行政院所屬各機關出國報告
（出國類別：考察）

赴德國考察核能電廠除役及核廢料處理暨相關法規事宜

服務機關：台灣電力公司
出 國 人 職　　稱：　副總經理
姓　　名：　陳 貴 明
出國地區：德國
出國期間：92. 2. 13.-- 92. 2. 23.
報告日期：92. 4. 18.

行政院及所屬各機關出國報告提要 C09201106

出國報告名稱：陪同監察委員巡察台電澳洲班卡拉煤礦投資計畫

頁數 23 含附件：■是□否

出國計劃主辦機關/聯絡人/電話

台灣電力公司/人事處陳德隆/23667685

出國人員姓名/服務機關/單位/職稱/電話

陳貴明/台灣電力公司/總經理副總經理室/副總經理/23666245

出國類別：■1 考察□2 進修□3 研究□4 實習□5 其他 (洽公)

出國期間：
92. 2.13.~ 92. 2.23.

出國地區：
德國

報告日期：
92. 4.18.

分類號/目

關鍵詞：

內容摘要：(二百至三百字)

㈠ 自從前蘇聯車諾比事件發生之後，德國已有廢除核能的共識與具體計畫，但其做法不是採跳躍式的方式進行，而是計畫周詳，且德國從政府部門、議會到行政單位，皆同意通過廢核的法令，層面週延地按步就班依據法律去推動執行。

㈡ 德國對於核廢料的處理，在安全規範等做得相當嚴謹，而且在實際執行上亦嚴守規範以確保安全。

㈢ 德國將於 2004 年春天舉辦「全球再生能源會議」，可以藉此會議尋求全球性的結盟與合作關係，台灣應積極參與。在會談時，葉政務委員表示我國非常樂意積極參與，亦獲得主辦者正面的回應。

目　　錄

壹、出國目的

奉派隨同行政院政務委員葉俊榮與經濟部次長陳瑞隆等非核家園推動委員會代表，共赴德國進行相關考察，期瞭解該國在非核家園推動過程的相關政策、替代措施、核廢料處置及實施方法。

貳、任務分工

1. 環境議題

   由原子能委員會、台電公司就核電廠除役，核廢料暨核能安全相關事務瞭解德國之作法與成功經驗。

2. 經濟議題

   由經濟部、能源會、工研院能資所就德國經濟發展研究與預測方法進行瞭解並與相關機構與智庫建立合作交流之管道。

3. 能源議題

   由能源會、工研院能資所就德國再生能源政策與產業界最新發展趨勢進行瞭解，以及掌握能源技術之發展方向。

4. 綜合議題

   由全體成員就環境、經濟、能源相關連之政策措施瞭解德國的運作機制與經驗。

參、代表成員

- 行政院：葉政務委員俊榮、樊助理雯
- 經濟部：陳政務次長瑞隆
- 行政院原子能委員會：陳處長宜彬
- 經濟部能源委員會：方執秘良吉、莊組長世明
- 台電公司：陳副總經理貴明
- 工研院能源與資源研究所：曲所長新生

肆、出國行程

日期	留宿地點	拜會行程	拜會人士
92.2.13(四)	啓程	N/A	
92.2.14(五)	Hammelburg	抵達法蘭克福，午餐後前往Hammelburg，中途若時間允許，駐德單位安排在伍茲保稍作遊覽	
92.2.15(六)	Berlin	1. 拜訪綠黨議員 Hans-Josef Fell 家庭，進行政治對話 2. 拜會 Hammelburg 市	1. 綠黨議員 Hans-Josef Fell 2. Hammelburg 市市長
92.2.16(日)	Berlin	1. 9:00 從柏林出發，9:30-12:00 Potsdam 覽勝 2. 中午 13:30-15:30 在柏林綠黨專屬的基金會 Heirich-boess-Stiftung，與綠黨國會議員 Michaela Hustedt 進行政治對話	綠黨能源政策發言人 Mrs. Michaela Husdedt
92.2.17(一)	Berlin	1. 10:00—12:00 應用生態研究所(Oeko Institut 綠黨在能源議題上最重要的民間智庫) 2.13:00—15:30Bewag 公司	Oeko Institut 柏林部門負責人 Dr. Felix Mattes
92.2.18(二)	Berlin	1. 8:00~9:30 早餐招商會 2. 13:30-14:40 拜會德國聯邦經濟及勞工部，與經濟部副部長午餐會 3. 拜會德國聯邦環境部及其二氧化碳排放量、再生能源、終止核能使用等部門主管，進行專業會談	1. 環境部副部長 Rainer Baake 2. 國家氣侯保護計劃負責人 Franzjosef Schafhausen 3. 再生能源部門負責人 Dr. Wolfhardt Durrschmidt 4. 副部長 Rezzo Schlauch 5.核能反應爐安全規劃負責人 Dr. Landfermann Wolfang Renneberg
92.2.19(三)	Berlin	1. 9:00-10:30 Kanzlei Groth(負責德國政府與電力集團終止核能使用合約簽署)	1. Prof. Alexander Rossnaged 2. Dr. Hans Joachim

		2. 14:00-15:30 核能反應爐安全委員會召集人暨核廢料最終處理場工作團隊 3. 16:00-17:00 草擬廢核法案與再生能源法之法律專家 4. 16:00-17:00 德國經濟研究所(Institut fuer Wirtschaftsforschung Deutschland)德國經濟發展趨勢研究與預測單位	Ziesing
92.2.20(四)	Bielefeld	1. 7:30 從柏林出發，10:00-17:00 葉政委、原能會與台電代表訪BfS 德國輻射安全局以及 Gorleben 的德國高輻射核廢料中期儲存場 2. 7:30 從柏林出發，11:00-17:00 陳政次率其他團員參訪下薩克森邦太陽能研究所 ISFH(研究單位與民間智庫)，與太陽能工業廠商與談 3. 20:00 所有團員會聚於 Bielefeld 與 Prof. Dr. Maria Blettner 餐敘	1. BfS 聯邦輻射安全局副總裁 Ruesel 2. 太陽能研究所 Prof. Dr. R. Hezel
92.2.21(五)	Wuppertal	1. 7:00 從 Bielefeld 出發，9:00-12:00 拜會德國北萊茵-威司法倫邦 Energy Agency 參訪推動再生能源與節能軟體設施，中午餐敘。 2. 14:00-15:00 於德國北萊茵-威司法倫邦 Energy Agency 與該邦能源部副部長針對能源政策進行會談 3. 17:00-18:00 與 Wuppertal Institut 針對二氧化碳排放政策與氣侯變遷議題進行專業會談 4. 19:00 與 Wuppertal 市市長 Dr. Kremendal ，工商總會會長及業界餐敘	1. Dr. Norbert H"uttenh"olscher/ Dr. J. Frielingdorf 北萊茵—威司法倫邦 Energy Agency 2. Jorg Hennerkes 北萊茵—威司法倫邦能源部副部長 3. Wuppertal 市市長 Dr. Kremendal
92.2.22(六) 92.2.23(日)	東裝返國 返抵國門	N/A	

伍、工作內容

本次參訪行程之主要工作內容，依照日程安排之參訪活動記述如下：

- **92.2.13(四)**—啓程出發，全體團員於晚上 7:40 集合，飛機於 21:10 起飛，離開國門。
- **92.2.14(五)**—自維也納轉機抵達法蘭克福，午餐後由駐德單位安排在伍茲堡稍作遊覽。
- **92.2.15(六)**—早上赴德國綠黨議員 Hans-Josef Fell 家中拜訪，並進行政治對話，中午拜會 Hammelburg 市長。

Mr. Fell 爲政治家族，因爲提出充分利用再生能源的理念，獲得民眾認同，因而獲選爲綠黨不分區國會議員。本日參訪最深刻的印象是 Mr. Fell 不但積極推動使用再生能源 (Renewable Energy) 與環境保護，更是身體力行，徹底實行。居家全爲木造，屋頂裝設太陽光電系統，地下室設置使用菜仔油之發電機(Diesel Engine)，以太陽能車作爲代步工具。德國園藝雜誌予以大篇幅報導其住處爲強調再生能源利用的生態屋，可以說是非常好的示範宣導。

早上 11:30 全團由葉政委員率隊，赴 Hammelburg 市政廳，由市長接待並召開記者會。Hammelburg 市長對我們此行拜訪非常重視，並引起當地新聞媒體的注意。葉政委介紹了國內推行「非核家園」的政策及成果。Hammelburg 市長爲了表示對訪問團的尊敬，還特別請到訪的每位成員在 Hammelburg 市貴賓訪問紀念册上簽名留念。

。 **92.2.16(日)**—在柏林綠黨專屬的基金會，拜會綠黨國會議員 Mrs. Michaela Hustedt，進行政治對話。

Mrs. Michaela Hustedt 同時兼任綠黨的能源政策發言人，特別提到德國綠黨於 25 年前成立時之宗旨就是達到建立「非核家園」的目標。剛開始推動時，大家並不熟悉也無共識，直到發生車諾比核電廠事故後，民眾開始瞭解，逐漸建立「非核」的共識。在此共識下，核電廠無法再生存，雖然現有核電廠可繼續運轉，但不再有新建者。

基本上，德國在實施非核家園方面有三點可提供參考：

1. 開始階段讓小型團體加入，並以農民爲主
2. 採行補貼政策
3. 推動策略聯盟

在能源政策措施方面，積極推動兩大部分的工作：

1. 增加再生能源的比例，由現有 5%水力，5%風力，2%生質能，再逐步提高。
2. 強化節約能源成效，提高能源使用效率。未來可能立法來推動燃料電池(Fuel Cell)，而能源與建築的結合亦是積極推動的項目。

此外，德國將於 2004 年春天舉辦「全球再生能源會議」藉此會議尋求全球性的結盟與合作關係，我國代表團也表達參與此會議的高度意願，並獲得正面回應。

。 **92.2.17(一)**—拜會應用生態研究所(Oeko Institut)，參觀 Bewag Energy Company。

上午拜會應用生態研究所(Oeko Institut)，由柏林部門負責人 Dr. Felix Mattes 接待，共同會談經濟與能源相關議題。

應用生態研究所爲一非營利機構，也是德國綠黨在能源議題上最重要的民間智庫。主要的工作是協助政策之擬定，包括能源政策(Energy Policy)，交通運輸政策(Transportation Policy)，氫經濟政策(Hydrogen Economy Policy)。雖然看似研擬個別的政策措施，但是彼此之間相互有密切關聯，也必須利用模型工具來模擬評估各種情境組合，尋求最佳的政策工具，以確保達成政策目標。

此機構也是運用 MARKAL Model 進行能源系統之模擬評估，並且協助德國政府進行氣候公約二氧化碳減量之國際談判，各方面的工作及技術能力與工研院能資所的研究工作相似，雙方應可加強交流與合作。

在氫經濟政策方面，建議制訂燃料電池法案(Fuel Cell Act)，積極推動以 SOFC 爲發展主軸，並以財稅措施(Tax Policy) 爲輔助工具，而非以「補貼（Subsidy）」爲主要策略。

葉政委特別請教 Dr. Felix Mattes 提供對台灣能源政策的建議與看法，Dr. Felix Mattes 提出的看法是應該先辯論什麼產業是我國必須確保與發展，同時政策的制定應由國會主動立法推動，而非僅賴行政部門單方面的行政措施。以德國的經驗來說，由於德國具備優勢的機械工程與製造工業，因此風力發電產業在再生能源政策的推動下，變成重要的產業之一。

陳政次問到風力發電與太陽能加入市場後對電力價格之影響程度。 Dr. Felix Mattes 認爲所有的事情決定於"技術發展"的層次，技術發展必然影響價格同時也影響政策的決策。

下午安排參觀柏林地區最大的電力及熱能供應公司 Bewag Energy Company。該公司表示在追求最佳總體能源效率 90％之目標上，汽電共生電廠以發電效率 48％加上熱能效率 42％之組合爲最佳。如果是純發電，則總體能源效率最高僅 55％。

Bewag 公司在 2002 年使用不同燃料之發電比例：煤佔 55.5％、天然氣佔 30.9％、褐煤佔 12.5％、燃油佔 1.1％。燃煤仍佔大部分的比例，約達 7 成；天然氣約佔 3 成，燃油佔極少的比例。

- **92.2.18(二)**—拜會德國聯邦經濟及勞工部，下午拜會德國聯邦環境部

中午拜訪經濟部，由副部長 Rezzo Schlaunch 接待。副部長屬綠黨，聯合執政後，認知到要廢除核能（Phase out nuclear energy）是項非常艱鉅的工作，必須「Step by Step」，一步一步推動以達到目標。同時必須大力推動使用再生能源，並提供充分的「經濟誘因」促使私人企業的投入。

Rezzo Schlaunch 副部長預定本年六月初訪問韓國，非常樂意同時訪問台灣，如時間恰當亦可參加我國舉辦之「全國非核家園會議」。

下午拜會德國聯邦環境部由 State Secretary 即副部長 Dr. Rainer Baake 接待。葉政委特別請教德國廢除核電廠做法與實行的經驗，以及可能發生的種種問題。Dr. Baake 說明車諾比事件促使德國民眾對核能所持態度產生更大改變。在德國國內的談判過程中，非政府組織（NGO）並未公開參與，而係政府與擁有核能電廠的電力公司，經由多次談判協

商，最後終於達成協議。

由於德國電力公司能夠轉置提前除役的核能電廠員工，未曾造成社會問題。至於核能電廠逐漸淡出之後，對德國政府產業而言，如何建立新的能源工業顯爲重要議題。

- **92.2.19(三)**—拜會 Lawer Agency 與德國經濟研究所 (Institute Fuel Wirtchaftsforschung Deutschland)

上午拜會 Lawer Agency, 此單位負責核能電廠之各項法案，安全規則與異常狀態之監督。包括政府與電力集團終止核能使用之合約，核電廠除役、核廢料暨核能安全相關事務之處理等。關於核能電廠用過燃料之再處理，德國原來計劃自建的核能電廠用過燃料再處理廠，因爲人民抗議而關閉，目前與法國 COGEMA 及英國 BNFL 的再處理合約到 2005 年契約到期後，用過燃料將採直接處置而不經過再處理。

德國除了逐步廢除核能外，同時進行的是鼓勵使用再生能源與推動節約能源計畫，並且採行租稅減免的手段，擴大其成效。

明年德國必須儘快解決或面對的問題包括：

1. 再生能源的推展應如何加速腳步
2. 相關法律的制定及全國政治、經濟情勢的演變
3. 核能電廠十年一次「健康檢查」

下午拜會德國經濟研究所，此機構成立於 1926 年，爲一非營利機構，是德國經濟發展趨勢研究與預測單位。其下設 7 個部門，包括能源、環境等部門。依照該機構的說法：現階段，德國面臨最大的能源問題是廢除核能與 CO_2 排放減量。希望在 2020~2050 年期間，由於技術研究發展的結果，

德國可以解決所有能源問題，而最可能解決長期能源問題的技術發展應屬再生能源與生質能。未來極有潛力之Technology Improvement之一是燃料電池(Fuel Cell)。德國在因應氣侯公約二氧化碳排放減量的壓力下，開始進行排放交易(Emission Trading)之相關工作，及清潔發展機制(CDM)之運作模式研究。

- **92.2.20(四)**—分成兩組：葉政委率訪 BfS 德國輻射安全局及高輻射核廢料終期儲存場；陳政次率訪太陽能研究所 ISFH。

德國政府對放射性廢料打算採取深層地質最終處置場所方式，依據德國原子能法，放射性廢料的處置係由聯邦環境、自然保育暨核能安全部下的輻射安全局(BfS-Federal Office for Radiation Protection)負責。本日隨葉政務委員參訪位於Luechow-Dannenberg的Gorleben高放射性廢料處置場，並聽取BfS及其所委任的DBE公司簡報。

德國1965年就開始於ASSE鹽礦進行歐洲第一個深層地質最終處置的研究建造，DBE 公司成立於 1979 年，專門接受德國政府委託，從事最終處置場的規劃、設計、建造與營運。Gorleben 巨型地下鹽丘(saltdome)，位於地表下 1 公里左右，東西最寬約 15 公里，南北最遠約 4 公里。DBE 自 1979 年起進行詳實的地質科學鑽探研究，以評估該鹽丘是否適合做爲高放射性核廢料最終處置場，地表探勘工作基本上於 1985 年完竣，兩座工作豎井分別於 1986、1989 年開挖，於 1997、1995 年完成，並於地表下 840 米處可能適合之區域，展開水平橫坑開挖工作，前後累積相當多的鹽丘地質與結構資訊，初步可判斷 Gorleben 鹽丘是一大型均質鹽岩，下一階段探勘工作將集中在鹽丘的核心。依據 DBE 的評估，整個計畫需要再 5 年以完成所需鑽探資料，其後 1

至 2 年完成安全分析。惟 2000 年 6 月德國政府基於社會政治的考量，宣布 Gorleben 場址計畫暫時中止 3 至 10 年，俟德國其他地區地下岩層的適合性有所初步比較，且 Gorleben 有其初步適合性時，再行恢復。BfS 及 DBE 研判德國政府可望於明年底左右做成決定。本計畫開始迄今已歷 24 年，累計支出爲 12 億馬克，完成未來的鑽探及安全分析約再需 5 億歐元，而至整個場址竣工止預計總支出將達 30 億歐元。

有關德國放射性核廢料營運政策與發展，請詳參所附 BfS 所提供資料(已另送核後端營運處參考)。

。 **92.2.21(五)**—拜會北萊因—威司法倫邦 Energy Agency 參訪再生能源與節能軟體設備。

中午拜會北萊因—威司法倫邦之能源部(The NRW Energy Agency)與該邦能源部副部長 Jorg Henner Kes 針對能源政策進行會談。

NRW Energy Agency 成立於 1990 年，由北萊因—威司法倫邦之經濟部(Ministry of Economic Affairs and Small and Medium-Size Enterprises, Energy and Traffic) 所設置的獨立單位。

北萊因—威司法倫邦是德國主要的工業區與能源生產地，大約德國 1/4 的人口居住在此邦，也是德國最大的經濟區域。多年以來，此區域的能源政策採行能源多元化(Energy Mix)策略，推動能源使用必須確保環境友善之方式。自 1987 年起，推動所謂的 REN 計畫。REN 代表"Rational Use of Energy and the Use of Renewable Energy Sources"，相關技術 Know-how 的移轉主要是由 NRW Energy Agency 負責推動。

現階段，NRW Eneryg Agency 主要進行的工作有：

1. 加強自有能源
2. 強化再生能源的使用
3. 提高能源使用效率

同時，支持許多 CO_2 排放減量之研究工作，協助政府研擬能源政策。在工作推動上，亦積極進行國際交流合作，因此非常樂意與台灣合作交流。

NRW energy Agency 是一個小而美的單位，員工僅 50 人，其中 26 名爲顧問，20 名爲工程師，4 名秘書助理，主要的工作內涵是能源技術顧問服務與電腦網路之教育訓練(e-learning)，在公共關係上亦投入 10-20%之資源推動能源節約與利用再生能源的宣導。

下午拜會 Wuppertal Intitute，針對二氧化碳排放政策與氣候變遷議題進行會談。此研究所也是非營利機構，主要的工作是進行氣候變遷的基本研究及永續發展之策略研究。

在能源領域方面，從事永續能源系統的研究，企圖建立所謂永續能源系統的藍圖與願景。在氣候變遷方面也希望尋求創新的策略協助政府推動因應措施。

此研究所有 80 名正式人員，60 名聘雇人員，共計 140 人，經費方面 30%來自政策，70%來自不同的客户。

- **92.2.22(六)**—束裝返國

- **92.2.23(日)**—返抵國門

陸、心得與建議

㈠ 自從前蘇聯車諾比事件發生之後，德國經長期的政策辯論，終而建立廢除核能的共識與具體計畫，但其做法不是採跳躍式的方式進行，而是計畫周詳，且德國從政府部門、議會到行政單位，皆同意通過廢核的法令，層面週延地按步就班依據法律去推動執行。

㈡ 德國對於核廢料的處理，在安全規範等做得相當嚴謹，而且在實際執行上亦嚴守規範以確保安全。

㈢ 德國將於 2004 年春天舉辦「全球再生能源會議」，可以藉此會議尋求全球性的結盟與合作關係，台灣應積極參與。在會談時，葉政務委員表示我國非常樂意積極參與，亦獲得主辦者正面的回應。

Abstract

The Federal Republic of Germany intends to dispose of all types of radioactive waste in deep geological formations. This waste comprises spent fuel elements, vitrified fission product solution, nuclear power plant operational and decommissioning waste as well as spent sealed radiation sources and miscellaneous waste originating from small waste generators. The Atomic Energy Act gives the responsibility for the disposal of radioactive waste to the Federal Government with the Bundesamt für Strahlenschutz (BfS - Federal Office for Radiation Protection) as the legally responsible authority.

The Federal Government has made a pronounced change in energy policy since 1998, the most important feature of which is the abandoning or phasing out of nuclear energy. It is intended to irreversibly phase out nuclear energy use for electricity generation. Essential (basic) steps are the agreement which was achieved by the Federal Government and the utilities on June 14, 2000, and signed on June 11, 2001, and the April 2002 amendment of the Atomic Energy Act.

1. Introduction

Since the early sixties the German radioactive waste disposal policy has been based on the decision that all types of radioactive waste (short-lived and long-lived) are to be disposed of in deep geological formations.

The 1976 amendment of the Atomic Energy Act provided the legal basis for the disposal of radioactive waste. According to section 9a, disposal of radioactive waste was assigned to the Federal Government as a sovereign task with the Pysikalisch-Technische Bundesanstalt (PTB-Federal Institute for Metrology) as the competent authority. On November 01, 1989, this competency was transferred by law to the Bundesamt für Strahlenschutz (BfS - Federal Office for Radiation Protection). Thus, BfS is now responsible for the establishment and operation of a repository, acting on behalf of the Federal Government. In this respect BfS is supervised by the Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU-Federal Ministry for the Environment, Nature Conservation and Nuclear Safety) which, among other things, is responsible for nuclear safety and radiation protection in the Federal Republic of Germany.

All other radioactive waste management activities, e.g. spent fuel storage, reprocessing, conditioning, transportation and interim storage are within the responsibility of the waste generators. The Federal States must establish and operate regional depots for the interim storage of radioactive waste originating, in particular, from radioisotope application in industry, universities and medicine.

2. Radioactive waste management

A broad variety of different waste types and amounts are generated in Germany. At the end of 1999, an amount of approx. 33,000 m^3 of radioactive residues and of approx. 64,000 m^3 of conditioned radioactive waste with negligible heat generation (i.e., low-level waste (LLW) and intermediate-level waste (ILW)) was stored in engineered storage facilities. Due to a forecast into waste amounts to be expected in future, approx. 303,000 m^3 of conditioned waste with negligible heat generation and approx. 22,000 m^3 of conditioned heat-generating waste (i.e., high-level waste (HLW) and spent nuclear fuel (SNF)) are expected up to the year 2080.

Current issues

As a result of the 1998 federal elections a coalition of the Social Democrats and Alliance '90/The Greens came into power. The political aims of the Federal Government are given in the coalition agreement dated October 20, 1998. With respect to energy policy the most important feature is the abandoning or phasing out of nuclear energy. Thus, the Federal Government makes a pronounced change compared to the previous energy policy since 1998. It is intended to irreversibly phase out nuclear energy use for electricity generation. This has been performed in a stepwise procedure: in a first step so-called consensus talks with representatives of the utilities took place and in a second step respective legislative measures were taken.

The basic document on the future use of nuclear energy for electricity production in Germany was initialled on June 14, 2000, and signed on June 11, 2001. According to this document, the Federal Government and the utilities agree to limit the future utilization of the existing nuclear power plants. The most important agreements refer to operational restrictions. For each installation the amount of energy it may produce is calculated from January 01, 2000, until its decommissioning. In total, about 2,620 TWh (net) can be produced. According to this, the time of operation of a nuclear power plant amounts to 32 calendar years on aver-

age, starting at the beginning of commercial operation. The new policy is enforced by the latest amendment of the Atomic Energy Act which became effective on April 27, 2002.

New developments in spent fuel management

Up to now, spent nuclear fuel is either shipped to the French and British reprocessing facilities, stored on-site at the nuclear power plant or at centralized off - site interim storage facilities. HLW originating from reprocessing which is returned to Germany is stored at the Gorleben facility, too.

According to the agreement between the Federal Government and the utilities and to the April 2002 amendment of the Atomic Energy Act, the management of spent fuel will be restricted to direct disposal. Up to July 01, 2005, transports for reprocessing will be permissible. In addition, the nuclear power plant operators must provide interim storage facilities on-site. Subsequent to July 01, 2005, spent nuclear fuel may only be transported if no licensed interim storage capacity exists at the nuclear power plant site and if the operator of this site is not responsible for this situation.

As a consequence the utilities will construct and operate new engineered storage facilities at the sites of the nuclear power plants or near them. As far as necessary, additional storage places will be created on-site to bridge the time (up to 5 years) for licensing and erecting the proper interim storage facilities. Until these new facilities have been brought into operation, the utilities may transport spent nuclear fuel to the centralized interim storage facilities as well as to foreign countries until reprocessing will discontinue. As a result of the intended termination of reprocessing as well as the construction and operation of dry spent fuel interim storage facilities on-site, the number of shipments of spent fuel elements will considerably be reduced.

Regarding on-site engineered storage, starting in 1999 and continuing until fall 2000, applications were filed to initiate licensing procedures for the construction and operation of 12 interim storage facilities and 5 storage places with capacities in the range of 120 tons heavy metal (HM) to 2,250 tons HM and activities in the range of 7.6×10^{18} Bq to 2.7×10^{20} Bq. BfS is the competent licensing authority. All licensing procedures require a public hearing most of which were successfully held in 2001. There were significant regional differences in public interest and opposition. The number of objections varied between less than 2,000 against the storage facility at Brunsbüttel (Northern Germany) and more than 75,000 against the storage facility at Gundremmingen (Southern Germany). All together 250,000 objections were raised against the on-site interim storage facilities. In addition, a public participation for

citizens of the Republic of Austria was carried out for the six interim storage projects located in the south of Germany with regard to transboundary environmental impact assessment.

The licenses for the interim storage places at Neckarwestheim, Philippsburg and Biblis were issued by BfS on April 10, July 31 and December 20, 2001, respectively, as the first licenses for on-site interim storage places in Germany. The first license for an interim storage facility was issued by BfS on November 07, 2002; this facility is located at Lingen. It is intended to issue all other licenses in 2003. Operation of all new interim storage facilities is expected by 2005.

Disposal-related aspects

In the Federal Republic of Germany all types of radioactive waste are to be disposed of in deep geological formations. Up to now, according to the 1979 German radioactive waste management concept, two sites have been considered for disposal:

The abandoned Konrad iron ore mine in the Federal State of Lower Saxony has been investigated for disposal of radioactive waste with negligible heat generation, i.e. waste packages which do not increase the host rock temperature by more than 3 Kelvin (K) on an average (LLW, ILW). At a depth of 800 m to 1,300 m the emplacement of up to 650,000 m^3 waste package volume was planned. A total activity in the order of 10^{18} Bq and an alpha emitter activity of about 10^{17} Bq are anticipated in this facility. The licensing procedure was started on August 31, 1982.

The Gorleben salt dome in the north-east of Lower Saxony has been investigated for its suitability to host a repository at depths between 840 m and 1,200 m for all types of radioactive waste, mainly for heat-generating radioactive waste originating from reprocessing and spent fuel elements (direct disposal). The accumulated inventory of beta/gamma and alpha emitters is planned to be in the order of magnitude of 10^{21} Bq and 10^{19} Bq, respectively. Site-specific investigations were started in 1979.

Since 1971, short-lived low and intermediate level radioactive waste with an alpha emitter concentration of up to 4.0×10^8 Bq / m^3 originating from the operation of nuclear power plants and the application of radioisotopes in research, medicine and industry in the former German Democratic Republic was disposed of in the Morsleben repository, an abandoned salt mine located near the village of Morsleben in the Federal State of Saxony-Anhalt. Since

German unity on October 03, 1990, the Morsleben facility has the status of a federal repository in the sense of section 9a of the Atomic Energy Act. From 1971 through 1998 radioactive waste with a total volume of about 37,000 m^3 and about 6,100 spent sealed radiation sources were disposed of. The total activity of beta/gamma emitters amounts to 9.1 x 10^{13} Bq, that of alpha emitters to about 8.0 x 10^{10} Bq. According to a September 25, 1998, court order BfS has to immediately stop further radioactive waste disposal in the so-called eastern emplacement field of the Morsleben repository. Thus, last waste emplacement operations were carried out on September 28, 1998.

3. Approach to Radioactive Waste Disposal

Persuant to the coalition agreement and the agreement between the Federal Government and the utilities, the German radioactive waste management and disposal concept is being reviewed and will be adopted due to political decisions, new findings and specific evaluations. According to the agreements the most important issues are:

- The previous radioactive waste management concept has failed with regard to its content and no longer has a technical basis. A national waste management plan for the legacy of radioactive waste will be developed.
- A single repository in deep geological formations is sufficient for the disposal of all types of radioactive waste. The disposal of HLW by the year 2030 is the political objective for the disposal of all types of radioactive waste.
- There are doubts with regard to the suitability of the Gorleben site. Therefore, its exploration shall be interrupted and further sites in various host rocks shall be investigated for their suitability. The licensing procedure for the Konrad repository project shall be terminated; the Morsleben repository shall be decommissioned.

According to the coalition agreement, activities to develop a new national waste management plan have been initiated. This document will comprise main issues and important boundary conditions for the new approach of the Federal Government to radioactive waste management and disposal. About three years ago the BMU set up a special project group for its preparation. According to the work hitherto performed, the waste management concept (including the principles, radioactive residues, the waste management task, waste conditioning and quality assurance/quality control, interim storage and disposal), inventory and prognosis of residues as well as waste management planning have basically

been elaborated. The national waste management plan will be presented within this legislative period.

Nevertheless, the emplacement of waste packages into deep geological formations is still the preferred option for the safe disposal of all types of radioactive waste. Otherwise there is scientific evidence that a separate emplacement of radioactive waste with negligible heat generation as compared to the co-location of all types of radioactive waste in one single repository may have special advantage from a safety point of view, e.g. with respect to gas generation in the post-closure phase. Thus, the political aim to construct and to operate one single repository is still to be examined in detail focusing on safety-related aspects, specific issues of the waste management concept, and economical considerations.

Safety criteria

In the Federal Republic of Germany the "Safety Criteria for the Disposal of Radioactive Waste in a Mine" describes the basic aspects which must be taken into account to achieve the objective of disposal. They qualitatively specify the measures to be taken to achieve the protection goal of disposal and define the principles by which it must be demonstrated that this goal has been reached. The Safety Criteria were issued in 1983 and are at present being revised on behalf of BMU. The overall aim of this revision may be outlined as follows:

- Survey of the international status of the development of safety criteria for the disposal of radioactive waste and its evaluation as compared to the German situation.
- Consideration of respective activities being performed by international institutions such as the International Atomic Energy Agency (IAEA) (e.g., the RADWASS programme and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management), the Organisation for Economic Co-operation and Development/Nuclear Energy Agency (OECD/NEA) and the International Commission for Radiation Protection (ICRP).

Status of Gorleben, Konrad and Morsleben

Though the Federal Government has expressed doubts with respect to the suitability of the Gorleben site, it is not considered to be unsuitable and will be included in the future site selection process. According to the agreement between the Federal Government and the utilities a further exploration of the Gorleben salt dome can contribute nothing to clarify the

doubts of the Federal Government. For this reason the underground exploration will remain interrupted for at least 3, but at most 10 years (Gorleben moratorium); the moratorium became effective on October 01, 2000. A rapid clarification of these doubts has been initiated focussing on 13 research projects and studies:

- Isolation time frame
- Retrievability
- Human intrusion
- Nuclear criticality
- Gas generation
- Chemotoxic substances
- Nature observations
- Safety indicators
- Probabilistic safety assessments
- Geochemical processes
- Safeguards
- Multi barrier concepts
- Comparison of host rocks (synthesis)

These investigations aim to the clarification of conceptual and safety-related issues and are envisaged to be finished by the end of 2004.

The licensing procedure for the Konrad repository project was finished. On May 22, 2002, the competent licensing authority Niedersächsisches Umweltministerium (NMU – Ministry for the Environment of the Federal State of Lower Saxony) issued the license. Subsequently, the license was handed over to the licensee BfS on June 05, 2002, and published in the Gazette of Lower Saxony on June 12, 2002. According to the agreement between the Federal Government and the utilities BfS withdrew the application for immediate enforcement of the license on July 17, 2000, thus enabling court examination of the license. This withdrawal in particular means that the re-construction of the Konrad mine into a repository for all types of radioactive waste with negligible heat generation will only be possible after final court decision. The court cases are assumed to last for about four years; then further decisions on the Konrad project will have to be taken.

The Morsleben repository will not resume emplacement operations. An application for the licensing procedure for decommissioning was already filed on May 09, 1997. The assessment of the safety in the post-closure phase is of special importance. The site-specific safety assessment was originally based on a preliminary backfilling and sealing concept; more detailed site specific information and respective safety analyses proved this concept not to be acceptable. Thus, two alternative concepts have been developed. The sealing concept and the concept on extensive backfilling are being combined and the final concept is expected by the end of 2002. BfS is concentrating its activities on the licensing procedure and the preparation of respective documents. Latest important issues comprise

the backfilling of the so-called southern emplacement field with crushed salt from November 18, 2000, until March 09, 2001, and the statement of BfS dated April 12, 2001, that the Morsleben repository will definitely never again be used for radioactive waste disposal (renunciation of those parts of the Morsleben repository operation license dealing with the emplacement of radioactive waste). In addition, BfS intends to advance backfill measures in the central part of the Morsleben repository in order to maintain geomechanical stability and integrity. It is planned to start these backfill measures at the end of this year.

The siting process for a repository

According to the new approach to waste management and disposal, further sites in various host rocks shall be investigated for their suitability. The final site shall be selected upon a subsequent comparison of potential sites, including the Gorleben site. Thus, BMU set up a special expert group to develop repository site selection criteria and respective procedures on a scientifically sound basis. The criteria and procedures aim at finding the relatively best suited site in different host rocks in Germany. Such a set of criteria was not available when the Gorleben site was chosen in the seventies.

The principle objective of the site selection procedure to be developed is to identify - with public participation - potential disposal sites in a comprehensible and reliable way. Step by step and based on criteria which have to be defined beforehand, those areas, site regions and eventually sites shall be selected that offer particularly favourable conditions for the later demonstration of the site's suitability and its confirmation in a licensing procedure.

Of utmost importance for any site selection procedure is the question at which step of the procedure a decision on the host formation(s) has to be made. According to the expert group it is less this host formation but rather the integral geological setting at a site that provides for the necessary long-term isolation of the waste and for the justified assumption that even thereafter there should be no unacceptable releases. Therefore, the development of a site selection procedure is pursued which does not start with the fixing of host formations, but rather attempts to get host formations as a result of a selection process which is based on general criteria describing an integral geological setting with favourable properties for the disposal of radioactive waste.

The advantage of this approach is obvious: it avoids the never-ending protest of people living in the vicinity of, say, a salt site praising the merits of granite, and vice versa. Based on

these considerations, the present status of the site selection procedure's structure is as follows:

Step 1: Sorting out areas with potentially negative geological conditions.
Step 2: Identification of areas with potentially positive integral geological conditions.
Step 3: Sorting out areas with unfavourable societal conditions.
Step 4: Narrowing down to regions for which best favourable geological conditions can be expected.
Step 5: Narrowing down to sites where public acceptance for further site investigations can be achieved (local positive interest).
Step 6: Site investigations without mining activities.
Step 7: Evaluation of siting alternatives considering requirements from the safety/environmental viewpoint and local concerns.

The expert group has so far worked on steps 1 to 3. Results were presented and discussed in two workshops hold in fall 2000 and 2001, respectively. The final workshop will take place in October 2002.

Public acceptance is considered to be of central importance for the success of a site selection procedure:

- The site selection procedure needs a clear and transparent structure and must be based upon well founded criteria in order that progress, fairness and objectivity of the procedure can easily be followed and respective decisions are understood in the general public.
- The evaluation basis and criteria associated with the selection procedure must be fixed beforehand to avoid decisions which the public may perceive as not sufficiently justified or even arbitrary.
- Public participation is indispensable from the very beginning and in all phases of the selection procedure, particularly before and during the definition of the "rules of the procedure"

The time needed for the development of repository site selection criteria and respective procedures is estimated to be about 3 years. In February 1999 work started; completion of work is envisaged for December 2002. The recommended criteria and procedures will subsequently be discussed in detail (including stakeholders, environmental groups, other inter-

ested initiatives and the general public) and, after all, legally be implemented. During this criteria development phase, new sites will neither be selected nor investigated.

Provided that the site selection criteria and procedures will be available in 2002 and their discussion as well as implementation performed in 2003/2004, it may be possible to nominate potential sites, carry out respective investigations and finally select the site by 2010. In this case, for detailed site investigations, repository planning, licensing procedure and construction of the repository approximately 20 years would be available in order to start operation by 2030.

The ultimate goal of the site selection procedure to be developed is that it is accepted by virtually everybody as suitable and fair before it will be applied and local interests become effective.

4. Conclusions

Having the present radioactive waste disposal-related situation in mind, it is to be recognized that future developments and decisions will particularly be determined by the agreement between the Federal Government and the utilities and the April 2002 amendment of the Atomic Energy Act. Regarding the on-site interim storage of spent nuclear fuel, applications were filed, the licensing procedures are in progress and three licenses for interim storage places as well as one license for an interim storage facility were already issued. With respect to waste disposal, first steps have already been taken. In particular, the rapid clarification of the doubts on the suitability of the Gorleben site raised by the Federal Government has been initiated. The next important issue will be the final preparation and publication of the site selection criteria and procedures at the end of 2002.