underground storage developmental; CO_2 scrubbing with MEA: near commercial but too expensive	1.6	US: Cost, safety and efficacy issues, CO_2 scrubbing energy intensive; yielding unacceptable costs	High, US: requires major program (see write-up above); affordable CO_2 removal technologies need to be developed and demonstrated
Biomass as fuel gasified or co-fired with coal (renewable)	Commercial, steam cycles	1.3	Biomass dispersed source, limited to 20% when co-fired with coal	Medium, biomass/IGCC would enhance efficiency and CO_2 benefit; also genetic engineering to enhance biomass plantations
Nuclear Power-current generation	Commercial, Pressurized Water Reactors and Boiling Water Reactors (Generation III)	1.8	Plant siting, high capital costs, levelized cost 10 to 40% higher than coal or gas plants, potential U shortages, safety, waste disposal and proliferation	Medium, Waste disposal research

圖 III.1.1-34



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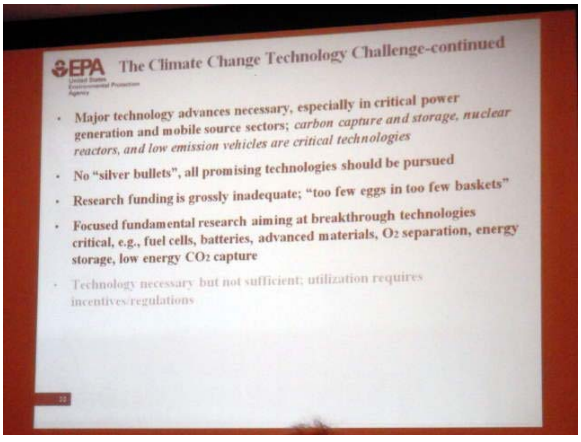

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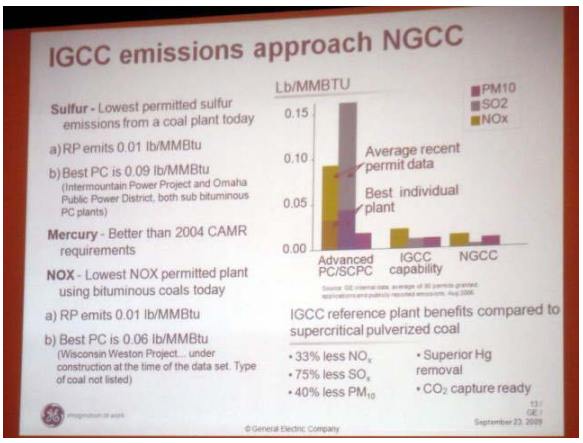
圖 III.1.1-37



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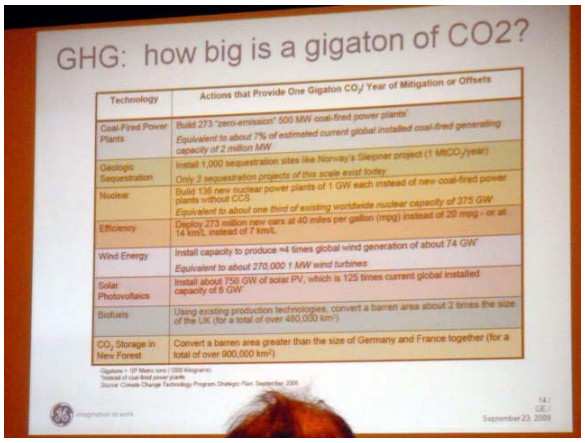

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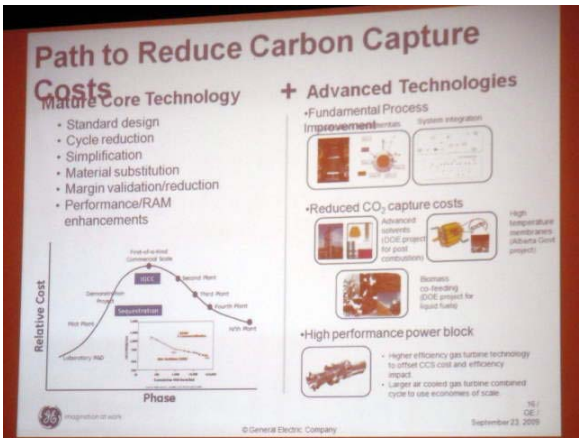

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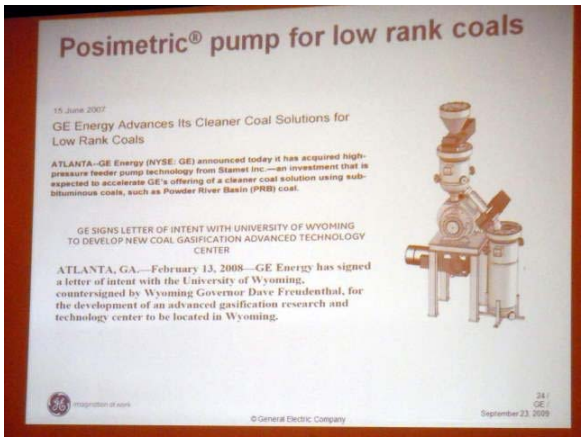

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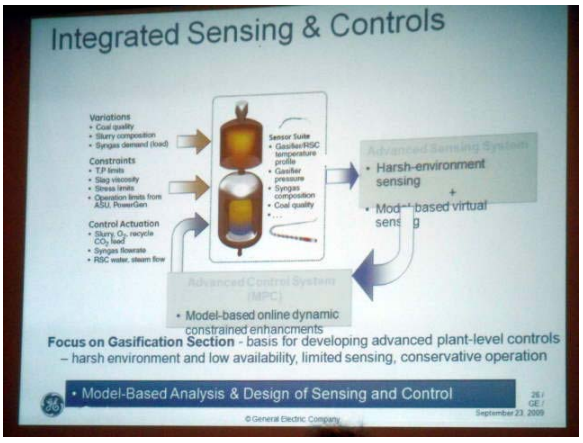

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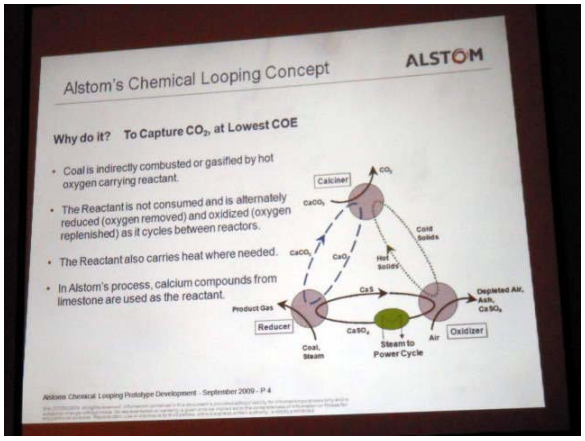
2. Technical Paper Sessions



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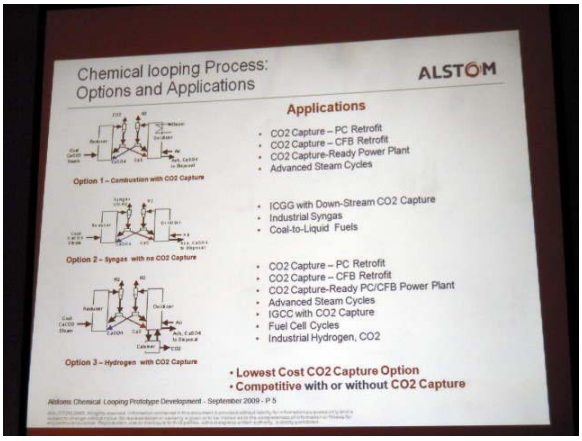

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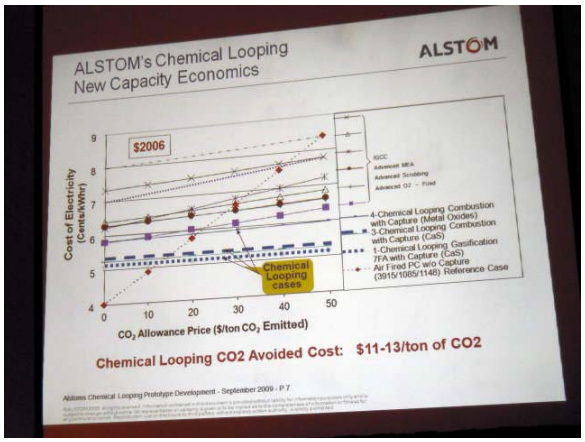

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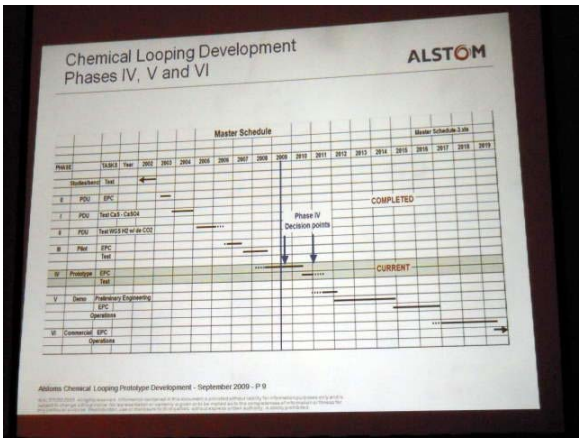

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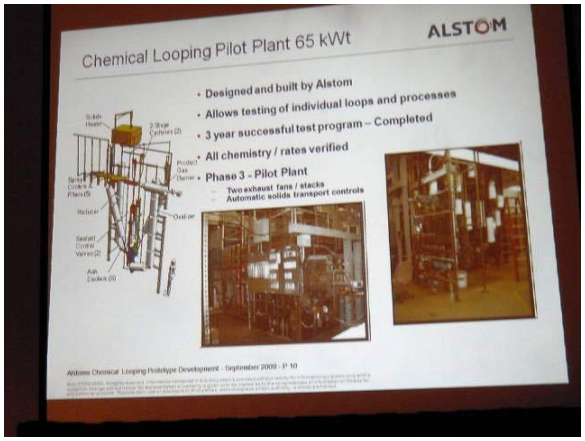

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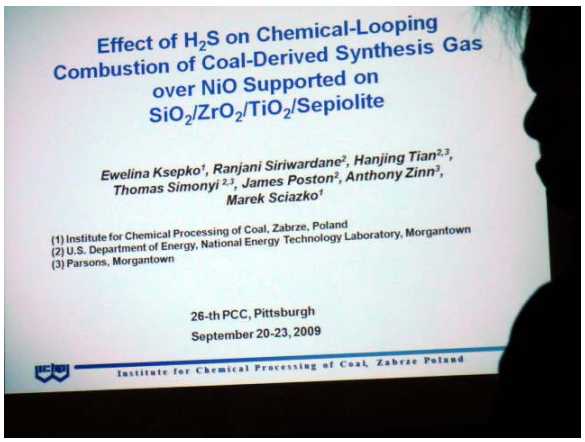
圖 III.1.2-6



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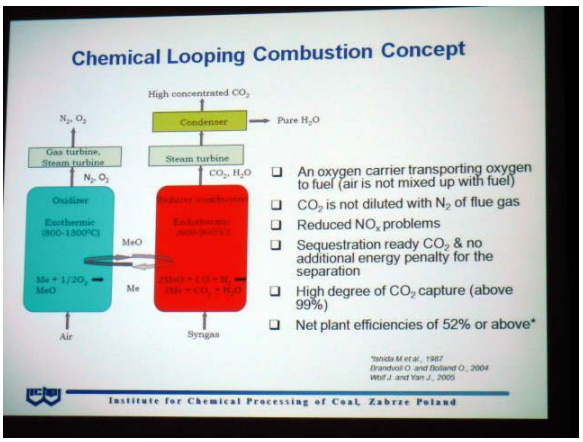

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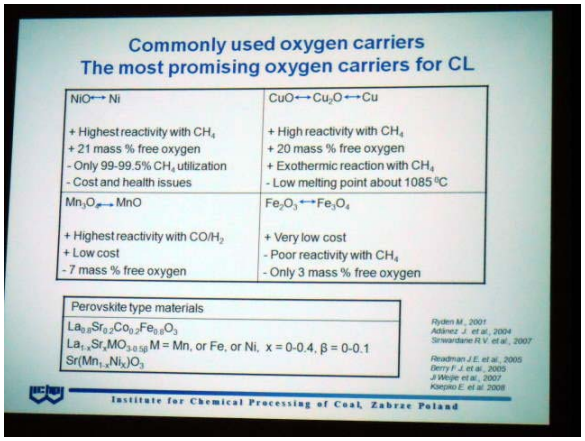

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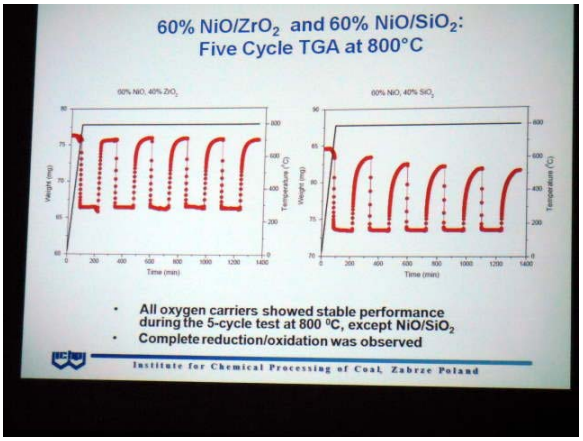

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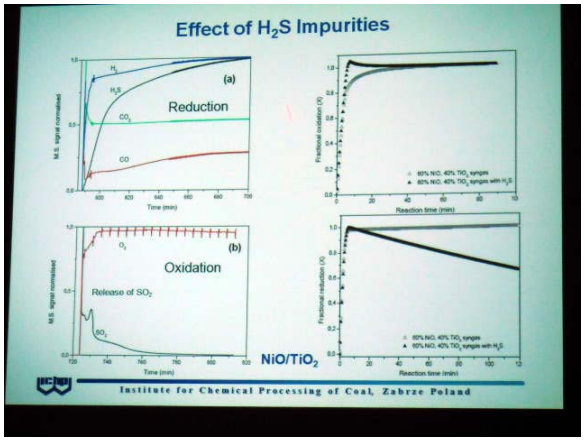

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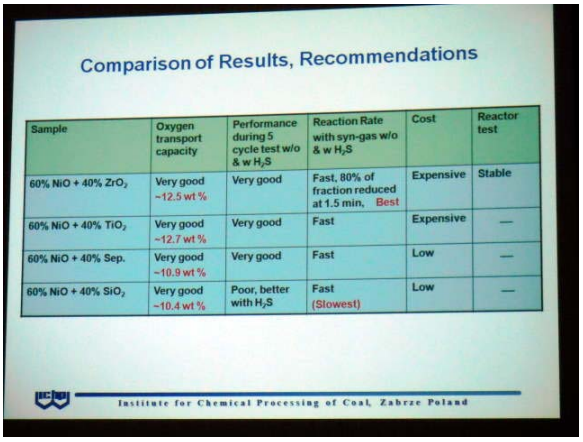

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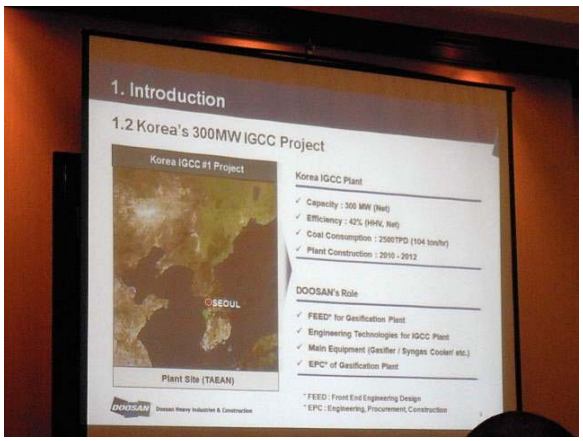

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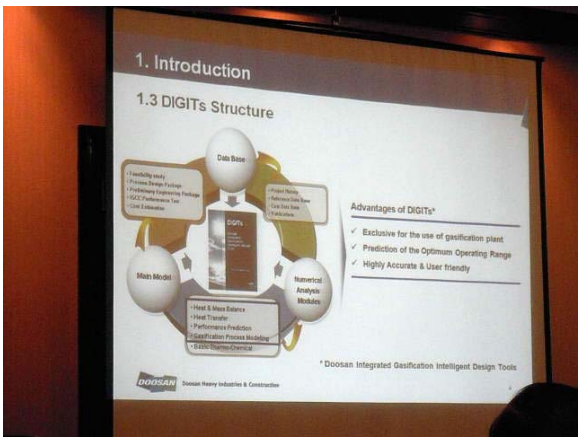

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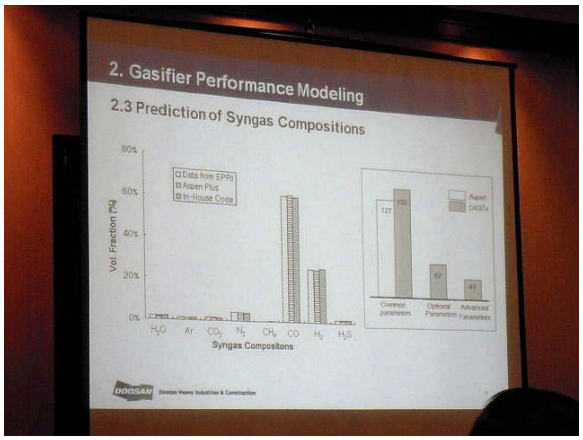

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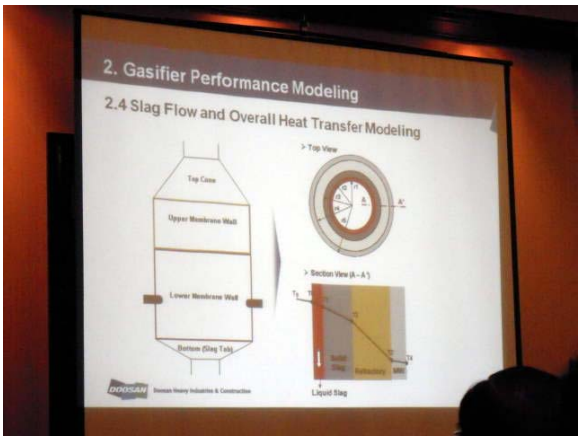

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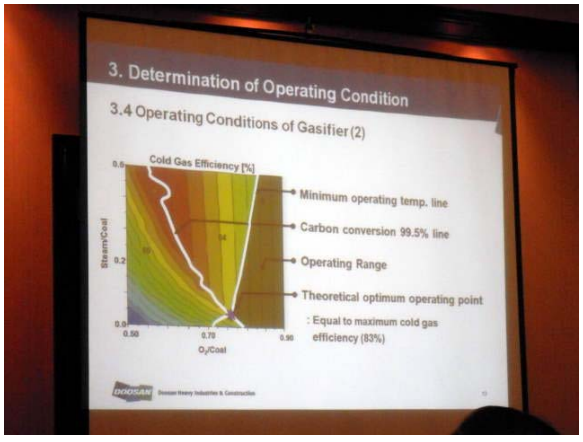

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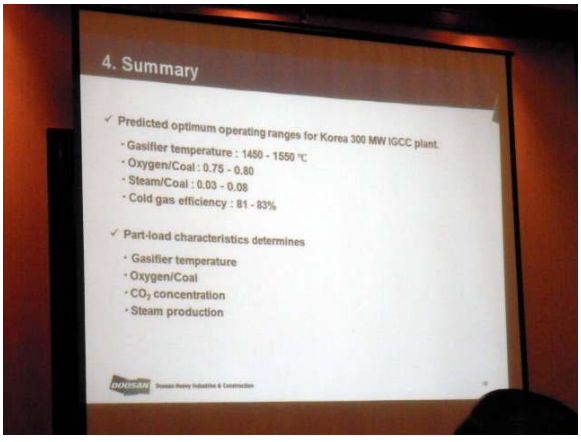

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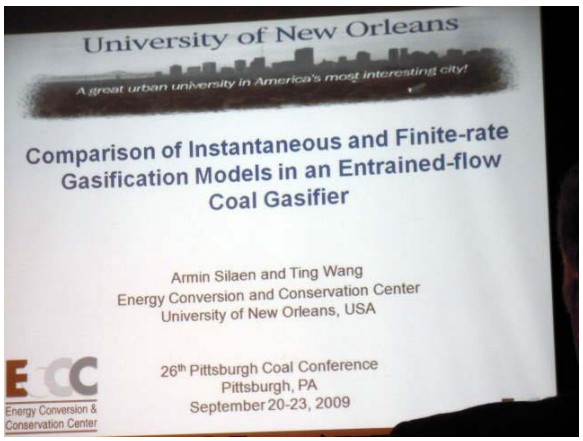

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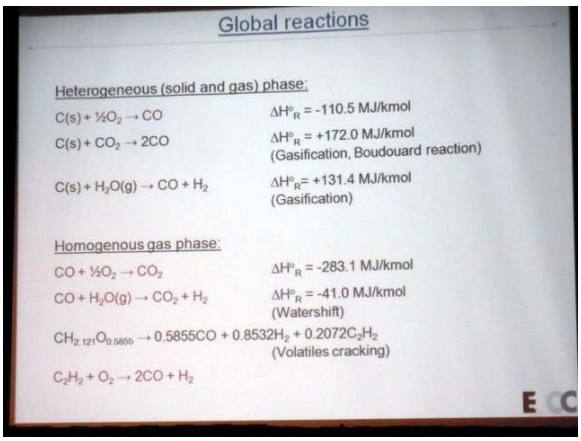

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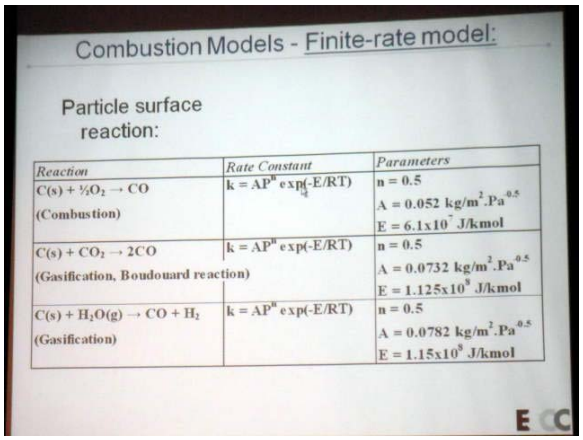

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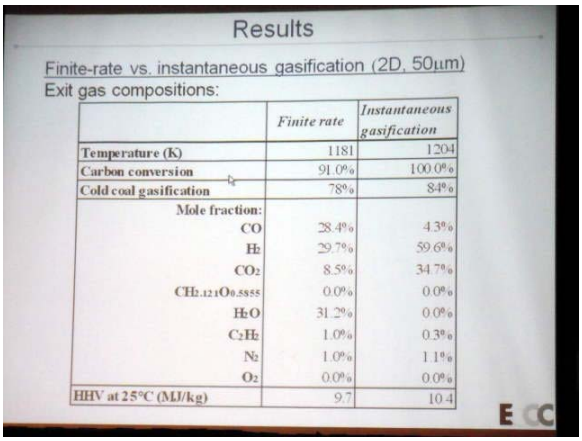

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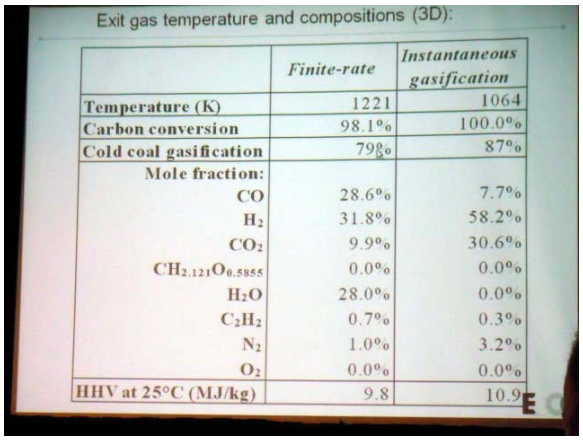

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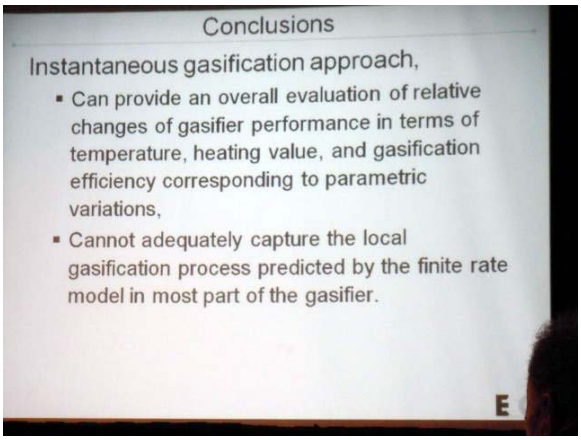

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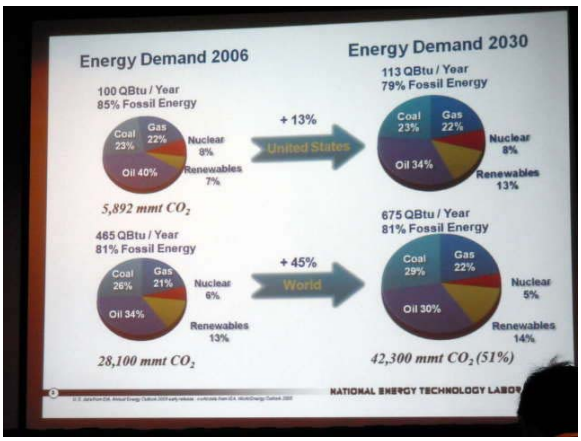
圖 III.1.2-25



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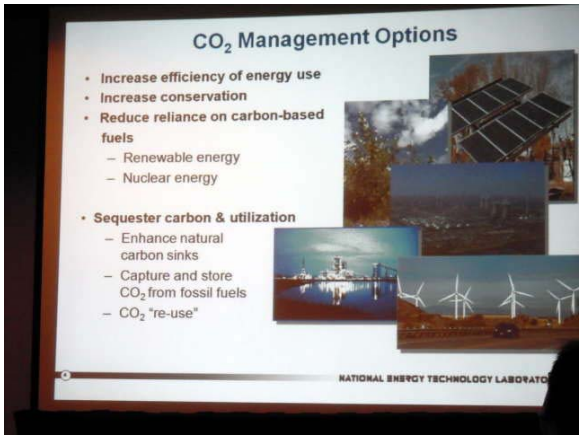

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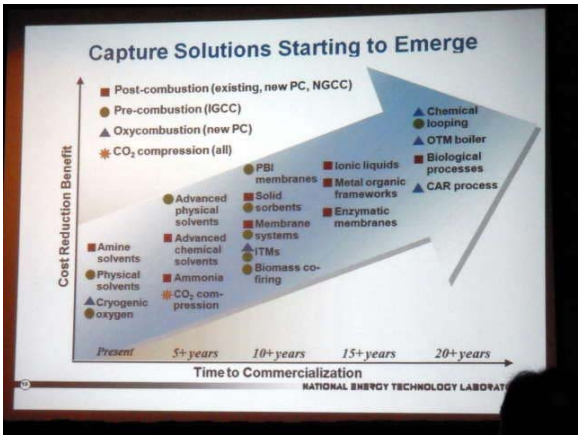

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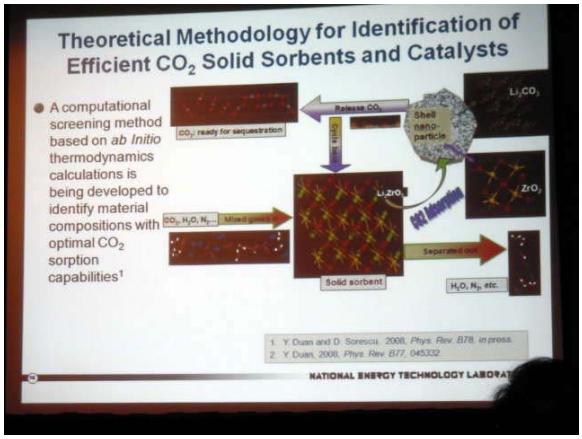

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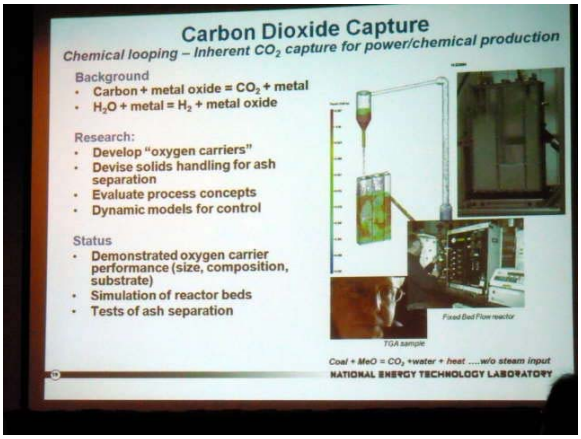

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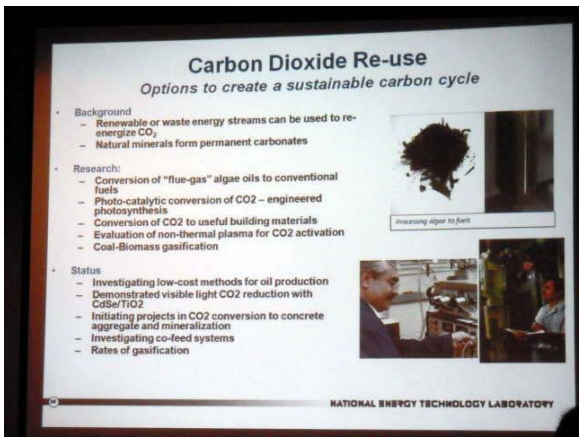

圖 III.1.2-31

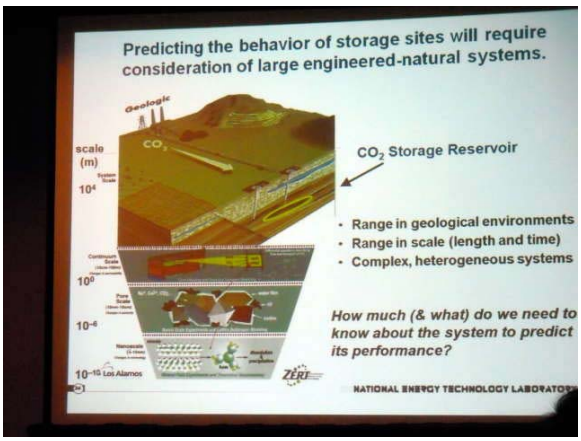

圖 III.1.2-32

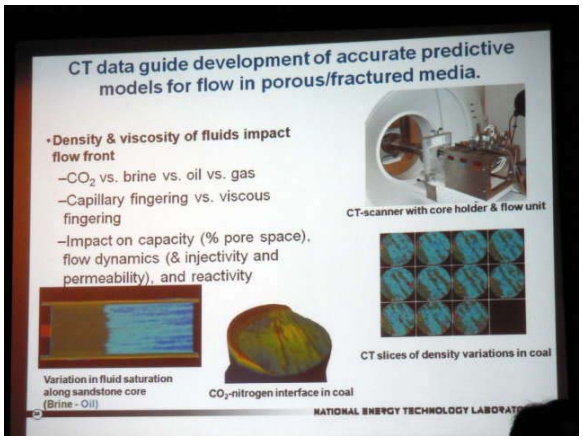

圖 III.1.2-33

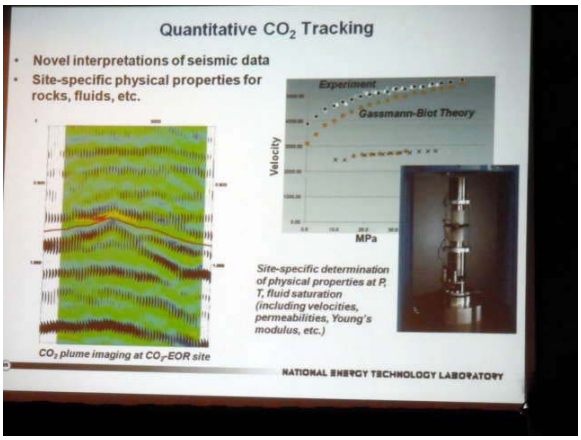

圖 III.1.2-34

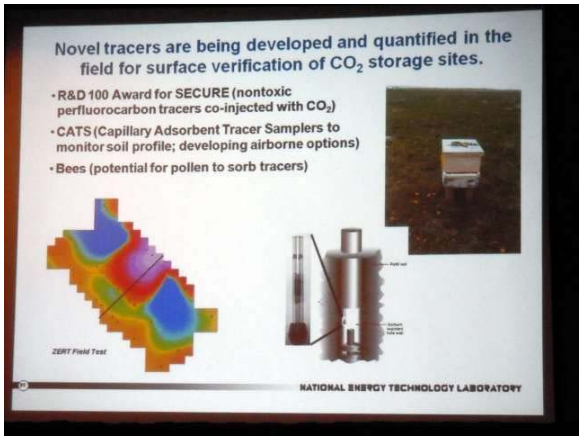

圖 III.1.2-35

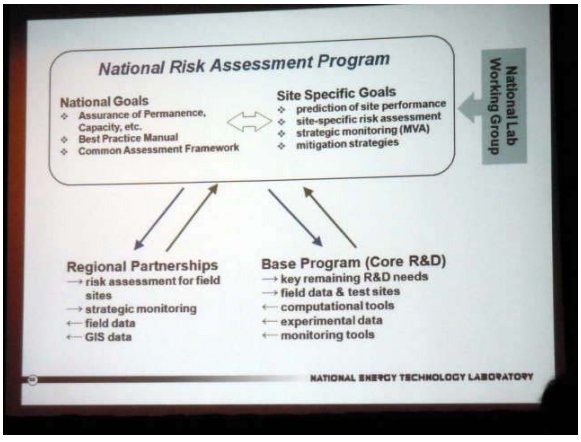

圖 III.1.2-36

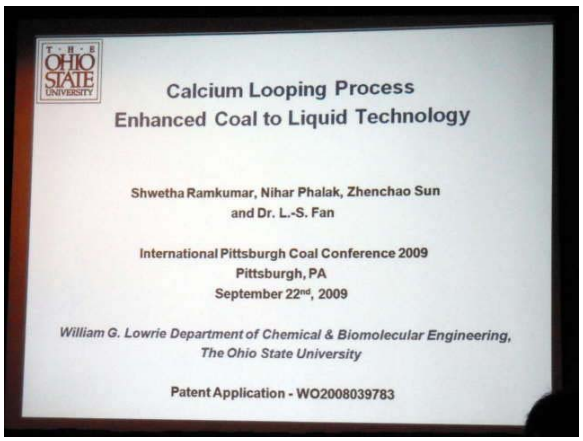

圖 III.1.2-37

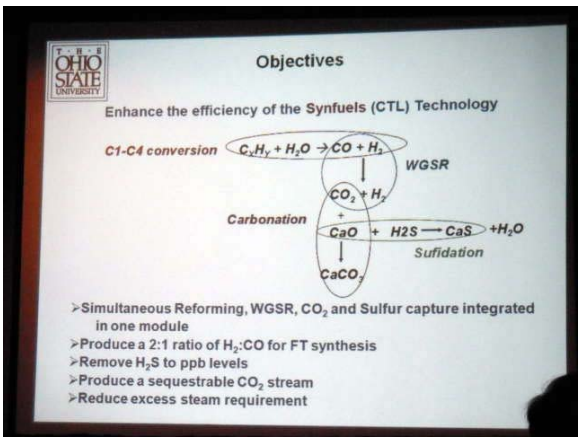

圖 III.1.2-38

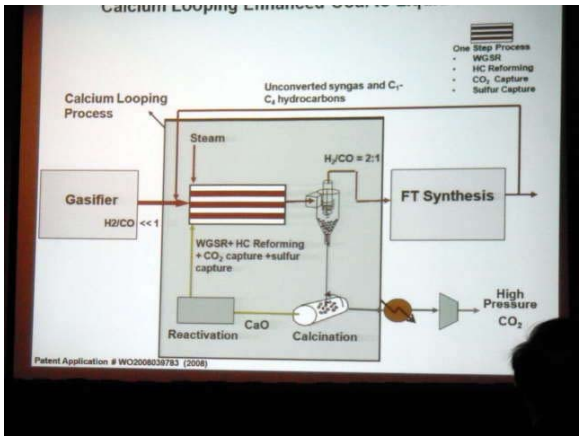

圖 III.1.2-39

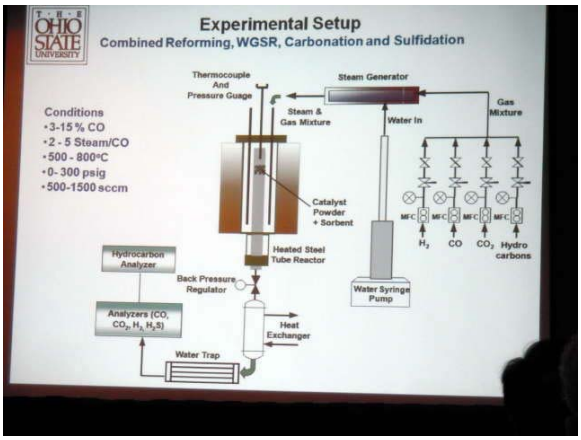

圖 III.1.2-40

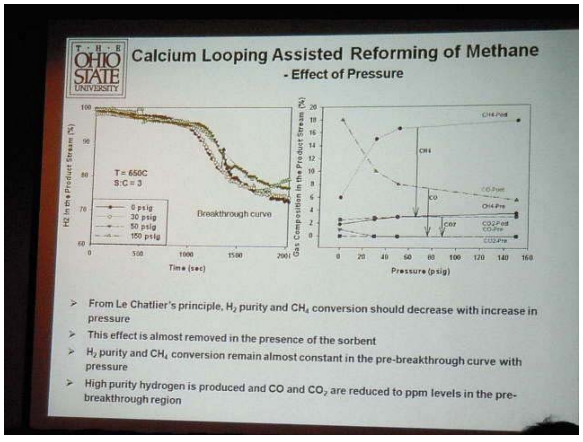

圖 III.1.2-41

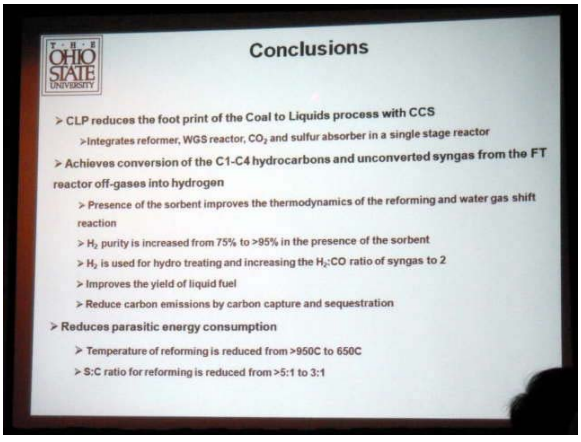

圖 III.1.2-42

3. Gasification Fundamentals Workshop

圖 III.1.3-1

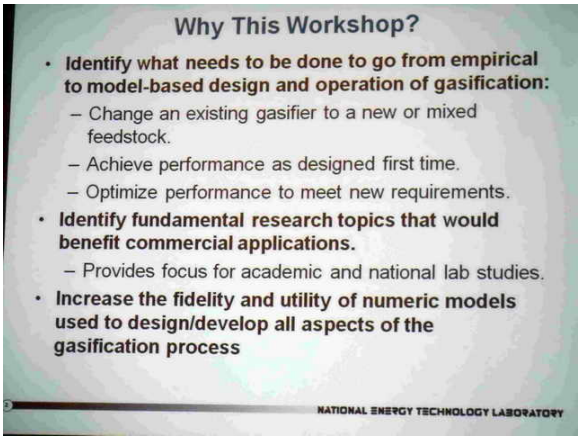

圖 III.1.3-2

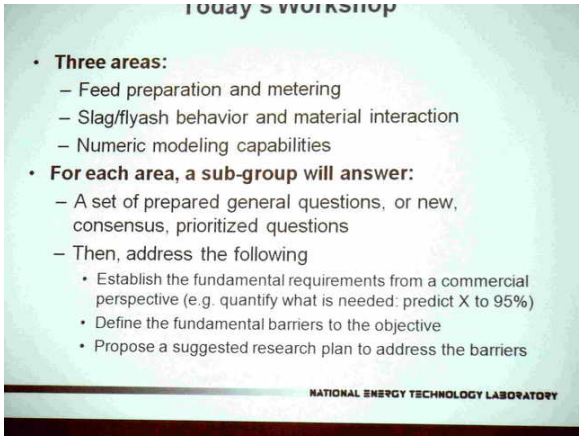

圖 III.1.3-3

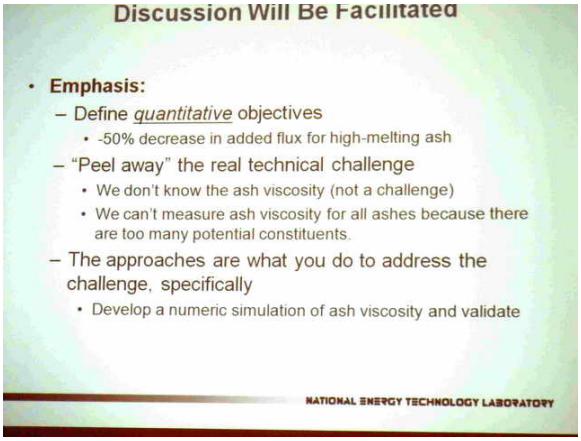

圖 III.1.3-4

圖 III.1.3-5

圖 III.1.3-6

§III.2　有關 2009 US 公差 UNO 之圖像

2. 見證極端氣候對社會與生態系統之衝擊

圖 III.2.2-1

圖 III.2.2-2

圖 III.2.2-3

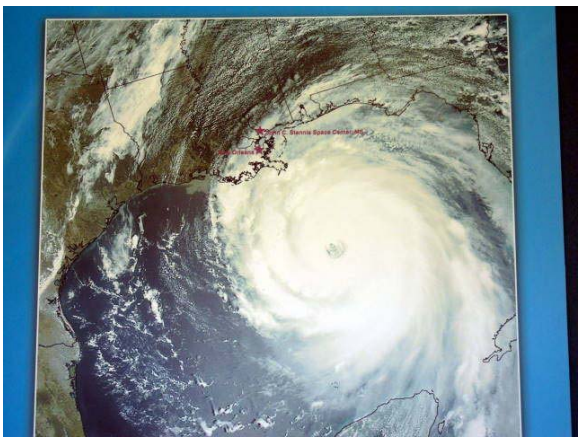

圖 III.2.2-4

圖 III.2.2-5

圖 III.2.2-6

3. 參訪 NASA/Stennis Space Center

圖 III.2.3-1

圖 III.2.3-2

圖 III.2.3-3

圖 III.3.2-4

圖 III.3.2-5

圖 III.3.2-6

圖 III.3.2-7

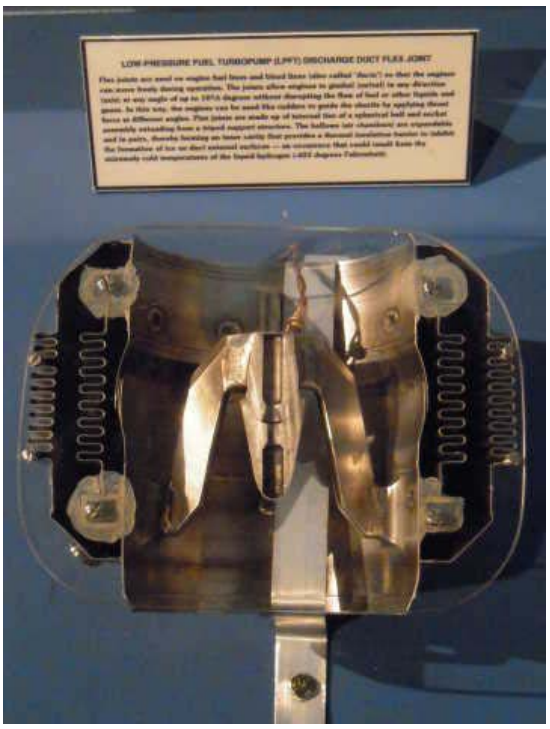

圖 III.3.2-8

圖 III.2.3-9

圖 III.3.2-10

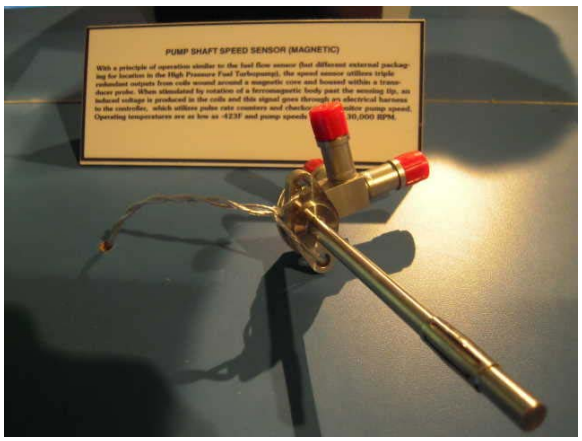

圖 III.2.3-11

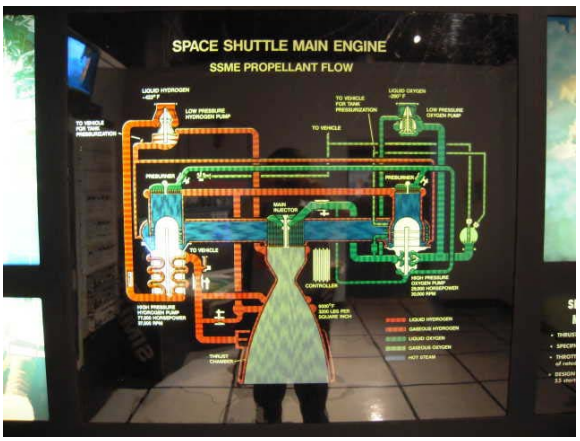

圖 III.2.3-12

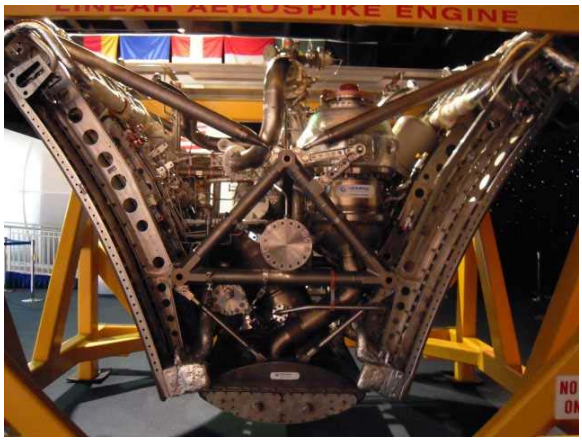

圖 III.3.2-13

圖 III.3.2-14

圖 III.3.2-15

圖 III.3.2-16

四、建 議 事 項

聯合國發佈之 IPCC 2007 AR4 已明確揭櫫氣候變遷之相關警訊，爲減緩全球氣候變化，政府必須儘速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。爲推動國家減碳政策，政府自 2008 年以來積極建構低碳能源發展藍圖，「永續能源政策綱領」更明確揭示電力部門應發展低碳潔淨能源；因此，相關部門須推動電廠整體效率提升計畫（含核能、燃煤），同時降低發電系統的碳排放。核能研究所接受台電公司委託執行「核三廠一號機二號機小幅度功率提昇技術服務案」，並積極進行能源國家型科技計畫領域之「永續淨煤整合系統關鍵技術開發」及「減碳政策評估與淨碳技術發展」研究計畫，冀望從**提升機組運轉效率**之方式增加電廠出力，以爲我國減碳情景略盡綿薄之力。此外，後者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，藉以提升國內能源自主性、**降低基載發電系統的碳排放**。

此次公差行程之建議事項可分爲數個面向分述如下：

(一) 環境永續性領域

1. 溫室氣體不僅造成**全球暖化**，亦引發了一些**氣候變遷**，而二氧化碳可存在於大氣中超過 100 年；因此，若要穩定大氣中的 CO_2 濃度，全球必須減排約 80%。**爲解決此一複雜問題，**並無簡單且具魔力的解決辦法 (亦即“no silver bullets”)；換言之，**我們將需要一套技術與策略的組合**。
2. 再生能源雖然具有 CO_2 減排潛能，但其價格卻居高不下；其次，其間歇性、來源不均等問題亦須加以考量。反觀基載電力，如核能、燃煤＋碳捕捉與封存 (CCS)、生質物氣化等，則各有其對 CO_2 減排之貢獻。總結而言，**面對氣候變遷挑戰，CCS、核能、與低排放車輛爲尤其重要之關鍵技術**，而所有具潛勢之技術均須加以追求。
3. 爲減緩全球暖化，**CCS 是解決問題必要的選項**。我們**必須停止“坐而言”，必須“起而行”**；開始建造商業級處置廠，否則將無法達成減量目標。

(二) 碳管理領域

1. 面對氣候變遷現象，**碳管理已成爲舉世矚目的優先研究議題**。碳管理的選項

包含提升效率、節約能源、降低對碳基燃料之依賴 (再生能源、核能)、碳封存與再利用。

2. 其次，CO_2 再利用領域可視爲**創造永續碳循環**的選項。
3. 利用燃煤轉化液態燃料 (CTL) 製程已有多年之歷史，其 CO_2 減量之議題包含製程效率提昇、無碳電源、替代的 H_2 生產、CCS 等。在無碳電源與水解產氫選項中，**核能皆可扮演相當程度之角色**。
4. 至 2030 年**化石燃料 (煤與 NG) 仍佔有全球約三分之二的發電燃料**，而至 2050 年之發電技術組合中，燃煤廠將轉爲配置 CCS (~ 1,800 TWh)，並且不受成本影響維持穩定之容量比率。至於**其他發電技術則可能因成本而有截然不同組合**：例如，在高成本案例中，再生能源將持續快速成長 (達約 1,500 TWh @ 2050)；反之，對低成本案例而言，核能反而急遽擴充 (> 2,000 TWh)。因此，多位國際政壇領袖大聲疾呼，**強調 CCS 之必要性**，而**目前應積極推動者當屬先驅型計畫與 CCS R&D**。

(三) 技術研發領域

1. 在 Coal Combustion 領域，Oxy-Combustion 及 **Chemical Looping Process (CLP)** 等議題**已成爲重要的顯學**；其中後者**亦是核研所科專計畫中所規劃的主要內容之一，其特色爲低成本之 CO_2 捕捉選項**，而無論是否整合碳捕捉皆具競爭力。在 CLP 新容量之進一步經濟效益分析案例中，**CLP 氣化結合碳捕捉最具成本優勢**。
2. **氣化**議題可謂是 IPCC 大會的重點項目，**有望成爲未來永續能源轉換的重要技術平台之一**；研究界與產業界之合作將是一項關鍵因素，且**國際合作及跨領域之途徑必須獲得鼓勵與支持**。美國 NETL 未來將組成**國際性的跨領域技術交流平台**，更希望能獲得 DOE 經費支持，成立相關研究計畫，推動各界合作。
3. **氣化爐內之化學反應相當複雜，**如熱裂解、異相/均相氣化、水氣轉移等，至今仍無完整之理論可精確描述；因此，**CFD 結合化學反應之模擬是進一步瞭解此複雜問題之必要手段**，進而建構有限速率的反應模式。
4. **韓國已開始推動第一座 300 MW IGCC 廠**，預計自 2010-2012 年間建廠；該計畫由其**國內廠商** DOOSAN 重工**主導建廠工程**，包含 FEED、主要設備、EPC 等。爲執行計畫，DOOSAN **開發了一套智慧型設計工具** DIGITs，**可進行運轉**

條件之優化分析，進一步更可獲得該 IGCC 廠之最佳運轉範圍，而**部分負載特性分析**則可決定相關之重要參數。**所謂「他山之石，可以攻錯」，韓國的案例或許值得國內相關單位深思！**

5. **碳封存**之需求則應符合環境可接受、安全、可驗證、經濟可行等條件。預測封存場址之行為必須考慮大尺度工程與微觀自然系統，從 10^{4} m (封存場址尺度)至 10^{-10} m (分子動力學尺度)。其**相關研發工作具有跨領域之特性**，而許多現有技術皆可提供一些另類的應用，例如，CT、地震量測、創新的 CO_2 顯跡物等。此議題之研究**可借鏡自**美國**國家風險評估計畫**，整合全國目標與場址特定需求，並**結合區域性夥伴與核心 R&D** 等。
6. **CLP 應用**於強化 CTL 技術之研究顯示，CLP 整合重組器、水氣轉化器、捕碳與除硫器等成為一單階段反應器，**可降低 CTL 含 CCS 程序之碳足跡**、提升 H_2 純度、增加液態燃料之產出、降低重組溫度、減少能源消耗等。
7. 從熱力學觀點而言，熱工系統之熱效率取決於操作溫度與環境背景之溫差。因此，許多先進型系統皆致力於將操作溫度推向高溫極限；然而，伴隨而來面臨的挑戰則是增強冷却效率之需求。**噴霧/蒸汽冷却**之效用遠優於傳統的空氣冷却，然而由於相關物理機制之複雜性，在數值模擬上，可**將蒸汽狀況視為離散相液滴，並利用隨機模式來描述紊流中的無規則運動**。前述研究亦**可類比應用於核電廠設備組件內二相流複雜輸送現象之數值模擬，以提升效率**。
8. 一般泵的特性曲線顯示，其運轉特性可選用高揚程或大流量，但兩者不可兼得。換言之，吾人常須串聯數級的泵陣列以獲得所需之流量與揚程。UNO 研發的**渦輪活塞泵**為一種創新的設計，**可同時滿足高揚程與大流量之需求；此特殊性能對工業增壓需求、排洪、電廠安全維護等應用將極具潛能**與未來市場。
9. **美國紐奧良大學 (UNO)** 的能源轉換及節約研究中心 (ECCC) 在潔淨能源、能源節約、氣體動力與熱輸送等研發領域**已具備核心技術能力與實績**，運用改善效率及節能來達成環境友善性與永續性。核研所與 UNO 已建立初步合作管道，筆者此行亦拜會了 UNO 主管研發事務的**副校長**兼研究院院長 Prof. Scott Whittenburg；Prof. Whittenburg 亦**期望未來 UNO 與核研所能建立進一步更密切之合作關係，國內相關單位應掌握先機積極推動國際合作**。

五、附　錄

（一）Invitation from UNO

（二）第 26 屆匹茲堡淨煤國際會議（International Pittsburgh Coal Conference, **IPCC**）之 Technical Program

Energy Conversion and Conservation Center University of New Orleans
College of Engineering, 932 Engineering Bldg., New Orleans, LA 70148-2220
(504) 280-7183, Fax: (504) 280-5539

September 3, 2009

Dear Dr. Chyou,

Considering the active research on clean coal technology you have been conducting at the Institute of Nuclear Energy Research (INER) in Taiwan, it is my great pleasure to invite you to visit Energy Conversion and Conservation Center (ECCC) of University of New Orleans (UNO) to exchange information on the new R&D results and explore potential collaboration opportunities.

The best time to visit ECCC will be from September to November 2009 for two to three weeks. I would strongly suggest that you attend the International Pittsburgh Coal Conference (IPCC) prior to your visiting ECCC because at IPCC you will have the opportunity to learn the most up-to-date information on clean coal technology including gasification, gas clean up, and power system efficiency as well as new economics and carbon capture and storage (CCS) policies. This information at IPCC will set a productive platform for our continued dialogue at UNO on exchanging information and exploring collaboration opportunities.

During your stay at ECCC, we will conduct the following activities:

1. You will introduce the current INER clean coal research activities.
2. We will provide you the opportunity to examine and practice the commercial software, Thermoflow, to design a clean coal power generation facility with/without CCS, such as IGCC.
3. Discuss potential collaboration opportunities including exchanging researchers, conducting joint research, co-authoring papers, and sending researchers to UNO to obtain advanced degrees.

Please let me know if you need our recommendation of lodging or any travel information. I look forward to your visit. Best regards.

Sincerely yours,

Ting Wang
Director and Professor
Jack & Reba Matthey Endowed Chair

Twenty - Sixth Annual International
Pittsburgh Coal Conference

PRELIMINARY PROGRAM

Coal - Energy, Environment and Sustainable Development

September 20 - 23, 2009
The Westin Convention Center
Pittsburgh, PA USA

Hosted By:

University of Pittsburgh
Swanson School of Engineering

General Information

2009 PCC

The University of Pittsburgh, along with the Advisory Board and Participating Organizations, invites you to attend the **Twenty-Sixth Annual International Pittsburgh Coal Conference**, September 20 - 23, 2009 at The Westin Convention Center in Pittsburgh, PA. The opening ceremony will take place on Monday, September 21, 2009. Over 300 technical papers, including posters, will be presented throughout the conference. Technical topics cover a wide spectrum of energy and environmental issues and technologies related to coal and its by-products. For detailed information on technical sessions, papers, and speakers, turn to the Technical Program in this brochure.

TECHNICAL TOUR:
CONSOL Energy Inc.
Research & Development Facility

Monday, September 21, 2009

13:00 - 17:45 (Pickup from the Westin)

Cost: $25

CONSOL Energy Inc.'s Research and Development department has provided energy and environmental research and technical services for over 60 years. The 80-acre facility is located approximately 9 miles south of Pittsburgh in South Park, Pennsylvania. The tour of CONSOL R&D will start with an introductory overview presentation of CONSOL R&D. This will be followed by a walk-through of our 20,000 sq. ft. state-of-the-art analytical laboratory, our carbonization test facility including the pilot coke oven, the coal pulverization facility, the coal mine fire rapid response units, and the pressurized fluidized-bed combustion pilot plant. For more information and to register, please visit our website.

Gasification Fundamentals Workshop

Wednesday, September 23, 2009

10:20 - 17:00

The Crawford Room

Free to all registered conference attendees

There is a paucity of information on the very fundamental aspects of gasification. The design of today's gasifiers have been more empirical rather than based on first principles and a solid understanding of the chemistry and thermodynamics. This lack of information prevents the optimum design and operation of a gasifier from being achieved. The National Energy Technology Laboratory (NETL) desires to identify needed research on gasification fundamentals. The workshop will focus on four areas: 1) Feed Preparation and metering, 2) Gasification kinetics for variable feedstock, 3) Slag and flyash behavior and material interactions, and 4) Modeling – CFD and process. Based upon participants' feedback, a workshop report will be prepared documenting what has already been established regarding gasification fundamentals and what are the critical needs to develop fuel-flexible gasification from which a subset of the most pressing issues will be identified.

Underground Coal Gasification Tutorial

Sunday, September 20, 2009

8:00 - 16:00

Westin Convention Center

The Westmoreland Room

Cost: $100

UCG Partnership in conjunction with Scientific Drilling, Lawrence Livermore National Laboratory, Carbon Energy, In-Situ Energy, and Edge Environmental, is running a tutorial on Underground Coal Gasification. The topics to be covered will include the history and development of UCG, its current status around the world and the advantages it offers as a large-scale energy source. We also plan to cover how the process works, environmental standards and practices, the drilling process, uses of syngas, physics and chemistry of UCG and costs. For more information and to register, please visit our website.

GATEWAY CLIPPER DINNER CRUISE

Monday, September 21, 2009

18:00 - 18:30 - Boarding at the dock
by the Convention Center

18:30 - 21:00 - Dinner and cruising

21:00 - Return to hotel

Please join us for a dinner cruise on Pittsburgh's three rivers! Back by popular demand, this cruise is complimentary for conference attendees, but there is a charge of $45 to bring a spouse or friend. However, you MUST RSVP to the PCC secretary to be included on the cruise. For more information and to RSVP, please visit our website.

JUST DUCKY TOUR

Monday, September 21, 2009

13:30 - 14:30

Tour leaves from the Westin Hotel

(Please meet in the Westin Hotel lobby at 13:15)

Cost: $18/person

For more than 10 years Just Ducky has been taking riders on Pittsburgh's only ADVENTURE through the city on LAND and WATER. The DUKW Boat first travels through the city's business district past local government buildings and the headquarters of the area's Fortune 500 companies. Next up is The Cultural District, the heart of downtown. Just when you think you've seen it all the DUKW effortlessly splashes down into one of the Three Rivers to offer a picture perfect view of the city skyline... For more information, please visit our website under "Day Tours".

CONFERENCE OVERVIEW

SUNDAY, SEPTEMBER 20, 2009

UCG Tutorial	08:00 - 16:00
Registration	15:00 - 19:00
Reception	18:30 - 20:30

MONDAY, SEPTEMBER 21, 2009

Registration	07:00 - 17:00
Opening Ceremony	08:00 - 08:20
Plenary Session – 1	08:20 - 10:05
Concurrent Tech. Sessions	10:20 - 12:00
Conference Luncheon	12:00 - 13:30
Technical Tour	13:00 - 17:45
Just Ducky Tour	13:30 - 14:30
Concurrent Tech. Sessions	13:30 - 17:25
Gateway Clipper Dinner Cruise	18:00 - 21:00

TUESDAY, SEPTEMBER 22, 2009

Registration	07:00 - 17:00
Plenary Session – 2	08:20 - 10:05
Concurrent Tech. Sessions	10:20 - 12:00
Conference Luncheon	12:00 - 13:30
Concurrent Tech. Sessions	13:30 - 17:25
Poster Session	18:00 - 21:00

WEDNESDAY, SEPTEMBER 23, 2009

Registration	07:00 - 17:00
Plenary Session – 3	08:20 - 10:05
Gasification Workshop	10:20 - 17:00
Concurrent Tech. Sessions	10:20 - 12:00
Awards Luncheon	12:00 - 13:30
Concurrent Tech. Sessions	13:30 - 17:25
Advisory Board Meeting	18:00 - 20:00

PLENARY SPEAKERS

MONDAY, SEPTEMBER 21, 2009

Energy Production/Policy Speakers

Granger Morgan
Head, Department of Engineering and Public Policy
Carnegie Mellon University, USA

Al Whitehouse
Director, International Program
U.S. Department of Interior, USA

Ben Yamagata
Coal Utilization Research Council, USA

TUESDAY, SEPTEMBER 22, 2009

International Issues

Selahaddin Anac
General Manager
Turkish Coal Enterprise (TKI), TURKEY

Harko Mulder
Manager Process Development
Sasol Technologies, SOUTH AFRICA

Zhongxue Gan
Vice President and CTO
ENN Group, CHINA

WEDNESDAY, SEPTEMBER 23, 2009

Environmental Issues

Frank Princiotta
U.S. Environmental Protection Agency, USA

Aaron Avagliano
New Product Initiative (NPI) Engineering Manager
GE Energy Gasification, USA

Xiao Yunhan
Director of Bureau of High-Tech R&D
Chinese Academy of Sciences, CHINA

Preliminary Program Schedule

Sunday, September 20, 2009						
8:00-16:00	UCG Tutorial – Westmoreland Room					
15:00-19:00	Registration – Butler Room (2nd Level)					
18:30-20:30	Reception – Pennsylvania Room (2nd Level)					
Monday, September 21, 2009						
13:00-17:45	Technical Tour – Westin Hotel Lobby					
7:00-17:00	Registration – Butler Room (2nd Level)					
8:00-8:20	Opening Ceremony – Allegheny Ballroom 2 & 3 (3rd Level)					
8:20-10:05	Plenary Session – Allegheny Ballroom 2 & 3 (3rd Level)					
10:05-10:20	**Break – Lobby (3rd Level)**					
ROOM	**Westmoreland (West and Central)**	**Cambria**	**Westmoreland (East)**	**Fayette**	**Washington**	**Somerset**
	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6
10:20-12:00	Gasification: General Session – 1	Sustainability and Environment: Policy	Carbon Management: Pre-Combustion – 1	Combustion: Oxy-Combustion – 1	Coal-Derived Products: Chemicals and Materials from Coal	Coal-Derived Products: Coal-to-Liquids: Technology – 1
12:00-13:30	**Conference Luncheon – Penn City and the Pennsylvania Room (2nd Level)**					
	Session 7	Session 8	Session 9	Session 10	Session 11	Session 12
13:30-15:10	Gasification: General Session – 2	Sustainability and Environment: GHG/GWP	Carbon Management: Pre-Combustion – 2	Combustion – 1	Coal Science: Coal Beneficiation – 1	Coal-Derived Products: Coal-to-Liquids: Catalysts
15:10-15:25	**Break – Lobby (2nd Level)**					
	Session 13	Session 14	Session 15	Session 16	Session 17	Session 18
15:25-17:25	Gasification: Underground Coal Gasification – 1	Gasification: Fundamentals – 1	Carbon Management	Combustion: Chemical Looping – 1	Coal Science: Coal Beneficiation – 2	Coal-Derived Products: Coal-to-Liquids: Technology – 2
18:00-21:00	**Gateway Clipper Dinner Cruise**					
Tuesday, September 22, 2009						
7:00-17:00	Registration – Butler Room (2nd Level)					
8:20-10:05	Plenary Session – Allegheny Ballroom 2 & 3 (3rd Level)					
10:05-10:20	**Break – Lobby (3rd Level)**					
ROOM	**Westmoreland (West and Central)**	**Cambria**	**Westmoreland (East)**	**Fayette**	**Washington**	**Somerset**
	Session 19	Session 20	Session 21	Session 22	Session 23	Session 24
10:20-12:00	Gasification: Underground Coal Gasification – 2	Gasification: Fundamentals – 2	Carbon Management: Post-Combustion – 1	Combustion: Oxy-Combustion – 2	Coal Science: Coal Chemistry – 1	Coal-Derived Products: Carbon Management for Coal Conversion
12:00-13:30	**Conference Luncheon – Allegheny Ballroom 2 & 3 (3rd Level)**					
	Session 25	Session 26	Session 27	Session 28	Session 29	Session 30
13:30-15:10	Gasification: Underground Coal Gasification – 3	Gasification: Fundamentals – 3	Carbon Management: Post-Combustion – 2	Combustion: Chemical Looping – 2	Coal Science: Coal Geoscience – 1: Coal Fires	Coal-Derived Products: Substitute Natural Gas (SNG)
15:10-15:25	**Break – Lobby (2nd Level)**					
	Session 31	Session 32	Session 33	Session 34	Session 35	Session 36
15:25-17:25	Gasification: Synthesis Gas Cleaning – 1	Gasification: Fundamentals – 4	Carbon Management: Sequestration – 1	Combustion: Mercury	Coal Science: Coal Chemistry – 2	Coal–Derived Products: Hydrogen Production – 1
18:00-21:00	**Poster Presentations – Pennsylvania Room (2nd Level)**					
Wednesday, September 23, 2009						
7:00-17:00	Registration – Butler Room (2nd Level)					
8:20-10:05	Plenary Session – Allegheny Ballroom 2 & 3 (3rd Level)					
10:05-10:20	**Break – Lobby (3rd Level)**					
10:20-17:00	**Gasification Fundamentals Workshop – Crawford Room (3rd Level)**					
ROOM	**Westmoreland (West and Central)**	**Cambria**	**Westmoreland (East)**	**Fayette**	**Washington**	**Somerset**
	Session 37	Session 38	Session 39	Session 40	Session 41	Session 42
10:20-12:00	Gasification: Synthesis Gas Cleaning – 2	Gasification: Advanced Technologies – 1	Carbon Management: Sequestration – 2	Combustion: Oxy-Combustion – 3	Coal Science: Coal Geoscience – 2	Coal-Derived Products: Hydrogen Production – 2
12:00-13:30	**Awards Luncheon – Allegheny Ballroom 2 & 3 (3rd Level)**					
	Session 43	Session 44	Session 45	Session 46	Session 47	Session 48
13:30-15:10	Gasification: Co-Gasification and Low-Rank Coal – 1	Gasification: Advanced Technologies – 2	Sustainability and Environment: General – 1	Combustion – 2	Coal Science: Coal Geoscience – 3	Coal-Derived Products: Syngas Utilization (Gas Turbines, Fuel Cells)
15:10-15:25	**Break – Lobby (2nd Level)**					
	Session 49	Session 50	Session 51	Session 52	Session 53	Session 54
15:25-17:25	Gasification: Co-Gasification and Low-Rank Coal – 2	Gasification: Advanced Technologies – 3	Sustainability and Environment: General – 2	Combustion: Flue Gas Clean Up	Coal Science: Coal Geoscience – 4	Coal-Derived Products: Coal Co-Conversion with Other Feedstocks
18:00-20:00	**Advisory Board Meeting**					

Technical Program

ORAL SESSIONS
Monday, September 21, 2009
10:20 - 17:25

SESSION 1
GASIFICATION:
GENERAL SESSION – 1
Bill Trapp and Stewart J. Clayton

10:20 - **The Clean Coal Hydrogen Power Generation Project**, Stephen D. Jenkins, CH2M HILL, Inc.; Jenifer Hedrick, Southern California Edison Company; George S. Booras, Electric Power Research Institute, USA

10:40 - **Performance and Cost Comparison of Four Alternate CO_2 Capture Technologies for IGCC Power Generation,** John Plunkett, David Gray, Noblis; Joseph DiPietro, DOE-NETL, USA

11:00 - **Design of IGCC Power Plants with Carbon Capture: Concept Simplification Impacts on Efficiency, Availability and Economics,** Karsten Riedl, E.ON Engineering GmbH; Johannes Eckstein, Hans Rainer, E.ON Energie AG; Mathias Rieger, Freiberg Energy Consultants GmbH; Bernd Meyer, TU Bergakademie Freiberg, GERMANY

11:20 - **IGSC – Retrofit Zero Emission Power Generation from Coal,** Stephen Scott, Jacobs, USA; John Griffiths, Mohan Karmarkar, Jacobs, UNITED KINGDOM

11:40 - **Conversion of Domestic Coal and Biomass Resources into Power with Net Zero Lifecycle Greenhouse Gas Emissions**, Michael Matuszewski, DOE-NETL, USA

SESSION 2
SUSTAINABILITY AND ENVIRONMENT:
POLICY
Frank Kranik and Steve Carpenter

10:20 - **Legislative and Financial Climate Change Developments and their Impact on the Sustainable Use of Coal,** Scott D. Deatherage, Thompson & Knight LLP, USA

10:40 - **The Partnership for CO_2 Capture,** Brandon M. Pavlish, Scott G. Tolbert, University of North Dakota Energy & Environmental Research Center, USA

11:00 - **Taking Action to Adapt Your Organization to Compete in a Carbon Constrained World,** Mary Ann Ferris-Young, Tony Gale, Ecology & Environment, Inc., USA

11:20 - **Pennsylvania's Carbon Sequestration Network Database: Where Policy Meets Geology,** Kristin M. Carter, Clifford H. Dodge, Thomas G. Whitfield, Jaime Kostelnik, PA DCNR Bureau of Topographic & Geologic Survey, USA

11:40 - **Trends in U.S. Recoverable Coal Supply Estimates and Future Production Outlooks,** Mikael Höök, Kjell Aleklett, Uppsala University, SWEDEN

SESSION 3
CARBON MANAGEMENT:
PRE-COMBUSTION – 1
Pradeep Indrakanti and Robert N. Miller

10:20 - **Effective Utilization of Hydrogen Membranes for CO_2 Capture,** Doug Jack, Carl Evenson, David Anderson, Damon Waters, Eltron Research & Development, USA

10:40 - **A Regenerative Process for CO_2 Removal and Hydrogen Production in Integrated Gasification Combined Cycle (IGCC) Processes ,** Javad Abbasian, Illinois Institute of Technology; Armin Hassanzadeh-Khayyat, Pyrophase, Inc., USA

11:00 - **The CO_2 and H_2 Permeability of Membranes Composed of Highly CO_2-Philic Polymers,** Mary Barillas, Robert Enick, University of Pittsburgh; Bryan Morreale, DOE-NETL; Philippe Buhlmann, Elizabeth Lugert, University of Minnesota, USA

11:20 - **Novel CO_2-Selective Membrane for Syngas Application,** Alvin Ng, Douglas E. Gottschlich, Membrane Technology and Research, Inc., USA

11:40 - **Sorbent-Enhanced Water Gas Shift Reaction Studies,** Ranjani V. Siriwardane, Robert W. Stevens, Abolghasem Shamsi, DOE-NETL; Stephen P. Carpenter, R.E.M. Engineering Services, USA

SESSION 4
COMBUSTION:
OXY-COMBUSTION – 1
John Wheeldon and Evan Granite

10:20 - **Status Report on the Jamestown Oxy-Coal CCS Demonstration Project,** Rick Victor, Dante Bonaquist, Praxair, Inc.; Dave Leathers, Jamestown Board of Public Utilities; Horst Hack, Foster Wheeler North America Corp., USA

10:40 - **Cost Reduction and R&D Strategies for Advanced Oxyfuel Technologies,** Michael Matuszewski, DOE-NETL, USA

11:00 - **A Thick-Film Wireless Metal Oxide Oxygen Sensor for Oxy-Fuel Powerplants,** Wei Wu, David W. Greve, Irving J. Oppenheim, Carnegie Mellon University, USA

11:20 - **Pathway to Supercritical Flexi-Burn™ CFB Power Plant to Address the Challenge of Climate Change,** Horst Hack, Zhen Fan, Andrew Seltzer, Archie Robertson, Foster Wheeler North America Corp., USA

11:40 - **Modeling and Testing of the 40 MWt Oxycoal™ Burner,** T.K. Klajny, A. Duncan, S. Yousif, E.D. Cameron, Doosan Babcock Energy Ltd, UNITED KINGDOM

SESSION 5
COAL-DERIVED PRODUCTS:
CHEMICALS AND MATERIALS FROM COAL
Sam Tam and Xiaoliang Ma

10:20 - **Upgrading of Low Rank Coal through Mild Solvent Treatment at Temperatures below 350°C,** Ryuichi Ashida, Satoshi Umemoto, Yusuke Hasegawa, Kouichi Miura, Kyoto University; Kenji Kato, Koji Saito, Seiji Nomura, Nippon Steel Corporation, JAPAN

10:40 - **Coal Derived High Performance Value Added Product,** Sunil K. Srivastava, Atma Ram Singh, Central Institute of Mining & Fuel Research, INDIA

11:00 - **Carbonization Properties of Coal Extract Prepared by Non-Hydrogenative Extraction of Coal – Application as an Additive for Metallurgical Coke Making,** Maki Hamaguchi, Takahiro Shishido, Noriyuki Okuyama, Koji Sakai, Nobuyuki Komatsu, Kobe Steel, Ltd.; Toshinori Inoue, Kobelco Research Institute, JAPAN

11:20 - **Novel Catalysts in Preparation of Humic Acid with Nitric Acid Oxidation from Shenfu Coal,** Peng Liu, Zhi-yuan Yang, Pan Ran, Xi'an University of Science and Technology, CHINA

11:40 -**High Quality Transportation Fuels from Direct Coal Liquefaction**, John E. Duddy, James B. MacArthur, Axens North America, Inc., USA

SESSION 6
COAL-DERIVED PRODUCTS:
COAL-TO-LIQUIDS: TECHNOLOGY – 1
Chunshan Song and Bryan Morreale

10:20 - **Secure, Clean Fuels from Coal: Indirect Liquefaction,** James Spivey, Louisiana State University; Anthony Cugini, Bryan Morreale, DOE-NETL; Chunshan Song, Pennsylvania State University; John C. Winslow, Leonardo Technologies, Inc., USA

11:00 - **High Efficiency Polygeneration through the Integration of CTL and IGCC,** William S. Rollins, NovelEdge Technologies, LLC, USA

11:20 - **Performance, Cost and Emissions Analysis of Coal-To-Liquids Plants with Different Gasification Technologies, under Carbon Constraints,** Hari Chandan Mantripragada, Edward S. Rubin, Carnegie Mellon University, USA

SESSION 7
GASIFICATION:
GENERAL SESSION – 2
Bill Trapp and Stewart J. Clayton

13:30 - **Cost and Performance Baseline for Fossil Energy Power Plants Low-Rank Coal to Electricity with CCS,** Jeff Hoffmann, DOE-NETL, USA

13:50 - **Air Blown Fluidised Bed Gasification of High Ash Indian Coals - BHEL's Experience in a 168 TPD PFBG,** G. Viswanathan, R. Jayapal, R. Kannan, M. Selvakumar, S. Krishnamoorthy, Bharat Heavy Electricals Limited, INDIA

14:10 - **Air-Blown Gasification Demonstration Facility – Alton, IL,** David W. Wakefield, Robert G. Jackson, Econo-Power International Corp., USA

14:30 - **Prediction of Gasifier Performance with Loads for Korean 300MW IGCC Plant,** Jin Hee Jeon, Bongkeun Kim, Jahyung Koo, Minsu Paek, Doosan Heavy Industries & Construction, KOREA

14:50 - **Optimal Integrated Design of Air Separation Unit and Gas Turbine Block for IGCC Systems**, Ravindra Kamath, Ignacio E. Grossmann, Lorenz T. Biegler, Carnegie Mellon University; Stephen E. Zitney, DOE-NETL, USA

SESSION 8
SUSTAINABILITY AND ENVIRONMENT:
GHG/GWP
Massood Ramezan and Scott Deatheridge

13:30 - **The Strategic Role of Coal in the Fight Against Global Warming,** Alex Wormser, Wormser Energy Solutions, Inc., USA

13:50 - **How a Coal Plant without CCS Can Become Greenhouse Gas Neutral under New National Standard, SCS-002-01 GHG Metrics,** Stanley Rhodes, Scientific Certification Systems, USA

14:10 - **Greenhouse Gas (GHG) Inventories Encourage "Portfolio-ing" of Sustainability,** Steven M. Carpenter, Marshall Miller & Associates, Inc., USA

14:30 - **The Improving Sweep Efficiency of Co_2 Flooding with Combining CO_2 Gas into Polymer Solution to Enhance Oil Recovery**, O. Arjmand, EOR Researcher; Mansour Kalbasi, Amir Kabir University; Alireza Roostaee, Marvdasht University, IRAN

14:50 - **Carbon Deposition by Methane Decomposition and its Influences on Carbon Dioxide Reforming of Methane over Carbonaceous Catalyst**, Chengsheng Tian, Yongfa Zhang, Taiyuan University of Technology, CHINA

Technical Program

SESSION 9
CARBON MANAGEMENT: PRE-COMBUSTION – 2
Pradeep Indrakanti and Robert N. Miller

13:30 - **Optimal Design of PSA Cycles for Pre-Combustion CO_2 Capture using a Superstructure-Based Approach,** Sree Rama Raju Vetukuri, Anshul Agarwal, Lorenz T. Biegler, Carnegie Mellon University; Stephen E. Zitney, DOE-NETL, USA

13:50 - **Carbon Capture Optimization for IGCC and PC Power Plants,** Eric Grol, DOE-NETL, USA

14:10 - **Molecular Simulations of Pure and Mixed Gases Physical Absorption in Ionic Liquid (IL) of [hmim][Tf_2N] for $CO_2/H_2/Ar$,** Wei Shi, Parsons Corporation and DOE-NETL; Dan Sorescu, DOE-NETL, USA

14:30 - **Coal and Biomass Process for CO_2 Reduction and CTL Production,** Ebbe R. Skov, Terrance L. Stringer, Dennis C. England, ConvertCoal, Inc., USA

14:50 - **Characterization of Dry Regenerable Sorbents for CO_2 Capture from Syngas,** Jeom-In Baek, Tae Hyoung Eom, Joong Beom Lee, Won Sik Jeon, Ji-Woong Kim, Korea Electric Power Research Institute, KOREA

SESSION 10
COMBUSTION – 1
John Wheeldon and Evan Granite

13:30 - **Corrosion Testing of Advanced-Ultrasupercritical Materials for Reduced CO_2 Emissions,** Michael S. Gagliano, Gregory J. Stanko, Horst Hack, Foster Wheeler North America Corp., USA

13:50 - **Flame Emission Spectroscopy in a Coal and Biomass Co-Fired Industrial Boiler,** Thangam Parameswaran, Patrick Hughes, CanmetEnergy, NRCAN, CANADA

14:10 - **An Experimental Investigation on Combustion Characteristics of Perverized Coals with Different Size, Mass, and Moisture Contents,** Yong-Gyun Kim, Jae-Dong Kim, Gyu-Bo Kim, Ju-Hun Song, Young-June Chang, Chung-Hwan Jeon, Pusan Clean Coal Center, Pusan National University, SOUTH KOREA

14:30 - **CO_2 Reduction Potential and Co-Combustion Possibilities of the FBC-Boilers on the Czech Conditions,** Dagmar Juchelkova, Helena Raclavska, Konstantnin Raclavsky, Pavel Kolat, VSB-Technical University of Ostrava, CZECH REPUBLIC

14:50 - **Integration of Coal Char Combustion Models and CFD-DEM Code in a Fluidized Bed,** Daoyin Liu, Xiaoping Chen, Chuanwen Zhao, Changsui Zhao, Southeast University, CHINA

SESSION 11
COAL SCIENCE: COAL BENEFICIATION – 1
B.K. Parekh

13:30 - **Moisture-Induced Swelling of Coal,** Richard Sakurovs, Robyn Fry, Stuart Day, CSIRO Energy Technology, AUSTRALIA

13:50 - **Online Analysis of Coal on a Conveyor Belt by Use of Machine Vision and Kernel Methods,** Johan van Dyk, JHP van Heerden, M.J. Keyser, Sasol Technology R&D; C. Aldrich, G.T. Jemwa, University of Stellenbosch, SOUTH AFRICA

14:10 - **Comparison of Spiral and MGS for Recovery of Fine Coal from Slimes,** Güven Önal, A.E. Yüce, O. Kangal, M. Özer, O. Kökkılıç, A. Güney, Istanbul Technical University, TURKEY

14:30 - **Laboratory Research on the Effect of Bulk Density of Coal Charge on Coke Quality,** Shizhuang Shi, Wuhan University of Science and Technology; Shangguo Liang, Wuhan Iron and Steel Co. Ltd, CHINA

SESSION 12
COAL-DERIVED PRODUCTS: COAL-TO-LIQUIDS: CATALYSTS
Rachid Oukaci and Sam Tam

13:30 - **Fischer-Tropsch Synthesis: A Comparison of Iron and Cobalt,** Burtron H. Davis, Shiqi Bao, Robert A. Keogh, Gary Jacobs, Center for Applied Energy Research, University of Kentucky, USA

14:10 - **Enhancing Gas Phase Fischer-Tropsch Synthesis Catalyst Design,** Debalina Dasgupta, Illinois Clean Coal Institute; Tomasz Wiltowski, Southern Illinois University, USA

14:30 - **Tailoring Gold-Mixed La/Ce-Oxide Catalysts for Water-Gas Shift,** Yanan Wang, University of Pittsburgh; Shuang Liang, Götz Veser, University of Pittsburgh and DOE-NETL; Robert Thompson, Christopher Matranga, DOE-NETL, USA

14:50 - **Catalyst Design for Coal-To-Liquid Processes: Iron-Cobalt Alloys for Fischer-Tropsch Enhancement,** Panithita Rochana, Shela Aboud, Jennifer Wilcox, Stanford University, USA

SESSION 13
GASIFICATION: UNDERGROUND COAL GASIFICATION – 1
Julio Friedmann and Rohan Courtney

15:25 - **UCG Project Permitting in the U.S.,** Mary A. Bloomstran, Edge Environmental, Inc., USA

15:45 - **UCG Technical Risk Reduction through Lessons Learned and Simulation**, Elizabeth Burton, Souheil Ezzedine, Lawrence Livermore National Laboratory, USA

16:05 - **Cougar Energy's UCG Commercialisation Plan,** Len Walker, Cougar Energy Ltd, AUSTRALIA

16:25 - **Rm-1 to Bloodwood Creek: A Status Report,** Burl E. Davis, Carbon Energy Pty Ltd, USA; Cliff Mallet, Carbon Energy Pty. Ltd., AUSTRALIA

16:45 - **Project Ramsay: Potential for Underground Coal Gasification with Carbon Capture and Storage (UCG-CCS) in the North East, England, UK,** L.K. Mudashiru, D. Roddy, Newcastle University, UNITED KINGDOM

SESSION 14
GASIFICATION: FUNDAMENTALS – 1
George Richards, Ron Breault and Ke Liu

15:25 - **Gasification Fundamentals Research - Planning for the Future,** George Richards, Ron Breault, DOE-NETL; Ke Liu, GE Global Research, USA

15:45 - **Chemical Reaction Kinetics for the Initial Stages of Entrained-Flow Coal Gasification,** Stephen Niksa, Niksa Energy Associates, LLC; Donald Eckstrom, Ripu Malhotra, Al Hirschon, SRI International, USA

16:05 - **Comparison of Instantaneous, Local Equilibrium and Finite Rate Gasification Models in an Entrained Flow Coal Gasifier,** Armin Silaen, Ting Wang, University of New Orleans, USA

16:25 - **Large Eddy Simulation of Near-Nozzle Region in an Entrained Coal Gasifier,** Philip J. Smith, Jeremy Thornock, Charles Reid, Julien Pedel, The University of Utah, USA

16:45 - **Modeling Entrained Flow Coal Gasifiers,** Mike Bockelie, Martin Denison, Dave Swensen, Connie Senior, Adel Sarofim, Reaction Engineering International, USA

SESSION 15
CARBON MANAGEMENT
Gary L. Leatherman and Robert N. Miller

15:25 - **Recent Developments in the Regulatory Regime for Coal-Fired Power Plants and their Implications for Carbon Management,** R.P. Detwiler, J. Philip DiPietro, Christopher J. Nichols, DOE-NETL, USA

15:45 - **Understanding Radical Technology Innovation and its Application to CO_2 Capture R&D,** Andrew Place, Edward S. Rubin, David Gerard, Carnegie Mellon University, USA

16:05 - **Pressure Swing Adsorption Technology for Post- and Pre-Combustion Carbon Dioxide Capture,** James A. Ritter, Amol Mehrotra, Hai Du, Armin D. Ebner, University of South Carolina, USA

16:25 - **Use of High-Pressure Oxy-Combustion in Coal-Fired Power Plants to Achieve Near Complete Carbon Capture and Storage,** Keith Pronske, Roger E. Anderson, Clean Energy Systems, Inc., USA

16:45 - **Near and Longer Term Solutions to Carbon Capture and Sequestration,** Adel F. Sarofim, Philip J. Smith, Ronald J. Pugmire, Kerry E. Kelly, The University of Utah, USA

17:05 - **Technical and Economical Comparison Between Different Coal-Based and CO_2-Free Power Generation Technologies**, Alberto Pettinau, Carlo Amorino, Sotacarbo S.p.A., ITALY

SESSION 16
COMBUSTION: CHEMICAL LOOPING – 1
John Wheeldon and Evan Granite

15:25 - **Alstom's Chemical Looping Combustion Coal Power Technology Development Prototype,** Paul Thibeault, Herbert E. Andrus, John H. Chiu, Alstom Power Inc.; Charles Miller, DOE-NETL, USA

15:45 - **Investigation of the Reaction Kinetics of Oxygen Carriers in Chemical Looping Combustion,** Richard Baraki, Gabor Konya, Edward M. Eyring, The University of Utah, USA; H. Paul Wang, National Cheng Kung University, TAIWAN

16:05 - **Materials and Process for Chemical Looping Combustion of Coal,** James White, Damon Waters, David Anderson, Doug Jack, Eltron Research & Development, USA

16:25 - **Dynamic Simulation and Advanced Controls for Alstom's Chemical Looping Process,** Xinsheng Lou, Carl Neuschaefer, Hao Lei, Alstom Power Plant Laboratories, USA

16:45 - **Chemical Looping Combustion of Coal and Woody Biomass,** Hyung "Ray" Kim, Fanxing Li, Deepak Sridhar, Liang Zeng, Andrew Tong, Nobusuke Kobayashi, Liang-Shih Fan, The Ohio State University, USA

17:05 - **Design of the Syngas Chemical Looping Sub-Pilot Scale Unit**, Andrew Tong, Fanxing Li, Deepak Sridhar, Liang Zeng, Fei Wang, Hyung "Ray" Kim, Liang-Shih Fan, The Ohio State University, USA

ORAL SESSIONS
Tuesday, September 22, 2009
10:20 - 17:25

SESSION 17
COAL SCIENCE:
COAL BENEFICIATION – 1
B.K. Parekh

15:25 - **Extraction of High Grade Magnetic Material from Fly Ash and its Evaluation for Dense Medium Coal Cleaning Application,** Baojie Zhang, Manoj K. Mohanty, Fan Yang, Richard Geilhausen, Southern Illinois University Carbondale; Joseph C. Hirschi, Illinois Clean Coal Institute, USA

15:45 - **Segragation of Coal Fines in Pulsating Gas Flow**, Eric Johnson, Bruce Kang, Jordan Musser, West Virginia University, USA

16:05 - **Abundance of FE-Bearing Species in Coal Extract and its Implications to the Iron Speciation in Raw Coal,** Lian Zhang, Eleanor Binner, Sankar Bhattacharya, Monash University, AUSTRALIA; Toshimasa Takanohashi, National Institute of Advanced Industrial Science and Technology (AIST), JAPAN

16:25 - **Segragation of Coal Fines in Jet Flow**, Eric Johnson, Bruce Kang, West Virginia University; Bryan M. Wimer, NIOSH, HELD, ECTB, USA

16:45 - **Design, Fabrication Dan Testing of Coal Dryer Prototype Model by Utilization Flue Gas as Drying Fluid,** Tonny Sarief, Mochamad Choliq, PT PLN (Persero), INDONESIA

17:05 - **Factors Affecting on Hangingwall Caving in Longwall Mining**, M. Rostami, IRAN

SESSION 18
COAL-DERIVED PRODUCTS:
COAL-TO-LIQUIDS: TECHNOLOGY – 2
Bryan Morreale and Sam Tam

15:25 - **Secure, Clean Fuels from Coal: Direct Liquefaction,** Anthony Cugini, Bryan Morreale, DOE-NETL; Chunshan Song, Pennsylvania State University; James Spivey, Louisiana State University; Edward Schmetz, Leonardo Technologies, Inc., USA

16:05 - **Direct Coal Liquefaction: The Reaction Pathway and the Politics,** Burtron H. Davis, Robert A. Keogh, Center for Applied Energy Research, University of Kentucky, USA

16:25 - **Accelergy Corporation's Integrated Coal to Liquids Technology,** Rocco A Fiato, Richard F Bauman, Steve Hua, Sam Zaczepinski, Youqi Wang, Accelergy Corporation, USA

16:45 - **Production of Clean Gasoline from Coal: Exxonmobil Research and Engineering Company's Methanol to Gasoline (Mtg) Technology,** Samuel A. Tabak, Mitch Hindman, ExxonMobil Research and Engineering Company, USA

17:05 - **Using Iron/Iodine Catalyst to Improve the Selectivity in Direct Liquefaction of Coal**, Zhen Yuan, Yonggang Wang, Deping Xu, China University of Mining and Technology, CHINA

SESSION 19
GASIFICATION:
UNDERGROUND COAL GASIFICATION – 2
Julio Friedmann and George Guthrie

10:20 - **The ENN UCG Progress,** Feng Chen, ENN Sci.& Tech. Co.Ltd., CHINA

10:40 - **Modelling of Deep Lignite Seams for Conventional Production and Underground Coal Gasification in Turkey,** S. Anac, S. Yurek, M. Ozdingis, B.S. Halicioglu, Turkish Coal Enterprises; B. Unver, E. Tercan, M.A. Hindistan, G. Ertunc, E. Akcan, Hacettepe University, TURKEY

11:00 - **Long-Term Groundwater Monitoring for Environmental Risk Assessment: Lessons Learned from UCG Pilot Experiments,** Souheil Ezzedine, Elizabeth Burton, Lawrence Livermore National Laboratory, USA

11:20 - **Underground Coal Gasification Performance Predictions using Compartment Models,** Sateesh Daggupati, Ramesh Naidu Mandapati, Sanjay M Mahajani, Anuradda Ganesh, Preeti Aghalayam, IIT Bombay; Sapru R.K., Sharma R.K., UCG Group, IRS, ONGC, INDIA

11:40 - **Seismic - An Integral Part of UCG Project (A Case Study),** Ashwani Lamba, P.P. Uniyal, Pankaj Bhuyan, R.K. Sharma, D.K. Sharma, ONGC, INDIA

SESSION 20
GASIFICATION:
FUNDAMENTALS – 2
George Richards, Ron Breault, and Ke Liu

10:20 - **FE-Mineral Transformations during the Initial Stages of Entrained-Flow Coal Gasification,** Stephen Niksa, Niksa Energy Associates, LLC; Donald Eckstrom, Ripu Malhotra, Al Hirschon, SRI International, USA

10:40 - **Investigation of Ash Deposition Behavior during Coal Char-Slag Transition under Gasifying Conditions,** Suhui Li, Kevin Whitty, University of Utah, USA

11:00 - **Evaluation of Entrained Gasification Char for Recycling into Gasifier,** Yongseung Yun, Institute for Advanced Engineering; Na Rang Kim, Seok Woo Chung, IAE-Ajou University Branch, KOREA

11:20 - **Slag-Refractory Interactions,** Larry Baxter, Brigham Young University, USA

11:40 - **Modeling Slag Viscosity with Atmospheric Effects,** Marc A. Duchesne, Arturo Macchi, University of Ottawa; Ben Anthony, Dennis Lu, Robin Hughes, David McCalden, CanmetENERGY, CANADA

SESSION 21
CARBON MANAGEMENT:
POST-COMBUSTION – 1
Michael L. Jones and Robert N. Miller

10:20 - **"Molecular-Basket" Sorbents for CO_2 Capture from Flue Gas,** Xiaoliang Ma, Xiaoxing Wang, Chunshan Song, Pennsylvania State University, USA

10:40 - **A Membrane Process to Capture Carbon Dioxide from Power Plant Flue Gas**, Tim Merkel, Xiaotong Wei, Bilgen Firat, Haiqing Lin, Jenny He, Richard Baker, Membrane Technology and Research, Inc., USA

11:00- **Update on RTI's Dry Carbonate Process: Carbon Dioxide Capture from Power Plant Flue Gas,** Thomas O. Nelson, Luke J.I. Coleman, Matthew L. Anderson, Joshua Herr, Maruthi Pavani, RTI International; José D. Figueroa, DOE-NETL, USA

11:20 - **Low Cost Solid Sorbent for CO_2 Capture on Existing Coal-Fired Power Plants,** Jeannine Elliott, Girish Srinivas, Robert Copeland, TDA Research, Inc., USA

11:40 - **The Hazelwood/CO2CRC H3 Capture Demonstration Project,** Barry Hooper, The University of Melbourne; Tony Innocenzi, International Power Australia Pty Ltd; Craig Dugan, The Process Group, AUSTRALIA

SESSION 22
COMBUSTION:
OXY-COMBUSTION – 2
John Wheeldon and Evan Granite

10:20 - **Effects of CO_2 on Char Burning Rate and Ignition Delay During Oxy-Coal Combustion,** Shengteng Hu, Dong Zeng, Andrew J. Mackrory, Alan N. Sayre, The Babcock & Wilcox Company Research Center, USA

10:40 - **Oxyfuel Combustion Properties Based on Horizontal Single Burner Furnace Tests,** Toshihiko Mine, Kenichi Ochi, Babcock-Hitachi K.K. Kure Research Laboratory; Hirofumi Okazaki, Hitachi,Ltd. Energy & Environmental Systems Laboratory, JAPAN; Pauli Dernjatin, Fortum Service, FINLAND

11:00 - **High-Speed Camera Observation of a Bituminous Coal Combustion in Air and O_2/CO_2 Mixtures and Particle Velocity Measurement,** Lian Zhang, Eleanor Binner, Sankar Bhattacharya, Monash University, AUSTRALIA

11:20 - **Ignition Characteristics of Single Coal Particles in Air (O_2/N_2) and Oxy-Fuel (O_2/CO_2) Conditions**, Zeenathul Farida Gani, Terry F. Wall, Behdad Moghtaderi, The University of Newcastle, AUSTRALIA

11:40 - **Effects of O_2 Partial Pressure on Flame Stability in Oxy-Coal Combustion**, Jingwei Zhang, Kerry Kelly, Eric G. Eddings, Jost O.L. Wendt, University of Utah, USA

SESSION 23
COAL SCIENCE:
COAL CHEMISTRY – 1
Jim Hower

10:20 - **Effect of Oxidative Heating in Air on Reactivity of Coal to Dilute Nitric Acid Oxidation,** Sunil K. Srivastava, Raja Sen, Central Institute of Mining & Fuel Research; Madan Mohan Singh, Banaras Hindu University, INDIA

10:40 - **Thermogravimetric Characteristics and Kinetics of Malaysian Bituminous Coal and Industrial Solid Waste (Tyre Waste and Plastic Waste) Blends during Co-Pyrolysis,** Sharmeela Matali, Norazah Abd Rahman, Azil Bahari Alias, Zulkifli Abdul Rashid, Siti Shawalliah Idris, University Technology MARA, MALAYSIA

11:00 - **Thar Coal Resources Mining Development & Applications**, Munawar Baseer Ahmad, EMR-Consult, PAKISTAN

11:20 - **Adsorption of Hydrogen and Methane by Coals,** Ch. N. Barnakov, A. P. Kozlov, Institute of Coal and Coal Chemistry SB RAS; S.K. Seit-Ablaeva, Kemerovo Technological Institute of Food Industry; Z. R. Ismagilov, Boreskov Institute of Catalysis SB RAS, RUSSIA

11:40 - **Kinetics Study of High Pressure Carbonation of Calcium Based Sorbents in Calium Looping Process**, Fu-Chen Yu, Fanxing Li, Zhenchao Sun, Shwetha Ramkumar, L. –S. Fan, The Ohio State University, USA

SESSION 24
COAL-DERIVED PRODUCTS: CARBON MANAGEMENT FOR COAL CONVERSION

Chunshan Song and Bryan Morreale

10:20 -**Secure, Clean Fuels from Coal: Carbon Management,** Anthony Cugini, Bryan Morreale, DOE-NETL; Chunshan Song, Pennsylvania State University; James Spivey, Louisiana State University, USA

11:00 - **Calcium Looping Process Enhanced Coal to Liquids Technology,** Shwetha Ramkumar, Nihar Phalak, Zhenchao Sun, L. S. Fan, The Ohio State University, USA

11:20 - **Experimental Investigation of Chemical-Looping Combustion using Iron Oxide as the Oxygen Carrier in a Bench Scale Fluidized Bed Reactor,** Wenguo Xiang, Shiyi Chen, Zhipeng Xue, Xiayan Sun, Southeast University; Wendong Tian, Xiang Xu, Yanji Xu, Yunhan Xiao, Chinese Academy of Sciences, CHINA

11:40 - **Evaluation of Inner Mongolia Coal in 30 Kg/day Pilot and 2 ton/day Process Development Scale Operations**, Theo L.K. Lee, Robert Y.H. Chang, Wayne Lin, Samuel Tam, Headwaters CTL, LLC, USA

SESSION 25
GASIFICATION: UNDERGROUND COAL GASIFICATION – 3

George Guthrie and Rohan Courtney

13:30 - **Coupled Geomechanical Simulations of UCG Cavity Evolution,** Joseph P. Morris, Thomas A. Buscheck, Yue Hao, Lawrence Livermore National Laboratory, USA

13:50 - **Coupled Thermal-Hydrologic-Chemical Simulations of Underground Coal Gasification,** Thomas A. Buscheck, Yue Hao, Elizabeth A. Burton, Lawrence Livermore National Laboratory, USA

14:10 - **Numerical Modelling of Underground Coal Gasification Process for Estimation of Product Gas Composition,** Chetan Ratnakar Chodankar, Bo Feng, A. Y. Klimenko, University of Queensland, AUSTRALIA

14:30 - **Surface Versus Underground Coal Methanation**, Jan Rogut, GIG - Central Mining Institute, POLAND; Marc Steen, Institute for Energy, Joint Research Centre, European Commission, THE NETHERLANDS

14:50 - **Building a Midwest CCS Industry: Where Does UCG Fit?**, Mike Fowler, Clean Air Task Force, USA

SESSION 26
GASIFICATION: FUNDAMENTALS – 3

George Richards, Ron Breault, and Ke Liu

13:30 - **Gasifier Model Development Using ANN Technique,** G. Viswanathan, C. Thirugnanam, S. Veeramani, BHEL, INDIA

13:50 - **Numerical Investigation of Top Fuel Injection Design in a Coal Gasifier,** Ting Wang, Armin Silaen, University of New Orleans, USA; Heng-Wen Hsu, Cheng-Hsien Shen, Industrial Technology Research Institute, TAIWAN

14:10 - **Gasification Kinetics: Modeling Tools Development and Validation,** Boris Eiteneer, Ramanathan Subramanian, Shawn Maghzi, GE Global Research, USA; Cai Zeng, Xiaofen Guo, Yinhua Long, GE Global Research, GE China Technology Center, CHINA; Lei Chen, Massachusetts Institute of Technology, USA; Ravichandra JS, Ashwin Raman, Jayesh Jain, GE Global Research, GE John Welch Technology Centre, INDIA; Tom Fletcher, Randy Shurtz, Brigham Young University, USA

14:30 - **Viscosity Measurements and Empirical Predictions for Coal Slags,** Josef Matyas, S. Kamakshi Sundaram, Carmen P. Rodriquez, Alejandro Heredia-Lagner, PNNL, USA

SESSION 27
CARBON MANAGEMENT: POST-COMBUSTION – 2

Michael L. Jones and Robert N. Miller

13:30 - **Results from the Carbonation-Calcination Reaction (CCR) Process,** Shwetha Ramkumar, Songgeng Li, William Wang, Siddharth Gumuluru, Zhenchao Sun, Liang-Shih Fan, The Ohio State University; Robert M. Statnick, ClearSkies Consulting, USA

13:50 - **Cryogenic CO_2 Capture as a Cost-Effective CO_2 Capture Process,** Larry Baxter, Brigham Young University and Sustainable Energy Technologies; Andrew Baxter, Sustainable Energy Technologies; Stephanie Burt, Brigham Young University, USA

14:10 - **Atomic-Level Modeling of CO_2 Adsorption and Transport in Nanoporous Materials,** Jinchen Liu, Rees B. Rankin, J. Karl Johnson, University of Pittsburgh and DOE-NETL, USA

14:30 - **Modeling Solid Sorbents for CO_2 Capture,** Bo Zhang, Yuhua Duan, J. Karl Johnson, University of Pittsburgh and DOE-NETL, USA

14:50 - **Superstructure-Based Optimal Design of PSA Cycles for Post-Combustion CO_2 Capture,** Anshul Agarwal, Lorenz T. Biegler, Carnegie Mellon University; Stephen E. Zitney, DOE-NETL, USA

SESSION 28
COMBUSTION: CHEMICAL LOOPING – 2

John Wheeldon and Evan Granite

13:30 - **Copper Oxide as a Carrier for Chemical Looping: A Status Report,** Kevin Whitty, Edward M. Eyring, JoAnn S. Lighty, Adel F. Sarofim, The University of Utah, USA

13:50 - **Effect of H_2S on Chemical Looping Combustion of Coal-Derived Synthesis Gas over Bentonite Supported Metal Oxide Oxygen Carriers,** Hanjing Tian, Tom Simonyi, Ranjani Siriwardane, Parsons/ U.S. Department of Energy, National Energy Technology Laboratory, USA

14:10 - **Performance of Nanocomposite Oxygen Carriers in Chemical Looping Combustion using Sulfur-Laden Coal Gas,** Rahul D. Solunke, Goetz Veser, University of Pittsburgh and DOE-NETL, USA

14:30 - **Effect of H_2S on Chemical Looping Combustion of Coal-Derived Synthesis Gas over NiO Supported on SiO_2/ZrO_2/TiO_2/Sepiolite,** Ewelina Ksepko, Marek Sciazko, Institute for Chemical Processing of Coal, POLAND; Ranjani V. Siriwardane, James A. Poston Jr,., DOE-NETL; Hanjing Tian, Thomas Simonyi, Anthony Zinn, Parsons, USA

14:50 - **Multiobjective Optimization Power Generation Systems Involving Chemical Looping Combustion**, Juan M. Salazar, Urmila M. Diwekar, Vishwamitra Research Institute: Center for Uncertain Systems Tools for Optimization and Management; DOE-NETL; Stephen E. Zitney, DOE-NETL, USA

SESSION 29
COAL SCIENCE: COAL GEOSCIENCE – 1: COAL FIRES

Jim Hower and Allan Kolker

13:30 - **Overview of Underground Coal Fires,** Evan J. Granite, DOE-NETL; Ali Rangwala, Worcester Polytechnic Institute, USA

13:50 - **The Tiptop Coal Mine Fire, Kentucky: Preliminary Investigation of the Measurement of Mercury, Carbon Dioxide, and Carbon Monoxide from Coal-Fire Gas Vents,** James C. Hower, Kevin R. Henke, University of Kentucky Center for Applied Energy Research; Jennifer M.K. O'Keefe, Morehead State University; Mark A. Engle, U.S. Geological Survey; Glenn B. Stracher, East Georgia College; Donald R. Blake, University of California-Irvine, USA

14:10 - **Measuring CO_2 Emissions from Spontaneous Coal Fires in the U.S.,** Allan Kolker, Mark Engle, U.S. Geological Survey; Glenn B. Stracher, East Georgia College; James Hower, University of Kentucky; Anupma Prakash, University of Alaska, USA

14:30 - **Extinguishing the Percy Mine Fire,** Stanley R. Michalski, Phillip E. Glogowski, Fred J. Bickerton, GAI Consultants, Inc., USA

14:50 - **Estimation of Susceptibility of Coal to Spontaneous Heating using Differential Scanning Calorimeter,** R. V. K. Singh, G. Sural, N. K. Mohalik, V. K. Singh, Central Institute of Mining & Fuel Research, INDIA

SESSION 30
COAL-DERIVED PRODUCTS: SUBSTITUTE NATURAL GAS (SNG)

Sam Tam and Chunshan Song

13:30 - **Hydrogasification Progress,** Raymond Hobbs, Arizona Public Service; David Haberman, IF, LLC, USA

13:50 - **Production of Methane Rich Fuel Gas from Coal using Steam Hydrogasification,** Arun SK Raju, Viresco Energy LLC; Chan S. Park, Joseph M. Norbeck, University of California, Riverside, USA

14:10 - **Bench Scale Hydrogasifier Testing for Production of Substitute Natural Gas (Sng) from Western Coal,** Raymond Hobbs, Xiaolei Sun, Arizona Public Service; Elaine Everitt, DOE-NETL, USA

14:30 - **Co Production of Substitute Natural Gas and Electricity via Catalytic Coal Gasification,** Brian S. Turk, Matthew L. Anderson, Luke J.I. Coleman, Andreas Weber, Raghubir P. Gupta, RTI International, USA

14:50 - Steam Hydrogasification of Lignite Coal, Yuh Jiun Tan, Chan S. Park, Joseph M. Norbeck, University of California, Riverside, USA

SESSION 31
GASIFICATION: SYNTHESIS GAS CLEANING – 1

Ragubir Gupta and Ting Wang

15:25 - **Warm Syngas Cleanup for Chemical Applications using Regenerable CO_2 Sorbents**, Brian S. Turk, Jason P. Trembly, Jian-Ping Shen, Maruthi Pavani, Pradeepkumar Sharma, Raghubir P. Gupta, RTI International, USA

15:45 - **A Compact, Regenerable, Hot Syngas Desulfurizer for Coal-Based Advanced Energy Systems,** Rachid B. Slimane, Chun W. Choi, Gas Technology Institute (GTI); Maria Flytzani-Stephanopoulos, Ioannis Valsamakis, Tufts University, USA

16:05 - **Multicontaminant Warm Gas Cleanup,** Girish Srinivas, Steven Gebhard, Will Spalding, TDA Research Inc.; Jason Vidaurri, Carbon Fiber Technology, LLC, USA

16:25 - **Warm Temperature Sorbents for Synthesis Gas Clean-Up,** Gokhan Alptekin, Ambalavanan Jayaraman, Bob Amalfitano, TDA Research, Inc., USA

16:45 - **Perovskite Sorbents for Warm-Gas Removal of Sulfur,** David A. Gribble, Sara A. Rolfe, Michael V. Mundschau, Eltron Research & Development Inc., USA

SESSION 32
GASIFICATION: FUNDAMENTALS – 4
George Richards, Ron Breault, and Ke Liu

15:25 - **The Use of 2,6-Dimethylnaphthalene as a Surrogate for Studying Soot Formation from Coal Tar**, Randy Shurtz, Thomas H. Fletcher, Brigham Young University; Ronald J. Pugmire, Mark S. Solum, University of Utah, USA

15:45 - **The Study on Charateristic of Coal Fouling Propensity and Grain Size using Two-Story Deposit Plate of Fly Ash under Gasification Condition,** Hyung-Taek Kim, Ajou University, USA

16:05 - **Performance of High Ash Indian Coals in Fluidized Bed Gasification under Different Operating Conditions,** P. D. Chavan, S. Datta, Sujan Saha, B. K. Mall, S. K. Srivastava, Central Institute of Mining and Fuel Research; T. Sharma, Indian School of Mines University, INDIA

16:25 - **Pyrolysis and Gasification of a Sub-Bituminous Coal at High Heating Rates,** Randy Shurtz, Thomas H. Fletcher, Brigham Young University, USA

16:45 - **Plant-Wide Dynamic Simulation of an IGCC Plant with CO_2 Capture**, Debangsu Bhattacharyya, Richard Turton, West Virginia University; Stephen E. Zitney, DOE-NETL, USA

SESSION 33
CARBON MANAGEMENT: SEQUESTRATION – 1
Sean Brennan and Ronald Affolter

15:25 - **Carbon Capture and Storage in Central Appalachia – What Would it Look Like?,** Steven M. Carpenter, Marshall Miller & Associates, Inc., USA

15:45 - **Fundamentals of Gas Adsorption in Coalbeds,** Yangyang Liu, Shela Aboud, Anthony R. Kovscek, Jennifer Wilcox, Stanford University, USA

16:05 - **Direct Observation of CO_2 Injection into Coal using Small Angle X-Ray Scattering (SAXS),** A. H. Clemens, CRL Energy Ltd, NEW ZEALAND; Soenke Seifert, Darren R. Locke, Randall E. Winans, Argonne National Laboratory; Joseph M. Calo, Brown University, USA

16:25 - **Results from the Central Appalachian Basin Field Verification Test in Coal Seams,** Nino Ripepi, Michael Karmis, Ilija Miskovic, Virginia Tech; Christopher Shea, J. Matthew Conrad, Marshall Miller & Associates, Inc., USA

16:45 - **Evaluation of CO_2 Storage Capacity in Unexploited Coal Deposits: Application to an Unexploited Area of Provence Coal Basin in France**, Zbigniew Pokryszka, Stéphane Lafortune, Candice Lagny, Christophe Didier, Delphine Charriere, French National Institute for Industrial Environment and Risks (INERIS); Didier Bonijoly, BRGM, FRANCE

17:05 - **Alberta's Carbon Management Strategy: An Integrated Aproach to Carbon Capture and Storage and Technology Development and Demonstration,** Duke du Plessis, Eddy Isaacs, Alberta Energy Research Institute, CANADA

SESSION 34
COMBUSTION: MERCURY
John Wheeldon and Evan Granite

15:25 - **Particle-Loaded Membranes as Mercury Capture System,** Edgar B. Klunder, Evan J. Granite, Richard A. Hargis, DOE-NETL, USA

15:45 - **Method to Improve Measurement of Mercury in Coal Combustion Flue Gas,** Keiichiro Kai, Seiji Ikemoto, Yasuyoshi Kato, Hirohumi Kikkawa, Yoshinori Nagai, Babcock-Hitachi K.K., JAPAN

16:05 - **Effect of Polarities of Pulsed Corona Discharge on Oxidation of Gaseous Elemental Mercury,** Youngchul Byun, Moohyun Cho, Won Namkung, Pohang University of Science and Technology; Kyoung Bo Ko, Hynix Semiconductor Inc; Dong Nam Shin, Dong Jun Koh, Research Institute of Industrial Science & Technology, KOREA

16:25 - **Homogeneous and Heterogeneous Mercury Reaction Chemistry in Coal Combustion Flue Gases**, Sang-Sup Lee, Erdem Sasmaz, Bihter Padak, Jennifer Wilcox, Stanford University, USA

16:45 - **Characterisation of Active Sites for Vapour Mercury Adsorption on Sulfur Impregnated Activated Carbon Derived by SO_2 Thermal Treatment by Xanes Analysis**, Shitang Tong, Wuhan University of Science and Technology, CHINA; Charles Q. Jia, Jenny H. Cai, Eric. A. Morris, University of Toronto, CANADA

17:05 - **Powdered Biocarbon as a Mercury Removal Technology in Utility Flue Gas Applications**, Hugh McLaughlin, Alterna Energy Inc., CANADA

SESSION 35
COAL SCIENCE: COAL CHEMISTRY – 2
Jim Hower

15:25 - **Effects of Lignite Ash on Pyrolysis Kinetics of Lignite**, Yaoling Chi, Fuchen Ding, Hong Wang, Cuiqing Li, Xiaoguang Ren, Beijing Institute of Petrochemical Technology; Shuyuan Li, State Key Lab of Heavy Oil Processing, University of Petroleum, CHINA

15:45 - **Study on the Effect of Coal Charge Properties on the Thermal Performance of Metallurgical Coke,** Shizhuang Shi, Hui Wang, Wuhan University of Science and Technology, CHINA

16:05 - **Thermal Evolution Characteristics of Coal Macerals Formed in Different Reductivity Environment by IN-SITU XRD,** Ke-Chang Xie, Wen-Ying Li, Haizhou Chang, Jie Feng, Taiyuan University of Technology, CHINA

16:25 - **XPS Analysis of Shenfu Coal with Different Density Macerals in UV Catalytic Photooxidation**, Zhi-yuan Yang, Xi'an University of Science and Technology & Xi'an Branch of China Coal Research Institute; Peng Liu, Zhou Anning, Xi'an University of Science and Technology CHINA

16:45 - **Experimental Research on the CO Impact on the Explosion Characteristics of CH_4,** Wang Hua, Wang Lianhua, Qufu Normal University; Deng Jun, Ge Lingmei, Wen Hu, Xi'an University of Science and Technology, CHINA

17:05 - **Simulation Aided Evaluation of Performance of FGX Separator on Turkish Lignites**, Nuray Yalcin, Mustafa Ozdingis, General Directorate of Turkish Coal; Levent Ergun, Oczan Gulsoy, E. Caner Orhan, Hacettepe University, TURKEY

SESSION 36
COAL-DERIVED PRODUCTS: HYDROGEN PRODUCTION – 1
Bryan Morreale and Rachid Oukaci

15:25 - **Concomitant Production of High Purity Hydrogen and Sequestration Ready Carbon Dioxide from Coal**, Tomasz Wiltowski, Kanchan Mondal, Southern Illinois University, USA

15:45 - **Utilization of High Temperature CO_2 Chemisorbents in Sorption Enhanced Reaction Concepts for Production of Fuel Cell Grade H_2 from Fossil Fuel Feedstocks**, Michael G. Beaver, Hugo Caram, Shivaji Sircar, Lehigh University, USA

16:05 - **CO_2-Free Hydrogen Production in the Sotacarbo Experimental Plant**, Alberto Pettinau, Francesca Ferrara, Sotacarbo S.p.A., ITALY

16:25 - **Producing High Pressure H_2 and High Pressure CO_2 Streams from a High Pressure CO_2-H_2 Mixture with Novel CO_2-Philic Solvents**, Matthew Miller, De-Li Chen, Hong Bin Xiao, Robert M. Enick, J. Karl Johnson, University of Pittsburgh; David Luebke, DOE-NETL, USA

16:45 - **Syngas Chemial Looping: Sub-Pilot Scale Demonstrations**, Deepak Sridhar, Fanxing Li, Andrew Tong, Rae Kim, Liang Zeng, Fei Wang, Liang –Shih Fan, The Ohio State University, USA

17:05 - **Interaction of Aromatic and Hydroaromatic Hydrogen of Coal with Alkali for Generating Clean and Green Fuel Hydrogen**, S.K. Srivastava, Atma Ram Singh, Shubha Srivastava, Central Institute of Mining & Fuel Research, INDIA

ORAL SESSIONS
Wednesday, September 23, 2009
10:20 - 17:25

SESSION 37
GASIFICATION: SYNTHESIS GAS CLEANING – 2
Ragubir Gupta and Ting Wang

10:20 - **Solid Regenerable Sorbents for H_2S Removal from Syngas at a Warm Temperature,** Jeom-In Baek, Tae Hyoung Eom, Joong Beom Lee, Won Sik Jeon, Chong Kul Ryu, Korea Electric Power Research Institute, KOREA

10:40 - **Experimental Tests on a High-Temperature H_2S Removal Bench-Scale System,** Caterina Frau, Alessandra Madeddu, Sotacarbo S.p.A., ITALY

11:00 - **Computational Methods for Evaluating Potential Warm Synthesis Gas Cleanup Technologies,** David Couling, Kshitij Prakash, Anubhav Jain, Seyed-Abdolreza Seyed-Reihani, Chris Fischer, Ujjal Das, Gerbrand Ceder, William Green, Massachusetts Institute of Technology, USA

11:20 - **Bechtel Pressure Swing Claus Sulfur Recovery Technology,** Robert Geosits, Charles Kimtantas, Bechtel Oil & Gas, USA

11:40 - **Development of Novel Multifunctional Selective Catalytic Reduction Systems for IGCC Plants,** Anatoly Sobolevskiy, Siemens Energy, Inc.; Joe Rossin, Guild Associates, Inc., USA

SESSION 38
GASIFICATION:
ADVANCED TECHNOLOGIES – 1
Johan van Dyk and Chuck McConnell

10:20 - **Enabling Clean Energy Production from Coal: ITM Oxygen Development Update,** Lori A. Vratsanos, Phillip A. Armstrong, Richard P. Underwood, VanEric E. Stein, E.P. (Ted) Foster, Air Products and Chemicals, Inc., USA

10:40 - **Oxygen Purity Control in the Air Separation Unit of an IGCC Power Generation System during Rapid Production Fluctuation,** Priyadarshi Mahapatra, B. Wayne Bequette, Rensselaer Polytechnic Institute, USA

11:00 - **Efficient and Reliable Coal Feeding System for Entrained Flow Gasification,** Thomas Metz, S. Henker, S. Stoye, F. Hannemann, R. Rüsseler, Siemens Fuel Gasification GmbH & Co., GERMANY

11:20 - **PWR Compact Gasification Development Status,** Kenneth Sprouse, Steven P. Fusselman, Timothy Saunders, Pratt & Whitney Rocketdyne; John W. Fulton, Mike Raterman, ExxonMobil Research and Engineering Co., USA

11:40 - **CFD Modeling for Moving Bed Reducer in Syngas Chemical Looping Process,** Liang Zeng, Fanxing Li, Zhao Yu, Deepak Sridhar, Ray Kim, Andrew Tong, Fei Wang, Liang-Shih Fan, The Ohio State University, USA

SESSION 39
CARBON MANAGEMENT:
SEQUESTRATION – 2
Sean Brennan and Ronald Affolter

10:20 - **U.S. Geological Survey Probabilistic Assessment Methodology for the Evaluation of Carbon Dioxide Storage,** Sean T. Brennan, R.C. Burruss, M.D. Merrill, P.A. Freeman, L.F. Ruppert, M.F. Becker, U.S. Geological Survey, USA

10:40 - **Hydrodynamics and CO_2 Injection in Saline Aquifers – Can Aquifer Flow Alone Immobilize the CO_2?,** Randall G. Larkin, R. G. Larkin Consulting, USA

11:00 - **CO_2 Sequestration: Temperature and Gas Compositional Effects on the Kinetics of Mineralogical Reactions,** Prashanth Mandalaparty, Kyeongseok Oh, Milind Deo, Joseph Moore, University of Utah, USA

11:20 - **Update on the AEP/ALSTOM CO_2 Capture and Storage Project,** Daniel Duellman, American Electric Power, USA

11:40 - **First-Order Estimates for CO_2 Leakage through Geological Seals Considered for Saline Reservoir Sequestration of Carbon Dioxide**, Craig Griffith, Yee Soong, Sheila Hedges, DOE-NETL; Gregory Lowry, David Dzombak, Mitchell Small, Carnegie Mellon University, USA

SESSION 40
COMBUSTION:
OXY-COMBUSTION – 3
John Wheeldon and Evan Granite

10:20 - **Investigation of the Effect of Inherent Water Content on the Combustion Characteristics of Victorian Brown Coal under Oxy-Fuel Conditions,** Eleanor Binner, Lian Zhang, Sankar Bhattacharya, Monash University, AUSTRALIA

10:40 - **Flameless, Pressurized Oxyfuel Combustion: The Advantaged Process for Carbon Capture from Coal Based Power Production,** Leo Salinas, Salinas Consulting, USA; Massimo Malavasi, ITEA Spa; Giancarlo Benelli, ENEL Spa, ITALY

11:00 - **CFD Modeling of Oxy-Coal Combustion,** Adrian Goanta, Valentin Becher, Jan-Peter Bohn, Hartmut Spliethoff, Technische Universität München, GERMANY

11:20 - **Partitioning of Alkali and Alkaline Earth Metals in Fine Ash from Oxy-Coal Combustion by Individual Particle Analysis**, Dunxi Yu, Will Morris, Jost O.L. Wendt, University of Utah, USA

11:40 - **Pelletization of Cao-Based Sorbents for CO_2 Capture**, Edward J. Anthony, Vasilije Manovic, CanmetENERGY, Natural Resources Canada, CANADA

SESSION 41
COAL SCIENCE:
COAL GEOSCIENCE – 2
Jim Hower and Allan Kolker

10:20 - **Relations between Petrographic and Geochemical Indices of HC Potential in Coals and Source Rocks,** Louis Loung-Yie Tsai, National Central University; Hsien-Tsung Lee, National Central University and Nan Kai Institute of Technology; Li-Chung Sun, Nan Kai Institute of Technology, TAIWAN

10:40 - **Distribution and Mode of Occurrence of Mercury and Sulfur in Illinois Coal,** Liliana Lefticariu, Rajesh Singh, Mohammad Wahidur Rahman, Southern Illinois University, USA

11:00 - **Partitioning of Iron in Organic and Mineral Phases: Sequential Extractions of Lignite and Bituminous Coal,** Amy Wolfe, Daniel Bain, Brian Stewart, Rosemary Capo, University of Pittsburgh, USA

11:20 - **Geological Studies on CBM Gassiness in Wongawilli & Bulli Seams of Sydney Basin, Wollongong, Australia,** Ashok K. Singh, Amalendu Sinha, Central Institute of Mining & Fuel Research, CSIR, INDIA; Joan S. Esterle, University of Queensland; Graham O'Brien, Mining Geosciences, QCAT, CSIRO; Hem Chandra, NRE Minerals Pty Ltd, AUSTRALIA

11:40 - **Structure and Properties of Different Genotypes Coals,** S. A. Aipshtein, Moscow State Mining University, RUSSIA

SESSION 42
COAL-DERIVED PRODUCTS:
HYDROGEN PRODUCTION – 2
Rachid Oukaci and Chunshan Song

10:20 - **Development of Cermet Membranes for Hydrogen Separation from Coal Gasification Stream,** U. (Balu) Balachandran, T. H. Lee, C. Y. Park, Y. Lu, S. E. Dorris, Argonne National Laboratory, USA

10:40 - **Hydrogen Transport through Palladium-Based Separation Membranes in the Presence of Hydrogen Sulfide,** Casey P. O'Brien, James B. Miller, Andrew J. Gellman, DOE-NETL and Carnegie Mellon University; Bret H. Howard, Bryan D. Morreale, DOE-NETL, USA

11:00 - **Co-Production of Pure Hydrogen and Electricity from Coal Syngas via the Steam-Iron Process using Promoted Iron-Based Catalysts,** Jason P. Trembly, Brian S. Turk, Raghubir P. Gupta, RTI International, USA

11:20 - **Calcium Looping Process for Clean Fossil Fuel Conversion,** Shwetha Ramkumar, L. S. Fan, The Ohio State University, USA

11:40 - **Poisoning and Corrosion of Pd-Alloy Hydrogen Separation Membranes by H_2S,** Bret H. Howard, Bryan Morreale, DOE-NETL, USA

SESSION 43
GASIFICATION:
CO-GASIFICATION AND LOW-RANK COAL – 1
Massood Ramezan and Kevin Whitty

13:30 - **Economics of Wyoming Coal Gasification,** William C. Schaffers, David Bell, University of Wyoming, USA

13:50 - **Gasification Characteristics of Western Canadian Feedstocks: An Overview of Current Projects and Results,** Duke du Plessis, Malcolm McDonald , Alberta Energy Research Institute, CANADA

14:10 - **Lignite Gasification Testing at the Power Systems Development Facility,** John Northington, Johnny Dorminey, Roxann Leonard, Ruth Ann Yongue, Southern Company Services, USA

14:30 -**Upgrading of Low Rank Coal for Enhancing its Gasification Reactivity,** Kouichi Miura, Ryuichi Ashida, Mitsunori Makino, Atsushi Nishida, Kyoto University, JAPAN

14:50 - **Gasification of Lignites to Produce Liquid Fuel, Hydrogen, and Power,** Joshua Stanislowski, University of North Dakota Energy & Environmental Research Center, USA

SESSION 44
GASIFICATION:
ADVANCED TECHNOLOGIES – 2
Jenny Tennant and Chuck McConnell

13:30 - **Solar-Assisted IGCC Concept,** Patrick H. Le, Walter W. Shelton, DOE-NETL, USA

13:50 - **1 Ton/day Class Dry Feeding Coal Gasification Facility,** Hai-Kyung Seo, Jae-Hwa Chung, Seong-Bok Lee, Jun-Hwa Chi, Dal-Hong Ahn, Korea Electric Power Research Institute (KEPRI); Ji-Sun Ju, Seok-Woo Chung, Institute for Advanced Engineering (IAE), SOUTH KOREA

14:10 - **Mild Airblown Gasification Integrated Combined Cycle (MaGIC@™) for Retrofitting Existing Coalplants,** Alex Wormser, Wormser Energy Solutions, Inc., USA

14:30 - **Study of Hybrid Fluidized Bed Gasifier for Industrial Applications,** Drew Spradling, Touchstone Research Laboratory; Donald Bonk, DOE-NETL, USA

14:50 - **Coal Gasification by New Generation of Plasma Torches,** Igor Matveev, Applied Plasma Technologies, USA

SESSION 45
SUSTAINABILITY AND ENVIRONMENT:
GENERAL – 1
Frank Kranik and Massood Ramezan

13:30 - **Assessment of Non-Traditional Sources of Water in the Illinois Basin for Use in Coal-Based Power Plants,** Seyed A. Dastgheib, David Ruhter, Chad Knutson, University of Illinois at Urbana-Champaign, USA

13:50 - **Minimization of Water Consumption under Uncertainty for PC Process,** Juan M. Salazar, Urmila M. Diwekar, Vishwamitra Research Institute: Center for Uncertain Systems Tools for Optimization and Management; DOE-NETL; Stephen E. Zitney, DOE-NETL, USA

14:10 - **Water Usage Estimation and Evaluation for Pulverized Coal Power Plants,** Haibo Zhai, Michael Berkenpas, Edward S. Rubin, Carnegie Mellon University, USA

14:30 - **Survey of Potential Uses for Carbon Dioxide Captured from Coal-Burning Power Plants,** Evan J. Granite, Bryan Morreale, Nathan T. Weiland, Henry W.

Pennline, David R. Luebke, Todd H. Gardner, Lindsay M. Bombalski, George A. Richards, DOE-NETL, USA

14:50 - **Sustainability and the Environment Balancing Local Concerns with Project Development**, Frank Kranik, Lauryn Burkhalter, Ecology & Environment Inc., USA

SESSION 46
COMBUSTION – 2
John Wheeldon and Evan Granite

13:30 - **Performance Improvement of 235 MWe and 260 MWe Circulating Fluidized Bed Boilers,** Wojciech Nowak, Czestochowa University of Technology; Roman Walkowiak, Tomasz Ozimowski, Janusz Jablonski, J. Wyszynski, PGE Elektrownia "Turow" S.A., POLAND

13:50 - **Characterising the Combustion Behaviour of Particles of European Ash with Different Shape Aspect Ratios and Moisture Contents,** Mark Flower, Jon Gibbins, Imperial College London, UNITED KINGDOM

14:10 - **Impact of Coal Properties on Combustion Characteristics in a Pulverized Coal Furnace,** Byoung-Hwa Lee, Ryang-Gyoon Kim, Ju-Hun Song, Young-June Chang, Chung-Hwan Jeon, Pusan National University, SOUTH KOREA

14:30 - **Highly Stable Bimetallic Nanocatalysts for Combustion Applications,** Anmin Cao, University of Pittsburgh; Goetz Veser, University of Pittsburgh and DOE-NETL, USA

14:50 - **Use Of CFD Modeling to Design the Nose of a Pulverized Coal-Fired Boiler**, Zumao Chen, Joseph T. Buckle, Scott A. Dudek, The Babcock & Wilcox Company, USA

SESSION 47
COAL SCIENCE:
COAL GEOSCIENCE – 3
Jim Hower and Allan Kolker

13:30 - **Transformation of Macerals and Minerals due to Magmatic Intrusions in Indian Coalfields,** Ashok K. Singh, Amalendu Sinha, Central Institute of Mining & Fuel Research, CSIR; Mamta Sharma, K. K. Bhattacharya, National Metallurgical Laboratory, CSIR, INDIA

13:50 - **Characterization of Oxidation Residues from $KMnO_4$ Oxidation of Coal with Respect to Properties of the Original Coal,** Sunil K Srivastava, Raja Sen, Central Institute of Mining & Fuel Research; Madan Mohan Singh, Banaras Hindu University, INDIA

14:10 - **Methodes for Preventing Spontaneous Combustion by the Help of the Inorganic Inhibitore Applied on the Working with Undemined Bed No. 74 at Lonea Mine Unit,** Ion Toth, Lorand Toth, Constantin Lupu, INCD INSEMEX Petrosani; Aronel Matei, Sorin Radu, University of Petrosani, ROMANIA

14:30 - **Natural Cokes of India - Recent Updates,** Mamta Sharma, National Metallurgical Laboratory, CSIR; Ashok K. Singh, Central Institute of Mining & Fuel Research, CSIR; Mahendra P. Singh, Banaras Hindu University, INDIA

SESSION 48
COAL-DERIVED PRODUCTS:
SYNGAS UTILIZATION (GAS TURBINES, FUEL CELLS)
Sam Tam and Chunshan Song

13:30 - **DOE's SECA Program: 2009 Progress & Plans,** Wayne A. Surdoval, DOE-NETL, USA

13:50 - **Concept Evaluations for an Efficient Coal-Fueled Solid Oxide Fuel Cell Power System Equipped for CO_2 Separation,** Arun K.S. Iyengar, Eugene E. Smeltzer, Daniel Danila, Wayne L. Lundberg, Siemens Energy, Inc., USA

14:10 - **Examination of the Performance of a Coal Based Gas Turbine Fuel Cell Hybrid Power Generation System with Pre-Combustion Carbon Capture and Staged Compression and Expansion,** John Van Osdol, Edward Parsons, DOE-NETL, USA

14:30 - **Progress in Coal-Based Solid Oxide Fuel Cell Power Plant Development,** Hossein Ghezel-Ayagh, Richard Way, Peng Huang, Jim Walzak, Stephen Jolly, Dilip Patel, Mike Lukas, Carl Willman, Keith E. Davis, FuelCell Energy, Inc; David Stauffer, Vladimir Vaysman, WorleyParsons Group Inc.; Michael Pastula, Randy Petri, Versa Power Systems, USA; Eric Tang, Versa Power Systems, CANADA

14:50 - **Liquid Tin Anode Fuel Cell for Direct Coal Conversion,** Thomas Tao, Jeff Bentley, CellTech Power, USA

SESSION 49
GASIFICATION:
CO-GASIFICATION AND LOW-RANK COAL – 2
Massood Ramezan and Kevin Whitty

15:25 - **Co-Gasification of Biomass and Lignite in the Indirect Gasifier Milena,** B.J. Vreugdenhil, A. van der Drift, C.M. van der Meijden, Energy Research Centre of the Netherlands, THE NETHERLANDS

15:45 - **Low Temperature Gasification of Biomass using Ni-Loaded Brown Coal,** Takayuki Takarada, Kayoko Morishita, Gunma University; Liuyun Li, Xianbin Xiao, Gunma Industry Support Organization, JAPAN

16:05 - **High Temperature Co-Gasification Behavior of Alberta's Oil Sand Coke and Coal,** Rajender Gupta, Farshid Vejahati, University of Alberta, CANADA

16:25 - **Thermochemical Conversion of Coal-Biomass Feed Mixtures**, Nicholas C. Means, Paul Zandhuis, DOE-NETL; NETL Site Support Contractor, Parsons; Goetz Veser, University of Pittsburgh and DOE-NETL; Dirk Link, Bryan D. Morreale, DOE-NETL, USA

16:45 - **Product Characterization for Entrained Flow Coal/Biomass Co-Gasification**, Boris Eiteneer, Ramanathan Subramanian, Shawn Maghzi, David Wark, John Arnason, GE Global Research, USA

SESSION 50
GASIFICATION:
ADVANCED TECHNOLOGIES – 3
Johan van Dyk and Jenny Tennant

15:25 - **NETL to Establish Dynamic Simulation Research and Training Center for Demonstration of IGCC Technology with CO_2 Capture,** Graham T. Provost, Herman P. Stone, Michael McClintock, Fossil Consulting Services, Inc.; Stephen E. Zitney, Eric Liese, DOE-NETL; Richard Turton, Debangsu Bhattacharyya, West Virginia University; Merrill Quintrell, Jose Marasigan, EPRI; Michael R. Erbes, Enginomix, LLC, USA

15:45 - **GTI's Syngas Sampling and Monitoring Systems for Performance Assessment and Environmental Characterization of Gasification and Downstream Processes,** Tanya S. Tickel, Rachid B. Slimane, Chun W. Choi, Osman Akpolat, Bruce G. Bryan, Gas Technology Institute (GTI), USA

16:05 - **Tunable Diode Laser Absorption Temperature Measurements in a Fluidized-Bed Gasifier,** Jay B. Jeffries, Andrew Fahrland, Wanki Min, Ronald K. Hanson, Stanford University; Daniel Sweeney, David Wagner, Kevin J. Whitty, University of Utah; Robert C. Steele, Electric Power Research Institute, USA

16:25 - **Decentralized vs. Centralized Control of IGCC Power Cycles,** Priyadarshi Mahapatra, B. Wayne Bequette, Rensselaer Polytechnic Institute, USA

SESSION 51
SUSTAINABILITY AND ENVIRONMENT:
GENERAL – 2
Massood Ramezan and Frank Kranik

15:25 - **Projections for Ultimate World Coal Production from Production Histories,** David Rutledge, Caltech, USA

15:45 - **Co-Firing Biocarbon Energy Pellets with Coal: Engineered Properties for Supply Chain and Combustion Compatibility,** Hugh McLaughlin, Alterna Energy Inc., CANADA

16:05 - **A Synergistic Analysis of Coal Based IGCC and Corn Based Ethanol Production,** Donald J. Chmielewski, Illinois Institute of Technology, USA

16:25 - **Disaggregated Consumption and Saving Potentials in the Tertiary Sector of Europe,** Houtan Moaveni, USA

16:45 - **Biogenic RDF: A New Emerging Renewable Fuel Source from MSW**, Kevin Furnary, LEEP Holdings, LLC; Tom Balkum, Balkrete, Inc; Bill Ellison, Ellison Consultants, USA

SESSION 52
COMBUSTION:
FLUE GAS CLEAN UP
John Wheeldon and Evan Granite

15:25 - **Regenerable Copper-Based Sorbents for Simultaneous Removal of SO_x And NO_x from Flue Gas**, Javad Abbasian, Illinois Institute of Technology; Vasudeo Gavaskar, Gas Technology Institute, USA

15:45 - **Selective Catalytic Reduction of NO with NH_3 on Activated Coke-Supported Sulfate Acid,** Zhanggen Huang, Zhenyu Liu, Zhenping Zhu, Xianniu Hong, Institute of Coal Chemistry, Chinese Academy of Sciences, CHINA

16:05 - **Fly-Ash Effects on Mercury Speciation and on Mercury Sorption on Minplus Sorbent,** Joep J.P. Biermann, MinPlus B.V., THE NETHERLANDS; Jost O.L. Wendt, Sung Jun Lee, University of Utah, USA

16:25 - **Hydrogen Chloride Removal from Flue Gas using Novel High Reactivity Calcium Oxide,** Zhenchao Sun, Fu-Chen Yu, Shwetha Ramkumar, Songgeng Li, William Wang, Liang–Shih Fan, The Ohio State University, USA

16:45 - **Functionalized Natural Zeolites for Removal of Mercury from Coal Fired Flue Gas,** Francis Via, Zeox Corporation, USA

17:05 - **Comparing Flue Gas Cleanup Options via Dynamic Simulation**, Nick Elder, TRAX Engineering, USA

SESSION 53
COAL SCIENCE:
COAL GEOSCIENCE – 4
Jim Hower and Allan Kolker

15:25 - **Surface Coal Mine Planning Against Large Landslides,** Celal Karpuz, Levent Tutluoglu, Middle East Technical University; Mustafa Ozdingis, Kıvanc Het, Turkish Coal Enterprises, TKI, TURKEY

15:45 - **Research on Coke Microstructure Coked by High Metamorphism Coal of Different Grain Size,**

Gaifeng Xue, Ru Xiang, Chen Peng, Junfang Bao, Wuhan Iron and Steel Corp, CHINA

16:05 - **Research on One Kind of High Volatile Matter 1/3 Coking Coal used into Blending-Coking,** Ru Xiang, Gaifeng Xue, Xuehong Zhang, Junfang Bao, Wuhan Iron and Steel Corp, CHINA

16:25 - **Structural Characterization of Lignite Derived Humic Acid and its Nitro Derivatives by Pyrolysis-gc/Mass Spectrometry and ^{13}C CP/MAS NMR Spectroscopy**, Saqib Nasir, Fuel Research Centre; Tahira B. Sarfaraz, University of Karachi, PAKISTAN

16:45 - **Studies on Oxidation of Mahanadi Coalfields Coal for Preparation of Adsorbent Precursor,** S.K. Srivastava, Debapriya Choudhury, Central Institute of Mining & Fuel Research; Radhey Shyam Prasad, VinobaBhave University, INDIA

17:05 - **Preparation of Activated Carbon from Indian Coal and its Application for Scavenging Phenolic Pollutants from Aqueous Wastes,** Shripal Singh, Anushka Srivastava, Pragya Patil, Rajesh L. Katley, A.L.V. Prasad, Central Institute of Mining & Fuel Research Nagpur Unit, INDIA

SESSION 54
COAL-DERIVED PRODUCTS: COAL CO-CONVERSION WITH OTHER FEEDSTOCKS

Bryan Morreale and Rachid Oukaci

15:25 - **Coal and Biomass to Gasoline: A Baseline Analysis of a Methanol-to-Gasoline (Mtg) System,** Thomas J. Tarka, John G. Wimer, DOE-NETL, USA

15:45 - **Determination of the Effect of Coal/Biomass-Derived Syngas Contaminants on the Performance of Fischer-Tropsch and Water-Gas-Shift Catalysts,** Jason P. Trembly, Matt E. Cooper, Brian S. Turk, Raghubir P. Gupta, RTI International, USA

16:05 - **Investigation of the Impact of the Contaminants Produced by Co-Gasification of Coal and Biomass on the Commercial Fischer-Tropsch and Water-Gas-Shift Catalysts,** Gokhan Alptekin, Ambalavanan Jayaraman, Bob Amalfitano, TDA Research, Inc., USA

16:25 - **Coal and other Feedstock to Power, Liquids, and Gas Plant with Co-Products,** Wm. Mark Hart, R&D Colorado School of Mines, USA

16:45 - **Study of Coliquefaction of Cornstalk and Coal**, Deping Xu, Xiangkun Guo, Zhihong Wang, Yonggang Wang, China University of Mining and Technology, CHINA

17:05 - **On Co-Carbonization Mechanism of Coal/Waste Pet Plastic by Microwave Heating**, Zhi-yuan Yang, Peng Liu, Pan Ran, Xi'an University of Science and Technology, CHINA

POSTER SESSIONS
Tuesday, September 22, 2009
18:00 - 21:00

POSTER SESSION 1
COMBUSTION

P1-1 - **Simulation Analysis of Multi-Fuel Hybrid Cycles,** Marcin Liszka, Janusz Kotowicz, Lukasz Bartela, Silesian University of Technology, POLAND

P1-2 - **Application of Color Measurements for Estimation of Composition of Ash Formed by Fluidized-Bed Combustion,** Dagmar Juchelkova, Helena Raclavska, Konstantnin Raclavsky, VSB-Technical University of Ostrava, CZECH REPUBLIC

P1-3 - **Pyrolyses of the Various Types of Fuels**, Dagmar Juchelkova, Helena Raclavska, Konstantnin Raclavsky, Vaclav Roubicek, VSB-Technical University of Ostrava, CZECH REPUBLIC

P1-4 - **Combustion Scrubbing Abstract,** Kevin P. Furnary, LEEP Holdings, LLC; Bill Ellison, Ellison Consultants, USA

P1-5 - **NO_x Control Policies and Emission Standards for Thermal Power Plants between China and U.S.**, Bingnan Ren, Qiao-wen Yang, China University of Mining and Technology(Beijing), CHINA

P1-6 - **Preventing Selenate Formation in a WET-FGD Liqour using Manganese**, Hiroyuki Akiho, Shigeo Ito, Hiromitsu Matsuda, Central Research Institute of Electric Power Industry, JAPAN

P1-7 - **A Comparison between Ignition Behaviours of 6 Different UK and World-Traded Coals in Air, and in a Mixture of Oxygen and Carbon Dioxide Gases Representative of Oxy-Combution Conditions**, Mark Flower, Jon Gibbins, Niall McGlashan, Imperial College London, UNITED KINGDOM; Chi Man, NIOSH, USA

P1-8 - **Deposit and Slag Emittances**, Richard Reid, Joseph Hoskisson, Larry Baxter, Brigham Young University, USA

P1-9 - **Numerical Simulation of Two Phase Flow and Combustion in the Preignition Chamber of a Pulverized-Coal Furnace**, Dabao Xu, Hao Cao, Lili Yan, Beijing Research Institute of Coal Chemistry, CHINA

P1-10 - **Research on the Agent of Denitrification by Selective Catalytic Reduction**, Yang Qiaowen, Ren Bingnan, Lu Lina, Wei Xiuju, Ma Xiaoyong, Gan Ke, China University of Mining and Technology, CHINA

P1-11 - **Research on the Relationship of the Catalyst Microstructure with Denitrification Condition**, Yang Qiaowen, Lu Lina, Ma Xiaoyong, Ren Bingnan, Gan Ke, Wei Xiuju, China University of Mining and Technology, CHINA

P1-12 - **Development of Ash Modification to Cementitious Material and Desulfurization Technology by Calcium Fine Particles Injection into Pulverized Coal Fired Boilers**, Akira Ohnaka, Tatsumi Tano, Takahiko Terada, Ube Industries, Ltd.; Ryunosuke Itokazu, Masato Tamura, IHI Corporation, JAPAN

P1-13 - **Update on the Thief Process for Mercury Removal from Flue Gas**, Evan J. Granite, Henry W. Pennline, Mark C. Freeman, William J. O'Dowd, Richard A. Hargis, DOE-NETL; Scott Renninger, Brian S. Higgins, Eric Fischer, John Meier, Nalco Mobotec, USA

P1-14 - **Update on GP-254 Process for Photochemical Removal of Mercury from Flue Gas**, Evan J. Granite, Henry W. Pennline, DOE-NETL, USA

P1-15 - **The Impact of Moisture on the Energetics for an Amine-Based Sorbent Used for Carbon Dioxide Capture**, Henry W. Pennline, James S. Hoffman, McMahan L. Gray, Daniel J. Fauth, DOE-NETL; Kevin P. Resnik, Deborah Hreha, Parsons, USA

P1-16 - **Proof-of-Concept Testing with an Electrochemical Cell for Carbon Dioxide Separation from Flue Gas**, Henry W. Pennline, Evan J. Granite, David R. Luebke, DOE-NETL; John R. Kitchin, James Landon, Ethan Demeter, Carnegie Mellon University, USA

P1-17 - **Evaluation of Effect of Particle Size on Oxy-Fuel Combustion of Pulverized Coal**, M. Geier, E. Hecht, C. R. Shaddix, Sandia National Labs, USA

POSTER SESSION 2
GASFICATION

P2-1 - **Millimeter-Wave Sensor Development for Coal Gasification,** J. S. McCloy, J. V. Crum, S. K. Sundaram, Pacific Northwest National Laboratory, USA

P2-2 - **Experimental and Model Results of Diesel Fuel Gasification in a Pilot Scale Gasifier,** Randy Pummill, Kevin Whitty, University of Utah, USA

P2-3 - **Effect of Layer Clay on Iron Oxide Sorbent in High-Temperature Coal Gas Desulfurization,** Hui-Ling Fan, Ju Shangguan, Li-Tong Liang, Fang Shen, Chun-Hu Li, Taiyuan University of Technology, CHINA

P2-4 - **The Potential Role of Nuclear Heat in Balancing and Greening the UCG Processes,** Marc Steen, Michael Fuetterer Institute for Energy, Joint Research Centre, European Commission, THE NETHERLANDS; Jan Rogut, GIG - Central Mining Institute, POLAND

P2-5 - **Hydrodynamics Testing of a Solid Circulating Fluidized Process for Desulfurization in a Pressurized Condition,** Young Cheol Park, Sung-Ho Jo, Ho-Jung Ryu, Chang-Keun Yi, Korea Institute of Energy Research, KOREA

P2-6 - **Computational Approaches for Geomechanical Evaluation of UCG Activities**, Oleg Vorobiev, Yuliya Kanarska, Joseph P. Morris, S. Julio Friedmann, LLNL, USA

POSTER SESSION 3
SUSTAINABILITY AND ENVIRONMENT

P3-1 - **The Coal Production in South Brasil and the Pyrite Challenge,** Michael Peterson, Júlia Pavanelo, Luciana Correa Heck, Universidade do Extremo Sul Catarinense; Adilson Oliveira da Silva, Fórmula Indústria Química do Brasil, BRAZIL

P3-2 - **Integration and Industrial Development of Innovative Technologies for High-Sulfur Coal Clean Utilization in Yanzhou Mining Area,** Guan Beifeng, Chen Guifeng, Wu Lixin, China Coal Research Institute, CHINA

P3-3 - **The Mechanism of Active Pulsing Air Classification and its Application in Discarded Catalyst Recycling,** Jingfeng He, Yaqun He, Weiran Zuo, Chenlong Duan, Baofeng Wen, China University of Mining and Technology, CHINA

POSTER SESSION 4
CARBON MANAGEMENT

P4-1 - **Commercializing CO_2 Capture Technology from Source to Sink,** Lionel Kambeitz, HTC Purenergy Inc., CANADA

P4-2 - **Prediction of CO_2 Solubility in Oligomers,** De-Li Chen, Hong-Bin Xie, J. Karl Johnson, University of Pittsburgh and DOE-NETL, USA

P4-3 - **Post-Combustion CO_2 Capture Utilizing Polymeric- and Silica-Based Supported Poly(ethylenimine) Sorbents: The Effects of Flue Gas Constituents,** Daniel J. Fauth, McMahan L. Gray, James S. Hoffman, Murphy J. Keller III, Henry W. Pennline, DOE-NETL; Kevin P. Resnik, RDS-Parsons, USA

P4-4 - **A Mechanistic Study on the Reaction of MEA with CO_2 in Aqueous Solution,** Hong-bin Xie, J. Karl Johnson, University of Pittsburgh and DOE-NETL, USA

P4-5 - **CO_2 Capture Capacity of CaO in a Small Pilot of Carbonation/Calcination Cycles**, Chin- Ming Huang, Chen-Ching Wang, Wan- Hsia Liu, Heng- Wen Hsu, ITRI, TAIWAN

P4-6 - **Recent Development and Scale-Up of a Fluidized-Bed Process Capturing CO_2 in a Coal-Fired Flue Gas using Dry Regenerable Sorbents**, Young Cheol Park, Sung-Ho Jo, Seung-Yong Lee, Chang-Keun Yi, Korea Institute of Energy Research; Chong Kul Ryu, Korea Electric Power Research Institute, KOREA

P4-7 - **Investigation on Carbonation and Regeneration of K_2CO_3/Al_2O_3 for CO_2 Capture**, Chuanwen Zhao, Xiaoping Chen, Changsui Zhao, Southeast University, CHINA

P4-8 - **Evaluating the Reaction Barrier of Amine Based Sorbents through Experimental Plug Flow Reactor Measurements**, W. Richard Alesi, John R. Kitchin, Carnegie Mellon University and DOE-NETL; McMahan Gray, DOE-NETL, USA

P4-9 - **Carbon Dioxide Absorption Behaviors of Calcium and Silica Compounds**, Choong-Gon Lee, Hanbat National University; Chong-Kul Ryu, Korea Electric Power Research Institute, KOREA: Minghua Wang, Northeastern University, CHINA

P4-10 - **Perovskite Catalyst Design for Electrocehmical Oxygen Separation**, James Landon, Carnegie Mellon University and DOE-NETL; John Kitchin, Carnegie Mellon University, USA

P4-11 - **Comparative Thermodynamic Evaluation of Oxygen Carriers for Chemical Looping Combustion using Steam and CO_2 as Oxidizing Gases**, Michelle Najera, Rahul D. Solunke, Goetz Veser, University of Pittsburgh and DOE-NETL; Selasi Blavo, University of Pittsburgh, USA

P4-12 - **Characterization of Solid CO_2 Sorbent and WGS Catalyst for SEWGS Process**, Joong Beom Lee, Tae Hyoung Eom, Jeom-In Baek, Won Sik Jeon, Ji-Woong Kim, Chong Kul Ryu, Korea Electric Power Research Institute, KOREA

P4-13 - **Seismic Evaluation of the Fruitland Formation with Implications on Leakage Potential of Injected CO_2**, Tom Wilson, West Virginia University; Art Wells, DOE-NETL; George Koperna, Advanced Resources International, USA

P4-14 - **Geophysical Characterization of the Marshall County West Virginia Pilot Sequestration Site**, Tom Wilson, Richard Bajura, Doug Patchen, West Virginia University; Richard A. Winschel, Ravi S. Srivastava, Roy Scandrol, CONSOL Energy Inc.; Art Wells, DOE-NETL, USA

P4-15 - **Experimental Study of Multiphase Fluid Transport in the Cleat and Matrix System of Coals: Implication for CO_2-ECBM**, Fengshuang Han, Chinese Academy of Sciences and RWTH Aachen University; Bernhard M. Krooss, RWTH Aachen University, GERMANY; Jianli Yang, Zhenyu Liu, Institute of Coal Chemistry, Chinese Academy of Sciences, CHINA; Niels van Wageningen, Andreas Busch, Shell International Exploration and Production B.V., THE NETHERLANDS

POSTER SESSION 5
COAL-DERIVED PRODUCTS

P5-1 - **Characterization of Zeolites from Polish Fly Ashes,** Aleksandra Ściubidło, Wojciech Nowak, Izabela Majchrzak-Kucęba, Czestochowa University of Technology, POLAND

P5-2 - **Adsorption on Materials on the Basis of Brown Coal**, Lukas Andel, Jaroslav Kusy, Marcela Safarova, Josef Vales, Brown Coal Research Institute, J.S.C., CZECH REPUBLIC

P5-3 - **Synthesis of Multiwalled Carbon Nanotubes from Few Indian Coking and Non-Coking Coals**, Ashish Kumar Ghosh, Raja Sen, S. K. Srivastava, Central Institute of Mining and Fuel Research; O. N. Srivastava, Banaras Hindu University, INDIA

P5-4 - **The Performances and Application of Zr-Ce Promoted Sulfur Tolerant Shift Catalysts Qdb-04**, Jing Hongjian, Tianji Coal Chemical Industry Group Co.,Ltd; Guo Jianmin, Xinjiang Guanghui New Energy Co., Ltd.; Zong Qiuyun, Qingdao University of Science and Technology, CHINA

P5-5 - **Spectrophotometric and Theoretical Study of Charge-Transfer Complex Formation of Coal Derived Asphaltene with Two Isomeric Chloranils**, Ashish Kumar Ghosh, S. K. Srivastava, Central Institute of Mining and Fuel Research; S. Bagchi, Indian Institute of Science and Education Research, INDIA

P5-6 - **Studies on the Properties of Mesoporous Materials Derived from Polish Fly Ashes**, Izabela Majchrzak-Kucęba, Wojciech Nowak, Aleksandra Ściubidło, Czestochowa University of Technology, POLAND

P5-7 - **Fischer-Tropsch Refining Issues**, David A. Bell, Sara Harkins, University of Wyoming, USA

P5-8 - **Secondary Phases of P-Impurity in Sofc Anode Operating on Coal Syngas: Theoretical and Experimental Investigation**, Fatma Nihan Cayan, Mingjia Zhi, Suryanarayana Raju Pakalapati, Nianqiang Wu, Ismail Celik, West Virginia University, USA

P5-9 - **Electrochemical Looping using the Liquid Tin Anode Fuel Cell for Direct Coal Conversion**, Jeff Bentley, Thomas Tao, CellTech Power, USA

P5-10 - **Effect of Preparing Conditions on Apparent Viscosity of Chinese Lignite Oil Slurry at Different Temperature and Atmospheric Pressures**, Yonggang Wang, Xiangkun Guo, Chu'an Xiong, Wei Chen, Deping Xu, China University of Mining and Technology -Beijing, CHINA

P5-11 - **Thermodynamic Analysis of Adsorption of H_2S on Modified Activated Carbon in Coke Oven Gas**, Bingnan Ren, China University of Mining and Technology, CHINA

P5-12 - **Update on Kinetic Modeling of a Fischer-Tropsch Reaction over a Cobalt Catalyst in a Slurry Bubble Column Reactor for Incorporation into a Computational Multiphase Fluid Dynamics Model**, Anastasia Gribik, Donna Guillen, Idaho National Laboratory, USA

P5-13 - **Potential Use of Suitable Waste Material for the Preparation of Blended Fuels with Defined Quality**, Josef Vales, Lukas Andel, Jaroslav Kusy, Marcela Safarova, Brown Coal Research Institute, J.S.C., CZECH REPUBLIC

P5-14- **Ab-Initio Studies of Palladium –Niobium Alloys for Hydrogen Separation**, Ekin Ozdogan, Shela Aboud, Jennifer Wilcox, Stanford University, USA

P5-15 - **Synthesis of High Surface Area Materials for Solid Oxide Fuel Cells**, Robin Chao, John Kitchin, Paul Salvador, Carnegie Mellon University; Christopher Matranga, DOE-NETL, USA

P5-16- **Environmental Benefits of Coal Combustion Products**, Vinio Floris, Exponent, Inc.; Jim Hicks, CeraTech, Inc., USA

P5-17 - **Below the Petroleum Baseline using Coal: A Response to Section 526**, Guido B. DeHoratiis, Mark Ackiewicz, U.S. Department of Energy, USA

P5-18 - **Status and Perspectives of Coal Gangue and its Utilization in China**, Jiang Cuirong, Liu Shuyun, Beijing Research Institute of Coal Chemistry, China Coal Research Institute, CHINA

P5-19 - **Effect of Potassium and Copper Additive on Iron-Ruthenium Composite Catalyst for Fischer-Tropsch Synthesis**, Qingjie Tang, Xiangkun Guo, Yonggang Wang, Fan Shao, Liu Bo, Caihong Wang , China University of Mining and Technology -Beijing, CHINA

P5-20 - **Upgrading of Coal Liquids by Adsorptive Denitrogenation over Carbon-Based Adsorbent**, Xiaoliang Ma, Na Li, Masoud Almarr, Chunshan Song, Pennsylvania State University, USA

P5-21 - **Bitum-Polymer Compositions as Precursors of Carbon Sorbents,** G. Makomaski, W. Ciesińska, J. Zieliński, T. Brzozowska, B. Pacewska, D. Szychowski, Warsaw University of Technology, Institute of Chemistry in Plock, POLAND

P5-22 - **Mesophase Oriented Growth of a Copolymer-Modified Coal Tar Pitch**, Ming-Lin Jin, Ai-Hua Huang, Shanghai Institute of Technology; Xiao-Long Zhou, Cheng-Lie Li, East China University of Science and Technology, CHINA

POSTER SESSION 6
COAL SCIENCE

P6-1 - **Research of New Emulsified Collector on Flotation,** Ya-na Bai, Mei-ling Guo, Hui Yuan, China University of Mining and Technology, CHINA

P6-2 - **Numerical Simulation of Carbon Catalytic Reforming Reactor**, Haizhu Cheng, Yongfa Zhang, TaiYuan University of Technology, CHINA

P6-3 - **Microwave-Assisted Fractionation Extracyion of Shenfu Coal and Simulate the Complicated Structure,** Hong Chen, Jianwei Li, Lingmei Ge, X i'an University of Science and Technology; Shenyang University of Technology, CHINA

P6-4 - **Research on the Micro Structure of Stamp-Charging Coke and its Performance**, Gaifeng Xue, Peng Chen, Shangchao Liu, Zikui Song, Wuhan Iron and Steel Corp, CHINA

P6-5 - **Research on the Standard System to Evaluate the Quality of Coking Coal**, Gaifeng Xue, Ru Xiang, Peng Chen, Shangchao Liu, Wuhan Iron and Steel Corp, CHINA

P6-6 - **Effect of Technical Property of Coking Coal on Optical Texture of Coke**, Ru Xiang, Gaifeng Xue, Shangchao Liu, Wuhan Iron and Steel Corp, CHINA

P6-7 - **Methodology Research on the Corodination Development between Coal Resources Exploitation and Environment Protection in Very Large-Sized of Shenhua Mining Region, China**, Zhang Jianmin, Gu Dazhao, China Shenhua Energy Company Limited, CHINA

General Information

P6-8 - **Hydropholized Limestone by Different Methods as an Antiexplosive Powder,** Bronislaw Buczek, Elzbieta Vogt, AGH, University of Science and Technology, POLAND

P6-9 - **Research on the Relation between Microcosmic Characteristics of Coal Oxidized under Low Temperature and its Self-Ignition Propensity**, Zhang Yanni, Deng Jun, Li Shugang, Li Shirong, Wang Caiping, Xi'an University of Science and Technology, CHINA

P6-10 - **Desulfurization and Kinetics of Removal of Sulfur from High Sulfur Coal under Hydrogen Atmosphere,** Yongfa Zhang, Guojie Zhang, Taiyuan University of Technology, CHINA

P6-11 - **Research on the Peculiarity of Coking Coal from Qinghai Province in China,** Gaifeng Xue, Shangchao Liu, Peng Chen, Xiang Ru, Wuhan Iron and Steel Corp, CHINA

P6-12 - **Study on Multi-Form Coal Impact Breakage using SHI's Breakage Model,** Weiran Zuo, Yaqun He, Jingfeng He, Nianxin Zhou, Baofeng Wen, China University of Mining and Technology, CHINA; Frank Shi, University of Queensland, AUSTRALIA

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For oral sessions, computer-operated LCD projectors will be provided for PowerPoint presentations. PowerPoint presentions can be emailed to the conference secretary at ipcc@pitt.edu at least 2 weeks before the conference or you may also bring it with you to the conference on a CD or memory stick. Each oral presentation including discussion is limited to 20 minutes.

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