行政院所屬各機關因公出國人員出國報告書

（出國類別：出席國際會議）

「韓國首爾 2013 年全球碳捕存技術發展現況年會 Global Status of CCS: 2013, Seoul」與會情形與心得建議

服務機關：行政院環境保護署

姓名職稱：簡慧貞 參事兼溫減管理室執行秘書

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派赴地點：韓國首爾

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摘要

「全球碳捕存協會(GLOBAL CARBON CAPTURE AND STORAGE INSTITUTE LTD ，GCCSI)」是由澳洲政府宣布在 2008 年 9 月開始籌組，2009 年 4 月正式成立，初期係由澳洲政府出資協助，屬非營利法人機構，GCCSI 致力於推動 CCS 技術發展，透過串連全球推動 CCS 技術之國家及研究機構，進行技術資訊分享，期望在 2020 年前完成至少 20 個大規模 CCS 投資合作示範計畫，為國際上推動 CCS 技術發展之代表性組織。

本次 GCCSI 年會會議於韓國首爾舉行，共分為六大主題，報告內容包含：全球碳捕存技術發展近況與趨勢、碳捕存技術扮演角色－因應氣候變遷與確保能源安全、碳捕存技術在亞洲的展望與未來、合作計畫確保有效推動碳捕存技術發展、碳捕存技術近期發展、執行中的碳捕存計畫、碳捕存技術與其他清潔發展技術選擇與比較及碳捕存議題與公眾溝通經驗分享等。本次會議展現碳捕存技術已臻成熟，惟仍須加強政策支持，並強化全球碳捕存技術整合研發與建立運輸與封存等基礎建設，以促進產業投資碳捕存技術；未來因全世界新增燃煤量將大部分在中國發生，中國在全球碳捕存技術發展將扮演關鍵角色，需持續關注中國碳捕存技術之發展。

未來我國可透過推動碳捕存技術政策環評，解決碳捕存技術發展時，所面臨運輸管線、封存場址選擇、監測管理及公眾溝通等問題，並可配套訂定相關管制措施，以創造有利碳捕存技術發展環境，另外，可參考韓國作法成立法人機構作為國內外專責窗口，整合相關資源推動碳捕存技術發展。

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壹、 前言：會議背景

「全球碳捕存協會(GLOBAL CARBON CAPTURE AND STORAGE INSTITUTE LTD ，GCCSI)」是由澳洲政府宣布在 2008 年 9 月開始籌組，2009 年 4 月正式成立，初期係由澳洲政府出資協助，屬非營利法人機構，GCCSI 致力於推動 CCS 技術發展，透過串連全球推動 CCS 技術之國家及研究機構，進行技術資訊分享，期望在 2020 年前完成至少 20 個大規模 CCS 投資合作示範計畫，為國際上推動 CCS 技術發展之代表性組織。

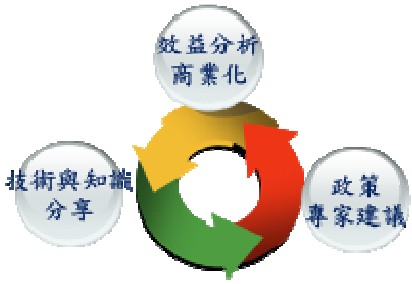
該研究組織藉由全球合作和資訊傳播等方式在公眾利益的基礎下加快推行安全、商業化和環境永續的 CCS，包括透過適當的努力獲得權利、共享訊息，預計於 2020 年前完成至少 20 個大規模投資組合合作示範計畫並積極的推展 CCS 訊息交流中心和訂定技術與程序相關標準。此外，該組織藉由出版各項研究刊物，持續更新全球 CCS 發展活動。出版刊物面向廣泛，除技術發展趨勢外，亦有針對 CCS 商轉、全球政府政策、乃至社會溝通教育皆有相關刊物與成員提供訊息彙整出版，不失為國際資訊之重要來源。

GCCSI 全球組織成成員達 370 個，國際參與度高，成員背景豐富，包含各國政府、財金、保險、工程、風險管理、非營利組織等。中央政府(如中國大陸、日本、韓國、澳洲等)、地方政府皆可申請加入，惟參加者須提出與 CCS 計畫投資與規劃相關性說明。我國台電公司、中油公司、中鋼公司(MAJOR INDUSTRY MEMBERS)及工研院(GENERAL MEMBERS)亦於 2010 年接受澳洲邀請加入該協會。

至 2012 年，該協會已召開 4 次國際研討會，分別就研究所成立目標確立與規劃 、全球推行現況 、示範計畫調查、示範場址介紹、國際政策推行 及 CCS 未來走向 、減碳成效確立 、CCS 助益、經驗與知識分享等主題進行討論，歷年會議重點成果詳見附表。

本次會議於韓國首爾汝矣島康萊德飯店會議廳舉行，共分為六大主題，經由組織報告全球碳捕存發展近況與趨勢後，由各專家學者進行專題性報告，內容包含：碳捕存扮演角色－因應氣候變遷與確保能源安全，碳捕存在亞洲的展望與未來，合作計畫確保有效推動碳捕存， 碳捕存技術近期發展，執行中的碳捕存計畫，碳捕存與其他清潔發展技術選擇與比較等。報告內容中除全球技術近況分享，各國推動現況與經驗外，部分議題中亦報告碳捕存議題與公眾溝通經驗分享。

圖 1-1、GCCSI Global Status of CCS: 2013 會場內情形



貳、 行前準備、參訪任務與行程

一、 會前準備：

為順利達成本次出訪任務，本署於出訪即開始進行各項行前準備，包含會議資訊蒐集、參訪單位規劃與聯繫、代表團籌組、行程規劃等事宜。並透過舉辦數次的行前籌備諮詢討論會議，針對參訪任務、目標單位與人士、代表團籌組、行程安排等事宜進行討論。

透過資料蒐研過程中了解,GCCSI 已與多國政府及產業單位進行諸多合作研究，自 2010 年日本京都會議介紹長岡計畫合作外，更定期歸納彙整各國 CCS 發展現況並出版相關訊息報告。此外，本次韓國首爾會議規劃於保寧市(Boryeong)、河東市(Hadong)之參訪廠址亦於網站上提供相關資訊，本署團隊更深入蒐研兩者之比較後規劃前往較具規模的保寧電廠進行參訪(該電廠之資訊彙整如附件三)。

二、 代表團組成及本次出訪任務：

本次行程目的除參與國際 CCS 會議掌握國際趨勢外，提升我國技術與溫室氣體減量貢獻更為推動國際事務參與之重要目的。代表團於行前與 GCCSI 執行長（CEO） Brad Page、主管政策與會員事務總經理 Barry Jones，以及北亞事務高級專員 Kerry Brooks 取得聯繫，了解該組織對我國入會事宜會晤意願（Mr. Page 及 Mr. Jones 之專長背景說明如附件四)。經幾次聯繫後對方表示歡迎、並可於當地擇期擇地進行我國入會事宜交流。

經由多次會議討論與規劃後，我國代表團由本署簡參事兼溫減辦公室執行秘書慧貞擔任代表團長，率工研院特聘專家楊日昌博士、國立台灣大學地質系魏國彥教授、中國鋼鐵公司張西龍助理副總、衛生福利部臺北醫院張武修顧問、高

級環境技術師邱美璇、環境技術師薛加湧、中華經濟研究院劉哲良博士、工研院敖家綱副研究員等共 9 人參與本次行程；全團主要任務如下：

（一） 參與「全球碳捕集及封存協會」(Global CCS Institute，GCCSI) 2013 年年度大會:『全球碳捕集及封存現況』(Global Status of CCS: 2013)，掌握全球 CCS 技術發展最新資訊。

（二） 了解 GCCSI 組織架構未來動向，掌握會員申請流程與時間，以及未來可能的收費方式。

（三） 尋求 CCS 技術國際交流合作機會，並爭取我國以政府會員方式加入 GCCSI。

（四） 參訪活動：拜會韓國環境相關單位，針對氣候變遷政策、碳交易制度及市場機制等議題進行交流討論，尋求未來合作機會。

三、 本次參訪行程

為掌握本次年度大會的最新發展及參與示範計畫的現場參訪，本署代表陸續於 10 月 8 日（二）出發參訪相關行程，於 10 月 12 日（六）返境抵達台灣，**表 2-1** 為參與本次代表團的參訪行程說明。

表 2-1、本次活動參訪行程

時間	行程說明
10 月 8 日（二）	代表團成員啟程至韓國首爾
10 月 9 日（三）	參與 CCS 示範計畫 Boryeong 電廠現勘
10 月 10 日（四）	1.參與 GCCSI 年度大會 2.與 GCCSI 代表商談入會事宜
10 月 11 日（五）	1.參與 GCCSI 年度大會 2.拜訪韓國氣候遷中心（KCCC）
10 月 12 日（六）	啟程返國

參、 2013 年全球碳捕存技術發展現況年會

一、 國際專家交流會談

我國代表團長簡參事兼執行秘書慧貞及代表團專家成員，於參與會議其間積極與各國專家針對氣候變遷應對策略、我國 CCS 推動現況及經驗等議題進行交流互動。交流會談的專家包含：

- 國際能源總署能源與環境部（Energy Efficiency and Environment Division，International Energy Agency）主管：Mr. Philippe Benoit
- GCCSI 董事長：Mr. Paul Dougas
- GCCSI CEO：Mr. Brad Page
- GCCSI 總經理：Mr. Barry Jone
- GCCSI 北亞事務代表：Ms. Karry Brooks
- 韓國碳捕存協會（Korea CCS Association，KCCSA）主席：Han Chonghun 博士
- Southern 公司代表：Mr. Morton
- 韓國電力公司電力研究所首席研究員：張慶龍博士

於交流過程中，我代表團長簡參事兼執行秘書慧貞向會談專家說明臺灣於減碳行動上的目標願景與實際政策作為及我國發展 CCS 的推動策略方向。我國於溫室氣體減量的各項行動及努力，皆獲得與會專家的肯定。

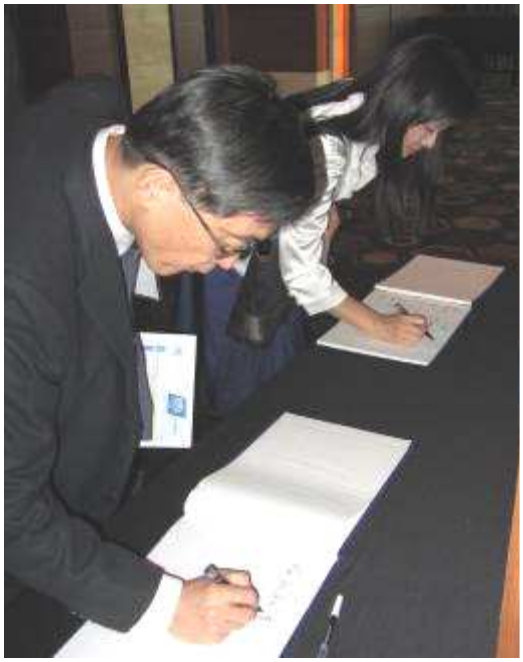


圖 3-1、簡團長與我代表團成員魏國彥教授

圖 3-2、簡團長與 GCCSI 董事長 Mr. Dougas 於會中進行交流

圖 3-3、IEA 主管 Philippe Benoit 與我國代表團進行互動交流

圖 3-4、與 GCCSI 北亞事務代表 Ms. Brooks 互動交流

圖 3-5、我國代表團員楊日昌專家與 Southern 公司 Mr. Morton

圖 3-6、我國代表團員張西龍副總與韓國電力公司張慶龍博士

二、 專題報告紀要

本次 GCCSI 大會為國際級的 CCS 年度盛事，吸引了來自界各地的會員國代表及產業人士參與。此次會議分享主題內容十分豐富，除了涵蓋技術及政策層面的討論外，各國推動經驗及推動進度的分享，更是此次會議中的一大焦點。

對於 CCS 是否成熟到可做為一個穩定的減量技術選項，首重於其本身的技術成熟度，目前一般對於使用 CCS 做為減量技術選項的看法，即是認為此技術尚未達到完全成熟可應用的技術層次。然隨著近年相關技術的加速推展，目前的技術發展現況為何，乃是本次會議的重點觀察議題。

除了 CCS 本身的技術成熟度外，要能成功推動 CCS，整體性的法制架構，亦是不可或缺的必要項目。本次會議中除了技術觀點的討論外，亦有許多國家代表分享其國內的研發及推動經驗，透過這些經驗分享，亦得以從中學習到一些有利於健全法制架構的元素。

此外，對於 CCS 此一技術而言，其市場潛力龐大、但目前該產業的參與者結構尚未成形，對於有志參與此產業者來說，目前的發展階段，無疑是切入此技術市場的良好時機。在本次會議中，我們觀察一些和我國存在較密切競爭關係，如中國及韓國，其對於切入 CCS 技術市場所展現的企圖心。因此，對於這些國家對於 CCS 或氣候相關政策的推動現況，亦是本次代表團所觀察的重點。

綜合上述，本次代表團依上述觀點，將本次會議紀要彙整為 10 項主軸重點，其涵蓋了技術層次及政策層面的討論，有助於我國後續擬定相關推動策略之參考，其內容包含：

（一）碳捕存(CCS)技術發展現況

（二）中國在 CCS 發展扮演關鍵角色

（三）須有完整的政策協助 CCS 發展

（四）CCS 推動是需要強制性的法規命令或碳價格的制定形成自由市場機制，未有定論

（五）2020 年前發展 CCS 七大關鍵行動

（六）加速 CCS 商轉的架構

（七）CCS 公眾溝通的推動重點

（八）CCS 潛力評估要項程序與建議：ADB 經驗

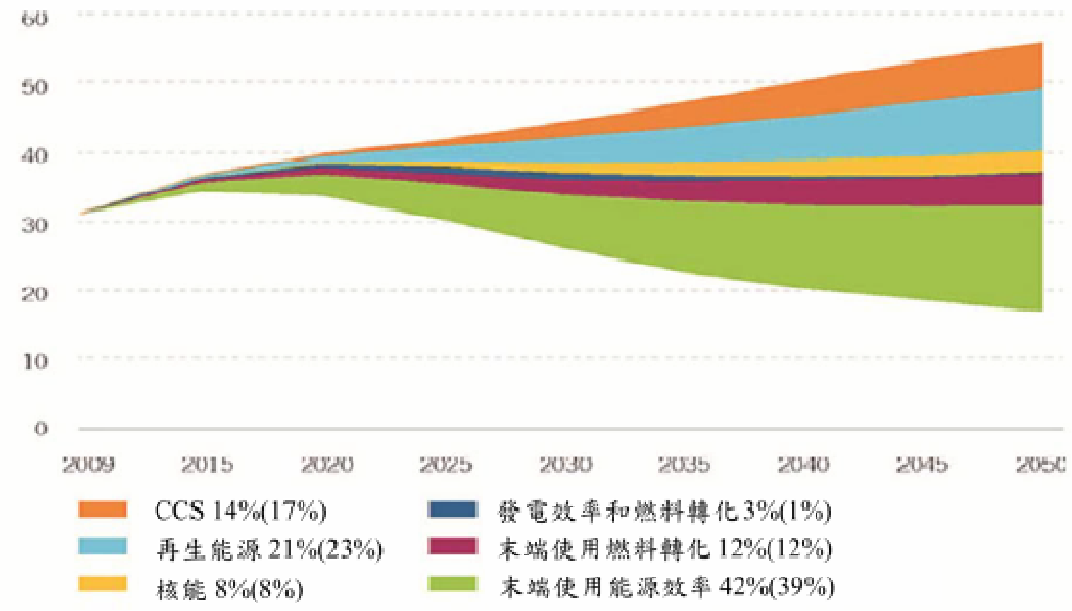
（九）CCS 於清潔能源技術組合中的定位：UK 經驗

（十）中國推動碳捕集、利用和封存現況觀察

以下即分別針對上述主軸重點內容進行摘述。

（一）碳捕存(CCS)技術發展現況

為了有效地減緩氣候變化和保障能源安全，促進碳捕集存示範項目在全球取得適當之發展是現在的當務之急。成功的示範將通過在技術的運用展示並結合在捕集技術方面的創新和進步以降低成本來建立市場投入信心，加速全球暖化減緩。根據 GCCSI 彙整統計碳捕存對全球溫室氣體減量效益評估，其具有 14%至 17%間的減碳能力，且與各項再生能源投入所需成本為相當具競爭力的一項減碳技術，根據國際能源總署(IEA)估算，發電業若排除 CCS 減碳技術，到 2050 年全球將增加 2 億美元減量成本。因其他減量技術與 CCS 比較之成本仍相對偏高，顯現出 CCS 仍為具有經濟潛力的減量技術。



單位：10 億噸

圖 3-7、碳捕存與其他技術溫室氣體排放總減量貢獻比較

在各項政策與產業推動以及全球減碳技術比較研究成果下，碳捕存邁向商業化發展之重點項目，包括：

1、加強政策支持，如訂定強制性法律規範， 促進產業投資 CCS。

2、強化全球 CCS 技術發展整合與研發，降低成本。

3、透過建立 CCS 運輸與封存等基礎建設， 加速技術商業化發展。

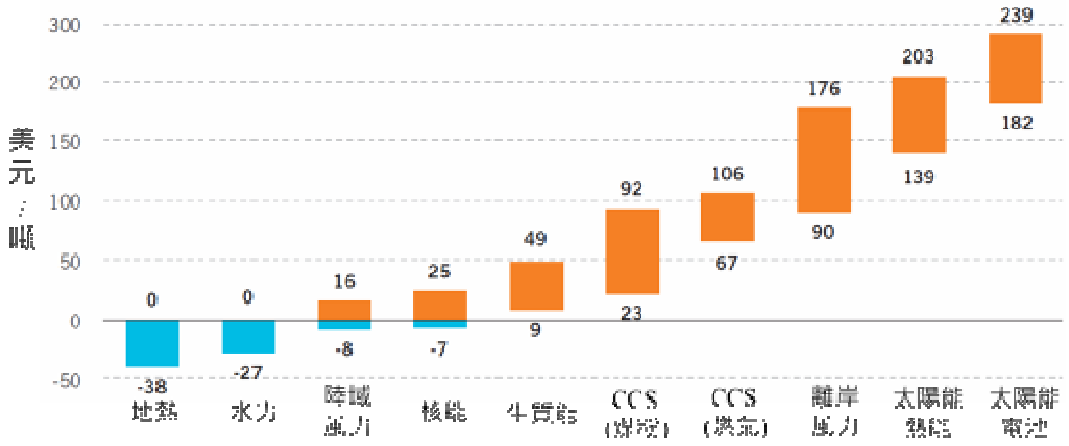
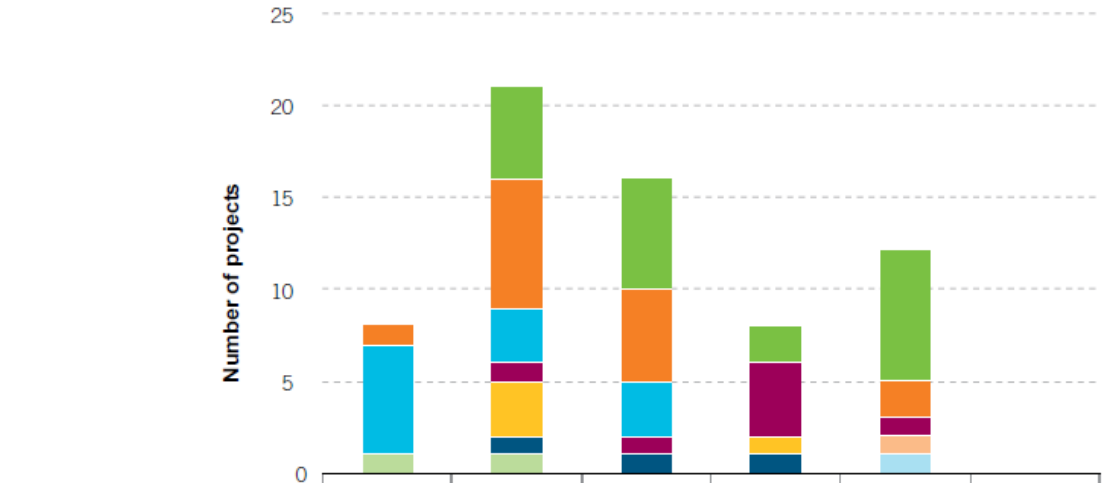


圖 3-8、碳捕存與其他技術單位溫室氣體減量成本比較

（二）中國在 CCS 發展扮演關鍵角色

國際能源總署 IEA 估計，至 2035 年非世界經合組織國家的能

源需求增長將占世界總增量的 90%以上。這些國家中的大多數都能獲得相對較便宜的化石燃料，因此，若不應用 CCS 技術，二氧化碳排放量將很可能會急劇增長。為減緩全球氣候變遷惡化，CCS 可滿足發展中國家的能源需求並兼顧全球暖化等環境問題。中國對未來碳捕存發展最主要的重要性是未來全世界新增燃煤量將大部分在中國發生，因此中國在全球 CCS 發展扮演關鍵角色，與 2010 年相比，中國目前有 12 個 CCS 的試驗計畫正在進行，在數量上僅次於美國，2012 全球 CCS 示範計畫發展情形如圖 3-9。



	Identify	Evaluate	Define	Execute	Operate	Total
United States	0	5	6	2	7	**20**
Europe	1	7	5	0	2	**15**
China	6	3	3	0	0	**12**
Canada	0	1	1	4	1	**7**
Australia	0	3	0	1	0	**4**
Middle East	0	1	1	1	0	**3**
Other Asia	1	1	0	0	0	**2**
South America	0	0	0	0	1	**1**
Africa	0	0	0	0	1	**1**
Total	**8**	**21**	**16**	**8**	**12**	**65**

圖 3-9、2012 全球 CCS 示範計畫發展情形

（三）須有完整的政策協助 CCS 發展

在《聯合國氣候變化框架公約》、清潔能源部長級會議、碳封存領導人論壇以及國際標準組織的會議議程中，一致認同 CCS 技

術在減緩未來氣候變遷方面將起著重要作用，卻沒有制定有效政策協助 CCS 發展，碳捕存關鍵重要性怠無疑義，但是在世界各國的推動並不順利，若要加快 CCS 商業化的腳步，必須落實以下問題：

1、強有力、永續長期的減量政策長期支持 CCS 技術推廣。

2、增強誘因機制以支持 CCS 示範工作(pilot) 。

3、需落實監管措施，確保安全機制。

（四）CCS 推動是需要強制性的法規命令或碳價格的制定形成自由市場機制，未有定論：

強制性的法規命令是強調 Command & Control， 碳價格的制定形成自由市場機制則強調交易。此部分於會議中討論雖激烈，但未得到定論，美國因頁岩氣的興起及自由經濟的體質，碳捕存的財務誘因減退，故就北美而言碳捕存的案例減少，而東亞的碳捕存案例卻有上升趨勢。

1、韓國作法：政府提供部分資金協助產業發展技術，以技術輸出為目標，同時配合發布排放交易法令，提供碳捕存驅動力。

2、中國大陸因應能源需求，未來將興建更多的燃煤電廠，成為全世界的排碳大國，由發改委主導推行各種減碳工程及碳捕存。

3、亞銀資助中國及東南亞 4 國進行碳捕存及煤化工，日本三菱在印尼碳捕存實作經驗，強調促成 EOR 才是碳捕存擴大與商業化的關鍵機制。

（五）2020 年前發展 CCS 七大關鍵行動

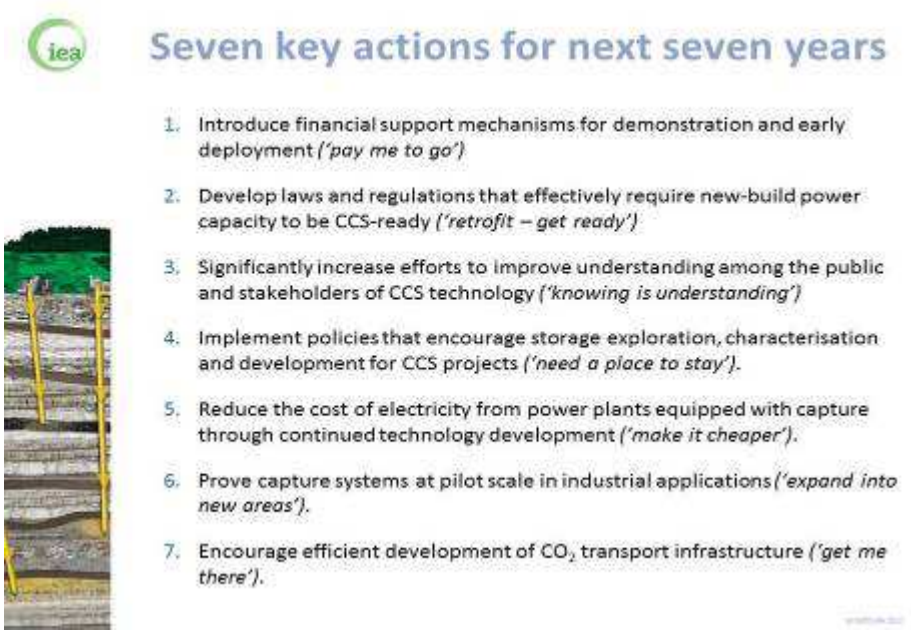
根據 International Energy Agency（IEA）能源與環境部門主管 Philippe Benoit 的說明，目前正處於全球 CCS 推展的重要關鍵階段，IEA 為此提出了相關的研析報告，以說明全球 CCS 發展現況與後續的關鍵行動。根據 IEA 的分析，為了順利推展 CCS 成為成熟的減量技術，未來七年共有七項關鍵行動（7 key actions for next 7 years）需要執

行，分述如下。

1、透過針對示範計畫導入財務機制，以誘發私部門的財務投資（introduce financial support mechanisms for demonstration and early deployment of CCS to drive private financing of projects）：

就目前的發展階段來說，CCS 的技術發展尚未完全成熟，對應的商業市場也因為全球碳訂價情況階明，因而無法隨之發展。因此在短、中期來說，為了加強 CCS 此一技術的持續發展，必須由公部門來給予足夠的經費與財務支持，方能促成 CCS 技術的成熟與實用化。

彙整相關的財務工具，這些工具至少可包含下列項目：（1）政府的直接財務支持、（2）對於營運上的直接支持，如相關程序的補貼、減稅等措施、（3）由公部門支應支持 CCS 發展及應用的相關基礎建設費用等。



資料來源：IEA（2013）

圖 3-10、未來七年順利推動 CCS 的七項關鍵行動

2、推動鼓勵封存場址的探勘評估（Implement policies that encourage storage exploration, characterisation and development for CCS projects）：

封存場址位置及潛力為推動 CCS 的最重要條件之一。依據 IEA 的初步估算，為了於世界各地進行封存場址的初步探測，於 2020 年可能需要花費近 10 億美金來執行此工作。對於許多國家來說，私部門難以在技術未明的情況下投入此一工作。因此，建議由公部門來支持此一工作，並為了經費的有效運用，應以完整性為考量，先透過檢視地質資料，找出有所不足之處；再將資源集中於補足資料不足之處，做為後續深入評估之基礎。

3、發展國家層級的相關規範與提供財務支持，以促使新設的化石燃料電廠能夠為 CCS 技術預留整合空間（Develop national laws and regulations as well as provisions for multilateral finance that effectively require new-build, base-load, fossil-fuel power generation capacity to be CCS-ready）：

就目前的市場條件來說，無法提供足夠的誘因讓新設的化石燃料發電機組自動為 CCS 預留做準備。然而，考慮到未來的減量目標，以及避免未來修建成本過高產生的鎖進效果（lock-in effect），建議各國可透過正式規範的方式，規定新設的化石燃料電廠須於設計時，預留未來搭載 CCS 設備的空間。

4、於目前尚未發展及試驗捕集技術之處推動試行計畫來進行驗證可行性（Prove capture systems at pilot scale in industrial applications where CO2 capture has not

yet been demonstrated)：

捕集技術目前發展的重點為燃燒前捕集、燃燒後捕集，以及富氧燃燒等技術。除了現有已進入示範計畫階段的應用案例外，為了加速捕集技術的成熟，須擴展其應用對象(以示範計畫形式為佳)，例如應用於水泥燃燒窯（gas scrubbing at cement kilns)、鋼鐵廠高爐（gas scrubbing at steel blast furnaces）等。

5、強化對於公眾及利害相關者對於 CCS 技術及重要性的了解及溝通（Significantly increase efforts to improve understanding among the public and stakeholders of CCS technology and the importance of its deployment)：

為增進 CCS 技術的順利推展，公眾的認同乃是必要條件之一。為了促進公眾對於 CCS—特別是執行風險—的了解，在強調技術研究發展的同時，亦必須就此技術的重要性、發展現況、執行風險等議題，與利害相關者及公眾進行充分溝通及教育。

6、設法降低電廠搭配採用捕集技術的成本（Reduce the cost of electricity from power plants equipped with capture through continued technology development and use of highest possible efficiency power generation cycles)：

對於發電機組而言，為了搭載 CCS 技術，其發電效率值將會降低，進而增加發電成本。因此，為了增加 CCS 的經濟競爭力，須持續於各關鍵技術上進行研究發展，以降低電廠搭載 CCS 技術的執行成本。

7、加強鼓勵二氧化碳運輸的基礎建設（Encourage efficient development of CO2 transport infrastructure by anticipating locations of future demand centres and future volumes of CO2）：

除了在捕集技術上的持續研發與應用示範外，加強捕集後的二氧化碳運輸基礎建設也是不能夠被忽視的重點項目。IEA 建議，須綜合考慮未來運輸需求（例如捕集點及封存地點），來建設整合性的運輸網路，以達到運輸成本極小化的成果。此外，政府亦應釐清其於運輸基礎建設上的定位，至少在初步的階段中，應由公部門扮演啟動支持的角色。

（六）加速 CCS 商轉的架構（CCS is ready for scale up）

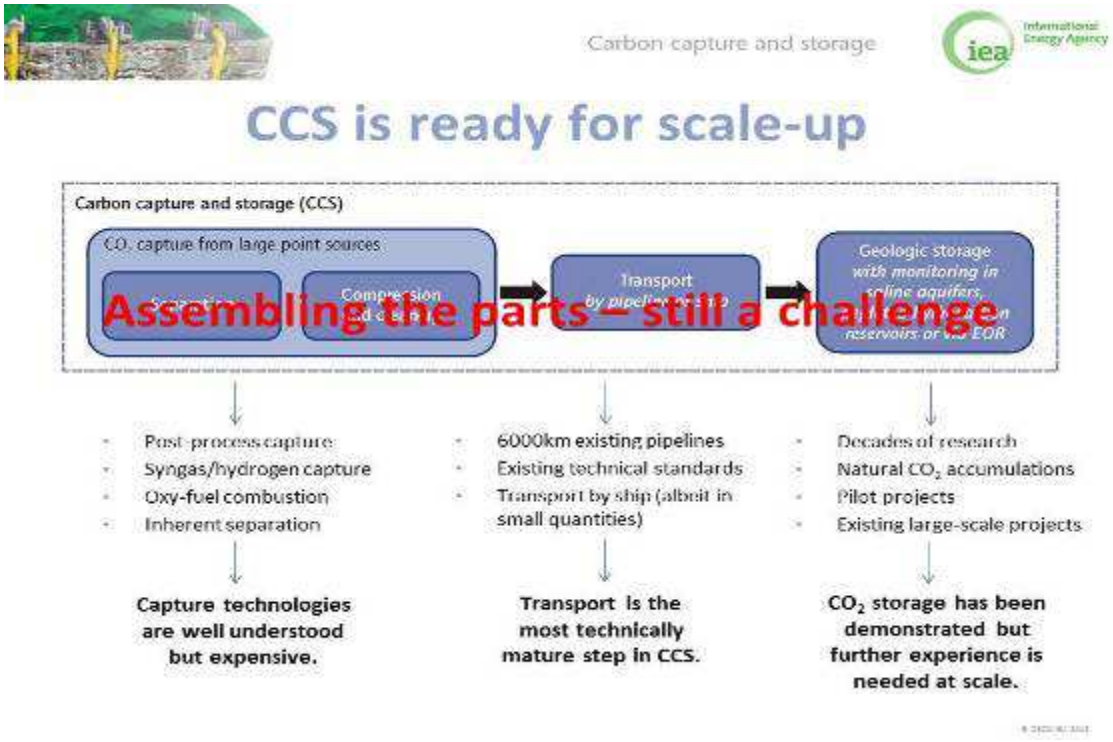
IEA 透過現階段的 CCS 技術盤點，以整體生命週期角度，分別說明捕集、運輸、封存等面向的發展現況，以及整合概況。在其報告中，可歸結出以下重點：

1、捕集技術現況：捕集技術已被充分理解，但成本昂貴（well understood but expensive）：

目前捕集技術的應用種類，大致分為四種，分別是（1）事後捕集（post-process capture）、（2）合成氣捕集（syngas/hydrogen capture）、（3）富氧燃燒（oxy-fuel combustion），與（4）既有分離技術（inherent separation）等四種。IEA 依技術成熟度，將其區分為已成熟應用的第一階段產業應用捕集技術（first-phase industrial applications）以及尚須持續進行技術研究與發展的第二階段產業應用捕集技術（second-phase industrial applications）。

依目前世界各地的現況來說，第一階段產業應用捕集技術多應

用於電力部門；相較於此，其他部門多處於第二階段的發展位置上，尚待更多的研發能量及技術投入。



資料來源：IEA（2013）

圖 3-11、CCS 技術發展現況盤點

Table 2: Routes to CO_2 capture in power generation (by fuel) and industrial applications (by sector)

		Syngas-hydrogen capture	Post-process capture	Oxy-fuel combustion	Inherent separation
First-phase industrial applications	Gas processing	-	-	-	Sweetening
	Iron and steel	direct reduced iron (DRI)*, smelting (*e.g.* Corex)		-	DRI*
	Refining	-	-	-	Coal-to-liquids; synthetic natural gas from coal
					Hydrogen production
	Chemicals	-	-	-	Ammonia/methanol
	Biofuels	-	-	-	Ethanol fermentation
Power generation	Gas	Gas reforming and combined cycle	Natural gas combined cycle	Oxy-fuel combustion	Chemical looping combustion
	Coal	Integrated gasification combined cycle (IGCC)	Pulverised coal-fired boiler	Oxy-fuel combustion	Chemical looping combustion
	Biomass	IGCC	Biomass-fired boiler	Oxy-fuel combustion	Chemical looping combustion
Second-phase industrial applications	Iron and steel	Hydrogen reduction	Blast furnace capture	Oxy-fuel blast furnace	-
	Refining	Hydrogen fuel steam generation	Process heater and combined heat and power (CHP) capture	Process heater and CHP oxy-fuel	-
	Chemicals	-	Process heater, CHP, steam cracker capture	Process heater and CHP oxy-fuel	-
	Biofuels	Biomass-to-liquids	-	-	Advanced biofuels
	Cement	-	Rotary kiln	Oxy-fuel kiln	Calcium looping
	Pulp and paper	Black liquor gasification	Process heater and CHP capture	Process heater and CHP oxy-fuel	-

Legend: technical maturity of operational CO_2 capture plants to date.

Commercial　Demonstration　Pilot　Lab or concept

資料來源：IEA（2013）

圖 3-12、捕集技術發展現況盤點

2、運輸技術現況：為目前 CCS 整體技術架構中最成熟的一個部分（transporting CO2 is the most technically mature step in CCS）：

運輸技術為 CCS 整體技術發展中，目前最成熟的一個部分。舉例而言，在美國已有總長度超過 6,000 公里既有 CO2 運輸管線；而在挪威，則有採用離岸管線執行 CO2 運輸的實務經驗。此外，建設此類型運輸管線的國際技術標準目前亦已完備（ISO 13623、ASME B31.4）。

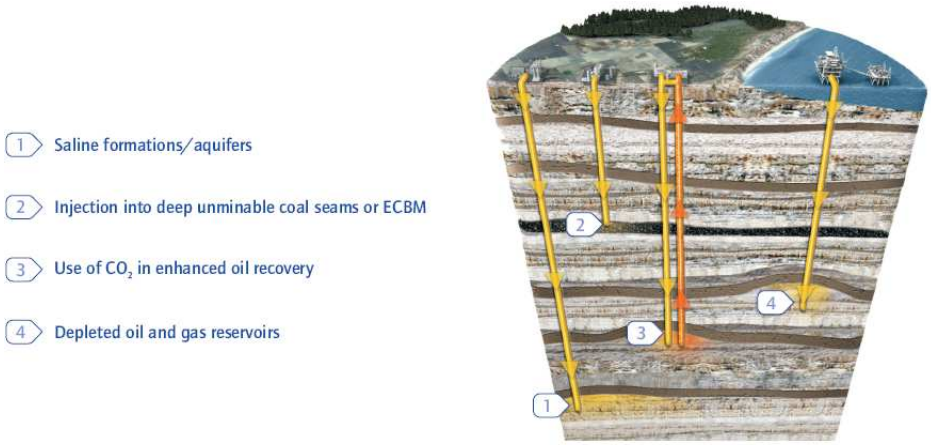
對於運輸技術的下一步，則是需要將暨有管線進行整合及串連（例如跨國界的管線串連、船運規畫等），這些工作需要基礎建設的支持，也唯有朝向此方向擬定策略及行動，方能有效地降低運輸成

本，進一步提高 CCS 之經濟可行性。

3、封存技術現況：已有示範計畫，但需要更進一步的應用執行經驗（has been demonstrated but further experience is needed at scale）：

就目前的技術發展概況而言，陸域型態的封存點可選擇：（1）地下含水層、（2）較深的地下礦脈層、（3）用於 EOR，以及（4）注入已耗盡的天然油氣儲存點。

以目前的技術進展而言，封存技術在技術層面上已被分了解；但這些了解主要是立基於過往的技術研究及實驗模擬結果。在此一階段，需要的是進一步的封存地點探測，包含封存潛力、技術可行性、經濟可行性，以及風險程度等，皆是需要各地投入資源加以辨知及釐清之處。



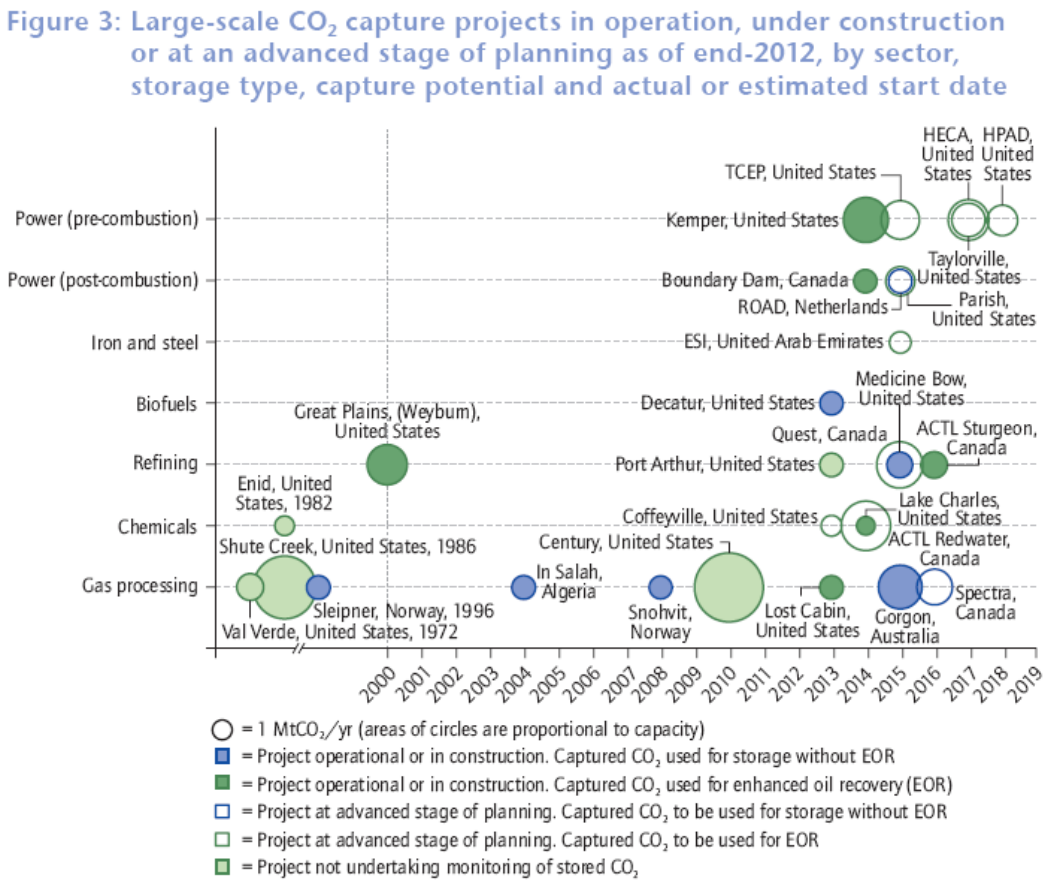
資料來源：IEA（2013）

圖 3-13、儲存技術發展現況

4、整合性計畫現況（progress with integrated projects）：

目前世界各地共有超過 20 個以上的CCS整合性計畫正在運轉及

規劃，然而，此一規模仍不足以提供足夠的技術發展動力。在這些整合性計畫中，有超過三分之二的案例是採用 EOR（可透過 EOR 的營收降低執行成本）、以及受到政府一定程度的資源支持。換言之，成本及財務上的考量，仍是支持這些計畫得以運轉的主要因素。



資料來源：IEA（2013）

圖 3-14、目前世界各地的 CCS 整合計畫

（七）CCS 公眾溝通的推動重點

在溝通前，溝通對象對溝通議題內容可能具有既定之成見與立場，講者針對這些立場以生活化方式舉例，如選擇房子為案例，這些立場可分為下列數點：

1、是否喜歡鄰居（周圍社會環境狀況認同）

2、建商的聲譽(對執行者、業者的信心及信任)

3、是否有人建議(其他利害關係人的影響)

4、建商是否有能力(業者的技術與管理能力)

5、是否喜歡他們的做法(對計畫規劃狀況是否滿意)

6、是否可信(業者的聲譽)

7、是否值得支出(和本身理想的落差是否值得取捨)

8、聯繫是否容易(溝通是否流暢)

9、親友的看法為何(主要利害關係人的想法)

在經由上述概念的說明後，講者提出對於 CCS 溝通上各項影響因子間的相互關係如圖 3-15：

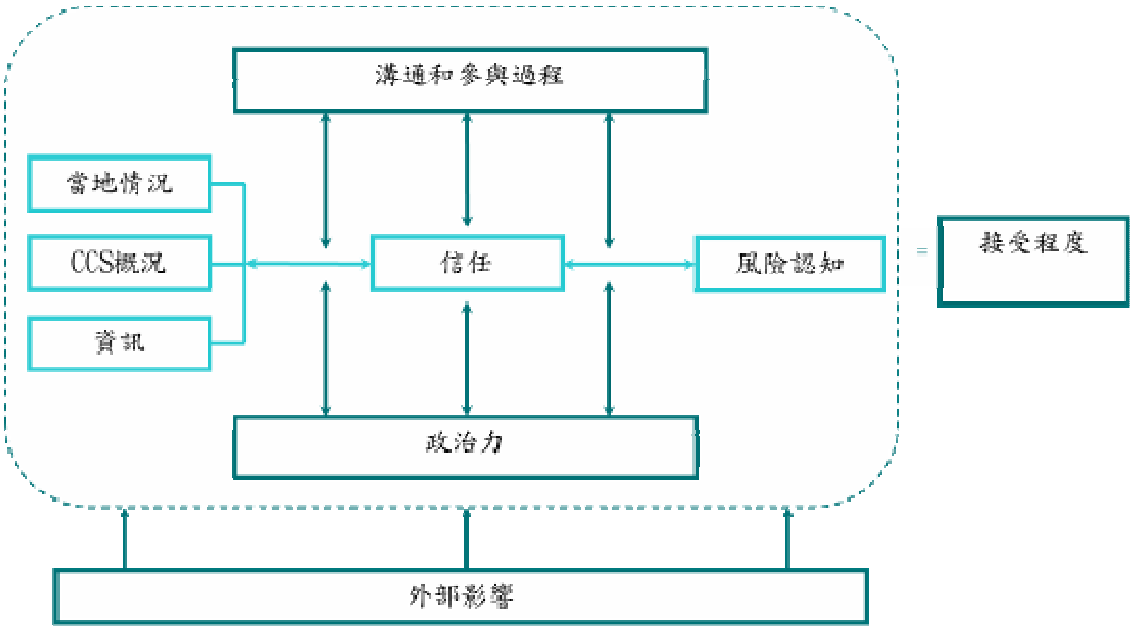


圖 3-15、CCS 溝通發展影響架構

（八）CCS 潛力評估要項程序與建議：ADB 經驗

為提供亞洲發展中國家使用 CCS 做為減碳工具之機會，亞洲開發銀行（ADB）投入資源於技術諮詢及提供計劃財務支持。在相關事務的財務支援上，於 2009 年，ADB 創設 CCS 基金（CCS fund），以提供推展 CCS 事務之用。CCS 基金由 GCCSI 提供 21.5 百萬澳洲做為初始基金，於 2012 年，英國亦捐助基金 35 百萬英鎊。

Table 3 **Carbon Capture and Storage Opportunities in the Focus Countries**

Item	Natural Gas Processing	Supercritical Pulverized Coal	Natural Gas Combined-Cycle
Capture Opportunities			
Indonesia	Potential existing source identified	Potential existing source identified	
Philippines		Potential existing source identified	Potential existing source identified
Thailand	Potential existing source identified	Potential existing source identified	Potential existing source identified
Viet Nam	Potential future sources from new high CO_2 gas fields	Potential future source identified	Potential future source identified
Storage Sites with Enhanced Oil Recovery Potential			
Indonesia	Potential existing site identified		
Philippines	Non immediately available/potential nonconventional storage sites recommended for more detailed analysis		
Thailand	Potential existing site identified		
Viet Nam	Potential existing site identified		

資料來源：ADB（2013）

圖 3-16、南亞國家執行 CCS 的潛力與機會

於亞洲該發銀行的技術報告中提及，為審視 CCS 計畫投資方案可行性，及協助成員國中的申請單位降低執行障礙，亞洲開發銀行建立一套技術評估程序，用以達成上述目的。ADB 所建立之技術評估架構，第一階段主要包含下列 4 項內容：

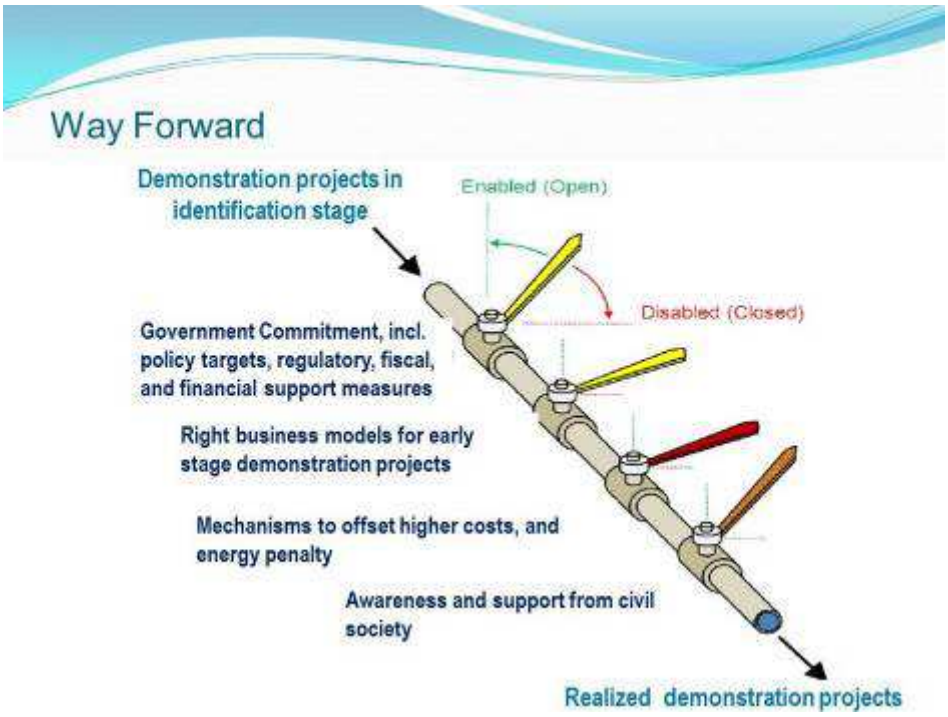
1. 建立可行的環境(establish the enabling environment)。
2. 捕集及封存的技術衡量(examine the technical aspects related to capture and/ or storage)。
3. 準備示範計畫的可行規劃報告(identify and prepare prefeasibility reports for pilot projects)。

4. 完成初步的地質封存探勘報告(carry out initial geological investigations for the storage aspects of the pilot projects)。

透過上述的技術評估後，ADB 可初步掌握成員國中具有發展潛力的會員及其概況。

在經由上述第一階段的可行性與風險評估後，ADB 透過歷年研究及實務推展經驗，建議可經由延伸配套方式激勵計畫順利運行，降低不確定性與執行障礙。這些克服關鍵障礙要素的項目包含：

1. 政府支持、政策目標明確、法規與財務規劃完善(government commitment, incl. policy targets, regulatory, fiscal, and financial support measures)。
2. 合適的商業模型(right business models for early stage demonstration projects)。
3. 成本降低機制(mechanisms to offset higher costs, and energy penality)。
4. 公眾支持溝通(awareness and support from civil society)。



資料來源：ADB（2013）

圖 3-17、順利推動 CCS 的關鍵要素

（九）CCS 於清潔能源技術組合中的定位：UK 經驗

檢視目前對於 CCS 的相關討論，在推動策略上，仍主要單純強調及著重於單一技術的討論，而非將其放置在整體能源政策架構及呼應對應政策目標的角度來進行思考。DECC 說明，在考慮到上述的問題後，英國主要是以一個整合性的能源政策概念架構來檢視及挑選英國適用的清潔能源技術組合，CCS 所扮演的角色，僅為技術組合中的一種候選技術，如此方能透過技術組合之選取，以達成能源政策目標。

英國的整合性能源政策概念架構包含以下三個重點面向：

1、確保能源供應（ensuring secure supply）：必須確保能源使用需求能夠得以滿足；

2、經濟可行（maintaining affordability）：挑選的能源技術必須具經濟可行性，這部分包含先期計畫時的財務支持，以及中後期的成本降低策略與市場機制的建構。

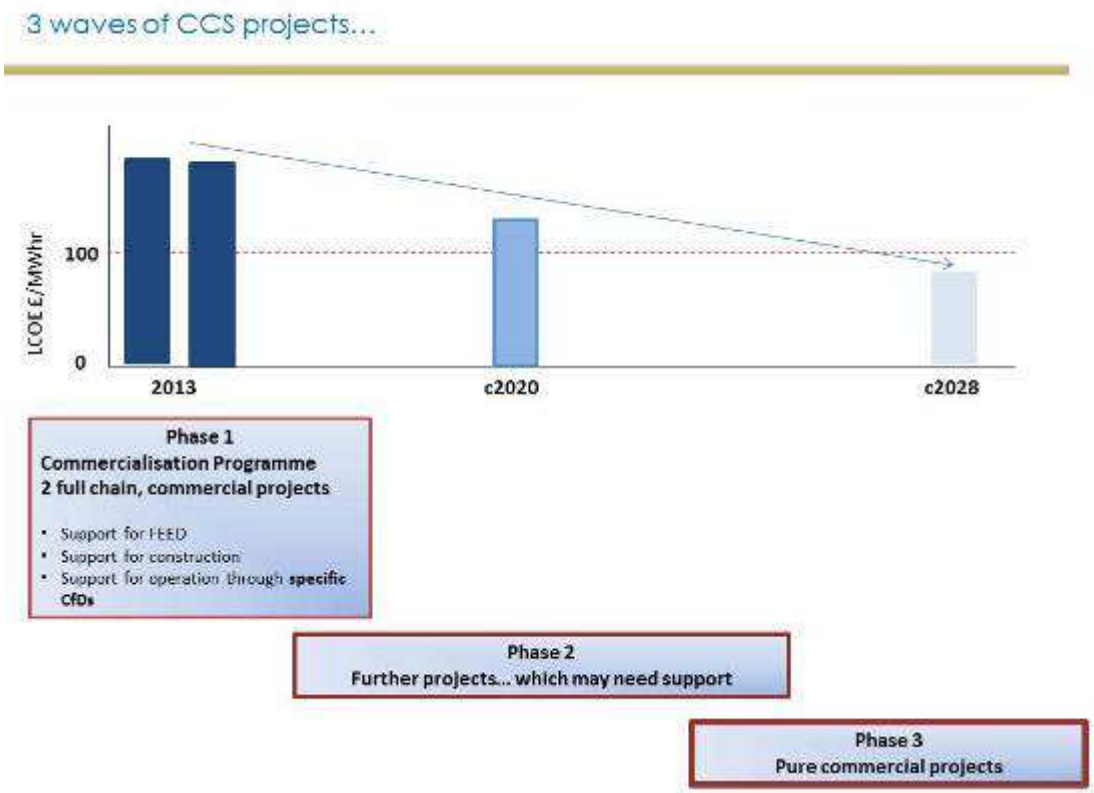
3、應對氣候變遷（tackling climate change）：挑選應對氣候變遷問題有利的能源技術組合。

資料來源：DECC（2013）

圖 3-18、UK 的整合性能源政策概念架構

在這樣的整合性概念架構之下，UK 在制定能源政策時，從原本單一的技術目標導向（例如 2020 要達到再生能源政策目標），轉向綜合利用各種可行手段的「去碳目標」（decarbonisation target）。

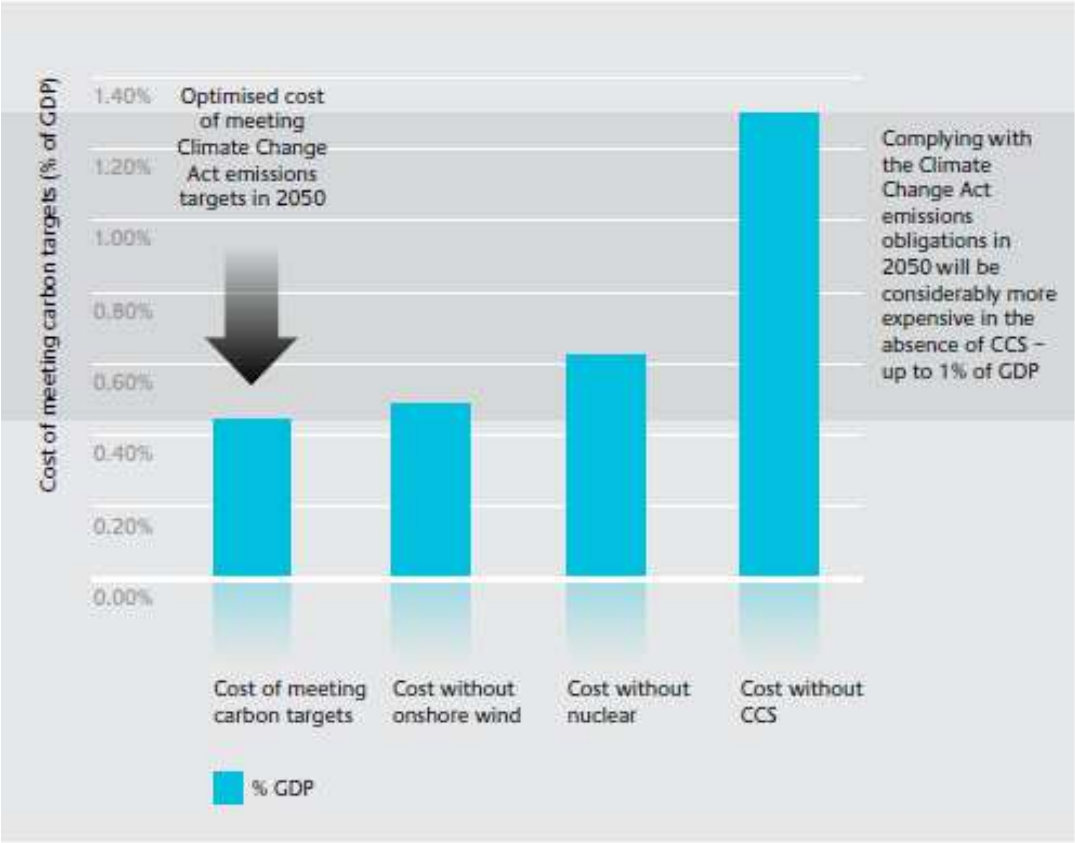
為了評估 CCS 是否能得成為 UK 達成能源政策的候選技術，UK 亦投入許多資源進行技術評估及研究。在目前的推動規劃上，此階段（2013）仍屬於辦理少量示範性計畫的階段。根據其規劃目標，希望可於 2028 年達成完全的商業化。



資料來源：DECC（2013）

圖 3-19、UK CCS 推動規劃

此外，為了達成其「去碳」的政策目標，UK 政策亦配合能源技術組合進行衝擊評估。根據評估結果，為了達成 UK 所宣示的政策目標，在採用所有可行的減量技術後（包含 CCS），於 2050 年為了達成此目標的代價為 0.4%的 GDP 下降；反之，如果屆時無法採用 CCS，則代價將升高為 1.4%的 GDP 下降。由此可得知 CCS 對於降低減量經濟衝擊的重要性。



資料來源：DECC（2013）

圖 3-20、UK 能源技術組合的經濟衝擊模擬結果

（十）中國推動碳捕集、利用和封存現況觀察

中國大陸國家發改委今年 4 月發出通知，要求各地及有關部門推動碳捕集、利用和封存試驗。通知從示範項目、基地建設、激勵機制、規劃、標準、國際合作六個方面，推動碳捕集、利用和封存的試驗示範工作。

1、結合碳捕集和封存各環節實際情況開展相關試驗示範項目：鼓勵　在煤化工、油氣等行業開展針對高純度二氧化碳排放源進行捕集的示范項目，在火電廠開展燃燒前、燃燒後、富氧燃燒等各種二氧化碳捕集技術路線的試驗示范項目，加強不同二氧化碳捕集工藝路線間的技術和經濟比較，不斷解決相關技術實現產業化應用面臨的各種實際問題。

2、開展碳捕集、利用和封存示範項目和基地建設：優先支持符合國情、成本較低、規模適度、有行業、地區特色和自有知識產權、近期有較大推廣價值的半流程及全流程示範項目，加強對中長期較大規模，涉及捕集、驅油（氣）和封存的一體化示範項目的引導。

3、建立相關政策激勵機制：研究探索有助推動碳捕集、利用和封存試驗示範的引導和激勵機制，落實現行有關稅收扶持政策。

4、加強碳捕集、利用和封存發展的戰略研究和規劃制定。

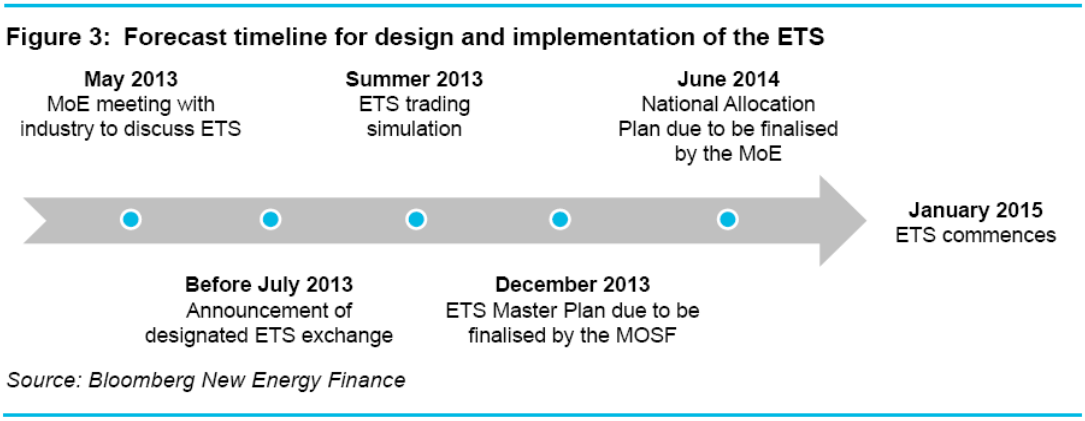
5、推動碳捕集、利用和封存相關標準規範的制定。

6、加強能力建設和國際合作(經濟與技術)。

報告中提及，中國將 CCS 技術定義為一項二氧化碳再利用技術，主要應用於天然資源開發(如：EOR)，由於在中國內陸地區水資源缺乏，油田開發每年需要注入水量約 7000 多萬立方公尺，產出大量污水需要處理，在陝北半乾旱地區給環境造成很大的壓力。因此透過 CCUS 灌注二氧化碳將大大降低水資源壓力，且其副產物亦可作為其他工業用途。

三、 韓國排放交易制度推動

南韓排放交易制度之法源基礎《Allocation and Trading of Greenhouse Gas Emission Allowances Act》（the ETS Act）於2012.11.13通過，預定2015.01.01實施。此制度之規劃及執行涉及不同行政單位的合作及協調，但主要權責機關為韓國環境部（Ministry of Environment，MoE），由其負責整體制度規劃及跨部會溝通協調。韓國於2012年通過「溫室氣體排放權核配及交易法案施行令」；現階段正積極建置相關配套措施，財政部預計於2013年12月公布排放交易機制之總體計畫，2014年6月由環境部提出核配計畫。



資料來源：Ernst & Young（2013）

圖 3-21、韓國排放交易制度之推動期程規劃

南韓「綠色成長」（green growth）政策推動法源為2010年所頒布實施之《Framework Act on Low Carbon, Green Growth》。政策目標為至2020年時，其排放量將減量至較BAU更低30%，以及要求國內大型排放主體及能源消費者，須每年就溫室氣體排放量及能源使用量進行申報（此工作由韓國的「溫室氣體盤查及研究中心」（The GHG Inventory & Research Center of Korea，GIR）負責）。

韓國的 ETS 制度的前期重點之一，在於「溫室氣體與能源目標管理系統」（GHG and Energy Target Management System）之執行。此一制度的相關設計及執行重點如下：

（一）由「溫室氣體盤查及研究中心」（The GHG Inventory & Research Center of Korea，GIR）為權責機關，主管能源使用、排放量申報、排放及能源使用目標設定等工作。

（二）受管制主體條件：每年排放 20kt CO2e/yr 或能源使用超過 90TJ/yr 者；對於包含多重設備的管制主體（例如同一公司，但設備分散在不同地區者），只要排放量超過 87.5 CO2e/yr 或能源使用超過 350TJ/yr 者，皆須列管。

（三）根據 2011 年的資料，全國約 76%的排放量受到此管理系統的管制，總受管制排放量約為 542Mt CO2e/yr。

（四）受管制對象須每年申報其排放量及能源使用量，而後 GIR 依其資料設定管制目標。在接到管制目標後，管制對象須依此提出對應的目標達成方案回報給 GIR。

（五）在 CCS 的推動方面，目前韓國已有二個整合型的 CCS 計畫正在執行中，韓國官方的政策目標，乃是希望能在 2020 年完成正式的商業化商轉技術。根據目前的進度規劃，第一個整合性的示範計畫（搭配燃燒後捕集技術的燃煤電廠）預定將於 2016 年完成；而第二個整合性示範計畫，則預定將於 2018 前完成(搭配燃燒前捕集技術的燃煤電廠或 300MW 的 IGCC 電廠)。

此外，在 CCS 的政策協調上，**以 Korea CCS Association（KCCSA）作為推動 CCS 主要窗口並負責協調企業排放權核配事宜**：與 KCCSA 執行長 CHONGHUN HAN 與會議過程中交流得知，韓國排放交易係採中央統一核配方式核配排放權（依歷史朔往原則），關鍵核配方式係透過 KCCSA 與企業溝通減量方式與核配額度規劃，經由該組織對企業之溝通協調建立雙邊橋梁，促進 CCS 成為企業可行減量措施，並由政府提供資金支持

CCS 技術發展，降低企業減碳壓力，同時減少政策推行之阻礙。

四、 韓國 CCS 示範計畫：Boryeong 電廠參訪行程

過去 3 年，韓國政府共投資 1.2 億美元進行碳捕存研究，主要(約 80%經費用於 CO2 捕集技術研發)，韓國碳捕存協會(KCCSA))針對碳捕存技術路徑圖，規劃如圖。目前參訪對象 Boryeong 電廠於 2012 年 10 月完成 10MW Pilot Plant 安裝工作，並已經完成 0.1MW 試驗、2013 年 10 月初正進行 10MW Pilot Plant 試驗，近程希望於 2015 年將捕集技術進行商轉，並預計 2020 年之前完成 100~500MW 二氧化碳捕集示範廠技術建立。

圖 3-22、韓國碳捕存技術路線規劃

韓國西部 Boryeong 電廠 8 號燃煤機組，其計畫以發展韓國本土化 amine 乾式溶劑回收系統，並較 MEA 系統減少 30%能源使用(MEA 約 3.6~3.9 GJ/ t CO2)為主要目標。本次參訪報告展示出計畫發展出之吸附材(命名：KoSol-4)，這種溶劑的再生能源是介於 3.1 和 3.3 GJ/ t CO2（KoSol-4：3.0 和 3.1 GJ/t CO2 在沒有流程優化標準過程中，） - 能源降低約 14%和 23%間，低於再生 MEA 的能源。其結果符合技術路線設定之目標。將以其吸附材進行循環利用，了解材料與現今吸附材比較之優劣，以 2.0 GJ/ t CO2 為研究目標並進行推廣。自 2010 年 10 月以來，試驗場設計每天捕捉 2 噸二氧化碳。研發單位 KEPCO 證明其專有的溶劑 KoSol-4 是能夠捕捉到超過 90%的氣流和 CO2 純度大於 99%。KEPCO 計畫主持人張慶

龍博士表示願意接受邀請至台灣交流進行技術交流訪問。

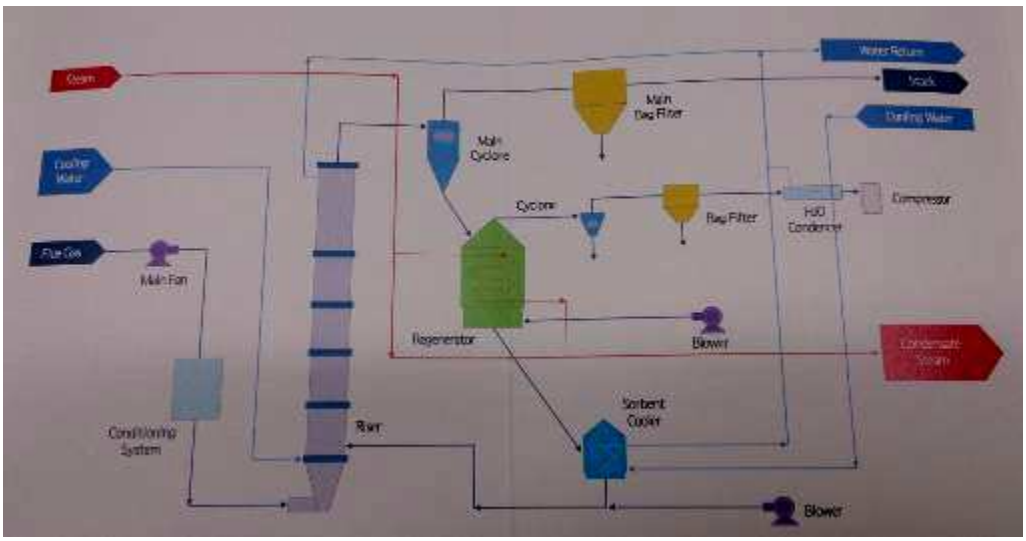


圖 3-23、Boryeong 電廠捕集流程圖

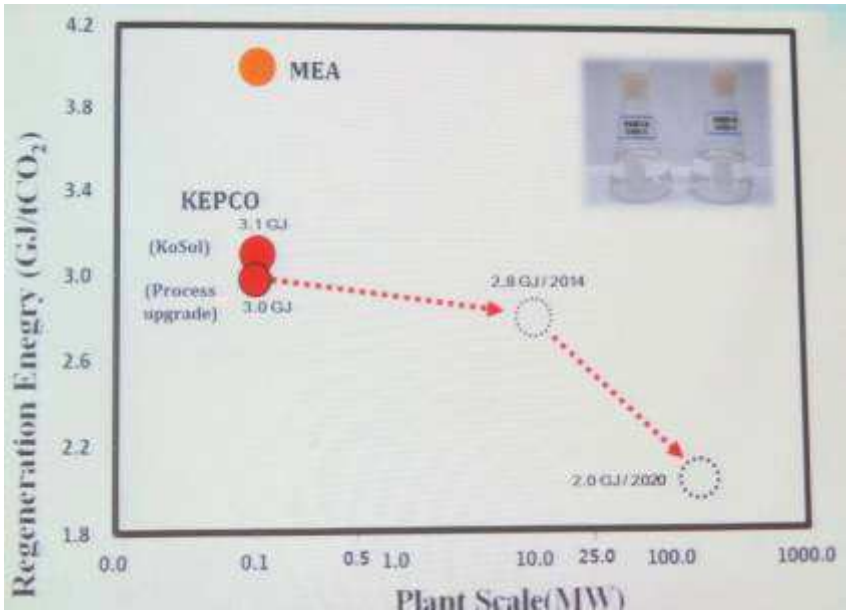


圖 3-24、KEPCO 開發 KoSol-4 能耗目標及 MEA 能耗比較

圖 3-25、Boryeong 電廠捕集設備與 2 噸捕集床

Boryeong 計畫為證明煤發電站燃燒後二氧化碳捕集技術，廠區試驗以一個 0.1MW 的試驗床，逐漸發展到 10MW。該電廠未來計畫增設二部 1，000MW 燃煤機組，機組將搭配碳捕存設備以降低電力排碳量。此計畫目前捕集 CO2 濃度達 90%以上，並未再利用；未來將優先再利用，剩餘之 CO2 再注入鹽水層儲存。韓國碳捕存協會規劃未來將 Boryeong 所捕集之 CO2，透過海運船隻或陸運管線，輸送到韓國東方日本海水域(近浦項廠)進行海底鹽水層封存作業。

圖 3-26、Boryeong 電廠位於海邊之燃煤機組

圖 3-27、參訪 Boryeong 電廠碳捕集設施

五、 參訪韓國氣候變遷中心（KCCC）

KCCC 成立於 2008 年，為一推動氣候變遷活動的 NGO。其核心宗旨為結合政府、企業、學界、及公民共同關注拯救全球氣候議題，組織目的包含：

- 管理政府、企業和公民氣候變遷教育課程
- 支持基礎研究和關於氣候變化問題舉行會議
- 激勵公民對氣候變化關注
- 為解決氣候變化問題提供政策建議
- 提供最新的訊息和國際部會間的合作關係

本次參訪主要會見了KCCC的中心主任Kim, So Hee、教育部門經理Kim, Sun Ae、公關部門經理 Han, Beetsnara，以及中心經理 Choi, Jung Hoon。代表團成員針對韓國的氣候變遷政策、溫室氣體排放交易制度規劃及推動現況、碳捕集政策及技術發展公眾溝通及教育等面向，進行意見交換。並透過此次參訪建立交流溝通管道，尋求長期合作契機。

圖 3-28、我代表團成員與 KCCC 中心工作人員互動交流

由於 KCCC 近年的主要工作重點為公眾教育及溝通，因此可由參訪過程得到許多不同官方面向的資訊。根據參訪談話內容，可歸結出幾項重點，摘要如下：

（一）產業對政策抱持觀望態度

雖然韓國於國際上大力宣示其執行溫室氣體減量的決心，但對於產業界來說，其普遍仍多採觀望態度面對政府所提出的各項政策。主要理由在於，目前的減量目標及相關政策方向為前任政府團隊所訂定，在執政團隊輪替改變後，推動排放交易制度的腳步不若過往積極，這也讓原本就對排放交易制度抱持反對意見的產業，順勢持續抱持觀望態度。

（二）公眾對於氣候變遷認識仍不普及

基於近年推動各項教育活動的經驗，KCCC 認為，一般民眾對於氣候變遷的認識，事實上仍未普及。為了後續各項政策之推行，持續透過創意設計各種教育及溝通活動，將是 KCCC 後續主要的任務工作。

（三）政府政策缺乏透明度：

在訪談過程中亦得知，政府的許多溫減相關規劃與政策規範，設計過程中仍缺乏公民意見蒐集。往往官方在國際上所宣示的各項政策，民眾事實上並不了解。

（四）CCS 被視為與核能風險相當的技術：

對於 CCS 此一技術而言，KCCC 認為，目前韓國民眾普遍認識不足，許多人並不了解 CCS 的內容及重要性。專門辦理民眾溝通的承辦經理亦透露，甚至有不少民眾認為 CCS 的風險與核能無異，因而抱持保留或反對態度。然而，承辦經理也提到，這主要是突顯了推動方在溝通與公眾教育上之不足。

（五）推廣活動交流上的建議

在未來可能的合作議題上，KCCC 中心主任提及，近年 KCCC 著重於氣候變遷的政策溝通及公眾教育宣導，已開發出許多適合不同對象的教育課程及推廣活動。除了在這些活動內容資訊可以相互分享

之外，也建議台灣加入一些與氣候變遷調適活動推動相關的跨國性網路社群（如Corporate Leaders Network for Climate Action）。透過跨國網路平台的參與，除了得以推廣台灣在氣候變遷政策上的努力外，亦能透過資訊分享，學習相關推廣活動的形式及程序，以及尋求跨國合作的機會。

肆、 全球碳捕存研究所（GCCSI）會員大會

一、 會員大會重點紀要

由於GCCSI將於2013年起將由原先協會組織(法人機構)轉變為公司型態，因此，該協會將進行組織章程修改與董事會人員舉薦及變動，本年度之會員大會在完成財務報告後，進行人事變更、組織章程變動等議題投票，項目如下：

（一）Paul Dougas 董事任命；

（二）續聘退任董事Rachel English；

（三）續聘退任董事Dr Mario Ruscev；

（四）廢除及變更組織章程；

（五）董事會及遴選委員會章程修正；

（六）基本權利變更修正案；

（七）董事會及遴選委員會基本權利變更修正案；

（八）政府會員基本權利變更修正案；

（九）主要工業會員基本權利修正案；

（十）一般會員基本權利修正案；

有關政府及相關會員權益變更內容，主要係由於該組織之成立受到澳洲政府公司法(Company Act)所規範，必須經由該法案的規定進行成員權益與費用收取等權利義務進行修正。因此，大會透過現場會員紙本投票及代理投票後，未在會議中進行計票與宣布(將另行通知成員其投票結果)，僅提供代理投票之計票結果如下表。

表 4-1 、GCCSI 2013 會員代表大會議決項目

投票議題	贊成	反對	棄權
(一)Paul Dougas 董事任命	46	-	-
(二)續聘退任董事 Rachel English	45	-	1
(三)續聘退任董事 Dr Mario Ruscev	45	-	1
(四)廢除及變更組織章程	38	6	2
(五)董事會及遴選委員會章程修正	41	3	2
(六)基本權利變更修正案	39	3	4
(七)董事會及遴選委員會基本權利變更修正案	40	3	3
(八)政府會員基本權利變更修正案	4	1	-
(九)主要工業會員基本權利修正案	22	1	2
(十)一般會員基本權利修正案	26	1	2

圖 4-1、GCCSI 年度會員大會

二、 GCCSI 入會會談

了解 GCCSI 組織架構未來動向，掌握會員申請流程與時間，並爭取我國以政府會員方式加入 GCCSI，同時尋求 CCS 技術國際交流合作機會，乃是本次代表團的主要任務之一。

為順利完成此一任務，本次代表團出訪前，已事先與 GCCSI 執行長（CEO）Brad Page、主管政策與會員事務總經理 Barry Jones，以及北亞事務高級專員 Kerry Brooks 等 GCCSI 管理決策高層進行多次聯繫，並針對我國入會事宜進行會晤安排，最後 GCCSI 同意於年會期間與我方代表團進行會談，並針對入會事宜給予建議。

於會談當日，GCCSI 參與會談者主要為 GCCSI 總經理 Barry Jones，以及北亞事務高級專員 Kerry Brooks。我代表團長簡慧貞博士於會談之中，首先向 GCCSI 代表說明我國於 CCS 推動上的目標方向及執行現況，並進一步洽詢以政府會員方式加入 GCCSI 之可行做法。GCCSI 代表表示，除了對於臺灣推動 CCS 此一事務之努力現況表達肯定之意外，亦十分歡迎臺灣以任何形式加入 GCCSI、一同為後續的 CCS 推動事務進行合作。

在執行進度上，GCCSI 與談代表提及，目前 GCCSI 正處於組織將由研究單位轉型為公司單位的過程。建議我方持續與 GCCSI 保持聯繫，待新的組織架構更加確立後，即可提出入會申請。惟 GCCSI 與會代表亦提及，即便在未正式加入成為會員之前，亦十分歡迎臺灣持續參與 GCCSI 所舉辦的各項活動，並對未來的合作機會，抱持樂觀態度。

三、 會員收費標準評估

經後續與 GCCSI 聯繫及國內各會員公司提供之資訊彙整，GCCSI 欲於 2015 年正式轉型為公司型態，未來在會費收取機制上亦有所變化，目前已針對政府會員、主要工業會員等不同會員別訂出初步的組織轉型收費標準，並提出現有會員收費優惠：

- 首期會費（2015/01~2015/12）收取所需會費之 25%。
- 次期會費（2016/01~2016/12）收取所需會費之 50%。
- 三期會費（2017/01~2017/12）收取所需會費之 75%。

我國若以政府會員身分申請加入，會費收取機制將採 GDP 與二氧化碳排放當量之各級別乘積作為收費標準，兩指標之分級級別如**表 4-2**，而各級距之乘積收費標準如**表 4-3**。

表 4-2、國家 GDP 及年度二氧化碳排放量之級別級距

等級	[A]GDP(US$)	[B]CO_2年排放量(百萬噸)
1	>20000	>500
2	10000 - 20000	250 - 500
3	5000 - 10000	100 - 250
4	<5000	<100

表 4-3、國家 GDP 及年度二氧化碳排放量之級別級距

收費 等級	年費 (AU$)	乘積 [A] x [B]
1	1,000,000	1
2	**750,000**	**2**
3	500,000	3, 4
4	100,000	6,8,9,12
5	50,000	16

透過上述級距試算，我國 2012 年 GDP 約 20,527 美元(等級 1)，二氧化碳排放量以國家通訊最新版提供之資訊為 284.515 百萬噸(等級 2)，以此結果計算，我國若可以政府會員入會，入會費需 750,000 澳幣(約新台幣 2058 萬元)。此外，我國目前尚非該組織會員，但已與組織提出入會意願，是否得於 2015 年享有會員優惠仍需與 GCCSI 持續溝通，即 GCCSI 願意提供我國既有會員之優惠，首年會費仍需新台幣 514.5 萬元，雖 GCCSI 於碳捕存工作上提供相當之資訊與技術交流，但入會後合作上是否需額外費用仍需詢問與觀察。

伍、 與會心得與我國政策建議

依據本次出訪會談及觀察所得，對於我國未來的政策走向的影響與啟示，大致上可區分為幾點，分述如下。

一、 CCS 政策推動可參考方向

（一）CCS 政策環評推動架構

我國正值 CCS 政策擬定及推動階段，透過本次參訪過程中亦了解到，政策環評為一個有效之推動工具。因此，本署後續可透過推動 CCS 政策環評，進行 CCS 技術發展整體面向評估。其將有助於釐清及解決推動 CCS 時，所面臨的政府權責定位、政策推動方向、配套法規架構，以及公眾溝通等問題，創造有利 CCS 技術發展之制度環境。

此外，本次會議內容可做為後續形塑我國政策環評報告架構及內容之基礎，這些參考資訊包含：

- CCS 於清潔能源技術組合中的定位：UK 整合性觀點
- CCS 潛力評估要項程序架構：亞洲銀行經驗；
- IEA 2013 CCS 技術路徑圖；
- 2020 年前成功推動 CCS 的 7 大關鍵行動；
- CCS 政策公眾溝通重點與案例。

這些資訊可透過定位於結構關係，而將其彙整為圖 5-1 的推動架構。

根據此架構，透過探討不同政策目標（例如環保政策、能源政策、經濟政策…等）之競合，方能釐清 CCS 在未來國家政策藍圖中所扮演的角色與定位。

其次，則是可參考 ADB 所提出的 CCS 潛力評估要項程序架構，逐一盤點為完成我國 CCS 潛力評估，尚缺乏的程序與資料內容，以進一步透過補足這些程序要項，完成完整的技術面向評估。在完成技術評估程序後，可參考 IEA 最新路徑圖

對於未來推動 CCS 所需的關鍵行動項目來擬定我國之行動方案計畫及修正技術路徑圖，以確認我國發展 CCS 之技術可行性及潛力。

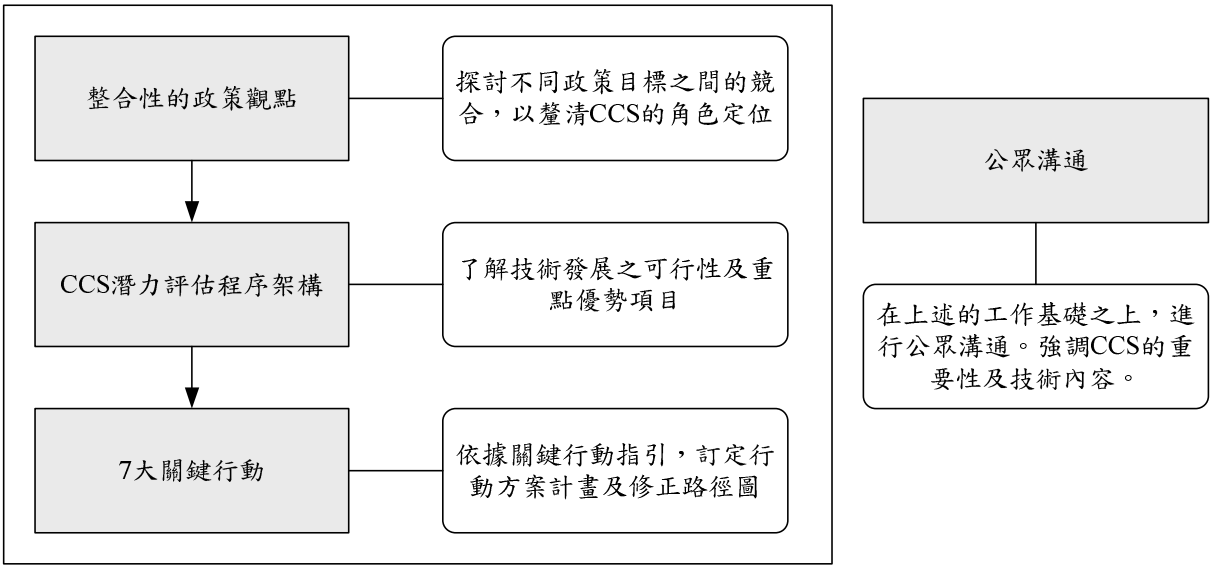


圖 5-1、後續參考推動架構

在完成上述的工作之後，為了順利推動 CCS 之落實，必須於上述的工作基礎之上，與一般社會大眾進行公眾溝通。目前在於讓公眾了解 CCS 的重要性、技術內容與可能風險，透過共識的達成，以利後續相關政策之推展。

（二）配套管制策略之擬定

會議中針對 CCS 推動是需要強制性的法規命令或碳價格的制定形成自由市場機制，目前尚無定論。然而，以追求較低行政成本的角度來說，配合我國現有的法制架構來進行政策推動，或為較有效率的進行方式。

在目前我國以《空污法》做為溫室氣體管制策略依歸的做法，我國可配合技術發展期程，透過相關強制性規範制訂(如:參考美國新設電廠排放標準訂定)或二氧化碳空污費徵收（為碳定價），提供台灣 CCS 發展之政策支持。

另一方面，就目前的發展階段來說，CCS 的技術發展尚未完全成熟，對應的商業市場也因為全球碳訂價情況未明，因而無法隨之發展。因此在短、中期來說，為了加強 CCS 此一技術的持續發展，必須由公部門來給予足夠的經費與財務支

持，方能促成 CCS 技術的成熟與實用化（韓國作法即為政府和企業各出資一半，投資 CCS 試驗計畫）。彙整相關的財務工具，這些工具至少可包含下列項目：（1）政府的直接財務支持、（2）對於營運上的直接支持，如相關程序的補貼、減稅等措施、（3）由公部門支應 CCS 發展及應用的相關基礎建設費用等，都是我國降低政策執行成本的參考工具。

二、 參考韓國作法成立 CCS 推動專責法人單位

韓國 CCS 協會（Korea CCS Association，KCCSA）為一法人組織，主要由產業推派代表所形成的實體法人，作為推動 CCS 主要窗口並負責協調政府與產業之間的相關事宜。與 KCCSA 執行長 CHONGHUN HAN 與會議過程中交流得知，經由該組織對企業之溝通協調建立雙邊橋梁，促進 CCS 成為企業可行減量措施，並由政府提供資金支持 CCS 技術發展，降低企業減碳壓力，同時減少政策推行之阻礙。

參考韓國作法，依我國目前的相關法令規章，可成立以「環境保護」為目的財團法人，以實體運作方式（例如參考韓國做法，請各相關企業派代表參與此法人），來協助各項事務的推動。此外，配合現有的制度架構，至少可二個參考方案可做為初擬基準：

方案一：以現有單位，如以現有之「CCS 策略聯盟」，參考韓國 KCCSA 工作內容進行工作方向設定及調整，轉型為財團法人，以執行相關推動工作。

方案二：另成立一專責的法人單位來執行相關工作。

陸、 附件參考資料

1. GCCSI Global Status of CCS: 2013 會議議程
2. GCCSI 歷年會議重點摘錄
3. 保寧（Boryeong）電廠 CCS 資訊
4. GCCSI 執行長（CEO）Brad Page、主管政策與會員事務總經理 Barry Jones 專長背景
5. 與會專家簡報資料

附件一、GCCSI Global Status of CCS: 2013 會議議程

GLOBAL CCS INSTITUTE

THE GLOBAL STATUS OF CCS 2013

AGENDA

	TIME	ITEM	DETAIL
WEDNESDAY 9 OCTOBER	All day	Site Tours	
	1800 – 2000	Welcome Reception	
THURSDAY 10 OCTOBER	0830 – 0930	Delegate registration and tea/coffee	
	0930 – 0940	Meeting open	**Claude Mandil**, Chair - Global CCS Institute International Advisory Panel
	0940 – 1010	Welcome and opening addresses	• **Man Ki Jeong**, Deputy Minister - Ministry of Trade, Industry and Energy (MOTIE), Government of Korea • **Won Wook Lee**, Congressman - National Assembly of Korea • **Paul Dougas** - Chair, Global CCS Institute • **Hwan Eik Cho** - Chair, Korea CCS Association (KCCSA) and CEO - Korea Electric Power Corporation (KEPCO)
	1015 – 1045	Break, including official exhibition booth tour	
	1045 – 1110	International launch of the *Global Status of CCS: 2013*	**Brad Page**, CEO
	1110 – 1210	PANEL 1 Tackling climate change and ensuring energy security – the role of CCS	• **Professor Myles Allen**, University of Oxford • **Tim Bertels**, Shell • **Philippe Benoit**, International Energy Agency • **Dr Subho Banerjee**, Department of Industry (Australia)
	1210 – 1310	PANEL 2 CCS in the Asian Century – insights and next steps	• **Chen Zhihua**, National Development and Reform Commission of the People's Republic of China • **Ashok Bhargava**, Asian Development Bank • **Professor Chonghun Han**, Seoul National University & KCCSA
	1310 – 1410	Lunch	
	1410 – 1510	PANEL 3 Delivering collaboration to ensure the safe and effective deployment of CCS	• **David Hawkins**, Natural Resources Defense Council • **Peta Ashworth**, CSIRO • **Sean McClowry**, Global CCS Institute
	1510 – 1540	Break	
	1540 – 1640	PANEL 4 CCS technology – recent developments and opportunities	• **Takaya Watanabe**, MHI • **Dr Elizabeth Burton**, Lawrence Berkeley National Laboratory and California Energy Commission • **Dr Kunwoo Han**, Research Institute of Industrial Science and Technology (RIST)
	1900 – 2200	Conference Dinner	
FRIDAY 11 OCTOBER	0830 – 0930	Delegate registration	
	0930 – 1030	Institute AGM (Member representatives only)	
	1030 – 1040	Morning break	
	1040 – 1140	PANEL 5 CCS projects in action	• **Dr Chong Kul Ryu**, Korea Electric Power Research Institute (KEPRI) • **Dr Gao Ruimin**, Yanchang Petroleum • **Professor Jon Gibbins**, University of Edinburgh
	1140 – 1240	PANEL 6 The case for equal policy treatment of CCS with other clean energy technology options	• **Jeff Chapman**, Carbon Capture and Storage Association • **Dick Wells**, National CCS Council (Australia) • **Matthew Billson**, Department of Energy and Climate Change (United Kingdom)
	1240 – 1250	Closing remarks	**Brad Page**, CEO
	1250 – 1340	Delegate Lunch	

附件二、GCCSI 歷年會議重點摘錄

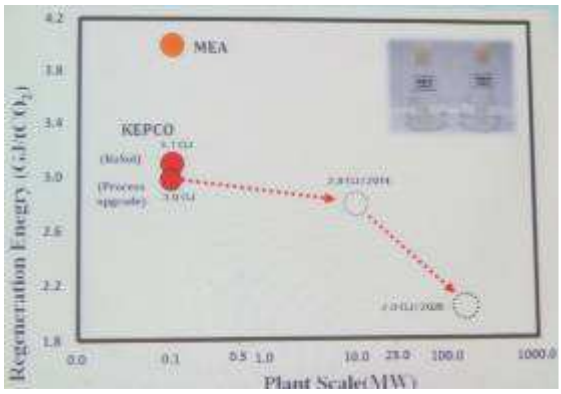
年度	會議 地點	會議報告與結論	會議討論重點
2009	堪培拉 澳洲	• 起始會議，確認研究所各項研究目標和成員相關訊息。	• 研究所成立目標確立與規劃
2010	京都 日本	• 目前全球政府及企業對 CCS 規劃多屬於示範場規劃階段。 • 安全性、建設與營運成本、捕集技術的開發為發展重點。 • 尚需要顯著的財政和補貼支持 • 全球試驗計畫正蓬勃發展，至 2010 年共有 234 個計畫規劃 • 許多不確定性仍存在(場址安全、技術、政策等)	• 全球推行現況 • 示範計畫調查 • 示範場址介紹(長岡)
2011	卡加利 加拿大	• 目前發現 EOR 是一項具有誘因的成功因素之一。 • 仍需要政府的資金支持以及明確政策方向。 • CCS 已經列入 CDM 之方法學中，為 CCS 推行提供助力。	• 全球推行現況 • 國際政策推行 • CCS 未來走向
2012	日內瓦 瑞士	• CCS 確實為減緩全球暖化之工具，初步已有成效並有迫切執行的必要，但全球的 CCS 計畫目前推行相對緩慢 • 需要政策與獎勵措施推動 • 技術上仍有些障礙需要解決以加速推動 • 需要經由示範計畫改善並降低成本 • 共享知識平台的建立對發展具有相當幫助	• 全球推行狀況 • 減碳成效確立 • CCS 助益 • 經驗與知識分享 • 知識分享平台

附件三、保寧(Boryeong)電廠 CCS 資訊

- 總發電量：5,358MW
- 韓國電力公社研究所參與規劃(KEPRI)
- 計畫期程：2011-2014
- 總經費：3,850 萬美元
- 計畫研究目標：
  - ✧ 發展再生胺基溶劑並較 MEA 排放減少至少 30%(3.6 and 3.9 GJ / t CO2)。
  - ✧ 發展燃燒後捕集技術，從 0.1MW 之試驗床逐步升級至 10MW 之試驗廠

第一階段試驗已成功完成(2013/10)，未來將著重放大規模至試驗場並於 2015-2020 年間商轉。近年將有擴廠計畫(1000MW 二座)，透過捕集減少排放衝擊。目前捕集後並未封存，將其還原排放回大氣，韓國封存規劃於 2016 年進行。

保寧電廠技術中長程目標

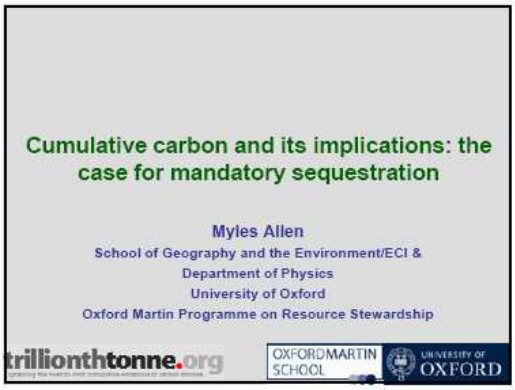


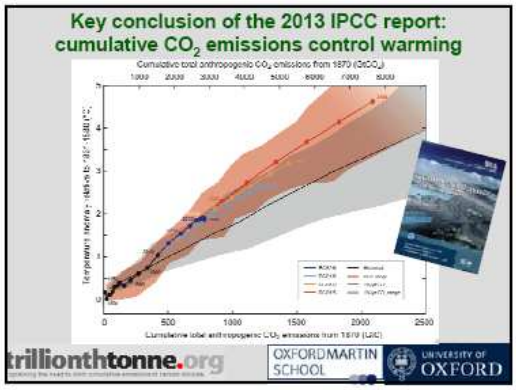
保寧電廠吸附材料研究目標

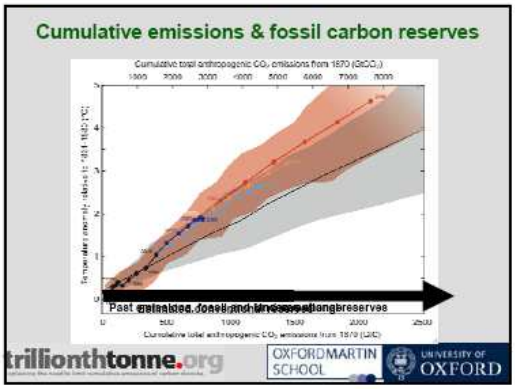
附件四、GCCSI 國際專家背景資料

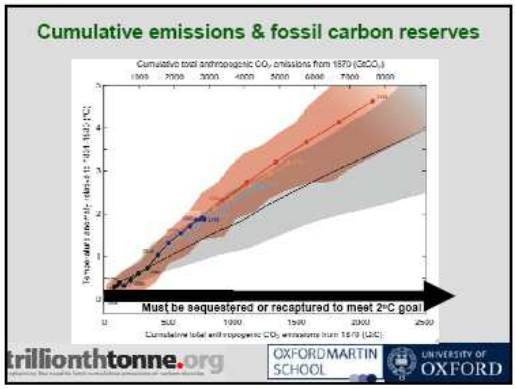
拜會對象	背景介紹
Brad Page 	**服務單位與職稱：** Global CCS Institute(GCCSI), 執行長 **專長背景：**能源專長、能源規劃 **介紹:** Mr. Page 曾任職於澳洲能源供應協會(Energy Supply Association of Australia, esaa)長達七年並擔任該協會的發言人，在此期間代表該協會多次參與澳洲氣候變遷圓桌會議等業務。此外，參與該協會前，Mr. Page 也積極參與澳洲政府推動的微經濟改革措施包含澳洲電力市場與天然氣管線三方驗證等。另其也多次輔導澳洲中小型能源產業發展。在各項能源與經濟專長下，於 2011 年 8 月出任 GCCSI 總裁一職。
Barry Jones 	**服務單位：** Global CCS Institute(GCCSI) 總經理(政策與會員) **專長背景：** 公共政策、產業政策、氣候變遷政策 **介紹：** Barry Jones 畢業於澳洲大學公共政策研究所，其曾任職於澳洲多間公司總裁及澳洲旅遊局研究單位董事長，在政府政策、研究以及商業服務上具有廣泛經驗。曾在能源、資源、氣候變化、旅遊、產業政策，及中小型企業問題等領域推動相關政策與策略。經由策略規劃與推動經驗，Barry Jones 於 2011 年 8 月出任 GCCSI 總經理一職。

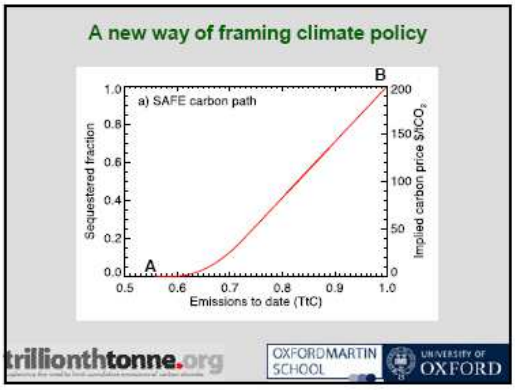
附件五、與會專家簡報資料

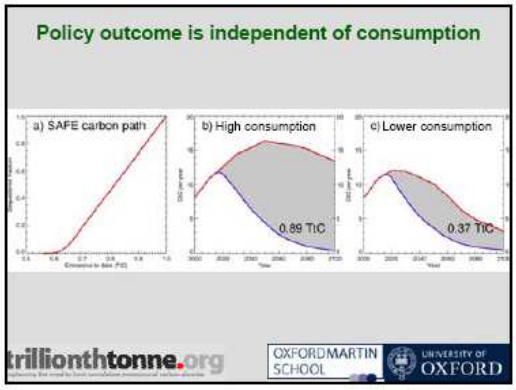












Mandatory sequestration works

Gorgon gas project, Western Australia

trillionthtonne.org

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trillionthtonne.org

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Thank you

myles.allen@ouce.ox.ac.uk

trillionthtonne.org

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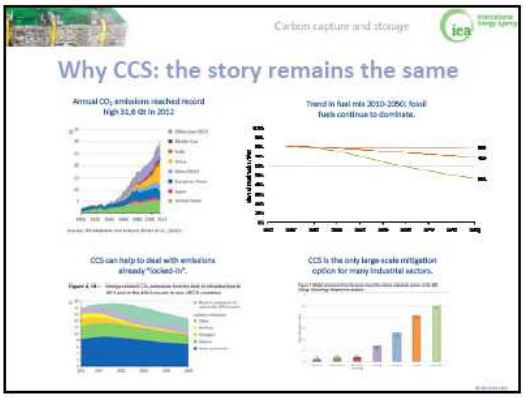
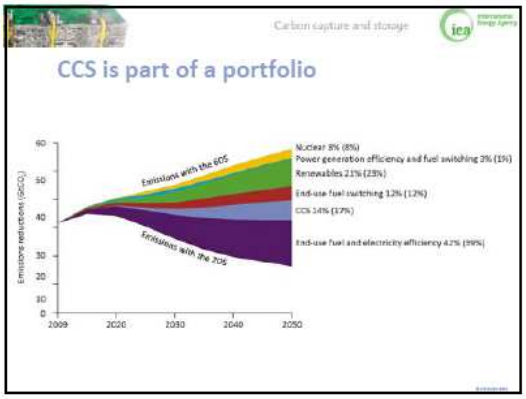
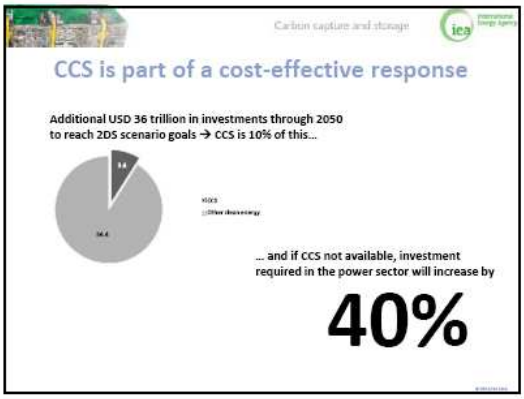
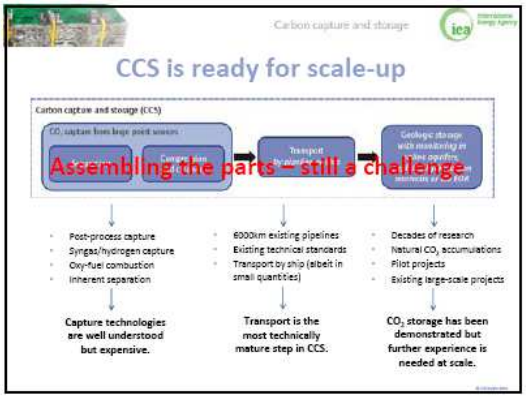
Carbon capture and storage
Technology Roadmap
CCS: Where do we go from here?
GCCSI Members' Meeting, Seoul, 10 October 2015
Philippe Benoit
Head of Division, IEA

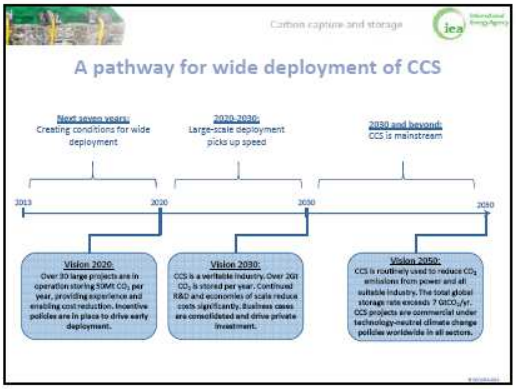

Carbon capture and storage
Why CCS: the story remains the same
Annual CO2 emissions reached record high 31.6 Gt in 2012
Trend in fuel mix 2010-2050: fossil fuels continue to dominate.
CCS can help to deal with emissions already "locked-in".
CCS is the only large-scale mitigation option for many industrial sectors.

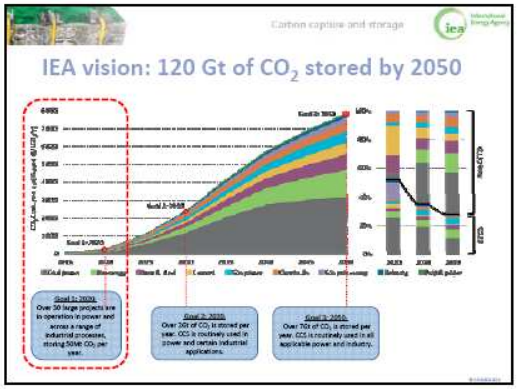

Carbon capture and storage
CCS is part of a portfolio
Emissions with the 6DS
Emissions with the 2DS
Nuclear 3% (8%)
Power generation efficiency and fuel switching 3% (1%)
Renewables 21% (23%)
End-use fuel switching 12% (12%)
CCS 14% (17%)
End-use fuel and electricity efficiency 42% (39%)
Emissions reductions (GtCO2)
2009
2020
2030
2040
2050

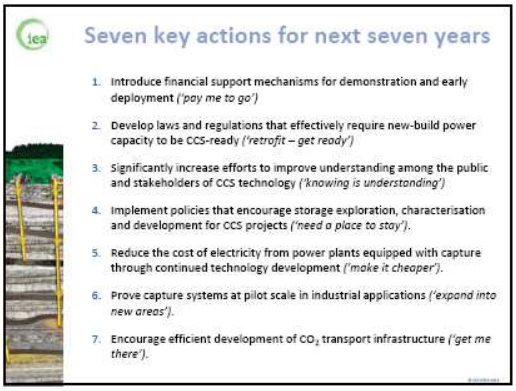

Carbon capture and storage
CCS is part of a cost-effective response
Additional USD 36 trillion in investments through 2050 to reach 2DS scenario goals → CCS is 10% of this…
… and if CCS not available, investment required in the power sector will increase by
40%


Carbon capture and storage
CCS is ready for scale-up
Carbon capture and storage (CCS)
Assembling the parts – still a challenge
Post-process capture
Syngas/hydrogen capture
Oxy-fuel combustion
Inherent separation
Capture technologies are well understood but expensive.
6000km existing pipelines
Existing technical standards
Transport by ship (albeit in small quantities)
Transport is the most technically mature step in CCS.
Decades of research
Natural CO2 accumulations
Pilot projects
Existing large-scale projects
CO2 storage has been demonstrated but further experience is needed at scale.

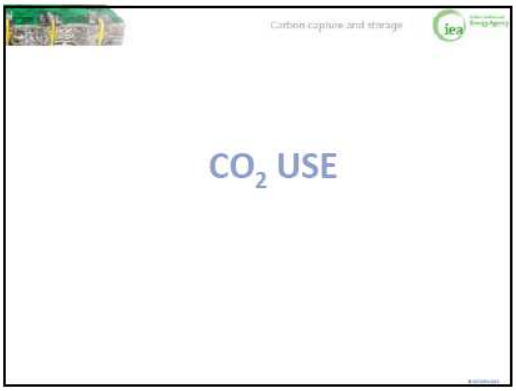

Carbon capture and storage
A roadmap forward
Technology Roadmap
Carbon capture and storage


Carbon capture and storage
A pathway for wide deployment of CCS
Next seven years:
Creating conditions for wide deployment
2020-2030:
Large-scale deployment picks up speed
2030 and beyond:
CCS is mainstream
2013
2020
2030
2050
Vision 2020:
Over 30 large projects are in operation storing 50Mt CO_2 per year, providing experience and enabling cost reduction. Incentive policies are in place to drive early deployment.
Vision 2030:
CCS is a verifiable industry. Over 2Gt CO_2 is stored per year. Continued R&D and economies of scale reduce costs significantly. Business cases are consolidated and drive private investment.
Vision 2050:
CCS is routinely used to reduce CO_2 emissions from power and all suitable industry. The total global storage rate exceeds 7 $GtCO_2$/yr. CCS projects are commercial under technology-neutral climate change policies worldwide in all sectors.


Carbon capture and storage
IEA vision: 120 Gt of CO_2 stored by 2050
Goal 1: 2020:
Over 50 large projects are in operation in power and across a range of industrial processes, storing 50Mt CO_2 per year.
Goal 2: 2035:
Over 2Gt of CO_2 is stored per year. CCS is routinely used in power and certain industrial applications.
Goal 3: 2050:
Over 7Gt of CO_2 is stored per year. CCS is routinely used in all applicable power and industry.


Seven key actions for next seven years
1. Introduce financial support mechanisms for demonstration and early deployment (*'pay me to go'*)
2. Develop laws and regulations that effectively require new-build power capacity to be CCS-ready (*'retrofit – get ready'*)
3. Significantly increase efforts to improve understanding among the public and stakeholders of CCS technology (*'knowing is understanding'*)
4. Implement policies that encourage storage exploration, characterisation and development for CCS projects (*'need a place to stay'*).
5. Reduce the cost of electricity from power plants equipped with capture through continued technology development (*'make it cheaper'*).
6. Prove capture systems at pilot scale in industrial applications (*'expand into new areas'*).
7. Encourage efficient development of CO_2 transport infrastructure (*'get me there'*).

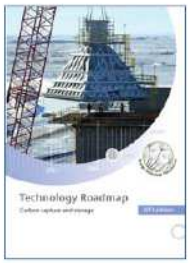

Carbon capture and storage
OUTREACH TO THE PUBLIC


Carbon capture and storage
CO_2 USE


Carbon capture and storage
Moving upstream to
FOSSIL FUEL production

Energy Efficiency and Renewable Energy NOT ENOUGH

Increase AMBITION



DOWNLOAD THE ROADMAP AT:
http://www.iea.org/topics/ccs/ccsroadmap2013

THANK YOU!

philippe.benoit@iea.org

Australian Government
Department of Industry

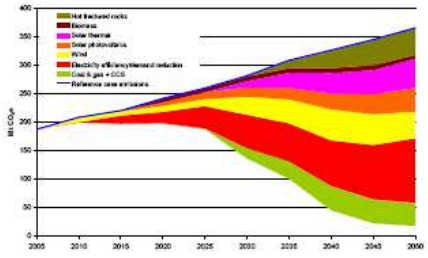
TACKLING CLIMATE CHANGE AND ENSURING ENERGY SECURITY – THE ROLE OF CCS

Dr Subho Banerjee / Deputy Secretary

Global Status of CCS Conference
10 October 2013

Australian Government
Department of Industry

In any scenario, CCS is a part of a portfolio of solutions



Source: CSIRO Sept 2009

Australian Government
Department of Industry

Australia's CCS story from R&D through to commercialisation

Australian Government
Department of Industry

Australian government and industry partnerships

South West hub

Gorgon CO_2 injection Project

Callide Oxyfuel project

Australian Government
Department of Industry

Moving forward, we need to focus on two questions:

1. How can we continue to demonstrate tangible progress on the ground?
2. How can we continue to improve international collaboration?

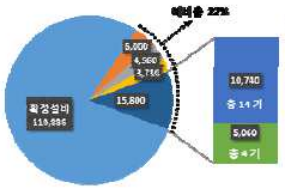
CCS Policy & Cooperation

Current Status and Outlook of CCS in Korea

October 10, 2013

Prof. Chonghun Han
Seoul National University (KCCSA)

6th Electricity Supply Plan: More New Fossil Fuel Power Plants



New Power Plants

14 Coal-fired

4 Natural Gas

KCCSA

Major Carbon Gas Emission Sources in Korea

Cement

40 million tons/yr

Iron & Steelmaking

Posco Kwangyang

3.2 million tons/yr

Power Plants

Kepco 158 million tons/yr

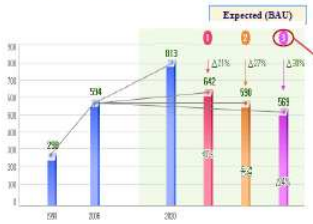
Petrochemical

40 million tons/yr

KCCSA

Korean National Plan for Reduction of CO2 Emission

- South Korea : 8th Most GHG Emitting Country (2009)
- Emission Reduction Target :
  BAU 30% Reduction of CO2 Emission by 2020 (Nov. 2009)



KCCSA

Korean National Roadmap for CCS (2009)

KCCSA

CO2 Capture Projects in Korea

Post-combustion, wet solvent

10MW
Boryeong
(2011~2014)

Post-combustion, dry sorbent

10MW
Hadong
(2011-2014)

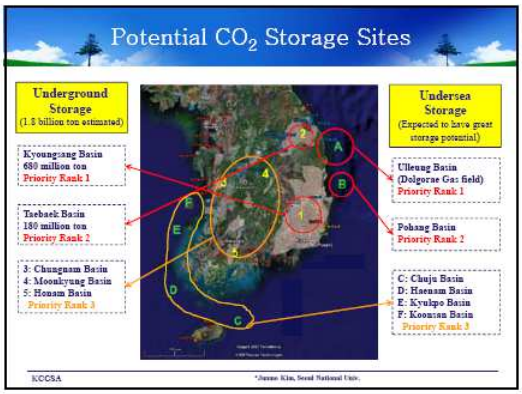
Oxy-fuel combustion

150MW
dual slip str
Yeongdong
(2010~2012)

Pre-combustion,

5~10Mw
(with 150Mw
IGCC)
Taean
(2011~2015)

KCCSA


Potential CO_2 Storage Sites
Underground Storage
(1.8 billion ton estimated)
Kyoungsang Basin
680 million ton
Priority Rank 1
Taebaek Basin
180 million ton
Priority Rank 2
3: Chungnam Basin
4: Moonkyung Basin
5: Honam Basin
Priority Rank 3
Undersea Storage
(Expected to have great storage potential)
Ulleung Basin
(Dolgorae Gas field)
Priority Rank 1
Pohang Basin
Priority Rank 2
C: Chuju Basin
D: Haenam Basin
E: Kyukpo Basin
F: Koonsan Basin
Priority Rank 3
KCCSA


CCS Plan in Korea
Taeahn 150MW
Precombustion, IGCC
Younddong 150MW
Oxyfuel combustion
by Ship
By Pipeline
Koonsan Basin
Ulleung Basin
Hadong 10MW
Postcombustion
Cheju Basin
Boryung 10MW
Postcombustion, Wet Amine
주요 배출원
주요 저장지


Industrial Applications of CCS in Korea
As alternatives for storage…
CO2 capture in Steel industry (POSCO)
[27 million(USD), 2009~2014]
- Capture CO2 from blast furnace using ammonia liquid (10 ton/day, 0.5MW equiv)
- Purification/liquefaction process integrated with capture facility
- Production of liquid CO2 using the capture facility (3 ton/day)
CO2 conversion using microalgae (Korea District Heating Co.)
[11 million(USD), 2012~2017]
-CO2 fixation through microalgae photosynthesis
- Conversion of CO2 into high value-added products (astaxanthin)
- Developing photo-culture process (1 ton)
Green Polymer (SK)
- Convert CO2 into polymerized compound and produce plastic
- Aims for commercialization in 2014
KCCSA


Korea CCS Association (KCCSA)
National CCS Master Plan
(2010. 7)
Goal and Roles (KCCSA)
KCCSA
Presidential Committee on Green Growth
CCS R&D Center
CCS Environmental Center
Regulatory /Incentive System
International Collaboration
Demonstration & Commercialization
Sharing & Networking
Promotion & Expansion


Members of KCCSA:
All Major Players in Korea
CO_2 EMISSION
CO_2 CAPTURE
CO_2 TRANSFER
CO_2 STORAGE
Korea National Oil Corporation
* Newsletter recipients (bimonthly): 62,000
KCCSA


Active Participation in
International CCS Networks
KCCSA

Summary

- CCS will play an important role in CO2 emission reduction.
- Large scale integration projects (LSIP) may be postponed until international regulation on CO2 emission is to be effective.
- Capture-Ready may be required for new power plants in the future.
- Korea will keep investing in CCUS R&D.
- Korea needs international collaboration in CCS in general, and Storage in particular.

KCCSA

Thank you

- Email : kccsa@kccsa.or.kr
- Tel : +82-2-888-1022
- KCCSA Homepage
  http://www.kccsa.or.kr/

CCS Activities in Developing Asia–
Insights and Next Steps

Ashok Bhargava
Director, Energy Division
East Asia Department

Seoul, 10 October 2013

ADB

ADB CCS Fund

- In June 2009, ADB established a CCS Fund with an initial contribution of AUD 21.5 million from the Global CCS Institute, Australia. In 2012, Government of the United Kingdom also pledged £35 million in the fund.
- **Specific Eligibility Criteria**
  - Accelerate demonstration of CCS technologies
  - Identify, lower and / or eliminate general or country specific barriers for CCS demonstration
  - Identify, eliminate or mitigate risks in capture, transport and storage technology demonstration

ADB

… in the People's Republic of China

ADB

PRC – Overview of ADB Activities
Capacity Development and Policy Advisory Assistance

• Key Partner	Department of Climate Change, NDRC
• Target three major capture technologies	China Huaneng : pre-combustion capture – IGCC
	China Datang : post-combustion capture - natural gas plant
	Dongfang Boiler – Oxy-fuel combustion capture - coal-based power plant

Support upstream analytical work, analyze issues, identify costs and risks on real projects

ADB

PRC – Overview of ADB Activities
Develop CCS Roadmap

- Aims to develop a key planning tool for the Government to demonstrate and deploy CCS

- Includes following major outputs
1. Time bound action plan for demonstration (up to 2020) and deployment (up to 2025)
2. A policy and regulatory framework with an accompanying set of incentives
3. Shortlist and ranking of early-stage CCS demonstration projects
4. Suitable business models for implementing early-stage projects

Establish enabling environment for CCS demonstration and possible deployment.

ADB

Next Steps in the PRC …….
Pilot Project

ADB

Next Steps ……
Pilot CCS Project at Tianjin IGCC Power Plant

- Capture up to 100,000 tons CO_2 / year to partially used for EOR and partially for storage
- Due diligence is underway: power and oil company collaboration proving difficult
- ADB may provide up to $10 million grant for CapEx and a compensatory mechanism to offset energy penalty
- Pilot project likely to be in operation by 2015

ADB

Next Steps ……
FEED Studies for a large-scale CCS project

- Need to scale-up CCS efforts urgently
- Discussions underway to select one of the early-stage projects identified through the ongoing CCS road map work

ADB

What have we learned so far in the PRC

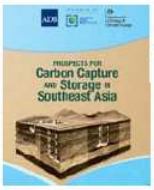
- Technical readiness
- Weak policy support
- Fragmented institutional setup across CCS chain
- Need for public financing

- In-country technical capacity exists; large number of point sources in close proximity to potential storage sites
- CCS is not a strategic choice; no national target, incentives or support mechanism in place.
- Negligible cooperation between power and oil companies not conducive for CCS
- Early projects will need risk sharing or preferably risk bearing by the Government

ADB

Moving on to Southeast Asia ……

Potential for CCS in Southeast Asia



- A regional study with focus on Thailand, Vietnam, Indonesia, Philippines completed recently
- **Study aimed to:**
  i. Establish inventory of CO_2 emission sources
  ii. Estimate storage potential
  iii. Determine source-sink matches for CCS
  iv. Identify potential pilot projects
  v. Propose Road Map for CCS development
  vi. Develop "CCS Working Groups" which could provide leadership on CCS

ADB

Potential for CCS in Southeast Asia - Main Results

- Sufficient capture streams are available

Annual inventory of 200 million tons of CO_2 emissions from sources (coal and gas power plants, natural gas processing facilities, future power plants, and smaller sources such as fertilizer plants)

- Natural gas processing and new power plants are best sources for capture

Natural gas processing facilities are preferred because of lower incremental cost of capture, storage site proximity, and existing transport infrastructure

ADB

Potential for CCS in Southeast Asia - Main Results….contd

- Large storage capacity

Estimated storage capacity of 56 giga tons of which about 90% is in saline aquifiers. But due to uncertainties of aquifiers, study concentrated on oil and gas fields

- Large number of oil and gas fields provide adequate storage for early stage projects

143 oil and gas fields offer more than 3 giga tons of capacity. Since the geology is well understood of these fields, they were ranked for early stage projects.

ADB

Potential for CCS in Southeast Asia - Main Results….contd

Carbon Capture and Storage Opportunities in the Focus Countries

Item	Natural Gas Processing	Supercritical Pulverized Coal	Natural Gas Combined-Cycle
Capture Opportunities			
Indonesia	Potential existing source identified	Potential existing source identified	
Philippines		Potential existing source identified	Potential existing source identified
Thailand	Potential existing source identified	Potential existing source identified	Potential existing source identified
Viet Nam	Potential future sources from new high CO_2 gas fields	Potential future source identified	Potential future source identified
Storage Sites with Enhanced Oil Recovery Potential			
Indonesia	Potential existing site identified		
Philippines	Non immediately available/potential nonconventional storage sites recommended for more detailed analysis		
Thailand	Potential existing site identified		
Viet Nam	Potential existing site identified		

ADB

Next step in Southeast Asia Region – Pilot Project in Indonesia

- Collaborative approach

Collaboration with JICA, Pertamina, and Institut Teknologi di Bandung

Follows on a JICA scoping study ($5 million, 5-year) at Gundih gas field in Central Java

- Due diligence support

ADB to provide due diligence support to PERTAMINA to review preliminary design of surface facilities for test injection, identify legal and regulatory issues and develop regulations and apply for permits as appropriate.

- Pilot project financing support

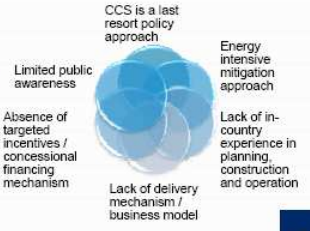
ADB may follow with a $10 million grant for capture and test injection from its CCS Fund

ADB

What did we learn so far in developing Asia for CCS …….

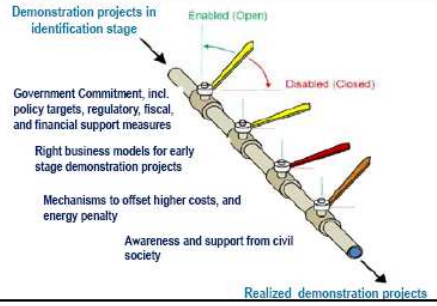
Key Issues and Barriers

ADB (2011): "… key barriers to CCS are amplified in developing countries …."



ADB

Way Forward



THE CARBON BUDGET

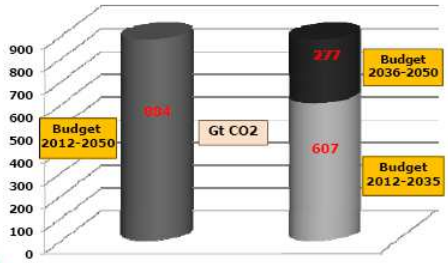
To prevent global temperatures from rising above any given level there is one cumulative budget for all future GHG emissions.

This is not an annual budget; it is a single budget for the future

that we can spend only once.

IEA 2° Energy CO2 Budget

50% chance of exceeding 2°

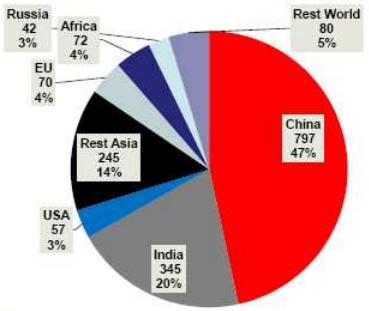


Source: IEA, WEO 2012

Lock-in from Coal Power

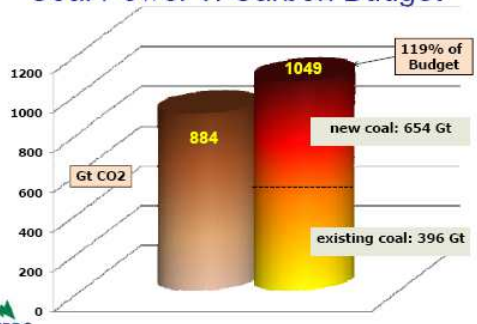
- Large budget lock-in from:
  - existing coal plants
  - and new planned coal plants

New Coal Build 2012-2035: CPS (1709 GW)



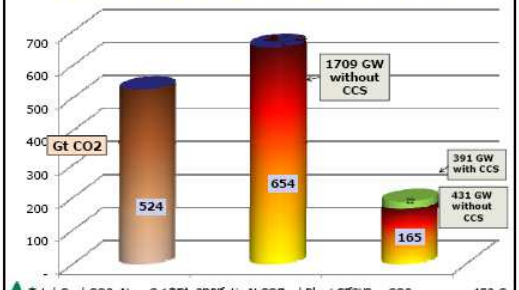
Source: IEA, WEO 2012

Coal Power v. Carbon Budget



Based on IEA, WEO 2012

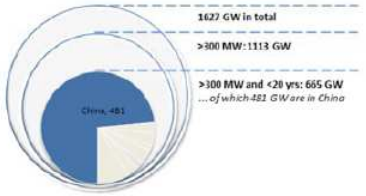
Cutting CO2 Lock-in from New Coal



Source: IEA, WEO 2012

Prime CCS Retrofit Candidates

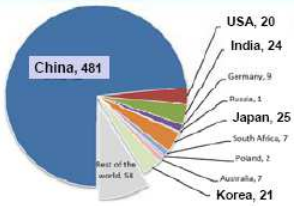
Figure 9 • Installed total coal-fired power plant capacity in all countries and breakdown by age and capacity



Source: IEA CCS Retrofit Paper, 2012

Prime CCS Retrofits by Country

Figure 10 • Breakdown of young (<20 years) and large (>300 MW) coal-fired power plants



Source: IEA CCS Retrofit Paper, 2012

Carbon/Energy Impacts of CCS

- Cut CO2 from new fossil sources
- Cut CO2 from existing sources pre-retirement
- Create space in the budget for easier transition away from oil.
- Reduce bio-energy pressure on forested lands

Proposed CO2 Stds – New Power Plants

- New NGCC: 1000 lbs/MWh
- New Coal: 1000-1100 lbs/MWh
- Coal limit based on use of partial CCS
- CAA does not require EPA to show a technology is in commercial use at current power plants.
- EPA estimates LCOE of coal with partial CCS:20% more than SCPC w/out EOR; +/-5% with EOR sales
  (SCPC: $92; SCPC+CCS (no EOR):$110; SCPC+CCS+EOR:$88-96;Nuclear:$107)

CO_2 Standards for *Existing* Plants

- 2.4 billion tons CO_2 from existing plants each year
- Clean Air Act requires CO_2 standards for existing plants (Section 111(d))
- EPA sets performance standards; states implement through SIPs
- Proposal 6/14; Final 6/15; SIPs due 6/16

NRDC PROPOSAL: LARGE BENEFITS, LOW COSTS

Pollution cuts: 560 million tons less carbon pollution in 2020; twice the reductions from the clean car standards

Health protections: up to 3,600 lives saved, and thousands of asthma attacks and other health incidents prevented in 2020 alone

Clean energy investments: $90 billion in energy efficiency and renewables investments between now and 2020

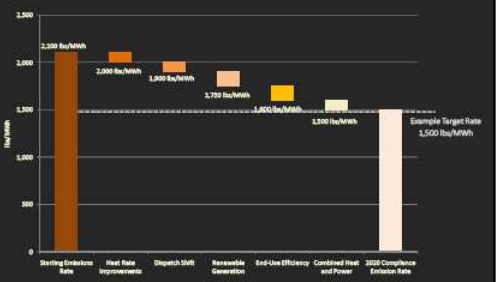
Low costs: only $4 billion in compliance costs in 2020

Large benefits: $25-60 billion value of avoided climate change and health effects in 2020

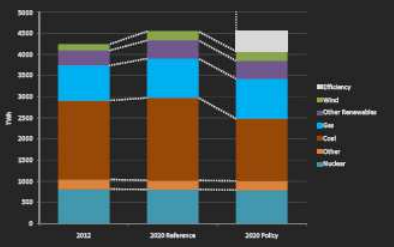
POLICY DESIGN
STRONG STANDARDS, MAXIMUM FLEXIBILITY

- **FAIR:** State-specific fossil-fleet average CO_2 emission rate standards
  - Different standard for each state, recognizing differences in baseline coal/gas generation mix
  - All fossil fuel generators within a state subject to same lbs/MWh standard in 2020 and 2025
- **FLEXIBLE:** Full range of emission reduction measures count
  - Reducing heat rates at individual power plants
  - Shifting dispatch from high-emissions to low-emissions units
  - Credit for incremental renewables and energy efficiency
  - States may opt in to interstate averaging or credit trading
  - States may adopt alternative compliance plan that achieves equivalent emission reductions

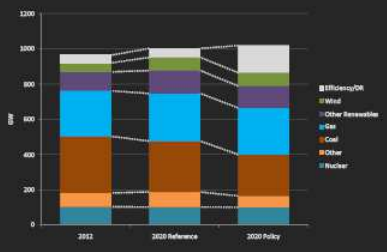
FLEXIBLE COMPLIANCE OPTIONS



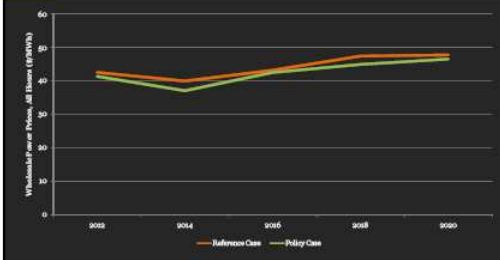
PROJECTED GENERATION CHANGES IN THE U.S. POWER SECTOR



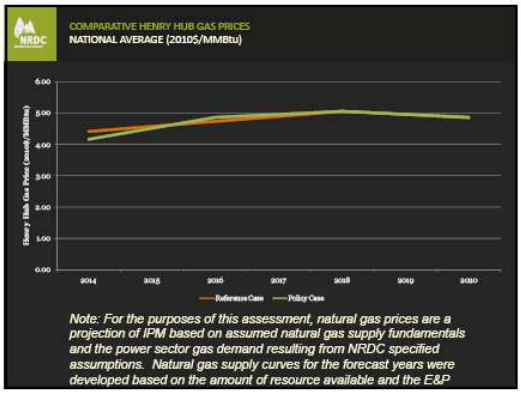
PROJECTED CAPACITY CHANGES IN THE U.S. POWER SECTOR

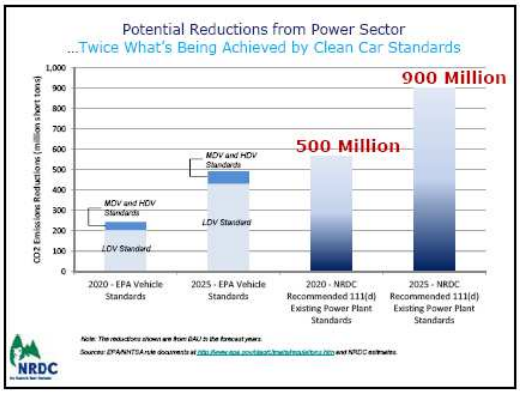


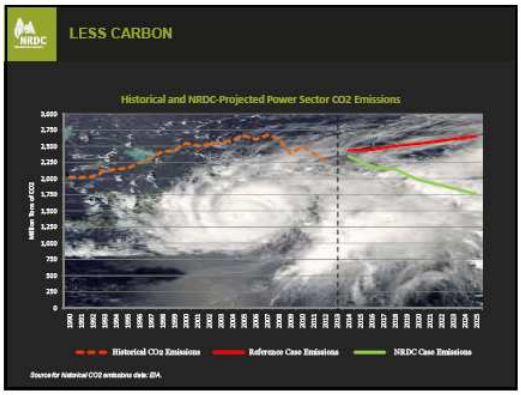
COMPARATIVE WHOLESALE POWER PRICES
FIVE-REGION AVERAGE (2010$/MWh)

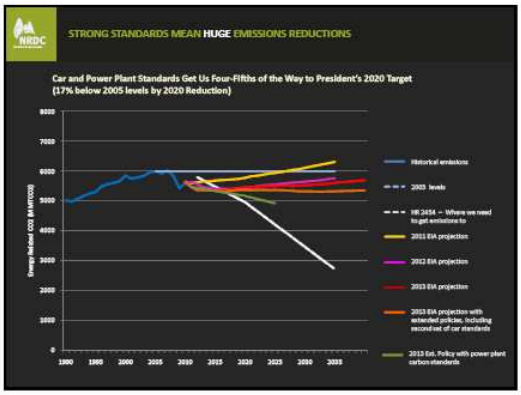


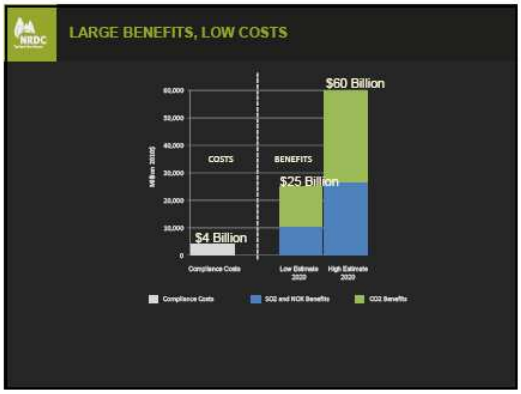
Note: Generation-weighted average of PJM, Southeast (excluding Florida), MISO, NYISO, ISO-NE, accounting for 60% of national generation

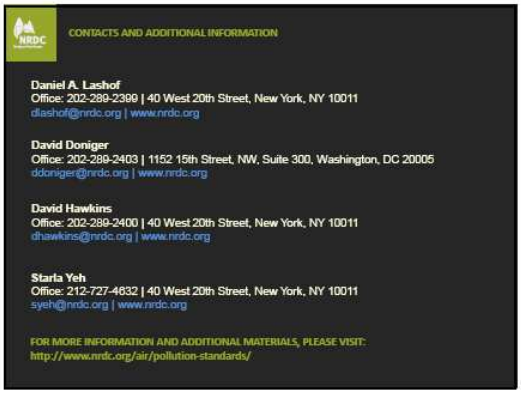

COMPARATIVE HENRY HUB GAS PRICES
NATIONAL AVERAGE (2010$/MMBtu)
Henry Hub Gas Price (2010$/MMBtu)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
2014
2015
2016
2017
2018
2019
2020
Reference Case
Policy Case
Note: For the purposes of this assessment, natural gas prices are a projection of IPM based on assumed natural gas supply fundamentals and the power sector gas demand resulting from NRDC specified assumptions. Natural gas supply curves for the forecast years were developed based on the amount of resource available and the E&P


Potential Reductions from Power Sector
...Twice What's Being Achieved by Clean Car Standards
CO2 Emissions Reductions (million short tons)
1,000
900
800
700
600
500
400
300
200
100
0
900 Million
500 Million
MDV and HDV Standards
LDV Standard
MDV and HDV Standards
LDV Standard
2020 - EPA Vehicle Standards
2025 - EPA Vehicle Standards
2020 - NRDC Recommended 111(d) Existing Power Plant Standards
2025 - NRDC Recommended 111(d) Existing Power Plant Standards
NRDC


LESS CARBON
Historical and NRDC-Projected Power Sector CO2 Emissions
Million Tons of CO2
Historical CO2 Emissions
Reference Case Emissions
NRDC Case Emissions


STRONG STANDARDS MEAN HUGE EMISSIONS REDUCTIONS
Car and Power Plant Standards Get Us Four-Fifths of the Way to President's 2020 Target
(17% below 2005 levels by 2020 Reduction)
Historical emissions
2005 levels
HR 2454 – Where we need to get emissions to
2011 EIA projection
2012 EIA projection
2013 EIA projection
2013 EIA projection with extended policies, including reconsiderat of car standards
2013 Est. Policy with power plant carbon standards


LARGE BENEFITS, LOW COSTS
$60 Billion
COSTS
BENEFITS
$25 Billion
$4 Billion
Compliance Costs
Low Estimate 2020
High Estimate 2020
Compliance Costs
SO2 and NOX Benefits
CO2 Benefits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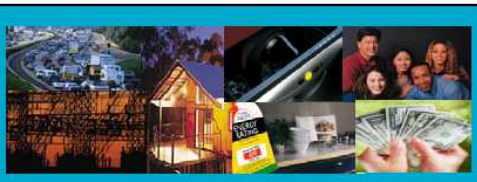
FOR MORE INFORMATION AND ADDITIONAL MATERIALS, PLEASE VISIT:
http://www.nrdc.org/air/pollution-standards/



Delivering collaboration for CCS deployment

Peta Ashworth| Group Leader, Science into Society
10th October 2013

EARTH SCIENCE AND RESOURCE ENGINEERING

What is collaboration?

- **Collaboration** is working with each other to do a task and to achieve shared goals. It is a recursive process where two or more people or organizations work together to realize shared goals (this is more than the intersection of common goals seen in co-operative ventures, but a deep, collective, determination to reach an identical objective) — for example, an endeavor that is creative in nature—by sharing knowledge, learning and building consensus.
- **Related words:** co-operation, coordination

Source: http://en.wikipedia.org/wiki/Collaboration

Building a house

Some questions you might ask

- Do I like the neighbourhood?
- What is the reputation of the builder/company?
- Did someone recommend them to me?
- Do they have the capability?
- Do I like what they do?
- Can I trust them?
- Is it value for money?
- Can I contact them easily?
- What will my friends and family think?

A framework of interactions for CCS projects

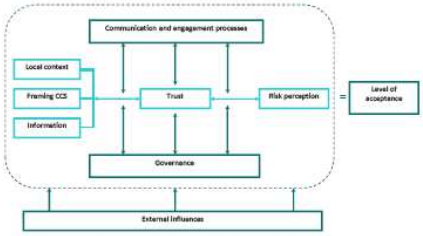


Figure 1 A framework of interactions for CCS projects

Transparency

We did not start with a long term policy of **transparency** in our process and this is possibly one of the most important things .....
you need it to engage the public for their support and without it, it won't progress

Key Energy Leader, July 2013

Building Trust

- Share information
- Share responsibility
- Seek mutual understanding
- Concentrate on relationships
- Acknowledge different sources of power
- Be transparent about decision-making
- Use a neutral facilitator

GLOBAL CCS INSTITUTE

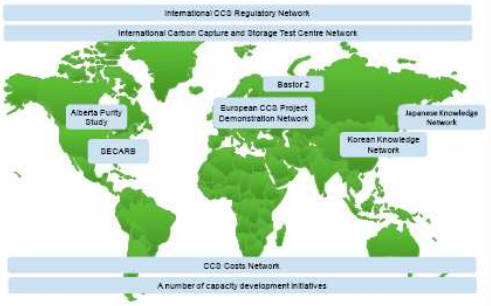
Delivering collaboration to ensure the safe and effective deployment of CCS: Knowledge Networks

Sean McClowry
General Manager - Information Management, Global CCS Institute
October 2013

Introduction

- Status of knowledge sharing
- International knowledge sharing
- Improving knowledge sharing

Many CCS knowledge networks exist, examples include



Networks are hard work, global networks are harder

- If knowledge networks are not designed or managed properly, little tends to be achieved.
- Many knowledge networks have a country or regional focus.
- We need to improve international knowledge sharing, but:
  - International knowledge sharing can be more difficult
  - Barriers to sharing are more significant and the incentives fewer.
- We need to follow the lessons learnt from our most successful networks.

How we can improve international knowledge sharing

Clear outcomes
- Focus the network on solving problems in a collaborative way.
- Clearly identify knowledge gaps and areas of expertise.

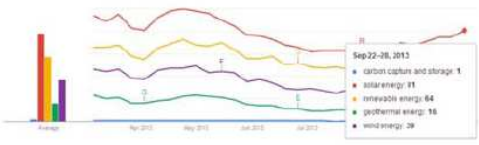
Practical approaches to information sharing
- Remove the focus on sharing confidential information (CI).
- Leverage the large amounts of public information already available.

Digital technology for better connectivity
- Use advanced digital technologies for international knowledge sharing.
- Make use of the digital systems of the Global CCS Institute.

Engagement outside the CCS community
- Some content from the network should be written for an external audience.
- Promoting key content to non-CCS practitioners should be a key priority.

Engagement outside the CCS community: web context

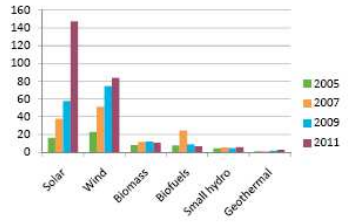
There is very little interest in CCS information compared with renewables.



Source: Google Trends

Engagement outside the CCS community: $ context

Not surprisingly, investments track interest from the public.



Source: http://fs-unep-centre.org/publications/global-trends-renewable-energy-investment-2012

Closing recommendations

- International knowledge sharing can work, if we:
  - Build on our existing networks,
  - Leverage existing frameworks and digital platforms.
- To drive CCS forward it is important to engage beyond our immediate community:
  - The web offers many opportunities to do this effectively.
- The Institute has new initiatives underway that we think can help solve this problem.

GCCSI, The Global Status of CCS 2013, Seoul, October 9-11

EOR/CCS & Clean Coal Project in Asia

EOR/CCS Project, as Low Carbon Infrastructure, is a key for Clean Coal Project in Asia

250MW IGCC Power Plant, Nakoso (Japan)

MITSUBISHI HEAVY INDUSTRIES, LTD.

Today's Topic

Main Focus in this presentation:

- Market : Asian Coal Rich Countries
- Technology : Coal Gasification & EOR/CCS
- Live Stock: Low Rank Coal
- Case Study: Indonesia SNG Project

Conclusion of this presentation :

EOR/CCS Demonstration Project, as Low Carbon Infrastructure, is a key for introducing Commercial Clean Coal Project to Asia

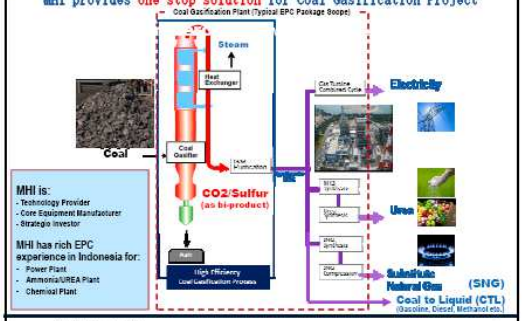
Clean Coal Technology

MHI provides one stop solution for Clean Coal Power Generation

Technology Provider/Core Equipment Supplier/EPC Contractor

Coal Gasification Technology

MHI provides one stop solution for Coal Gasification Project



MHI is:
- Technology Provider
- Core Equipment Manufacturer
- Strategic Investor

MHI has rich EPC experience in Indonesia for:
- Power Plant
- Ammonia/UREA Plant
- Chemical Plant

Ready for Commercial (250 MW IGCC Demonstration Completed)

Nakoso 250MW IGCC Plant, Japan

Successful Demonstration Result			
Performance	Output	250MW(*)	
	Efficiency	42.0% (*)	
	Carbon Conversion	> 99.0%	
Emission	Sox Nox Dust	All Japanese Emission Regulations have been cleared	
Operational Flexibility	Fuel	Design Coal: China Tested: PRB (USA) Indonesia, Columbia and other 6 coals	
	Minimum Load	98%	
	Ramping Rate	3%/min	

(*)Due to Grid requirements, Capacity was limited to 250MW at Nakoso. For a Commercial IGCC, MHI standard design is 500MW Class & 40% efficiency.

- A single EPC Contract (Engineering, Procurement & Construction) by MHI
- Plant construction completed in 2007 (fund: 30% Government Grant, 70% Utility Companies)
- All Demonstration Tests (incl. Long Term/Continuous Operation Test) successfully completed in 2007-2012
- In March 2013, the plant was sold to a private utility and currently running as a commercial power plant

MHI Coal Gasification Technology is ready for "Commercial" application

CO2 Off-Taker is a Key for Coal Gasification Project

- Many Studies for Coal Gasification Project have been conducted but only a few have proceeded to FEED/EPC Phase.
- For the case of MHI, 12 studies have been conducted in last 3 years, and only one (1) project in U.S. (HECA IGCC/Fertilizer Project) has gone to FEED Stage
- Many say " High Cost of Coal Gasification Technology is the issue". MHI disagree.
- In several studies, the conclusion was "Coal Gasification Project is commercially feasible" but the project development was on-hold due to:
  - Non-availability of FEED sponsor (a huge engineering cost prior to project investment decision/finance close)
  - Uncertainty of Carbon Management Plan (Capture is OK but goes to where?)
- HECA project was "Go" because FEED is sponsored by US DOE, and EOR Project of Oil Producer will off-take CO2 captured (DOE fund is available because of CO2 EOR is available)
- MHI believes that "No CO2 Off-Taker, No Coal Gasification Commercial Project"

Case Study: Indonesia SNG Project

- With Government support (both Indonesia (ESDM) and Japan (METI/NEDO), MHI conducted the detailed study in 2010-2013 (see Attachment for results):
  - Market Survey (Screening to identify Indonesia/Low Rank Coal/SNG)
  - Project Scoping Study/Site Selection
  - Low Rank Coal Gasification Test (by 50 ton/day Pilot Plant, MHI Nagasaki, Japan)
  - Plant Basic Design/Cost Estimate
  - Business Model/Cash Flow Analysis
- Conclusion :

  SNG Project in South Sumatera (Indonesia) is commercially feasible subject to CO2 Off-Take Scheme
- Until "Carbon Credit Market" is commercially established, EOR is the only solution commercially available for off-taking CO2 from Coal Gasification Project.
- Recommendation :

  EOR Demonstration Project should be developed in parallel with SNG Commercial Project in Indonesia

EOR is already Commercial Business in USA

Actual Experience of CO2 EOR Project

Wasson CO2 EOR Project, Texas USA, has resulted in more than 120M BBL of incremented oil thru Year 2008

EOR is already "Commercial Business " in North America

"Rules of Thumb" for CO2 EOR Project :

2.5 BBL Recovered Oil per 1 CO2-ton injection

- Typical CO2 Volume from a Coal Gasification Plant : 3M CO2-Ton/Year
- Potential Crude Oil Recovery: 7.5M BBL/Year
- Potential Income from CO2 EOR Project: US$750M/Year (@$100/BBL)
- Typical EOR Project CAPEX : US$500M

Note: Values are subject to change due to Reservoir Characteristics, Pipeline Length, CO2 Recycle Rate etc.

MHI IGCC Project in USA

- MHI has completed FEED (Front End Engineering Design) of IGCC Project in USA with DOE Support (Grant)
- The Project has a CO2 Off-Taker. Oil Producer of near-by oil field will off-take CO2 for its Private EOR Project (Take or Pay Off-Take Agreement)

EOR/CCS is Low Carbon Infrastructure

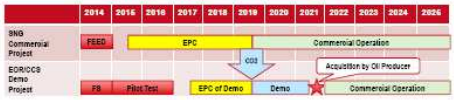
- In addition to commercial business in North America, many EOR Studies and Small Scale Tests have been conducted/planned and now is the time to implement a large scale Demonstration Project to prove that CO2 Injection actually increases oil production.
- MHI can form a Japanese Consortium to execute EPC/O&M of CO2 EOR Project, but no Oil Producer shows interest. Oil Producers in Asia are not yet ready to implement CO2 EOR Demonstration Project due to :
  - No previous experience of CO2 EOR in the region
  - Huge CAPEX (say 100M$) and OPEX (say 10M$/Year) required
  - CO2 EOR is a future opportunity (after Water Injection/Steam Injection)
- MHI can also propose a private business (BOO Scheme) for CO2 EOR Project if the Oil Producer is willing to share revenue from the recovered oil (for instance export to Japan), but the Oil Producers are not interested due to:
  - No Government Policy/Regulation for CO2 EOR
  - Under Ground Oil and its data is strictly my property

⇒ No private business approach is possible for CO2 EOR Project. EOR / CCS Demonstration Project should be implemented as Low Carbon Infrastructure and developed as "non-commercial" project

EOR/CCS Demonstration Project

Coal Gasification Project needs CO2 Off-Taker. EOR Demonstration Project needs a large scale CO2 source

- "SNG Commercial Project" and "EOR/CCS Demonstration Project" should be developed in parallel.



- For EOR/CCS Demonstration Project, Oil Producer to provide Oil Field Data and land use for CO2 Injection and MHI will form a Japanese Consortium for executing EPC/O&M of Demo Project Scope (CO2 Dry/Compress, Pipeline, Injection Well, Wellhead Facility etc.)
- EPC/Demo Plant requires funding support from Japanese Government and other public funding such as ADB subject to request from Indonesia Government
- When Demonstration completed (Oil is actually recovered by CO2 injection), Oil Producer will buy the Demo facility and continue to operate the same to enjoy the benefit of recovered oil production.
- If demonstration is not successful, the facility should be utilized for further EOR/CCS Testing

MITSUBISHI HEAVY INDUSTRIES, LTD.

Our Technologies, Your Tomorrow

For Question/Enquiry, please send an e-mail to "takaya_watanabe@mhi.co.jp"

Attachment

Case Study:
Indonesia Sumatera SNG Project

Case Study: Indonesia SNG Project: 1. Overview of "Power" in Indonesia

➢ Indonesia needs more power
- Power Generation Capacity: 41GW(in 2012) ⇒55GW (in 2020)

➢ Indonesian depends on Coal:
- Coal is "major Power Source" (45% in 2012)
- Coal is "2nd major Export Product "(13% in 2012) • • Indonesia is 2nd Largest Coal Provider to Japan
- Low Rank Coal (LRC): Huge Reservoir Capacity (7,800 billion tons) confirmed but yet to be developed (due to Low Calorie/High Transportation Cost etc.)

➢ Shortage in Domestic Natural Gas Supply Capability:
- NG is " 2nd major Power Source" (23% in 2012) but shortage in Domestic Natural Gas Supply
- Oil & LNG is "1st major Export Product" • • Indonesia is 4th Largest LNG Provider to Japan

⇒ Coal Gasification Project with Low Rank Coal should be best fit to Indonesia's need

Case Study: Indonesia SNG Project 2. Preliminary Study

- MHI conducted Coal Gasification Test /Feasibility Study of Indonesian Low Rank Coal in 2012 with corporation of Indonesian Government (ESDM/LEMIGAS/PLN/PERTAMINA) and Funding Support from Japanese Government(METI/NEDO)
- 200Ton of Indonesian Low Rank Coal was shipped to Japan (MHI R&D Pilot Plant) and tested to confirm the same is suitable for MHI Coal Gasification Technology
- Result of Preliminary Economic Study by MHI

Plant Use By Product	Plant Output / CAPEX	Expected Product Price	Market Price in 2012	CO2 Emission (M ton/Year)	Coal Consumption (M ton/Year)	Remarks
Electricity (IGCC)	800MW (Net) US$2.6 Billion	@$85/MWh	@$80-90/MWh	approx. 8.0	approx. 6.0	Market Tariff is too low. Not feasible w/o Government Incentive (such as FIT)
SNG	140,000MMbtu/day (≒ 150MMSCFD) US$2.6 Billion	@$12/MMbtu	@$10-12/MMbtu (LNG Price)	approx. 4.6	approx. 10.0	Feasible as "Alternative to Domestic/Import LNG"
Fertilizer	4,700 ton/day US$2.6 Billion	<@$400/Ton	@$400/Ton	approx. 4.0	approx. 10.0	Feasible with current High International Market Price

Note: Values are for reference & discussion purpose only and subject to change with various factors given by each project

- **Conclusion:**
  - Indonesia LRC is suitable for MHI Coal Gasification Technology
  - SNG Project is recommended from commercial reasons (Off-taker/Market Price Level & Revenue in US$)

Case Study: Indonesia SNG Project 3. Why South Sumatera?

South Sumatera has been selected by :
- Low Rank Coal Mine (no coal transportation)
- Natural Gas Pipeline (SNG off-take)
- Oil Field (for EOR/CCS)

Case Study: Indonesia SNG Project 4. Plant Capacity/SPEC, Business Model

➢ SNG Plant Capacity/Specifications (Technical Study Completed):
- SNG Production: Approx. 150 MMSCF/Day (with SNG Specifications required by NG Pipeline can be commercially guaranteed after FEED)
- LRC Consumption: Approx. 10 Million Ton/ Year (Consumption based on Design Coal can be commercially guaranteed after FEED)
- Volume of CO2 Captured: Approx. 5 Million Ton/ Year (with CO2 Specifications required for EOR need further study)
- Power used in SNG will be generated by steam from MHI Gasifier (Power Independent Plant)

➢ Business Model: BOO (Built, Own & Operate) by JV of Strategic Investors
- Due to "First-of-a-Kind" concern for "Commercial Size Coal Gasification", Strategic Equity Participation by Coal Mine Owner, SNG Off-Taker, EPC Contractor (Gasification Technology Provider) is appreciated by "Financier"
- Spirit of "One for All, All for One" is a key to success

➢ Funding Plan: Project Finance
- Non-Recourse Project Finance based on Long-Term Fuel Supply/SNG Off-Take/Fixed & Lump-Sum EPC Agreement
- MHI is discussing with Japanese Government (JBIC) for the project finance
- SNG, which can be off-taken by "payment in US$", can avoid Long-Term Currency Exchange Risk between Project Revenue and Expenditure (EPC Payment)

Case Study: Indonesia SNG Project 5. Project Status

2010 ESDM/MHI Joint Presentation made in 11th Energy Round Table:
ESDM will consider this project as "Strategic National Flagship Project" because:
-Additional source for Indonesian Natural Gas network – *Energy Security*
-Commercial plant utilizing Indonesian Low Rank Coal (LRC)
-Compliance with Indonesian Policy of CO2 Reduction
-International Collaboration between Indonesia and Japan"

2011/2012 Feasibility Study/Coal Gasification Test (funding Support from METI/NEDO)
Conclusion: SNG Project is feasible with additional revenue from CO2
Nobody interested in CO2 EOR as business ⇒ SNG Project "On-Hold"

2012/E Coal Mine Owner (w/45% Moisture LRC) conducted Pre-FEED Study for LRC Utilization and selected SNG Project w/MHI Technology
⇒ SNG Project is feasible w/o CO2 Revenue due to less CAPEX/OPEX by eliminating Coal Pre-Drying System with 45% Moisture LRC

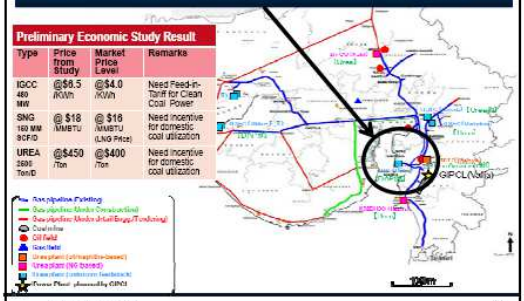
Current Status:
Ready to go for FEED Stage subject to Carbon Management Plan acceptable to Government (Indonesia/Japan) and Investor/Financier

Coal Gasification Opportunity in India : Gujarat

All in one place (Lignite mine / Gas pipeline / Oil field(for EOR) / Urea Plant)

Preliminary Economic Study Result

Type	Price from Study	Market Price Level	Remarks
IGCC 460 MW	@$8.5 /KWh	@$4.0 /KWh	Need Feed-in-Tariff for Clean Coal Power
SNG 150 MM SCFD	@ $18 /MMBTU	@ $18 /MMBTU (LNG Price)	Need incentive for domestic coal utilization
UREA 3500 Ton/D	@$450 /Ton	@$400 /Ton	Need incentive for domestic coal utilization



Recent Developments and Opportunities for CCS

A Look at California

GCCSI Annual Meeting
Seoul, S. Korea
October 8-10,2013

Elizabeth Burton
Lawrence Berkeley National Laboratory and WESTCARB

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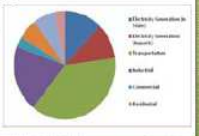
(925)899-6397

BERKELEY LAB

WESTCARB

Why Look at California?

- 7th largest global economy
- 17-18th largest carbon emitter globally
- In top 5 globally for carbon efficiency:
  - lowest carbon emissions per capita
  - highest economic output per ton of emissions
- Climate and CO_2 emissions reductions policies in place
- Studies of energy future show clear need for CCS to meet goals



Substantial CCUS/ CO_2-EOR opportunity

Type of Oil Reservoir	# Potential Fields	Estimated Capacity (MMT CO_2)
Miscible	121	3,186
Immiscible	18	178

CO_2 must come from captured anthropogenic sources
Price point estimated $40/tonne

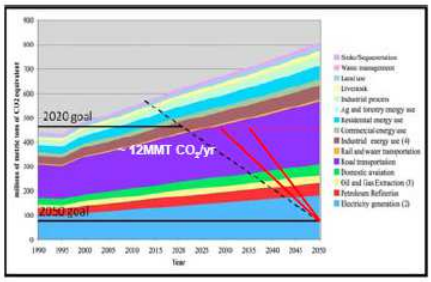
BUT—CCS Projects Are Not Happening---

WHY NOT?

California's Climate Policies

- 2005 Governor's Executive Order, S-3-05, established target GHG reduction levels
  - **2020**: roll back to 1990 levels *(~436 million metric tons) (became law as Assembly Bill 32—Global Warming Solutions Act)*
  - **2050**: 80% below 1990 levels—not "law"
- Many policies enacted to meet 2020 goals include CCS only nominally:
  - Emissions Performance Standards (EPS)
  - Renewable portfolio standards (33%) (RPS)
  - Low carbon fuel standard (LCFS)
  - Cap-and-trade

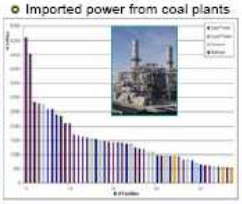
Should CCS "wait" until after 2020?



CCS Must Adapt to Changes in Point Sources

Today:

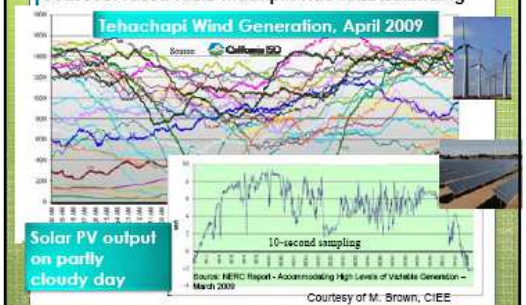
- In-state: natural gas baseload power, refineries and cement plants
- Imported power from coal plants



Tomorrow:

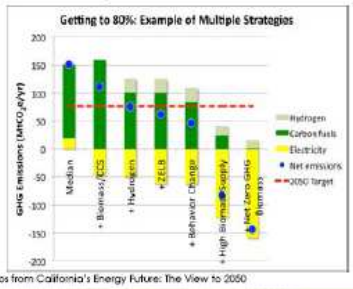
- Divesture of all coal-fired power contracts by 2030
- Retirement of all natural gas plants with once-through cooling by 2020
- More rapid response fossil power, not baseload
- Geographic shifts in demand inland
- Sea level rise impacts on coastal infrastructure?

RPS means large fractions of intermittent energy sources: fossil fuels must provide load balancing



Courtesy of M. Brown, CIEE

Meeting 2050 goals requires CCS on electricity to create net negative emissions



Scenarios from California's Energy Future: The View to 2050

So what has happened?

- Projects—
  - two cancelled, one remains
- Policy—
  - Interest in reports
  - Attempts at legislation
  - R&D funding declining
  - Inclusion of CCS very limited in 2020 planning documents

Hydrogen Energy California (HECA)

What must happen?

- Write CCS methodologies for compliance
- Eliminate short-term (2020) focus
- Fully integrate CCS in future energy policy and infrastructure planning
- Define regulatory agency roles and jurisdictions
- Include CCS in carbon reduction technologies that qualify for incentives, loading orders, subsidies, etc. to "force" a business case

External Advocacy and Technical Input

Conclusions

California is a good test case for studying challenges to CCS deployment

California needs expertise and advocacy NOW to assure CCS for 2050

Thank you
감사합니다

Contact information:
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陕西延长石油（集团）有限责任公司

延长石油集团CCUS实践与认识
CCUS Practice and Understanding of Yanchang Petroleum

高瑞民
GAO RUIMIN

中国 陕西延长石油（集团）有限责任公司
Shaanxi Yanchang Petroleum (Group) Co., Ltd， China

Seoul , Korea (2013.10)

1

提　纲
(Outline)

2

一、陕北能源资源概况
Energy Resources Background of Shanbei Area

陕西延长石油(集团)有限责任公司
SHAANXI YANCHANG PETROLEUM(GROUP)CO.,LTD.

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一、陕北能源资源概况
Energy Resources Background of Shanbei Area

陕北鄂尔多斯盆地有丰富的油、气、煤、盐资源，将是中国最重要的能源化工基地。

The Rich energy resources in Shanbei area, such as oil, gas, coal and salt is full of this area.
It will be the most important energy chemical industry base in China.

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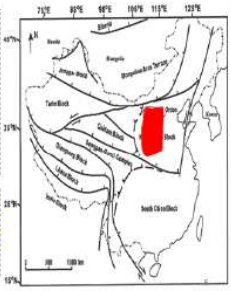
一、陕北能源资源概况
Energy Resources Background of Shanbei Area

1.盆地煤炭资源 (Coal Resources)

盆地内煤炭资源总量3.98万亿吨，探明储量为3667.08亿吨，占全国煤炭保有储量的三分之一以上， 居全国各盆地之首。

Total coal resources of this basin is 3.98×10^{12}tons, almost one third of the coal total resources in China.



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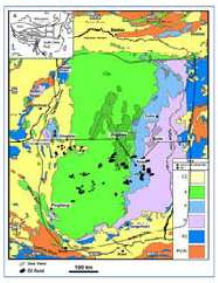
一、陕北能源资源概况
Energy Resources Background of Shanbei Area

2.盆地油气资源（Oil and Gas Resources）



油气资源居全国各盆地第三位
油气资源量：（total resources）
•石 油：(Oil)
12.8×10^{9} tons
•天然气：(Gas)
10.95×10^{12} m^3
探明地质储量：（proved reserves）
•石油：(Oil)
5.5×10^{9} tons
•天然气：(Gas)
2.2×10^{12} m^3

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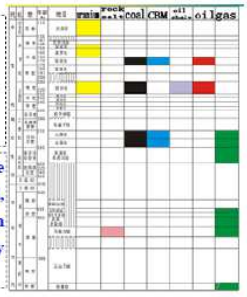
一、陕北能源资源概况
Energy Resources Background of Shanbei Area

3.资源分布 (Resources Distribution)

在空间上，自下而上天然气、盐、煤炭、煤层气、石油、铀、水资源呈现有序的空间叠加组合，为这些资源的综合勘探、开发、利用提供了十分有利的条件。

From bottom to top, the resources, such as gas, salt, coal, coal-bed methane, oil, uranium and water, present orderly superposition combination.



二、陕北能源化工面临的主要问题
The Main Problem for Energy and Chemical Industry of Shanbei Area

陕西延长石油(集团)有限责任公司
SHAANXI YANCHANG PETROLEUM(GROUP)CO.,LTD.

1、油田开发每年需要注入水量约7000多万方，在陕北半干旱地区矛盾非常突出，同时大量产出污水需要处理，给环境造成很大的压力。

1. It needs water more than $7000\times10^4 m^3$ for EOR every year, then the large amount of sewage should be treated. It put great pressure on environment of Shanbei which is semi-arid area.

2、陕北煤化工产业迅速发展：(1)原油加工装置约1800 万吨/年；(2)甲醇合成装置约2404 万吨/年；(3) 兰炭装置约1060 万吨/年；(4)合成氨装置约90 万吨/年；(5)尿素装置约82 万吨/年；(6)煤制油125万吨/年；（7）聚烯烃约290 万吨/年；（8）PVC装置150 万吨/年 。这些项目将产生大量的 CO_2排放，需进行有效的捕集与处理。

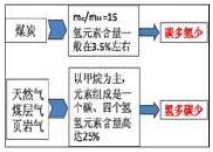
2. The coal-chemical industry project under construction and having been built in Shanbei areas.

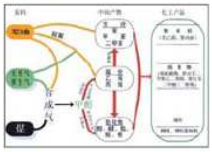
We need to capture and deal with the abundance CO_2 effectively which release from the above projects .

三、延长石油在煤化工中的创新
Innovation of Yanchang Petroleum in Coal-chemical Industry

陕西延长石油(集团)有限责任公司
SHAANXI YANCHANG PETROLEUM(GROUP)CO.,LTD.

1. 实施碳氢互补提高能源效率，减少CO_2排放 (Carbon-hydrogen comprehensive utilization , reduced carbon emissions)





Yanchang Petroleum comprehensively utilizes multiple resources such as coal, petroleum and natural gas, that realized the carbon-hydrogen complementation and comprehensive utilization of resources, instead of only one kind of resources that will waste abundant energy resource.

三、延长石油在煤化工中的创新
Innovation of Yanchang Petroleum in Coal-chemical Industry

延长石油集团煤化工项目节能减排表
Energy conservation and emissions reduction data tables of Jingbian project by Yanchang Petroleum Group

序号	项 目	本项目 This Project	国际先进 International advanced level	国内先进 domestic advanced level	与国际先进比较 Compared with International level	备注
1	甲醇产量(10kt/a) Methanol production	180	165.35	153.12	+8.86%	原料数量一致
2	相对节约煤炭 Save coal		67.3	79.6		标煤
3	能耗(GJ/t甲醇) Energy consumption	37	48	50	-23.0%	
4	甲醇用水(m³/t甲醇) Water consumption for methanol	4.1	10	15	-59.00%	
5	烯烃用水(m³/t烯烃) Water consumption for olefin	19.8	27	27	-26.67%	
6	CO_2排放(10kt/a) CO_2 emission	285	720	720	-60.42%	
7	SO_2排放(t/a) SO_2 emission	634	1389	1389	-54.36%	
8	废水排放 (m³/H) Wastewater discharge	83.4	252.9	252.9	-67.02%	
9	固废排放(10kt/a) Solid waste discharge	12.82	39.82	39.82	-67.81%	建场填埋

三、延长石油在煤化工中的创新
Innovation of Yanchang Petroleum in Coal-chemical Industry

Yanchang Petroleum oil-gas-coal-salt comprehensive transformation model was highly appreciated by specialists and scholars from domestic and overseas at the China international forum of coal conversion high-tech, 11 November 2009. And, this model has be identified as "UN Clean Coal Technology Demonstration and Popularization Project", Yanchang Petroleum Group also has be honored with "UN Clean Coal Technology Demonstration and Popularization Enterprise".

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三、延长石油在煤化工中的创新
Innovation of Yanchang Petroleum in Coal-chemical Industry

2. 低成本的煤化工二氧化碳捕集技术(Low-cost CO_2 capture)

（1）利用低温甲醇洗技术直接从无硫中压甲醇富液中分离出高纯度的CO_2产品，成本可低至100元左右；

（2）研究利用新的化学吸收法，捕集二氧化碳可大量降低能耗，降低捕集成本。

(1) Using the low temperature methanol washing technology, it can separate the high purity CO_2 from the medium-pressure rich fluid methanol without sulfur, the cost can reduce by CNY100/ton,

(2) Study the other new chemical absorption method to further reduce energy consumption and the cost.

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四、延长石油CCUS的意义及优势
Significances and Advantages for Yanchang Petroleum CCUS

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四、延长石油CCUS的意义及优势
Significances and Advantages for Yanchang Petroleum CCUS

1. 意义 (Significance)

（1）是国家兑现《联合国气候变化框架公约》承诺的积极行动

（2）有效开发低特低渗透储量，提高特低渗油藏采收率重要手段

（3）是油田节水、高效开发的需要

（4）是解决陕北煤化工CO_2埋存问题，在煤化工、石油开发间发展循环经济的有益探索

(1) It is the positive practice for the China to fulfill the promise in "United Nations Framework Convention on Climate Change",

(2) It is the important means of effectively developing and improving the recovery factor for ultra-low-permeability oil reserves,

(3) It is necessary for water saving and high-efficiency of the oil field development,

(4) It is the beneficial exploration for resolving the CO_2 storage problem and developing circular economy between coal-chemical industry and petroleum industry.

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四、延长石油CCUS的意义及优势
Significances and Advantages for Yanchang Petroleum CCUS

2.优势 (Advantages)

(1) 有充足的低成本、高纯度二氧化碳资源；

(2) 捕集、埋存与利用处于同一地域，进一步降低了CCUS成本；

(3) 有大量的油藏适宜二氧化碳驱油提高采收率；

(4) 鄂尔多斯盆地岩性地层构造稳定、无较大的断层，适宜二氧化碳的长期稳定封存；

(5) 油田开发后油藏废弃，有足够的储存空间，埋存能源化工产生的二氧化碳。

(1) There are plenty of low cost and high purity carbon resources

(2) Capture storage and utilization in the same region, it can further reduce the cost of CCUS

(3) There are a large number of reservoirs suitable for CO_2 flooding

(4) Ordos basin is suitable for CO_2 long-term and stable storage

(5) After the reservoirs abandoned, there are enough space for CO_2 storage

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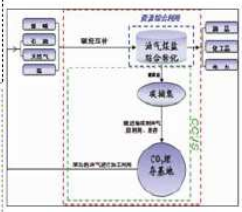
四、延长石油CCUS的意义及优势
Significances and Advantages for Yanchang Petroleum CCUS

3. CCUS一体化模式 (Integrated CCUS mode)

陕北地区煤化工产业和油气产业的同区发展，为在鄂尔多斯盆地有效集成CO_2捕集、封存与驱油的CCUS一体化项目的实施创造了条件。

It can effectively integrate CO_2 capture, storage and EOR for CCUS integration project in Ordos basin, because of the coal-chemical industry and oil-gas industry in the same region.



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五、延长石油CCUS进展情况
Progress of Yanchang Petroleum CCUS

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五、延长石油CCUS进展情况
Progress of Yanchang Petroleum CCUS

1.承担CCUS相关项目 (Relation Projects)

(1) 启动《延长油田CO_2驱提高采收率配套技术研究》；
(2) 启动国家科技支撑计划项目-《陕北煤化工CO_2捕集、埋存与提高采收率技术示范》；
(3) 2012年启动国家863计划项目“燃煤电厂烟气CCUS关键技术”一课题三《CO_2地质埋存关键技术》；
(4) 今年开展中澳国际合作项目 《中-澳CCUS一体化国际合作示范项目》

(1) "Supporting technical research of Yanchang Petroleum CO_2 EOR"
(2) 2012, National Key Technology R&D Program "Technology Demonstration of CO_2 Capture Storage and EOR of Shanbei Coal-chemical Industry"
(3) 2012, State 863 projects "Key technical research of exhaust gas CCUS of coal-fired power plant"---sub-project " Key technical research of CO_2 geological storage"
(4) 2013, Sino-australian international cooperation project "Demonstration Project of Sino-Australian International Cooperation on CCUS Integration"

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五、延长石油CCUS进展情况
Progress of Yanchang Petroleum CCUS

2. 二氧化碳捕集进展 (Progress of CO_2 capture by Yangchang Petroleum)

(1) 延长石油榆林煤化有限公司于2012年11月建成了5万吨/年的二氧化碳捕集装置；
(2) 延长石油兴化新科气体有限责任公司，利用先进的工艺技术和工艺装备捕集提纯工业废气，生产食品级液态二氧化碳8万吨/年；
(3) 延长中煤榆林能化有限公司预计2013年底建成36万吨/年的捕获装置，2014年7月投产。

(1) The 50000 ton/year CO_2 capture facility has be built at November 2012 by Shaanxi Yanchang Petroleum Yulin Coal Chemical Company.
(2) The 80000 ton/year CO_2 with food grade is produced by Shaanxi Xinhua-Xinke Gas Company, the sub-company of Yanchang Petroleum.
(3) The 360000 ton/year CO_2 capture facility construction project has be started by Shaanxi Yanchang China-coal Yulin Energy Chemical Company.

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五、延长石油CCUS进展情况
Progress of Yanchang Petroleum CCUS

2. 二氧化碳捕集进展 (Progress of CO_2 capture)

榆林煤化5万吨/年二氧化碳捕集装置
The 50000 ton/year CO_2 capture facility by Shaanxi Yanchang Petroleum Yulin Coal Chemical Company

五、延长石油CCUS进展情况
Progress of Yanchang Petroleum CCUS

2. 二氧化碳捕集进展 (Progress of CO_2 capture)

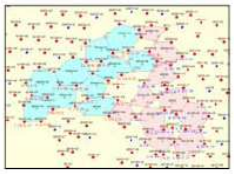
榆林能化捕集设备建设情况
The CO_2 capture facility construction project by Shaanxi Yanchang China-coal Yulin Energy Chemical Company

五、延长石油CCUS进展情况
Progress of Yanchang Petroleum CCUS

3. CO_2驱油先导试验（CO_2 EOR）

靖边试验区面积9.88km²，第一期从2012年9月5日开始3口井的CO_2注入，单井日注量（液态CO_2）20t，初始注入压力约1MPa，目前注入压力达到8MPa，累注入液态CO_2 6113吨。

The area of Jingbian test field is 9.88 km². The first stage, we have started 3 wells CO_2 injection, the accumulation CO_2 injection is 6113 tons.



靖边油田CO_2驱油先导试验区井网图
The well pattern of CO_2 pilot test in Jingbian Oil-field

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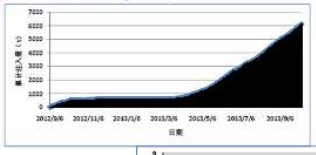
五、延长石油CCUS进展情况
Progress of Yanchang Petroleum CCUS

3. CO_2驱油先导试验（CO_2 EOR）



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五、延长石油CCUS进展情况
Progress of Yanchang Petroleum CCUS

3. CO_2驱油先导试验（CO_2 EOR）

CO_2驱油现场
CO_2 EOR Pilot Test in Jingbian Oil-field

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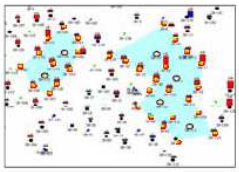
五、延长石油CCUS进展情况
Progress of Yanchang Petroleum CCUS

3. CO_2驱油先导试验（CO_2 EOR）

第二期在吴起油区开展CO_2混相驱提高采收率试验，实验区面积14.8km²，2013年下半年先开展6口井注CO_2，单井日注量30吨，2014年将完成35口井的CO_2注入，年注CO_2量达20万吨。



The second stage, we will start the CO_2 miscible displacement test at Wuqi oil-field, the area is 14.8km². The second half of 2013, we will start 6 wells for CO_2 injection, the daily CO_2 injection is 30 tons. By 2014, there will be 35 wells for CO_2 injection, the injection rate will be 200000tons/year.

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五、延长石油CCUS进展情况
Progress of Yanchang Petroleum CCUS

4.开展CO_2地质封存安全监测技术研究(MMV)

（1）CO_2 埋存的安全评估；
（2）CO_2 驱替前缘监测；
（3）5平方公里的四维地震监测；
（4）压力监测；
（5）井筒与地表监测；
（6）产出流体监测。

(1) The safety evaluation of oilfield CO_2 storage;
(2) Research of CO_2 displacing front;
(3) The 4D seismic monitoring of 5 km²;
(4) Monitor the pressure;
(5) The well hole and the surface monitoring;
(6) Well production flow monitoring.

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五、延长石油CCUS进展情况
Progress of Yanchang Petroleum CCUS

5. CO_2压裂工艺技术研究与应用 (CO_2 Fracturing Technique Research and Application)

- 试3井压前产气量6400m³/d、无阻流量为21533m³/d（第一次采用液氮增能胍胶压裂工艺），采用VES-CO_2泡沫压裂后，产气量38511m³/d、无阻流量为99293m³/d，增产360%；
- 延293井压前无阻流量为3249m³/d，采用VES CO_2泡沫压裂后，无阻流量为5224m³/d，增产60.8%；

We have used the CO_2 clean fracturing fluid, which researched and produced by Yanchang, for fracturing test, the increase production is significant.

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五、延长石油CCUS进展情况
Progress of Yanchang Petroleum CCUS

5. CO_2压裂工艺技术研究与应用 (CO_2 Fracturing Technique Research and Application)

六、实施CCUS面临的挑战与认识
Challenge and Understanding Faced with CCUS

陕西延长石油(集团)有限责任公司
SHAANXI YANCHANG PETROLEUM(GROUP)CO.,LTD.

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六、实施CCUS面临的挑战与认识
Challenge And Understanding Faced with CCUS

1. 挑战(Challenge)

（1）CCUS项目的投资成本较大；
（2）不同油藏条件的二氧化碳提高采收率技术还需要进一步研究；
（3） CO_2注入地层后的安全性评估，无系统科学的方法。

（1）The investment of the CCUS project is very large;
（2）The CO_2 EOR technology need further study for different reservoir conditions ;
（3） No systematic and scientific method for the security evaluation after CO_2 injected into the reservoir.

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六、实施CCUS面临的挑战与认识
Challenge And Understanding Faced with CCUS

2. 认识（Understanding）

（1）低成本的捕集埋存与高效的提高采收率技术是关键；
（2）鼓励企业开展CCUS工作，应建立相关政策激励机制；
（3）需要碳捕集、利用和封存相关标准规范的制定；
（4）加强国际合作与CCUS技术共享 。

（1）The key point is the low-cost capture technology and the efficient EOR technology ;
（2） Explore to establish relevant policy incentive mechanism, and encourage enterprises to participate in CCUS ;
（3） Promote the standards for CCUS;
（4）Enhance the international cooperation and technology sharing of CCUS.

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六、实施CCUS面临的挑战与认识
Challenge And Understanding Faced with CCUS

3. 建议（Suggestions）

（1）先实施CO_2-EOR、EGR和ECBM试验工作，为CO_2埋存积累技术降低埋存成本；
（2）发挥各行业部门的特点和优势，构建广义的CCS-EOR产业链。
（3）通过碳税试点引导和调整碳捕集的积极性。

（1）Start the test of CO_2-EOR, EGR and CBM , technologies accumulate for low-cost CO_2 storage;
（2） Build a broad CCS - EOR industry chain by exerting the advantage and the characteristics from different industry;
（3）Guide and adjust the initiative of CCS by making experiments of "carbon tax".

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Thank you for your attention!

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GCCSI International Meeting
The Global Status of CCS
Seoul, October 2013

CCS Projects in Action

Jon Gibbins
Professor of Power Plant Engineering and Carbon Capture
University of Edinburgh
jon.gibbins@ed.ac.uk

Acknowledgements to Hannah Chalmers, Mathieu Lucquiaud, Jia Li, Xi Liang

About the UKCCSRC

The UK Carbon Capture and Storage Research Centre (UKCCSRC) **leads and coordinates a programme of underpinning research on all aspects of carbon capture and storage** (CCS) in support of basic science and UK government efforts on energy and climate change.

The Centre brings together nearly 200 of the UK's world-class CCS academics and provides a **national focal point for CCS research and development**.

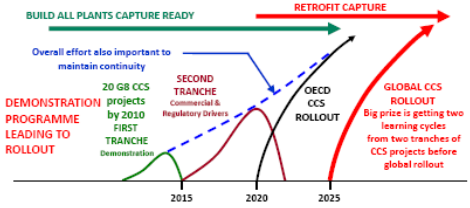
The Centre operates the **CCS Community Network,** open to anyone with an interest in CCS (please join!).

http://www.ukccsrc.ac.uk

(but rest is personal comments by author)

Bringing CCS into action to get big cuts in emissions

Gibbins, J. and Chalmers, H. Preparing for global rollout: A 'developed country first' demonstration programme for rapid CCS deployment. Energy Policy, 2008, 36(2), 501-507.



But rollout of CCS requires global commitment

2008 timing was based on agreement in the Copenhagen process and healthy global economy

Effective actions NOW to help get big cuts in emissions

- **Projects that contribute to getting global commitment to tackle climate change - global commitment is the watershed for CCS**
- **Projects that make it more feasible to get rapid deployment of the right technologies after global commitment**
- **Technology development**
- **People and skills**
- **Learning by doing at scale**
- **Reference plants that you would want to build again**
- **Regulations that enable the right things**
- **Incentive mechanisms that reward the right things**
- **Capture ready plants for easier retrofit**

Big cuts in emissions require the right CCS projects

Class 1 = carbon positive CCS
Class 2 = (near) carbon neutral CCS
Class 3 = carbon negative CCS

Class 1: Usually producing hydrocarbons, CCS gets the carbon footprint down to conventional hydrocarbon levels e.g. LNG, coal-to-liquids, oil sands

Class 2: Producing carbon free energy vectors: electricity, hydrogen or heat with most of the CO_2 permanently stored

Class 3B: Biomass plus CCS (takes CO_2 from the air)
Class 3A: Technology to process air directly to capture CO_2

CO_2 utilisation instead of permanent storage may also see the captured CO_2 eventually released to the atmosphere.

J. Gibbins and H. Chalmers, Is all CCS equal? Classifying CCS applications by their potential climate benefit, GHGT10, Energy Procedia, Volume 4, 2011, 5715-5720. doi:10.1016/j.egypro.2011.02.566 | How to Cite or Link Using DOI

Definition of carbon capture and storage ready (CCSR)

- **A CCSR facility is a large-scale industrial or power source of CO_2 which could and is intended to be retrofitted with CCS technology when the necessary regulatory and economic drivers are in place.**
- **The aim of building new facilities or modifying existing facilities to be CCSR is to reduce the risk of carbon emission lock-in or of being unable to fully utilise the facilities in the future without CCS (stranded assets).**
- **CCSR is not a CO_2 mitigation option, but a way to facilitate CO_2 mitigation in the future.**
- **CCSR ceases to be applicable in jurisdictions where the necessary drivers are already in place, or once they come in place.**

http://www.iea.org/publications/freepublications/publication/ccs_q8.pdf

Essential Requirements of a CCSR facility

The essential requirements represent the minimum criteria that should be met before a facility can be considered CCSR. The project developer should:

- Carry out a site-specific study in sufficient engineering detail to ensure the facility is technically capable of being fully retrofitted for CO_2 capture, using one or more choices of technology which are proven or whose performance can be reliably estimated as being suitable.
- Demonstrate that retrofitted capture equipment can be connected to the existing equipment effectively and without an excessive outage period and that there will be sufficient space available to construct and safely operate additional capture and compression facilities.
- Identify realistic pipeline or other route(s) to storage of CO_2.
- Identify one or more potential storage areas which have been appropriately assessed and found likely to be suitable for safe geological storage of projected full lifetime volumes and rates of captured CO_2.
- Identify other known factors, including any additional water requirements that could prevent installation and operation of CO_2 capture, transport and storage, and identify credible ways in which they could be overcome.
- Estimate the likely costs of retrofitting capture, transport and storage.
- Engage in appropriate public engagement and consideration of health, safety and environmental issues.
- Review CCSR status and report on it periodically.

http://www.iea.org/publications/freepublications/publication/ccs_q8.pdf

Definition application

These essential requirements represent the minimum criteria that should be met before a facility can be considered CCSR. However, a degree of flexibility in the way jurisdictions apply the definition will be required to respond to region- and site-specific issues and to take account of the rapidly changing technology, policy and regulatory background to CCS and CCSR, both globally and locally. More specific or stringent requirements could be appropriate, for instance, in jurisdictions where the CCSR regulator is working on the assumption that CCS will need to be retrofitted to a particular facility within a defined time frame.

Source: CCS-ready information from the Ad-hoc CCS-Ready working group set up at the 2010 IEA/CSLF/GCCSI CCS Ready workshop in Ottawa Canada.

http://www.iea.org/publications/freepublications/publication/ccs_q8.pdf

Effective actions NOW to help get big cuts in emissions

- Projects that contribute to getting global commitment to tackle climate change - global commitment is the watershed for CCS
- Projects that make it more feasible to get rapid deployment of the right technologies after global commitment

Effective actions NOW to help get big cuts in emissions

- Technology development
- People and skills
- Learning by doing at scale
- Reference plants that you would want to build again

Getting weaker

Effective actions NOW to help get big cuts in emissions

- Regulations that enable the right things
- Incentive mechanisms that reward the right things
  - Examples are there
  - Need to resist taking the path of least resistance
  - But be objective about LSIPs – consider benefits for achieving action on big cuts in future systems through capture, transport and storage separately
- Capture ready plants for easier retrofit
  - Recognise that today's CCSR plants are tomorrow's major Class 2 projects
  - Include CCSR plants in GCCSI statistics
  - Work hard to get effective CCSR approaches that will allow for technical progress – and use a lot more engineers than lawyers

Jeff Chapman

The Carbon Capture & Storage Association

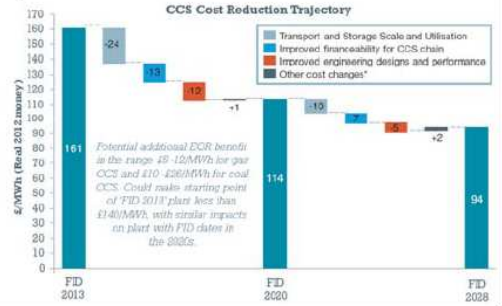
Equal treatment of CCS

Observations on UK industry experience

GCCSI
Global Status of CCS 2013 Seoul

What is equal treatment - power?

- Same payment per MWh?
- Enhanced payment for flexibility?
- Availability payment?
- Availability of budget (LCF in UK)?
- Contribution to infrastructure?
- Do we mean equality of terms or equality of opportunity?



Electricity Market Reform

- CfD FiT central to incentive for low carbon generation
- Should CfD be same for all technologies
- RE and nuclear not fuel cost dependent
- Capacity mechanism could reflect flexibility of CCS

Policy anomalies

- In EU renewable targets
- In UK nuclear sites selected for development
- No clear indication of market potential for CCS
- Third Party Access
- Long term liabilities
-

Planning Signals

- Wide range of scenario planning for CCS
- Lack of vision on geographical location of capture
- Indeed consenting CCGTs in locations to preclude CCS retro-fit
- Lack of CCS infrastructure plans

The perils of competitions

- Definition of technology
- Selection criteria
- High levels of risk
- Higher cost to consumer
- Wasting developer input leading to lost confidence

Rhetoric – Quotes on CCS at LibDem Conference

- "and this would be particularly the case if CCS was found not to have worked." – Ed Davey
- ". A mixed, diverse strategy was needed in case CCS or certain renewable technologies failed." – Ed Davey
- "Noting that Carbon Capture and Storage (CCS) would not be viable before 2030" – Rebecca Taylor MEP LibDem

What is equal treatment – industrial CCS

- Does not compete with other technologies
- Emissions trading aims to levelise incentive
- But international competition inhibits investment
- Needs equality of treatment across international boundaries

Contact

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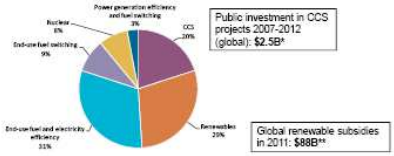
The case for equal policy treatment of CCS with other clean energy technology

Dick Wells
Chair, National CCS Council (Australia)

Presenting to:
The Global Status of CCS 2013, South Korea
Friday 11 October, 2013

National CCS Council

The Case for CCS



Public investment in CCS projects 2007-2012 (global): **$2.5B***

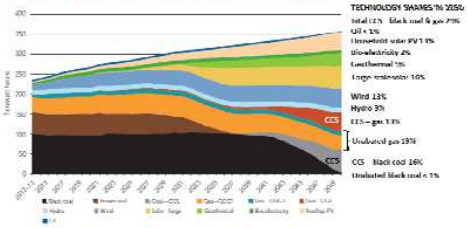
Global renewable subsidies in 2011: **$88B****

IEA Energy Technology Perspectives 2012

* IEA CCS Technology Roadmap 2013
** IEA World Energy Outlook 2012

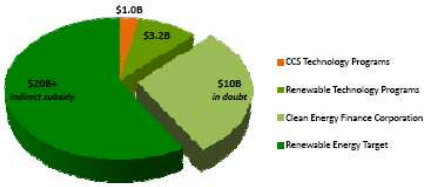
National CCS Council

An Australian Case Study: Future Electricity Generation Mix in 2050?



National CCS Council

An Australian Case Study: CCS v Renewable Support



National CCS Council

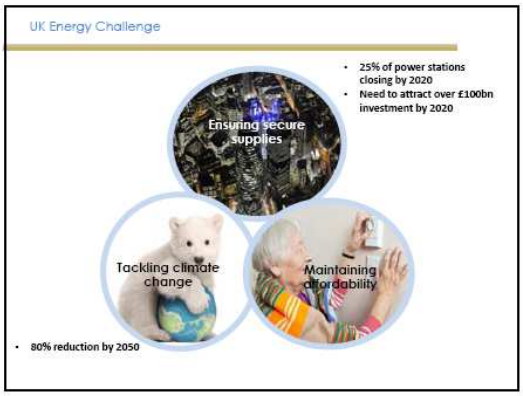
Is equal policy treatment the solution?

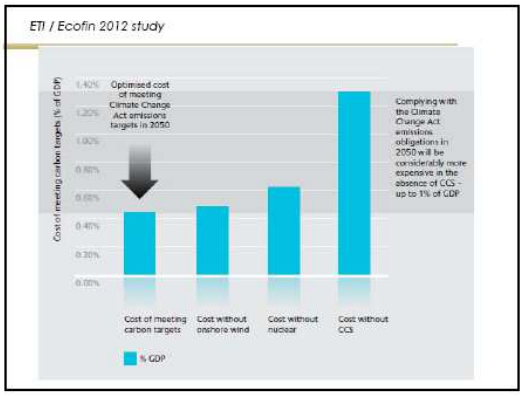
- Support must be commensurate with the anticipated role of CCS – in Australia and globally
- Australian CCS Roadmap: targeted, transitional support needed to facilitate:
  - Exploration and appraisal of CO_2 storage resources
  - Early-mover, integrated CCS projects
  - Planning and development of CO_2 storage hubs
  - Continued investment in R&D – particularly storage
  - National CCS Communication Strategy

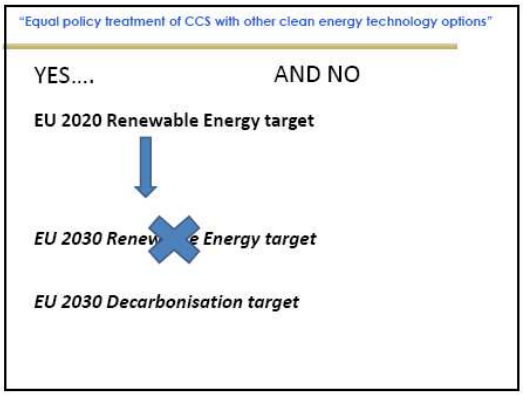

Department of Energy & Climate Change
The case for equal policy treatment of CCS with other clean energy technology options
Matthew Billson
Office of Carbon Capture and Storage

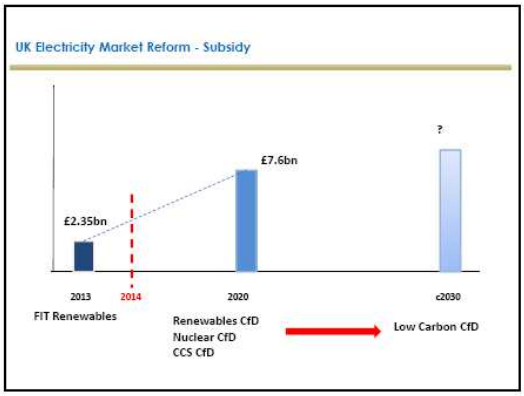

BBC
NEWS BUSINESS
Myanmar power shortages hurt growth prospects
10 October 2013
theguardian
Growing risk of power blackouts within 18 months, says Ofgem

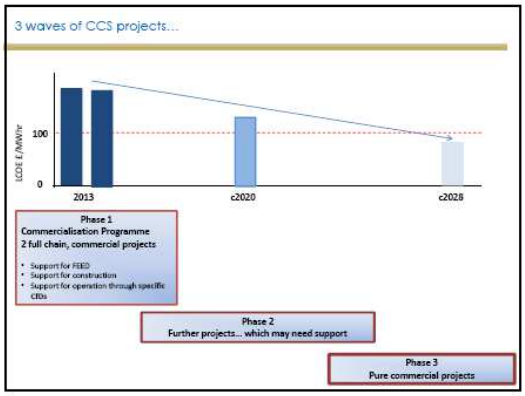

theguardian
Heat or eat? Or take out a loan, do both, and hope for the best?
German energy transition caught in subsidies' trap
The Telegraph
Germany industry in revolt as green dream causes cost spiral

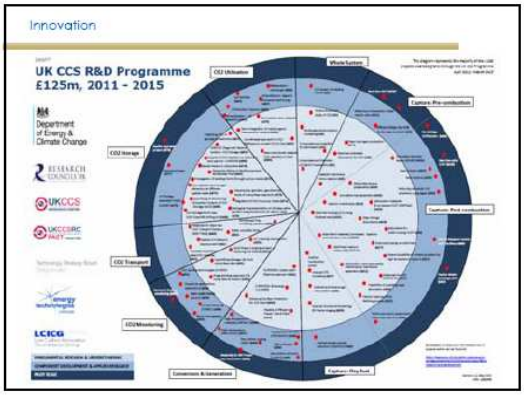

UK Energy Challenge
25% of power stations closing by 2020
Need to attract over £100bn investment by 2020
Ensuring secure supplies
Tackling climate change
Maintaining affordability
80% reduction by 2050


ETI / Ecofin 2012 study
Optimised cost of meeting Climate Change Act emissions targets in 2050
Complying with the Climate Change Act emissions obligations in 2050 will be considerably more expensive in the absence of CCS - up to 1% of GDP
Cost of meeting carbon targets
Cost without onshore wind
Cost without nuclear
Cost without CCS
% GDP


"Equal policy treatment of CCS with other clean energy technology options"
YES....
AND NO
EU 2020 Renewable Energy target
EU 2030 Renewable Energy target
EU 2030 Decarbonisation target







Department of Energy & Climate Change

- Portfolio of energy generation (nuclear, renewables, CCS, gas)
- Secure, affordable, **low carbon** mix
- Creating long term, market mechanisms