

MOVING FORWARD WITH GEOLOGICAL DISPOSAL OF HIGH-ACTIVITY RADIOACTIVE WASTE

— A collective statement of the NEA RWMC

推動高強度放射性廢棄物地質處置

-核能署/放射性廢棄物管理委員會之共同陳述

The NEA Radioactive Waste Management Committee (RWMC) is a forum of senior representatives from operators and industry, safety authorities, policy makers, and research and development institutions engaged in the management of radioactive materials and waste. With its broad representation and the wide range of external expertise that its members can muster, the RWMC is a uniquely placed international forum to assist OECD countries to address issues concerning the management of radioactive materials and waste. The Committee has underscored the environmental and ethical basis for geological disposal as well as its technical feasibility in a number of previous collective statements. In the intervening time there have been advances and evolving views regarding the relevant methodologies, policies, and decision-making processes, and much further practical experience has accumulated. The Committee expresses hereunder, in a concise form, its collective views on why geological disposal remains an appropriate waste management choice for the most hazardous and long-lived radioactive wastes, on the current status of geologic disposal, on challenges and opportunities to implementation, and on expectations for further developments.

核能署所屬之放射性廢棄物管理委員會(以下簡稱“委員會”)，是一個集合產、官、學、研從事放射性物料及其廢棄物管理的資深人士所組成之論壇，由於委員會的廣泛代表性及厚實的

技術背景，使得委員會能夠扮演獨一無二的角色，來協助經濟發展暨合作組織會員國，面對放射性物料及其廢棄物管理的相關議題。

在先前的數個共同陳述裡，委員會已強調了地質處置的環境及道德依據，同時也強調了其技術的可行性。其間，針對相關的方法論、政策、決策過程等方面已提出不少前瞻的看法，更累積了許多實際實踐經驗。委員會願意簡明地針對為何地質處置仍然作為大多數有害廢棄物及長壽期放射性廢棄物的合適處理方式，目前地質處置現況、其實施面的挑戰與機會以及未來之展望，提出以下共同的想法：

Why is geological disposal appropriate for high-activity, long-lived radioactive waste?

高強度長壽期放射性廢棄物適於地質處置的理由

Radioactive waste is associated with all phases of the nuclear fuel cycle and with the use of radioactive materials in industrial, medical, research and defense-related applications. All such waste must be managed safely and in a manner that protects humans and their environment.

The most hazardous and long-lived radioactive wastes, such as spent nuclear fuel and high-level waste from fuel reprocessing, must be contained and isolated from humans and the environment for many tens of thousands of years.

Whatever the future of nuclear power in the different countries, it is universally recognized that safe and acceptable disposal solutions must be pursued for existing and projected inventories of high-activity, long-lived radioactive waste from current practices.

A geological disposal system provides a unique level and duration of protection for high-activity, long-lived radioactive waste. The concept takes advantage of the capabilities of both the local geology and the engineered materials to fulfill specific safety functions in complementary fashion providing multiple and diverse barrier roles.

The overwhelming scientific consensus world-wide is that geological disposal is technically feasible. This is supported by the extensive experimental data accumulated for different geological formations and engineered materials from surface investigations, underground research facilities and demonstration equipment and facilities; by the current state-of-the-art in modelling techniques; by the experience in operating underground repositories for other classes of waste; and by the advances in best practice for performing safety assessments of potential disposal systems.

Disposal can be accommodated in a broad range of geological settings, as long as these settings are carefully selected and matched with an appropriate facility design and configuration and engineered barriers.

不僅是在核燃料循環的各個階段，以及與放射性物料使用相關的醫、農、工、研甚至於國防應用上，產生放射性廢棄物是無可避免的，這些廢棄物必須安全地管理以保障人類健康及環境安全。

對那些極端有害且長壽期的放射性廢棄物，如用過核燃料或核燃料再處理產生之高強度放射性廢棄物，必須加以封存，並從人類與環境中隔離數萬年。

不同國家對核能利用之未來發展或有不同，但針對當前活動已產生或預計產生的高強度長壽期放射性廢棄物存量，尋求一種安全且可接受的處置方法，是大家共同的認知。

地質處置系統能對高強度長壽期放射性廢棄物提供特需且持久的安全保護，其概念善用了當地的地質與工程材料等條件之優點，提供多重且多樣的安全障壁，使得地質處置系統能以互補式方，來實現設施特需的安全功能。

全球性的科學共識是：地質處置在技術上是可行的。此可由下列事實得到支持：(1) 從對地表調查、地下試驗設施、或示範設備與設施取出的不同地質組成或工程材料，進行廣泛實驗所驗證累積之數據；(2) 從目前現代化模擬技術的結果；(3) 從其他種類廢棄物之地下處置設施的運轉經驗；(4) 對未來潛在地質處置系統所做之最優化安全評估所獲得的進展等。

只要當地的地質條件與經過仔細挑選之設施設計、配置及工程障壁相匹配，地質處置行為可與多類的地質條件相容。

Where do we stand with geological disposal in OECD countries?

針對經濟發展暨合作組織會員國的地質處置—我們的立場

Having taken into account significant public and stakeholder involvement, many countries have adopted geological disposal as the reference long-term management solution for their high-activity, long-lived radioactive waste.

Progress towards implementation is evident in a number of countries. For countries that have faced challenges and setbacks with respect to implementation, geological disposal still remains the reference option.

With the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, the Safety Standards of the International Atomic Energy Agency, and the recommendations of the International Commission on Radiological Protection there is now a common framework that guides national regulatory oversight and implementation of disposal.

For programmes that are most advanced, implementation of geological disposal builds on a strategy that accommodates continuous learning and includes a willingness to incorporate evolution in technical advances and societal requirements.

The search for, and selection of, a site are critical steps that have proven to be politically and socially challenging. Recent successes show the benefit of open and transparent processes that allow sufficient time and include a concerted effort to assure that there is meaningful involvement of all stakeholders in the decision-making processes by following a flexible and adaptable strategy.

Ethical aspects, including considerations of fairness to current and future generations, are important for the development of disposal programmes.

Cultural, societal, and geographical similarities and differences have resulted in a variety of paths towards implementing national disposal solutions, but a common safety and security objective underlies all these paths.

透過公眾及利益相關方建設性的參與，很多國家已經接受將地質處置作為高強度長壽期放射性廢棄物 的長期管理” 參考” 解決方法。

一些國家的地質處置工作推動已有相當的進展，但對那些在推動過程遭遇困難或阻礙之國家，地質處置仍然被保留做為參考選項。

在國際原子能總署的” 用過核燃料安全管理及放射性廢棄物安全管理聯合公約” 之安全標準規範，以及在國際輻射防護委員會的建議下，針對地質處置的推動與進行國家法規之監督，現在已有共同的架構來指引。

最先進的計畫應該是將地質處置之推動，建立在可以接納持續學習，及有願意整合技術精進與社會需求的策略上。

場址的尋找及選擇是關鍵的步驟，而且充滿政治與社會挑戰性。目前成功案例顯示，一個開放的、透明的程序允許充足的時間來接納協和一致的努力，並容許所有利害關係者均能有意義地參與決策，取得一個有彈性、可調整策略是最有利的。

地質處置計畫推動時道德方面的考慮相當重要，此應包括對當代及未來世代的公平性考量。文化、社會及地理上的差異性與相似性導致各國推動地質處置的方法與途徑將會有所不同，但確保安全無害的共同目標應凌駕在各條途徑之上。

Challenges and opportunities in practical implementation

實際執行面的挑戰與機會

Regulators, implementers and policy makers have increasingly become aware that confidence by the technical community in the safety of geological disposal is not, by itself, enough to gain public confidence and acceptance.

There is consensus that a broadly accepted national strategy is required. This strategy should address not only the technical means to construct the facility but also a framework and roadmap allowing decision makers and the concerned public the time and means to understand and evaluate the basis for various proposed decisions and, ultimately, to gauge whether they have confidence in the level of protection that is being indicated by the implementing organisation and evaluated by the regulator through its independent review.

Reversibility and retrievability are considered by some countries as being important parts of the waste management strategy. Reversibility implies a disposal programme that is implemented in stages and that keeps the options and choices open at each stage, and provides the capacity to manage the repository with flexibility over time under specified conditions. Retrievability is the possibility to reverse the step of waste emplacement. There is general recognition that it is important to clarify the meaning and role of reversibility and retrievability for each country, and that provision of reversibility and retrievability must not jeopardise long-term safety.

Technical development and implementation of disposal projects demand decades to realize. The long implementation times afford opportunities for programme adaptation and enhancement. The related challenge is to maintain the support at both local and national levels, the necessary infrastructure, and human resources for knowledge preservation and transfer.

Phased decision-making has come to the fore as the preferred approach to deal with the long implementation times. Besides allowing for continued research and learning, phased decision-making provides the opportunity to build broad societal confidence in the concept and

to develop constructive relationships with the most affected regions. The related challenges are to maintain the processes and relationships, integrate advances, and ensure forward momentum.

管制者、執行者、政策決定者已越來越意識到：只有工程技術界對地質處置安全有信心，尚不足以獲得公眾的信心與接受。

一套被廣泛接受的國家策略是大家的共識。策略中不只應交待建造地質處置設施之技術問題，同時應提出體系架構與路線圖，給決策者與關心的大眾時間與方法來了解與對話，以及對各種方案進行評估，來衡量其對由設施建造者提供並由管制者完成獨立審查的安全保障程度之信心。

確保”可逆性”與”可再取出性” 在某些國家是放射性廢棄物管理策略的重要部分。可逆性指地質處置計畫將分階段執行，每一階段之選項與決定權保持開放，因此在特定的條件下，該處置計畫仍可彈性調整；可再取出性則指可以回復廢棄物掩埋步驟的可能性。各國應進一步澄清”可逆性”與”可再取出性”之確切意涵，並且保留可逆性與可再取出性，不可損及地質處置系統之長期安全性。

地質處置計畫的執行及技術發展需數十年來實現。冗長的執行期使得有機會調整方案的執行並持續精進建設技術，然而伴隨而來的挑戰是：如何長期保持來自中央與地方政府的支持、如何維持必要的基礎建設、與確保因知識保存與傳承所需的人力資源。

由於地質處置計畫執行期間太長，分段決策於是相對重要也是可取的做法。分段決策除允許持續的研究與學習外，尚有機會來建立在觀念上的社會信心，以及發展與受影響區域的建設性關係。但伴隨而來的挑戰是：如何維持這些發展進程與關係，如何整合各項進展及保持前進之動能。

Broad expectations on further development of geological disposal

對地質處置未來發展之期望

Collective experience and knowledge transfer have been helpful in facilitating development. International cooperation and sharing of research projects, experiences and lessons learnt should continue.

Delaying work on geological disposal – i.e. by adopting a “wait and see” strategy – would require increasingly more demanding care for the waste and its storage facilities. Wastes stored at or near the surface will be more vulnerable over time to extreme natural events or terrorism than wastes disposed deep underground. Geological disposal thus provides an ethical basis for current generations to deal with the waste and it should be implemented.

經驗的累積與知識的傳承確實有助於計畫推展，因此國際合作、研究計畫經驗之分享及心得交流應該繼續進行。

延遲地質處置工作之推展--即採”走著瞧”策略--無疑地將會增加對廢棄物本身及貯存設施的照護需求。與深層地質處置比較，廢棄物採行地表或近地表貯存，隨著貯存時間拉長將更易受天然事件或恐怖份子之威脅。準此，地質處置提供了當代人們處理廢棄物的道德依據，且應該予以執行之。

GEOLOGICAL DISPOSAL PROVIDES A UNIQUE DURATION AND LEVEL OF PROTECTION FOR HUMANS AND THE ENVIRONMENT IN A MANNER THAT DOES NOT REQUIRE CONTINUED MONITORING, MAINTENANCE AND INSTITUTIONAL CONTROL. GEOLOGICAL DISPOSAL IS TECHNICALLY FEASIBLE AND WIDELY ADAPTABLE TO DIVERSE GEOLOGICAL SETTINGS. IT IS BEING DEVELOPED WORLDWIDE, WITH INCREASING INVOLVEMENT OF STAKEHOLDERS TO ASSURE THAT SOCIETAL REQUIREMENTS ARE TAKEN INTO ACCOUNT. MOVING FORWARD NOW WITH IMPLEMENTATION OF GEOLOGICAL DISPOSAL IS DESIRABLE FROM THE POINT OF VIEW OF BOTH ETHICS AND SAFETY. SUFFICIENT INFORMATION EXISTS NOW TO TAKE THE FIRST STEPS AND PUT A PLAN IN PLACE COMMENSURATE WITH THE CURRENT GENERATION'S RESPONSIBILITY.

地質處置提供人類及環境一個獨特的期程與一定程度的保護水平，而且並不須要我們持續的監測、維護與制度上的監管。地質處置在技術上可行且能廣泛調整以適合不同的地質組成。目前它被全世界採用推進，增加利害關係者的參與以保證將社會的要求被納入考量。從安全與道德的角度看，地質處置計畫現在就值得推動。目前擁有的資訊已足夠支持踏出地質處置的第一步，現在就請著手建置一套與這一代人們責任相稱的規劃案吧！