出國報告（出國類別：其他）

隨經濟部國貿局赴英國、丹麥參加相關經貿訪問公差報告

服務機關：核能研究所
姓名職稱：施建樑　研究員
　　邱太銘　副所長
派赴國家：英國、丹麥
出國期間：101 年 4 月 21 日~101 年 4 月 28 日
報告日期：101 年 5 月 25 日

摘　要

本次隨經濟部長官及國際貿易局等人員赴歐洲英國與丹麥參訪，係應經濟部國際貿易局之邀，主要目的為陪同經濟部長官等拜訪英國核子除役局(Nuclear Decommissioning Authority, NDA)，作為我國未來推動核電廠除役時之參考。並希望能汲取英國透過公法人運作處理核後端業務之經驗，以作為未來我國推動成立核後端管理專責機構時之參考。另外，國際貿易局此行亦安排至丹麥哥本哈根拜訪 Vestas 公司，台電公司目前運行的風機中，約有一半採購自該公司，未來我國將發展離岸風力，並由於台灣之特殊環境，需有防颱與防震的風機設計，雙方可朝此目標共同合作發展。此行，已透過雙方之溝通、討論，已為未來之合作交流打下基礎，將伺機推動後續相關工作。

關鍵字：核能、除役、離岸風機

目　　次

一、 目 的

本次隨經濟部長官及國際貿易局等人員赴歐洲英國與丹麥參訪，係應經濟部國際貿易局之邀，主要目的為陪同經濟部長官等拜訪英國核子除役局(Nuclear Decommissioning Authority, NDA)，作為我國未來推動核電廠除役時之參考。另外，國際貿易局此行亦安排至丹麥哥本哈根拜訪 Vestas 公司，台電公司目前運行的風機中，約有一半採購自該公司，未來雙方可朝離岸風機共同合作發展。此外，亦配合全團進行相關經貿參訪與會議，如分別與駐英代表沈大使及駐英銀行界等座談、拜訪丹麥 BWE 公司，以及參加由丹麥工業總會舉辦的圓桌論壇會議等。

二、 過 程

本次國外公差行程如表 1 所示，自民國 101 年 4 月 21 至 28 日共八天；主要在英國倫敦停留三天，在丹麥哥本哈根則有二天行程，其餘三天為旅程及資料整理。以下分別說明之。另外，全體團員共 11 位，分別來自經濟部本部、國際貿易局與能源局，台電公司核後端處與再生能源處、工研院綠能所、工商協進會及本所，成員名單如表 2。

表 1 赴英國、丹麥行程表

日 期	時 間	內 容	備 註
4 月 21 日(六)	23:15	經濟部長官搭乘華航 CI61 在法蘭克福轉機（23:15-06:50【+1】）	
4 月 22 日(日)	10:00-10:40	搭乘法蘭克福航空 LH904 抵達倫敦	
	16:00	1.與沈大使座談 2.團務會議	出席人員：全體團員
4 月 23 日(一)	上午	資料準備	
	14:00	拜會行程 1.核能除役局倫敦辦公室 2.與駐英銀行代表座談	出席人員： 1. 經濟部長官 2. 台電李處長清山 3. 核研所邱副所長太銘 4. 核研所主持人施建樑 5. 陳副局長銘師 6. 陳組長聰潔 7. 張秘書長炯昌 8. 宋明豪 9. 鍾宜珊
4 月 24 日(二)	10:00-18:30	拜會赴 Berkeley 核能廠	台電及核研所代表
4 月 25 日(三)	07:00	由旅館出發赴機場	
	09:50-12:45	自倫敦赴丹麥哥本哈根	北歐航空 SK502
	13:30-15:00	拜會風力發電設備大廠 Vestas，由該公司資深副總裁 Mr. Peter Brun、政府關係部門主任 Mr. Morten Dyrholm 及新興離岸風電市場部門主任 Mr. Casper Toft 接待	出席人員：全體團員
	16:00-17:30	1.參訪丹麥 BWE 公司，由該公司營運長 Mr. Claus Andreasson 接待 2.與陳代表座談	出席人員：全體團員
4 月 26 日(四)	9:30-11:00	圓桌論壇會議： 1.由丹麥工業總會能源事務處長 Mr. Hans Peter Slente 主持 2.哥本哈根經濟研究院 Mr. Martin H. Thelle 與會簡報該院接受我方委託所撰擬台歐盟 ECA 研究專文之初步結果	經濟部長官致詞，貿易局陳副局長、能源局蘇組長及張秘書長於會中進行簡報： 1. 地點：丹麥工總會議室 2. 出席人員：全體團員
	18:05-19:35	搭乘北歐航空 SK 1635 赴法蘭克福轉機住一晚	宿法蘭克福
4 月 27 日(五)	11:20-06:25	搭乘華航 CI62	
4 月 28 日(六)	06:25	抵達台北	

表 2 團員名單

所屬單位	姓名	職稱
經濟部本部	XXX	經濟部長官
經濟部國際貿易局	陳銘師	副局長
核能研究所	邱太銘	副所長
經濟部能源局	蘇金勝	組長
工研院綠能所	童遷祥	所長
台電公司核能後端營運處	李清山	處長
台電公司再生能源處	陳一成	處長
核能研究所	施建樑	計畫主持人
工商協進會	張炯昌	秘書長
經濟部本部	宋明豪	商務秘書
經濟部國際貿易局	鍾宜珊	科員

(一) 與沈呂巡大使座談(4/22)

由沈大使親自接待，說明目前台英之經貿情形；截至 2011 年底的資料，英國人口 6,304 萬人，土地面積為 244,103 平方公里；GDP 為 2 兆 1,684 億美元，平均 GDP 為 35,900 美元，經濟成長率為 0.7%，失業率為 8.1%，平均基本利率為 0.5%，外匯準備為 1,261.4 億美元(2012 年 2 月)，進口值為 6,696 億美元，其中自台灣進口 46.2 億美元(2011 年成長率為 27.57%)；出口值為 5,119 億美元，其中像台灣出口為 19.3 億美元(2010 年成長率為 15.46%)；台灣對英投資 2011 年累計 170 件，金額達 5 億 4,267 萬美元；英國對台灣投資 2011 年累計 616 件，金額達 67 億 7,281 萬美元。

(二) 與駐英經濟組陳組長等商談英國行程(4/22)

由駐英經濟組陳聰潔組長等，準備訪英行程手冊並向經濟部長官說明訪英注意 事項，說明明天(4/23)拜會英國商業部副部長 Lord Green，以及參加第 14 屆台英商務協會聯席會議的相關事宜。另外，亦說明 4 月 24 日行程，有關參訪 GL Garrad Hassan 公司，洽談離岸風力發電；原本要出海參觀 Vattenfall 公司 Kentish Flats 離岸風機海域，後因天候不佳而取消。

(三) 與駐英銀行代表們座談(4/22)

由駐英經濟組安排，與國內駐英銀行代表們座談。包括有：台灣銀行倫敦分行華科副理、華南銀行倫敦分行黃俊傑經理、陽明海運英國分公司許世芳總經理、彰化銀行倫敦分行孫慧蘭經理、倫敦台灣茂易中心呂文瑞主任等。

(四) 拜訪英國核子除役機構(4/23)

政府於 2011 年 11 月 3 日宣布「穩漸減核」之新能源政策， 現有運轉中之 3 座核電廠在其運轉執照 (40 年)屆滿時不延役而須進行除役。據此，核一廠一號機預定運轉至 2018 年底後永久停機。

依原能會「核子反應器設施管制法」之規定，於核電廠預定永久停機前 3 年，台電公司須提出除役計畫陳報原能會核准後據以執行。據此，核一廠除役計畫須於 2015 年底前研擬完成；另，依環保法規之規定，台電公司亦須提出除役環境影響報告書陳報環保署審核。

NDA 簡介及其除役策略如下，詳細的 NDA 介紹則如附件一。

1. NDA 成立於 2004 年，為一公法人(non-departmental public body)，英國政府之能源暨氣候變遷部(Department of Energy and Climate Change, DECC)為其主管機關。主要負責工作包括：
   (1)接續管理前英國原子能管制局(UKAEA)及英國核能燃料公司(BNFL)之 19 個核能廠址。
   (2)完成前述 19 個核能廠址之除役、復原及再利用。
   (3)詳審國能源公司(British Energy, 擁有先進氣冷式與壓水式核能機組)之核電廠除役計畫。
   (4)發展英國低放射性廢棄物之處理策略及計畫。
   (5)英國用過核子燃料與高放射性廢棄物長期營運管理。
2. 依英國 2004 年能源法規定，NDA 係定位為策略機構(strategic authority)。因此，NDA 不直接負責營運其所擁有之廠/場址，而係採契約委外方式辦理。
3. NDA 擁有之 19 個廠址中，有 11 個廠址為英國第一代氣冷式核能機組(英國稱為”Magnox

gas－cooled reactor”)，目前該等機組中有 10 座已永久停機，僅餘 Wylfa 核能機組尚在運轉中。其除役策略為：依廠址之特定狀況及對環境影響風險之程度，在合理可行之原則下，儘快完成核能廠址之除役、復原及再利用。

4. NDA 已分別就其擁有之 11 座核能機組廠址特性，擬定除役計畫。目前已永久停機之 10 座核能機組中，有 3 座進行用過核子燃料移除(defueling)至再處理廠之作業中，餘 7 座已完成用過核子燃料移除並進入監護準備階段(care and maintenance preparations)，最終目標為廠址復原並再利用。另，除役期間如部分廠址土地已達可釋出再利用之程度，則就該部分土地申請解除核能執照管制(de-licensing)並做資產活化處理。迄今，NDA 已成功釋出總計約 53 公頃之廠址土地，並轉售供建新核能機組或商業園區用。

4 月 23 日下午，由經濟部長官率領陳副局長銘師、台電公司李處長清山、陳組長聰潔、張秘書長炯昌、本所邱副所長太銘與施建樑，以及宋明豪與鍾宜珊等，一同前往拜會 NDA，由 NDA 主管國際事務的 John Mathieson 負責接待，當天議程如表 3。

表 3 拜訪 NDA 議程

Welcome and Introductions
Overview/update of NDA (by John Mathieson, NDA)
Taiwan Presentation (by 台電公司李清山處長)
Magnox Presentation on Decommissioning Strategy (by Peter Ireland, Magnox)
Way forward

由 NDA 所做的 NDA 介紹，與附件一類似，包括 NDA 之成立、任務、所轄資產與現狀、未來十年二十年發展等，詳細簡報如附件二。台電公司李清山處長則說明我國核電廠之發展，以及目前我國核後端之現狀；包括在蘭嶼、三座核電廠暫貯之低放廢棄物桶，用過核子燃料中期貯存之執行與規劃，低放廢棄物處置場之規劃，高放廢棄物再處理與處置規劃，以及目前因應國內核能政策修訂而啟動的除役活動之現況與未來構想等；截至 2012 年 3 月底，台電公司的核後端基金已累計有 2,180 億元新台幣，預計六部機在再運轉 40 年期限內，將累計收取達 3,350 億元，其中六部機組 之除役經費約佔 20%。並也與 NDA 討論雙方未來如何進一步合作。

至於由 Magnox 的 Peter Ireland 所做簡報，大致內容如下：

Magnox 公司之母公司為來自美國的 EnergySolutions，係為承接 NDA 的委辦工作所特別成立的公司；她所承辦的廠址包括一仍運轉中之電廠、四座已移除燃料電廠、五座正除役中電廠，並在 Berkeley、Oldbury 與 Daresbury 設有辦公室。不過，上述廠址均由 NDA 所擁有。

Magnox 為在英國運轉的第一代核電廠，使用非氧化的鎂合金護套天然鈾燃料、壓力槽為鋼與預力混凝土結構、緩和劑為石墨，並以二氧化碳為冷卻劑。其中之 Berkeley 電廠，為第一座全商業運轉的 Magnox 反應器，於 1962 年開始運轉，1989 停止運轉。而 Wylfa 電廠則為最後(1971 年)開始運轉的 Magnox 電廠，目前還有一部機組運轉中，原規劃於 2012 年 12 月停止運轉，但目前已計劃延至 2014 年再停止運轉。

根據 NDA 賦予之 Magnox 任務為：

- 建立現有的安全與環境功能
- 僅存發電電廠的最大值化並使其安全地在 50 年運轉期限後結束
- 完成剩餘用過核子燃料之處理計畫-Magnox 運轉計畫
- 提出降低風險與費用的 Magnox 最適化除役專案(Magnox Optimized Decommissioning Program, MODP)
- 至少在一廠址執行監護(Care and Maintenance State)
- 提出先進與可轉換的解決方案與方法
- 重組與降低人力
- 與工作人員及工會發展出夥伴關係
- 逐漸地將 Magnox 公司轉型為世界級、高效能的除役組織

詳細的簡報資料如附件三。雙方簡報結束後，進行內容交換與討論。由於核電廠除役為我國首例，且須於 2015 年底前研擬完成核一廠除役計畫，核電廠除役涉及核安、環境保護、放射性廢棄物管理、社會經濟、土地利用及公眾溝通等諸多因素，須有周詳妥善之規劃。我方考量 NDA 在核電廠除役之策略規劃、技術整合、計畫管理、環境影響評估與公眾溝通之經驗豐富且績效卓著，台電公司未來將與英國核能除役局(Nuclear Decommissioning Authority, NDA)就核電廠除役相關議題。屆時，本所將協助台電公司處理技術部份。

(五) 赴英國 Gloucestershire Berkeley 核電廠參訪(4/24)

位於 Gloucestershire 的 Berkeley 電廠，為英國早期第一座核能電廠之一，廠區有 27 英畝；廠址包括有緊鄰核電廠的 Berkeley 實驗室中心與辦公室。電廠於 1962 至 1989 年運轉，電廠持照人為 Magnox 公司，其母公司為 EnergySolutions；其全生命期(總折舊核子債信)則為 660 百萬英磅。燃料自反應器移除並於 1992 年完成；廠址周圍環境屬環境敏感並被指定為特別保護區、特別保留區、國際重要濕地及特定科學有興趣場地。

目前該廠正進行準備工作，以進入看顧與維護階段。Berkeley 電廠之重要活動如表 4，而表 5 則為 Berkeley 電廠基本資訊與重要數據。

表 4 Berkeley 核電廠重要活動回顧

Year 年	**Key Activities 重要活動**
2070 -2079	Final site clearance 最終廠址解除管制
2021	Site enters Care and Maintenance phase 廠址進入監護階段 During this stage the reactor is left to cool. Most of the structures are removed, and the reactor building is left in a safe state which requires minimum supervision, until final site clearance. Progress solution for Intermediate Level Waste (ILW) treatment 在此階段，反應器保持在冷的狀態；大多數結構已移除，只有反應器廠房留置在安全狀態，僅需維持最少的監管，直到最終廠址解除管制。 Design and manufacture of retrieval equipment for the Active Waste Vaults (AWV)設計與製造 AWV(Active Waste Vaults)的回收設備
2011	Start retrievals of Intermediate Level Waste (ILW) from the Active Waste Vaults (AWV)開始自 AWV 回收中放廢棄物(ILW)。
2008	**Retrieved, removed and processed for disposal all highly contaminated aloxite from Berkeley Power Station sand pressure filters**回收、移除與處理所有來自Berkeley電廠砂壓力過濾器的高污染鋁砂，以進行最終處置。
2007	**Started processing accumulated Intermediate Level Waste (ILW) in vaults**開始處理在窖中之ILW
1989 - 1992	Defuelled 移除燃料 Once a site has finished operating and the fuel has cooled down it can be removed and taken to Sellafield for reprocessing.一旦電廠結束運轉且燃料冷卻到能被移至 Sellafield 進行再處理

表 5 Berkeley 電廠基本資訊與重要數據

Basics 基本資訊	
Location:位置	Gloucestershire
Nearby towns/cities:鄰近城鎮：	Berkeley, Gloucester

Site area:廠面積：	27 hectares	
Number of current employees:線友職員數：	209	
Key dates 重要數據	**電廠**	**實驗室**
Construction start:建造起始	1957,	1959
Construction end:建造結束	1962,	1960
Start operation:開始運轉	1962,	1961
End operation:結束運轉	1989,	2004
Defuelling start:燃料移除開始：	1989,	N/A
Defuelling end:燃料移除結束：	1992,	N/A
Care & Maintenance Preparations start: 監護準備階段開始：	1992,	2003
Care & Maintenance Preparations end:		2011
監護準備階段結束：		
Plant description 電廠描述		
Reactor type:反應器型式：	Magnox	
Number of reactors:機組數：	2	
Number of fuel channels per reactor:反應器燃料元件數：	3,275	
Number of fuel elements per channel:每燃料元件之單元數：	13	
Number of control rods:控制棒數：	132	
Fuel material:燃料材料：	Natural uranium 天然鈾	
Reactor coolant:反應器冷卻劑：	Carbon dioxide 二氧化碳	
Number of turbo generators:汽機發電機數：	4	
Electrical output – design (net):電力輸出(設計)	300MW	
Station lifetime output to date:電廠全聲命其發電量：	43TWh	
Previous operators:原運轉者：	CEGB, Nuclear Electric, Magnox Electric/BNFL	
Adjacent nuclear power station:鄰近核電廠：	None 無	

為了實際了解英國核電廠之除役現況，特別經由駐英經濟組安排，自倫敦搭乘火車前往位於英格蘭西南的 Gloucestershire 的 Berkeley 電廠參訪，NDA 的 John Mathieson 亦特別陪同前往；參訪 Berkeley 電廠的行程與陪同人員如表 6。

由 Berkeley 電廠 Sean Sargent 先進行除役現況簡報，重要內容包括第一座最先開始除役的 Magnox 電廠(1989)，第一座燃料移除者(1992)，第一座燃料池拆除者(1996)，第一

座降低電廠執照者(2007)，第一座英國 Magnox 反應器進入安全貯存(Safestore)者(2010)。其中反應器置入被動建築狀態，即沒有火災負擔或點火源、防震品質、水進入最小化與泵監測抽水、水災防禦、五年維護期、衰減貯存之狀態。另外，為了回應利害關係人之意見，特別將反應器廠房高度降低。其鍋輪利用鄰近的河流，直接運往瑞典除污並外釋。接著由 Sean Sargent 等人陪同到現場參訪，如附件四照片。

表 6 參訪 Berkeley 電廠行程(Tuesday 24th April 2012)

11:45	Visitors arrive on site – please report to Main Power Station Gatehouse
12:00	Lunch
12:30	Introduction/ Safety Message
12:40	Presentation on Decommissioning at Berkeley Site
14:00	Site Tour
15:30	Q & A
16:00	Visitors Leave Site

英方與會人員：

NDA: David Rushton, John Mathieson

Site: Sean Sargent, Paul Oswald, Jim Payne, Tom Pattinson, Kirsty Roger, Catherine Harrington, Mike Tayloe

(六) 赴丹麥 Vestas Wind System A/S 集團參訪(4/25)

丹麥的 Vestas Wind System A/S 集團創建於 1945 年，1979 年開始製造風力發 電機，1987 年開始專門集中力量於風能的利用研究，此後便從一個行業先鋒發展至在全球設有 60 個高科技的市場領軍團隊、員工逾 9,500 人(至 2004 年 6 月)的大型企業，是全球風機設備供應商之首，其核心業務包括開發、製造、銷售和維護風力發電系統。

Vestas 亞洲區總裁 Thorbjorn Rasmussen 看好台灣風力發電市場，決定來台設立公司，同時與經濟部達成工業合作協議，未來台電公司風力發電三期計畫將是高度爭取的目

標。 Rasmussen 表示，台灣西部沿海的風力資源、架構和地理條件非常適合風力發電，再加上政府強力支持風力發電產業，未來對岸上和離岸的風力發電都是高度可預期的，因此 Vestas 決定在台灣設立分公司，將風機零組件供應鏈延伸至台灣，並與台灣業界加強合作。

Vestas 公司已擁有 20 年的離岸風力經驗，20 年的經驗教會他們「數據的品質」是最關鍵的，據關乎整個計畫的成敗。所以，事前妥善的規劃工作是非常重要，所面臨的挑戰包括前期資料必須是廣泛全面性的，並須考慮到海床條件是變動性的、海底的流砂會移動、海象影響及鹽漬環境，還有更複雜的安裝及維護工作，在前期資料的蒐集必須注意到風、海、距離及碼頭等重要風險因子。

台電公司於 2001 年推出的長期風力開發計畫，將分三期建造 200 座風力渦輪發電機，如以每部發電機組的成本 1 億到 1.5 億元來計算，政府為此計畫將撥款 300 億元以上金額採購，若能借助 Vestas 在離岸風力的豐富建置經驗及相關技術，將有很大助益。然台灣的土壤承載力及氣候(颱風)因素是 Vestas 於丹麥建置風場時無須面臨的問題，對於這些問題應有因應措施。

1. 風力發電計畫

台電公司自 89 年起迄今已完成風力發電一期至三期計畫及離島風力計畫，運轉中之風力發電機組共 161 部，總裝置容量 286.76 千瓩，其中彰化王功風力 10 部機計 23,000 瓩、林口風力 3 部機計 6,000 瓩、大潭風力 5 部機計 10, 600 瓩皆於 100 年完工並開始商轉，風力發電第四期計畫 100 年 6 月奉核定，預定 101-104 年執行。

(1) 風力第一期計畫(92 年 1 月~97 年 12 月)：

共設置 59 部風力發電機組，總裝置容量為 98.96 千瓩，計完成石門風力(660 瓩x6 部)、大潭(I)風力(1500 瓩x3 部)、觀園風力(1500 瓩x20 部)、香山風力(2000 瓩x6 部)、台中港區風力(2000 瓩x18 部)、台中電廠風力(2000 瓩x4 部)及恆春風力(1500 瓩x3 部)等廠址，風機皆已商轉，詳如表 7。

表 7 風力第一期計畫(92 年 1 月~97 年 12 月)

Site	Wind Turbine Type	Rated Power	Hub Height
Shinmen	VESTAS V47 (DK)	660 kW	45m
Tatan (I)	GE 1.5Se (USA)	1,500 kW	64.7m
Guanyuan			
Shianshan	Gamesa Eolica G80 (ESP)	2,000 kW	65 m
Taichung Harbor	STX Z72	2,000 kW	65 m
Taichung Power Plant			
Hengchun	GE 1.5Se (USA)	1,500 kW	64.7 m

(2) 風力第二期計畫(94 年 1 月~100 年 9 月)

共設置 58 部風力發電機組，總裝置容量為 116 千瓩，計完成彰工Ⅰ風力(2000 瓩x23 部)、雲林麥寮風力(2000 瓩x15 部)、四湖風力(2000 瓩x14 部)、林口風力(2000 瓩x3 部)及大潭風力(2000 瓩x3 部)等廠址，風機皆已商轉，詳如表 8。

表 8 風力第二期計畫(94 年 1 月~100 年 9 月)

Site	Wind Turbine Type	Rated Power	Hub Height
Changgong	VESTAS V80 (DK)	2,000kW	67m
Yunlin Miailiao			78m
Sihu			
Linko			
Tatan			

(3) 風力第三期計畫(96 年 1 月~100 年 7 月)：

共設置 28 部風力發電機組，總裝置容量為 59.6 千瓩，計完成彰工Ⅱ風力(2,000 瓩x8 部)、雲林麥寮Ⅱ風力(2,000 瓩x8 部)、彰化王功風力(2,300 瓩x10 部)及大潭Ⅱ風力(2,300 瓩x2 部)等廠址，風機皆已商轉，詳如表 9。

表 9 風力第三期計畫(96 年 1 月~100 年 7 月)

Site	Wind Turbine Type	Rated Power	Hub Height
Changgong II	VESTAS V80 (DK)	2,000 kW	67 m
Yunlin Mailiao II			
Changhwa Wanggong	ENERCON E-70 E4 (DE)	2,300 kW	64 m
Tatan II			

(4) 澎湖中屯、金門金沙及澎湖湖西計畫：

共設置 16 部風力發電機組，總裝置容量 14.2 千瓩，計完成澎湖中屯風力(600 瓩x8 部)、金門金沙風力(2,000 瓩x2 部)及澎湖湖西風力(900 瓩x6 部)等廠址，風機皆已商轉。

(5) 風力發電第四期計畫(101 年~104 年)：

規劃設置 12 部風力發電機組，總裝置容量為 14.8 千瓩，計有蘆竹(850 瓩x8 部)、四湖Ⅱ(2,000 瓩x1 部)及核三廠Ⅱ(2,000 瓩x3 部)等廠址，目前申辦籌設中。

2. 太陽光電發電計畫

第一期計畫原規劃於民國 100 年底以前設置 10MW 太陽光電系統，投資金額 35.7 億元，設置地點包括台電自有房舍建物、土地及外界提供合適之處所。迄 100 年底已完成 15 個場址共 10.43MW 太陽光電系統併聯發電。

由於光電設備價格大幅下跌，致原第一期計畫投資總額仍有節餘款約 15.7 億元，本計畫修正在總投資金額不變下增設 9,200 瓩，並預計於 103 年底完成。

4 月 25 日下午，由經濟部長官率全體團員赴丹麥哥本哈根拜訪 Vestas 集團，由其資深副總裁 Peter Brun, 政府關係部門主任 Morten Dyrholm 及新興離岸風電市場部門主任 Casper Toft 負責接待，並簡報其近期在離岸風機之研發與規劃。另外，也由工研院綠能所童遷祥所長簡報台灣近期推出之「千架風機、百萬屋頂光電」計畫。參訪照片如附件五。

(七) 赴丹麥 Burmeister & Wain Energy A/S (BWE)集團參訪(4/25)

丹麥的 BWE 成立於 1843 年，是一家從事先進的超臨界蒸汽鍋爐設計的歐洲知名工程公司，它還設計、加工系列的鍋爐配套設備，主要包括低氮氧化物的燃燒爐、煤粉超級分離器以及高效熱交換器等，此外，BWE 公司也對現有鍋爐進行改造和改進。

BWE 是全球生物質發電技術的領導者，率先研發秸稈燃燒發電技術，在這家歐洲著名能源研發企業的努力下，丹麥於 1988 年誕生了世界上第一座秸稈生物燃燒發電廠。

丹麥潔淨能源發展技術，有助於提升臺灣在節能減碳及能源有效利用之不同新思維。參考丹麥在推動區域冷/熱供應系統的經驗，都市垃圾焚化爐所產生之大量熱能亦可作為冷熱電聯產，形成小型區域能源中心，此執行經驗可作為我國都市垃圾焚化爐轉型為能資源中心之重要參考。

4 月 25 日下午，由經濟部長官率全體團員赴丹麥哥本哈根拜訪 BWE 集團，由其執行長 Claus Andreasson, 市場部門副總裁 Paolo Danesi 及工程部門副總裁 Flemming Skovgaard Nielsen 負責接待，並做簡報。

(八) 與駐丹麥哥本哈根代表處陳國璜代表座談(4/25)

4 月 25 日下午，由駐丹麥哥本哈根代表處陳國璜代表及駐丹經濟組曾組長等，與全體團員座談，並邀請丹麥相關民意代表與外交、經濟政府官員與會，包括丹麥國會議員兼外交政策委員會主席 Jeppe Kofod、丹麥僱主協會(Confederation of Danish Employers)執行長 Henrik Bach Mortensen、丹麥外交部外人投資局代理局長 Helle Meinetz、哥本哈根經濟研究院 Martin H. Thelle 等與會。

(九) 參與丹麥工業總會舉辦的圓桌論壇會議(4/26)

4 月 26 日上午，由經濟部長官率全體團員赴丹麥工業總會，參加圓桌論壇會議，由丹麥工業總會能源事務處長 Mr. Hans Peter Slente 主持，由哥本哈根經濟研究院 Martin H. Thelle 簡報該院接受我方委託所撰擬台歐盟 ECA 研究專文之初步結果；並也由我方的貿易局陳副局長、能源局蘇組長及張秘書長，分別於會中進行簡報兩岸 ECFA 談判之現況與成果、我國在生能源發展規劃等，其中由蘇組長報告的我國再生能源發展現況簡報資料如附件六。另外，也安排丹麥在地廠商，對其公司與產品作簡介。

三、 心 得

（一）目前國家能源政策定調為穩健減核，未來經濟部在推動我國核後端業務勢必加強；尤其是核一廠很快面臨除役，國內低放射性廢棄物處置選址處於停滯狀態，本所即將於明年改隸經濟及能源部等因素；故此次參訪英國核子除役局(NDA)，主要是由經濟部長官提議，函請本所與台電公司派員隨團參加，希望能汲取英國透過公法人運作處理核後端業務之經驗，作為未來我國推動成立核後端管理專責機構時之參考。而由此次之參訪，獲知 NDA 於 2005 年成立時，政府即將幾個準備除役的電廠所有權轉移給 NDA，但它不直接管理所擁有的核設施；而是經由國際招標方式，與有執照運轉人(即廠執照公司(Site Licence Companies, SLCs)簽訂管理及運轉合約，在每一廠址發包一廠址專案計畫。管理廠址包括準備廠計畫、執行與再下包工作。母公司(Parent Body Organizations, PBOs)在 SLCs 與 NDA 合約期間，擁有部分持股，PBO 負責管理廠址專案計畫。例如，我們於 4 月 24 日參訪的 Berkeley 電廠，即由美國母公司 EnergySolutions 所成立的 Magnox 公司持有 Berkeley 電廠廠址執照，並負責其除役工作。NDA 並透過競標，定期讓各 PBO 間相互競爭。由上述之委辦方式，若套用到我國，必須面對的問題是：我們是否足夠國際化？我們的採購法規是否容許？委由國際廠家負責執行，國內廠商能否受益？我國的核後端管理機構能否擁有待除役核電廠？上述問題有待經濟部組織一專案小組逐一釐清。

（二）由於核電廠除役為我國首例，且須於 2015 年底前研擬完成核一廠除役計畫；而核電廠除役又涉及核安、環境保護、放射性廢棄物管理、社會經濟、土地利用及公眾溝通等諸多因素，須有周詳妥善之規劃。我方考量 NDA 在核電廠除役之策略規劃、技術整合、計畫管理、環境影響評估與公眾溝通之經驗豐富且績效卓著，台電公司將與英國核能除役局(Nuclear Decommissioning Authority, NDA)就核電廠除役相關議題，包括：除役策略與規劃、核電廠特性調查、除污與拆除技術、除役計畫管理、除役廢棄物管理、除役成本估計、安全與環境影響評估、利害相關人溝通及訓練等，進行人員互訪、專業諮詢及資訊交流等事宜，以利於我國核電廠除役計畫之規劃與

執行。目前，本所為台電公司所規劃的研究計畫，上述議題均有所涵蓋，未來本所可協助台電公司處理技術部份之議題。

（三）至於參訪 Berkeley 電廠部分，由於其已進入監護階段，目前之除役工作集中在其周圍實驗室之拆除與整理方面；故相關除役作業可提供本所 TRR 後續拆除計畫之參考。

（四）參訪 Vestas 公司方面，在其向參訪團的簡報，提及未來將開發防颱與防震的離岸風機；由於只停留約 2 小時，我們只與相關技術人員互換名片，希望日後有機會相互合作。另外，Vestas 公司提到可能於今年(101)6 月，與丹麥駐台辦事處合作，來台辦理離岸風機研討會；我們已於事後去信告知本所過去在中小型風機之發展與累積能力，希望未來與 Vestas 公司合作；並邀請他們若 6 月間來台的話蒞所訪問，對方也回信同意。

（五）至於其他配合國貿局行程，從中也觀察並了解到經濟部做事之縝密，由事前規劃、連繫、問題掌握、會議紀錄及敬業態度；未來本所將改隸經濟及能源部，值得我們及早適應與安排。

四、 建 議 事 項

（一）未來台電公司若承經濟部指示，成立專案小組進行我國核後端管理專責機構之規劃時，建議本所積極派員參與；除了可以提供廣泛技術建議外，亦能為本所未來參與我國核後端業務鋪路。

（二）未來台電公司與 NDA 開始除役合作交流後，且台電公司亦委託本所執行核一廠除役計畫，則本所亦應積極協助台電公司處理與 NDA 之合作交流事務。

（三）有關離岸風機之設計分析技術，本所已積極準備藉由參與主軸計畫第二期計畫，做為拓展相關能力之第一步。也希望能有機會與國外有經驗廠家之技術交流合作，以逆向工程快速複製建立相關設計分析計算能力，期望在五年內能協助國內業者(含台電公司)接收國外相關技術文件。

五、 附 錄

附件一、英國核子除役局(Nuclear Decommissioning Authority, NDA)簡介

核設施除役機構(Nuclear Decommissioning Authority, NDA)是依據英國 2004 年能源法，於 2005 年成立的一非政府部門公眾機構；係一策略性機構，擁有以往隸屬 UKAEA(United Kingdom Atomic Energy Authority)與 BNFL(British Nuclear Fuels plc)的民用核子債務與資產。負責：

- 這些核子設施的除役與清理
- 確保所有的放射性與非放射性廢棄物產出，均被安全地管理
- 執行政府的核子廢棄物之長期管理政策
- 發展全英之核子低放廢棄物(LLW)策略與計畫
- 詳細檢查英國能源之除役規劃

NDA 的目的為以安全及經濟有效的態度，將英國的民用核子遺產除役與清理，並可能的話，加速專案工作來降低危害。NDA 將藉由一系列競爭下，引進創新技術及委託專家來達成。NDA 向能源及氣候變遷部(Department of Energy and Climate Change, DECC)負責；然對於 NDA 在蘇格蘭的某些功能方面，則對蘇格蘭部長負責。

NDA 的高優先任務為對安全、環境責任，以及提供納稅人繳費被有價值的使用。NDA 不直接管理 NDA 所擁有的設施；而是經由與有執照運轉人(即廠執照公司(Site Licence Companies, SLCs)之管理及運轉合約，在每一廠址發包一廠址專案計畫。

管理廠址包括準備廠計畫、執行與再下包工作。母公司(Parent Body Organizations, PBOs)在 SLCs 與 NDA 合約期間，擁有部分持股，PBO 負責管理廠址專案計畫，如表 10 所示。NDA 並透過競標，定期讓各 PBO 間相互競爭。

NDA 的放射性廢棄物管理理事會(Radioactive Waste Management Directorate, RWMD)將負責提供地質處置場，截至目前，它的擁有權將開放給其他 NDA 廠址相互競爭。但在決定這是否為一適當的執行方法前，政府、主管機關與供應廠家間之進一步對話是有需要的。

能源及氣候變遷部(United Kingdom's economics and finance ministry)與女王資產部(Her Majesty's Treasury(HM Treasury))共同來決定 NDA 的年度運作預算，包括有來自政府之資助及 NDA 商業資產之營收。2011/12 年之預算為 29 億英鎊，其中 20 億為政府資助，9 億屬商業營收。

NDA 目前 19 個核子廠址，如下圖 1 所示。英國民用核電廠計畫在戰後軍用核武生產鈽而滋長；自 1946 年來，英國在全英推展核研究與發展場址之主要核子計畫，在包括有 1953 至 1971 年間，建造 26 部反應器。另核子在處理設施也有興建，以因應來自軍民用計畫需求之增加。這個遺產的問題之一，對照到現代核電廠為有限的可得資訊。例如，在某些老舊設施，廢棄物的詳細盤存並不存在及缺乏可靠的設計圖。某些圍繞著清理的技術議題，在它們能被處理前將需要創新與先進的科技。

過去 60 年間，來自核電廠第一代 Magnox 艦隊，已實質成為全英供電之一部分。這些 11 座電廠已產生超過 900 TWh 電力，相當於過去 45 年間供應 5 百萬家庭所需用電。其中只有 2 部仍運轉中，但已接近運轉生命壽限。這個核子遺產目前已成為英國的一主要公共資產，而必須以有規劃及聚焦的態度處理之。NDA 就是這樣於 2005 年創立，以取代之前為 BNFL(British Nuclear Fuels plc)與 UKAEA(United Kingdom Atomic Energy Authority)所擁有廠址的除役責任。

NDA 的資產

Sellafield

Sellafield 自 1940 年代以來，就在核工業扮演著樞紐的角色，它在 2 平方哩範圍內，提供了核子燃料再處理、核子燃料製造及核子物料與放射性廢棄物之貯存。他亦存放某些有害廢棄物，故是我們優先適當處理的對象。

在 Sellafield 廠址亦座落著 Calder Hall 核電廠，為第一座併網供電者；另擁有 3 部反應器之 Windscale 核電廠，其中一部在 1957 年因火災而嚴重損毀，因而增加除役之額外挑戰。

Magnox 反應器廠址

Magnox 核電廠艦隊包括有 11 座核電廠：Berkeley, Bradwell, Calder Hall, Chapelcross, Dungeness A, Hinkley Point A, Hunterston A, Oldbury, Sizewell A, Trawsfynydd 與 Wylfa。

所有電廠均依下列階段演變轉換(請參表 11)：

a) 運轉及發電(目前僅 Wylfa)
b) 核子燃料移除-核子燃料自反應器移出並轉送至 Sellafield 進行再處理：Chapelcross, Dungeness A, Sizewell A，而 Calder Hall 將在 2012 年執行。
c) 監護準備-在這階段，核子廢棄物如渣泥/樹酯及有害廢棄物如石棉均已移出廠址(Trawsfynydd, Berkeley, Hinkley Point A, Bradwell and Hunterston A)。
d) 監護-這階段，廠址與反應器廠房於最終廠址解除管制前，維持在安全狀態下。
e) 最終廠址解除管制-這是當地質處置場已完成，可提供除役產生之剩餘廢棄物移往處置，才可以發生。當這些活動完成後，廠址即達到其指定的最後狀態。

Dounreay

Dounreay 為英國的快滋生反應器研究中心，自 1955 年開始至 1994 年結束；目前成為蘇格蘭地區最大的核子清理與拆除計畫。

Harwell and Winfrith

Harwell 在 1946 年設立，為英國第一個原子能研究機構；而 Winfrith 則為 ground breaking reactor 之主要研究中心，自 1950 年代末期開始發展至 1990 年代結束。兩個廠址均包括有許多核子研究設施，包括鈽操作設施、放射性實驗室、核子廢棄物處理與貯存設施；除役均已展開中。

低放射性廢棄物處置場

低放射性廢棄物處置場位於近 Drigg 的 West Cumbria，自 1959 年起接收低放射性廢棄物。主要來源為以鐵路運自 Sellafield 的廢棄物；英國其餘核設施及如醫用、研究用非核設施的廢棄物則以陸運。

Capenhurst

Capenhurst 內有鈾濃縮廠及其他相關設施，於 1982 年停止運轉。它同時安全地貯存全英之耗乏鈾與六氟化鈾存量。Capenhurst 廠址緊鄰 Urenco 廠址，其為商業用濃縮鈾廠。

Springfields

自 1940 年代起，Springfields 即為全英核電廠及國際客戶製造核子燃料元件；除了核子燃料製造外，它亦開始執行各種除役活動。在 2010 年 3 月，NDA 與西屋簽約，將 Springfields 的商業運轉與工作人員轉移給西屋；而西屋過去曾在 NDA 委託下，成功地管理了 Springfields 五年時間。

表 10.NDA 各廠址所屬 SLC 及 PBO

Site	Site Licence Company	Parent Body Organisation (& owning consortia)
Berkeley Bradwell Dungeness A Hinkley Point A Sizewell A	Magnox South	Reactor Sites Management Company Ltd (Energy Solutions Inc)
Chapelcross Hunterston A Oldbury Trawsfynydd Wylfa	Magnox North	Reactor Sites Management Company Ltd (Energy Solutions Inc)
Calder Hall Capenhurst Sellafield Windscale	Sellafield Ltd	Nuclear Management Partners Limited (URS, Amec and Areva)
Low Level Waste Repository	LLWR Ltd	UK Nuclear Waste Management Limited (URS, Studsvik, Areva and Serco)
Dounreay	Dounreay Site Restoration Ltd	UKAEA Limited (Babcock International Group PLC)
Harwell Winfrith	Research Sites Restoration Ltd	UKAEA Limited (Babcock International Group PLC)
Springfields	Decommissioning activity on this site is performed by Springfields Fuels Limited, a wholly-owned subsidiary of Westinghouse Electric UK Holdings Limited.	

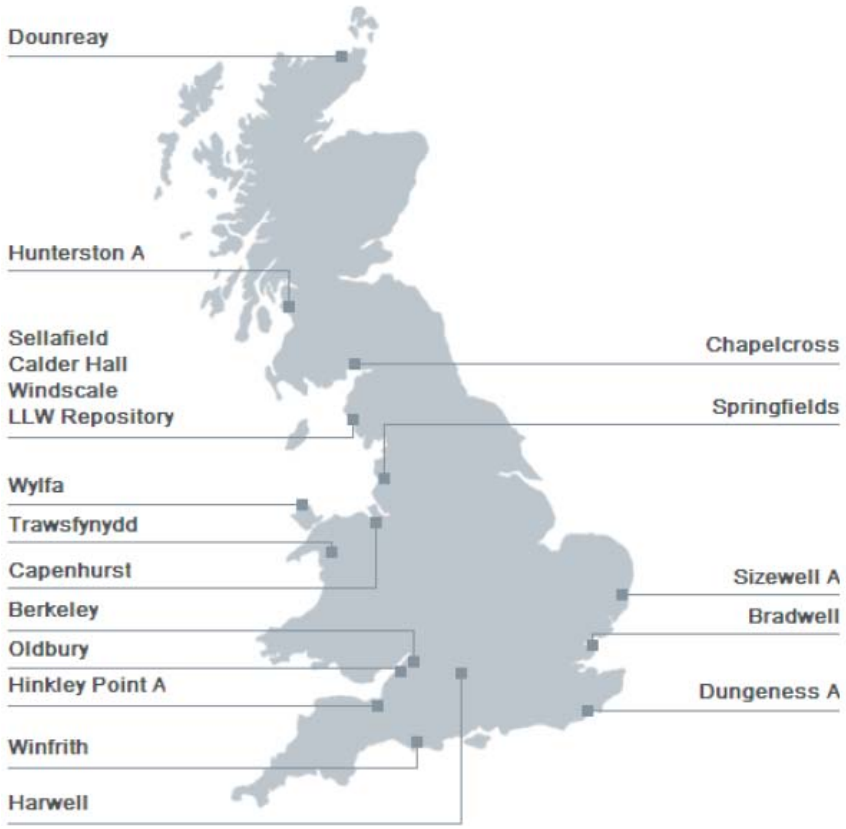


圖 1. NDA 所轄廠址分佈

表 11. NDA 所轄廠址之各階段年譜

Station	Generation	Defuelling	Care & Maintenance Preparations	Care & Maintenance	Final Site Clearance
Calder Hall	1956-2003	2012-2015	2015-2024	2024-2105	2105-2115
Chapelcross	1959-2004	2008-2011	2011-2022	2022-2116	2116-2128
Berkeley	1962-1989	1989-1992	1992-2026	2026-2074	2074-2083
Bradwell	1962-2002	2002-2006	2006-2027	2027-2095	2095-2104
Hunterston A	1964-1990	1990-1995	1995-2020	2020-2081	2081-2090
Dungeness A	1965-2006	2008-2011	2011-2034	2034-2102	2102-2111
Hinkley Point A	1965-1999	2000-2004	2004-2030	2030-2095	2095-2104
Trawsfynydd	1965-1993	1993-1995	1995-2021	2021-2088	2088-2098
Sizewell A	1966-2006	2009-2012	2012-2034	2034-2102	2102-2110
Oldbury	1967-2011	2012-2014	2014-2027	2027-2095	2096-2101
Wylfa*	1971-2012	2011-2015	2015-2025	2025-2116	2116-2125

*Generation dates subject to regulatory and DECC approval. Defuelling commencement date will be driven by the generation extension, however the end date will be maintained within MOP constraints.Dates are correct at the time of going to press, for latest information visit www.nda.gov.uk

Nuclear Decommissioning Authority
Overview

Presented to: Taiwanese Delegation, London 23 April 2012

John Mathieson，Head of International Relations
April 2012

1

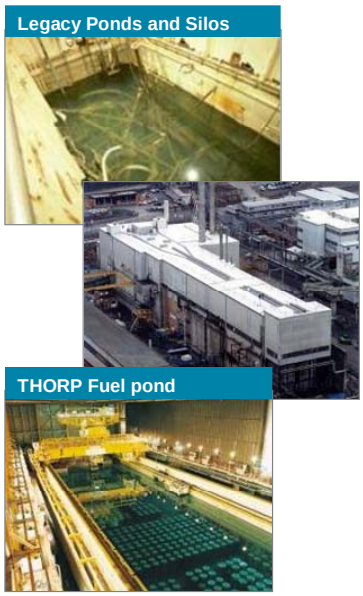
NDA strategic approach

Our activities are grouped under six strategic themes that translate into key programmes of work that must be delivered in the short to medium term.

Reduce hazards and liability across our estate (eg legacy ponds & silos)	**Ensure fuel from 1st and 2nd generation is reprocessed and managed in a safe and secure way**	**Implement storage and disposal arrangements for LLW, ILW and HLW inc GDF**	**Deal with plutonium and uranium in a safe and secure way**	**Maximise commercial value from our assets**
SITE RESTORATION	SPENT FUELS	WASTE MANAGEMENT	NUCLEAR MATERIALS	BUSINESS OPTIMISATION
CRITICAL ENABLERS				
Build an effective industry (skills, R&D, competition, pensions, socio-economic)				

4

The NDA Estate - Sellafield



- **Key role in nuclear industry since 1940s**
- **Largest nuclear site in Europe**
- **Most diverse portfolio of any nuclear site in the world**
- **Providing fuel reprocessing, fuel fabrication, storage of nuclear materials and radioactive wastes**
- **Dealing with high hazards is a top priority and making progress with Legacy Ponds and Silos**
- **Also on the site:**
  - Calder Hall, the first nuclear power station to supply the grid and Windscale which comprises three reactors

The NDA Estate - Magnox

All 11 sites are in transition through the following phases:

- **Operations and electricity generation** (Oldbury finished in Feb 2012, Wylfa still running)
- **Defuelling** – removal of fuel from reactor and transported to Sellafield for reprocessing (Chapelcross, Dungeness A, Sizewell A, Calder Hall)
- **Care and Maintenance preparations** – removal of hazards such as sludges/resins/asbestos (Trawsfynydd, Berkeley, Hinkley Point A, Bradwell and Hunterston A)
- **Care and Maintenance** – site and reactor buildings are left in a safe state until Final Site Clearance
- **Final Site Clearance –** Provision of a GDF will enable final decommissioning of the sites to take place

The NDA Estate - Dounreay

PFR clean-up

Demolition work

- The UK's centre of fast reactor R&D 1955 – 1994
- Scotland's largest nuclear clean-up and demolition project
- Experimental nature of the 'fast breeder' research work has led to complex decommissioning challenges that require real technological innovations

The NDA Estate – Harwell and Winfrith

Harwell building demolitions

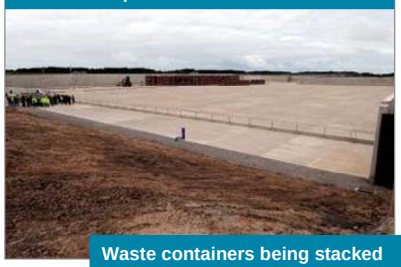
Waste storage at Winfrith

- Harwell – UK's first Atomic Energy Research Establishment (1946)
- Winfrith – Centre for ground breaking reactor development from the 1950s – 1990s

- Both sites contained nuclear research facilities, including plutonium handling facilities, radioactive laboratories, nuclear waste treatment and storage facilities.
- Decommissioning is well underway at both sites.

The NDA Estate - LLWR

New Vault opens at LLWR



Waste containers being stacked

- Low Level Waste Repository near Drigg has operated as a LLW disposal facility since 1959
- Compacted wastes come from Sellafield by rail
- Other waste arrives via road from facilities such as hospitals and research establishments
- LLW is disposed of in engineered concrete vaults
- Vault 9 opened in 2010
- Key emphasis on recycling and reusing material to reduce the volumes being disposed of at LLWR

9

The NDA Estate - Capenhurst

Uranic material stored at Capenhurst

Former diffusion plant demolition

- Home to uranium enrichment plant which ceased operation in 1982
- Stores the bulk of the UK's inventory of depleted uranium and uranium hexafluoride

10

The NDA Estate - Springfields

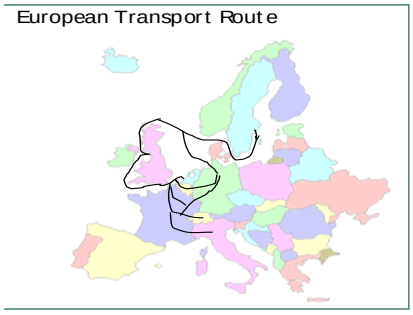
Fuel manufacture at Springfields

Springfields site

- Manufactured fuel products for UK nuclear power stations since 1940s
- Commercial operations and workforce of Springfields Fuels Limited transferred to Westinghouse in 2010.

Transport capability

European Transport Route



Direct Rail Services Limited
Safe Secure Reliable

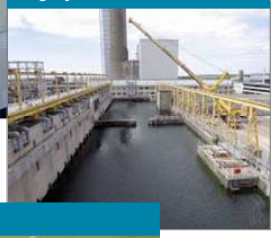
INS and DRS are wholly owned subsidiaries of the NDA

During the next 10 years we expect:

- All Magnox stations defuelled and spent fuel reprocessed to long-term stable form
- Four Magnox sites to have entered Care and Maintenance
- Progress on high hazard reduction, including retrievals from Legacy Ponds and Silos
- Management of all NDA sites to have been competed
- All NDA's non core assets to have been disposed of
- To commence Surface-Based Investigations Phase for the GDF

Chapelcross defuelling

Legacy Ponds



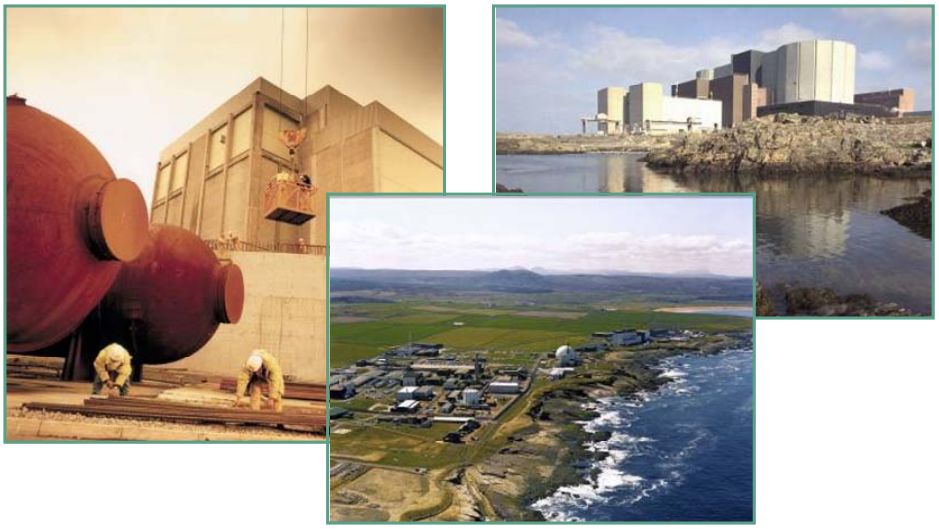
GDF

During the next 20 years we expect:

- All other Magnox sites to have entered Care and Maintenance
- Decommissioning to have been completed at Harwell and Winfrith
- At Dounreay, all ILW to have been removed from the shaft and all residues from the Dounreay Fast Reactor (DFR)
- At LLWR, the Plutonium Contaminated Material (PCM) facilities to have been removed
- Confirmation of a site's suitability to host a GDF

Harwell

Dounreay Fast Reactor



Magnox Decommissioning

Peter Ireland
Baseline Strategy Manager

Who are we?

- Magnox Limited
  - One generating site
  - Four defuelling sites
  - Five decommissioning sites
  - Offices at Berkeley, Oldbury and Daresbury
- Our customer, the Nuclear Decommissioning Authority (NDA), owns the sites
- Energy*Solutions,* our Parent Body Organisation, manage and operate the company

NDA Nuclear Decommissioning Authority

Magnox

ENERGYSOLUTIONS

Where are we?

- Two sites in Scotland
- Two sites in Wales
- Six sites in England

Nuclear Decommissioning Authority

Magnox

ENERGYSOLUTIONS

Magnox Reactors

- First generation of nuclear power stations in the UK
  - Natural uranium fuel clad in a non-oxidising magnesium alloy (Magnox)
  - Steel and pre-stressed concrete pressure vessels
  - Graphite moderated
  - CO_2 cooled

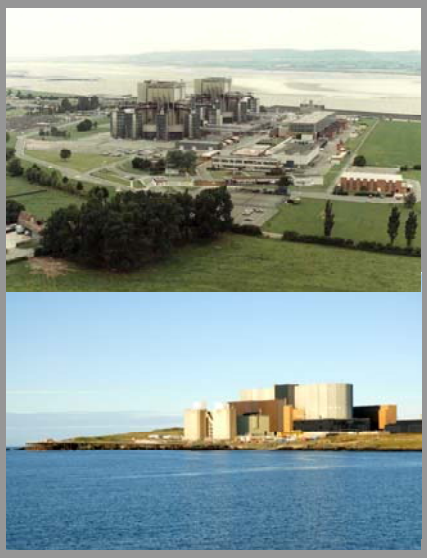
Nuclear Decommissioning Authority

Magnox

ENERGYSOLUTIONS

Magnox Reactors

- Berkeley – first fully commercial Magnox reactor; started generation in 1962, shutdown in 1989
- Wylfa – last Magnox reactor started generation in 1971



NDA Nuclear Decommissioning Authority Magnox ENERGYSOLUTIONS

The Magnox Mission

- Build on existing safety and environmental performance
- Maximising value from the remaining generating sites and bring safely to an end over 50 years of generation
- Complete the programme for dealing with the remaining spent fuel - Magnox Operating Plan
- Reduce risk and cost by delivering the Magnox Optimised Decommissioning Programme (MODP)
- Deliver a Care and Maintenance state to at least one site
- Pioneer innovative and transformational solutions and ways of working

NDA Nuclear Decommissioning Authority Magnox ENERGYSOLUTIONS

The Magnox Mission (cont.)

- Reshape and reduce workforce
- Deliver in partnership with workforce and unions
- To progressively transform Magnox into a world class, high performing decommissioning organisation

NDA Nuclear Decommissioning Authority Magnox ENERGYSOLUTIONS

Magnox Optimised Decommissioning Programme

- The Magnox Optimised Decommissioning Programme (MODP) is our programme of work over the next five years:
  - Extended Generation
  - Magnox Operating Plan
  - Strategic Programme Delivery
  - Workforce Restructuring

NDA Nuclear Decommissioning Authority Magnox ENERGYSOLUTIONS

NDA Objectives – Business Optimisation

- To create an environment where existing revenue can be secured, and opportunities can be developed against criteria agreed with
  - Revenue Optimisation: To maximise the value provided by our commercial revenue generating activities and operations

NDA Nuclear Decommissioning Authority Magnox ENERGYSOLUTIONS

Business Optimisation – Extended Generation

- Generation optimisation at Wylfa and Oldbury
  - Oldbury, extended generation by 4 years to February 2012
  - Wylfa, originally scheduled to shut down in December 2010, plans to continue through to 2014 by moving the fuel from one reactor to another

NDA Nuclear Decommissioning Authority Magnox ENERGYSOLUTIONS

Spent Fuel – Magnox Operating Plan

- Defuel in line with the Magnox Operating Plan (MOP)
  - As soon as reasonably practicable following cessation of electricity generation
  - The MOP details the defuelling process at each sites
  - Working with a range of organisations and regulators

NDA Nuclear Decommissioning Authority Magnox ENERGYSOLUTIONS

NDA Objectives – Site Restoration

- To restore our designated sites and release them for other uses
  - Decommissioning: To deliver Site End States as soon as reasonably practicable with progressive reduction of risk and hazards
  - Land Quality Management: To ensure that Land quality is managed to protect people and the environment
  - Site End States: To define credible objectives for the restoration of each site (or part of a site)

NDA Nuclear Decommissioning Authority Magnox ENERGYSOLUTIONS

NDA Objectives – Integrated Waste Management

- To ensure that wastes are management in a manner that protects people and the environment, now and in the future, and in ways that comply with Government policies and provide value for money
  - Higher Activity Waste: To treat and package retrieved HAW and place it in safe, secure and suitable storage facilities until it can be disposed of, or be held in long term storage in the case of a proportion of HAW in Scotland

NDA Nuclear Decommissioning Authority Magnox ENERGYSOLUTIONS

NDA Objectives – Integrated Waste Management

- Lower Activity Waste – Solid Low Level Wastes: To provide capability and capacity for managing solid low level radioactive waste to support our decommissioning and operations and make facilities available to other LLW producers
- Lower Activity Waste – Liquid and Gaseous Discharges: To reduce the environmental impact of radioactive liquid and gaseous discharges in accordance with the UK Strategy for Radioactive Discharges
- Non-Radioactive and Hazardous Waste: To reduce waste generation and optimise management practices for non-radioactive and hazardous wastes at NDA sites

NDA Nuclear Decommissioning Authority Magnox ENERGYSOLUTIONS

Decommissioning Phases

- Care & Maintenance Preparations
  - Significant hazards made passively safe
  - Operational Higher Activity Wastes put into Interim Storage Facility awaiting appropriate disposal route
  - Reactors put into Safestore
  - Other buildings manage (deplant, decontaminate or demolish) as appropriate

NDA Nuclear Decommissioning Authority Magnox ENERGYSOLUTIONS

Decommissioning Phases (cont.)

- Care & Maintenance
  - Quiescence period gaining benefit from radioactive decay
  - Monitoring and inspection
  - Disposal of Higher Activity Wastes if disposal route becomes available during this period
- Final Site Clearance
  - Dismantling of reactors and any other structures
  - Current assumption 85 years after cessation of generation
  - Restore site and release for alternative use

NDA Nuclear Decommissioning Authority Magnox ENERGYSOLUTIONS

Preparation for Decommissioning

- UK Legal requirement to gain consent from Health and Safety Executive (HSE) prior to start of decommissioning
  - Covering the entire decommissioning project including Final Site Clearance
- Other developments on site may also require (separate) EIA as part of planning law
  - e.g. Erection of Interim Storage Facility for wastes
- Results of Environmental Impact Assessment (EIA) presented in Environmental Statement
  - Broad content defined in law
  - Formal consultation period

➥ Upfront project definition key to success

NDA Nuclear Decommissioning Authority Magnox ENERGYSOLUTIONS

Environmental Topics

- Wide range of issues considered
  - Noise and vibration
  - Air quality
  - Geology, hydrogeology and soils
  - Surface water quality
  - Ecology
  - Traffic and transport
  - Landscape and visual
  - Socio-economic
  - Archaeology and cultural heritage

NDA Nuclear Decommissioning Authority Magnox ENERGYSOLUTIONS

Consultation

- Wide range of consultees involved:
  - Town, District & Borough councils
  - Non-governmental Organisations e.g. Greenpeace
  - Wildlife trusts
  - Conservation agencies
  - Government departments
  - Water companies
  - Tourist boards
  - Emergency services
  - Health authorities
  - General public

➥Know your stakeholders and their concerns

NDA Nuclear Decommissioning Authority Magnox ENERGYSOLUTIONS

Mitigation and Compensation

- Significant potential environmental impacts to be mitigated (prevented or reduced) or compensated (alternative or replacement)
- Mitigation and compensation incorporated into site projects
  - for example, prevention of water pollution during demolition
- Environmental Management Plan updated annually and monitored by the HSE
- Impact of any changes in projects have to be assessed in advance
  - Significant adverse impact may lead to further consultations

NDA Nuclear Decommissioning Authority Magnox ENERGYSOLUTIONS

Strategic Programme Delivery

- Implementation of Programmisation
  - Optimisation of work
  - Use of consistent solutions and innovative technologies
  - Mobile programme teams integrated with site workers maximising cross-site learning
  - Minimisation of cost

↪ Programme integration = cost effective delivery

NDA Nuclear Decommissioning Authority Magnox ENERGYSOLUTIONS

Strategic Programme Delivery (cont.)

- Strategic Programmes for Decommissioning
  - Ponds Decommissioning
  - Plant and Structures

- Strategic Programmes for Waste Management
  - Fuel Element Debris (FED) Treatment
  - Intermediate Level Waste (ILW) Management
  - Graphite Disposal

NDA Nuclear Decommissioning Authority Magnox ENERGYSOLUTIONS

Strategic Programme Delivery (cont.)

- Accelerated Care and Maintenance
  - Bradwell (2015) and Trawsfynydd (2016) as lead sites
  - Define and underpin the cost to achieve entry into Care and Maintenance
  - Deliver significant hazard reduction
  - Demonstrate new technologies at Bradwell
  - Towards significant future reduction in decommissioning costs

NDA Nuclear Decommissioning Authority Magnox ENERGYSOLUTIONS

Strategic Programme Delivery (cont.)

- Safe and Efficient Decommissioning
  - Tackling the highest hazards first
  - Implementation of the Berkeley Active Vaults Retrieval Project
    - Retrieval of significant volume of legacy waste
  - Moving Chapelcross and Dungeness A into a low cost interim state to release funding for other higher hazard projects
- Effective Waste Management
  - Reduce, reuse, recycle

NDA Nuclear Decommissioning Authority Magnox ENERGYSOLUTIONS

Strategic Programme Delivery (cont.)

Nuclear Decommissioning Authority

Magnox

ENERGYSOLUTIONS

The MODP – Workforce Restructuring

- Restructuring the workforce to deliver programmes of work
  - As each phase ends there is significant transition on the site in terms of plant and people
  - We will deliver through a programmes approach
  - We will ensure that our people are given opportunities to re-skill within the business
  - We will reduce our workforce, ensuring our people are treated fairly

Nuclear Decommissioning Authority

Magnox

ENERGYSOLUTIONS

Summary

- Build on Magnox's excellent safety and environmental performance
- Delivering the Magnox Optimised Decommissioning Programme

➥ Progressive transforming into a world class high performing decommissioning organisation

NDA Nuclear Decommissioning Authority

Magnox

ENERGYSOLUTIONS

附件四、參訪 Berkeley 電廠照片

附件五、參訪 Vestas 集團照片

附件六、我國再生能源發展現況

The Development of Renewable Energy in Taiwan

Bureau of Energy, MOEA

April 26, 2012

Outline

- Foreword
- Current Development of Renewable Energy
- Renewable Energy Development Act
- Offshore Wind Power Policy
- New Prospects for Renewable Energy
- Concluding Remarks

Foreword

- Vulnerability of Taiwan's energy supply system
  - High dependency on imported energy supply
  - High concentration of energy supply (fossil fuels dominated)
- Key to reduce energy supply vulnerability
  - Accelerate indigenous energy supply
  - Diversify energy sources
- Acknowledging the importance of renewable energy
  - Source 8% of final energy supply from renewable energy by 2025

Current Development of Renewables (1/4)

- **Targeted renewable power generation capacity is 9,952 MW by 2025, which subject to available resources and technological development.**

Year / Renewables	Feb. 2012		2025	
	Capacity (MW)	%	Capacity (MW)	%
1. Hydropower	2040.7	5.04	2,502	3.72
2. Wind Power	563.8	1.39	3,000	4.46
3. Photovoltaics	111.9	0.28	2,500	3.72
4. Biomass	798.5	1.97	1,400	2.08
5. Geothermal	—	—	150	0.22
6. Fuel Cell	—	—	200	0.30
7. Marine Energy	—	—	200	0.30
Total	3,515	8.68	9,952	14.8
8. Solar Water Heater	2.16 million m^2		4.09 million m^2	

Source: Bureau of Energy, Ministry of Economic Affairs, R.O.C. (Taiwan)

Current Development of Renewables (2/4)

☐ Conventional Hydropower

- Total hydro power capacity of 2,040.7 MW, of which the Public utilities (Taipower) accounted for 99.9% of large hydro power plants (2,001.6 MW), privately owned 39.1 MW only

☐ Wind Power

- Total wind power capacity of 563.8 MW, 288 wind turbines being erected.
- Another 277.5 MW projected capacity is under developed, of which 146.3 MW project approved and 131.2 MW under evaluation

Tao-Yuan: 30 MW

Chuntung, Penhu: 4.8 MW

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Current Development of Renewables (3/4)

☐ PV: 111.9 MWp installed

- Bureau of Energy, MOEA funds many ongoing deployment programs：Solar City, Solar Top, Solar Campus, Emergency Systems in Remote Areas or Isolated Islands, Demo Farms, Solar Communities, Bidding Procedure of Solar Power Equipment, etc.

111.9MWp

- Completed prior to RES Act: 11 MWp
- Commissioned after RES Act: 90.5MWp
- Installed by Taiwan Power Company: 10.4 MWp

BIPV demonstration system

The Main Stadium of The World Games 2009 Kaohsiung: 1 MW

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Current Development of Renewables (4/4)

☐ Biomass power: 798.5 MW

- Municipal Solid Waste Incineration: 622.5 MW (25 plants)
- Biogas: 8.5 MW (3 landfills)
- Waste from Industries and Agriculture: 167.5 MW
- Annual Generation: 4.7 TWh

☐ Solar Water Heaters

- 2.16 million m^2 of heat collectors installed, penetration rate 7% (around 560 thousand households)
- Ranked No. 5 globally for installed density (land area based)
- Annual Energy Production: 147 million litres oil equivalent

☐ Biofuels

- Biodiesel: Mandatory B1 since July 2008, B2 on June 2010
- Bioethanol: E3 Gasohol Programme in Taipei and Kaohsiung Cities
- Annual Consumption: 100 thousand kilolitres of biodiesel, over 4 thousand kilolitres of bioethanol.

Renewable Energy Development Act (1/6)

☐ Promulgated on 8 July 2009

☐ Essence of the Act

- Regulate market competition and lift installation barriers for renewables
  - ➢ Obligation: purchase obligation and grid connection for the energy from renewables; public constructions prioritized of utilizing renewable energy
  - ➢ Incentive: fixed feed-in tariffs (FIT) for renewable electricity; subsidies for installations
  - ➢ Deregulation: removal of limitations for land use and requirements for self-usage power facilities
- Internalization of externalities of traditional energy
  - ➢ Fund: financial burdens to fossil fuel and nuclear power generations
  - ➢ Users and polluters pay principle: power utilities may pass the costs onto end-users by surcharging electricity bill

Renewable Energy Development Act (2/6)

- Goal: 6,500~10,000 MW (new installations)
- Provisions of grid connection and eligibility of Fixed Feed in-Tariffs for the certified renewable power equipment.
- Electricity from RES has priority connection to the grid nearby and wholesale to the power grid operator, which subject to economic rationality.
- Transmission lines from the RES equipment to the power grid shall be constructed and maintained by the RES operator.

Renewable Energy Development Act (3/6)

- Feed-in Tariffs for Renewables
  - The Feed-in Tariffs and calculation are reviewed every year by the committee that MOEA organized with related Ministries, scholars and experts, and other groups
  - 2012's Tariffs with 20 years contract are applicable for the electricity from renewables (except PV) and the PPA signed in 2012

Item	Types	Range (kW)	2012 Tariff (NT$/kWh)
Photovoltaics system	Roof type	≧1 ~ <10	9.4645
		≧ 10 ~ < 100	8.5394
		≧ 100 ~ < 500	8.1836
		≧ 500	7.3297
	Ground type	≧1	6.9027
Wind Power	Land base*	≧ 1 ~ < 10	7.3562
		≧ 10	2.5971
	offshore	--	5.5626
Stream-Type Hydropower	--	--	2.3302
Geothermal Energy	--	--	4.8039
Biomass Energy	No anaerobic digestion equipment	--	2.3302
	With anaerobic digestion equipment	--	2.6995
Refuse Derived Fuels	--	--	2.8240
others	--	--	2.3302

*for the systems require LVRT, the tariff is NT$ 2.6574/kWh

Renewable Energy Development Act (4/6)

☐ Renewable Energy Development Fund

- Budget source: power utilities and the operators whose self-usage power generation has exceed the certain capacity need to pay every year in proportion to their non-RES quotas
- Usage: Subsidies to renewable electricity price, renewable energy equipment and renewable energy demonstration, and other deployments
- The fund deviations of utilities may surcharge end-users electricity bill.

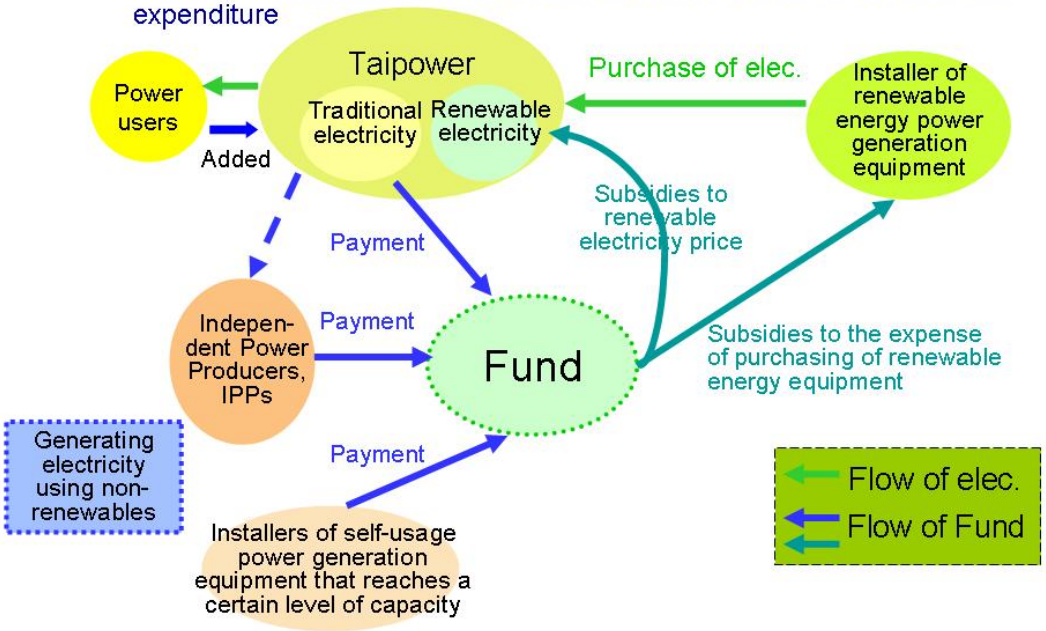
☐ Subsidies to power utilities for purchasing and self-generating renewable electricity

- Expiration: available up the targeted capacity the ACT has set.
- Subsidy: the difference between the feed-in tariffs and the avoided cost

Renewable Energy Development Act (5/6)

☐ Mechanism of Renewable Energy Development Fund

- Principle: income based on expected expenses to balance revenue and expenditure



Renewable Energy Development Act (6/6)

☐ Demonstrative incentives

- granted to the potential renewable power technologies in their early stage of development : BIPV, Marine Energy, Offshore Wind Power (under negotiation)

	BIPV	Marine Energy
Subsidy	NT$ 80,000~100,000/kW	5~100 kW: NT$ 250,000/kW >100 kW: NT$ 150,000/kW

☐ Incentives to thermal applications

- solar and bio-fuels
- Budget source: Petroleum Fund
- Financial incentives granted to biofuels from the energy crops of fallow land and idle lands, forestry and animal husbandry (under negotiation)

☐ New & renovating public construction works or buildings granted priority to those construction conditions fit renewable energy facilities

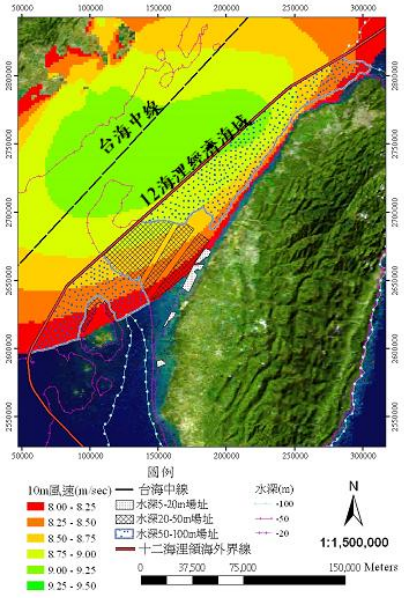
Offshore Wind Power Policy(1/4)- Potential

I. The development potential of offshore wind power is over 15 GW which has the market incentive and large scale development opportunity

■**Water deep 5-20 m (shallow sea)**
- ●**About 177,920 hectare**
- ●**About 9 GW in potential**
  - **1.2 GW exploitable (13% development)**

■**Water deep 20-50 m (deep sea)**
- ●**About 654,700 hectare**
- ●**About 48 GW in potential**
  - **6.2 GW developable (13% development)**

■**Water deep 50-100 m (deeper sea)**
- ●**About 1,195,400 hectare**
- ●**About 90 GW in potential**
  - **9 GW developable (10% development)**



※ The wind power device of 3 MW is estimated by 4Dx10D wind farm within the boundary of 12 nm territorial sea (D: the diameter of the blade 100 m).

Source: ITRI/GEL (Apr. 2011)

Offshore Wind Power Policy(2/4)- Strategies

Priority measure

I. Develop first offshore wind farm with Demonstration Incentives

(1) The developers choose the appropriate wind farm site and prepare for the demonstration offshore wind farm plan. The government offers the subsidy.

(2) Complete the pre-stage preparation procedures (artificial island, EIA, fishery right, national defense, shipping, etc.) by eliminating law and regulation obstacles.

(3) Establish cross department negotiation and simplify the administration procedure for wind farm development application.

II. Technology development for large scale offshore wind farms with Demonstration Incentives

(1) Set up large test site and develop competitive large scale offshore wind power system.

(2) Set up local fleet and develop technology of marine construction and turbine installation.

(3) Impetus industrial R&D alliance and direct industrial energy to the development of offshore wind farm.

III. Impetus large offshore wind farm development with industrial zone

(1) Begin zonal development of commercial scale for cost efficiency.

(2) Accelerate in creating domestic markets to spur the development of offshore wind industry.

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Offshore Wind Power Policy(3/4)- Draft Content

I. Demonstration wind farm: in the ocean of 5 m isobaths or deeper, with total capacity above 100 MW but not exceeding 200 MW.

II. Demonstration devices: 2 offshore wind power systems of single capacity above 3 MW

III. Complete 1 offshore meteorological observation tower and the application of ecological environmental investigation; complete basic, structural, parallel construction test, business operation, and maintenance.

Demonstration wind farm: depth ≧ 5 m ; total scale ≧ 100 MW and ≦200 MW

ecological investigation and environmental evaluation

Demonstration devices
2 devices ≧ 3 MW

Offshore meteorological observation tower: depth ≧ 10 m ; height ≧ 75 m

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Offshore Wind Power Policy(4/4)- Draft Content

IV. Incentive amount

■ The incentive includes "demonstration incentive" and "development incentive".

(1) Demonstration incentive:

- The limit of each kW: shall not exceed 50 % of the announced whole sale rate of the initial set up cost of that year (e.g. the parameter of the initial set up cost of 2011 is 159,000 TWD/kW, so the subsidy limit is 79,500 TWD/kW)
- The upper limit: shall not exceed 50% of the total cost of demonstration device set up.
- To avoid double rewards, the subsidy of this part must be returned by receiving lower FIT until the subsidy is totally returned.

(2) Development incentive:

- The limit is TWD 250 million. This part of subsidy is in full reward and won't be returned. But the technical and cost information shall be put into public as future reference for the review of FIT.

New Prospects for Renewable Energy (1/4)

- **Removing regulatory barriers and offering incentive feed-in tariffs to facilitate the small renewable equipment in households.**
- **The extensive applications of renewable energy in public constructions may speed the renewables integration into the living environment.**
- **Solar PV moves to focus on larger-scale power plants while the industry benefit from the experiences collected from realizing world-class projects.**
- **Wind power moves from onshore to offshore.**
- **The demonstration project incentives provide opportunities for advanced renewable resources (e.g. marine energy & BIPV).**
- **50 low-carbon communities in 2 years; 6 low-carbon cities in 5 years; 4 low-carbon regions by 2020**

New Prospects for Renewable Energy (2/4)

- **Expanding renewable energy development to maximum potentials**
  - **Subject to technological maturity and feasibility**
    - ✓ Wind: onshore first, followed by offshore
    - ✓ PV: large scale deployment after cost substantially reduced
    - ✓ Others: continued R&D to make more commercially viable
  - **Cost effectiveness**
    - ✓ Priority to those with lower generation cost (e.g. onshore wind)
  - **Development in phases**
    - ✓ PV: roof-top first, followed by land-based
    - ✓ Offshore wind: shallow water first, then deep water areas
  - **Acceptable increase in electricity price**
  - **Facilitating development of related industries**

New Prospects for Renewable Energy (3/4)

- **6,500 MW goal of Renewable Act to be reached 5 yrs earlier then expected (2030 ➔ 2025), with capacity further expanded to 12,502 MW by 2030**
- **Strategies**
  - Wind: 1,000 onshore & offshore wind turbines
    - ✓ Onshore: good wind sites by 2015, then less wind sites
    - ✓ Offshore: shallow water by 2020, then deep water
  - PV: million roof-top PV systems (3 kW/system on average)
    - ✓ Limited annual quota before grid parity (2020 expected)
    - ✓ Roof-top first by 2020, then on polluted agricultural lands
  - Biomass: MSW incineration transformed to Energy Centre
  - Hydropower: environmentally sound resources (small scale)
  - Geothermal: shallow natural geothermal reservoirs first, then EGS (enhanced geothermal systems)
  - Marine Energy: accelerated R&D in OTEC, wave and ocean current power

New Prospects for Renewable Energy (4/4)

- **Demonstration Incentives of Offshore Wind Power Systems (draft)**
  - 2 demonstration wind farms: in the ocean of 5 m isobaths or deeper, 100 MW ≤ capacity (each) ≤ 200 MW
  - 2 demonstration devices (≥ 3 MW each) for each farm
  - sea meteorological observation tower required
  - Incentives separated into 2 parts
    - ✓ Demonstration incentive
      - ➢ ≤ 50% of installation cost announced by MOEA while deciding feed-in tariff (e.g. TWD 79,500/kW for 2012)
      - ➢ ≤ 50% of the total cost of demonstration devices
      - ➢ subsidy of this part must be returned to MOEA after demonstration wind farm completed
    - ✓ Demonstration incentive
      - ➢ ≤ TWD 250 million (need not be returned to MOEA) and the technical and cost information must be put into public
  - Construction, transportation and installation of demonstration devices required by using marine fleets

Concluding Remarks

- **The Renewable Energy Development Act and its supplementary rules have paved the way for a long term sustainable development of renewables in Taiwan. Many incentives have succeeded to encourage investment into renewables.**
- **Renewable energy has great potential and a prosperous future in Taiwan.**
- **Taiwan has great potential in wind power and setup a demonstration project to prompt the wind power.**
- **We would continue existing and expand efforts to embrace renewable energy.**