PNC ZN1600 94-004

OECD／NEA

長寿命放射性廃棄物の環境的及び倫理的側面に関するワークショップ

議　事　録

（海外出張報告）

1994年12月

動力炉・核燃料開発事業団

〒319-1184　茨城県那珂郡東海村大字村松4番地49
核燃料サイクル開発機構
技術展開部　技術協力課

Technical Cooperation Section,
Technology Management Division,
Japan Nuclear Cycle Development Institute
4-49 Muramatsu, Tokai-mura, Naka-gun, Ibaraki, 319-1184
Japan

〒107　東京都港区赤坂１－９－13
動力炉・核燃料開発事業団
技術協力部　技術管理室

社 内 資 料
PNC ZN1600 94-004
1 9 9 4年1 2月

ＯＥＣＤ／ＮＥＡ
長寿命放射性廃棄物の環境的及び倫理的側面に関するワークショップ
議事録
（海外出張報告）

大澤　正秀*

要　旨

標記ワークショップは、平成６年（1994年）９月１、２日、ＯＥＣＤ／ＮＥＡ（パリ）において開催され、15カ国及び３機関（約50名）が参加した。

本ワークショップは、1993年２月のＮＥＡの放射性廃棄物管理会議（ＲＷＭＣ）における、倫理、環境問題をコレクティブオピニオンとして取りまとめるとの合意に基づき実施されたもので、原子力界以外の意見を聞くためＯＥＣＤ環境局等の参加を得ている。

本ワークショップでは、地層処分の倫理的側面、例えば、回収可能性、代替法としての長期貯蔵、実施手続きの公開性、が討議された。

この議論の結果等を基に上記のコレクティブオピニオンが取りまとめられ、ＲＷＭＣの審議を経て公開される予定である。

* 環境技術開発推進本部　社会環境研究グループ

長寿命放射性廃棄物の環境的及び倫理的側面に関するワークショップ　議事録

作成者　環境技術開発推進本部
大澤　正秀

1.開催日及び場所

平成6年9月1、2日　　ＯＥＣＤ／ＮＥＡ（パリ）

2.出席者

議長　FLOWERS　（英国）　他47名（15カ国（ｲﾀﾘｱ欠席）、CEC 、IAEA、OECD）

3.議題

(1)　開催挨拶

(2)　セッション１　基調報告（４件報告）

(3)　セッション２　環境と倫理（６件報告）

(4)　セッション３　長寿命放射性廃棄物の地層処分戦略とその実施に関するレビュー

(5)　セッション４　討議と結論

4.議事

(1)開催挨拶

（植松ＮＥＡ事務局長）

最近の15年間、RWMCは長期にわたる処分問題、特に地層処分に力点を置いており、安全評価研究と処分候補サイトの特性評価が計画の柱であった。もう一つの主要な視点は、政治的、または倫理的、哲学的次元であり、科学技術の進展にともなって重要になってきた。最近RWMCは適切なサイトをを選べば地層処分は安全に行い得るというコレクティブオピニオンをまとめた。しかし、一方、我々の科学的技術的知識を使って、我々の子孫や環境を長期にわたって守ることにともなって不可避的に関連する哲学的課題に答えなければならない。

（議長）1993年２月のRWMCにおいて倫理、環境問題をコレクティブオピニオンに纏めれば政策決定者や公衆に有用との合意がなされた。この問題は、原子力界以外の知見が必要であり本ワークショップが設定された。

オックスフォード辞典によれば、"ethics"は "morally correct human conduct" と、"moral" は "concerned with the distinction between right and wrong"と定義されている。従って、倫理的に何が正しいかを知るためには多くの人々の意見を考慮しなければならない。ここでの議論は、世論の趨勢として、倫理的に正しい有害廃棄物処分戦略は何かを見定めることである。この視点はコレクティブオピニオンに反映され、処分管理政策に関する各国の議論に利用されることが期待される。

(2)セッション1　基調報告

①放射性廃棄物管理戦略：背景の設定　(Paper No.1) ALLAN　(AECL)

・放射性廃棄物管理の目標は、現在及び将来の公衆の健康と環境を守り、且つ将来世代の負担を最小にすることである。そのための技術は整備されつつあるが、政府や産業に対する公衆の不信や放射能に対する恐れ等により公衆に関する不確実性が残っている。将来世代の負担を最小にするためには、将来世代の意思決定における選択と柔軟性を残しておく必要がある。

②環境政策に関する展開と現在の意見　(Paper No.2) LONG (OECD環境局長)

・環境意識と政策は、'65-'75 年の局地的汚染に対する「浄化と回復」、'75-'85 年の「先手と防止」、'85 年以降の「予防原則」と変化した。また'70 年代初期の「汚染者負担の原則」PPP (Polluter Pays Principle) も重要となっている。
・環境政策上重要な傾向：①長期的視野が取り入れられ、「世代間の公平」が提起、②技術的解決法の復活、③最小コストでの環境目標の達成（環境税等の市場原理の導入）④政府、産業、環境派の新たな協力（3D:'70代 Denial, '80代 Data, '90代 Dialogue)
・倫理に関しての幾つかの話題提供：①化学実験用動物を減らす動きから種の保存への動き、②自国内で使用を禁じている有害物の国際取引に関する議論、③貧しい市町村に多い処分場、④南北格差
・解決法は公序良俗の厳しい試練 (the crucible of public policy)

③有害な活動と物質の管理 (Paper No.3) MORGENROTH (OECD環境局)

・管理手順：①同定、②有害性／リスク評価、③リスク管理（評価、区分、実施、確認、モニタリング)
・政策と実行：特定の化学物質については、許容量を決めたり、ラベル表示したり法的措置で対応可能。様々な使用法や発生源を持つ水銀、カドミ等については包括的評価手法を開発中である。しかし化学物質については安全に関するデータが放射性物質に比べて非常に少ない。政策は時として経験と廃棄の一般原理に基づいて管理。
・新たなアプローチとして①代替品への移行、②最適で実行可能な環境選択の政策、③調整機関の設立、④当局の設立、⑤政府・産業・環境団体等から成る諮問委員会の設立等

④非放射性廃棄物の長期管理の概念と必要条件の明確化 (Paper No.4) VON REIN
（ｽｳｪｰﾃﾞﾝ国家環境防護評議会)

・スウェーデンの廃棄物管理目標：①量の低減、②健康と環境への危険性の低減、③適切な処分の確実化
・エコサイクル法：国が目標と枠組みを定め、生産者が目標達成の義務。有害化学物質の

流れと使用の低減、有害物質を含む流れの閉鎖、システマティックなリスク管理開発、有害化学物質使用の段階的廃止、幾つかの化学物質について5年以内のリスク制限計画立案

- 水銀について本年、国会が2000年までに使用禁止を決定。再使用せず隔離処分（地層処分）。深地層は安定な機械的システムを与える点で有利であり、地層は浸食、氷河、隆起に対して十分な防護であるとともに安定な化学環境と限定された水流で低移動を可能にする。水銀処分に対して何年先まで展望すれば良いか、その理由は、漏れの水準は、地層処分は最良の方法か、費用は誰が負担するのか。

(DEJONGHE) 参照値としてICRPのリスク値10E-5 、国際的規制では10E-6 、は受け入れられるのか。化学廃棄物にも類似のものはあるか。LD50以外の参照値はあるか。非放射性廃棄物の処分場の基準はプラスティクシートの厚さ、銅シートの厚さ、粘土層の厚さといったものと理解しているが、リスク的なものはないのか。

(LONG) その質問には、基準の整備状況や、放射性や非放射性廃棄物の貯蔵に関する合意への取り組みが含まれている。基準は、国やWHO といった機関によって異なる。非放射性分野での問題として有害廃棄物の国境間移動があり、OECDやECでそのあり方について議論された。その一つが、受入れ国では廃棄物は環境的に受入れ得る状態で取り扱われることである。しかし議論は放射性廃棄物分野ほど進んでいない。

(MORGENROTH) 化学分野では、10E-5 リスクのような参照値は複雑だ。癌、免疫毒性といった影響は別々に取り扱われる。一般的に、安全裕度や安全量への外挿は影響の性質、データの性質と量に依存する。動物実験による長期型データでは係数 100が用いられる。OECDでは"good assessment practice"と呼ぶ新しいリスク評価法を開発中である。科学的観点からの害毒の判断の一つは10E-6 という数字であり、化学分野で通常引用されるのは放射性分野における低線量での直線性である。化学分野では低い量における直線性は意味が無いと考えられ始めている。理由は低い量での影響は、放射線の場合と同様に突然変移と関係しているからである。人々はDNA の修復機構といったことを忘れ始めている。我々が洗練されれば、洗練されたモデルを得ることができよう。
オランダでは国土利用計画といった政策においても10E-6 に関する興味あるシステムを持っている。そのシステムへの反応として10E-8 、評価に関すること、規制に関することなどがある。しかし、動向としては相互理解であり、国は透明性に努めている。
有害物質の処分場に関する基準はあるが、これらは短期の浸出試験に基づくもので、地質学的な枠では考えられていない。

(BERNERO) 原子力分野で使う10E-5 、10E-6 は通常、潜伏癌死亡の年間当たりの確率である。米国では非原子力、又は一般廃棄物に関する立法で10E-6 係数が支配的になってきているが、これは生涯における癌の10E-6 の発生であり、約2桁の差がある。米国では"CERCLE"と呼ばれる法律の更新を審議中であるが、放射性廃棄物の浄化基準として

10E-6 の癌発生生涯リスクを加えようとしている。これは不条理な値で、現在論争中である。

(LEFEVRE) 公衆の問題についてコメントする。少し前、仏と独の相互の有害廃棄物の交換が問題となった。商業的な問題であったが、産業界のある操作が発覚し、原子力分野に対して激しい反応を引き起こした。スウェーデンでは、水銀廃棄物を無くすため、その使用を中止する方向にあるということであった。これは原子力と似ている。重大なリスクや重要と考えられる問題については、ニュアンスの問題ではなく、直ちに来るのは拒否の反応である。
フロンによるオゾン層破壊に対して公衆はその使用を中止を求めている。多くの国では放射性廃棄物に対しても同様の問題を抱えている。多くの共通の課題があり、有害物質廃棄物や放射性廃棄物の責任者が対話を続けることが重要。
公衆の受容の分野で重要なのは、秘密を避け、公開し過ぎを避けることである。秘密は明らかになったときスキャンダルになるし、過剰な公開は、公衆が直接的で極端に走り拒否する傾向があるからだ。

(LONG) 環境管理における傾向は、公衆の知る権利である。地域社会が産業と一緒に監査をし、どの様な廃棄物がどう扱われているかを地域社会に知らす。実施している国はそれが困難なことであるが長い間にはプラスになることを知りつつある。
次に、過大な期待をする公衆である。フロンに関して、産業界は最初は廃止に60億ドル必要で産業が成り立たなくなるといったが、翌年30億ドルに下がり、2 年後には廃止したどころかそれで利益を得た。このことから、公衆は産業界を充分圧力をかければ問題の解決法を見つけると考えるようになった。我々についていえばサイクルを閉じ放出を無くすことである。理想主義的ではあるが、それは公衆のものの見方であり挑戦である。
リスクの受け止め方は専門家と公衆で異なる。専門家は、例えば生物系の長期的課題が重要で、そこに研究資源を投資すべきだと提言する。これは公衆の癌の恐怖につながる課題と異なる。

(MORGENROTH) 化学の分野でも同じで、公衆は癌は重要と思うが専門家は免疫系の抑制に関する化学物質により関心が高い。手法や進め方が改善されれば公衆はリスクがどこに存在するかという点に興味が移る。
食品安全に関係する者は、自然毒や微生物の問題の方が広範な試験を受けた添加物質よりも重大な問題であることを知っている。連邦薬品局では以前黒胡椒に発癌性があることを見つけたが使用禁止はできないだろう。一方添加物は検査が続けられる。食品安全に係わる当局や産業とのリスクコミニュケーションが充分でない。さらに透明性を高め、評価では何が行われているがを正確に説明する必要がある。

(McCOMBIE) 放射性廃棄物の分野でも専門家と公衆の違いに関する同様の問題がある。
我々は、公衆の言うことを聞き非合理な恐怖感を全面的に取り入れるのか、技術基盤を持つ人間の考えることを教育し事態を変えるか、の 2 つしか方法を持たない。

化学分野ではどう考えるのか。環境局の役割は

(LONG) 環境局の役割は、第1は、フォーラムを開催し経験を共有し合うこと、第2は問題の一致点を見出し、更に可能ならば指針をつくることである。最も重要な役割は、合意作りである。それにより自国だけでなく各国共同じ方向であると国民に説明できる。

(MORGENROTH) 環境局の主要な活動を紹介する。1972年の始め、最初のストックホルム会議において270 の化学物質のリストや行動計画が公表された。1987年までに多くの活動がなされ、鉛、カドミウム、水銀は今でも研究されている。同時に、産業界で使用されている 99%に相当する2000の化学物質については3%しかLD50以外のデータしか持っていなかった。1987年にOECD加盟国は国際共同作業しか方法の無いことを認め、共同計画を作り、現在95の物質が試験され、そのうち3 つについて危険性が指摘された。これらの作業は自主的である。こうした活動は環境局の重要な役割と考える。

(ALLAN) 化学基準と放射線基準との係数100 の差は、動物モデルから人間モデルに外挿するときの不確実性を示すか。また、鉛、砒素、水銀のように自然の有害物質と有機有害物質の差は何か。

(BERNERO) その通りと思う。データは少なく入手が困難だが動物実験を外挿している。放射線基準については第2次大戦の不幸な経験によっている。

(MORGENROTH) 自然物質と有機物質の差は、自然物質については、原子力と同様人間についての不幸な経験があり、人間に対する毒性に関する情報がある。例えば鉛は係数は使用していない。有機物についてはデータは少ない。しかし物質代謝や事故によって安全裕度が変化している。安全裕度は、5から8万ないし9万である。ダイオキシンはある種の状態では動物よりも遙かに毒性が強い。有機物は非常に複雑である。

(3) セッション2　環境と倫理

⑤民主的社会における倫理原則と環境（Paper No.5）AHEARNE　（米シグマXi）

・米国の高レベル放射性廃棄物管理は、'56 AEC が地層処分を決定、'57 NAS が固化後岩塩の鉱山又は処分場に処分を勧告、'87 ネバダを選定。'88 BRWMがEPA の進め方を「データが揃う前に詳細な規制」として批判(Rethinking)。'87 合衆国裁判所がEPA の基準の一部差戻し。'92 エネルギー政策法(個人被曝に基づく基準/ 制度的管理の妥当性/ 一万年にわたる人間侵入についてﾅｼｮﾅﾙｱｶﾃﾞﾐｰに 回答要請）。'93 末 5箇所のサイト乾式貯蔵許可。
・世代間の公平については有史以前の人々は今日の問題の解決に何も寄与していないことからしても、我々自身の偏狭な価値を遠い将来に投影しようとすることは不条理。
・迷惑施設の受け入れ社会が保証や報酬を受けることは賄賂として位置づけられる。
・言及されていない要素：50-100年の短期的地表貯蔵、公衆が決定者であること、現世代の権利、国際的差異、不確実性の増大、処分場が今必要な理由、規制手続き等の検討の先送り、持続可能な開発の概念の通常の意味と異なった使用
・民主社会の手続きは公衆が決めること。
・４つの解決法：①強引にすすめる（決定ー通知ー弁護　プロセス）②完全技術解決（太陽への送り込み、深海底処分、高速炉内での完全燃焼）③魔法の国の処分（今も将来も誰も住まない場所に処分）④待つこと（中間的貯蔵）
①～③本気で解決しようとしていると思われない。中期的リスク評価は行われていない。④は選択されてよい。

⑥放射性廃棄物ー倫理と環境の考察ーカナダの展望（Paper No.6）ROOTS　（加　環境省名誉科学顧問）

・カナダは環境意識が高く、1887年「将来世代の利益と享楽のため自然の美を常に維持する」として世界的にも早期に国立公園を作った。
・'1984 と'86 に原子力エネルギー管理ボード(AECB)が出した「審議用文書」中の一般的要求事項：(a) 将来世代の負担の最小化(b) 環境保護(c) ヒトの健康の保護
・89年9 月に環境大臣がAECL概念の安全性と環境的受容性をレビューするための環境評価パネル(EAP) を任命。EAP は国内の様々な地域で「scoping 会議」を開催、様々な社会層の展望を把握。これに基づき'92 に「放射性廃棄物管理と処分に関する環境影響評価書の準備に対する最終ガイドライン」作成。この中では、倫理的道徳的社会的展望、処分場について考慮すべき期間の間の人間社会や環境の変化の考察、処分場閉鎖に対する倫理的議論などが求められている。
・環境省の研究グループの '92の報告書中の勧告：処分の全ての段階にわたって公衆の参加を確保すること、地域社会とのコミニュケーションは双方向であること、道徳的倫理的価値にもとづく社会的受容が重要
・廃棄物が既に発生しているという事実から発して、①直ちにではないが環境に影響を与

える前に恒久的解決を見出さなければならない、②すべきことを決め研究するのが早ければ早いほど我々と子孫にとってより安く安全になる、という議論が考えられるが、手順と詳細な技術を強調すれば社会を騙すことになり将来をより悪くする。

・カナダの３つの社会的価値体系：①エネルギー／経済的立場（人間中心的哲学）②平等主義／自然世界観（理想民主政治体系、人間と環境は倫理的関係）③環境学的／原住民的世界観（カナダ独特、世代を通して蓄積された経験と知識が判断の基礎）。①の信頼に必要なのは客観的事実に基づく知識②信頼に必要なのは公衆の参加③の信頼に必要なのは「長老」の経験や知識

・他の環境評価の過程において対話により成功した例あり。最近では軍事演習が野性動物の行動の妨げという新たな観点が見られる。（cynicism)

・世界観の異なる者の間で、それぞれの中心的価値が合法的と認識された場合、それぞれの政策的立場がお互いに説明でき、目標とその過程についての一致不一致が明らかにされ共通の場が期待できる。

⑦放射性廃棄物の最終貯蔵に関する倫理的問題（Paper No.7）GUNDELACH （独　環境・自然保護・原子力安全省）

・倫理は応用哲学で、その任務の一つは前提(Maxim) 作りである。前提１：倫理的に善の目的に供する行動は付随する負の副次的効果を最小化してのみ正当化。前提２：もし行動がとられないと起こるであろう悪よりも副次的に生じる悪が小さい場合にのみ善のための行動は正当化。（反対者：悪のリスクよりも何もしない方が良い。（反論）行動の放棄も結果を伴う。）

・放射性廃棄物の最終貯蔵への質問に関する考察①人類が自然に対する潜在的有害性を高める権利は無い（反論）この論は他の技術は受け入れているが原子力は悪いとしている。ある特定の技術の善悪の一般論的適用は出来ない。②有害性を将来世代に課す権利はない。（反論）将来世代がいかなるリスクも受けないよう現技術社会を設計することであり、即ち、守勢の人類学。人間の文化的発展の改革的特徴を否定。③現世代のみが利益を受け、将来世代が有害性の負担のみ被るなら、いかなる行動も許されない。
（反論）将来世代の生きるチャンスに大きな影響を与える効果に繋がらないか、またその程度に関して質問に答える。

・最終貯蔵に関するコメント：①中間貯蔵や再処理もいれたより広い文脈の中で処分問題をとらえる。②原子力使用の包括的な枠組みの倫理的正当化

・民主主義体系では討議を尽くさなければ多数決の原理は適用できない。全ての抵抗権は縮小されない。

⑧明日のための今日の管理(Paper No.8) ALLEGRE　（仏　ANDR)

・廃棄物に関する一般的原則：①最終廃棄物は毒性的にも量的にも最小化されなければならない。②廃棄物発生者が支払い者。③最初に害から守られなければならないのは現代世代。④有害製品を作る世代は将来世代の対する責任を有する。⑤世代間の連帯、国際

間の連帯、国内の連帯。⑥民主主義と公開性。

・コメント：①原子力を利用する前に放射性廃棄物問題への対処を示すべきではなかったかという批判があるが、我々以前の世代は基本的倫理に背いていない。また、新しい科学分野では常に知識は進展しているし、原子力では初期から廃棄物について研究しており専門家は地層処分が可能と考えている。②放射性廃棄物を純経済的に取り扱うのは不可能。③安全の証明において特徴的なのは、全ての許認可の前に安全証明が先行すること、技術と自然が関与すること、考慮すべき期間が非常に長いことである。④良く管理された状態で高レベル廃棄物を地上で管理するとか科学を信頼しＴＲＵ消滅まで貯蔵するとかの議論があるが、これは問題を解決するフリをすること。⑤回収可能性については、初期は可能だが、人間が退化／進化する可能性のあるような長期にわたることは危険。余りに長く、多様で費用のかかる研究は大衆にとって解決できないほど困難な問題に映る。⑥地層処分は自然の一部を不毛にするとの非難を受けるが、処分場は小さく、またその近くは開発可能。このような例は他にもある。

・何もしないは無関心の罪、ひたすら仮説的改良は反倫理的。最終目標は「nuclear world 」が明日には「new killer world」ではなく「new clear world 」になること。「未来に対する本当の寛大さは現在に全てを与えることにある」（カミュー）

⑨費用便益解析、持続性と長寿命放射性廃棄物管理(Paper No.9)BERKHOUT（英 ｻｯｾｸｽ大）

・放射性廃棄物の政策決定要因：①放射性廃棄物管理費用②放射性廃棄物への投入労働力③健康リスク④規制当局の設立と維持⑤放射性廃棄物政策に関する争議を解決する必要性⑥核兵器物質の盗みと分散の防止

・費用便益解析における「割戻し（discounting)」は、世代間の幸福の均等な割り付けを与える社会的割戻し率の設定が困難、正の割戻し率では長期の場合現在価値が無くなるため将来への資源と環境負荷の引渡への割戻し率の適用が困難、将来ガンの治癒が可能となればガンリスクは割戻しし得る等の理由により、費用便益解析は放射性廃棄物管理政策問題には適用され得ない。

・持続性の概念は、ＰＰ「予防原則：Precautionary Principle 」とＰＰＰ「汚染者支払原則：Pollution Pays Principle」と関連を有している。持続性の概念からすると、廃棄物の発生量に基づき費用が正しく算定されていれば、経済成長による剰余金（surplus）により将来世代に財政的負荷を与えることはない。この概念と貯蔵戦略は、廃棄物を受動的安全施設に保管することで成立するが、この考えが支持されるためには産業、制度等の基盤が維持されなければならない。持続性指針の下では安全基準はリスク付加概念に基づく。（処分場に関係する累積的リスクは、ウランがそのまま残っていた場合のリスクと比較される。）処分場の計画の財政は原子力発電の課税徴収とその安全な供託によって作られるが、その際、処分コスト等が常に見直され課税徴収の見直しがされること。持続的指針は現在の政策に良く似ているが、それが達成されないとすればその理由は政治的争いであり、将来世代に課せられる主な重荷は社会的政治的である。

⑩世代間に公平にリスクと便益を均衡する：費用便益的考察(Paper No.10) CATRON
（ジョージワシントン大教授）

事前に配付されたワーキングペーパにおいて提起された問題に対する私見

- 放射性廃棄物による長期の健康リスクに対する「割戻し」の適用性：以下の理由で米国ＥＰＡは反対①現在において救われる生命に対する将来からみた社会的利益を価値化できる割戻し率が無い。②将来世代を救うための費用は現世代を救うためのそれより効果がないように表される。③時間に関して不変である生命に金と同じ割戻し率を使うのは不適切。
- 将来世代に起こる事象は広範に評価すべきか廃棄物問題に限定すべきか：限定すべき
- 現世代の差し迫った必要性は世代間の公平さとどう均衡させるか：持続性や予防原則が意思決定のガイドとなる。
- 資源が他の社会的目標に適用し得るとして、放射性廃棄物の安全を確保するめに使う資源は適切にリスクと均衡させ得るか（"How safe is safe enough?"）：　適切な均衡は単にリスク評価からだけでは決まらないし、資源の再配分は将来にわたりより大きな防護となることが示されることが必要。

　世代間公平原則の提案：①いかなる世代もその後継者から不必要に、同水準の生活の享受の機会を奪ってはならない。②もし現世代とその子の利益が危うくされないならば将来世代を守る義務がある。③短期の具体的有害性は長期の仮想的有害性に対して優先度を有する。④不可逆的被害が問題となる場合は③の優先度は減少する。⑤ある行為が破滅的効果の恐れのあるときは、それを相殺するだけの必要性が無いときには実行してはならない。⑥資源の減少は代替物を開発する義務を伴う。

- 今日将来世代の責任を最小化するために全ての行動をすることは好ましいか：効率的であれば現代で全ての行動をとろうとしなくて良い。
- 今日受容不可なリスクに将来世代もさらすべきでないとの命題は適切か：世代間公平原則③～⑤
- リスク受容の基準は、個人的権利又は地域的権利、又は公衆の集団的権利の文脈で考えるべきか：これはレベルの問題であるが、レベルによって興味の対象が異なることに注意。多面的分析が必要。集団の善を基礎とする功利主義（最大多数の最大幸福）的議論は地域レベルの負担を課すのに使用されるので注意。
- 処分場付近の住民に不相応な負担を課さないために必要な基準：相応は環境正義の鍵の一つ。まやかしに注意（経済論理では低賃金の国が汚染コストが最も低く立地に適切）
- 処分場受入れ社会が補償を受け取る倫理的根拠：サービスを意識した補償は賄賂。

（BERNERO ）もし、将来への影響が無視できれば、割引率の問題は無いのか。

（BERKHOUT）将来リスクが無視でき、今日も無視できるのならば割引きは必要ない。費用便益解析は簡単に使用できる道具で、短期の財政的資源の割り振りをするのに適しているが世代間の公平さの問題には向いていない。

(ALLAN) 回収不可処分についてであるが、現在OECDの多くの国で考えられている概念は回収を意図していないが、回収の可能性を否定していない。その意味で、地表処分や地表貯蔵と基本的に変わらない。本質的な違いは、制度的管理に頼らない受動的安全システムである。地層処分は将来の人間侵入リスクを最小にすることにある。人間侵入に関するNEA では、故意ではない不注意の人間侵入リスクを最小にすることを求めていることで意見の一致をみている。

２、３世代後の問題は処分場を閉鎖するか否かであるが、回収可能性を維持するにはコストが必要だろう。現在行っている貯蔵と地層処分の差は受動的安全システムであり、制度的管理が失われても将来のリスクを最小にするだろう。

(McCOMBIE) 処分を実施しない理由に、技術的（特にサイト特性調査）に時間がかかること、経済的に短期では不利なこと、事態が好転するのを待つこと、更には政治家や社会的問題を冷却させることがいわれている。我々が将来世代に残す最大の負担は社会的制度的問題ということになる。これは政治的社会的負担を残すから非倫理的なのか、選択肢を残すから倫理的なのか。実施までの最も倫理的期間は何か。

(CATRON) 倫理の議論で難しいのは原理が一つだけでないことだ。時には幾つかの原理が相いれないことがあり、均衡を取る必要がある。将来の無視できるコストが議論される時、誰に対して無視できるかが問われなければならない。もしリスクに死が含まれるのなら、そのリスク評価がたとえ他のリスクに比較して小さいとしても、死ぬ人々に対してリスクは無視されるべきではない。それと同時に、功利主義的（議最大多数の最大幸福）議論が重要と思う。また、分布された公平さ（distributive justice）の検討も重要。功利主義的倫理の問題点は、それが分布された公平さの適切な原理を持たないことにある。この２つのやり方の均衡が重要。倫理の議論は本質的に様々な観点を均衡させるもの。

(BERKHOUT) 英国で２日前にＩＲＡが停戦要求をしたように解決しない問題は無い。放射性廃棄物処分問題はこれより易しく、対話の仕組み、教育の枠組み、公衆参加の枠組み、分別ある国の行動など、処分又は長期貯蔵の決定を可能にする方法があるはず。これらが片付けば、資金問題や基準といったものは然るべく落ち着く。悲観的になることはない。

(AHBARNE) 処分場立地において影響を受ける大衆がいる。最も影響を受ける大衆は、そのやり方が気に入らない人々である。倫理的問題は、その権利を乗り越える必要があるとして、高レベル廃棄物問題解決について何か危険や重大なことがあるかである。技術者は、公衆は非合理的に行動するし、問題解決には何も危険なことはないので、公衆は関係ないと考えるのではないかと疑念を持つ。

(McCOMBEI) 人々を乗り越えるのは倫理的でないが、それを理由に問題を棚上げするのも倫理的でない。間違いをして、その問題から離れ、じっとして事態が好転するまで待つのは倫理的でない。

(MREBER) 割引きは、子孫に対して責任を回避するようにみえる。将来になればなる程、責任があるとは思わなくなる。将来の人間は我々と異なったり、存在さえしない可能性がある。しかし、我々は今日の人間と殆ど同じと仮定することにより、更に責任を持ちそれを果たすことができる。また、選択の柔軟性、意思決定への参加、公平さ、公開性などは将来へも引き継がなければいけない。

(BERNERO) 仏のスレーヌ低レベル処分場は、多重バリアシステムであり、かつ放射性廃棄物が漏れたとしても無視できるという予測であるが、回収可能になっており、長期モニタリングも行われている。いずれかの将来世代がこの施設は時限爆弾になると思うかもしれないと、あたかもいっているようだ。高レベル廃棄物に関しての今日の問題は、今計画を実行するのか、今は単に検討だけしておけば良いのか、だ。

(LEFEVRE) 回収可能性は研究すべきである。我々は公衆に完全に決定的なこと、修復不可能なことをすることを説得できない。我々は前に進まなければならないが、同時にもし問題があれば取り出すことを公衆に言わなければならない。間違いをする権利は知らしめるべきである。
ルイ16世の大臣は、将来軍艦を造る目的で、ナラを植え、トロンセの森をつくった。
我々はその大臣が計画した目的にはそれを使わないが、エコロジーの観点で利用できる。

(THERGERSTRÖM) 我々は、処分に関する負担をモニタリングできる。それによって、フィドバックが可能になるし、さらに前進する決定か難しくなれば、進め方を遅らすか代替案を検討できる。この過程を車に例えれば、エンジンが産業界、運転は規制当局、ブレーキは反対者か何かである。倫理が慎重に車を前進させ、非倫理が車を止め、鍵を取り上げ、次の世代が問題を解決すると言うだろう。選択肢と代替を研究し本を棚に上げることは車を止めることのように思える。

(ALLEGRE) スレーヌの例は比較に良く、そこに300 年間低レベル廃棄物を監視することしたのは、第１に 300年で放射能は無くなるし、第２に 300年は政治制度はモニタリングを保証するのには充分持続できると判断したからだ。寿命が数千年といった長寿命廃棄物については、制度的管理は考えられず、地層処分が唯一の解決法である。何もしないことや次世代が問題を解決すると考えることはアリバイ作りにすぎない。次の数十年の間に、先ず科学者を、次いで世論と政治家を説得する必要がある。最大の決意をもって始めることが将来世代に対する責任ある態度だ。

(BERKHOUT) 知識の社会学或いは科学の社会学からの視点で議論したい。一つは知識は累積的であるという視点で、ある子馬が親馬になるように、科学が一定の合理性に従って進展し、又一定の軌道に縛られているとすると、放射性廃棄物の処分の方法に対して将来において何らかの概念が存在し、それも我々が考えているのに似ていると思われる。第2点目は、地層処分以外の選択肢に関係する基本的な物理的経済的問題があるとすると、評価技術やコンピュータモデル開発等の現在我々が行っていることは我々の持つ概念の合法化を目的とした科学であって、本来の流れの中で進展する科学ではないことである。我々の持つ概念を公衆に保証する特別な機能を持つ科学である。

(SCHALLER) 割引き手法は、遠い将来世代には適用できないかもしれないが、発熱する放射性廃棄物の冷却期間は財政を検討するための道具として使える。割引きを考えると処分は遅らせた方がいいという議論があるかもしれないが、純財政的な観点でみると、政策変更でコストが大幅に変わる危険性があるのでできるだけ早く処分すべきだ。

(BERKHOUT) 将来に必要と思われる事に関しては保守的になるべきだ。財政的な観点では原子炉の運転終了と同時に処分か始まると仮定して資金を用意すべきだ。

(CATRON) その要求は疑問だ。この問題に取り組む適切な方法は、今何を行い、何を先に延ばすかの戦略を決めることと思う。最初に効率の観点で、今全てを決めてしまうというのは確かでないと思う。

(SALTZMAN) 最も影響を受けるのは処分場周辺の住民であり、その視点を忘れてはならない。

(ALLAN) 我々は重要な科学的要素の理解の段階に達しており、次のサイト固有のプロジェクトの段階に入る。廃棄物の定置までには早くても15年はかかるので、その間技術開発を続け、定置に関する決定の選定は次の世代に保留しておく。更なる時代を経て別の世代が閉鎖の決定をするだろう。計画遂行を決めたとしても代替法は検討すべきである。ある程度廃棄物を改良する方法があるだろうが、最良の方法は地層処分であるという広範な合意があるので、その技術開発は継続するが、それによっていかなる選択肢も排除されるべきでない。

(RÖTHEMEYER) もし決定や行動が延期されるとすると社会的安定性が前提となっていなければならない。社会的安定性が無くなり、問題を扱う能力も手段も持たない国の存在を知っている。決定や行動を延期する時、社会の安定性は充分に取り組まれていない視点である。

(McCOMBIE) もし 150年前だとすると全ての人は現在皆馬に乗っていると予想したであろう。しかし、科学は直線的ではない。だから、何か新しいもの、素晴らしいものが将来でき得るという議論を常に聞く。しかしそれには反対したい。もし馬でできる旅をする場合、必ずしも車を待つ必要はない。それが最良の方法でなくても、社会的に受け入れられるのであれば、何かより良いものを待つのではなく、その方法で前に進むかが議論となる。我々が正しい解決法を持ってるか否かを認めるがどうかが大きな議論だ。

(AHEARNE) ここにいる人の多くは特定の処分サイトを持っていない。問題は、何時サイト選定を開始するのか、地層処分に関してどの様に進めるのかである。
過去15年に参加した議論の中でおぼえているが高速増殖炉に関する議論である。当時はウランが枯渇するので早急に高速炉を開発すべきであるという議論であった。しかし事態はそのように推移しなかった。
強調しておきたいのは、最も影響を受ける人々が意思決定手順に効果的に参加できる機会をもとことである。処分場建設可能性の研究と実際のサイト選定とその展開とでは非常に大きい差があることは米国の例にみられるところである。

(ALLAN) カナダや他のOECD諸国でも廃棄物発生者は、貨幣価値を考慮して、処分費用や処分時期の予測を基に財政的準備をしている。全ての費用が蓄えられるのではなく、預金利子や支出時期を考慮している。これは、もし資金準備に急激な変更をしないとすれば、処分事業の進捗率に関して財政的制約をうける。
予定地選定戦略や実施戦略において地方レベルでの住民参加は非常に重要な要素である。BIS でも望まない地域社会にはその施設は置かないことを明確にしている。この立地手順は、有害化学物質の管理施設設置に有効であった。全ての地域社会がそのような施設を受け入れるということではいが、幾つかはあるといことを経験した。

(議長) 地層処分は倫理的に正しい選択肢であり、他に取って替わるものは見当たらない。ナチュラルアナログとの比較は何かないか。

(ALLEGRE) 地層処分の正当性を自然の中の既成の事実に求める必要はない。むしろ反対派は、ネコは糞をした後それを穴に埋め見られないようにするという例を使い、原子力推進者は同じことをするという。
ナチュラルアナログは自然が物を長く保存するという例を研究するものである。自然は石油やウランの鉱床の様に保存能力の例を多く示す。自然は石油業者が良く使う言葉、「罠 (piège)」を我々に提供する。

(RÖTHEMEYER) ナチュラルアナログ研究により自然の隔離能力を証明してきた。我々の戦略は自然の隔離能力を妨げないように廃棄物を定置することであり、自然を真似る試みをし、自信も得た。しかし、これは全ての問題を解決するものではない。

(VAN ENST) 地表は自然の活動の場である。地上に長期に廃棄物を残した場合のリスク解析はできるが、洪水、氷河期、隕石など地表は自然が最初に打撃を与える場所である。100 年前の独の地図を見れば今と異なることがわかる。
地上に廃棄物を置くことは金をかければ技術的に可能であるが、何かが起これば、将来世代は自分のことしか考えず、廃棄物の面倒などみない。我々はそれを知っているから地層処分を選択している。しかし、公衆は我々を信頼していない。透明性が必要。

(CATRON) 倫理の原則の時間依存性であるが、文献等も考慮すると100 年から150 年でブレイクポイントが有るように思える。千年、一万年では人間社会がどのようなものかに関して合理性は無い。これが世代間の均衡を難しくしている。
付け加えたいのは、近い将来に対しては自然に感じる親近感を意識しなければならないことである。我々は遠い将来に影響を及ぼしうることを意識しなければならないが、その人達に対して子供や孫のような姻戚関係を持ちえない。しかし我々はその世代に感情移入する能力を開発する必要がある程度ある。

(SCHALLER) 深部処分は既に旧ソ連で行われている。トムスクの処分場で700mの地下に再処理の40,000㎥が注入された。西側では誰もこれをナチュラルアナログより良い例として利用しようとしない。将来もっと検討すべきだ。

(VAN MIEGROET) 我々は哲学的議論を含め、支持し得ない場所から抜け出るためもっと自分を捧げる努力をすべきだ。我々だけがそうした約束をしている印象だが、我々だけではだめだ。我々は今北極海の石油を枯渇させているが、それを将来世代に残そうという議論をした人はいない。別の例では、数十年前ヨーロッパでは退職手当てを払う所謂資本還元を所謂再分配技術に置き換えようとした。我々か前の世代かが、次の世代に年金手当てを払わせさせることで自分の快適さを増すことを決めた。その種の約束で我々は将来世代から隔離しようとしていると思う。

(4) セッション3　長寿命放射性廃棄物の地層処分戦略とその実施に関するレビュー

①　トピックスA　関係する問題を全て挙げたか

(BERNERO) 昨日の報告から3点を摘出する。

a．行動に対するリスクと責任は将来世代に課せられ得るか

b．現在の安全規範は将来に対しても適切か

c．世代間費用便益評価に対してどのような制御が適切か。

aに関して、技術分野で広く考慮され、廃棄物の最小化、廃棄物の再利用、貯蔵、処分が検討されている。しかし、化学産業の分野ではＣＦＣ（フロン）がR134A に置き換えられたが、原子力の分野においても放射性廃棄物は発電の副産物であり、代替発電とその廃棄物について検討することが必要ではないか。リスクコミュニケーションも重要な課題であって、専門家の考えるリスクの順番とと公衆の考えるそれとは逆さまではないか。米国では、「安全な処分を考えるのを止め、廃棄物の発生も止よう。我々が処分概念を理解してからだ。大量の廃棄物は取り合えず棚上げ」という議論がある。

bに関して、安全規範には判断の基本的原理も含まれる。将来世代の被曝に関しては不確実性の問題であるが、これは前のコレクティブオピニオンに纏められている。「何故、再取り出し性か」。我々は重大な誤りをする可能性があるので再取り出し性を維持するとすれば、どの程度の期間再取り出し性を維持するのかが問題となる。しかし、適切な処分場では漏れ出したとしても非常に遅いものだ。それでは独が述べたように代替計画決定に備えるものか。

cに関して、割引き（discounting)は避けた方が良いという提言であったと思う。

(MORGENROTH) ここでの議論で抜けている二点を指摘したい。一点は、化石燃料の代替品としての原子力の重要性である。第二点は貯蔵場所から処分場への輸送のリスク問題である。

(RÖTHMEYER) 損得の均衡に関する倫理的要求が述べられていない。これは原子力の代替まで拡張する必要があり、そうすることで広範な技術界に責任を課すことができる。

第二点は持続的開発の中で処分場を資源鉱床とみるか将来の不利益とみるかである。水銀にもし別の使い方があれば水銀処分場は将来にとって利益である。

(AHEARNE) BERNERO の発言に対して2点指摘したい。一点は、少なくとも米国原子力界内では廃棄物発生の代替、例えば太陽エネルギーの開発に力を入れている。第二点は、技術者のリストこそが公衆のリストと上下になっている点である。台湾の原発新設のためキャンペンを行ったが、キャンペン後の方が反対が多くなった。議論になったのは技術的事実ではなく、公平性、地域住民の決定権等であった。

(DEJONGHE) 割引きに関して、50～100 年については適用可能と思う。一万年といった長期は適用できないと思うが。

（議長）百年以上にわたって銀行に預けた預金が処分の物理的信頼性を補償するような遺産となるか問題だし、百年以上先の物理的義務を現実的に推定できるか分からない。

（ALLEGRE ）この議論は、放射性廃棄物の倫理問題に集中すべき。放射性廃棄物は、チェルノブイルの廃棄物とは異なること、原子爆弾とは関係ないこと、固体であること等を説明すれば、表層的な反応は避けられる。公衆はこのような情報を十分伝えられていない。可逆性についていえば、２つの面があり、一つは科学の発達により全てが解決するという考え方に基づくものであり、もう一つは政策的であり、放射性廃棄物に関する公衆の不信を和らげるためである。

（ROOTS ）原子力以外にも例えば水力発電など不可逆的に変わったケースがあり、どのように投資したか、出費を割り引いたかといった経験がある。

（議長）その通りで、我々の問題が最も大きなものと誤解してはならない。

（McCOMBIE）思い出して欲しいのは10～20年前はエネルギー当たりの廃棄物量は少ない事を誇っていたし、それは今も変わらない。またリサイクルも資源を効率的に使う点で倫理にかなっている。

（GREBER）袋小路を決定しないことの理由とすべきでない。これはリスクコミニュケーションに関連している。公衆を意思決定過程の重要な部分とみなすことで、設置が極めて困難な地下研究施設を設置できた。公衆と産業の視点が分極しているとは思わない。処分に可逆性の選択肢を加えることもできるし、自発思想や社会の利益を検討することもできる。

② トピックスＢ　処分の目標は公平かつ適切に明らかにされたか

（McCOMBIE）次の切り口で廃棄物処分の目的と原則を検討する
－我々が取り上げた目的と原則は適切に明確になっているか。
－目的と原則は倫理的原則と比較できるよう充分定義されているか。
－目的と原則は充分に完全か。何か見落としていないか。何かそれに対して提案があったか。
－倫理的原則に照らしたとき目的と原則は公平か。
－目的と原則は余りに野心的過ぎないか。我々は偏った方向に傾きすぎていないか。

この目的と原則はIAEAの資料に最良かつ簡便に述べられている。これは本ワークショップの準備資料にも纏められている。
1. 防御の受け入れられるレベル

2.環境防御
3.国境
4.将来の防御レベル
5.耐えられない負荷
6.可能な限り将来世代に選択肢を残す
7.公衆参加を含む増大的(imcremental) で透明性を持った手順の開発
8.最小化とリサイクル
9.希釈分散よりも濃縮と閉じ込め(CC/DD)

1～5は倫理的原則、6～9はシステム指向原則とでも呼ぶものである。

現在の目標は、現在の価値は一万年先も同じであるとの信念に基づいてるが、疑問だ。純技術的にみて、遠い将来より近い将来の世代により高い防御レベルが必要だが、我々の決めることではない。

我々は、より良い技術を待つとか、経済的に優るとか、政治的社会的平和といった理由で処分を遅らすことができる。それらの理由はそれぞれ倫理的理由を持っており、後ほど検討したい。

この3年ほど将来世代のために選択肢を残しておくという潜在的議論がある。これは将来世代に負担を残さないという原則と矛盾する。残すとすれば、方法としては貯蔵と回収可能性を残す2つがある。

上記6番目の原則については、皆そう思っているが明確に宣言していない。もし誰かが我々の優先度リストを逆さにするとしたらどうするのか。我々は、公衆の望むものを受け入れるのか。判断が必要だ。

補償の問題に関し、影響を受ける地域への直接的な補償は非倫理的であるという感情が10～15年前にあった。しかし、米国、仏、スイスでは、ことは始まっている。贈賄と同じことからくる補償への倫理的掛かり合いについて神経質なことから、普通のことへ移動があった。倫理的変化があったと思う。

CC/DD について、濃縮と閉じ込め(CC)が常に正しいとは思わない。一例が沃素129 である。半減期が1700万年で害の少ない物質である。もし、これを一か所に集めるとすればリスク集中で非倫理的だ。スウェーデンでは水銀についてそうする。地下で分散希釈されていたものを取り出して、濃縮して返す。これはリスク形態の変更であり、世代間のリスク変更である。CCがDDより原則とすれば、倫理的正当性は何か。

我々は、野心的過ぎるか。使用済燃料1t当たりの処分費用は数十万ﾄﾞﾙであるが、電気料金の3 ～5%に過ぎない。一万年から十万年にわたって年間0.1mSvはどうか。これは自然に比べて10～20倍低い。実際野心的である。自然程度まで多くの人々はは心配しない。我々以外の社会で不信用が無いかどうか多くの疑念がある。我々は野心的すぎないか。多くの見当違いの研究開発をしていないか。社会の反対が強くて技術的分野で気違いじみたことをしている。

(ROTHEMEYER) McCOMBIEは一万年、十万年に対して1mSvと言ったが、それ程長期間廃棄物は隔離できないし、長い時間の後にも放射性物質濃度は自然の濃度には下がらない。我々は他の技術との有利不利の均衡をとる必要があるのか。自然環境は元には戻らないだろうし、戻るとしても極めて長い時間が必要だ。

(議長) 放射性物質濃度は自然の状態にならないと述べたが、どこに置こうとそのことから逃れられない。

(VON REIN) 我々には既に水銀の廃棄物があり、問題は処分選択肢には何があるかだ。これは野心的な(ambition)水準よりは倫理に関係している。地層処分は地表処分より野心的か。この問題には野心の水準と廃棄物の管理の責任の2点がある。

(AHEARNE) 補償の問題を取り上げたい。有害廃棄物処分場を引き受けそうな地域社会は非常に貧しい所である。その結果、こうした地域社会は援助を受けたいためにこうしたサイトを引き受けるという疑念が起こる。これは環境正義の概念を引き起こす。そうすると、誰がこうしたサイトを引き受けることかをどの様に決めるかが問題になる。貧しい地域社会が受入れたいというと、他の組織が「それは不公平だ、受け入れるべきではない」という。こうした混乱がある。

(MORGENROTH) 化学の分野の補償については、施設の立地及び施設による事後の損害についての対応方策策定に向けた動きがある。もう一つの問題は、5年か10年前ならば安全と考えられていたものが、知見の集積により現在では受け入れられないという状況がある。従って、放射性廃棄物に関して公衆に、現在の基準は十分なデータに基づいているといった説明をする際十分注意する必要がある。

(ZURKINDEN) McCOMBIEが挙げた目的を我々が達成できないと思えば、我々は廃棄物について何ができるか議論することになるし、できると思えば、我々は何故公衆がその事実を信ぜず理解することに努め、公衆を納得させるのに努力を集中したほうがよい。

(ALEXANDRE) 明らかなのはリスク無しに生きることはできない。公衆にリスクは取り除くことはできると説明することは危険と思う。

(ALLEGRE) McCOMBIEは、自由な選択肢と現在価値化率を報告したが、その際、我々は将来世代とは、一万年先の世代のことか50~80年先の世代のことか区別する必要かある。今後30年程度は、様々な条件を検討するために可逆性を確保することはできるが、50~80年先の世代では一万年先の世代を巻き込むような決定をしなければならず、そこに倫理的問題がある。ことを早く効率的に進めなければならず、そのため科学技術と世論の妥協にいたる。これは解決法が公衆の信頼を獲るために原子力産業界が払わなければならない対価である。

(BERKHOUT) 今までの議論より広がるが、原子力には、技術遺産、炭素放出による気候変動といった別の環境コスト、経済発展のためのエネルギー供給といった将来世代への利益があると思う。しかし、これが本当か検討する必要がある。将来世代の嗜好が分からないからである。千年先にも原子力を使っているのか。炭素放出削減には別の方法も考えられる。利益は現在と将来で違うかもしれないが、健康負担と廃棄物管理負担は同じのように思える。

(CATRON) 補償と国家間の関係について述べる。もし、功利主義的進め方をとれば、貧しい地域社会に経済的な意味で得るものがあるようにして処分場を置く契約をすることは認められることになる。実際、米国ではメスカレロアパッチと電力会社グループが交渉している。国際的にみれば反放棄規定 (anti-dumping provision) である。しかし、世界銀行のエコノミストは、「アフリカの低人口国は大きな都市に比べて広く汚染している」と言っている。直接的な経済論理では、汚染コストを最小にするので低賃金国に有害物質が捨てられるべきである。これは拡大解釈された正義の概念であり、克服すべき公平さである。これは国際的な廃棄物処分においても避けるべき考えである。

③ トピックスC　実施戦略

(AHLSTRÖM) 使用済燃料管理には再処理と直接処分の２つの主要戦略がある。再処理は、持続的開発の考え方の線上にある。直接処分は、原子力をネネルギー生産戦略において挿入句的に捉えた国でとられる戦略である。いずれを選択するかは、現在と将来世代のリスクの均衡に関係する。私は、現代の作業者のリスクの方が大きいと思うが、どちらの戦略においても決定的なリスク水準にあるとは思わない。

技術と同様に地層処分実施のためには公衆の同意が必要なのは明らかだ。実施には、第１段階サイト選定、第２段階サイト特性調査、第３段階施設建設、第４段階操業と段階がある。スウェーデンでは２つのフェーズがあって、先ず 10%を処分し、その結果をみて第２フェーズに入る。第１段階が、実施者の倫理と環境問題における信頼性の基礎を築くときである。地域社会が意見を述べたり、質問に対する回答を受けたり、公平なやり方で手続きに影響を与える機会を確保しなければならない。処分場建設の過程では２つの原則ー将来世代に耐えられない負担を課さないー将来世代は制御し最善の努力ができる可能性と、我々がその可能性に対して有していると同様の責任をもつ、に適合するよう努めている。

20数年の第１フェーズの間に様々な経験が得られ、残りの90% の処分資金と、望むのならば別の方策をとる自由度があるが、決定するのはその時の意思決定者であり、我々ではない。この方法では、社会の決定的な運命を決めることを好まない今日の政治家の関与を避ける。20数年後では、経験があり、決定時にも余り運命的感情を持たないだろう。一方もし今、処分に向けた全ての行動を延期すれば、更に困難な状況になり、放射性廃棄物管理者、当局者、政治的リーダーの失望の感情が増大するだけだ。

倫理と環境の観点から実施戦略についての４つの要素を挙げる。

1. 将来実際の進展と考えられることをすることが重要
2. 慎重に計画された各段階において必要な技術的そして政治的決定をするとが重要
3. 選定されたサイト近くの住民と正当な関係を保つことが重要。地域住民と行動せよ。敵対するな。
4. 重大な決定をしなければならない将来の意思決定者に適切な選択の自由を与えることが重要

ダブリンの大司教 Richard Whatelyの言葉「我々はしたことだけでなく、しなかったことにも責任がある」

(LEFEVRE) 都市ゴミも再利用されており、廃棄物のリサイクルは公衆の確信となっている。再生ガラスや再生紙は直接作るよりも高価であることは知られており、このリサイクルは経済的理由よりも倫理的理由である。原子力も同様で、廃棄物のリサイクルの可能性を考えなければならない。原子力時代の終わりを考えると、再処理をしない国は、将来世代にプルトニウムとウランの鉱山を残す。もう一つの道はプルトニウム等を消滅させることである。もし、将来をきれいにしようと思えば、プルトニウム等のリサイクルをしておく必要がある。

(議長) リサイクルは、それによって環境影響が減るときに倫理的と言えるのであって、リサイクルするから倫理的と単純には言えないと思う。

(ALLAN) 処分の実施に向けた幾つかの段階において、次の段階に進かどうかの判断をしなければならないが、その時「我々は正しい戦略か」と問われる。これに対しては群分離核変換といった他の計画も考慮して答えられる。群分離核変換戦略は現在は好まれてていないが、30年後には再び検討されるかもしれない。

地域社会の意思を尊重するのは当然だが、地域社会が望んでも倫理的でない場合もある。環境正義と自身の将来を決める地域社会の権利の間の緊張関係は、地域社会が今したいことを決めるために費用便益解析を使うという問題に類似している。社会はより広範な観点での議論が必要で、それによって社会に共通基盤ができる。

(AHWARNE) 米国では再生紙やガラスは企業が使わなくなってきたために地域社会が受け取らなくなってきている。再処理はカーター大統領以来、核不拡散の理由で中止した。レーガンやブッシュ大統領は再処理に好意的であったが経済的な理由で断念した。ウランが無くなるという議論もあるが、現在需要がないため閉山する鉱山もある。再処理した後の処分が良いという議論もあるが、我々の研究では直接処分と殆ど差がないことが示されている。もし、何故あることをするかという議論を押し進め、その議論が支持されず、別の議論が進んだ時、公衆は次第にその議論はそのことを支持する議論ではなく別の意図があると結論づけるようになる。それは公衆の疑念を加えるだけだ。

(BLOSER) 国際基準は重要で、公衆や政治家を納得させるために重要な役割を果たす。政治家は技術的可能性を意識しない点を配慮すべきだ。独では再処理しないことが原子力利用の合意をえる道と考えられた。我々は政治家に信頼できる基盤を用意する必要がある。世界は狭くなり、世界基準が必要。リオ宣言の22章には参考になることが多い。
我々はこれと一致するか吟味が必要。

④ トピックスD　回収可能性：視野の範囲

(SMIT) ロバストな議論（攻撃されたとき守れる議論）が重要。
有害廃棄物の議論での焦点は次の6点である。
1.将来世代を考慮に入れる
2.予防と再使用又はリサイクル
3.ICM(Isolation, Control, Monitoring) 基準に基づいた安全な処分
4.廃棄物の回収可能性
5.廃棄物問題の重要性
6.廃棄物を輸出しないこと
　これらの焦点を用いても、議論の型と結論が異なるが、その理由は2つある。一つは議論の出発点であるものが強調され、他の焦点を凌駕し結論に到ることである。もう一つは出発点が異なる形で設定されることである。
簡単のため出発点において焦点の力点の置き方を変えて議論のシナリオをつくった。
（詳細は資料）

(BLOSER) 文献からみると、回収可能性は中心的課題ではないが、もし中心的課題になるとすると回収可能性は設計に要求されることはない。政治的に回収可能性が要求されるとすれば、中間貯蔵は適切な技術的回答である。（詳細は資料）

(BROWN) 英国では放射性廃棄物管理政策の審議中で、10月半ばには審議が終わる。審議書類の中で、回収可能性については80年代の中低レベル放射性廃棄物管理に対する最良環境選択研究から「中レベル放射性廃棄物は地層処分が最良であるが、地表貯蔵の方が良いという議論があるとすると、それは回収可能性及び可逆性に力点が置かれる場合」という部分が引用されている。また、地層処分においても坑道閉鎖前は回収可能性があると記載されている。回収可能性は、公衆の信頼性の問題という面を持つ。回収可能性は中心的課題ではない。もし、処分場の健全性に自信が無ければ中心的課題となるが。処分政策は、現代世代が将来世代に選択させないというものであることを認識すべき。

(ALLEGRE) フランスでは回収可能性の原則は1991年の法律にあり、その可否について研究することが定められている。しかし、最近、何故回収可能性を確保せよとの圧力が地下研立地予定地の住民の前で強まっているのか。回収可能性は、修復不可能なことを実施することに対する不安や恐怖を減少させるものである。回収可能性は結局大衆の意見

であり時の推移に任すしかない。

(LEFEVRE) 回収可能性については段階がある。廃棄物の暫定貯蔵は最も容易に回収できる。操業中も回収は可能。極論だか、閉鎖後でも廃棄物は回収可能であるからには充分な時間経過後でも健全な廃棄物を使うことすら可能である。人が既に掘ったところはもう一度掘れる。

(SCHALLER) 回収可能性を残すために、坑道を維持すると追加コストが必要。このコスト累計が閉鎖後再掘削するコストを上回る時点がある。これについて研究を依頼したことがある。回収可能性を維持するにはコストがかかることを公衆に説明しない限り問題として残る。

(VAN ENST) 処分の安全性は問題ないのに、公衆が政府の解決法に賛成しないのは、その解決法を押しつけられているという感情をもっていることと、別の解決法があるのではないかと思っているからだ。我々はいったん後戻りし、回収可能性は解決の選択肢として研究すべきだ。我々（オランダ）は岩塩層処分も放棄していない。様々な選択肢を研究し、公衆に提示し開かれた手順を踏むべきだ。

(THERGERSTRÖM) スウェーデンのサイト選定における公衆との議論において、回収可能性と制御・モニタリングが常に問題となる。原子力産業界は、処分場を説明する時、安全な処分場を作り、閉鎖し、別の問題に取り組み、処分場のことについて忘れるという印象を公衆に与えてきた。回収可能性は受動的安全性と相入れないことを説明すれば公衆は理解するが、公衆はそれでも処分場の「目印」や、超長期にわたるモニタング計画について質問する。これは、処分場の安全性の保証ではなく、処分場が忘れられないための責任の表示と一種の心理学的保証を求めている。

(AHEARNE) 回収可能であるという意味は、処分場閉鎖前は回収可能性の保証であり、それを維持する追加コストが指摘されている。処分後の回収可能性に対する自信は、人間侵入の可能性の自信につながる。これは難しい問題で、ＥＰＡや上院がＮＡＳに研究を委託し、現在、McCOMBIEと私が参加して研究中である。

(議長) 意図しない人間侵入リスクに対する防御としては、特定の場所、深さにおける人間侵入は起こりにくいところにあり、再取り出しの工学的可能性にはそれほど依存しないと思う。

(ALLEGRE) 回収可能性は、向こう数十年の世代を意識したものであり、また公衆の受容を得る方法の一つである。しかし、フランスでは地層処分研究と平行して、公衆の受容を得る別の方法として核変換の研究も行っている。これらの研究を今徹底的に行うことが重要であり、倫理は明日に延ばすべきでないことを我々に課している。
将来世代の倫理やその姿に関しては全く知見がない。将来世代が洞窟に住んでいるとす

れば、我々は将来世代の意思決定が全く不要で最大の保証を与える倫理に叶った解決法を見つけだすために最大の努力をしていることになる。将来世代が進化していて、かつ処分の記録が残って処分された物質が有用と判断すれば、進んだ技術を適用するだろうし、記録が残っていなければ洞窟に住む場合と同じである。

(SMITS) オランダでは、宗教的理由で保険に反対している少数グループがおり、政府はその人達のために例外を設けている。これは少数の意見を聞き尊重するという政府の倫理的振る舞いを意味している。地層処分が倫理的に正しいか否かという質問を取り扱う際にも少数の意見を考慮すべきである。

(McCOMBIE) 自動車に例えると、運転をしているのは規制者、エンジンは実施者、ブレーキは公衆である。車には乗らずタイヤの前にいることで車を止めようとするが、車のブレーキがかからないことを心配する公衆もいる。

(5) セッション４　討議と結論（地層処分は放射性廃棄物に対する倫理的環境的に健全な解決か？）

(BERNERO) 地層処分はより抜きの方法といえる。群分離核変換は地層処分を不要とする方法ではない。将来世代の負担の最小化には安全のみならず、管理負担または責任も含まれる。再取り出しは、もし社会がの望めばそれが取り除けるようにしておくことであり、それが受動的安全性と再取り出しに対する理論的解釈の論理的結合と思う。多重バリアシステムについては国際的コンセンサスがある。知識の増大につれ設計や評価が詳細化されるので増大的（incremental)決定過程は重要である。この過程の中で公衆の参加（public involvement）は極めて重要である。

(BROWN) 異なる３点の考慮すべき倫理の戦略がある。第１点は放射性廃棄物処分に関するもので既に十分な戦略がある。第２点は水銀といった他の廃棄物に関する戦略との相互比較である。第３点は更に大きな文脈の中（エネルギー生産との関係で放射性廃棄物管理を見る：石炭と酸性雨等）で廃棄物管理を考えることである。この大きな文脈の中で考えることが重要と考える。

(ROOTS) 公衆に技術的な説明のみで説得しようとするのは好ましくなく、公衆の参加が重要と考える。また、ブラウンが言うようにエネルギーや産業といった範囲で検討することなく廃棄物処分することは倫理的とはいえない。

(議長) もし今原子力を止めたとして、それが既に存在する廃棄物を処分するための倫理的戦略かという質問への答えはどうか。

(ROOTS) 手中の問題を解決する方法として最善と公言できるという点で倫理的である。

(LUMMERZHEIM) 独では年間４千ﾄﾝの放射性廃棄物に対して化学的毒性を有する廃棄物は１千万ﾄﾝであり、かつそれは数千の成分を有し、半減期はなく、放射性廃棄物ほど厳しい安全性試験をしていないことを考えても、放射性廃棄物問題を過大視しているかどうか答えられない。しかし、個人的な感情としては、社会のより小さな問題に過大な重要性を置いたり努力をしているように思われる。

(BERNERO) 我々が問題としているのはブラウンのいうレベル３の広範な領域のものではなく、地層処分は我々と将来世代に対して倫理的かというものである。

(AHEARNE) 倫理的選択を議論する際、決定過程が重要である。独が指摘するように、増大的進め方（incremental approach）は、単一ではなく幾つかの道筋をとる場合には正しいものとなる。アメリカが大きな過ちをおかしたのも到達点を固定し、その点にどの様に到達するのかのみを問題としたところにある。

(ALLEGRE) 賛成。段階的過程は技術的のみならず、問題の説明の難しさや公衆の受容の難しさからも必要である。またこの過程は、群分離核変換の研究を含む。例えそれが成功しても地層処分の必要性は無くならないが。

(BERKHOUT) レベル３のより広範な文脈で倫理を考えることについては過去上手くいった例が無い。範囲の設定自身が答えを決めるからである。また、エネルギー政策については経済市場を考慮して決められ、その決定の多くは倫理的考慮の外にある。この会議では、倫理的問題は世代間効果を持つこと及び全ての意志決定過程の中に倫理は含まれていることであることを学んだ。

(CATRON) 広範な文脈でとらえるというのは、技術的論説（technical discourse)と倫理的論説(ethical discourse) を区分する方法論的主眼点と考えたい。技術的論説は大きな問題を引き起こすことはないが、社会は現在及び将来世代のリスク低減に何をなすべきかといった倫理的論説は広範な問題を引き起こす。本ワークショップがこの広範な問題に取り組まないことは理解できるが、広範な問題は環境リスクへの倫理的応答の極めて重要な側面である。

(VON REIN) 善悪の判断は価値と態度（values and attitudes）の上に築かれる。この価値と態度は個人的履歴の上に作られるし、感情にも関係する。技術者は自身の知識を信頼するが、知識を持たない人は普段会話をする人を信頼する。このことからコミュニケーションが問題となる。

昨日述べたようにスウェーデンでは水銀濃度が場所によっては高く、人間と自然を尊重しつつ、今、行動しなければならない。環境影響の低減は、水銀の使用中止、放出低減、廃棄物の慎重な取扱によって出来る。汚染地域が環境に脅威とならないようにしなければならない。それが倫理的問題、即ちどの程度我々は頑張るのか、どのようにそれを正当化するのかといったことに帰着する。水銀の地層処分の提案は、単に倫理的に善悪かとして見るのではなく、全体の文脈の中で見るべきである。

(SCHALLER) 放射性廃棄物と水銀を比較したくない。水銀は現世代に直ちに脅威であり、選択の余地はない。使用中止も処分も万人が認める。放射性廃棄物は緊急性もなく、処分が嫌なら地上貯蔵もある。倫理的には異なる。

(LEFEVRE) 倫理は、最も一般的な、世界、環境、人間というレベルから、それぞれ特異性のある国毎の倫理、職業倫理、職業倫理、軍事倫理、個人倫理がある。そこで、地層処分が正しいかと質問に、技術者の自分は「はい」と答えるが、そこには、この唯一の選択だけでは満足できないというニュアンスが含まれる。問題は、専門家の選択が最も一般的な倫理に合致するかである。McCOMIE は我々は野心家すぎないかと問いたが、私は我々の問題に対して金がかかり過ぎないかと言い換えられると思う。これは政治家の判断だ。専門家は政治家に評価結果を伝え、政治家が判断すべきだ。

（議長）良い指摘だ。最終的にコレクティブオピニオンは各国の政府に送られるので、この点も議論の中で考慮して欲しい。

（BROWN ）ここに参加している人は、方向が一致しており、地層処分が倫理的と聞かれれば、そうだと答える。しかし、処分を意図しない拡大貯蔵（extended storage）が非倫理的という意見は聞かれないが。

（議長）永久貯蔵は受け入れられないしたのはGUNDELACH の論文に少しみられるだけだ。英国は長期貯蔵と処分はは政治的選択といっているし、米国は地層処分といっている。長期地表貯蔵に関して倫理的議論はあるか。

（BERNERO ）多くの議論は無いが、廃棄物管理責任を将来世代に引き継ぐべきでないと思う。AHEARNE 博士はこの問題に対処できる基金を将来に残すべきといったが、赤字に悩む米国では基金はすぐに無くなる。解決不可能な問題を将来世代に残すのは倫理的でない。非常に長期の地表貯蔵は解決不可能な問題だ。

（McCOMBIE）同感。拡大地表貯蔵は、広範な選択肢を残すが負担を転化する。問題はこの２つをどうバランスさせるかである。有効な技術と資金は我々が見つけるべきものであり、公衆を納得させるのが第３番目、最後は実施である。我々は３番目までは成すべきと思う。水銀について地層処分が受け入れられたことは素晴らしい。資金は幾つかの国で決められ、受入れは何処もなく、実施はその後である。拡大地表貯蔵は、もしあの世があることを知っていれば倫理的に正当化される。

（LONG）最近ワシントンにおける「RESOURCES FOR THE FUTURE」によって行われた仕事を紹介する。課題は「国境間にまたがって有害廃棄物を輸送することは倫理的であるか」であった。この場合、経済や環境の議論が倫理より勝っていた。これらも公衆との議論においては問題となる。第２点は、補償の問題で、ゴミ処分場や焼却場を引き受けた地域社会への補償を討議していた。これも重要な問題である。

（AHLSTROM）再現の無い地表貯蔵が議論されている。スウェーデンでは77年の法律で安全な処分が義務づけられている。将来世代が負担しなければならないものを地表に残すことは許されていない。地表貯蔵は管理を必要とする長期貯蔵を認めることであり、これが倫理的とすれば驚きだ。

（AHEARNE ）拡大貯蔵の問題は、永久地表貯蔵の問題でなく、中期的貯蔵が倫理的か否かである。英国では貯蔵か処分かは政治的決定といっていたが、我が国の原子力産業界は出来るだけ早く処分すべきといっている。私の論文で述べたように技術的解析の一方で政策を検討することは全く倫理的である。処分場の建設に先立ち、この種の手順を踏むことは重要である。しかし、数世代にわたる中間的な地表貯蔵に関しては倫理的問題は全くみられない。

(ALLAN) 永久貯蔵に反対する理由は、制度的管理が維持されない点にある。問題は中間貯蔵がどの程度期待し得るかである。妥当なところは数十年である。AHEARNE の議論でも50年であり大きな差はない。制度的管理の急激な崩壊は考えにくい。問題は暴力的活動や社会の疲弊によっておこる制度的管理の崩壊に対する予防的措置を取っておく方が良いかである。ある施設が身近にあると警戒感が薄れる。数年前のブラジルでの被曝死亡事故がその例だ。

(議長) 中期的選択は経済的、技術的に可能としても、この場で出ている批判に応えていない。

(ALLEGRE) 反対派は放射性廃棄物は地表に貯蔵すべきと主張する。この場合、期間は関係なく、科学が何時か解決すると考えている。地表貯蔵が倫理的に正しくないのは、地質学的時間にわたって制度の永続性が保証できないからである。漸進的進め方は良いが何十年か先かは分からないが何時かは決めなければならない。何もせず時を待ちながら地表に保管するのは全く倫理に反する。

(BERNERO) 永久的地表貯蔵は倫理的でないとしても、その実施に向けては増大的手順が必要である。問題は、この手順が数年でなく数十年必要という点にある。
処分の資金を用意する方法も重要である。米国では60～70億ドル集められ、今後その使い方について検討しなければならない。
米国の場合、ほぼ20年前に原子炉の認可にあたり廃棄物に関して中間貯蔵は少なくとも百年は安全といっている。処分の緊急性の概念はあるが法律の枠では百年の地表貯蔵は可能としている。

(議長) CATRON教授やFRANS BERKHOUTの述べた１ないし２世代をこえて貨幣価値を割り引くべきでないとすれば永久貯蔵は経済性の点で魅力は無い。処分の最終コストは現金払いでは同じだからである。更に、余計な期間、管理や貯蔵に支出が必要。早期の処分にくらべて貯蔵政策のために必要な資金は大きいだろう。

(ROOTS) 処分場の操業期間に関する増大的(incremental) 観点が必要。スウェーデンでも、1/10は疑問を呈する期間とされている。

(AHEARNE) 地層処分が中間貯蔵より安いという暗黙の了解は、議論する時間の長さに関係すると思う。永久地表貯蔵には賛成しないが、ユッカマウウティンで30億ドル使ったが適当な期間の貯蔵施設を指向していれば、こんなコストは必要なかったかもしれない。
ROOTS が指摘したようにロシアや旧ソ連は放射性廃棄物に悩んでおり、もし我々が地層処分を急げば、かれらに地下に捨てろと言うことになる。

(CATRON) 我々は今後数十年を更に多くを知るのに使える。それによって長期性に対するさらに適切な回答を出し得る。特に国際的解決の可能性は残すべき。

(VAN MIEGROET) 制度的管理の永続性を信用しないことが、長期の地表貯蔵を拒否する理由にはなっていない。浅地層処分をしている人は、２～３百年の制度的管理を認めている。我々が急ぐ本当の理由は、処分に必要な資金を貯める我々や政府を信用していないことではないか。

(AHLSTROM) 暫定貯蔵と最終処分は二者択一の問題ではない。最終処分に向けた初期段階が暫定地表貯蔵だ。これは倫理的要求にもかなう。

(ALLAN) 国際処分施設は、一つの可能性ある望ましい目標であるが全ての問題を解決するわけではない。社会のある部分が国際処分場を受け入れがたいものとみれば、同様な社会部分が、それは誰かの裏庭に処分することだと考えるようになる。これは限定的だと思う。

(SALTZMAN) 我々は、規定路線から出ようとしていない。頑丈でない倫理には反対すべきである。今日の議論は、我々はここにいるから、ここが正しいと聞こえる。

(SCHALLER) この疑問は国際処分場についてと思う。ＥＣの経験では、既に物品やサービスの流通は自由になってはいるが、どの国もいかなる形態の廃棄物に対して国境を閉じている。通常では、２万年の間放射性物質は流出しないと各国に説明する。２万年先にベルギーやポルトガルが存在するとは信じられないが、政治的には放射性廃棄物を受け入れる道は無い。政治家は近視眼的である。国際的解決は不可能である。ＥＣでは、処分場は１つで十分だが、６～７できるだろう。馬鹿げているが不可避である。

(議長) 馬鹿げてるとはいえない。一か所に集中しなければならないと考えて、サイトの確保の困難性を誇大すべきでない。

(WARNECKE) IAEAに関係する事項について述べたい。国際処分であるが、チェコスロバキアがチェコとスロバキアに分離した後も、一つの処分場計画である。この計画は妨げられるものではない。IAEAは、特に廃棄物量が少ない場合は、共同処分を支持している。アフリカで住民に脅威となり得るラジュウム資源の廃棄物について、IAEAはこれを集め地層処分する。廃棄物の一般的な国際間輸送は好ましくないが、受入れ国が適切に廃棄物を扱うことができれば、この選択肢は捨てるべきではない。国相互の合意があればそうした輸送は認められるべきである。
もう一点は、ウラン採掘と精鉱の廃棄物である。ある人は、これを長寿命廃棄物と考えているが、決定する前にその点を十分議論すべきである。今日の議論に取り上げる問題とは思わないが。

(ALLAN) もし我々が正しいと信じる戦略を続ける確信を持たず、我々が良い終着点と信じるところに向けて進まなければ、我々の次の世代は、その道を辿る動機を持たないだろう。処分から永久貯蔵に向かうような付随的戦略を考えることなく、暫定貯蔵を考え

るべきである。
ここに参加した方々は原子力界の人であり、一様な意見をもとことは当然かもしれないが、この会議の目的の一つは部外者の意見を聞き我々の見解の均衡を保つことであり、広範な社会に我々の意見を確かめてきたか否かを招待者に聞いてみたい。

(McCOMBIE) 国際処分は、国土の狭さや地質学的制限でなく、経済的最適化によるものであることを指摘しておきたい。スイスでは、政府の土地などの中にサイトを探す広大な国に比べ、より多くの地質学的な選択を取っている。国際的になることで地質学的に最適化できるという印象を与えるようにすべきでない。超国家的環境において最適な地質を見つけることが国際的解決を探す理由でないことを明らかにしておきたい。

(BERNERO) 米国では現在2万5千トンの使用済燃料があるが、ユッカマウンティンは1万トンの能力しかなく開発をする価値があるか重大な問題がある。開発コストや制度的コストは莫大である。低レベル廃棄物は分散政策をとったために、サイト開発に多大の制度的コストが必要である。
高レベル放射性廃棄物の国際間の輸送問題は、国際間移動をしない理由になり得るという意見があったが、もし、輸送のリスクが環境影響を与える程に大きいとしたら輸送基準が悪いのであって、輸送はそんなリスクをもたらさない。

(LONG) 地層処分を議論するとき最初にでる主張は、それは倫理的でないというものである。これに対する反論は、倫理と世代間平等を検討した結果、最も非倫理的なことが何もしないことであるということである。廃棄物は存在し、存在し続けるので何かの対策をしなければならない。そうすると「穴に入れるだけのことではないか。ここ数十年の環境問題の経験から、この方法は上手く機能しない。ほっておくことは上手く機能しない。」と反論する。その応えは「我々は穴に入れるのではなく、処分場に処分する」である。更に監視し取り出しも可能であるということもでき、これは重要な反論である。
難しいのは「原子力が発達して、廃棄物を無くすことを希望する。新しい方法が魔法のように発見されると信じるべきでないから、地表貯蔵はだめだと以前聞いた。穴に入れるとすれば、そのために誰も新しい方法を見つけることを望まなくなることを意味する」という意見である。
貯蔵中によりよい方法を研究することを示すことは重要である。

(植松事務局長) 環境局参加を得て放射性廃棄物問題を比較できたことは有益であった。政治家の決定に依存するという問題はあるが放射性廃棄物は既に存在し、解決しなければならない。技術だけでは十分でなく、ここでの議論が問題解決の助けとなることを期待する。

(議長) 事務局が論文と議論を公表する形にまとめると思う。次にRWMCを経てコレクティブオピニオンにまとめられると思う。

以　上

ワークショップ資料

ORGANISATION FOR ECONOMIC
CO-OPERATION AND DEVELOPMENT

RESTRICTED

NUCLEAR ENERGY AGENCY

Paris, 1st September 1994

RADIOACTIVE WASTE MANAGEMENT COMMITTEE (RWMC)

WORKSHOP ON THE ENVIRONMENTAL AND ETHICAL ASPECTS OF LONG-LIVED RADIOACTIVE WASTE DISPOSAL

Paris, 1st-2nd September 1994

Programme

WORKSHOP ON THE ENVIRONMENTAL AND ETHICAL ASPECTS OF LONG-LIVED RADIOACTIVE WASTE DISPOSAL

Paris, 1st-2nd September 1994

BACKGROUND, OBJECTIVES AND SCOPE

As an initial step in the preparation of a new RWMC collective opinion on the fundamental environmental and ethical aspects of the disposal of long-lived radioactive waste, the RWMC decided in January 1994, to organise a topical workshop on these aspects with the participation of specialists outside the radioactive waste management field. The purpose of the workshop is to review the information available, stimulate an exchange of views on these questions, and provide the RWMC with a broad basis for an in-depth reflection on long-term waste disposal issues, notably the non-technical ones which may not have been discussed and explained to a sufficient extent.

A background document setting the scene for the workshop has been prepared following an enquiry made within the RWMC as an attempt to identify the main environmental and ethical issues involved. This document (already available to Workshop participants and RWMC members), as well as the programme of the workshop, were established by a small group composed of Mrs. B. Gray (Canada), Messrs. Barber (France), Bernero (USA), Bloser (Germany), Flowers (UK), Norrby (Sweden) and representatives from the OECD Environment Directorate (Mr. Morgenroth) and the NEA (Messrs. Olivier and Jung).

The background document:

- includes a brief reminder of the main elements of current radioactive waste management approaches, their general environmental and technical bases and the principles which have led most countries to recommend the long-term isolation of radioactive waste under passive conditions in deep geological repositories; and

- identifies for discussion at the workshop a list of non-technical environmental protection and ethical issues raised by the management of radioactive waste (and other hazardous wastes), such as liabilities to future generations in a "sustainable development" context and the application of this principle.

The focus of the workshop will be the concept of deep geological disposal and the associated non-technical issues identified in this document. Invited specialists in environmental protection and ethics will be asked to address these issues and, to the extent possible, offer practical guidance regarding their resolution. Ultimately, the results of the workshop will be published by NEA and used by the RWMC to discuss the appropriateness of the concept of geological disposal of radioactive waste in a broad environmental and ethical perspective. The conclusions of the RWMC review will constitute its next "Collective Opinion".

PROGRAMME

1st September 1994

09.30 **Registration**

10.00 **Opening**

- **Introductory Remarks**

  - *Kunihiko UEMATSU, Director General of NEA*
  - *Ron FLOWERS, Workshop Chairman.*

- **Paper No. 1:** Radioactive Waste Management Strategies: Setting the Scene *(Colin ALLAN, AECL Research, Canada, RWMC Vice-chairman).*

10.30 SESSION I: **Background to Current Environmental Policies and their Implementation**

- **Paper No. 2:** Evolution and Current Thoughts about Environmental Policies *(Bill L. LONG, Director, OECD Environment Directorate).*

- **Paper No. 3:** Management of Hazardous Products: Selected Case Examples *(Victor MORGENROTH, Environmental Health and Safety Division, OECD Environment Directorate).*

11.10 **BREAK**

11.30 • **Paper No. 4:** Emerging Concepts and Requirements for the Long-term Management of Non-radioactive Hazardous Waste. Would Geological Disposal Be an Appropriate Solution for Some of These Wastes? *(Mrs Kristina von REIN, Swedish Environmental Protection Board).*

11.50 **General Discussion on environmental policies**

12.30 LUNCH

14.00 SESSION II **Ethics and the Environment**

a. General Perspectives

- **Paper No. 5:** Ethical Principles and the Environment in a Democratic Society *(John F. AHEARNE, Executive Director of Sigma XI, United States).*

- **Paper No. 6:** Radioactive Waste Disposal - Ethical and Environmental Considerations: A Canadian Perspective *(Fred ROOTS, Environment, Canada).*

b. Intergenerational Equity, Bequest of Risks to Future Generations and Responsibilities for Future Actions

- **Paper No. 7:** Ethical Questions in the Context of Waste Disposal *(Mrs Herlind GUNDELACH, BMU, Germany).*

- **Paper No. 8:** Responsible Today for Tomorrow *(Yves QUERE, Ecole Polytechnique and Maurice ALLEGRE, ANDRA, France).*

15.40 **BREAK**

16.00 ***c. Cost/benefit Considerations***

- **Paper No. 9:** Cost Benefit Analysis, Sustainability and Long-lived Radioactive Waste Management *(Frans BERKHOUT, Science Policy Research Unit, University of Sussex, United Kingdom).*

- **Paper No. 10:** Intergenerational Equity: Balancing Risks and Benefits Across Generations *(Prof. Bayard L. CATRON, The George Washington University, United States).*

16.50 ***d. General Discussion on Ethics and the Environment***

18.00 **Reception** (Room A, Château de la Muette).

2nd September 1994

09.30	Session III	**Review of the Geological Disposal Strategy for long-lived radioactive waste and its Implementation** (Discussion topics to be introduced by rapporteurs and invited speakers)
	• **Topic A**	Have all relevant issues been identified? *(Rapporteur: Robert M. BERNERO, USNRC/RWMC).* Discussion on completeness of issue list.
	• **Topic B**	Disposal objectives: Are they fair and properly defined? *(Rapporteur: Charles McCOMBIE, NAGRA, Switzerland/RWMC).* Discussion.
10.40	Break	
11.00	• **Topic C**	Implementation strategies (with emphasis on storage/disposal and timing of programmes) *(Rapporteur: Per-Eric AHLSTRÖM,* SKB, Sweden/RWMC). Discussion.
	• **Topic D**	Retrievability: A spectrum of views - *Wim A. SMIT, University of Twente, The Netherlands* - *Manfred BLOSER, BMU/Helmut RÖTHEMEYER,BfS, Germany/RWMC* - *Steven BROWN, DOE,United Kingdom/RWMC.* Discussion.
12.30	Lunch	
14.00	Session IV	**Discussion and Conclusions:** Is geological disposal an ethically and environmentally sound solution for radioactive waste? • What have we heard during the Workshop? Are there views, concepts or practices which need to be revised or reconsidered? What are the lessons learned? *(Rapporteur: Robert M. BERNERO).* • Final discussion
16.00	**End of the Workshop.**	

WORKSHOP ON THE ENVIRONMENTAL AND ETHICAL ASPECTS OF LONG-LIVED RADIOACTIVE WASTE DISPOSAL

Paris, 1st-2nd September 1994

TENTATIVE LIST OF PARTICIPANTS

SPEAKERS

Dr. John F. AHEARNE — **Paper No. 5**
Executive Director of Sigma Xi
P.O. Box 13975
Research Triangle Park, NC 27709
United States
Tel: 1 (919) 549 4691
Fax: 1 (919) 549 0090

Dr. Colin J. ALLAN — **Paper No. 1**
Vice-President
Environment, Sciences and Waste Management
Atomic Energy of Canada Limited
Whiteshell Laboratories
Pinawa, Manitoba ROE 1LO
Tel: 1 (204) 753 2685
Fax: 1 (204) 753 2455

Mr. Maurice ALLEGRE — **Paper No. 8** (jointly with Mr. Quéré)
President
Agence Nationale pour la Gestion des Déchets Radioactifs (ANDRA)
Route du Panorama Robert Schumann
B.P. 38
92266 Fontenay-aux-Roses
France
Tel: 33 (1) 41 17 80 00
Fax: 33 (1) 41 17 82 25

Dr. Frans BERKHOUT
Research Fellow
Science Policy Research Unit
Mantell Building
University of Sussex
Falmer
Brighton BN1 9RF
United Kingdom
Tel: 44 (273) 686758
Fax: 44 (273) 685865

Paper No. 9

Prof. Bayard L. CATRON
The George Washington University
Department of Public Administration
2115 G. Street NW
Room 302
Washington D.C. 20052
United States
Tel: 1 (202) 994 3960
Fax: 1 (202) 994 6792

Paper No. 10

Mrs. Herlind GUNDELACH
Ministerialrätin
Federal Ministry of the Environment, Nature
Conservation and Nuclear Safety (BMU)
RS III 6
Postfach 12 06 29
D-W-53117 Bonn
Germany
Tel: 49 (228) 305 2951
Fax: 49 (228) 305 3746 or 2899

Paper No. 7

Mr. Bill L. LONG
Director
OECD Environment Directorate
15, boulevard Amiral-Bruix
F-75016 Paris
France
Tel: 33 (1) 45 24 93 00
Fax: 33 (1) 45 24 78 76

Paper No. 2

Mr. Victor MORGENROTH
Hazard Assessment
Environmental Health and Safety Division
OECD Environment Directorate
Franqueville 1
2, rue André Pascal
F-75016 Paris
France
Tel: 33 (1) 45 24 97 75
Fax: 33 (1) 45 24 16 75

Paper No. 3

Mr. Yves QUERE
Directeur des Etudes
Ecole Polytechnique
91128 Palaiseau
Tel: 33 (69) 33 47 36
Fax: 33 (69) 33 30 01

Paper No. 8
(jointly with
Mr. Allègre)

Mrs. Kristina von REIN
Section for Hazardous Waste and Site
Remediation
National Environmental Protection Board
S-171 85 Solna
Sweden
Tel: 46 (8) 799 11 27
Fax: 46 (8) 799 12 22

Paper No. 4

Mr. Fred ROOTS
Science Advisor Emeritus
Department of the Environment
3rd Floor, Jules Leger Building
10 Wellington Street
Hull, Quebec K1A 0H3
Canada
Tel: 1 (819) 997 2393
Fax: 1 (819) 953 5813

Paper No. 6

PARTICIPANTS

Austria

Dr. Peter KREJSA
Head, Waste Management
Osterreichisches Forschungszentrum Seibersdorf
A-2444 Seibersdorf
Tel: 43 (2254) 780/2650
Fax: 43 (2254) 74060

Belgium

Dr. Paul DEJONGHE
Conseiller Général
Centre d'Etude de l'Energie Nucléaire
200 Boeretang
B-2400 Mol-Donk
Tel: 32 (14) 332595
Fax: 32 (14) 318936

Mr. Jean VAN MIEGROET
Directeur Etudes et Projets
Organisme National des Déchets Radioactifs
et des Matières Fissiles
ONDRAF/NIRAS
Place Madou 1, Boîtes 24/25
B-1030 Brussels
Tel: 32 (2) 212 1015
Fax: 32 (2) 218 5165

Canada

Dr. Peter A. BROWN
Director, Radioactive Waste and
Radiation
Electricity Branch
Energy Mines and Resources Canada
580 Booth Street
Ottawa, Ontario K1A OE4
Tel: 1 (613) 996 2395
Fax: 1 (613) 995 0087

Ms Mary GREBER
Manager, Public and Government Affairs
Atomic Energy of Canada Limited
Whiteshell Nuclear Research
Establishment
Pinawa, Manitoba ROE 1LO
Tel: 1 (204) 753 2311
Fax: 1 (204) 753 2455

Finland

Mrs. Margit HOVI
Special Adviser
Ministry of Trade and Industry
Energy Department
P.O. Box 37
SF-00131 Helsinki
Tel: 358 (0) 160 5226
Fax: 358 (0) 160 2695

Mr. Tero VARJORANTA
Finnish Centre for Radiation and Nuclear Safety
P.O. Box 14
SF-00881 Helsinki
Tel: 358 (0)
Fax: 358 (0) 759 8500

France

Mr. Denis ALEXANDRE
Département Stockage Déchets
DSD/CSC
CE/Cadarache
13108 St-Paul-lez-Durance Cedex
Tel: 33 42 25 76 82
Fax: 33 42 25 46 46

Mr. Pierre. BARBER
Relations Internationales
Agence Nationale pour la Gestion des Déchets Radioactifs (ANDRA)
Route du Panorama Robert Schumann
B.P. 38
92266 Fontenay-aux-Roses
Tel: 33 (1) 41 17 80 68
Fax: 33 (1) 41 17 82 68

Mr. Jean-Claude BARESCUT
IPSN
Commissariat à l'Energie Atomique
B.P. N° 6
F-92265 Fontenay-aux-Roses Cedex
Tel: 33 (1) 46 54 79 06
Fax: 33 (1) 47 35 14 23

Mr. Jean LEFEVRE
Conseiller Scientifique du CEA
pour l'aval du cycle du combustible
Direction du Cycle du Combustible
Commissariat à l'Energie Atomique
Bâtiment 121
Centre d'Etudes Nucléaires de Saclay
F-91191 Gif-sur-Yvette Cedex
Tel: 33 (1) 69 08 91 09
Fax: 33 (1) 69 08 48 35

<u>Germany</u>

Dr. Manfred BLOSER
Ministerialrat
Federal Ministry of the Environment, Nature
Conservation and Nuclear Safety (BMU)
RS III 6
Postfach 12 06 29
D-W-53117 Bonn
Tel: 49 (228) 305 2951
Fax: 49 (228) 305 3746 or 2899

Dr. Deter LUMMERZHEIM
Head of Waste Management Division
Bundesministerium für Forschung und Technologie
Godesberger Allee 185-189
Postfach 200240
D-53170 Bonn
Tel: 49 (228) 59 3762
Fax: 49 (228) 59 3605

Prof. Dr. Helmut RÖTHEMEYER
Bundesamt für Strahlenschutz
Postfach 100149
D-3320 Salzgitter 1
Tel: 49 (531) 592 7600
Fax: 49 (531) 592 7614

<u>Japan</u>

Mr. Masahide OSAWA
Presentation Management Research Program
Power Reactor and Nuclear Fuel Development Corporation (PNC)
Sankaisho Building, Akasaka 1-9-13
Minato-ku
Tokyo 107
Tel: 81 (3586) 3311
Fax: 81 (3586) 2786

Italy

Mr. Giuseppe GROSSI
Scientific Adviser for Radwaste Management
ANPA
Via Vitaliano Brancati 48
I-00144 Roma
Tel: 39 (6) 3048 4053
Fax: 39 (6) 3048 4965

The Netherlands

Dr. Wim A. SMIT
School of Philosophy and Social Sciences
Department Philosophy of Science and Technology
TW-RC Building, r. RC-310
University of Twente
Postbus 217
7500 AE Enschede
Tel: 31 (53) 89 9111
Fax: 31 (53) 35 0625

Dr. J.W.A. VAN ENST
Ministry of Economic Affairs
Directorate General for Energy
Bezuidenhoutseweg 6
Postbus 20101
2500 EC Den Haag
Tel: 31 (70) 3797849
Fax: 31 (70) 3797841

Norway

Mr. Gordon C. CHRISTENSEN
Head, Health and Safety Department
Institutt for Energiteknikk
Postboks 40
N-2007 Kjeller
Tel: 47 (63) 80 60 00
Fax: 47 (63) 81 25 61

Spain

Mr. Antonio ACHA
Subdirector for Siting
Consejo de Segurida Nuclear
c/Sor Angela de la Cruz 3
28020 Madrid
Tel: 34 (1) 519 52 55/62 63
Fax: 34 (1) 519 52 68

Mr. Pedro CARBONERAS
ENRESA
Calle Emilio Vargas, 7
28043 Madrid
Tel: 34 (1) 519 52 58
Fax: 34 (1) 519 57 95

Sweden

Mr. Per-Eric. AHLSTRÖM
Swedish Nuclear Fuel and Waste
Management Company (SKB)
Box 5864
S-102 40 Stockholm
Tel: 46 (8) 665 2834
Fax: 46 (8) 661 5719

Dr. Conny HÄGG
Swedish Radiation Protection
Institute (SSI)
S-17116 Stockholm
Tel: 46 (8) 729 7100
Fax: 46 (8) 729 7108

Mr. Sören NORRBY
Director, Office of Nuclear Waste
Swedish Nuclear Power Inspectorate (SKI)
Box 27106
S-102 52 Stockholm
Tel: 46 (8) 665 4482
Fax: 46 (8) 661 9086

Mr. Claes THEGERSTRÖM
Swedish Nuclear Fuel and Waste
Management Co. (SKB)
Box 5864
S-102 48 Stockholm
Sweden
Tel: 46 (8) 665 2806
Fax: 46 (8) 661 5719

Dr. Stig. WINGEFORS
Office of Nuclear Waste
Swedish Nuclear Power Inspectorate (SKI)
Box 27106
S-102 52 Stockholm
Tel: 46 (8) 665 ....
Fax: 46 (8) 661 9086

Switzerland

Dr. Charles McCOMBIE
Director, Science and Technology
Société Coopérative Nationale pour
l'Entreposage de Déchets Radioactifs (NAGRA)
Hardstrasse 73
CH-5430 Wettingen
Tel: 41 (56) 37 11 11
Fax: 41 (56) 37 12 07

Dr. Beat WIELAND
Chef de la Section Technologie Nucléaire et Sûreté
Office Fédéral de l'Energie
CH-3003 Bern
Tel: 41 (31) 322 5647
Fax: 41 (31) 311 09 85

Dr. Auguste ZURKINDEN
Head, Section for Radioactive
Waste Management
Swiss Nuclear Safety Inspectorate
CH-5232 Villigen-HSK
Tel: 41 (56) 993937
Fax: 41 (56) 993907

United Kingdom

Dr. Steven BROWN
Head of Radioactive Substances Division
Department of the Environment
Room A5.16
Romney house
43 Marsham Street
London SW1P 3EB
Tel: 44 (71) 276 8089
Fax: 44 (71) 276 8909/8938

Dr. Ron H. FLOWERS
Nuclear Technology Consultant
Stewart Memorial
The Street
Brightwell-cum-Sotwell
Wallingford
Oxfordshire OX10 ORR
Tel: 44 (491) 836306
Fax: "

<u>United States</u>

Mr. Robert.M. BERNERO
Director
Office of Nuclear Material Safety and
Safeguards
Nuclear Regulatory Commission
Washington D.C. 20555
Tel: 1 (301) 415 7800
Fax: 1 (301) 415 5371

Mr. Jerome SALTZMAN
Director, Office of External Relations
Office of Civilian Radioactive
Waste Management
US Department of Energy
Forrestal Building, RW-5
Washington D.C. 20585
Tel: 1 (202) 586 2277
Fax: 1 (202) 586 7259

<u>CEC</u>

Mr. Werner BALZ
Head, Fuel Cycle and Radioactive Waste Unit
European Commission
Directorate General XII F 05
ARTS 2/21
200 rue de la Loi
B-1049 Brussels
Belgium
Tel: 32 (2) 295 4164
Fax: 32 (2) 295 3024

Mr. Karl SCHALLER
Division Cycle du Combustible Nucléaire et
Politique des Déchets
Commission des Communautés Européennes
Direction générale XI D
200 rue de la Loi
B-1049 Bruxelles
Belgium
Tel: 32 (2) 295 4063
Fax: 32 (2) 295 0061

IAEA	Dr. Ernst WARNECKE RADWASS Programme Co-ordinator Division of Nuclear Fuel Cycle and Waste Management International Atomic Energy Agency P.O. Box 100 A-1400 Vienna (Austria) Tel: 43 (1) 2360 Fax: 43 (1) 234564
NEA	Dr. Kunihiko UEMATSU Director General OECD Nuclear Energy Agency Le Seine Saint-Germain 12, boulevard des Iles 92130 Issy-les-Moulineaux Tel: 33 (1)45.24.10.00 Fax: 33 (1) 45.24.11.10
	Mr. Sam THOMPSON Deputy Director General OECD Nuclear Energy Agency Tel: 33 (1) 45.24.10.02
NEA Secretariat	Mr. Jean-Pierre OLIVIER Head, Radiation Protection and Waste Management Division OECD Nuclear Energy Agency Le Seine St-Germain 12, boulevard des Iles 92130 Issy-les-Moulineaux (France) Tel: 33 (1) 45 24 10 40 Fax: 33 (1) 45 24 11 10

Workshop on Environmental and Ethical Aspects of Long-lived Radioactive Waste Disposal

1st-2nd September 1994, OECD, Paris

Dr. Uematsu's Introductory Remarks

Ladies and Gentlemen,

I am glad to welcome you here today to this Workshop on Environmental and Ethical Aspects of Long-lived Radioactive Waste Disposal organised by the NEA Radioactive Waste Management Committee. NEA has a long tradition in the field of radioactive waste management and this meeting gives me the opportunity to note the considerable evolution which has taken place over the last few decades in this area and the role which NEA is playing. Our general objective at NEA is to be at the forefront of the scientific and technical debate in the field of nuclear energy, and to provide a forum for the discussion of policy-oriented issues of major interest to our Member countries. In radioactive waste areas, we started to be active on radiation protection and technical questions related to the management of radioactive waste some 30 years ago, with the discussion of effluent releases and treatment, conditioning and storage techniques. However, we always have considered that disposal was the key step to be addressed because interim storage is usually designed as a temporary solution which needs to be followed up by action, at some point in time, which takes care of the uncertainties of the future in a responsible manner and which has a more definitive character. Gradually, therefore, NEA activities in this field evolved to cover disposal of solid waste and received strong support when the RWMC was set up in 1975, almost 20 years ago.

In spite of all the technical efforts at national and international levels, we have to admit that the final disposal of radioactive waste continues to be regarded as a significant challenge, particularly with regard to its non-technical aspects, which directly affects the further deployment of nuclear energy programmes in most countries. This may be the reason that radioactive waste management is sometimes referred to as "Techno-Political Engineering".

The Radioactive Waste Management Committee has put the emphasis, in its programme during the last 15 years or so, on long-term disposal issues and notably on the concept of geologic disposal. Accordingly, safety assessment studies and the characterization of potential disposal sites are the main constituents of our programme. These are essentially scientific and technical activities. The other major aspect of the issue is of a different but related nature. Its political and, let's call it ethical or philosophical, dimensions are well recognized and become more and more important with the progress made on science and technology. From the recent Collective Opinion of the Radioactive Waste Management Committee, we know that geologic disposal of long-lived radioactive waste could be made safe, provided we select suitable sites which we can evaluate well enough. However, given the need to ensure safety over many thousands of years, we need to use our scientific and technological expertise to the best of our ability to offer satisfactory answers to uncertainties and philosophical issues unavoidably associated with the long-term protection of our descendants and the environment. This is where our Workshop comes about.

In view of the debate going on in many of our Member countries, this Workshop does seem particularly timely, and may constitute an important step in the resolution of the difficulties faced at the non-technical level in general, although this resolution may take time. I am relatively optimistic, though, since more and more people in various sectors and from different perspectives are conscious of the need to discuss these issues objectively and constructively. Nuclear experts are increasingly involved in larger exchanges concerning the protection of the environment, and we ourselves welcome external contributions. I am very pleased in this respect, to note that we have been able to benefit from the strong support of the

OECD Environment Directorate during the preparation of this Workshop, notably from Mr. Bill Long, its Director, who is going to be one of this morning's speakers, together with his colleague, Victor Morgenroth. I am also impressed by the list of the speakers who are going to make presentations on topics which are of considerable interest to us and I would like to thank them all in advance for their assistance.

Before giving the floor to Dr. Ron Flowers, the Workshop chairman, and the previous chairman of the Radioactive Waste Management Committee of NEA, to talk more specifically about the Workshop, I would like to invite all of you to a reception tonight at about 6 o'clock in Room A in the OECD Château. I hope this will facilitate your exchanges and help in promoting a good understanding of the relevant environment and philosophical arguments for the continuation of the discussion tomorrow.

I wish you success in your deliberations, look forward to knowing the results and thank you for your attention.

Radioactive Waste Management Strategies: Setting the Scene

C.J. Allan
RWMC Vice-Chairman
AECL Research, Whiteshell Laboratories
Pinawa, Manitoba, Canada

Background

The development of technology and industrial infrastructure has contributed to the high quality of life now enjoyed by modern societies. Since the early part of this century, research and development has been ongoing in the field of nuclear science, leading to a variety of applications of the technology

- in medicine;
- in industry; and
- in electricity generation.

As with all human endeavours these applications lead to the production of waste. The diversity of uses of nuclear technology results in varied forms of waste and a variety of potential hazards, depending on the concentrations and half-lives of radionuclides and the physico-chemical nature of the waste [1].

Waste may occur:

- in gaseous form, such as ventilation exhausts from facilities handling radioactive materials;
- in liquid form, ranging from scintillation liquids from research facilities to highly radioactive liquids from the reprocessing of spent fuel; or
- in solid form, ranging from contaminated trash and glassware from hospitals, medical research facilities and radiopharmaceutical laboratories, to vitrified waste from reprocessing used fuel, or used fuel from nuclear power plants, when it is considered a waste.

The radioactivity in such waste may range from very low levels, as in waste resulting from the use of radioisotopes in medical diagnostic procedures, to very high levels, such as waste resulting from reprocessing used fuel, or in spent radiation sources used in radiography, radiotherapy or sterilization. Radioactive waste may be very small in volume, such as a spent sealed radiation source, or very large and diffuse, such as the tailings from mining and milling of uranium ores.

While the generation of radioactive waste should be minimized where economically possible, the waste exists nonetheless, and will continue to be produced in the future. Therefore it must be managed to ensure protection of human health, both now and in the future. The hazards of radioactive waste are known, and consequently it is handled with care. Current radiological protection principles and regulations provide for the careful and safe management of radioactive waste.

As with other waste, there are two main options for managing radioactive waste. The first is to contain and isolate the waste from the environment for as long as is necessary. The second option is to disperse material in the environment at levels which do not produce an unacceptable radiological risk. In the case of dilution and dispersion, the quantities released to the environment must be controlled, to ensure that human health and the natural environment are protected. While dilution and dispersal have been used to a limited extent, the majority of radioactive waste produced in OECD countries is contained and isolated. Many years of experience have been accumulated with storage systems to contain and isolate such waste. Such systems have clearly demonstrated that they meet the objectives of protecting public and occupational health and the environment.

Systems for the final disposal of wastes that contain predominantly short-lived radionuclides have been licensed and are in operation in a number of countries, e.g., Finland, France, Japan, Spain and Sweden. Once the waste has been emplaced, there is no intent to retrieve the waste for further processing. In developing disposal strategies for wastes that contain predominantly short-lived radionuclides, advantage can be taken of the fact that the hazard from such waste will decay to a level at which there is no residual risk to human health or the environment after a suitable period of time (up to a few hundred years). For short-lived wastes, disposal strategies can include monitoring as an integral component of the strategy since the required monitoring period is relatively short.

Some radioactive materials, particularly used nuclear fuel and the long-lived waste that occurs from reprocessing used fuel, have a much longer half-life and present a hazard for many thousands of years. (For the purpose of this discussion, nuclear fuel waste is defined as either used nuclear fuel, if it is considered a waste and is not reprocessed (as is the case in countries such as Canada, Spain, Sweden and the U.S.A.), or the highly radioactive waste that results from reprocessing used fuel and separating the plutonium and uranium from the fission and other activation products (as is done, for example, by France, Germany, Japan and the U.K.).) The long-term management of such material presents special considerations. The remainder of this paper will focus on nuclear fuel waste, but the discussion is generally applicable to waste containing significant quantities of long-lived radionuclides.

Nuclear fuel waste is presently stored, either in wet storage systems (water-filled pools) or in dry storage systems (concrete or metal structures). While supporting research and development indicates that such storage practices can safely continue for many decades to come, there is a recognition that storage must be considered an interim measure for long-lived waste. Such systems require active institutional controls, such as monitoring and maintenance of the system and the implementation of security measures to ensure safety, e.g., to prevent inadvertent human intrusion. In addition, the nuclear waste management community has long recognized that radioactive waste should be managed in a way that will not impose undue burdens on future generations.

Consideration for future generations is a fundamental concern in the management of radioactive waste. This concern arises from the ethical principle that the generation that produces waste should bear, to the extent possible, the responsibility to manage it [1]. The responsibility of the present generation includes, constructing and operating storage facilities, providing a funding system and sufficient controls for the management of radioactive waste, and developing the means and the technology for disposal. Disposal may be defined as an indefinite and passive solution for the containment and isolation of long-lived radioactive waste from the environment; there would be no requirement for further intervention by humans, nor a requirement for institutional control. In addition, there would be no intention to retrieve the waste or handle it further in the future, although retrieval may be possible.

The timing and implementation of disposal of individual radioactive waste types involves a number of scientific, technical and economic factors, such as the availability and development of suitable sites and the decay of radioactivity and heat during interim storage. Timing and implementation are also affected by political and public acceptance.

Based on the need to ensure long-term safety and an ethical concern for future generations, many countries are developing the technology to dispose of long-lived radioactive waste. The alternatives which have been examined internationally include disposal under the deep seabed, transportation into space and separation and transmutation. Some countries that reprocess fuel (e.g., France and Japan) are investigating ways to treat the waste from reprocessing operations to simplify waste management by developing practical techniques for transmuting the long-lived radionuclides into short-lived species [2]. The potential impacts of separation and transmutation have been reviewed by many agencies. Early studies [3] of partitioning and transmutation (P&T) as a waste management option concluded that while P&T was technically feasible, there were "no cost or safety incentives for P&T of the actinides for waste management purposes." In 1992, Ramspott et al., concluded [4], "P&T is neither an alternative to the current geologic disposal program nor essential to its success . . . There remain no cost or safety incentives to introduce P&T into the HLW (High-Level Waste) Management System." Studies by international agencies are also consistent with this opinion. In 1991, an IAEA Advisory Group concluded that current and proposed P&T programs are long-term projects that could not impact on the present fuel cycle strategy, and that the P&T option "cannot avoid the need for long-term deep geological disposal" [5]. In 1992, the Radioactive Waste Management Committee of the OECD Nuclear Energy Agency re-emphasized that "actinide separation and transmutation should not be considered as an alternative to geological disposal" [6]. Thus, the current perspective is that disposal of nuclear fuel waste and other material contaminated with long-lived radionuclides will be required whether or not used fuel is reprocessed, and whether or not practical techniques can be developed for separating and transmuting the long-lived waste components [7].

There is a broad international consensus among waste management experts that the preferred method of waste management for long-lived radioactive waste is that based on deep geological disposal, utilizing a system of engineered and natural barriers to ensure long-term safety. (The Netherlands is a notable exception and has adopted a position incorporating the principles of reduction, storage and retrievability, rather than disposal.)

Assessments of national programs have been carried out, (e.g., Sweden and Switzerland), as well as reviews of the concept of deep geological disposal by international organizations, and the approach is considered to be feasible in providing a passively safe option for disposal which will not harm either humans or the natural environment. In 1982, the World Health Organization stated [8]:

> "The technology required for the safe disposal of radioactive waste is considered to be already available. Although none of the options has yet been used or proven, conservative engineering practices and the use of multibarriers (combinations of man-made or natural barriers between the waste and the environment) may be expected to make up for the lack of knowledge and degree of uncertainty in predicting what may actually be required of a repository."

Currently, the international perspective is that disposal facilities for long-lived waste will not be operational before about 2010-2020. National efforts, for the most part, are concentrated on research and development activities to evaluate the safety and feasibility of various alternatives, the selection of suitable disposal sites and optimization studies covering safety, environmental, industrial and economical issues.

Objectives for Radioactive Waste Management

The objectives of radioactive waste management are to manage radioactive waste in a manner that protects worker safety, public health and the environment, now and in the future, and to do so in a manner that minimizes, to the extent possible, the burden placed on future generations.

To meet the objective of minimizing the burden on future generations, one of the goals of deep geological disposal is to develop a facility that will be passively safe, that is, one that does not require institutional controls for long-term safety. This does not mean that society will not choose to exercise institutional control, but it does mean that if institutional control is lost-for whatever reason-war, neglect, oversight, or loss of institutional will or memory-that future generations will not be exposed to a health risk or an environmental detriment.

Although there is a wide variety of technical issues that still need to be addressed, there is widespread consensus within the technical community that these issues are tractable.

The Multi-barrier System

The disposal concepts being developed internationally for deep geological disposal are based on a combination of engineered barriers and the natural barrier provided by the host geological medium. The key engineered barriers are a stable waste form, either used fuel or vitrified waste from reprocessing used fuel; long-lived containers into which the waste form is packed; clay-based buffer materials that separate the containers from the host geological structure and control the movement of water to, and corrosion products away from, the containers; and seals and backfill materials to close the various openings, tunnels, shafts and boreholes. There is international consensus that this approach can best achieve the goal of safely managing used nuclear fuel in the long term. The biosphere, although not a barrier per se, is an important part of the overall system because it contains the pathways for direct exposure of humans and non-human biota to contaminants. Consequently, its study must be part of any waste management program. A variety of geological media are under consideration, including crystalline rock (Canada, Finland, Japan, Sweden and Switzerland), clays and shales (Belgium and Hungary), volcanic tuff (U.S.A.) and salt (Germany and Spain).

In many countries, the approach to development of the disposal concept has been to consider the performance of the system as a whole, rather than focussing on performance requirements for individual components. This approach allows flexibility in implementation to be retained and it increases the likelihood of identifying any counterintuitive interactions or synergisms among system components that could adversely affect safety. Thus, the performance of individual components, such as waste containers, is analyzed in the context of the system. The goal is to develop a thorough scientific understanding of the performance of the different components of a disposal system and how these components interact and influence one another, so that the overall system can be designed to provide defence in depth.

Acquiring and building the necessary knowledge base is a continuing process, and in implementing disposal, flexibility must be retained so that the program can use and benefit from new information and understanding over time.

To date, however, no country has demonstrated deep geological disposal and public uncertainty remains. This is fuelled in part by the public's mistrust of the industry and of governments, and in part by their fears of radiation and their skepticism about the industry's ability to safely contain its waste for periods of thousands of years. Thus, the challenge that faces society and those charged with responsibility for management of nuclear fuel waste is to develop sufficient confidence in the technology to permit decision-making, regarding the implementation of disposal.

Considerable efforts have been made to evaluate the behaviour of deep geological repositories with time, and their long-term safety. Scientific methods exist to establish the safety of particular disposal sites and there is an international consensus among experts that "appropriate use of safety assessment methods, coupled with sufficient information from proposed disposal sites, can provide the technical basis to decide whether specific disposal systems would offer to society a satisfactory level of safety for both current and future generations" [9].

Much of the evidence needed to evaluate any site that would be considered for deep geological disposal can be obtained from geologic information developed as the site is characterized. Field studies, including studies of natural analogues can extend the short-term evidence from the laboratory studies to the longer times of interest-tens and even hundreds of thousands of years-and provide systematic evaluation and verification of the understanding incorporated in the mathematical models used to assess long-term performance of a disposal system.

Incremental Decision-Making Process

In developing disposal facilities for nuclear fuel waste, a number of countries are following a strategy of staged or incremental decision-making, as an integral part of the process. Each phase, its review and subsequent decision-making should lead to an increased confidence in the technology. This is the case in the evolution and development of national programs in Belgium, Canada, Finland, France, Spain, Sweden, Switzerland and the U.K. By proceeding with the development of waste management technologies in a staged manner, assessing safety can be separated from the implementation activities that often create public concern, such as the siting of a facility.

While the details vary from country to country, the basic elements involved in achieving disposal are:

- Conceptual and technology development/demonstration, followed at the appropriate time, by site-specific activities beginning with site screening, to select one or more sites for detailed surface-based characterization studies.

- Surface-based site characterization leading, with appropriate review, to a selection of one or more sites for exploratory excavation and more extensive in-ground characterization, or to a decision to abandon the site.

- In-ground characterization studies leading to a decision, following appropriate reviews of the status of our knowledge, to initiate construction and then operation of a repository. During characterization, a site-specific facility would be designed. At this stage, performance assessments would also be done to assess the long-term performance of a facility at a given site with a given design.

- Construction and operation of a facility which will unquestionably involve ongoing review, reassessment and recommitment, leading, if appropriate, to continued operation and eventually to a decision to cease operations and decommission. Initial operation of any facility will likely involve a demonstration phase. Sweden, for example, is planning on a demonstration emplacement of waste in a deep geological repository by about 2010. At an early stage of repository construction, possibly during the demonstration phase, or as part of sub-surface characterization studies, an area of the repository could be dedicated to component testing in the actual conditions at the site. Such testing might continue over the many decades of operation, and as part of confidence building, the components could be eventually retrieved and examined to establish how closely their behaviour conformed to the anticipated performance.

- Decommissioning and eventually, the sealing of all shafts, tunnels and exploratory boreholes to close the facility and to place it in a passively safe state. The results of component testing, operational reviews and monitoring, and post-operational monitoring would form the basis on which to make a decision when to close and seal the repository. The long-term safety of this system would need to be convincingly demonstrated, prior to closure.

This approach would utilize the observational method where information is continuously acquired and incorporated into the design. The observational method is central to the use of performance assessment analyses as part of the design and implementation process. Beginning during the site selection phase, assessments are made of the site condition using all available data. The understanding of the site is incorporated into models for use in design and in performance assessment studies.

Both the designs and the assessments become more refined as the knowledge of a site increases. As work proceeds, observation and evaluation of the actual conditions encountered are compared with the previous understanding which, if necessary, is then modified. This cycle continues throughout site selection, construction and operation, so that at each point when significant licensing and operational decisions need to be made, a long record of observation and a series of increasingly refined performance assessments are available on which to base the decisions.

Throughout this process, regulatory standards would apply and regulatory approval and licenses would be required at various points in the process. An extensive monitoring program beginning with the start of site screening activities, would be maintained throughout the process. Many years' worth of data from monitoring and studying the site and a series of increasingly refined evaluations would have been accumulated before the decision would be made to emplace the waste. After the repository had been filled with nuclear fuel waste, it would likely be maintained under surveillance for an extended period to confirm that it was behaving as intended. The decision whether or not to close the repository would then be made on the basis of the accumulated evidence and experience from the site selection, construction, and operational stages, a process extending over many decades.

Throughout the process, judgements regarding the performance of the disposal system would be based on an ever-expanding knowledge and experience base, a knowledge base that should lead to progressively greater confidence. Although uncertainty could not be entirely eliminated, the long history of past performance should provide the basis for building both public and technical confidence in the site and its future evolution, and the long-term safety and the performance of the facility.

This approach provides ample opportunity for ongoing review, and at any point in the process, if ongoing review and assessment indicates the objectives of safe disposal cannot be met, it is possible to cease operations and retrieve the waste.

Public Involvement

In OECD countries, and increasingly in other countries of the world, decisions on implementing new technologies and siting large-scale facilities, even facilities that do not involve hazardous materials, can no longer be made based solely on technological considerations. For example, in Canada, where the concept for deep geological disposal of Canada's nuclear fuel waste is currently undergoing a review under the federal environmental assessment review process, the Guidelines for the Environmental Impact Statement [10], that the proponent is to submit to the review panel, noted that:

> "Ethical and moral perspectives, along with various social issues, as evidenced by presentations to the Panel at the scoping meetings, are as important as scientific, technical and economic considerations. The proponent should investigate how relatively narrow and focussed considerations of a scientific, technical or economic nature should be viewed in the much broader context of ethical, moral and social considerations."

The process for establishing disposal facilities therefore requires consultation with, and the active participation of, a wide spectrum of society. This includes the waste management agency itself, which must have confidence in the safety and environmental performance of the system, since it is accountable for this performance. It involves the technical community who need to be assured, and who need to provide assurance to others, that the technical basis is sound and supportable. It involves regulatory agencies who need assurance that the risks to society and to the environment can be managed. It involves the community that will host such a facility who need near-absolute assurance of safety, but who also have concerns about a wide range of other possible impacts such as employment, property values, quality of life and change. It involves politicians who are accountable to their constituents, and in the end, it involves society at large who are concerned about issues such as safety and economics, but who also require that the broader ethical and environmental issues be addressed and that due process be followed.

Due process requires that siting practices be open and participative and that waste management agencies develop and maintain effective working relationships with potential host communities and with communities along transportation corridors. For these relationships to be effective, the waste management agencies must demonstrate a commitment to principles of fairness, openness, shared decision-making, and above all to safety, so that affected communities can participate appropriately in decision-making.

Conclusion

Since the inception of the nuclear power industry, the industry has shown environmental leadership by containing its radioactive waste using safe management practices. The industry has also recognized the need to establish a passively safe, long-term method of isolating the waste from the environment. It is, I believe, in the forefront of managing and accounting for its full life-cycle costs, including environmental costs.

The incentive for selecting a permanent disposal concept to manage long-lived nuclear fuel waste is derived from two fundamental ethical principles:

- the waste must be managed in such a way that human health and the environment are protected in both the short- and long-term, and
- as the principal beneficiaries of the energy which gives rise to the waste, our generation should assume, to the extent possible, the burden of managing the waste.

Minimizing the burden on future generations means more than simply making financial provisions. It means developing and demonstrating the technology to implement disposal, to the extent reasonably possible; it means ensuring that the technology can be implemented in such a way that future generations retain options and flexibility in their decision-making; and it means proceeding toward implementation without unnecessary delay.

All countries that have nuclear power programs are proceeding towards disposing of their fuel waste to respond to public concerns about nuclear energy. The waste exists, and definitive solutions for dealing with it must be implemented whether nuclear power generation programs are to be continued, expanded, or even phased out.

The waste may take either the form of used fuel or suitably stabilized waste from fuel reprocessing. The nature of the disposal and details of the disposal systems used will depend to some extent on whether or not the fuel has been reprocessed, but based on current regulatory requirements, it appears that all waste contaminated with other than small quantities of long-lived nuclides will require deep geological disposal.

Treatment of used fuel by reprocessing, possibly augmented by partitioning and transmutation of long-lived radionuclides, does not obviate the need for deep geological disposal.

The public and decision-makers have a right to expect, today and in the future, that industries will respect the goal of sustainable development. For the nuclear industry that means that we must continue to make progress towards isolating our hazardous waste materials from the environment for as long as they remain hazardous. But it also means that we must ensure that our approach is based on a sound and coherent ethical framework, and that is the issue we will explore over the next two days.

References

1. IAEA (International Atomic Energy Agency), Division of Nuclear Fuel Cycle and Waste Management. Draft Safety Fundamentals. The principles of radioactive waste management. Safety Series #111-F, A Publication within the RADWASS Programme, 1994 February, Appendix 1 to the OECD/NEA (Organization for Economic Co-operation and Development/Nuclear Energy Agency) Radioactive Waste Management Committee Background document for the workshop on the environmental and ethical aspects of long-lived radioactive waste disposal. Working document, Paris, 1994 June 10.

2. Ravier, J., P.-E. Ahlström, L.H. Baetslé, H. Gruppelaar, K. Hesketh, H. Kusters, P.-A. Landeyro, and M. Segev. 1994. Destruction of long-lived waste, Nuclear Europe Worldscan, 1-2, pp. 17-19.

3. A.G. Croff et al. 1980. Actinide partitioning - transmutation program final report, Oak Ridge National Laboratory Report No. ORNL-5566.

4. Ramspott, L.D., J-S. Choi, W. Halsey, A. Pasternak, T. Cotton, J. Burns, A. McCabe, W. Colglazier and W.W-L. Lee. 1992. Impacts of new developments in partitioning and transmutation on the disposal of high-level nuclear waste in a mined geologic repository, Lawrence Livermore National Laboratory Report, California, U.S.A., UCRL ID-109203.

5. IAEA (International Atomic Energy Agency). 1991. Final report of the advisory group meeting on partitioning and transmutation of actinides and selected fission products from HLW. Vienna, 1991 October 21-24.

6. OECD/NEA (Organization for Economic Co-operation and Development/Nuclear Energy Agency). 1992. Statement by the NEA Radioactive Waste Management Committee on the partitioning and transmutation of actinides. Paris.

7. Baetslé, L.H. 1993. Burning of actinides: A complementary waste management option? Nuclear Europe Worldscan, 5-6, p. 40.

8. World Health Organization. 1982. Nuclear power: Management of high-level radioactive waste. Report of a World Health Organization Working Group, Bruges, 1980, June 2-6, on Health Implications of High-Level Radioactive Waste Disposal. World Health Organization Regional Publications, European Series No. 13, Copenhagen.

9. OECD (Organization for Economic Co-operation and Development). 1991. Disposal of radioactive waste: Can long-term safety be evaluated? An International Collective Opinion, Appendix 2 to the OECD/NEA (Organization for Economic Co-operation and Development/Nuclear Energy Agency) Radioactive Waste Management Committee Background document for the workshop on the

environmental and ethical aspects of long-lived radioactive waste disposal. Working document, Paris, 1994 June 10.

10. Federal Environmental Assessment Review Panel. 1992. Final guidelines for the preparation of an environmental impact statement on the nuclear fuel waste management and disposal concept. Federal Environmental Assessment Review Office, 13th Floor Fontaine Building, 200 Sacré-Coeur Blvd., Hull, Quebec, Canada K1A 0H3.

Paper No. 2

EVOLUTION AND CURRENT THOUGHTS ABOUT ENVIRONMENTAL POLICIES

Bill L. Long
Director for Environment

OECD

Remarks Presented
on the Occasion of the

Workshop on the Environmental and Ethical Aspects of

Long-Lived Radioactive Waste Disposal

Sponsored by the

Radioactive Waste Management Committee
of the
Nuclear Energy Agency

Paris
1st-2nd September 1994

EVOLUTION AND CURRENT THOUGHTS ABOUT ENVIRONMENTAL POLICIES

On behalf of the OECD Environment Directorate, I am pleased that Dr. Morgenroth and I have been invited to participate in this workshop.

I say this, in particular, because I find it unfortunate that OECD's Environment Policy Committee, for a variety of reasons, continues to resist engaging the Nuclear Energy Agency in joint work on nuclear energy issues. The matter of nuclear waste disposal is clearly a critical public policy issue that deserves a truly "collective" opinion. I thus hope that our presence here today -- as OECD Secretariat members in our own capacities -- will help pave the way for expanded collaboration in the future.

We have been invited to present an overview of trends and current thinking in environmental management, broadly defined, as a context for your consideration of the environmental and ethical aspects of the disposal of long-lived radioactive wastes. I will try to set out a general framework of the principles and strategies which have been, and are being, used by OECD Member countries to manage environmental problems and risks. Dr. Morgenroth will then focus explicitly on the management of non-nuclear toxic materials and hazardous substances.

One way to address this subject is to examine the changes in environmental policy-making over the last three decades, beginning in the mid-1960s when environmental concern first began to emerge in a major way in OECD countries.

At that early juncture, roughly from about 1965 to 1975, environmental awareness and government policies were largely focused on locally-derived pollution detectable by the human senses ... pollution which could be seen, smelled or heard. Industry was widely perceived to be the principal villain; "clean-up and cure" was seen as the challenge; and government "command and control" regulation was the policy response of choice.

There were also two interesting counter-currents. On the one hand, the "Limits to Growth" world model was embraced by many, with its projections of the collapse of economic, social and environmental support systems from the onslaught of population growth, industrial pollution and natural resource consumption. On the other hand, there seemed to be a vast reservoir of usable space for man's waste products. Smokestacks were thus built higher, and sewerage outfalls extended into marine environments, based on a belief that "the solution to pollution is dilution".

By the mid-1970s, environmental policymaking became more sophisticated and also much more complex and uncertain.

../..

The emergence of transboundary environmental problems ... notably acid rain and river pollution ... raised both ecological and political challenges for environmental policymakers. Solving one's own problems through dilution and dispersion became much less of an acceptable solution.

And, when situations like the "Love Canal" episode in the U.S. alerted citizens there and elsewhere to the fact that their residences might have been built on top of old toxic wastes dumps, there was a strong public backlash to any type of "out of sight, out of mind" approach to pollution control and waste management. This experience has, I believe, important implications for the management of radioactive wastes, particularly if the public is expected to "buy in" on a non-retrievability approach to deep geologic disposal of wastes of almost any type.

The period from 1975 to 1985 was thus characterised by a move toward "multimedia" approaches to environmental management, based on concern that earlier strategies were merely moving the pollution back and forth among the air, water and land media. Further, the "react and clean up" approach gave way to the philosophy of "anticipate and prevent" .. buttressed by projections of both significant environmental benefits and substantial economic savings.

The public attitude was that industry had to be pushed, and if necessary compelled, by government to find ways to produce goods and services with less pollution, resource inputs and waste generation. Fully closed manufacturing processes were seen as a proper goal.

Driven by the growing complexity of the environmental threats, the rising costs of pollution control, and the need to find ways to promote development of cleaner technologies, government policymakers undertook programmes of "regulatory reform" ... and also began to experiment with the use of "economic instruments" (e.g., taxes and charges).

Risk assessment and risk management came into vogue during this same period, particularly to cope with environmental threats which expressed themselves at microscopic levels ... pollutant levels undetectable by the unaided human senses. The challenge here ... and one that remains relevant today, particularly for the nuclear industry ... was reflected by Lee Thomas, former head of the U.S. Environmental Protection Agency who used to agonize (privately and publicly) about the fact that the priorities for environmental risk recommended by his science advisory committee were almost the complete opposite of what the public and the Congress perceived as the major risks. He complained that just the slightest hint that some pesticide might pose a cancer risk ... regardless of the odds ... was enough to set lawmakers running to draft complex and costly legislative remedies.

../..

Let us now move to the last ten years, and consider the recent evolution and transformation of environmental issues and strategies. In particular I will highlight several major current trends that I believe may have consequences for the disposal of long-lived radioactive wastes.

Among the "defining" developments since 1985 have been: the publication in 1987 of the report of the World Commission on Environment and Development, prescribing the "Sustainable Development" world model; the expansion of environmental concern to encompass global-scale threats, ozone depletion and climate change in particular; the 1992 "Earth Summit" in Brazil; and a recent recession in OECD countries which has challenged the staying power and resiliency of public support for environmental protection.

The "Precautionary Principle" of environmental management emerged during this same period, adding to what is really a rather small set of environmental principles. Other notable principles are the "Polluter Pays Principle" of the early 1970s which is, in effect, a principle of non-subsidization of polluters; and a somewhat less codified and less accepted "User Pays Principle" of the 1980s, promoting full-cost pricing of natural resources. The Precautionary Principle, which calls upon policymakers to take prudent preventive action to deal with potential environmental risk in the absence of compelling scientific evidence to the contrary, remains controversial. It does command quite widespread support internationally, and hence is a difficult barrier to surmount for certain types of proposed activities. This has obvious implications for nuclear waste disposal.

As we in the OECD address environmental issues today, we identify a number of trends that will likely be key determinants of environmental policymaking throughout the remainder of this decade, and into the next millennium. Each has, I believe, potentially important implications for nuclear energy, including waste management.

The first trend is that a much longer-term time horizon is beginning to be applied to environmental planning and assessment. Stimulating this is (1) the requirements of the Sustainable Development strategies called for at the Earth Summit in Rio, which virtually all countries are grappling with; and (2), the time dimensions required to cope with the climate change threat.

This holds out both promise and problems for radioactive waste disposal. Taking a longer-term look into the future has given rise to the issue of "intergenerational equity", an issue well-covered in the excellent background document prepared for this workshop.

../..

Certainly the contention that deep geologic disposal of radioactive wastes just unloads the problems on future generations will not easily be dispelled. One might also point out, however, that future generations will not only absorb costs but will also reap benefits from the development of the nuclear energy option, and the associated environmental safeguards, created in the last half of the 20th Century. Balancing costs and benefits thus should become the issue; although cost-benefit calculus is invariably contentious when applied even to traditional environmental issues.

The matter of intergenerational equity ... how to interpret it and how to provide for it ... is hotly debated today within the environmental community, with no clear consensus and guidance in hand. The issues go well beyond the nuclear area, obviously, involving such considerations as clearing of forests, draining of wetlands, and covering rich topsoil with urban settlements.

On the more positive side, this longer-term view of environmental challenges and development needs is focusing a spotlight on the pivotal role played by the energy sector -- as both the solution and the problem -- and particularly on the need to move societies away from fossil-fuel based energy sources. As one looks at realistically available options over the next century, nuclear energy (from fission and fusion) appears on most of the lists I have seen.

A second current and notable trend involves a renewal of interest in finding technological solutions to environmental problems. As testimony to this, even a cross-section of environmental activists now appear to accept the fact that the goal of Sustainable Development can only be reached through a new technological "revolution", one designed to permit expanded production with much reduced throughputs of raw materials and outputs of pollution and wastes.

Governments are thus examining their role in stimulating the development and transfer of "cleaner" technologies; and part of the OECD's environmental work programme is designed to assist in this effort.

There may be an important consideration here for nuclear waste disposal strategies. The environmental community is placing great stock on an evolutionary form of technology that will enable ever-higher environmental quality to be achieved, and to move toward total reduction of pollution and waste generation. If deep geologic disposal of nuclear wastes were to be proffered as the "final" solution, it would likely be challenged from some quarters on the basis that this would have a chilling effect on investments in next-generation waste management strategies and technologies which might provide even better environmental safeguards.

../..

A third noteworthy trend in environmental management is the high priority governments are attaching to finding ways to achieve environmental goals at lowest cost. This reflects the rising cost of environmental protection at a time of budget stringency, and also attests to the fact that environmental protection remains a priority concern of governments.

Efforts to lower costs are underway on two fronts. One involves the greater use of markets to achieve environmental goals, involving eco-taxes, pollution charges, tradeable permits, deposit-refund schemes, and the reform of national tax systems ... to cite some of the most widely used tools. The OECD has just published an updated assessment of the use of economic instruments in OECD countries. One of our conclusions is that environmental policymaking in the years just ahead will be based on trying to find judicious combinations of government regulations and economic instruments to solve particular problems. There is indeed no evidence that regulatory approaches are being replaced, despite the theoretical advantages that market-based measures seem to have.

A second way of lowering environmental protection costs is to find and remove policy conflicts. Here the focus today is on examining key economic sectors ... manufacturing, energy, transport and agriculture ... with a special priority attached to assessing the environmental implications of production-based subsidies. It seems likely that this analysis will be deepened and extended, with policymakers seeking clarification of, for example, what are the "true" economic costs to society of different energy sources.

A final trend worth noting for this gathering involves what has been called a "new partnership" among government, industry and environmental interest groups. At the Earth Summit in Rio two years ago, a business representative said that, in his view, the evolution of environmental management can be described as the "three Ds". "The 1970s were the age of Denial, with industry arguing that it was not to blame. The 1980s were the age of Data, with government and industry debating over whose data was better. But, the 1990s appear to be the time of Dialogue, with all parties agreeing that there is more reason to work together than to argue apart." I believe that this is a pretty good encapsulation of where we are today.

Last December, OECD's Environment Policy Committee discussed the question, "How are we doing within the OECD family after two-plus decades of investment in environmental protection?" The strong consensus was that we are really not doing too badly in the manufacturing sector, with significant improvements evident in pollution control and waste generation. The major challenges were seen as controlling dispersed, non-point pollution sources, particularly in the agriculture and transportation sectors.

../..

This perspective ... that industry can get it right, especially with respect to controlling pollution related to fixed installations ... would seem to offer some interesting prospects for the nuclear industry.

I should hasten to point out, however, that environmental NGOs and Parliamentarians are applauding industry for their efforts to reduce waste generation at the source ... and not for being innovative in their ability to dispose of unwanted residuals.

Finally, allow me just a brief word about the matter of ethics in environmental management. Ethical concerns have been raised by many parties, on a spectrum of issues, over the past three decades, with varying degrees of impact on policymaking. I frankly have never heard a coherent discussion of this, and thus look forward in particular to what will be said about the subject in this workshop.

Let me simply point to a number of environmental issues which have stimulated debates on ethics. The use of laboratory animals for the testing of chemicals is one that comes quickly to mind. OECD's work on chemicals management has been, in part, designed to help reduce such testing. Then there are the ethical considerations associated with the possible elimination of other species of animals through hunting, which have led to international treaties to protect threatened or endangered species. International whaling bans are now apparently based on ethical grounds, since certain species of whales are continuing to be protected even in the face of scientific evidence that the species are not endangered.

Ethical arguments continue to be raised against international trade in hazardous chemicals and dangerous products by a country that has banned such commodities for its own domestic use. Here the outcome, in terms of changing policy, has been mixed.

Objections on ethical grounds are also being heard, and examined by Environment Ministries, to the perceived preponderance of sanitary landfills and waste disposal sites in the poorest parts of towns and cities. Other examples include claims by environmental NGOs that tradeable emission rights schemes for managing pollution are simply unethical grants to industry of the "right to pollute"; and claims by developing countries that the "North" is consuming an unethically high proportion of the earth's "environmental space" and natural resources base.

So, as you consider the ethical aspects of the disposal of long-lived radioactive wastes, you may be assured that ethical assertions and considerations enter into many types of environmental debates.

However, the resolution of environmental issues invariably is hammered out in what has been called "the crucible of public policy"; and the weight given to ethical concerns seems to vary from issue to issue, from culture to culture, and from time to time.

- end -

MANAGING HAZARDOUS ACTIVITIES AND SUBSTANCES

Victor H. Morgenroth
Principal Administrator
Environmental Health and Safety Division
Environment Directorate
OECD

REMARKS PRESENTED ON THE OCCASION OF THE

WORKSHOP ON THE ENVIRONMENTAL AND ETHICAL ASPECTS OF LONG-LIVED RADIOACTIVE WASTE DISPOSAL

Sponsored
by the
RADIOACTIVE WASTE MANAGEMENT COMMITTEE
of the
NUCLEAR ENERGY AGENCY

PARIS
1ST-2ND SEPTEMBER 1994

MANAGING HAZARDOUS ACTIVITIES AND SUBSTANCES

BACKGROUND

On behalf of the OECD Environmental Health and Safety Division of the Environment Directorate, I am pleased to have been invited to be a member of the small group that assisted with the preparations for this Workshop on the Environmental and Ethical Aspects of Long-lived Radioactive Waste Disposal. My thoughts about the aims and contents of this paper began to evolve following a meeting last April of the workshop preparatory group. That meeting was the beginning of a valuable educational process for me involving, first, a recognition that there are a number of preconceptions of the similarities and differences of certain aspects of the management of hazardous activities, products, and wastes depending on whether you have been brought up in the nuclear and chemical cultures. Second, there is a great deal of benefit to establishing a continuing dialogue and exchange of ideas, concepts and even technical information on the approaches and methods used in each culture for the assessment and management of health and environmental risks.

The primary purpose of this paper is to provide background information for this workshop that is focused on the process, principles and policies being employed in OECD Member countries for managing hazardous activities (non-nuclear) and products involving chemicals (non-radioactive). In addition, I will try to highlight certain areas in the risk management process where certain assumptions and conclusions maybe of particular relevance to the goal of a review, reconsideration and restatement of the *Collective Opinion* on the disposal of radioactive wastes (*DISPOSAL OF RADIOACTIVE WASTE: Can Long-Term Safety Be Evaluated,* OECD 1991).

MANAGING HAZARDOUS ACTIVITIES AND SUBSTANCES: THE PROCESS

In the broadest sense managing non-nuclear hazardous activities and substances involves a process which includes a number of activities:

- Identification
- Hazard/Risk Assessment
- Risk Management
  - Signification (Valuation)
  - Discrimination
  - Implementation (Compliance)
  - Assurance
  - Monitoring
- Risk Communication

This process is used to serve a variety of purposes. For example, the determination of potential adverse health and/or environmental effects associated with a particular activity (e.g., municipal waste incineration) or a substance (e.g., mercury) in order to undertake actions to mitigate the occurrence of such effects; comparison of technological alternatives in order to ascertain the effectiveness of different control or mitigation techniques designed to reduce a certain risk; and, evaluation of the magnitude and location of the effects resulting from potential accidents based on different possible scenarios in order to select sites for a potentially hazardous facility.

Identification involves a determination whether the degree of concern, associated with the potential risks to health and the environment posed by a particular activity or substance, warrants further scrutiny with respect to the need to manage or reduce the risks presented. Normally such determinations are made via administrative or legal caveats based on past experience as well as technical or scientific information related to the possible occurrence of harm to human health or the environment from certain types of activities or classes of substances. The administrative or legal requirements normally include provisions calling for hazard/risk assessment and the development and implementation of appropriate measures for risk management, control or reduction. Such provisions normally cover large groups or classes of activities (e.g., facilities were hazardous substances are handled, chemicals added to food, drugs, new industrial chemicals). Examples include: legislation requiring the assessment of potential health and environmental risks of new chemicals prior to its manufacture and use; administrative procedures associated with granting building permits or land-use permission for facilities involving the presence and handling of hazardous materials; and the assessment of the possible environmental impacts of new technologies that may alter the normal background levels of exposure of humans or the environment to hazardous environmental constituents.

Hazard/risk assessment involves evaluation of both the potential of a chemical to harm man or the environment and the potential for exposure to the chemical. Evaluating the potential for exposure includes defining the exposure conditions under which harm is likely to result. Where possible, in the course of hazard/risk assessment, the uncertainties associated with these evaluations are identified along with specific target characteristics and the expected incidence and severity of potential hazards. Aspects such dose-response relationships and inter-species extrapolations are also important in this context. Since clear ad valid human data related to the risks of hazardous substances is available only in rare situations, inter-species extrapolations is one of the more uncertain and most contentious areas in hazard/risk assessment. Interestingly, this does not seem to be a significant issue in the context of the review and reconsideration of the *collective opinion.*

In hazard/risk assessment activities there is often a direct relationship between disagreement and controversy, and uncertainty. Thus "managing" the degree of uncertainty is a critical factor in most assessments and the acceptance of assessment results. Important to this process is the identification of assumptions made in a clear and transparent manner; the determination of the "sensitivity" of assessment results to changes in the assumptions; an evaluation of the quality of the data used in the assessment (including the rationale for selection of "critical" studies and for the rejection or limited use of other data; as well as efforts to ensure that further data requests will actually lead to a reduction in uncertainty when such data is generated and evaluated.

Another significant component of the hazard/risk assessment process is **Exposure assessment**. It involves the determination of the extent of human and environmental exposure to hazardous substances before and after the application of management or control options. It includes source/release assessment, i.e., estimating the amounts, frequencies, and locations (e.g., the workplace, the home, indoors or outdoors) of the introduction, release or escape of material of concern from a specific source into a variety of environmental media (e.g., air, water, biota); the estimation of probable quantities; duration; concentrations in various media; transport between media; and, the environmental fate of the potentially hazardous material released. Such information is related, in part, to the environmental conditions at the time and place of the release. Exposure assessment should provide quantitative data on individuals, populations, or ecosystems that are, or may be exposed. Confidence in the data derived from exposure assessments is critical to not only the acceptance of results of the risk assessment but also to estimating the effectiveness of any risk management measures. This area of hazard/risk assessment is likely to be highly significant with respect to the identification of alternatives for the disposal of radioactive wastes.

Multi-exposure analysis is a technique that considers the different pathways through which exposure to chemicals may occur. Traditionally, exposure analysis is performed in some detail for human exposure to chemicals in food or drinking water or at the workplace. In order to derive a complete picture of exposure all routes, or parts of those routes, that pose a significant risk of exposure of selected human or environmental targets to a chemical must be identified. For the environment, exposure via environmental media (air, water, soil and biota) must be analyzed; for humans, exposure via consumer products or other materials (e.g., drinking water) should be considered as well.

The effectiveness, efficiency and confidence in managing the risks of an activity or hazardous substance depends on the amount and quality of data available and on the results of hazard/risk assessment. Improved assessment practices lead to better management of the risks identified. Since they provide the basis for risk management, it is desirable that hazard/risk assessments be performed in such a way that the objectives and requirements of risk management are taken into account.

The general objectives and requirement of **risk management** are derived from the broader environmental and health goals and policies that Mr. Long set out in the previous paper. The concepts of "Sustainable Development", the "Precautionary Principle", longer-term time considerations, balancing present and future risks, costs and benefits, sectoral integration find and remove policy conflicts ad the increasing use of clearer technology market based incentives and other economic instruments in conjunction with regulation. The greatest impacts of these policies is on the breadth of information concerning an activity or hazardous substance needed for the more comprehensive assessments required to reflect new concerns ad policies. Potentially hazardous activities and substances are now assessed not even from cradle to grave but from conception and design to possible impacts long after ultimate disposal.

Risk Management activities involve integration of the results of hazard/risk assessments with other technical, social, economic and political considerations. Once the risk has been determined — i;e., the probability that hazards will occur under specific exposure conditions — the following activities or steps can be taken.

Signification (Valuation) involves a determination of the gravity and acceptability of a given level of risk based on the results of hazard/risk assessment. This is an activity in the process of managing the risks of hazardous activities and substances that is beginning to receive greater attention from the public as well as policy-makers that it has in the past. Considerations in this area involve a number of the societal and ethical issues set out in the Background Document for this workshop. It is in this area that there is the greatest similarity between the nuclear and chemical cultures in that the interface between science, policy and public perception is poor to non-existent.

Discrimination includes the choice of appropriate and realistic management, control or risk reduction measures. This choice takes statutory requirements into account and considers combinations of measures such as regulatory actions, socio-economic incentives, and voluntary or negotiated agreements and requirements for effective provision of information.

Discrimination involves the development of alternative risk management strategies designed to avoid or reduce significant risk. Such strategies can include establishment of exposure limits; direct control of emission from sources; control of use, ranging from partial restriction to total ban; protection of the exposed target; and hazard warnings. The range of risk management measures covers precautionary, advisory or educational strategies as well as stringent regulatory controls.

Analysis of other factors, such as the availability of the control or cleaner technologies or safe substitutes; the enforceability and cost of control measures; socio-economic implication of the various actions or of taking no action; and public perception of the risks and benefits of the measures, need to be considered in the decision-making process in order to evaluate the overall feasibility of each option.

Implementation (Compliance) involves the execution and enforcement of the measures chosen.

This step is followed by Assurance of compliance with, and Monitoring the effectiveness of, control measures, the latter in terms of protection of health or the environment. In terms of present policies related to measures calling for the sequestration of non-nuclear hazardous substances continuous monitoring of environmental media near the sight is usually mandated. On the surface, this appears to differ from the previous *collective opinion* concerning the geological disposal of radioactive wastes.

MANAGING HAZARDOUS ACTIVITIES AND SUBSTANCES: POLICIES AND PRACTICES

Risk management measures for specific chemicals can be quantitative in so far as they aim at specific desired levels of risk reduction. Examples are air or water quality standards; permissible emission concentrations; permissible concentrations in food for pesticides or food additives based on acceptable daily intakes or residues; and, workplace standards based on threshold limit values. In general, these are control measures which are required or recommended by governments for specific chemicals and are based on detailed reviews of exposure and toxicity data in the form of an hazard/risk assessment. Due to the quantitative target levels of the risk reduction specified, enforcement of this kind of control measure is generally relatively easy. Its effectiveness is usually determined by monitoring the extent of the reduction in exposure to humans or in levels in the environment.

More general types of risk management measures which can be applied to specific chemicals include labelling requirements; material safety data sheets; use registration; and recommended conditions for use. Such measures which do not specify target levels for risk reduction, are also generally imposed or recommended by governments, often after consultation with industry. They are based on limited evaluations of use patterns and/or of one or more toxic responses. Enforcement of these kinds of measures for specific chemicals is relatively easy, as is determination of compliance with them. Due to their precautionary nature, quantitative monitoring of their effectiveness is more difficult.

Similar general risk management measures, which are usually applied to all chemicals or to groups of chemicals, include licensing requirements for the users of certain products (e.g., pesticides); codes of practice for industry; training of users; and consumer awareness programmes. Such measures usually rely on the responsibility of industry and on the competence and knowledge of handlers of chemicals. These measures are often developed through co-operation between government and other parties involved. They are usually based on general information on the handling and use of classes of chemicals and on broad toxicological principles. Neither their enforcement, nor determination of compliance with them, is easy. Quantitative monitoring of their effectiveness is difficult.

Management of chemicals often focuses on the risk caused by a specific use (e.g., food additives, drugs or pesticides); by a specific source (e.g., factory releases); or to a specific medium (e.g., air or water). The resulting control measures usually focus on particular populations (e.g., consumers, workers, ecosystems or species) or on a specific phase of the life cycle of a chemical. Management of these risks by either specific or general measures has been successful in the past and will continue to be an important way to protect human health and the environment.

However, the effectiveness of managing the risk of chemicals in these specific ways may not always be optimal. Various uses, sources and exposure routes can play a significant role in the total risk that some chemicals pose. (e.g., the various sources, uses and exposure pathways for elements such as mercury and cadmium). By focusing only on specific risks, other important pathways or sources of exposure, and their interaction, may be overlooked and fully effective control measures therefore not instituted.

More comprehensive risk assessment and management policies and practices, consistent with concepts of "Sustainable Development", are now being used to address the reduction of the total risk posed by chemicals which are used extensively and/or distributed widely in the environment. The basis for these approaches to the management of hazardous activities and substances is the evaluation of the commercial and environmental life cycle of a chemical together with multi-exposure analysis.

Use of these approaches increases the need for interaction among the different authorities in Member countries involved in chemicals control. Examples of activities undertaken to improve co-ordination of administrative practices and statutory requirements are given below. Such activities address, e.g., the coherency of different regulations; timing (or sequence) if regulation; harmonization of permitting procedures; duplication of efforts for information gathering and assessment; and the co-ordination of the setting, implementation and enforcement of standards at the national, regional and municipal levels.

These more comprehensive approaches do not require that every possible detail be investigated and documented in a completely quantitative way. Indeed, the data needed for a fully comprehensive approach are often inadequate or incomplete. Methods exist for estimating some of the data or for making use of assumed values or scenarios. The total risk posed by a chemical can be taken into account by using such methodologies should the validity of the method and the need to approximate missing data justify doing so. Through the use of such approaches, risk reduction or management measures can be developed as an alternative to taking no action because data are inadequate, or to taking actions that deal with only part of the total risk.

In analysing a chemical's commercial life cycle, its various stages (manufacture, storage, transport, use and disposal) are evaluated in order to systematically identify the sources of exposure and nodes of risk. All sources of release to the environment — before the commercial introduction of the chemical, during its consumption, and via waste — are considered and assessed with respect to their contribution to the total release. In so doing, account is also taken of the relative importance of the various releases during the entire commercial life cycle.

The environmental life cycle is evaluated by examining the transfer of a chemical between environmental media after its release and the transformation processes occurring in these media. Most heavy metals and many organic chemicals are found in significant amounts in more than one medium. An analysis of the environmental life cycle contributes to the identification of measures that can be aimed at the most significant media; at the same time, it can ensure that measures are taken which result in real risks reduction rather than merely shifting of the substance and associated risks from one medium to another.

Unlike nuclear materials, for most chemicals there is very little safety data available, sometimes none at all. The potential risks posed by these chemicals are managed differently from those of chemicals for which more safety data are available. In-depth analyses are obviously not possible, nor can control measure which requires quantitative specification of risk reduction be employed in the absence of adequate data. ~~In-depth analyses are obviously not possible, nor can measures which require quantitative specification of risk reduction be employed in the absence of adequate data.~~ General management practices are used for these chemicals until more information is available for development of specific policies.

Risk management in the absence of extensive data is similar in several respects to the management of non-nuclear hazardous waste. For waste, data on composition and toxicity are often lacking but general policies concerning its treatment and disposal are nevertheless implemented. These policies usually deal with categories of wastes which are identified based on general criteria like the origin of the waste; the basic characteristics of the process by which the waste is produced or the likelihood that the waste contains certain specific hazardous substances. Under such an approach, all of the usual steps of the risk management process are not followed. Policy decisions are often based largely on experience with management of similar materials and on general principles.

Likewise, for management of chemicals in the absence of data, an attempt is made to deal with chemicals in general, or with a specific group of chemicals, in order to reduce the total exposure burden. Such groups of chemicals can be established, based on: similar uses; similar behaviour in their commercial or environmental life cycles; or in parts thereof; or a similar potential for toxicity. Examples of the kinds of chemicals of which the risks have been managed in this general way are: natural products, synthetic flavours, industrial chemicals, intermediates, polymers, low-volume chemicals ad research chemicals. Many Member countries have begun programmes aimed at inventories of potentially toxic chemicals. Most of these programmes call for reduction in the emissions of the chemicals listed. These "Pollution Prevention Programmes" usually involve issuing estimates of the quantities of hazardous chemicals released by a industrial entity to the public and voluntary commitments on the part of industry to reduce emissions by a specified amount over a specific time period.

The risk management of chemicals in the absence of extensive data is a developing area which will become increasingly important as large numbers of chemicals with little data are identified in the systematic investigation of existing chemicals. Only limited information and experience are available in this area to date. Many of the precautionary measures described above can be applied. Although there are many more chemicals without extensive data than there are chemicals which have been subjected to the more comprehensive approaches to manage risk.

Several Member countries are developing more integrated and comprehensive policies for risk management. A number of new arrangements involve modifications of administrative practices. The various initiatives relate to specific chemicals or industry sectors; to specific agencies or ministries (or groups thereof); or to all parties involved in managing chemical risks. Some approaches being used are:

— addressing a group of chemicals with the same use pattern simultaneously (e.g., chlorinated organic solvents), taking into account possible shifts in use pattern or increased use of alternatives resulting from various control actions;

— addressing a particular industrial sector and developing an overall plan for implementing a number of environmental measures over a certain time period, rather than introducing various new measures on an *ad hoc* basis;

— developing a policy of "best practicable environmental options" seeking a concerted approach to problems of air, land and water pollution;

— instituting a co-ordinating body within an agency or ministry to review proposed risk management measures originating from its various sections;

— developing a multi-year programme which integrates the policies of the (sections of)ministries involved;

— instituting within government an authority which can co-ordinate activities concerning chemicals undertaken by different agencies or ministries, and

— instituting an advisory group of representatives from government, industry, trade unions, environment groups and consumers to address general aspects of chemical risk management.

This list is incomplete. Other innovative activities in this area are being initiated in Member countries. Even though the exact scope and detail of the activities have not been elaborated here, their existence shows that relevant initiatives are being taken as health and environmental policies evolve.

Emerging Concepts and Requirements for the Long-Term Management of Non-Radioactive Hazardous Wastes. Would Geological Disposal be an Appropriate Solution for some of these Wastes?

Kristina von Rein
Swedish Environmental Protection Agency
Section for Hazardous Waste and Site Remediation

As a result of industrialization, population growth and the rapid development of technology, man has had a growing impact on the natural environment. The environment has not been assigned a price and has consequently been overexploited. Environmental legislation and other measures have brought about considerable progress, but we still have a long way to go before we - producers and consumers alike - can be said to have assumed full responsibility for the environmental effects we cause.

Environmental policy must be preventive and long-term. It must ensure that the interests of future generations are taken into account in decisions made today. In order to find solutions to environmental problems we must look not only to the technical causes, but also to the underlying economic, political and social mechanisms. There is a need for changes in economic signals and in political and social patterns to encourage environmentally sound technologies and environment-friendly behaviour. And this takes time, time to change the way we think and the way we act. This in turn requires a broad-based knowledge of and commitment to environmental issues, so that environmental interests can make themselves heard over other interests. This is true of the environmental field in general, and it is also true within the field of waste management.

Waste is something that has always followed in the wake of human activities, but the content and amount of the waste has changed with time, reflecting the development and industrialization of society. Our modern production and consumption society gives rise to very large quantities of waste, and in many cases the waste contains a large amount of metals and chemicals. Waste is something we want to get rid of. But today's society is finding it increasingly problematical to get rid of it.

We still need to know more about the toxicity of different substances, their transport pathways to and in the environment, and their effects on human health and the environment. But we have learned from the waste management experience of previous generations that we must not dump waste without any protective measures whatsoever. There are contaminated sites in many countries that constitute an environmental threat, such as old waste dumps or industrial sites where contaminated wastes have been used as fill. It is we, the generations of today and tomorrow, who must face the task of rehabilitating these sites by adopting the necessary cleanup measures and paying for them.

To gain control over today's and tomorrow's wastes, the Swedish Government and the Swedish Riksdag, or parliament, have, like the governments and legislatures of many other countries, established goals for waste management, namely to:

- reduce the waste quantities
- reduce the danger posed by the wastes to health and the environment
- ensure proper disposal of generated wastes

In response to proposals in the Ecocycle Bill, the Swedish Riksdag has decided on guidelines for sustainable development within a number of different areas. The basic idea is that the state should specify goals and frames for the work, after which the producers should take responsibility for achieving these goals. The Ecocycle Bill also states that the flows and use of harmful chemicals should be reduced, flows that nevertheless contain harmful chemicals should be closed wherever possible, systematic risk management of chemicals needs to be further developed, use of the most harmful chemicals should be phased out, and plans for risk limitation should be drawn up for a number of substances within a five-year period.

Mercury is a very hazardous substance, harmful to both human health and the environment. Several years ago the Swedish Riksdag decided that the use of mercury for most purposes should eventually cease altogether. This year (1994), the Riksdag passed a motion that mercury use should be phased out, the target year being 2000. In the form of amalgam, mercury may not be used in the teeth of children and young people after 1 July 1995, and its use for adults should cease by no later than 1997. There are certain exemptions for mercury use, e.g. for the chlor-alkali industry.

Collection of discarded mercury-containing products and goods has been under way for many years in Sweden. These discarded products and goods are classified as hazardous waste and dealt with accordingly. A mercury phase-out means that it is firstly the input of new mercury to society that is reduced. Large quantities of mercury are still present in goods and products still in use. The collection rate varies for different types of products and will be improved through targeted measures.

Today Sweden lacks the capacity to dispose of its own mercury waste. Until recently, collected waste has been stored at SAKAB or exported for reprocessing and reuse, as in the case of amalgam.

The Swedish Environmental Protection Agency was instructed by the Government a few years ago to investigate how the collection of discarded mercury-containing products and goods could be improved, and how the waste should be disposed of. In the course of the investigation, which resulted in the report "Phasing-out our unseen mercury stock", the Swedish Environmental Protection Agency proposed that mercury-containing waste should not be reclaimed and reused since Sweden has decided not to use mercury in the long run. Instead other solutions should be sought. The Swedish Environmental Protection Agency believes that mercury-containing waste should be disposed of in such a manner that the mercury is isolated in such a form and way that leakage to the external environment is as little as possible, viewed in a very long time perspective.

As already mentioned, mercury is a very toxic metal. Mercury is also a volatile metal that readily vaporizes and can travel long distances in the atmosphere. Today we are faced with a situation in Sweden with generally elevated levels of mercury in the natural environment. The concentration of mercury in fish in more than 10,000 of our lakes is now higher than 1 mg/kg and the levels continue to rise. (It is a goal in Sweden that the mercury level in fish should not exceed 0.5 mg/kg if the fish is to be fit for human consumption.) The mercury load on our environment in large areas in Sweden is well above the acceptable level today. The Swedish Environmental Protection Agency therefore believes that very vigorous pollution control measures are required both in Sweden and in surrounding countries in order to improve the situation. This has led the Agency to conclude that one far-reaching pollution control measure for mercury waste is safe geological disposal, for example in a deep rock repository.

The Agency believes that capacity for disposal of mercury-containing waste should exist within the country, and that mercury waste should not be reprocessed for reuse. This also means that the Agency believes that exports of mercury waste for reprocessing and reuse abroad is not a feasible alternative, at the same time as use of mercury in Sweden is deemed to be such a great threat that it shall cease, the target year being 2000. Exports of mercury waste are therefor no longer permitted.

The Swedish Government and Riksdag have considered the proposals submitted by the Swedish Environmental Protection Agency in its report, and the Government has decided to give the Agency an assignment that includes both an action programme for more efficient collection of used goods and products containing mercury and preparation of a proposal for final disposal in Sweden of mercury-containing waste. Achieving a long-term safe disposal of mercury may therefore entail that the waste has to be placed in an underground rock cavern. Experience from the field of radioactive waste disposal should be drawn upon in designing such a repository. The Swedish Environmental Protection Agency has received an appropriation of about SEK 2 million per year for three years to prepare the proposal for a final repository.

The prospects of realizing a final repository differ appreciably when a comparison is made between radioactive waste and mercury waste. Due to the general perception of the risk posed by nuclear power and radioactive waste, no one questions the highest possible level of ambition for disposal of radioactive waste. Mercury, which has long been used and which many of us still carry around in our teeth, does not pose as strong a perceived threat.

If we compare the time perspective for radioactive waste disposal (10,000 - 100,000 years) with that for hazardous waste, there is a great difference. When planning landfills, even landfills for hazardous waste, we speak today of a time horizon of 1,000 years in Sweden, in other words until the next ice age. This represents a great increase in the level of ambition in the past few years, so that today's landfills do not yet live up to these ambitions. The question is: what time perspective should we have for an underground repository for mercury waste? Should we choose 1,000 years or more? What is reasonable?

The next question is what level of ambition we should have for acceptable leakage levels. For mercury there is no established acceptable leakage level. Today there are many sources of emissions and deposition from the atmosphere. The most logical answer would be to set a level that nature can take. But our knowledge of what nature can take is incomplete, and here again the question is what time perspective should be applied in establishing effect levels or critical levels, since metals accumulate gradually in the environment. Is it possible that new future knowledge of effects will compel future generations to adopt measures anyway, and should we put in additional safety margins to allow for this?

Another question is: Is a deep rock repository the only conceivable alternative for achieving a given maximum acceptable leakage level? Are the risks greater for leakage with other alternatives, such as surface disposal? Could such a greater risk be accepted? Or is the relatively large concentrated quantity of mercury in a final repository and the risk it represents sufficient in itself to warrant an underground repository?

The advantage of disposal in deep crystalline rock is that the rock provides a stable mechanical system. The rock itself can be regarded as a very qualified cover layer with a powerful protective capacity. The rock provides sufficient protection against such processes as erosion, glaciation, land uplift, etc. In the case of surface disposal, similar processes can lead to a degraded protective effect of the cover layer and therefore alter the conditions presumed when the landfill was designed and assessed. Viewed in a longer time perspective, great difficulties can be assumed to exist in the case of surface disposal in counteracting various weathering processes, for example as a result of oxygen intrusion. Large uncertainty factors can be accepted for harmless materials deposited there, but for mercury-containing waste, where a more qualified disposal is required, a deep repository would offer a very large safety margin. Additional advantages with a deep rock repository, providing extra safety, include the stable chemical environment and the limited water flow, which means a lower transport capacity for the mercury. In surface facilities, moreover, there is a greater risk of gaseous mercury emissions.

If we assume we can build a deep rock repository in Sweden, one important question remains, however. Who is to pay the extra cost for the higher level of ambition entailed by an underground repository? Funds have not been set aside in any reserve for the final disposal of mercury in Sweden, with the exception of for batteries. A retroactive producer responsibility would be difficult to impose, since many producers are no longer in business. And the national budget is already highly strained. Should the mercury use of the last few years therefore be burdened with costs that include the environmental costs for the mercury use of previous decades? A fundamental shortcoming has been, and still is, that the risks of environmental impact from goods and chemicals have not previously been taken into account, due to the fact that the negative environmental effects have not had any assigned cost and have therefore not been included, and are still not included, in the calculations of the producers and consumers.

Ethical Principles and the Environment in a Democratic Society

John F. Ahearne
Executive Director
Sigma Xi, The Scientific Research Society
and
Adjunct Scholar, Resources for the Future

Introduction

In the United States, the responsibility for handling the high-level nuclear waste resides with the federal government, whose agent is the U.S. Department of Energy. To carry out this obligation involves three federal agencies. The Department of Energy has a responsibility of selecting a site for a repository, characterizing that site, getting a license, constructing, and operating the repository. The Environmental Protection Agency has the responsibility for establishing the basic standards which the site must meet. These standards are to be focused on protection of individuals outside the site. The U.S. Nuclear Regulatory Commission (NRC), which has the responsibility for overseeing the construction and operation of the repository, and, if the regulations are satisfied, will issue a license to the Energy Department for the repository, must develop NRC regulations to implement the EPA's regulations.

There are four key points in this process:

1. Locating a site;
2. Characterizing the site;
3. Developing EPA regulations; and
4. Licensing the site.

In the United States, as well as in other countries, these steps have become very controversial. Attempting to implement them has led to major public confrontations with government in several countries.

In the United States, and in some other countries, there are actually two problems of high-level waste. The spent fuel, commercial, or "civilian" high-level waste, and the military high-level waste, coming from the manufacture of nuclear weapons. In this paper I am in principle addressing both, although I will refer only to the commercial waste. However, the fundamental characteristics of the waste from the military operations are not different, although their current conditions can be quite different.

Most of the Energy Department's reactor waste consists of material from the production of nuclear weapons: 84% from production reactors, 15% from commercial reactors, 1% from research reactors, and less than 1% from naval reactors. The percentages are a total inventory when expressed as irradiated heavy metal. ("Spent Fuel Working Group Report", Vol. 1, November 1993, U.S. Department of Energy, p. 5.)

The United States government has struggled for nearly four decades with the problems of disposal of high-level wastes. Historians will find many "new starts". For example, in 1980, President Jimmy Carter sent a message to the Congress on waste management in which he stated: "...past governmental efforts to manage radioactive waste have not been technically adequate. Moreover, they have failed to involve successfully the States, local governments, and the public in policy or program decisions." He ended by stating that this policy was intended to "build public confidence in the ability of the government to do what is required in this area to protect the health and safety of our citizens." (Message from the President of the

United States, transmitting a report on his proposals for a comprehensive radioactive waste management program, February 12, 1980.)

It failed.

History

In the United States the official government position for the permanent solution of high-level waste has been to place it in a geologic repository. This position, developed by the Atomic Energy Commission, a predecessor to the current Department of Energy, was endorsed by the nuclear utility industry and has been the official United States policy from the late 1950's. Of course, for the first 20 years there also was the assumption that the waste would be from the reprocessing of spent nuclear fuel. Studies by the National Academy of Sciences supported this position. Periodically, some objections would be raised, primarily concerning whether there was enough scientific knowledge to speak with certainty about the performance of such a repository.

The Atomic Energy Commission in 1956 put in place regulations that "in effect would require all high-level wastes to be permanently isolated from the environment." ("Federal Policy for the Disposal of Highly Radioactive Wastes From Commercial Nuclear Power Plants: An Historical Analysis", Richard G. Hewlett, Chief Historian, U.S. Department of Energy, 9 March 1978, p. 6.) The Commission was thinking both of the military wastes, because by that time, they had "millions of gallons of high-level waste stored at Hanford", as well as "the high-level materials that would be produced in nuclear power reactors." This concern led the AEC to ask the National Academy of Sciences to study the feasibility of disposing of waste in geological formations.

In 1957, the National Academy of Sciences, "recommended solidifying the high-level waste and disposing of it in salt mines or repositories." ("Nuclear Waste Policy and Politics", Luther J. Carter, Forum for Applied Research and Public Policy, Fall 1989, p. 6, referring to "The Disposal of Radioactive Waste on Land", Report of the Committee on Waste Disposal of the Division of Earth Sciences, NAS-NRC Pub. 519, Washington, D.C., 1957.) Consequently, "...by the end of 1970 the AEC had committed itself on...a policy for ultimate disposal of radioactive waste: (1) fuel elements from civilian power reactors would be processed by commercial plants and the high-level waste would be solidified in a form acceptable to AEC for shipment to a federal repository; (2) AEC would build a federal repository using a bedded salt formation for permanent, irretrievable storage of these wastes..." (Hewlett p. 15).

In the United States, site selection took more than 20 years, and may have to begin again. The Atomic Energy Commission initially selected as a demonstration facility a salt dome in Lyons, Kansas, based on the belief that salt would be the best medium for a repository. This position was based on (1) that water had not been present for hundreds of thousands years, as evidenced by the existence of large salt deposits, and (2) that the creep of salt under the heat of the waste material would lead to good containment, as the salt closed around the material.

Lyons turned out to be a poor choice and, under much public criticism, the AEC abandoned the site. A historian has called it "The Lyons Debacle" (Hewlett, p. 17). It was about this time that political changes in the United States, first a decision by President Ford and then carrying out election promises by President Carter, led to the United States official position being that there should be what is called the direct cycle for the fuel cycle, which eliminates reprocessing and ends with disposal of spent fuel directly into a repository. This decision, reiterated by the current Administration, is related to proliferation concerns and has been strongly opposed by the U.S. nuclear industry for its claimed significant impact on potential future sales of nuclear power, both in the United States and abroad. The decision has little to do with high-level waste disposal and I do not intend to discuss the issues surrounding reprocessing.

In a letter report to the Nuclear Regulatory Commission, in 1978, the National Academy of Sciences supported the use of a deep-geological repository, but said "unreprocessed spent fuel elements should not be placed in a non-retrievable repository for radioactive waste." (Section 4.1, "The Geological Criteria For Suitable Sites of High-Level Radioactive Waste Repositories", August 3, 1978, Panel on Geological Site Criteria, National Academy of Sciences, Washington, D.C., 1978.) The Academy based this position on not creating a potential future source for valuable material, which could lead to repository intrusion.

The 1982 Nuclear Waste Policy Act established procedures to select sites for high-level waste repositories. The search for a site became a major political controversy, not only in the potential selected site areas. After a panel of the National Academy of Sciences validated the criteria by which the Energy Department would select a site, the Energy Department identified four possible sites, all in Western States. Three sites immediately led to strong protests, one for its closeness to the Columbia River, another for its closeness to the Ogallala aquifer, and the third, for its closeness to a national park. Thus, although there were four sites being characterized, only one, initially, seemed to have caused significantly less objection, a site near the nuclear test site in Nevada. The nuclear test site had been the location of more than 100 underground nuclear tests by the United States over a period dating back to the 1950's. At the same time, there was a provision in law that the DOE also should be searching for an eastern site, along with a western site. This provision reflected the need for a second site, because of a 70,000 metric ton constraint on the first site, but also it made selecting a western site more palatable, politically. There are many more nuclear reactors generating spent fuel in the eastern U.S. than there are in the west.

After several years of slow, if any, progress towards selecting a site, Senator Johnston became frustrated and introduced legislation that would select the Nevada test site and do away with any analysis of comparison to the other three. This was passed in 1987. To some, this was fitting, because Nevada, in much of the United States, is seen as the home of the major gambling city, Las Vegas, and the reaction of some in the U.S. was that Nevada had participated in a lottery and had lost.

This action did not resolve the controversy, since the people of Nevada and, in particular, the senior elected officials, senators and governor, were not in favor of this selection and were able to use the highly faulty selection process to generate considerable opposition in Nevada to the selection of Nevada for the high-level waste repository.

At the same time, the U.S. Environmental Protection Agency (EPA) very slowly developed regulations that a repository must meet. EPA's regulations were criticized by its own Scientific Advisory Board, by the National Academy of Sciences' Board on Radioactive Waste Management, and by a U.S. Federal Court. Some of these criticisms also laid out broad views of what should be included and what are the responsibilities of the technical community.

In 1988, the Board on Radioactive Waste Management, a permanent branch of the United States National Academy of Sciences, met to review the Environmental Protection Agency's approach to developing regulations for high-level waste repository. The Board was extremely critical: "The United States appears to be the only country to have taken the approach of writing detailed regulations before all of the data are in. As a result, the U.S. program is bound by requirements that may be impossible to meet." ("Rethinking High-Level Radioactive Waste Disposal, A Position Statement of the Board on Radioactive Waste Management", National Academy Press, Washington, D.C., July 1990, p. vii.) "The Board believes this use of geological information and analytic tools -- to pretend to be able to make very accurate predictions of long-term site behavior -- is scientifically unsound." (p. 5).

"The primary goal of the program is to provide safe disposal; a secondary goal is provide it without any gross unfairness. As a result, the mechanisms of negotiation, persuasion, and compensation are fundamental parts of any program to manage and dispose of radioactive waste -- not mere procedural hoops through which program managers must jump. The second ethical point is also important: the demand for accountability in our political system has fostered a tendency to promise to a degree of certainty that cannot be realized." (p. 6).

"Science and engineering are part of broader human activities, and as science enters the public arena, decisions can no longer be purely scientific; good science is not enough. Science has also become an important source of information and analysis for the public policy process, and scientists find themselves being called to account for, and to justify the results of, those decisions...Scientists have been sheltered...in the past, but the increasing scale, sophistication, and pervasiveness of technical information require a corresponding increase in the sophistication with which these value judgments are made." (p. 18).

EPA's criteria also were criticized by the Nuclear Waste Technical Review Board set up by the Congress to review the high-level waste program:

"...the release limits [in the draft revision of 40 CFR 191, the EPA high-level waste regulation] appear very conservative and inconsistent with present day regulatory practice and scientific consensus." (Nuclear Waste Technical Review Board, First Report to the U.S. Congress and the Secretary of Energy, March 1990, p. 31.)

In addition, the criteria have been criticized by EPA's own Scientific Advisory Board:

"The Committee concludes that the EPA standard for disposal of high-level waste will have to be reevaluated to ensure that a standard that is both adequate and feasible is applied to the geologic waste repository." (Collier, H., Chairman, High-Level Radioactive Waste Disposal Committee. 1984. Report of Science Advisory Board. Letter to William Ruckleshaus. Report on Proposed Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes, 40 CFR 191. High-Level Radioactive Waste Disposal Subcommittee, Science Advisory Board, U.S. Environmental Protection Agency. February 17, 1984)

In 1987, the federal court remanded part of the EPA standard, effectively halting any NRC licensing process, because the NRC regulations had to be based upon the now remanded EPA regulations.

Senator Johnston, once again frustrated by the slow approach of EPA, successfully put into law a provision that the standards should be set based on a study of the National Academy of Sciences. In particular, the law asked the National Academy to answer three questions (Section 801, Energy Policy Act of 1992):

1. "Whether a health-based standard based upon doses to individual members of the public from releases to the accessible environment...will provide a reasonable standard for the protection of the health and safety of the general public".

2. "Whether it is reasonable to assume that a system for post-closure oversight of the repository can be developed, based upon active institutional controls, that will prevent an unreasonable risk of breaching the repository's engineered barriers or increasing the exposure of individual members of the public to radiation beyond allowable limits".

3. "Whether it is possible to make scientifically supportable predictions of the probability that a repository's engineered or geologic barriers will be breached as a result of human intrusion over a period of 10,000 years".

In the United States, spent fuel was stored at reactor swimming pools. The basic initial concept was that after 10 years this would have been transferred to a reprocessing facility. Once it was clear that reprocessing was not going to be done in the United States, extending life at the fuel pools was selected. Many utilities then reracked the spent fuel pools to increase their capacity. When the capacity began filling up even with the reracking, some large utilities with more than one plant shifted spent fuel from an older plant to a newer plant that had more pool capacity. In the absence of any off-site storage, other utilities have used dry-cask storage. This is sometimes called Independent Spent Fuel Storage Installation (ISFSI). At the end of 1993, five on-site dry-cask storage facilities had licenses from the NRC: Surrey (Virginia

Power), Robinson-2 (CP&L), Oconee (Duke), Fort St. Vrain, a closed plant in Colorado, and Calvert Cliffs (Baltimore Gas and Electric). Another plant, Palisades (Consumers Power) is using dry-cask storage under a general license. The first of these facilities was the Virginia Power facility that began in 1986. (Nuclear News, December 1993, p. 35, "On-site Dry Spent Fuel Storage: Becoming More of a Reality", Betsy Tompkins.)

A study done for decommissioning a United States reactor indicates that significant funding can be saved by using dry rather than wet spent fuel storage. For this particular plant, the Rancho Seco PWR, a total of 493 fuel assemblies had to be stored. Dry storage is estimated to save $7.5 million annually over wet storage, with the primary savings being in utilities staff. ("Spent Fuel Storage: A Decommissioning Perspective", Rita W. Bowser, Dan R. Keuter, N. R. Miller, Journal of Nuclear Materials Management, May 1991, pp. 13-16.)

Different Views

There have been many environmental objections surrounding nuclear waste disposal in the United States. Sometimes it is difficult to tell whether these are related to concerns about the hazard or to opposition to nuclear power. The latter opposition can be based on concern about safety, concern that the environment cannot be protected from nuclear waste, or that nuclear power is inherently linked to proliferation, which must be halted and reversed.

For at least two decades, the United States has been caught in a dilemma regarding nuclear waste. The two horns are positions taken by the technical community and by the environmental community. When I speak of positions of a community, the technical community or the environmental community, I do not mean to imply that every member of that community takes the position that I will attribute to the community. Rather, it is what I perceive to be the dominant view of members in that community, recognizing that, as with most distributions, there are tails on both sides of the peak.

The technical community supports the use of nuclear power. This community believes that nuclear power has proven advantages over fossil fuels relating to atmospheric pollution. The technical community also believes that the disposal of nuclear waste is a solvable problem, which has been solved, and that geologic repositories are not the hazard which the environmental community describes them to be.

One articulate nuclear proponent has concluded a repository would pose little harm, although he recognizes the public disagrees:

"There have been other scientific analyses of the high-level radioactive waste hazards using very different approaches that I believe to be less valid than mine, but they come out with rather similar results. They also find the health effects to be trivial...Nevertheless, there can be no question but that the fear abounds...Probably the best evidence for this fear is that our government is willing to spend huge sums of money on the problem. The fear is surely there. Perhaps the most important reason for it is that disposal of high-level waste is often referred to as an 'unsolved problem.'" (Bernard L. Cohen, "The Nuclear Energy Option", Plenum Press, 1990, p. 199.)

On the other side, the environmental community believes that nuclear power is not worth the risk. Environmentalists perceive that other sources of energy are eventually less environmentally damaging than nuclear power. The damage they see from nuclear power is a combination of that from accidents, to which they characteristically ascribe a higher probability and greater consequence than does the nuclear community, and to the lack of a convincing solution to handling the nuclear waste. This latter position was the underlying rationale for the State of California in the mid-1970's passing a law which banned the construction of any new nuclear power plants until the government had demonstrated that a current solution to high-level waste disposal could be developed. Given that, in the United States, radiation protection regulations are reserved by law to the federal government, this California position led to lengthy arguments in the courts. In the end, the lower courts upheld California's right to pass the law, and the Supreme Court chose not to review the case, accepting the argument that this was not a radiation protection law, but rather an economic law, in which the State of California was merely concerned about the economic burden imposed on the ratepayers, if there were not any demonstrated solution to the waste to be generated by the California utilities.

One ironic aspect of this environmental debate is that the pro-nuclear groups argued that the nuclear waste must be taken off the surface, where it is a greater hazard to individuals, and placed deep underground. Thus, the environmental community, arguing not to use a repository, is ironically in a position of supporting keeping the hazard in a position of potentially greater exposure and the technology community is advocating placing it in position of less exposure. Of course, underlying the environmental community's position is a mistrust and disbelief of those organizations, such as the Energy Department, that are advocating the underground repository.

This mistrust stems from the governmental policies of the past, which have been simply described as "decide, announce, and defend."

The principles that are supposed to be applied in a democratic society are that a potential decision should be announced well before the decision is to be made, with all the necessary data and analyses made available to any concerned citizen. After a reasonable length of time, meetings should be held between the concerned public and the government officials and their staffs to discuss the ramifications of the potential decision, to discuss what new information is needed, and to discuss any other issues relating to the potential decision.

This has seldom been done, particularly with nuclear waste decisions.

The technical community has tended in the past to take the position that their technical analyses should suffice for the potential impacted area. However, the technical community has taken its responsibilities seriously. The boundaries of the repository have been examined extensively. A problem that the environmental community sees is that the time scale of consideration is not the time scale of consideration in such related items as a nuclear power plant's operation. In a repository, there is not much doubt that a canister can be designed to contain the waste for hundreds of years and that a geologic site can be found to keep the waste from the accessible biosphere for an additional several hundred years after the canisters have failed. Thus, at a minimum, combining these two, technologists are quite confident that 1,000 year protection against the accessible environment is quite feasible. Longer times, even of an order of magnitude, are also quite possible.

However, the radioactivity will remain much longer than that, which means that the calculations will have to be carried out for that time frame, adding significant calculational uncertainty, as well as individual concern.

In addition to the nuclear community, the environmental community also has urged that action be taken, although not necessarily the same actions as the nuclear community suggests.

Matthew L. Wald, in the New York Times, quoted an environmentalist: "It is almost philosophical...we simply can't rely on distant generations to have the same sort of institutional controls over this very dangerous material that the current society does. We need to isolate this from the environment to the greatest extent possible, so we don't have to rely on distant generations to make sure that it's kept safely." ("Finding a Burial Place for Nuclear Waste Grows More Difficult", Science Times, 5 December 1989.) The speaker was Dan Reicher, then a lawyer at the National Resources Defense Council, who had won the case against the EPA's original standards and who is now Deputy Chief of Staff of the Department of Energy. (Quoted by Luther Carter op cit., p. 7.) Speaking in opposition to the AEC proposal of the early 1970's to build a retrievable surface storage facility, Gus Speth, now the Director of the U.N. Environmental Program and at that time another lawyer for NRDC, said "The big problem was, and is, that it implies long-term decoupling of waste from reactors. That is, we could have countless reactors without any assured means of permanent disposal." (Wald).

The nuclear power community is pushing for a repository. Some in the environmental community are thinking of other options:

"To leave a legacy that does not merely impoverish future life but may endanger it for millennia to come, constitutes an act of unprecedented irresponsibility." ("Nuclear Waste: The Problem That Won't Go Away", Nicholas Lenssen, World Watch Paper 106, December 1991, p. 44.) However, as critical as this World Watch document is towards the program of high-level waste disposal, not just of the United States, but for all nuclear power countries, Lenssen does note: "In recent years, a growing number of independent environmental researchers have endorsed the concept of long-term, on-site storage of nuclear waste." He is not in favor of a monitored surface storage site in which fuel would be brought together, but dry-cask storage on utility sites seems to be within his framework.

Part of the difficulty in reaching a conclusion that a repository should be constructed now is related to the uncertainty of the estimates of long-term releases. In 1991, the OECD published an international collective opinion "Disposal of Radioactive Waste: Can Long-Term Safety Be Evaluated?", which states "...it is recognized that the long-term safety of the solution offered must be convincingly shown prior to disposal." It is "convincingly" that those opposed to going ahead with a repository have not been shown, i.e., they do not believe that a convincing case has been made that the current repositories will be long-term safe. This OECD document goes on to state "Absolute proof of continuing safe behavior is impossible for all technical systems, including radioactive waste disposal systems. What must be achieved is a convincing and indirect demonstration that the proposed disposal system provides a sufficient level of safety to both current and future generations."

This statement really says nothing to resolve the dilemma. Because what are "convincing" and "a sufficient level of safety" are quite different for those opposed to a repository now and those advocating a repository now. The terms "convincing" and "sufficient" are judgmental, not objective. In the sections under "Judging Safety", the OECD document states "The treatment of uncertainties and safety assessments is, however, part of a wider issue: the necessity of *building confidence* in disposal system safety." (emphasis in original). At least in my country, confidence must be built in the process, not just the disposal system, and it is that process, at the moment, in which there is little confidence.

Intergenerational Equity

In addition to local objections to a repository and concerns about safety of the local (or current world) population, considerable discussion has focused on future generations -- what is the responsibility of the current generation to future generations, and how should that responsibility be met.

Some views are straightforward:

"...it seems clear to me that we should not punish our children and grandchildren today, in order to fend off wholly imaginary demons in the unforeseeable future. The human race itself is going to have a hard time surviving the 21st century in the face of uncontrolled population growth and other hazards, and our primary responsibility to future generations, towering above all others, is to leave them conditions under which they have a chance at survival. The misanthropic assumption that everything we leave them is bound to be bad is not supported by history....the technical problem of spent-fuel storage has several entirely feasible and satisfactory solutions...those who work so hard to prevent its solution must have a grudge against tomorrow's people. Why else would they seek to obstruct the reasonable solution of today's problems, solutions that can contribute to a better world for our children? Remember that the people of ten thousand years ago lived before any recorded human history. Then ask yourself how, even with the best of intentions, they could have made any contributions then to the solution of today's problems, like nuclear war or measles. It is just as absurd for us to try to project our own parochial values that far into the future." (Opening remarks by Harold Lewis, Chair of Panel on People Issues at Yucca Mountain, American Nuclear Society, New Orleans, LA, June, 1994.)

Several international organizations have supported the concept that future generations should be exposed to no greater hazard or risk than current generations. In its "Principles of Radioactive Waste Management" (Safety Series Number 111-F, February 19, 1994, draft safety fundamentals), the IAEA states: "The objective of radioactive waste management is to deal with radioactive waste in a manner that protects human health and the environment now and in the future without imposing undue burdens on future generations." (Paragraph 201).

The preceding paragraph 314, IAEA Principle 4, "Protection of Future Generations", states that "Radioactive Waste shall be managed in a way that predicted impacts on the health of future generations do not exceed relevant levels that are acceptable today." Principle 5, "Burdens of the Future Generations", states "Radioactive Waste shall be managed in a way that will not impose undue burdens on future generations." Principle 5 is explained as being "based on the ethical consideration that the generation that produces waste should bear the responsibility to manage it." (Paragraph 315). This document explicitly takes the position that it is the responsibility of the current generation to dispose of the material. The document goes on to say "Some activities, however, may be passed to a succeeding generations, e.g., the continuation of institutional control over a repository." (Paragraph 315).

Those most strongly supporting building a repository as soon as possible argue that the generator of the waste received benefits and, therefore, should handle the problem. In another version, this is called the "polluter pays principle". As you know, in environmental management, the "polluter pays principle" means that a polluting industry must pay for the cleaning up of any of the pollution it has caused. In general, industry has tried to slow down those initiatives, although some industries are extremely enlightened. In the high-level nuclear waste case, the industry is in favor of the polluter -- the utility industry and the government -- handling the waste and putting it into a repository.

The concept of intergenerational equity is difficult. Similar arguments have been made on population, on fisheries, on protection of the oceans, and on pollution of the atmosphere. That is, we must act now to protect the future. One issue that is seldom asked, and perhaps it is of only historical interest, is whether it would have been irresponsible to go ahead with nuclear power, if at that time, when nuclear power was beginning, it was known what we now know about how difficult it is to resolve the waste problem.

Some argue that actions such as siting and building a repository should require "informed consent". Since future generations are not giving informed consent to a present-day action, this argument concludes a repository should not be built. However, one can ask how can nonexistent people, future generations, have rights? Those asking this question will come from the philosophy that having a right must carry with it a responsibility. Since future generations do not have any responsibilities, then how can they have any rights?

It is true that future generations will inherit the world we leave to them. If we leave them with enormous debts, such as overpopulation, we have been irresponsible. If we can establish a concrete correlation between our actions and the deprivation of future generations, then one can clearly conclude that other actions must be taken. Therefore, we must look at any action and ask whether it is a benefit to the future generation. We have to operate in a context of uncertainty and we must accept certain risks for advancement.

If we look at the costs and benefits to future generations, a tally may look as follows:

Benefits. A major problem will not be presented to them, since the nuclear waste will have been disposed of.

Costs. If the method of disposal turns out to be inadequate, they may have a greater burden, because the waste may be more difficult to retrieve than had it been handled in some other fashion. The beneficial use resulting from any additional funds required to build and operate a repository versus storing the waste on the surface will have been lost.

However, arguing the fungibility of federal funds is never prudent. It is always easy to argue that if a project is cancelled that will free up funds for some other specific actions. Unfortunately, historical precedents, at least in my country, indicate that cancellation of a project and freeing up any monies seldom leads to those monies being targeted in the areas of those advocated by those in favor of cancellation. Cancellation of projects should be supported on the principle that going ahead with the project is an imprudent use of resources, not that there are explicitly better uses for the money.

I believe that the true cost of going ahead is the overriding of a state's wishes, or, to be more accurate, of the people of that state. There is a minor associated cost in that there may be better solutions in the future or that better understanding may modify the method of repository disposal, the location of a repository, or the concern of the public.

Impact Aid-or-Bribe

The Background Paper, asks: "Can risk, or responsibility for essential action, be imposed (on future generations) when the benefits are perceived to be incurred by others (the current generations) and, if so, under what conditions?" And "Do current generations have the right to make decisions today which would foreclose options of future generations?" (p. 9, emphasis removed.)

In the same long list of questions to be addressed is "Are resources devoted to assuring safety of radioactive waste disposal appropriately balanced with risks, given that these resources could be applied to other societal goals?" (p. 11, emphasis removed.) As mentioned, I do find that the "given" is not an accurate representation of what happens, at least in the United States. Another issue raised, "...is there an ethical basis for a 'host' community to receive some sort of compensation and recognition of the service that it is providing to society?" (p. 11).

This has frequently been characterized as a "bribe", those using this pejorative term sensing something illegal or inappropriate. On the other hand, in the United States, there had long been a tradition of providing impact aid to communities in which there were large numbers of federal installations. In the U.S., a federal government facility, such as a large military base or one of the Department of Energy's weapons production facilities, is not taxed by the local community. Of course, all of the workers at the DOE facilities and many of the employees of the military bases do live in the local economy, requiring services such as schools, fire departments, and police. Impact aid was designed to assist the local communities in meeting these additional requirements placed upon them by the presence of the federal facilities. However, proponents of significant impact aid to a local community where a repository would be located, they have been opposed on one of two grounds, either (1) such additional aid is not necessary, so long as the normal impact aid formulas are applied, and (2) such impact aid should not be provided because it is likely to make the local communities accept something which they would not, in the absence of such a lure. The concern of those advocating the second argument is that poverty-stricken communities will be forced to accept a hazardous facility because they are in desperate need of funds. This issue frequently is raised in the debates on environmental justice, where, it is charged, poor and often minority communities are disproportionately the location of unwanted facilities, such as toxic waste dumps.

Missing Elements

I believe the background papers for this Workshop illustrate two commonly missed elements of options and practices: a true mid-term solution, and consideration of the "stakeholders", i.e., those most likely to be affected by a repository.

In addressing the ethical issues involved in making decisions about a repository, it is useful to note that there are several factors, often neglected, that should be taken into account.

The people must decide the final solution. I do not see an overriding reason that this waste must be put underground now. High-level nuclear waste is not the case of some infectious disease that, if left unchecked, can cause wide-spread death. It is not the case of some natural event which could be forecast and mitigated, if action were taken early enough. Rather, it is the choice between near-term alternatives. Frequently the argument is couched as though the only options were geologic disposal, permanent surface disposal, sending the waste to the sun, or disposing of it in the deep seabed.

This list misses the actual situation by implicitly eliminating one option. The eliminated option is short-term surface storage, for example, for 50-100 years. The difficultly that I see in the United States, and perhaps in other countries, is a great reluctance on the part of the government and its advising technologists to consider that case. The overriding pressure is for something to be done "now", even though "now", in the best of circumstances, means not for another 10-15 years. The OECD 1991 collective opinion does, in its discussion of safety assessments, introduce the concept of risk: "Consequences must, therefore, be seen in the light of *how severe* they may be and *how likely* they are to occur, in order to assess the actual risks." (Emphasis in original.) Similarly, the discussion of cost benefit evaluation in NEA/RWM/DOC (94) 1 (p. 15) does introduce the concept of discounting of long-term health risks. However, I do not find anywhere in these documents the concept of examining the relative risk of going ahead with a repository or planning on surface storage for the next 50-100 years. It would seem that is a far more logical risk evaluation to be undertaken, if one truly wishes to consider the risk of various options.

The background paper provided for this conference has the same confusion that is present in many debates on these issues, namely, the discussion focuses on short-term solutions and permanent solutions, often called long-term, without recognizing there actually is a middle term.

Furthermore, I believe the public should be the decider of what should be done. This decision should be informed and the role of the technologist is to do that informing.

A first problem is lack of understanding of what is meant by "informing". "Informing" is not merely the technologists lecturing the public: "Scientists and engineers can help improve public understanding of policy issues and policy...Listen to and discuss issues with the public. The public's resources will be used and their lives will be affected by your technologies. This listening should be a true dialogue. A public hearing should be a hearing, not, as a recent New York City Board of Estimates meeting was described in a news account, only a "public talking." (John F. Ahearne, "Addressing Public Concerns in Science", Physics Today, September 1988, p. 41.)

Technologists and government and industry officials have much to learn about communicating with the public. This includes learning what should be called successful communication in a democracy: "The risk communication process -- usually with many messages from many sources -- can be considered successful only to the extent that it, first, improves or increases the base of accurate information that decision makers use, be they government officials, industry managers, or individual citizens, and, second, satisfies those involved that they are adequately informed within the limits of available knowledge. This does not always result in the responses a particular source might wish, nor does it always lead to consensus about controversial issues or to uniform personal behavior. People do not all share common interests and values, and so better understanding will not necessarily lead them all to the same conclusion. ("Improving Risk Communication", National Academy Press, Washington, D.C., 1989, p. 8.)

A second issue frequently adds confusion to technological discussions on subjects in which risk of some technological activity is involved. The affected public frequently is using a different set of values than are the technologists, the industry, or the government. It is because these values are different that even if extremely good information is presented, the final public decision may be in opposition to that of the technologists. A clear example was seen several years ago in Taiwan, when initial public polls showed there was opposition for building another nuclear power plant. The utility funded a major public education program, which appeared to be quite objective and quite extensive, focused upon both the safety of the reactor as well as the safety of the surrounding areas. At the completion of this careful campaign, which both sides agreed did elevate the understanding of the public, a second poll showed that the public was now more in opposition.

A third factor is the issue of providing long-term protection of the environment. This is goes back to the irony I mentioned earlier. Both sides in the dispute argue that they are providing long-term protection of the environment. Consequently, and I accept the sincerity of their views, this is a situation where the goal is the same and therefore the debate is about the means to achieve that goal.

A second missing element can be seen by examining the list of 16 questions in the background paper, in Section IV, "Environmental and Ethical Issues to be Addressed at the Workshop". Viewed from the U.S. perspective, particularly a perspective shaped by many debates in risk analysis and risk management, I find striking the absence of anything about the rights of current generations and any questions on who should do the assessing and the judging that is called for in these questions.

A technical solution is necessary, but not sufficient. The IAEA principle shares the same flaw. There is no mention of stakeholder rights.

I recognize that there are differences between countries. Differences in cultures, differences in governmental practices, differences in the role of nuclear power, differences in energy resources, differences in financial resources, and differences in the relative perceived need for development in environmental protection. I have found it quite difficult to sort these issues out in the United States and I make no pretense of being able to provide answers for other countries. Can permanent disposal of high-level waste be done? The technical community's consensus is "yes". The U.S. National Academy of Sciences took that position as far back as 1957. I note that the Netherlands also recently took that position (May 14, 1993, "The Position of the Dutch Government on Deep Burial"): "The conclusion [of the Lower House in 1989] was that a storage facility for radioactive waste in rock salt formations in the Netherlands would, in principle, be technically feasible." It should also be noted that the final position of the Dutch government was not to go ahead with such a facility.

There is some confusion about "what is being asked". For example, can a repository be safe for 1,000 years? The answer is "yes". Can it be safe for 10,000 years? The answer is, "most likely", especially if using appropriate canister design. Will it be safe for 100,000 years or 1 million years? At this point, uncertainty can grow large.

Is a repository necessary now?

(a) To prevent risk to the current public? I believe the answer is "no". There is a <u>caveat</u> on military waste, which has a different problem, in that some of the facilities in which it is stored are probably not safe and that the waste must be transferred from those facilities to others. Once so transferred, the answer would have been "no", it is not a risk to the current public.

(b) Is it necessary now for a "restart" of nuclear power? In the United States, there are many who argue that here the answer is "yes" and they point to the California law. However, I believe cost has killed the nuclear industry in the United States and that the presence of a repository is not going to have much of an effect.

(c) Then why is it necessary now? The arguments are on intergenerational equity and ethical considerations. However, if those are the reasons, we must look at the United States in a democratic society and, therefore, take into account the people's views.

We have been told that this workshop does "not deal in any detail with specific features of licensing systems and regulatory review processes such as the setting of safety standards, consultation and decision-making procedures, the use of an independent peer review, etc. Similarly, perception, communication, and other social and public acceptance aspects related to the practical implementation and siting of specific waste disposal systems are not covered either." (NEA/RWM/DOC (94) 1, p. 6.) However, these are not merely additional features of the process to be addressed after the technical decisions have been made. In a democratic society, these are the heart of ethical practices and considerations. Leaving them out, or leaving them until last, reinforces the view of the general public who, in a democratic society are the fundamental decision makers, that the technical community does not really want to consider their views and does not want to take into consideration the true ethical practice of involving those most effected.

Finally, I note that the background paper written for this conference does quite explicitly lean on the United Nations Conference on Environment and Development (UNCED) (usually called the Rio Conference, since it was held in Rio de Janeiro in 1992). The background paper notes that UNCED used "sustainable development" as its main theme and the report defines this as "satisfying the needs of the present without compromising the ability of future generations to meet their own needs." The concept of "sustainable development", once enthusiastically endorsed, has become questioned since Rio, primarily because of its apparent emphasis upon continuing development. It is starkly true that the world suffers great disparities between standards of living, poverty levels, food, clothing, and medical care. As the ardent pro-nuclear Bernard Cohen remarked, after having studied health related effects worldwide: "...it is abundantly clear that wealth makes health, and poverty kills". (Cohen, op cit., p. 122.) Thus, with its emphasis on development, "sustainable development" may be interpreted by the developed countries that the call is for their continued development. The follow-on activities to the Rio Conference instead have begun to stress the need to constrain the developed world, while at the same time empowering the developing world to alleviate hunger, terrible health conditions, and stark poverty. The role of nuclear power in doing that is highly questionable and is an entirely different subject. I only mention this because I found it slightly unusual to find the concept of "sustainable development" being used as a framework item in the background paper.

Procedures in a Democratic Society

In 1984, the NEA Secretariat addressed "The question of an obligation towards future generations". The "Long-term Management of Radioactive Waste: Legal, Administrative and Financial Aspects" suggested that a reasonable compromise on the question of moving ahead now versus forestalling decision "should be based on this elementary notion of fairness: 'At a minimum, the current generation should not pose larger risks on a future generation than it would be willing to accept for itself.'" (Paragraph 17, p. 41.) In this, the NEA was quoting a 1978 EPA Proposed Criteria For Radioactive Waste. The NEA went on to suggest that "the economic and social cost of the risk should be added to this formula." (p. 41). While not going much beyond that statement, the NEA did conclude that "it seems reasonable not to bequeath to future generations[,] along with the benefits of a given technology[,] risks -- or the burden of needing to protect themselves against such risks -- of a level that we ourselves would not deem acceptable or which would effectively outweigh the direct or indirect benefits they would acquire from the technology in question." (pp. 41-42). The NEA concludes that, in practice, "the political authorities will define the acceptable level of risk from radioactive waste with regard to the population for which they are responsible, taking into account the social advantages of the activities given rise to this waste and the social cost of waste management." (p. 43).

The issue then is how should the political authorities proceed, in a democratic society.

In a democracy, the people decide what should be the government policy. Thomas Jefferson, a major figure in the early formation of the United States, wrote:

"I know of no safe depository of the ultimate powers of the society but the people themselves; and if we think them not enlightened enough to exercise their control with a wholesome discretion, the remedy is not to take it from them, but to inform their discretion by education." (Thomas Jefferson, letter to William Charles Jarvis, September 28, 1820, "Writings of Thomas Jefferson", Paul L. Fork (ed), Vol. 10, 1899, p. 161.)

One method used in the United States to involve the public is the rule-making procedure. In rule-making, a federal agency drafts a regulation and publishes it for comment. The public has typically 60 or 90 days to provide comments back to the agency on the draft regulation. By law, the agency is then required to review those comments and respond to them. The agency does not have to accept the comments, but does have to provide a reasonable response, in writing. Once the agency has published its final regulation, it is open to court challenge on the grounds that it did not adequately respond to the comments. The courts have sent regulations back to the initiating agency, judging that the agency had been "arbitrary and capricious" in dealing with the comments. The advantage of the rule-making process is that it does enable public policy to be set in areas in which science is uncertain, but yet a federal agency must establish a position.

Why a Repository Now?

As I mentioned earlier, I do not see a major hazard associated with surface storage for many decades, and I have not seen a risk analysis comparing 50-100 year surface storage with going ahead with a repository. I also believe that the major problem nuclear power has, at least in the United States, is cost.

In looking at the impasse the United States seems to have reached on nuclear waste disposal, I reached the conclusion ("Proceedings of the First MIT International Conference of the Next Generation of Nuclear Power Technology", MIT-ANP-CP-001, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1990.) that there are four possible solutions:

(1) I refer to an individual in American History, Daniel Farragut, for the Daniel Farragut Solution. In a battle during our Civil War, Daniel Farragut, in charge of a warship, ordered his captain to go ahead full speed in spite of weapons in the water. This is frequently quoted, possibly correctly, as "Damn the torpedoes. Full speed ahead." This approach can be seen in the "decide, announce, defend" approach mentioned before and also in the Congressional selection of Nevada, as the winner of the nuclear waste lottery.

(2) A second solution is the technological solution. Advocates of this approach believe that there must be a significantly improved technological fix to our current problem. They look for a method that will satisfy a risk assessment criteria. Several have been suggested in the past, included sending the material to the sun or deep sea bed disposal. Another more recently debated and discussed solution is to burn the actinides in a fast reactor. None of these approaches have proven to be economic or publicly acceptable. Most recently, in the United States, Congressional action has supported the current Administration's proposal to close down the Integral Fast Reactor program, one of whose stated goals was to demonstrate actinide burning.

(3) A third is the Magic Land solution. Since there are so many objections at siting repositories, in the United States, in France, in England, and, I suspect, elsewhere, this approach is based on the belief that somewhere there is a perfect location. This perfect location would be one where no one lives now, and it can be shown that no one ever will live there. And preferably there is absolutely no risk involved in bringing nuclear waste material to that location. Although this may seem to be an absurd description, it is an inference that can be drawn from the description of what would be required for some opponents to agree that a solution would be acceptable.

I must note that I sympathize with these opponents. They suspect that no government has been serious about finding an environmentally acceptable solution.

(4) The fourth and final solution is to wait. In this approach, an interim solution would be required, such as the one mentioned by World Watch, that is, storing waste at reactor sites, perhaps in dry storage or above-ground casks, or perhaps sending the spent fuel to a central location. This wait approach is the default that has been used for the last 30 years for commercial waste in the United States and elsewhere. Unfortunately, this solution has not obviously been deliberately chosen, but has resulted from not being able to take action. As Harvey Cox has said, "not to decide is to decide".

In a process that seems to place greater concern on future generations than the present, some argue we cannot solve the repository problem because there are too many unknowns. Others argue that we must build a repository, even if that means overriding the wishes of the local, and most affected population. Risk analyses have not been done of mid-term options. The wait option continues to be chosen.

Acknowledgments: I am grateful for discussions with Robert Budnitz, Harold Lewis, Richard McCormick, and Gilbert White. This paper has been funded by a grant from the U.S. Nuclear Regulatory Commission.

Radioactive Waste Disposal - Ethical and Environmental Considerations - A Canadian Perspective

Fred Roots
Science Advisor Emeritus
Department of Environment (Canada)

Introduction

The national institutions and policies of any country reflect not only the practical and political problems and opportunities that the country must deal with and the political and economic means available to deal with them, but also reflect the mores and ethos of the societies that comprise the country. The mores and ethical values of each country tend to be distinctive - they are a large part of what constitutes the distinctiveness of each nation -, and are a compound result of the various cultures, histories, geographical and environmental situations, resources, economies and other influences that shape the collective character of its citizens. Thus, different countries may develop different policies and distinctive approaches to formulation and implementation of policies, even when responding to similar issues. The issues of management and disposal of radioactive waste present similar or nearly identical technical challenges to several industrialized countries, yet nearly every country has a somewhat different response. The way that this issue is being addressed reflects to a large extent the ethical and cultural characteristics of each involved country. The actions being taken by Canada and the institutions and processes through which the decisions are made are an expression not only of Canada's scientific and technical capacity but the nature and evolution of environmental consciousness and ethical values of its citizens.

Canadian Attitudes Toward Nature and the Environment

The relationship that Canadian citizens in general have to "the environment" and to "the future" differs in several ways from that of most other countries with developed nuclear energy. This relationship has influenced Canada's energy policies and the structure of institutions dealing with energy and environmental protection, and thus has influenced the Canadian approach to management of the nuclear fuel cycle. Canadian society is perhaps more heterogeneous and rapidly changing than most of its "nuclear energy" neighbours, and so generalizations about attitudes and causes are perhaps foolish; yet one characteristic that is surprisingly deep and widespread in Canada, compared with many other countries, is awareness of and concern for the natural environment. Part of this awareness comes from the Canadian climate, geography, and history. The climate, with long cold winters in most parts of the country, wide regional climatic differences, and frequency of extreme weather events makes all Canadians continually conscious of the natural environment. Canada is a predominantly urban nation - 85 per cent of the citizens live in settlements of more than 20,000 people -, yet most of the country is very sparsely settled. Most Canadians have easy access to essentially "wild" countryside, and carry a mental picture of Canada as a predominantly "natural" land. The country's economy, also, has throughout its history been closely connected with the natural environment. The indigenous inhabitants developed cultures and economies closely attuned to the varieties of climate and living resources in different parts of the country, with a well-developed regional trading network that was tapped into by continent-wide commercial fur trading companies in the seventeenth century to establish the beginnings of "modern" European-type economic policies and administration. When European settlers came to Canada in the seventeenth to nineteenth centuries and established the present economic and political institutions of the country, they were challenged to defend against or "overcome" what seemed threatening Nature, and to make a living from her abundant natural resources; to adapt to a harsh climate and to use technical ingenuity and lots of energy to cope with it; to learn from the experience of resident natives and at the same time attempt to copy or transplant their immigrant institutions and cultures.

This complex background, compressed into a couple of centuries in a land where, compared with much of inhabited world, the environment is a difficult one in which to make a good living, has given Canadians an intense but ambivalent feeling about Nature and environment, about natural resources and about developed energy. The concern and ambivalence is displayed in our daily practices and our institutions. Canada has more artificially heated indoor space per capita than any other country; Canadians are the highest or second-highest (depending on how it is calculated) consumers of mechanical, electrical and thermal energy per capita; we spend a much larger portion of our national income on maintaining year-round transportation and communications services. Canadians are said to talk about the weather more than any other people except sailors and aircraft pilots, and it has been observed that Canadian radio and television stations devote twice as much time to weather forecasts and commentaries as their counterparts in Europe or Japan. Despite efforts to focus on cultural or other attractions, tourism in Canada, both domestic and foreign, is overwhelmingly Nature-oriented; and despite the presence of Nature on the doorstep of most cities (or perhaps because of it), Canadians at all income levels share with the Nordic countries the highest percentage of "second houses in the country" occupied only part of the year, in as natural setting as possible, to satisfy a psychological yearning to be close to a natural environment and yet, somehow, to be in control of it.

These behavioural characteristics, combined with rapid social, economic and demographic changes and changes in landscape and use of resources within living memory, has developed among Canadians in general a sense of time that is also possibly nationally distinctive and different, in general, from that of our neighbours to the south or in Europe. There is a pervasive sense of change:- change in natural conditions and environment as much as social and economic change. Most citizens or their immediate ancestors are immigrants who left a more stable society and more uniform environment for a "New World" that was visibly becoming different, partly through their own efforts. Even the abundant evidence of the recent Ice Age, showing clearly that the land was drastically different not long ago, reinforces a widespread awareness that both Nature and society in Canada are evolving from generation to generation. Canadians of indigenous ancestry have no less seen their entire world change under their feet, and yet their cultures, closely attuned to dynamic Nature, do not in general seek stability but place these changes in a long-term fluid perspective.

The deeply embedded collective environmental consciousness and sense of change have given Canadians in general a relatively long time perspective, without, as a whole, sharing fully the optimism for an expanding future that is cultivated vigorously in the United States or the awareness of continuity that is characteristic of much of Europe. Although there are many exceptions to any generalization, many analysts and commentators have noted that Canadians collectively tend to be more cautious and at the same time less conservative than citizens of many other industrialized countries, "addicted to moderation in excess" as a famous Canadian author, Stephen Leacock, put it, but ready to experiment. They appear to be less optimistic that change equates to progress, and less alarmed by disasters. This time sense and cautious gambling on the future affects Canadian investments, resource policies, and decisions about the environment. It clearly influences the approach to long-term issues like the management of radioactive waste.

Canadian Institutions Reflecting an Environmental Ethic

Canadian political structures and institutions, also, display the national awareness and importance of natural resources and natural environment. The dependence of the economy on natural resources is reflected in the Canadian Constitution, which determines the institutional structure of the country by allocating authority over such resources, with a few exceptions, to provinces rather than to the national government. One of the exceptions where the central government has responsibility is nuclear fissionable materials and their radioactive products. The value placed by Canadians on the natural environment in terms other than economic utility is shown by many examples in which Canada has led other countries in acts to preserve or conserve natural values. Canada was one of the first countries to set aside forest reserves and national parks (the first Canadian park in 1887 "to maintain natural beauty for all time for the benefit and enjoyment of future generations")[1]. In contrast to the "conservation movement" in some other countries that was led by a few concerned and influential individuals, environmentally related political developments in Canada have been based for the most part on widespread public interest, well before "environment" became a political term. Public concern about the disappearance of well-known animals led to establishment of preserves to protect bison (from 1914), prairie antelope (from 1916), and Canadian leadership in international legislation to protect migratory birds, and polar bears. Although there have been game wardens to protect private or royal lands for many centuries, Canada appears to have been one of the first to establish a "wildlife service" as a government office, with nation-wide responsibilities for conservation rather than management for exploitation. Today, Canadians support a network of parks, preserves, reserves and conservation areas established at all levels of government; citizen committees with political influence continually monitor the status of wildlife and wild plants. Environmentally-minded industry enjoys a rapport with citizen vigilante groups that, while not without clashes and disagreements is co-operative to a degree unusual in the United States or Europe. Canada's flag carries not the colours of its political history but a natural symbol endemic to every province:- a common maple leaf. And our national symbol is not an animal of power or dominance, but a ubiquitous hard-working rodent who uses the natural environment for practical purposes:- the beaver.

These examples of the consciousness of nature, environment and changes with time in the Canadian psyche are manifest in the national approach to modern environmental issues. When in the late 1960's the effects and threats of industrial pollution and inappropriate land use called for political action in many industrialized democracies, several countries responded by creating ministries or offices for environmental protection. The Canadian government accommodated the widespread environmental ethic not by emphasizing pollution control but by bringing together, under a single Minister, the "positive" environment-related functions that had until then been parts of disparate Ministries:- meteorological services, forestry, wildlife, fisheries, hydrology, marine science - and adding to them an environmental protection unit. Such an approach fitted well the Canadian jurisdictional structure and the Canadian mood that the environment in all its forms was a dynamic natural resource and the setting for all our actions, but it was out of step with many other countries in which political action in the environment meant confrontation with polluters and authoritative defense of environmental quality. Canada however attempted to promote this concept in playing a strong role in the United Nations Conference on the Human Environment in 1972,[2] and in the establishment of the United Nations Environment Programme. In 1974, an in-depth review of the organization and outlook for environmental policy responsibilities in Canada concluded

> "The co-ordinating role of the (federal ministry of environment) needs to be strengthened, not at the expense of its pollution control operations, but as an essential part of long-term integrated national planning. This commitment would bear witness that our irresponsible "smash it and patch it" days are over, that we now accept the role of "custodians for the future" - and that Environment is no longer a purely physical concept but one with ethical dimensions."[3]

It is within this institutional policy and ethical context that Canada has developed its approach, policies and programmes for management and disposal of radioactive waste.

The Development of a Canadian Radioactive Waste Management Policy

Design of Canadian nuclear fission power reactors started in the 1940's and the first plants were put into commercial service in 1962. All nuclear power plants in operation in Canada are heavy water (D_20) moderated and use natural uranium fuel in $U0_2$ pellets. The fuel wastes from such reactors, after average burnup of approximately 650 GJ/Kg U, contain about 0.22% ^{235}U, 0.38% total plutonium (0.26% ^{239}Pu) and 0.76% fission products, mainly ^{85}Kr, ^{90}Sr, ^{99}Tc, ^{106}Rh, ^{129}I, $^{135,137}Cs$, ^{144}Ce. The UO^2 pellets are physically intact, contained within a zirconium alloy sheath in bundles each 10 cm. diameter, 50 cm. long and weighing about 24Kg[4]. There are no plans in the Canadian programme for re-processing spent fuel or break-up of the bundles to recondition the waste. The current (1994) accumulated inventory of spent fuel in Canada is about 720,000 bundles, or about 1800 tons, which is being added to at the rate of 70,000 bundles per year.

As the spent fuel decays, the radionuclides and fission products migrate to or are developed at boundaries of $U0^2$ grains, gaps between pellets, and on linings of sheaths or bundles of containers. Some fission product gases are produced (^{85}Kr is of short-term concern). The fuel bundle is highly radioactive upon removal from the reactor. After storage for one year in water-filled bays, the radioactivity typically decays to about 7.3×10^{14} Bq per bundle, with heat output of 78 watts. With the presently constituted fuel and bundles, radioactivity will fall to 7×10^{12} Bq after 100 years, with heat output about one watt; and to 1.5×10^{11} Bq and negligible heat after 10,000 years[5].

The long-lived radionuclides in the typical CANDU spent fuel - ^{14}C, ^{99}Te, ^{129}I, ^{135}Cs, $^{234,238}U$, ^{237}Np, and $^{239,240}Pu$ are critical to environmental safety and environmental control [6], and are the focus of waste disposal planning and assessment. Their specific characteristics, and the possibility of their migration into the environment, are the subjects of the technical aspects of waste disposal. It is, however the threat or perception of a possible threat of environmental or health impact from any of the nuclides individually or the wastes collectively (plus concerns over the existence of separated plutonium) and the apparent requirement for an elaborate and expensive technical facility to provide safety, that lies at the basis of the ethical concerns. Right from the beginning, Canadian nuclear fuel waste gives rise to two different kinds of concerns:- engineering and ethical.

Technical studies to develop a concept for safe disposal of nuclear wastes started in Canada about 1970, with examination of the potential of various rock types for underground disposal.[7] Public concern over nuclear power programmes focused largely on the perceived dangers of reactor unplanned releases and accidents, and on uranium mines. Questions of the environmental safety of the waste disposal were left mainly to the "experts". The first formal Environmental Assessment and Review of a proposed nuclear generation station installation in Canada, for Point Lepreau, New Brunswick, in 1974-75 (which also was the first occasion in Canada when an open public hearing was conducted under the newly established Environmental Assessment Review process), gave surprisingly little attention to the issue of waste disposal. Although the submitted briefs were 5 to 1 against the proposed nuclear power plant, almost all were concerned with fears of environmental damage from routine discharges, particularly into productive coastal fishing waters; with questioning the need for more electricity; with the physical safety of the proposed plant; and with the political decision-making process. In its report (1975), the Environmental Assessment Panel accepted at face value the reassuring statement from the government agency that the fuel waste would be safely looked after by means as yet unspecified, but added:

> *"The Panel feels that government policy with regard to long term storage, and ultimate disposal of highly radioactive wastes should be developed expeditiously. Furthermore, in development of this policy, public discussion on salient points should take place."*[8]

In 1975, Atomic Energy of Canada Limited, the government agency responsible for developing the technology of nuclear power in Canada, decided to focus research on radioactive waste management on the concept of permanent disposal in plutonic rock in the Canadian PreCambrian Shield. A primary reason was that such rocks were abundant and the chances for finding a suitable site were seen to be good in the same region and political jurisdiction where the main production of fuel wastes could be expected in the next decades. Increasing public pressure for a national policy that would address safety and environmental concerns over wastes from nuclear reactors[9], and the need for a policy that would guide both the utilities and the regulators led to establishment in 1977 of an independent study on the magnitude and nature of the problems of long-term storage and disposal of radioactive wastes. The study focused on technical aspects and on safety to humans. Its report, which became known as the Hare report[10], was delivered in August 1977. It concluded that "there are good prospects for the safe permanent disposal of reactor wastes and irradiated fuel", and foresaw no reason to delay Canada's nuclear power programme, provided the government undertook a recommended research and development programme. Among the various options for disposal, the study group considered deep underground disposal in igneous rocks to be the most promising. It recommended that there should be initially one site, located in Ontario, owned and managed by the federal government, but paid for by charges against the organizations producing the wastes. However, the Government of Canada should finance all the costs for developing the technology for safe storage and disposal of radioactive wastes. It also recommended that "no commercial fuel processing plant should be approved in Canada until fully satisfactory methods for dealing with the associated wastes had been developed". It was the opinion of the study group that "we expect no environmental or health impacts once the wastes and irradiated fuel have been emplaced in the depository."

Despite the fact that it was widely criticized on both conceptual and technical grounds, even to being publicly called "an embarrassment to the Canadian scientific community" by a leading Canadian scientist in the subject[11], the Hare report became a principal basis for Canadian policy and institutional developments with respect to nuclear fuel wastes. The recommendations facilitated formal endorsement and financial support for research and technology development that was already started by Atomic Energy of Canada Limited. At the same time, the focus on technical issues and the fact that ethical questions or environmental values were ignored by the Hare study, just at a time when environment impact assessment processes were receiving much attention in Canada and public concern about the way that nuclear power issues were being made had led to powerful but responsible citizen's groups like the "Committee on Nuclear Issues in the Community", served in a paradoxical way to enhance public awareness of the role of waste disposal in the public debate over environmental and ethical aspects of nuclear power as one of the energy options for Canada.

In 1978, the governments of Canada and of the province of Ontario entered into an agreement to co-operate in the development of technologies for the safe, permanent disposal of Canada's nuclear fuel waste.[12] Under this agreement, the federal corporation, Atomic Energy of Canada, Limited, is responsible for research on immobilization and disposal of waste material, while the provincial utility, the Ontario Hydroelectric Corporation, is responsible for research on interim storage and transportation of spent fuel. This agreement has led to the initiation in 1981 of a co-ordinated long-term research and development programme:- the Canadian Nuclear Fuel Waste Management Programme, that was to lead to a "concept" for waste management and disposal that would be submitted to formal environmental assessment and review, with public examination, for approval before a disposal site would be selected and a disposal programme would be embarked upon[13]. This programme then became the focus of Canadian public and policy interest regarding the technical, philosophical and financial aspects of radioactive waste.

In 1984 and 1986, the Canadian licensing and regulatory agency, Atomic Energy Control Board, issued "consultative documents" that set forth the criteria to be met by a depository for radioactive waste before it would be approved in Canada. The general requirements are that (a) burdens placed on future generations must be minimized; (b) the environment be protected; (c) human health must be protected. The criteria stipulate that the region in which the depository is situated should be geologically stable, that the host rock should be shown to be capable of withstanding stresses imposed upon it or caused by the depository, that the risk to humans from radioactivity emissions from the waste be predicted quantitively for at least 10,000 years (with an acceptable level set at less than 10^{-6} serious health effects per year), and that reasoned arguments must be presented that there will be no dramatic increase in risk following the initial 10,000 years after closure[14]. These criteria provided the "targets" for the Canadian Nuclear Fuel Waste Management Programme, and for the public comment and criticism.

Establishment of Formal Assessment and Review Process for a Nuclear Fuel Waste Disposal Facility

In September 1988, Atomic Energy of Canada Limited submitted for assessment and public review its concept for disposal of nuclear fuel waste. The Federal Environment and Assessment and Review Office (FEARO) set in motion the formal process of environmental assessment, and the Minister of the Environment appointed in October 1989 a Environmental Assessment Panel of independent citizens to review the safety and environmental acceptability of the AECL concept[15]. The Panel conducted a series of public information and "scoping" meetings at various locations across the country to obtain a perspective of the views and concerns of citizens, businesses, environmental groups, indigenous and religious organizations and government agencies at various levels with respect to the most important questions that should be addressed in an assessment of the social, technical and environmental acceptability of a concept for geological disposal of nuclear fuel waste. Based on these hearings, on its own discussions, and with the aid of an arms-length scientific advisory body of technical experts, the Scientific Review Group, the Panel issued in March 1992 "Final Guidelines for the Preparation of an Environmental Impact Statement on the Nuclear Fuel Waste Management and Disposal Concept"[16].

The guidelines state in detail the issues to be addressed by the Environmental Impact Statement. The statement is to outline the scope of the problems presented by nuclear fuel waste in Canada, the management and disposal concept, the characteristics and the expected performance of the components of the concept. The guidelines require the proponent to forecast and explain the social, economic and environmental impacts of the implementation of a disposal facility and of the contents of the proposed disposal vault on humans, human communities and the environment to be expected at the site to be selected if the concept is approved. The proponent is required to consider the different viewpoints of society when presenting its Environmental Impact Statement, particularly the viewpoints of aboriginal peoples and the viewpoints of other public groups that have a significant potential of being impacted. Ethical and moral perspectives, along with social issues are to be addressed as providing the broader context for focused considerations of a technical, scientific and economic nature. The guidelines also ask the proponent to consider and discuss the changes in human communities and the natural environment that can be expected over the period of time that the facility is designed to be effective in accordance with the AECB criteria, and how such changes may affect the performance of the facility. The risks of unforseen events and their environmental, health or social consequences are to be considered, and "the EIS should also discuss the ethical dimensions of disposal vault closure in relation to possible long-term impacts on humans and the natural environment."

The Guidelines issued in March 1992 form the basis of the Environmental Impact Statement currently being prepared by Atomic Energy of Canada Limited which, as of this writing, is scheduled to be submitted to the Panel in October 1994. This Statement is being preceded by nine Primary Reference Documents that provide technical detail to various aspects of the concept. These documents are all public and will be the basis of comment and review by the Panel, by its Scientific Review Group, and the interested public[17].

Studies of the Ethical and Risk Dimensions of Nuclear Waste Decisions in Canada

In view of the evidence of an increasingly important role that issues of risk and of ethical values would play in the assessment of the public, policy, and environmental acceptability of a generic concept for management and disposal of nuclear fuel waste in Canada, the Panel in 1992 identified a small advisory group, the so-called Risk and Ethics Team, to look in more depth into those aspects of the subject that were of social concern but were not amenable to resolution by study and analysis from the physical, biological and financial aspects alone. There has been much attention in recent years to various aspects of risk perception and risk analysis as it applies to decision-making and public acceptance of controversial decisions, and to the psychological and ethical bases of attitudes toward nuclear energy in general and waste disposal in particular. The international literature on these subjects is quite large. However, much of it describes the situation in countries where the decision-making process is different than in Canada and where the various public opinions have different complexities.

The Department of the Environment of the federal government (Environment Canada), which has undertaken scientific studies of various aspects of radioactivity in the environment since 1974, was in 1988 committed by the Government of Canada to carrying out a review of the AECL concept assessment to ensure that all environmental factors were adequately addressed [18]. Among the areas given attention by the Department in fulfilment of this commitment were consideration of the possible effects on environmental processes independently of their current or perceived importance to humans, and of the various dimensions of assessment of social acceptability. In its interim 1992 report "Defending the Environmental Standpoint"[19], the Environment Canada study group pointed out that standard methods of public involvement and social assessment cannot be used for assessment of a concept that is at the time of review only a proposal, because no specific site or environmental situation is being assessed, and because the long period in the future during which protection must be assured makes evaluation based on experience or comparisons impossible. Therefore, analysis of physical or economic or cultural impacts must be replaced by discussion of broad national or regional perceptual issues. These issues are based in ethical concepts and societal values which must be openly recognized and respected if the concept is to be assessed by the authorities and the public. The group recommended that direct involvement of the public must be assured at all stages in decisions about the waste disposal process from concept assessment to siting and construction; and that education and community discussion be genuinely two-way, rather than provision of information from the technical experts to the public, as has commonly been the practice in the past. It suggested that separate but related strategies be developed for dealing with public involvement and with social impact assessment, and "that social acceptability based on moral and ethical values will be as important as technical acceptability in terms of assessing the overall acceptance of the concept."

The Environment Canada teams have further pursued investigations into issues raised by various assumptions and lines of evidence related to the relative responses of humans and other living organisms to different levels of ionizing radiation, and are examining the claim sometimes made that if human beings are adequately protected, the living environment as a whole will be protected.

The various published studies on risk and ethical questions, the questions raised by the recommendations from Environment Canada, and the wide range of thoughtful opinions expressed by a variety of Canadians at the "scoping" meetings organized by the Panel, have provided a basis for some comparison and analysis of Canadian attitudes toward radioactive waste disposal and the Canadian environmental assessment process.

The Canadian Societal Response to Issues of Radioactive Wastes

The terms of reference of the Environmental Assessment Panel state that in its review of the safety and acceptability of the management and disposal concept developed under the Canadian Nuclear Fuel Waste Management Programme, the Panel will take into consideration "the degree to which we should relieve future generations of the burden of looking after the wastes"[20]. It was also instructed to examine the "social, economic, and environmental implications of a possible future nuclear waste management facility". Thus the Panel is obliged to take ethical and environmental considerations, together, in its review.

In accordance with this remit, and in anticipation of the Environmental Impact Statement that will address a wide range of social, ethical and environmental issues as required by the Guidelines, the Panel and the Risk and Ethics Team have undertaken and commissioned a number of studies. These studies have reviewed the published literature and analysed the material submitted to and presented at the "scoping" meetings held by the Panel across Canada, in order to elucidate the value systems adhered to by those who generally supported nuclear-generated power and the concept of geological disposal of the wastes, and by those who in different ways were opposed to or highly sceptical of the nuclear fuel cycle as a component of energy generation in Canada. In some cases, the different value systems were directly apparent from the literature or the presentations. More often, they were more subtle and became apparent only when several statements were grouped or compared.

Even though it is not the mandate of the Environmental Assessment Review Panel for the Nuclear Fuel Waste Management and Disposal Concept to examine the energy policies of Canada and its provinces or any aspects of nuclear power plants as such, it was no surprise that during the "scoping" hearings the public did not accept this limitation, and insisted in commenting on the whole nuclear power "business" and not just the matter of waste disposal. The published literature on radioactive waste disposal, also, frequently puts the examination of the technical aspects of waste into the context of the system that generates the waste and makes the policy decisions about its management. These broader viewpoints have helped make apparent the underlying value systems to which people adhere, and which condition their approach toward acceptability or rejection of a waste disposal concept.

An understanding of the value systems held by people concerned about or likely to be affected by the use of nuclear power for electricity generation is an important part of assessing the ethical and subjective environmental implications of decisions about management and disposal of radioactive waste. The concept of risk to health from buried waste, mathematically very small and outside direct human or medical experience and yet overlain with all the associations of wartime holocaust, reactor accidents, and mistrust of mysterious highly technical science, is as much psychological as rational; and the very long time frame for safety criteria, longer than the time span of human civilization, places the evaluation beyond the analyses of economics and political forecasting. Thus it must be societal value systems - gut feelings that whatever is done is correct and sensible or is somehow "terribly wrong" - that determine acceptability or non-acceptability.

The issues raised by nuclear fuel disposal and the policies and decisions that must be made about it fall in Canada into two main categories. There are convincing arguments that we must take a pragmatic and technical view:- we have the waste on hand and are adding to it about 200 bundles of "hot stuff" per day; it is not an immediate threat but a permanent solution or disposal will have to be found before managing it becomes a high cost and could become a threat to health and the environment; and the sooner we decide what to do and begin to invest in doing it, the cheaper and safer it will be for all of us and our descendants. At a somewhat different level there are genuine concerns about the fact that we have the stuff in the first place; that emphasis on processes and technical details of dealing with the problem presently on our hands may be lulling society into acceptance of an intractible problem and encouraging industry and the economy into continuing practices that will make the future problem worse. Both of these categories are issues of genuine concern about the present and future environment, and about the safety and well-being of present and future human generations. It is probable that many Canadians appreciate, quite strongly, both categories of concern. In Canada at least, the issues and debates are more complex than pro-nuclear and anti-nuclear, although there is some of that in facile statements and, as elsewhere, nuclear power issues and waste disposal issues are used as vehicles to express dissatisfaction with government, business, industrial power, or the decision-making "Establishment". But the deliberate and protracted public assessment of a concept for disposal of fuel waste, which will take at least six years of investigation and discussion before approval is given to select a disposal site and thereafter another fifteen years and a lot more money under continual public scrutiny before any waste is actually "disposed", has given Canadians at large a chance to examine their own value systems and sustained ethics, to put nuclear energy and national and regional energy policies into a larger and longer-term economic and societal perspective, and to consider not only the costs and possible consequences of any decisions made at this time but also the costs of no action.

Differing "World Views" and Value Systems

An analysis of the values expressed in the presentations and submissions made to the scoping hearings held across Canada in 1990 shows that, at that time, Canadians expressing themselves on the subject of nuclear fuel waste management did so, in general, from the basis of one or other of several distinct "world views" about society, economy, environment, and the place of humans as individuals or as citizens. The following comments in this section are based mainly on the work of Ann Wiles[21], who is undertaking a detailed scholarly analysis of the ethical assumptions revealed in the interventions.

One social value system, which for simplicity I shall here call the energy/economy position although that term does not describe it very well, holds that economic growth is the essential means, at least in the present century, to drive the improvement in material conditions so needed in the world; and that improvement in material conditions is a pre-requisite to improvement of human health and social conditions. Science and technology are essential and must be applied to utilize natural resources and to manage the environment to achieve both economic and social goals. Such a position holds that those with expert knowledge in specialized fields are in the best position to recognize opportunities and dangers, assess options, and to take decisions, and indeed have the obligation to do so in the interests of society at large. Under such a world view, individual efforts as well as economic and institutional activity, although undertaken for their own sake, contribute to the whole and to society at large. Differences in status, authority, and reward reflect efficiencies or inefficiencies within the system and differentiation among individuals with specialized skills and knowledge, but do not diminish the unity of society. This value system, which is focussed almost exclusively on human activities, benefits and costs, has been dominant in the development and recent operation of industrialized societies and economies.

A different social value system, which I shall refer to as a egalitarian/nature world view, although that also is not a satisfactory label, starts from the basis that the public as a whole has a right to participate in, and not just to be informed about, major decisions that have long-term or broad consequences, and that policy decided without such participation is illegitimate. It holds that Nature has intrinsic value aside from any utility to human economic or social ends, and that human actions, to be successful must take into account the effect on and need for harmony with natural and environmental processes. This means that society must have an inherent respect for other forms of life. Economic rationality cannot be justified as the leading social value, and net community values should transcend individual actions or values. Improvement of social conditions is not inexorably tied to material progress. It is the role of technical experts to inform the public so that they can make the best decisions taking all subjective and objective factors into account; it is not for the technical experts to make decisions. This world view lies at the centre of the ideal democratic political system, but has not been dominant in economic or corporate decision-making. It is found most strongly but by no means only, in citizens' organizations.

A third world view, perhaps unique to Canada among OECD countries with nuclear power systems in its influence on forthcoming fuel waste decisions, arises from the concensus of indigenous peoples and might be called an ecological/aboriginal world view. This view holds that human activities, individually or collectively and including all technological and economic actions, are an integral part of dynamic ecosystems, and that to separate "man" from "nature" is a convention with little meaning when dealing with environmental impact. Such a view is long-term by the standards of modern industrial and economic practices;- the native cultures in Canada stress "seven generations" as a reference for accountability[22]. It is also holistic and contextual, and resists dissecting issues into separate problems and authorities for piecemeal decisions. The logical analyses brought forward by this world-view and their relevance to many of the social and economic problems that lie at the fringes of modern industrial/economic society have probably been a factor in its increasing political and public recognition in Canada. All major policy decisions that affect the environment or a broad spectrum of society must give careful consideration to the indigenous viewpoint. The Guidelines for the Environmental Impact Statement for the Nuclear Fuel Waste Disposal Concept, for example, specifically require the proponent to "consider the different viewpoints when presenting its EIS, particularly the viewpoints of aboriginal peoples"[23]. The long-term and holistic perspective of the ecological/aboriginal view, and the fact that any disposal facility is very likely to be in a location where indigenous people have lived for a long time and have their own knowledge base, makes the ecological/aboriginal viewpoint an important factor in any Canadian assessment of a concept for disposal of radioactive waste.

There are some interesting philosophical underpinnings to these different world views as regards the approach to nuclear power and the management of fuel wastes. These are not as simple as pro-nuclear or anti-nuclear, or acceptance or rejection of a government-imposed decision system. The energy/economy value system, as expressed in the hearings, tends to accept nuclear power as a net benefit, although not without honest admission, at times, of problems, dangers, and costs. But it tends to view the pros and cons in the tradition of humanism, and judges them in the context of net direct human benefit, which is taken to be the necessary measure of the real value of all things. Such an anthropocentric philosophy places confidence in human goals and the rightness of material and social progress, and in the ability of human ingenuity and technology to transcend the limitations imposed by "nature". The natural environment is regarded as a physical, chemical and biological setting which, once its processes and characteristics are known, can be manipulated and its materials used for human purposes. Human goals and aspirations, limited by human fallibility, form the social context. Scientific fact and econommic rationality lead to objective and "real" knowledge; feelings and moral judgements are subjective and "not real". The measure of achievement is technological capability and increase of materials and energy under human control for human benefit.

The egalitarial/nature world view, on the other hand, tends by and large to be distrustful of or against nuclear power systems, while acknowledging their energy contribution and some comparative environmental advantages. The objections are in part because of the rigourous and unforgiving nature of the technology[24], the potential risks of accidents or mismanagement, and some unsolved questions of technology and safety of waste disposal, but are equally or more because of the origins of the technology, the way that decisions are made about it, the dependence on "big science" and "control by experts" against which an individual outside the system can have little influence. This value system is based in the main on an acceptance that the principles of humanity are essentially social, not material; and that both intellectual and material success is in the long run bound up with living in harmony with nature. The whole complex of natural systems and environment is determined by processes independant of humans; humans can use those processes for their own ends successfully if they remain within "natural" limits, but if those limits are exceeded, the distortion or disturbance of nature will defeat human purposes. Although as much knowledge and understanding of nature as possible is desireable, and advanced technologies are necessary both to use the materials and processes of nature and to protect it from over-use or damage, full knowledge and certainty about the natural world can never be attained and the relationship of humans to their surroundings, and to one another, remains essentially an ethical one. A dependence on scientific so-called rationality tends to be seen as intolerant of the essential emotional, ethical and cultural aspects of knowledge that are vital to good judgement.

The ecological/aboriginal viewpoint, as expressed to date, avoids taking a position "for" or "against" nuclear power systems, but has called on the one hand for long-term energy and economic policies that will allow the optimum mixture of energy technologies and economic/industrial strategies to be selected, and on the other hand for the strictest priority to be given to the environment in all its aspects when dealing with the wastes that already exist and the energy facilities and the industrial geography that are presently in place[25]. Economic practices that discount the future or put faith in continued inter-substitability of capital and labour without assessing the effect on the environment or total biosystem are taken to be unrealistic. The absence of an accepted spiritual bond between human consciousness and environmental processes, typical of most industrial and management thinking, is seen to be a practical as well as philosophical handicap to long-term progress. As humans and their technical toys are inescapably integral parts of but also strong perturbers of a dynamic ecosystem, the idea that "Man" can act separately from "Nature" or that there are natural limits within which humans can operate without affecting their surroundings is viewed as a self-delusion[26]. Science and all forms of knowledge are useful and desireable, but human experience and wisdom accumulated through generations should remain the basis for judgement, even on questions such as radioactive waste disposal that are new challenges, different in detail but not in context, to those with which humankind has always had to deal.

These different viewpoints appear to lead to interesting divergences in the matter of credibility and trust, and in use of the established Canadian Environmental Assessment and Review Process to achieve an "acceptable" nuclear fuel waste disposal system. For those with a typical energy/economy world view, credibility is largely a matter of approved credentials. Expertise and relevant experience must be earned through qualifications and performance in the field of interest; they imply accountability to the public or the authorities who can discredit them or undo their work if they fail. Credibility also depends on a common assumption or trust that actions taken, whether within an institution or for an employer, will in net effect be for the good of the public. It depends upon the sharing by the public in the confidence that the most reliable knowledge is based on objective information evaluated or interpreted by technical experts. Thus it was evident from the "scoping" hearings that the organizing principle for interventions on basic questions to be addressed in an environmental impact statement was the adequacy or otherwise of objective fact. There was acceptance that the best decisions will be based on competent knowledge of physical reality and biological response, and therefore technically sophisticated expert advice to the Assessment Panel is essential. Those who do not have the education or training, or have not applied themselves diligently to the issues, are in this view insufficiently informed to contribute to the decisions. It is the obligation of the expert to protect the uninformed public and act in its interest. This, it is felt, is what the public expects and pays for. Those who hold these value systems tend to accept the established Environmental Assessment and Review Process as a vehicle through which the best and most convincing technical information can be laid before the Panel in such a way that the Panel can make a transparent and accountable technical decision that will be acceptable to the authorities and to all but the irrational segments of the public.

For those whose interventions are based on an egalitarian/nature world view, credibility does not appear to lie in better and more objective data. There is evident a decline in confidence in experts and centralized "decision-makers". Disillusion with science is not so much because it is felt to be in error, or that it is biased, although there is often suspicion or evidence that it is, but that it is not telling the public or the authorities what they need to know. Science and fact-gathering are felt to be addressing irrelevant questions, or to be working toward goals not accepted by society at large. Some go so far as to say that the industrial and scientific establishment are pursuing invalid goals in the service of a disintegrating socio-political and economic order. In this world view, trust and credibility is earned only through demonstrated sharing of common values, and independence from the established economic and vested interests who promote the practices that exacerbate the problems. The organizing principle around which assessment of the concept must be built is broad public participation. Those who wish decisions to be made must provide ample information to the public, not on technical details but on fundamental issues, alternatives, and possible consequences. Public values, in a range that reflects the heterogeneity of society and of its goals, must be expressed in policy, and the policies must reflect the ethical nature of public responsibility. Cultural values, in all their complexities and contradictions, but particularly their relationship to the natural environment, are essential factors in any decision with long-term implications. It is imperative that a decision that leads to a long-term policy and financial commitment with irreversible consequences, as is the case for some objectives and schemes for permanent disposal of nuclear fuel wastes, not be made by a small group of experts based on available technical data and current policy and financial exigencies. Such decisions must be made by direct participation of as broad a range of the public as possible, in the light of ample information. Those holding these views see the Environmental Assessment and Review Process not as a vehicle for assembling the best and most complete information leading to expert decision, but as a public forum where a range of fundamental questions can be asked and discussed, and the values of society at large placed against the values and priorities of the political, industrial and economic establishment. They see Panel members not as arbiters of information but as guardians of the range of societal goals, who will not be swayed by scientific double-speak, and whose main task, and strength, is to apply rare common sense.

Credibility, within the ecological/aboriginal world view, is usually stated to reside in the accumulated experience and wisdom of those who have been a highly sensitized part of nature as well as part of humankind through a variety of conditions and stresses, and in whose judgement the community has confidence. Such persons are commonly called "elders", but there is no term in the European languages that adequately addresses the concept. Repeated experience, largely unfortunate, with the policies, commitments and changing practices of European cultures has led to a skepticism about their value and dependability. The emphasis on short-term human economic gain is seen to be immature and ephemeral, and the dissassociation of human actions from environmental responses unworkable; both of these habits of industry and government are stated to be incompatible with an announced intention to demonstrate environmental safety of radioactive waste over thousands of years. The organizing principle for assessment of a waste disposal concept is seen to be essentially spiritual:- is the proposed facility acceptable to "Nature"? The elders are in the best position to judge this; - they will welcome and consider all available technical, environmental, and social-impact information, but not rely on it. The Environmental Impact Assessment and Review Process is viewed as an essentially government institution, well-intentioned but subject to pressures, influences, policies, time and budget constraints that may obscure the real issues and make it hard to keep a sense of proportion. The biggest limitation, in this world view, is that the Panel is obliged to make recommendations only on nuclear fuel waste disposal and not on energy policy or industrial and economic practices that give rise to the need for energy that promotes the practices that produce the waste. Thus the main issues are not being addressed by the Panel, and, accepting the reality that the Panel mandate cannot be changed, the main area where this world view can have an influence will be later, on a local scale, when sites are selected and construction of a facility is started.

Analyses of Risks Associated with Fuel Waste Disposal

Coincident with the studies of societal value systems held in Canada as revealed in the submissions and interventions in the public "scoping" hearings, the Scientific Review Group and Risk and Ethics Team undertook investigations into the subject of risk analysis as it may be useful to the Panel in its evaluation of the Environmental Impact Statement and of the submissions that may be brought before it at the final public hearings. In this work, the teams have benefited greatly from the researches of Professor Lind[27] and Professor Brunk[28], both of the University of Waterloo, Ontario, from whose writings some of the following comments are taken.

Concerns about the safety of nuclear power systems were inherited from the historical beginning of fission energy applications in the Second World War, and have led to many studies, in several countries, to assess the safety and risk of accident or possible harm from nuclear reactors[29]. Gradually, some of these assessments began to include discussions and analyses of the possible hazards of wastes. The Atomic Energy Control Board, in its 1987 "guidelines"[30] selected some levels of risk to human health that became target criteria for the Canadian Nuclear Fuel Waste Management Programme.

Almost all of these studies were concerned with "probabilistic" risk, and followed, and in some instances contributed substantially to, the advancing science and methodology of probabilistic risk assessment. They were concerned with: What is likely to go wrong? What are the probable consequences if something does go wrong? How likely is something harmful to happen? How good are the detection and control systems and possibilities of prevention or mitigation? Most such analyses then devise some procedure for comparing the probability of an incident and the magnitude of likely harm with other systems, or with costs and benefits. Such analyses and comparisons can be formalized and in their operation (although not in the identification and ranking of different types of harms) can be objective and largely mathematical.

When nuclear power systems are analyzed according to Probabilistic Risk Assessment Procedures, they almost always turn out to be very "safe" in comparison with other power systems or other common risks that the public in industrialized countries accept as part of modern living. And yet the evidence is clear that in many countries, large segments of the public are not reassured by these analyses of comparative safety, and continue to feel, sincerely, that the risks to humans and the environment, in the short term or the longer-term future, are unacceptable.

The lack of acceptance by the public of the results of analyses and comparisons of probabilistic risks of nuclear power systems, is often felt, by those in the risk analysis industry, to be due to failure of communication of the natures of risks, and to a blindness of much of the public to the risks that they are already accepting from other sources. There has been considerable study of this problem. In the industrial area in general, management practices in Canada have reached a considerable degree of sophistication so that risk assessment and communication can be a positive tool for decision-making on investments and modification of commercial processes[31]. Canada has issued the world's first formal standard guidelines for risk analysis for small and medium-sized technical installations[32]. However, while acknowledging that factors of culture and ethics which are essentially non-quantifiable and non-transferable or comparable are important to social satisfaction or acceptance, these risk analysis approaches remain safety-oriented, and search for quantitative indices of social well-being[33]. They thus appear to miss the main area of rejection by the public to technical risk analysis of issues such as nuclear power systems, where the areas of concern are not probability of accident or harm but its <u>possibility</u>, no matter how remote; not the multiple safety features in the design but the very need for them; not the statistical proportion of risks but their <u>distribution</u> in place, in time, and in society[34].

Some of the studies of the safety and costs and benefits of nuclear power systems in Canada have recognized, from the beginning, that major issues in the acceptability by the public could not be addressed by quantitative risk analysis or by assessing risk of environmental change purely in human benefit values. The 1980 report of the Royal Commission on Electric Power Planning stated

> *"It is impossible to understand the nuclear debate without understanding the different world views which underlie the two sides of the debate... Different world views [reflect] different visions of reality... The debate about nuclear power has evolved into a debate about the most fundamental values of society"*[35].

and

> *"It is not a trivial matter to balance the worth of a dead turtle against the value of a megawatt of power available at the flip of a switch. The people of Ontario must be encouraged to think carefully and seriously about the irreversible tradeoffs they may be making, step by step, between convenient power now and a permanently impoverished natural world. At some point, an impoverished natural world leads inexorably to an impoverished human society and an endangered human race. We have a responsibility to assess the importance of the effect [of expansion of nuclear energy systems] on wildlife in terms more basic than short-term economic profitability and 'practical' convenience"*[36].

However, despite these acknowledgements that the questions of risk must consider non-quantifiable ethical and environmental values, the major reviews of risk of nuclear power systems have remained technological, analytical, and focussed on probabilities of safety[37]. The public responses in Canada, however, increasingly have stressed areas such as effects on ecosystem productivity, genetic diversity, environmental resiliency, fairness in distribution of risks among society, and the social risk of increasing dependence of the public on a technically sophisticated elite[38]. These challenges have moved nuclear risk issues from technical risk analysis to the field of ethics and environmental valuation.

The assessment of potential risks from a concept for waste disposal that has never been implemented, at a site yet to be chosen, and whose safety is to be assured for thousands of years beyond any foreseeable social, economic or political system faces particular difficulties of credibility and acceptance. The uncertainties of "what can go wrong?", "how serious could it be?", "how likely is it that we have not today thought of everything that might happen centuries from now?" are made more difficult by the fact that disposal of the type envisaged has not been done yet, there is no way gradually "to learn by doing", especially if a prime objective is to relieve future generations from the burden of having to correct 20th century mistakes. Radioactive waste risk assessments are further compounded because it is clear that the distribution of benefits and costs are very skewed from the beginning:- the benefits are in the present, and the unquantifiable costs, if there are to be any, to the environment and to the public, will be far in the future.

The terms of reference for the Nuclear Fuel Waste Environmental Assessment and Review Panel specifically instruct it, as noted above[39], to review the safety and acceptability of the concept, and, to consider the risk that future generations may have to bear the burden of looking after the wastes. The Panel is therefore obligated to assess the risks presented by the concept both from a technical and ethical viewpoint.

Influence of other Energy-Related Environmental Assessments

The development of a Canadian Nuclear Fuel Waste Management and Disposal Programme and the steps toward formal Environmental Assessment of the fuel waste disposal "concept" has not taken place in isolation. Both the environmental and social/ethical issues raised by the nuclear power systems and the provincial and federal environmental assessment and review processes have evolved during the period since the concept was submitted for assessment in 1988, and the evolution is continuing. These changes are inevitably having an effect on the way that the issues are described and presented in the Environmental Impact Statement and Primary Reference Documents, on the priorities and approaches of the public and institutional future intervenors, the background setting in which the assessment and review process must operate, and, no doubt, on the personal views of members of the Environmental Assessment Panel.

Of the 44 "major" environmental assessment reviews that have been conducted by the federal government, or by the federal government in co-operation with provincial environmental assessment agencies, the majority have been related to energy developments. A large number of the best-known, which have captured nation-wide attention and left a mark on subsequent policies, projects, and public attitudes, have been connected with energy developments in rural or northern Canada, where the imposition or the prospect of an economically-driven, technical, high-cost operation onto or into essentially natural environments where local people do not at present share the sophisticated urban life-style of those who are initiating the development provides opportunity for expression of the different world views and value systems that became so apparent in the nuclear fuel waste "scoping" hearings. These reviews have shown that the value systems being brought to the assessment of the nuclear fuel waste disposal concept in Canada are not specific to "nuclear issues", but are rooted in the deeply held ambivalent Canadian concern about environment and energy and the societal perspective that acknowledges continual change but is skeptical of equating it automatically with social or economic "progress". These concerns transcend the so-called "nuclear debate"; rather, they appear to be typical Canadian attitudes, hopes and worries, applied in this instance to the question of nuclear waste disposal.

The successive public interventions and debates concerning environmental assessment of a variety of energy-related major industrial prospects have revealed different facets of the Canadian environmental ethic. Inasmuch as the ethical values held by a society, or components of it, are developed over time, based largely on teachings handed down through generations but continually modified, sometimes even reversed, by successive relevant experiences[40], these assessments and the publicity attending them, have no doubt themselves had an influence in shaping the Canadian environmental ethic. In the present context, these other assessments can provide a useful perspective to the problem that the Assessment Panel must face in examining the acceptability, in the complex Canadian context, of the proposed concept for waste disposal.

The different value systems held by Canadian society in respect to a large-scale technical project that some feared would result in a long-term or irreversible change to the natural environment and possibly have impact on those who were not seen to be beneficiaries from the project, except for some local employment, was dramatically brought to the attention of Canadians in general through a study with extensive on-site public hearings, in 1975-77 of a proposal to build a 2000-Km oil pipeline from the shores of the Arctic Ocean to connect with the energy distribution networks of the developed part of western Canada. The hearings, and the very extensive socio-economic studies undertaken by the pipeline proponents together with skilful encouragement of constructive dialogue between industrial proponents and a wide range of residents, local businesses and institutions who might be affected, significantly changed both the style and the expectations of major energy-related environmental assessments in Canada. In particular, the study and review set in train an acceptance of the right of all segments of society to be heard, and built an atmosphere of official and media respect for different societal value systems. It led to credibility of the ecological/aboriginal world view as an important factor in making decisions that would have long-term environmental consequences in Canada. The report from this study displays in its title, "Northern Frontier, Northern Homeland"[41], acknowledgement of the distinctly different ethical perspectives that must be respected, and not over-ruled by a simple yes-or-no decision, in issues of this nature. This study has undoubtedly had an influence on subsequent environmental assessments of mega-projects in Canada, and is part of the background to the current assessment of the nuclear waste disposal concept.

Many formal environmental assessments in subsequent years show the evolving ethic. An assessment and review of a proposed project for oil drilling in a marine strait in an almost uninhabited part of the Canadian arctic recommended against proceeding because of inadequate information about the potential for impact on components of the biosystem that had no known or forseeable human value[42]:- a landmark recommendation at that time, but less strange today, and a viewpoint that has relevance to assessment of unknown future effects of a buried waste depository on, say, presently unidentified microbiota. Assessments and reviews of hydroelectric projects in Labrador[43] and of a natural gas pipeline along the Mackenzie Valley[44] gave progressively more attention to social perception issues as well as socio-economic and "practical" environmental effects, and to the dichotomy between local aspirations and the industrial interests both of which sincerely had economic progress and environmental protection in mind. The effect that a large quickly imposed industrial project might have on shared lifestyles and traditions, on community cohesion and sense of identity were identified as integral factors to be included in environmental impact assessment[45].

A joint-federal-provincial panel reviewing the environmental effects of development of uranium mines in Saskatchewan[46] gave attention to the category of "public concern" as separate from professional concern and economic importance in the criteria for Valued Ecosystem Components to be taken into consideration in environmental assessment. This review drew a clear distinction between the social impact and acceptability of a single mine and the possibly quite different effects of a series of mines or of sustained exploration and development activity. Such cumulative impacts can be positive or negative, differently to different components of society in the region. The study also drew attention to the potential importance that a perception of possible risk to health from radioactive materials, even though there may be no basis in medical evidence, can have as a "community value" factor in assessing environmental impact of the production end of the nuclear fuel cycle. A recent controversial assessment of a proposal for an irrigation dam[47] has brought to the fore, and into the law courts, conflicts between the distribution of proposed economic benefits and the loss of cultural or sacred values and human rights, and shown inconsistencies in policies at different levels of government. And a current assessment of the environmental effects of military training operations in a sparsely-settled part of northeastern Canada where the residents are dependent on wildlife that are prone to disturbance but the effect on the wildlife is behavioral rather than physical has pitted quite different ethical values and perceptions of what is the legitimate "use" of natural countryside against one another[48].

This varied and cumulative experience with the purposes, operations, and effectiveness of environmental impact assessment and review in Canada, although it has not been on the subject of nuclear fuel waste disposal, provides an important part of the setting for policy decisions and public involvement, the expectations and perhaps the cynicism, in which the Assessment Panel must weigh the information and the intentions brought before it, and make its recommendations.

Common Ground and Possible Accommodation between Different Views

It is clear that the environmental, ethical and perceived risk issues raised by disposal of radioactive wastes are much more complex than can be described by determination of a boundary between "safe" and "unsafe", or by classifying those with strong opinions into two camps, one in favour and another opposed to present developments and proposed practices. In Canada at least, the issues to be dealt with in assessment of acceptability are articulated by well-informed sincere persons who have in common a concern for maintaining a healthy environment and economy, and for the well-being of future generations, but who have quite different views about how those concerns should be satisfied. If the interests and goals of the different viewpoints are similar or shared, it is reasonable to expect that there should be areas of common ground, and that various lines of approach can each contribute to the best decisions that can be made at this time to the management and disposal of nuclear fuel wastes. It therefore is useful to search for and identify areas of shared interest, or where there is more in common between the views held than often may be recognized or acknowledged by those who hold the views.

A preliminary analysis of areas of common ground and possible accommodation between what may be called "pro" and "anti-" positions expressed in the "scoping" hearings in Canada has been made for the Risk and Ethics Team by Wiles[49]. Some of the following comments are based on her study. In addition, experience with past environmental assessment exercises has shown that where the acceptability or rejection of a proposal can be based on what appears to be in part the interests of two or more "sides" who have quite divergent views, constructive communication can continue, rather than being terminated because one group feels it has "won" and the others are perceived to have "lost". Such accommodation or constructive input in no way needs to result in a mediocre common denominator, or to diminish the legitimacy of real differences in values. In this respect, the whole process of environmental assessment and review can be a powerful instrument of social learning and adaptive policy development[50].

It becomes evident from analysis of the public and proponent's stated positions that any common ground must recognize the legitimacy of quite different "core values" about society, the environment, and the role of economic factors in motivating policy or decision. If different core values, which underlie the distinct world views that have become evident in Canadian discussions on nuclear power and waste disposal are held to be valid and legitimate, not up for mediation or challenge, then the politicized positions that arise from them in the nuclear fuel waste management context can be examined in a non-threatening way, to identify differences and similarities in immediate goals and approaches, and to look for common ground and actions to which the respective opinions could contribute.

Wiles has identified seven areas described by ethical statements,where the expressed public and institutional opinions, both "pro-nuclear" and "anti-nuclear", show some convergence. Although the words, emphasis and implications may be quite different or even opposed in the minds of the presenters, it is evident that all sides have some agreement with the following:

1. It is desireable for Canadian society to be in a strong economic position; governments and institutions have an obligation to manage public money responsibly.

2. Credible knowledge is empirical, a product of close observation and experience.

3. Experts and specialized knowledge are influential within the scope of their fields; participants in decision-making have a responsibility to be informed.

4. Public acceptance legitimates policy decisions.

5. Those who produce the waste, or benefit from its production, should take responsibility for its disposal.

6. Future generations should not be burdened with the management of our waste.

7. Risks to environment and human health should be evaluated in detail so that they can be avoided or minimized.

For each of these areas, it is immediately apparent that there are differences in interpretation and meaning to, for example, those with an energy/economy world view from those with an egalitarian/nature or an ecological/aboriginal value system. Without disagreeing with the simple statement, each may take a different approach to questions such as: Where does economic strength fit as a driving force among other values?; What is the relationship of so-called objective scientific knowledge to value-laden experiential, qualitative knowledge or spiritual insight?; What is the role of the expert with technical qualifications in selecting and defining the decisions that should be made? - etc. But once the legitimacy of different core viewpoints is acknowledged and accepted, so that the purpose of the discussion or hearing is not to discredit the other viewpoints but to bring forth genuine concerns about the issues at hand, these common areas provide fruitful ground for identifying those incompatibilities that are quite intractible, and for which a decision on the proposed waste disposal will be a victory for one and a defeat for others, and the areas where differences in approach can be accommodated and each or all can contribute to a better decision. It would seem that there are many issues raised in the hearings and to be addressed in the Environmental Impact Statement where each of the different "world views" can contribute to the common objectives that a waste disposal facility should be as safe as possible prior to closure and pose minimum threat to the environment and human health during its projected life; and that public money not be wasted in achievement of this goal. Wiles has discussed for each of these ethical areas the obvious incompatibilities and differences, and the potential for commonality, that underlie the statements made at the scoping hearings. She has made some suggestions for facilitating constructive debate and building compatible positions.

Examination of the areas of commonality and convergence, however, brings into the open a serious problem for the Nuclear Fuel Waste Management Process in Canada and its current Environmental Assessment and Review. This is the relationship of the Nuclear Fuel Waste Management and Disposal Programme to Canadian energy policy and the place of nuclear fission energy in the Canadian energy spectrum. The Environmental Assessment Review Panel is mandated only to review the Nuclear Fuel Waste Disposal Concept. It is not empowered to assess and review whether the waste should be disposed of at all. Some of the "core values" underlying the world views described above have led to genuine convictions in sincere persons that to implement the nuclear power system to the extent it has been done in Canada has, however well-intentioned, been an error. The fact that we now have wastes that must be managed or disposed as safely and environmentally cleanly as possible is reality; this is not disputed. But persons holding those convictions have stated that to take part constructively in finding "acceptable" conditions for a concept to dispose of the wastes presently on hand amounts to legitimizing and approving the continued and expanding use of nuclear power and thus be sanctioning a regrettable error; this in turn will lead to continued generation of more waste. To persons who hold such views, the Environmental Assessment and Review may be seen as the only current mechanism to halt the compounding of what is seen to be a national mistake, or at least to bring about a more comprehensive review of the whole assemblage of nuclear and energy policies. If the Nuclear Fuel Waste Environmental Assessment Review Panel is to stand credibly behind its declared intention that all value systems sincerely held by Canadians are legitimate and will be carefully listened to, it will need to deal with value systems that do not accept the limitations of its mandate.

Conclusions

The issue of disposal of nuclear fuel waste in Canada, currently half-way through a formal environmental assessment and review process, has been a vehicle that has brought into the open many complex and distinctively Canadian aspects of environmental and social values related to energy, government, popular and authoritative decision-making, and what citizens value about the land in which they live. Canadian geography, climate, history, racial and cultural heterogeneity, resources, economics and political structure contribute to a complex environmental ethic and approach to economic/industrial projects that is perhaps somewhat different from that of other industrialized countries concerned with nuclear waste disposal. At least three distinct value systems, here called energy/economy, egalitarian/nature, and ecological/aboriginal, are well developed and have political sanction and popular credibility in Canada. The elaborate and protracted formal environmental assessment and review process in Canada, transparent at all stages and with extensive public input at several intervals, gives open access to all value systems, and places the assessment and acceptability of nuclear fuel waste disposal in the context of a large number of other major, commonly energy-related assessments which have high public and political profile. The ethical and social responsibility aspects of nuclear waste disposal concept assessments have openly and officially been given importance alongside the technical and safety aspects as an inherent part of environmental assessment, and special consideration is afforded to the views of aboriginal peoples.

The issues involved in environmental assessment of nuclear fuel waste in Canada are broader and more complex than a "debate" between pro-nuclear and anti-nuclear opinions in society. They are issues that bring forth the contradictions and richness of Canadian society and its collective view of its own future. All this will have to be considered by the Panel in its forthcoming decision. Whatever the decision, that too will have an influence on Canada that will be felt well beyond the disposal of nuclear waste, important though that is.

References

(Unpublished reports are available in photocopy)

1. Lothian, W.F., (1977). A History of Canada's National Parks, Parks Canada, Ottawa.

2. Environment Canada, (1972). Canada and the Human Environment: A Contribution by the Government of Canada to the United Nations Conference on the Human Environment, Information Canada, Canada, Ottawa.

3. Office of the Science Advisor (1974). A Perspective on the Next Decade for Environment Canada. Planning and Finance Service, Environment Canada, Ottawa, (unpublished report).

4. Dormuth, K.W., and K. Nuttall, (1977). "The Canadian Nuclear Fuel Waste Management Program", Radioactive Waste Management and the Nuclear Fuel Cycle, vol. 8 (2-3), p. 93-104.

5. Wiles, D., (1992). "The Radiochemistry of Nuclear Fuel Waste", in SRG March 1992 Seminar, Compilation of Presentations by Scientific Review Group. FEARO, Ottawa (unpublished report).

6. Raven, K.G., and R.P. Timlin, (1992). Assessing Radionuclide Migration from a Nuclear Fuel Waste Disposal Facility. Proceedings of the 45th Canadian Geotechnical Conference on "Nuclear Waste Disposal", Toronto, Paper 94, p-1-9.

7. Scott, J.S. and R.G. Charlewood, (1979). "Canadian Geoscience Research and Design Concepts for Disposal of High-Level Waste in Igneous Rocks, International Atomic Energy Agency, Report SM 243/168.

8. Logie, R.R. (Chairman), (1975). Point Lepreau, New Brunswick Nuclear Generation Station: Environmental Assessment Panel Report to the Minister of the Environment, Government of Canada Environmental Assessment Review, Ottawa.

9. Jackson, R.W., and J. Potworowski, (1976). A Nuclear Dialogue: Issues in Nuclear Power for Canada. Science Council of Canada, Ottawa.

10. Aiken, A.M., J.M. Harrison and F.K. Hare (chairman), (1977). The Management of Canada's Nuclear Wastes. Energy Mines and Resources, Report EP 77-6.

11. Hincks, E.P., (ed.), (1979). Nuclear Issues in the Canadian Energy Context, Committee on Nuclear Issues in the Community, Royal Society of Canada/Science Council of Canada, p. 88.

12. Joint Statement by the Minister of Energy Mines and Resources Canada and the Minister of Energy, Ontario, 5 June 1988, Dept. of Supply and Services, Ottawa.

13. Dept. of Energy, Mines and Resources, (1981). "Radioactive Waste Management Review", in Nuclear Policy Review Background Papers, Dept. Energy Mines and Resources Canada, Report ER 81-2E, p. 219-231.

14. Atomic Energy Control Board, (1987). Regulatory Objectives, Requirements, and Guidelines for the Disposal of Radioactive Wastes. AECB Regulatory Policy Statement R-104, Ottawa.

15. Federal Environmental Assessment Review Office, (1989). "Minister of the Environment Appoints Panel to Review Nuclear Fuel Waste Management and Disposal Concept." News Release October 4, 1989 with accompanying "Terms of Reference".

16. Federal Environmental Assessment Review Panel, (1992). Final Guidelines for the Preparation of an Environmental Impact Statement on the Nuclear Fuel Waste Management and Disposal Concept. Federal Environmental Assessment Review Office, Ottawa.

17. Atomic Energy of Canada, Limited, (1993). "AECL Primary References Cited in the Environmental Impact Statement on the Concept for Disposal of Canada's Nuclear Fuel Waste", attachment to Davis, P.A., et al, (1993), The Disposal

of Canada's Nuclear Fuel Waste: the Biosphere Model, BIOTRAC, for Postclosure Assessment. AECL Document COG 93-10.

18. Department of Energy, Mines and Resources, (1988). "Response of the Government of Canada to the Report of the Standing Committee on Environment and Forestry, High-Level Radioactive Wastes in Canada: the Eleventh Hour", Dept. of Supply and Services, Ottawa.

19. Department of Environment, Canada, (1992). Defending the Environment Standpoint: A Report of the Work of Environment Canada in Assessing the Canadian Fuel Waste Management Concept. Ontario Region, Environment Canada, Toronto.

20. Reference 15, above.

21. Wiles, A., (1994). "Analysis of Ethical Assumptions Underlying Positions of Intervenors to Nuclear Fuel Waste Management Scoping Hearings", working document for the Federal Environmental Assessment Panel.

22. Clarkson, L., et al, (1992). Our Responsibility to the Seventh Generation: Indigenous Peoples and Sustainable Development. International Institute for Sustainable Development, Winnipeg.

23. Reference 16 above, p. viii.

24. Knelman, F.H., (1976). Nuclear Energy: The Unforgiving Technology. Hurtig Publishers, Edmonton.

25. Parr, P.A., and T. Oleksyn, (1985). Prince Albert District Chiefs Study of the Uranium Industry. Report of a study conducted for the Chiefs of the Indian Bands of the Prince Albert District, Saskatchewan, submitted to the Joint Federal-Provincial Panel reviewing the environmental and economic aspects of Saskatchewan Uranium Mining Development. (See Reference 46, below).

26. IUCN Inter-Commission Task Force on Indigenous Peoples, (1993). Draft Guide for the Involvement of Indigenous Peoples in Strategies for Sustainability. International Union for the Conservation of Nature and Natural Resources, Gland, Switzerland.

27. Lind, N.C., (1992). "Risk Assessment in Scientific Environmental Review", in SRG March 1992 Seminar, Compilation of Presentations by Scientific Review Group, FEARO, Ottawa (unpublished report).

28. Brunk, C., (in press) "Technological Risk and the Nuclear Safety Debate", in Crabbé, P. (ed.), An Environmental Ethics Perspective on Canadian Public Policy, University of Ottawa Press.

29. A well-known example is -
U.S. Nuclear Regulatory Commission, (1975). Reactor Safety Study: An Assessment of Accident Risks in the U.S. Commercial Nuclear Power Plants. NUREG 95/100, WASH-1400, U.S. Govt. Printing Office, Washington.

Canadian examples include -
Inhaber, H., (1978). Risk of Energy Production. Atomic Energy Control Board, Report AECB 1119, Ottawa,
and
Porter, A. (Chairman), (1980). A Race Against Time: Report on Nuclear Power in Ontario. Royal Commission on Electrical Power Planning in Ontario, Toronto.

30. Reference 14, above.

31. Lind, N.C., J.S. Nathwani, and E. Siddall, (1991). Managing Risks in the Public Interest. Institute for Risk Research, University of Waterloo, Waterloo, Ontario.

32. Canadian Standards Association (CSA), (1991). Risk Analysis Requirements and Guidelines. CSA Q634-1991, Canadian Standards Association, Ottawa.

33. Nathwani, J.S., E. Siddall, and N.C. Lind (1992). Energy for 300 Years: Benefits and Risks of Nuclear Power in Canada. Institute for Risk Research, University of Waterloo, Waterloo, Ontario (Uses sophisticated probabilistic risk analyses to determine social safety in terms of "quality-adjusted life-years").

34. Torrie, R., (ed.), (1977). Half Life: Nuclear Power and Future Society. Ontario Coalition for Nuclear Responsibility, Ottawa.

also:
Brunk, C., L. Haworth, and B. Lee, (1991). Values and Asseumptions in Risk Assessment. Wilfrid Laurier University Press, Waterloo, Ontario.

35. Porter, A., Reference 29 above, p. 153.

36. Porter A., Reference 29 above, 2nd submission from Dept. of Fisheries and Environment, p. 140.

37. Hare, K., (Chairman), (1988). The Safety of Ontario's Nuclear Power Reactors: A Scientific and Technical Review. Ontario Nuclear Safety Review Commission, Toronto.

38. See Reference 9 above for early expression; the "scoping" hearings submissions provide recent examples.

39. Reference 16 above.

40. Roots, E.F. (in press). "Ethics, Environment and Sustainable Development Policies", in Crabbé, P. (ed.), An Environmental Ethic Perspective on Canadian Public Policy, University of Ottawa Press

41. Berger, T.R., (1977). Northern Frontier, Northern Homeland: The Report of the Mackenzie Valley Pipeline Inquiry. Dept. of Supply and Services, Ottawa.

42. FEARO, (1979). Lancaster Sound Offshore Drilling Project, N.W.T.: Report of the Environmental Assessment Panel. Federal Environmental Assessment Review Office, Report 7, Ottawa.

43. FEARO, (1980). Lower Churchill Hydroelectric Project: Report of the Environmental Assessment Panel. Federal Environmental Assessment Review Office, Report 15, Ottawa.

44. FEARO, (1984). Beaufort Sea Hydrocarbon Production and Transportation Proposal: Report of the Environmental Assessment Panel. Federal Environmental Assessment Review Office, Report 25, Ottawa.

45. Reference 44 above, page 42.

46. Sadar, M.H., D. Cressman, et al, (1992). Assessing Cumulative Effects of Saskatchewan Uranium Mines Development; a Study Prepared for the Joint Federal and Provincial Environmental and Economic Review of Uranium Mining Development in Northern Saskatchewan. Ecologistics, Waterloo, Ontario.

47. FEARO, (1992). Oldman River Dam: Report of the Environmental Assessment Panel. Federal Environmental Assessment and Review Office, Report 42, Ottawa.

48. FEARO, (1987). Guidelines for the Preparation of an Environmental Impact Statement on Military Flying Activities in Labrador and Quebec. Issued by the Environmental Assessment Panel, Federal Environmental Assessment and Review Office, Ottawa.

49. Wiles, A., (1994). "Analysis of Areas of Possible Accommodation Between Pro- and Anti-Nuclear Positions on Nuclear Fuel Waste Disposal." Preliminary report prepared for the Environmental Assessment Panel for the Nuclear Fuel Waste Disposal Concept. (unpublished report).

50. Holling, C.S., (1977). Adaptive Environmental Assessment and Management, University of British Columbia, Institute of Resource Ecology, Report PR-6. Also published under the same title by John Wiley and Sons, Chichester, 1978.

Paper No. 7

Ethical Questions within the Context of Final Storage of Radioactive Wastes

Dr. Herlind Gundelach
Federal Ministry for the Environment, Nature Protection and Nuclear Safety

Management of radioactive wastes represents a specific problem within the framework of the public discussion on the question of a peaceful use of nuclear energy and in Germany has been the subject of lively and controversial discussion over the past few weeks and months. This makes manifest that basic differences and uncertainties exist with regard to the ethical justification of the kind of storage preferred by politics, i.e. final disposal.

It is not my task here to explain which kind of rock formations are better suited for disposal and in which way disposal should take place. Rather my task is to address these questions, for which a satisfactory answer must be provided if the procedure as a whole is to be chraracterized as responsible.

...

Ethics is part of the so-called "practical philosophy" since it strives to answer the question "What are we to do?". Ethics teaches to assess the individual situation in order to allow action in a way which is ethically, that is to say morally right. Therefore ethics also always deals with the standards and criteria which are referred to as justification for the individual action.

As we have learned from the history of evolution, man cannot exist for himself alone. His existence depends both on other people existing along with him and on the surrounding environment as a basis for life. This means that his action always has to relate to three levels if it is to be characterised as an ethically good and therefore responsible action:

1. man is responsible for himself as an individual;
2. man is responsible for the well-being of society;
3. man is responsible for the well-being of the natural environment surrounding him.

All the three levels of responsiblity are of individual importance when a decision has to be arrived at. Here are the roots of possible conflicts since the interests of the individual person, the requirements of society and the

...

justified concerns of the environment are as a rule not elements of a harmonious and pre-fabricated, stably-structured network. The target conflicts and juxtapositions of different types of good can only be solved by weighing up the different aspects if action is to be responsible. Therefore it is one of the tasks of ethics geared to practical implementation to develop rules and maxims for action which can be applied generally for weighing up the different solutions when having to come to a decision. This is where my function lies today. It certainly is not my task to give you a conclusive answer to the question as to whether, and if so, which method of final disposal is the right one. Rather it is my task to present ways and criteria how to find responsible solutions for this question.

Wherever aspects of good are competing with each other and negative side-effects or risks have to be taken into account we need an ethical method of weighing up the good and evil aspects. There is no morale free of conflicts and therefore there is no other possibility - above all from the aspect of ethics - than to weigh up the evils to be faced and to chose the lesser.

...

In any case however, minimisation of evils, the rule of which can be formulated as follows, has to be the step prior to the weighing-up process: Action which is to serve an ethically good aim can only be justified from an ethical point of view if the negative side-effects linked with it can be reduced to a minimum.

It certainly would mean to carry coals to Newcastle if I were to try to tell you as experts on the peaceful use of nuclear energy that the risks linked with this technology are not zero. Therefore we have to ask the question as to which standards have to be applied to an action which is linked with negative side-effects that can no longer be minimised. The second general maxim for action to be applied here says: An action which is to serve a good moral aim can only be justified from an ethical point of view if the evils arising as a side-effect are smaller than the evils which would arise if the action were not taken.

Opponents of nuclear energy continue to argue in this context that it would be better in such a case not to take any action at all than to risk evil. The objection to this argument is however that renunciation of action is also not without consequence. For renunciation of action

...

ultimately means not including the negative side-effects resulting from such renunciation into the decision-making process and thus the approving acceptance of even higher possible risks. Let me mention here as an example the higher susceptibility to disturbance of interim storage as compared to final storage in deep geological formations. However I should also like to add here that this alone does not yet answer the question as to whether it is responsible from an ethical point of view.

In order to allow better understanding of this theoretical concept of weighing up good and evil which I have just presented, let me address practical application and mention some focal questions which are repeatedly asked when discussing justification of final storage of radioactive wastes. These are questions concerning the particular hazard or safety in general, the relationship between the protection of today's and future generations as well as the necessary limitation of burdens for the future generations.

re 1: In this context the reproach is made that it is not man's right to increase the natural hazard potential by himself contributing towards them. This is also expressed by R. Spaemann in his view that we do not have the right

...

to create additional hazards on our planet over and above the risks inherent in nature such as earth quakes, volcano eruptions and tornados etc. by our transforming of material." This argument obviously contains an erroneous premise. It suggests that it was for the first and only time nuclear energy – both with regard to use and final storage – that an artificial hazard was added to the natural hazard potential. In fact however, it is the following aspect which nuclear technology has in common with any other technology: any technology, be it large or small implies an additional hazard for our planet. This argument can therefore not be used against a certain technological action but, at most, against technology in general – which has already been positively welcomed as a rule by our modern industrialised society. Thus, this general argument cannot be applied when weighing up good and evil aspects of a specific technology. It can at most be used with regard to the specific hazards and risks of such a technology.

re 2: In this context it is argued that we do not have the right to impose on future generations the lasting existence of hazards such as those linked with final storage as an unchangeable fact since we do not know whether they will still be able to cope with controlling

...

these hazards in the year x and whether governmental institutions will still exist which guarantee the protection from hazard impacts.

This argument is based on a concept of responsibility which refers to a time prior to any historic-cultural development of mankind and therefore makes future generations' own responsiblity superfluous or negates it. If this argument were to be followed, we should have to design our present-day technological world in a way our descendants would not have to face any risk due to burdens caused at an earlier stage even if they (our descendants) underwent a backward-development to a clearly more inferior level. Such an understanding of responsibility is the result of an extremely defensive anthropology which does not serve the purposes of the cause since it denies the innovative character of human cultural development. As a veto and a result of possible weighing-up processes it can only be argued in this context that a hazard potential may not be imposed on future generations only if control of this hazard potential cannot now be accepted as a burden for the present generation.

re 3: Here the assertion is made that man is not permitted to engage in any action which is linked with hazards and

...

risks if he alone benefits from its advantages while future generations only have to bear the burden of the continuing hazards emanating from it. Without any doubt this idea is of highest significance when compared to the arguments used so far since it is based on the idea of justice. The present generation must not always seek advantages while placing the burdens these advantages bring on future generations. Nevertheless such an assertion, being an ethical statement, has to be examined in a more differentiated way and has to be thoroughly weighed up. For it is in this context too that the question has to be weighed up as whether and to what extent renunciation of an action which involves negative consequences itself leads to effects which, in the main, also lead to gross impacts of the chances for life of future generations. Let me mention the increased use of fossil fuels and their effects on the climate as an example here. Let me remind you of the climate changes on our planet with all their effects on flora and fauna, rise of the sea level, melting of the ice-caps etc.

If we want to make progress in this matter and want to achieve balanced-out results with regard to an ethical assessment of final storage of radioactivewastes there is

...

no way round considering the whole context of relevant patterns of causes and effects.

As has already been mentioned, it is not the task of ethics to judge in how far facts are stated correctly, for example the half-life period of radioactive substances or the physical and geological conditions of safe final storage. Its indispensable task rather is to monitor the decisions based on these facts as well as on a plethora of further empirical premisses and the weighing-up processes linked with it and to check whether all essential aspects have been taken into consideration. With regard to the problem of final storage of radioactive wastes the following comments of a very basic nature have to be made:

1. The problems of final storage have to be considered within the wider context of the questions of disposal in general. In addition to the disposal form of final storage, interim storage which in general comes prior to final storage and the disposal form of reprocessing also have to be included in the weighing-up process.

With regard to interim storage it must be said that it always represents a provisional form of disposal which, as

...

the comparatively greatest hazard, requires more far-reaching solutions, i.e. either direct final storage of the respective radioactive material or its reprocessing with subsequent final storage of the remaining material that cannot be processed. Thus, it cannot in any way be justified to perpetuate transitional storage as a permanent form of disposal without there being any need for it.

With a view to reprocessing, it has to be taken into account that the use of such reprocessed radioactive material which thus becomes possible does indeed reduce the quantities of highly radioactive wastes but at the same time, it creates major quantities of medium and low radioactivewastes for which storage capacities have to be made available. Another problem given here is the plutonium arising during reprocessing. When assessing reprocessing one also has to take into account that it involves a higher risk of possibly releasing radio-activity into the environment than final storage - not least due to its direct handling of radioactive residual material. In any case however one may be sure that an option for reprocessing radioactiveremaining products only makes sense if further use of nuclear energy - be it in

...

the short-term, the medium-term or the long-term - is considered necessary.

2. The question concerning final storage goes beyond the specific context and refers to the more comprehensive framework of the use of nuclear energy and its problems of ethical legitimisation.

As a general guideline for an ethical justification of the use of nuclear energy the following principle applies: **Evidence has to be provided as a matter of principle that the hazard potential linked with its use can be minimised to such an extent that it is considered the lesser evil when compared with all the evils which would result from renouncing its use.** The hazards linked with final storage and disposal only represent one part of the overall hazard potential to be minimised. In particular it has basically to be distinguished from the hazard potential linked with the direct operation of nuclear power plants. **Considering this requirement the question as to how the use of nuclear energy can be justified has to be asked at both hazard levels.**

This however means that even if the hazard of a core meltdown accident with simultaneous release of hazardous

...

substances can in principle be ruled out the use of nuclear energy cannot be justified as long as the question of disposal of the radioactive substances resulting from normal operation is not appropriately guaranteed.

This means in particular that due to the fact that under prevailing conditions the peaceful use of nuclear energy cannot be stopped in the foreseeable future, the question as to what is to be done with the radioactive wastes must in any case be solved in the immediate future.

Before I conclude, I should like to make some comment on the relationship between social acceptance and ethical legitimation. Social acceptance results from a variety of reasons which, to some extent, may certainly be of an ethical nature, but always comprise pre-ethical and sometimes even unethical motives. Here public opinion, trends and fashions play as great a role as individual interests, moods and the personal and the different stocks of factual knowledge and competency of assessment. Therefore it is quite natural that the same matter meets with with support in one society while it is rejected in another. For this reason social convictions and ethical justifications must not be automatically equated since this would imply either reducing the question of morality

...

to the question of acceptance or avoiding the question of acceptance by society by asking the question of what can be justified ethically.

What makes dealing with the phenomenon of social consent and rejection so extremely difficult - and this is demonstrated most clearly by the pros and cons in society with regard to final storage of radioactive wastes - largely depends on the fact that the opponents usually believe themselves to be unrefutably right. They claim the dogmatic truth of their stance and therefore make it to a question of personal conscience. Resulting from this, the conflicts to be resolved here inevitably lead to conflicts of conviction which in general give no room for compromise.

Therefore the question must be asked here finally as to whether our society is still prepared at all to enter the process of weighing up aspects of good and evil or whether the opposing fronts are so hardened already that a true discussion is no longer possible. Given the importance of this problem however, we must, I believe, try once more to embark on this way and to resume the discussion.

But even then - and I consider it important to mention this before concluding - we may again be faced with the result that we cannot agree on any consensus. Action however is required and in a democratic system this can only mean that the principle of majority is applied. A constitutive element of this form of government also implies that the minority accepts these decisions while retaining the possibility of supporting a shift of majorities and to obtain this at elections. No right of resistance can thereby be deducted.

Responsables aujourd'hui pour demain

M. Allègre
Président de l'Andra
Agence nationale pour la gestion des déchets radioactifs

Y. Quéré
Président du Conseil Scientifique de l'Andra

L'éthique a pour objet d'énoncer des principes qui puissent garantir les droits fondamentaux des hommes. Elle vise à conjurer l'instinctive priorité que donnent à leurs intérêts chaque homme, chaque groupe, chaque nation, aux dépens de tous les autres. En un mot elle essaie d'établir le plus d'équité possible dans une société.

Une règle morale impérieuse ...

Quoique la moralité diffère d'une civilisation à une autre, ou d'une époque à une autre, elle porte des caractères universels : on ne saurait nier que tous les hommes se rallient à quelques grandes prescriptions. L'une d'elles, la règle dite d'or, a le mérite de les résumer toutes en une formulation commune sur tous les continents : "ne fais pas à autrui ce que tu ne voudrais pas qu'on te fasse". Le message judéo-chrétien a insufflé à cette règle une force supplémentaire en proclamant "frères" tous les hommes, au nom d'un Dieu dont il les dit fils. Recevant ainsi l'appui de la transcendance, une règle d'abord pratique s'érige ainsi en absolu.

Quelle que soit la référence, laïque ou religieuse, de cette loi, nous en voyons les articles s'élargir au fur et à mesure que s'éloignent de notre champ de vision les hommes qu'elle désigne à notre sollicitude. Du clan au village, du village à la nation, de la nation à la planète, des devoirs nous sont intimés, de plus en plus abstraits puisque nous connaissons de moins en moins nos obligés. Chez les anciens déjà, on n'ignore pas le secours porté à l'inconnu : l'étranger, le voyageur, y sont l'objet de protection même s'ils ne paient pas de retour leur bienfaiteur. Cette aide fournie au tout venant, qu'illustre dans l'Evangile le récit du Bon Samaritain, est sans doute plus méritoire que les services rendus à des tout proches. Il est le signe que nous ramenons l'homme lointain dans notre proximité, que nous lui conférons la substance, les attributs et les privilèges d'un véritable frère.

... qu'il nous faut étendre ...

Mais voici que des nuisances durables que nous engendrons et laissons à d'autres en héritage nous invitent à introduire non plus seulement l'homme d'ailleurs mais l'homme du futur dans notre champ éthique et à l'y installer. Comment ne pas discerner ici ce que cette intrusion a de profondément inédit ? L'obligation, si noble en soi, d'hospitalité et de fraternité que nous venons d'évoquer était moins abstraite qu'il n'y paraissait. La rencontre d'homme à homme, entre contemporains, était toujours possible. Elle devient ici impensable. Aucune cordialité ne s'établira jamais entre des êtres que des siècles séparent. Nous voilà désormais confrontés à cette inquiétude sans précédent : la règle d'or jusqu'ici appliquée aux hommes d'ailleurs - si différents fussent-ils, au moins étaient-ils contemporains et pouvaient-ils entrer en relation - en étendant son obligation aux hommes de demain nous prescrit des devoirs envers une humanité pour nous irrémédiablement sans visage.

Non que ce lien éthique qui nous relie à nos descendants lointains soit une idée neuve : il n'a sans doute pas existé un charpentier, un tailleur de pierre, qui aient bâti un pont sans méditer plus ou moins confusément sur leur responsabilité face aux hommes futurs qui, des siècles durant, franchiraient ce pont d'un pas confiant. Mais ce devoir éthique prend une extension singulière en notre temps en raison de l'accroissement de notre capacité de nuisance, lequel affine notre sentiment de responsabilité vis-à-vis de nos descendants. Nous avons appris à tenir l'exploitation intensive des richesses de la planète pour un vol à leur détriment et de même l'accumulation des déchets de nos activités industrielles pour une iniquité à leur égard. Nous serions gravement coupables si nous négligions cet élargissement de l'éthique : par le biais des risques que nous leur imposons elle nous charge de devoirs spécifiques de frères aînés.

... à un avenir indéterminé

De surcroît, un domaine nouveau de l'activité humaine apparaît qui repousse à des distances inédites le champ temporel de l'éthique. Jusque là, les durées s'évaluaient en générations : "je veux laisser à mes arrière petits-neveux une Terre où ils puissent vivre dans la paix et le bien-être". L'horizon de notre sollicitude nous laissait imaginer avec quelque vraisemblance les hommes du futur, nos enfants en somme, encore à notre image. Avec la gestion de nos déchets industriels apparaissent des durées radicalement autres : s'ils sont nucléaires, les "périodes" se comptent parfois en millénaires, voire en centaines de millénaires. S'ils sont chimiques, nous n'avons bien souvent même plus d'échelle disponible : les durées sont illimitées. Se trouve là mise en scène une humanité proprement inimaginable.

Des questions insolubles ...

Nous voici invités à prendre en compte la paix et le bien-être d'humains rigoureusement inconcevables dans leurs moeurs, leur savoir, et leur rapport avec la Nature. Seront-ils, par évolution naturelle ou artificielle, des "surhommes" ? Seront-ils au contraire redevenus, après d'effroyables cataclysmes, des "hommes des cavernes" ? Sauront-ils déchiffrer nos messages ? Auront-ils même une notion de leurs lointains ancêtres ? Cela a-t-il un sens d'essayer de percer ces brumes, et de penser à eux ?

... et cependant une certitude

Mais à quoi bon nous interroger sur cette humanité future vu l'impossibilité de répondre ? Discernons plutôt dans le stockage des déchets radioactifs de longue période, et plus généralement dans celui des déchets de l'industrie chimique, des sommations éthiques d'une ampleur imprévue. C'est elles que nous devons considérer : nous n'avons pas le droit de laisser des risques en héritage à des générations lointaines ; et nous ne pouvons pas esquiver la question en postulant que les progrès scientifiques les préserveront.

Certes nous nous devons en priorité à la sécurité et à la santé de nos contemporains. C'est à eux que nous devons d'abord appliquer notre éthique. Ce sont eux en premier lieu que nous devons protéger des résidus, s'ils sont nocifs, de nos activités industrielles. Mais au moins ces activités sont-elles les leurs. Bénéfiques, ils en profitent. Maléfiques, ils ont la possibilité de les combattre. En regard de quoi nous impliquons aujourd'hui par nos stockages d'innombrables générations futures totalement non-responsables. Afin d'assurer un "développement durable" à nos descendants, nous devons leur transmettre notre savoir-faire technique sans rejeter sur eux la charge d'en assumer les nuisances, contrepartie des bénéfices que nous en avons nous-mêmes retirés. Parmi tant d'inconnues qui nous harcèlent, au moins avons-nous une certitude : que notre négligence nuira. Que nos conduites présentes ont acquis le redoutable pouvoir d'exercer des effets quasiment illimités dans le temps. Et la dimension du mal donne l'étendue de la vigilance requise.

Une peur stimulante ...

Soyons honnêtes. Sans doute notre génération n'aurait-elle pas tracé avec autant de fermeté cette "nouvelle frontière" de l'éthique si elle n'avait été aiguillonnée par la peur. Des accidents comme ceux de Bhopal pour le risque chimique, ou de Tchernobyl pour le nucléaire, ont inauguré une nouvelle méfiance envers les activités industrielles polluantes et leurs retombées immédiates mais aussi futures. L'écologie y a trouvé une justification supplémentaire à ses mises en garde, dénonçant, outre les nuisances humaines, les blessures portées à la Nature. Dans cette méfiance, saluons ce qu'elle a de fondé, et donc de stimulant pour nos recherches sur la sécurité et l'environnement, mais sachons aussi démêler ce qu'elle peut avoir d'irrationnel et de subjectif.

Notons à ce sujet que bien d'autres risques (accidents d'avion, etc...) beaucoup plus tangibles sont parfaitement acceptés parce qu'intégrés dans le quotidien et donc banalisés. Comme le fait remarquer J.C. PETIT, le stockage de déchets radioactifs présente de nombreuses caractéristiques qui rendent malaisée son acceptabilité par le public. Relative nouveauté, manque de familiarité du grand public avec des questions techniquement aussi ardues, sentiment d'impuissance des populations proches, étalement dans le temps des effets nocifs éventuels, etc, sont autant de paramètres défavorables à cet égard. Ajoutons le péché originel d'Hiroshima, les erreurs passées de communication, le comportement irresponsable de certains pays, et le caractère insidieux de l'irradiation.

... qui ne peut fonder une éthique

Quoi qu'il en soit sur les origines de la peur, ici sur son bien-fondé ou là sur sa déraison, ce n'est pas sur elle que peut se bâtir une réflexion éthique. La peur, démultipliée par la rumeur, ou les média, a été trop souvent un ressort de violences, d'intolérances ou d'intégrismes pour que l'on ne tente pas d'abord de l'analyser. Ainsi sera-t-on peut-être amenés à relier la peur croissante des déchets à l'incontestable amélioration de conditions globales de fonctionnement des usines chimiques, ou à la relative banalisation des centrales nucléaires, un "transfert de peur" s'opérant d'objets qui semblent maîtrisés vers les résidus qu'ils produisent, et qui s'accumulent. Une semblable diabolisation des déchets nucléaires ne serait pas plus admissible qu'une présentation systématique lénifiante des problèmes à résoudre.

Un autre grand ressort des intolérances et des intégrismes est l'ignorance. L'éthique et la simple raison se rejoignent pour exiger que l'on veille avec un soin et une constance sans faille à la formation et à l'information du public, ainsi que de toutes les instances de décision.

Des principes valables pour tous les déchets ...

Il s'agit maintenant, à la lumière des quelques réflexions précédentes, de poser les principes qui doivent, à nos yeux, guider les recherches en matière de stockage des déchets.

La singularité des déchets radioactifs est beaucoup moins grande qu'on ne le croit généralement. En effet, l'approche ne devrait pas être fondamentalement différente pour un cylindre de verre contenant des déchets de retraitement vieux de quelques centaines d'années, devenu un très faible émetteur béta-gamma mais contenant des émetteurs alpha à vie très longue d'une part, et pour un déchet chimique toxique dont la durée de vie est "éternelle" d'autre part.

En revanche la formulation des problèmes, la recherche de solutions fiables et l'internalisation des coûts correspondants sont beaucoup plus avancées pour les déchets nucléaires que pour les autres.

Au delà du souci de protection de la santé humaine qui est à la base de toute éthique relative à la gestion de déchets de toute nature, quelques principes généraux valables pour tous types de déchets peuvent être dégagés :

1 - **Le "déchet ultime" doit être minimisé en nocivité et en volume.**

- Sans entrer dans la polémique "retraitement ou stockage direct", il est clair que l'industrie du retraitement fait en permanence de gros efforts pour réduire très sensiblement le volume des déchets conditionnés.

- Pour la réduction de la nocivité, les études concernant la transmutation / incinération peuvent laisser espérer à long terme des résultats à condition de procéder à un retraitement poussé. Même en cas de succès de ces études, prévues par la loi de décembre 1991 et menées activement en France, on ne pourra pas tout transformer et le recours au stockage souterrain a toutes chances de demeurer nécessaire ; mais la nature des déchets à stocker en sera modifiée.

2 - **Le producteur de déchets est le payeur.**

Ce principe est respecté pour les déchets nucléaires plus que partout ailleurs puisque cette industrie prévoit dès le départ d'inclure dans ses coûts des provisions correspondant au démantèlement final des installations et à la gestion des déchets.

3 - **C'est la génération présente qui doit en premier lieu être protégée des nuisances**

Notre réflexion éthique concernant le futur ne doit en aucune façon nous faire négliger la protection due à nos contemporains

4 - **La génération qui engendre les produits polluants est responsable vis-à-vis des générations futures au même titre que l'industriel pollueur est responsable vis à vis de son environnement proche.**

Ce principe de responsabilité signifie qu'il appartient à la génération bénéficiaire de l'activité polluante de ne pas faire supporter à celles qui la suivront les nuisances ni le coût de la remise en ordre de la nature afin de proscrire tout risque "anormal" pour ces générations à venir.

Ceci revient à dire que dans toute entreprise l'homme doit laisser le lieu de son activité aussi "propre" lorsque cette activité se termine qu'il l'était au commencement. En termes plus imagés, le principe est **"prière de laisser la nature au moins aussi propre en partant qu'on l'a trouvée en arrivant"** afin que l'homme futur dispose initialement pour son développement d'autant de chances que l'homme d'aujourd'hui.

C'est bien ainsi que devra s'effectuer le démantèlement des centrales nucléaires. La gestion des déchets au jour le jour devra être telle qu'elle permette in fine le respect strict de ce principe.

5 - **Solidarité**

Solidarité intergénération puisque la gestion des déchets aujourd'hui doit permettre d'éviter les nuisances demain.

Solidarité internationale puisqu'il ne s'agit pas bien sûr de reporter les nuisances sur le voisin. L'extrême sensibilité de la question des déchets radioactifs et les abus commis par certains en exportant leur pollution sans précaution dans les pays sous-développés ont conduit à juste titre à admettre que chaque Etat doit s'occuper de ses propres déchets. Telle est du moins la loi française. Dans un avenir plus ou moins éloigné, à condition que toutes les précautions soient prises sur un plan international, aucun principe éthique fondamental ne devrait interdire à plusieurs pays de s'associer pour résoudre en commun le problème du stockage de leurs déchets radioactifs. Nous en sommes encore très loin mais une telle évolution n'est pas impensable dans la mesure où les progrès réalisés auront permis de donner toutes les garanties quant à l'absence de nocivité d'un tel stockage.

Solidarité nationale puisque l'ensemble des déchets produits sur le territoire seraient vraisemblablement stockés en un seul site. La population-hôte doit comme il est normal tirer avantage de l'accueil d'une activité industrielle sensible mais, cet avantage ne représente en aucun cas l'achat du silence devant un risque excessif.

6 - **Démocratie et ouverture**

Les études et les choix doivent s'opérer par étapes dans le cadre d'un processus démocratique et ouvert assurant une large information-formation du public ainsi qu'une complète transparence, avec une difficulté tenant à l'importante technicité du domaine. Tel est le principe sur lequel repose la loi française de décembre 1991 pour les déchets radioactifs. Telle est aussi la raison d'être d'autorités de sûreté indépendantes.

... et quelques commentaires relatifs au secteur nucléaire

1 - **Un reproche est souvent formulé : il aurait fallu savoir exactement comment régler le problème des déchets radioactifs avant de lancer l'ensemble des opérations industrielles.** La génération qui nous précède aurait-elle de ce fait contrevenu aux règles les plus élémentaires de l'éthique ? Comme le dit François Michelin, "lorsque l'on monte dans un train on aime bien savoir où il va".

Tout d'abord il est clair que dans une science nouvelle, les progrès des connaissances se réalisent en parallèle sur tous les fronts. On peut d'autant mieux démontrer la fiabilité d'un stockage que l'ensemble des connaissances scientifiques sur lesquelles on s'appuie est vaste.

D'autre part, le nucléaire a dès le début fait un effort important pour la gestion des déchets qui ont été très vite conditionnés sous une forme solide [1] et depuis longtemps les experts internationaux considèrent le stockage géologique comme une solution possible à condition de l'étudier suffisamment à fond

Aujourd'hui, en surface les centres de stockage pour déchets faiblement radioactifs sont opérationnels, ainsi que les entreposages pour les déchets haute activité. En ce qui concerne le stockage profond, nous sommes dans la phase des études appliquées.

2 - **Certains calculs purement économiques**, comme par exemple ceux faits en matière de sécurité routière, introduisent une valeur chiffrée de la vie humaine. Une telle approche parait impossible dans notre domaine car le moindre coefficient d'actualisation, sans lequel il n'est pas de calcul économique, reviendrait à tenir pour négligeables les générations au delà de quelques dizaines d'années, donc à se désintéresser totalement de leur sort.

3 - **La démonstration de sûreté** est la caractéristique essentielle des stockages de déchets radioactifs. Elle présente trois traits originaux :

- Elle est un préalable indispensable à toute autorisation. A ce titre, elle constitue même la garantie essentielle sur le plan de l'éthique.

- La technique (colis et barrières ouvragées) et la nature elle-même (géologie), concourent toutes deux à réaliser le confinement des déchets, sans intervention ultérieure.

- L'intervalle de temps à prendre en compte (cent mille, voire un million d'années) est d'une durée tout à fait inhabituelle. [2]

  Les déchets radioactifs les plus dangereux, les verres issus du retraitement (ou les combustibles irradiés) contiennent en mélange intime des produits de fission, très actifs mais à vie courte ou moyenne et des transuraniens, beaucoup moins actifs mais à vie très longue. On peut en déduire schématiquement que la sûreté d'un bon stockage repose

  . pendant les premiers siècles (500 à 1000 ans) à la fois sur la qualité de la barrière ouvragée et de la barrière géologique pour confiner les éléments à très haute activité mais à vie courte ou moyenne

  . au delà, presque exclusivement sur la qualité de la barrière géologique pour le confinement des radionucléides émetteurs alpha à vie longue.

---

(1) *En France la vitrification des produits de fission a été étudiée dès 1960 et industrialisée au même rythme que le programme électro-nucléaire.*

(2) *100 mille ans est une durée au delà de l'entendement humain et pourtant, si l'épaisseur d'une feuille de papier représente 100 mille ans, l'âge de la Terre correspond à une pile de feuilles de papier de 5 mètres de haut.*

Dans la mesure où l'eau est le vecteur du transfert des radionucléides vers la biosphère, une barrière géologique sera d'autant meilleure que l'eau n'y circulera pas ou infiniment peu et que la mobilité-solubilité des radionucléides y sera négligeable. Ces deux paramètres sont essentiels pour qualifier un site de stockage profond.

La géoprospective, science qui essaye de prédire la vitesse de variation des évolutions géologiques futures à partir de l'étude du passé permet de comprendre à quel point l'échelle des temps géologiques est différente de l'échelle du temps humain.

Les analogues naturels (par exemple piles naturelles d'Oklo au Gabon) montrent combien les transferts des radionucléides dans le sous-sol peuvent être dans certaines circonstances extraordinairement limités. D'autre part, les nombreux gisements d'hydrocarbures présents dans le monde sont là pour démontrer que la nature a su confiner pendant des dizaines ou des centaines de millions d'années, jusqu'à ce que l'homme les découvre, des substances beaucoup plus fugaces que les radionucléides.

4 - Si l'on admet ce "devoir de faire de notre mieux" à l'égard des générations futures, ne leur ferait-on pas courir un moindre risque en laissant les déchets les plus dangereux en surface sous bonne garde ? Ce serait à bon compte décharger notre conscience autant que notre portefeuille. "Faire confiance à la science" qui réglera un jour le problème de la destruction des transuraniens et les laisser en surface en attendant serait faire un pari aussi incertain dans son issue que dans sa date de réalisation ; de plus la totalité du problème ne s'en trouverait par pour autant réglée. Dans la mesure où un terme suffisamment précis et proche ne pourrait être fixé à un tel entreposage de surface, ce serait spéculer indûment sur l'avenir pour faire semblant de résoudre un problème actuel. Il est impossible de raisonner sur la continuité de l'ordre social et politique, partant sur le devenir des déchets radioactifs à vie longue entreposés en surface, au delà de quelques siècles. Au contraire les stocker dans une formation géologique revient à les faire passer de l'échelle du temps présent à l'échelle des temps géologiques en bénéficiant de la pérennité et de la très faible variabilité que cette notion impose.

Quel que soit l'homme futur, le confinement géologique doit être choisi pour assurer un retour négligeable dans la biosphère. Il n'y a aucune difficulté à adopter pour l'homme d'après demain des normes identiques à celles - très basses - aujourd'hui admises dans la mesure où celles-ci s'inscrivent dans la variabilité de la radioactivité naturelle. En effet quelle que soit sa sensibilité aux radiations, l'homme futur devra toujours supporter la radioactivité naturelle.

5 - Défausser totalement la responsabilité des choix sur les générations futures n'est pas acceptable. A l'inverse est-il conforme à l'éthique de figer - pour leur bien - tous les choix sans qu'elles aient la possibilité d'y revenir ? C'est le problème de la réversibilité du stockage souterrain.

Une certaine forme de réversibilité est sans doute possible et souhaitable au tout début de la vie d'un stockage souterrain. Pendant cette période, de l'ordre du siècle, on pourra vérifier de très près la validité des solutions techniques et être prêt à retirer éventuellement certains colis si les besoins de la recherche scientifique le justifient. De plus il n'y a sans doute pas de problème moral majeur à s'en remettre à la génération n + 2 ou n + 3 du soin de procéder à la fermeture d'un stockage, pour autant que tout ait été préparé par la génération n.

En revanche maintenir un stockage souterrain ouvert pendant une très longue durée (ce qui l'assimilerait d'ailleurs à un entreposage de longue durée en surface) présenterait plus de risques - miniers et autres - que d'avantages et serait d'ailleurs en contradiction avec la notion même de sûreté à très long terme puisque le stockage ne pourrait de ce fait être considéré comme étanche. Nous n'avons aucune idée de l'avenir de notre espèce :

- Ou bien nos lointains descendants auront régressé par rapport à nous et à ce moment là il vaut mieux avoir mis en oeuvre jusqu'au bout des solutions qui garantiront pleinement leur avenir.

- Ou bien ils seront nettement plus avancés que nous et alors ils n'auront aucune peine, tant que la mémoire du stockage sera conservée, à revenir s'ils le jugent utile récupérer les déchets par des techniques minières appropriées. Une fois la mémoire perdue, et on ne peut pas supposer qu'elle ne le soit pas dans la longue période, on se trouvera ramené au cas précédent si le "gisement" de déchets est redécouvert par hasard car cela ne pourra être que par des descendants évolués.

Il faut bien reconnaître que la fermeture d'un stockage dans le souci de ne pas faire porter aux générations futures le poids de la gestion des déchets, présente aux yeux du public un inconvénient majeur ; elle est marquée du sceau de "l'irrémédiable". Mais (voir ci-dessus) l'irréversibilité n'est pas irrémédiable pour des descendants évolués et cette notion sera d'autant mieux acceptée que les scientifiques auront su démontrer, notamment par une expérimentation sérieuse dans des laboratoires souterrains, que le risque encouru dans le long terme est réellement négligeable. Attention toutefois à ne pas tomber dans l'excès inverse : des études trop longues, trop diversifiées et trop coûteuses pourraient amener le public à penser que le problème est tellement complexe qu'il est impossible de le résoudre !

6 - Un stockage souterrain encourt le reproche de stériliser une partie de la nature.

Un stockage peut effectivement empêcher les générations futures d'exploiter des ressources minières situées dans son voisinage immédiat. Il est certain qu'il rend inaccessible pour longtemps un volume de sous-sol de l'ordre du kilomètre cube. Est-ce exceptionnel ? Toute activité humaine stérilise peu ou prou le lieu sur lequel elle s'exerce.

Sans faire appel à l'intervention de l'homme, les roches situées sous l'inlandsis antarctique sont totalement hors d'atteinte, et ce pour de nombreux millions d'années.

Si le lieu de stockage est convenablement choisi, de tels inconvénients sont réellement mineurs et ne paraissent en rien contraires à l'éthique.

En guise de conclusion

Nous avons rappelé comment de nouveaux problèmes éthiques émergent dès lors que nous incluons, dans notre sphère d'attention aux hommes et à la nature, les millénaires à venir. Si nos déchets industriels ont initialement suscité ces questions d'une manière globale et quelque peu imprécise, ceux d'origine nucléaire ont eu ce "mérite" pédagogique d'afficher des durées chiffrables et de poser les problèmes en termes clairs.

L'immensité de ces durées interdisant toute connaissance des hommes concernés par nos déchets et sujets de notre préoccupation, nous sommes réduits à poser des principes éthiques simples et élémentaires - ce qui ne les rend que plus contraignants - en amont de nos travaux de recherche sur le stockage de ces déchets.

S'agissant de déchets nucléaires, outre le stockage de surface pour les parties les moins radioactives, il apparaît actuellement qu'un stockage géologique profond bien conçu doit pouvoir être particulièrement respectueux de ces principes. Cette solution a une très haute probabilité de se révéler indispensable. L'éthique nous commande de l'étudier à fond et sans attendre, tout en menant activement des études sur les autres voies de recherche.[1] Ne rien faire et s'en remettre exclusivement à d'hypothétiques améliorations drastiques à venir serait en revanche commettre un véritable "péché d'indifférence" et agir contrairement à l'éthique.

Une fois cette direction prise, la grande majorité des questions soulevées apparaîtront sans doute d'une importance toute relative et ne devront pas constituer des freins à l'action.

L'éthique personnelle du gestionnaire de déchets radioactifs consiste alors à réunir le maximum d'éléments afin de s'assurer qu'une combinaison adéquate de la géologie et de la technologie permet de démontrer l'absence de nocivité d'un stockage souterrain, aussi bien à court-moyen terme qu'à très long terme. Ainsi, ce gestionnaire devra-t-il acquérir l'intime conviction que la solution proposée n'entrainera pas de risque de radiotoxicité pour les générations actuelles et futures, ou tout au moins pas plus que celui résultant des phénomènes naturels. Une telle solidarité dans le temps (inter-générations) et dans l'espace (dépassant les frontières politiques) n'est-elle pas le fondement même de l'éthique tel que rappelé plus haut ?

L'objectif ultime est de contribuer à ce que le "nuclear world" ne soit pas demain comme certains le disent un "new killer world" mais au contraire un "new clear world". En s'engageant à fond dans l'étude d'un projet de cette importance, en prenant tout le temps nécessaire, en travaillant avec un maximum de sérieux et de compétence, en acquérant finalement l'intime conviction que la solution proposée sera valable aussi bien pour les générations présentes que futures, en étant enfin suffisamment convaincants pour faire partager cette intime conviction aussi bien à l'autorité de sûreté qu'au grand public, les responsables des études de stockage souterrain donneront tout son sens à la formule d'Albert Camus : "la vraie générosité envers l'avenir consiste à tout donner au présent". Ce faisant, ils auront le sentiment d'avoir agi conformément à l'éthique.

---

[1] *Comme la loi de décembre 1991 l'impose en FRANCE.*

Managing Today for Tomorrow

M. Allègre
Chairman of the Board, Andra
Agence nationale pour la gestion des déchets radioactifs

Y. Quéré
Chairman of the Scientific Advisory Board, Andra

The purpose of ethics is to set forth principles that can guarantee basic human rights. Ethics attempts to repress the priority instinctively given by each individual, each group, each nation to its own interests to the detriment of all others. In a word, ethics is an attempt to establish as much equity as possible in a society.

An imperative moral rule...

Although morality differs from one civilization to another or from one era to another, it has universal characteristics. One cannot deny that all men rally around a few major prescriptions. One of them, the so-called Golden Rule, has the advantage of summing them all up in an expression known on all continents: "Do unto others as you would have them do unto you." Judeo-Christian doctrine breathed added force into this rule by proclaiming that all men are the sons of a God and therefore "brothers". Thus armed with transcendence, a rule that was above all practical was given the force of an absolute.

Regardless of whether the reference is secular or religious, we are seeing a widening of its applicability, even as the men that it commends to our solicitude retreat from our field of vision. From the clan to the village, from the village to the nation, from the nation to the planet, the duties conveyed to us become increasingly abstract because we are increasingly unfamiliar with the recipients of our grace. We know of the assistance given to the unknown man in ancient societies: the foreigner, the traveller is protected even if he does not return the favor to his benefactor. This succor given to all and sundry illustrated in the Evangel by the story of the Good Samaritan is doubtless more meritorious than services rendered to our close ones. It is the sign that we bring those who are distant into our midst, that we give them the substance, attributes and privileges of true brothers.

...we must expand...

But now the long-term harmful effects that we generate and leave as an inheritance for others prompt us to introduce not just the man from elsewhere but the man of the future into our ethical field of vision and to ensconce him there. How can one fail to recognize that this intrusion is profoundly unprecedented? The obligation just described, so inherently noble, to provide hospitality and fraternity was less abstract than it appeared. The meeting of contemporaries, one man to another, was still possible. In this scenario it becomes unthinkable. No cordiality will ever reign between beings centuries apart. Henceforth, we find ourselves confronted with this unprecedented anxiety: expanding the Golden Rule to include men of the future obliges us towards hopelessly faceless human beings, whereas it previously applied to outsiders who, as different as they might be, were at least contemporary and capable of communicating with us.

Not that this ethical tie that links us to our remote descendants is a new idea: doubtlessly, the carpenter or stone cutter never existed who built a bridge without somewhat vaguely meditating on his responsibility to future men who will cross this bridge with a confident step for centuries to come. But this ethical duty takes on a unique dimension in our time due to our increased capacity for harm, sharpening our sense of responsibility for our descendants. We have learned to regard the intensive mining of the planet's riches as pillage to our descendants' detriment and the accumulation of waste from our industrial activities as flagrant injustice in their regard. We would be guilty of gross negligence not to heed the widening of the ethic; with the risks that we subject them to come the special duties of elder brothers.

...to the indefinite future

Furthermore, a new field of human activity that pushes the time scale of the ethic to unprecedented lengths is appearing on the scene. Before, time frames were quantified in terms of generations: "I want to leave my great nephews an Earth where they can live in peace and well being." The horizon of our solicitude allowed us to picture future men, our children, somewhat plausibly in our own image. With industrial waste management came radically different time frames: if the waste is nuclear, "half lives" are sometimes counted in thousands or even hundreds of thousands of years. If the waste is chemical, we often no longer have an available frame of reference: the time scales are unlimited. Then, human beings who are totally unimaginable to us enter the scene.

Questions without answers...

Now we are asked to take into consideration the peace and well being of human beings whose customs, knowledge and rapport with nature we cannot even imagine. Will they be supermen, through natural or artificial evolution? Or will dreadful cataclysms return them to the caveman state? Will they be able to decipher our messages? Will they have any awareness of their distant ancestors? Does it even make sense to try to penetrate the mists of time to ponder their situation?

...yet a certainty remains

Given the impossibility of finding answers, what purpose is served by asking ourselves questions about future humankind? Let us instead see in the disposal of long-lived radioactive waste, and more broadly in the disposal of the waste from the chemical industry, an ethical command of unforeseen magnitude. It is this injunction that we must consider: we have no right to leave behind a heritage of risks for generations in the distant future, and we cannot dodge the issue by postulating that scientific progress will protect them.

Certainly, our first responsibility is the health and safety of our contemporaries. We must apply our ethic to them first and foremost. We must protect them above all from any harmful byproducts of our industrial activities. But at least these activities are conducted for them. They profit from their beneficial effects. They can combat their harmful effects. For this, we are affecting untold numbers of future generations by the repositories we create today, for which they are totally irresponsible. To ensure our descendants' "sustainable development", we must give them our technical know-how without making them assume the responsibility for dealing with the harmful effects accompanying the benefits that we ourselves have gained. Among all the unknowns that torment us, at least one certainty remains: that our negligence will cause harm. That our present behaviors have acquired the formidable power of exercising influences that are practically unending in time. The magnitude of the harm sets the tone for the breadth of the vigilance required.

Driving fear...

Let's be honest. Our generation would probably not have mapped out this "new ethical frontier" so unwaveringly had it not been driven by fear. Accidents such as those of Bhopal in the chemical field or of Chernobyl in the nuclear field unveiled a new mistrust of industrial operations that generate pollution and of their fallout now as well as in the future. In these accidents, the field of ecology found added justification for its warnings, denouncing the wounding of nature as much as the harmful effects to man. In this mistrust, let us salute the part of it that is well-founded and that therefore spurs our research on safety and environmental protection, but let us also know how to sort out what is irrational and subjective in it.

In this regard, let us note that many other much more tangible risks--airplane crashes, etc.--are completely accepted because they are part of daily life and therefore commonplace. As J.C. Petit notes, radioactive waste disposal has several characteristics that make public acceptance uncomfortable. Its relative newness, the public's lack of familiarity with such complex technical issues, the affected community's feeling of powerlessness, the long-term duration of potential harmful effects, etc., are just some of the unfavorable parameters in this regard. To this let us add the "original sin" represented by Hiroshima, mistakes made in the past in communicating, the irresponsible behavior of certain countries and the invisibility of irradiation.

...cannot pave the way for an ethic

Regardless of where the fear came from or whether it is well-founded or irrational, it cannot serve as a foundation for ethical reasoning. Fear, fueled by rumor or by the media, has been a springboard for violence, intolerance or reactionary behavior too often to not attempt to analyze it first. In doing this, one might conclude that the growing fear of waste is connected to the fact that overall operating conditions have improved at chemical plants or that nuclear power plants are now relatively commonplace, and that the fear has been transferred from objects that appear to be under control to the growing amounts of byproducts they produce. This "demonization" of nuclear waste is no more acceptable than a systematically soothing presentation of the problems to be resolved.

Another big springboard for intolerance and reactionary behavior is lack of knowledge. Ethics and simple reason converge in requiring that unrelenting care and perseverance be given to informing and educating the public as well as to any entitv involved in the decision-making process.

Principles applicable to all waste...

In light of the foregoing, it is now time to set forth the principles that should, in our opinion, inform waste disposal research.

Radioactive waste is much less unique than generally believed. In fact, the approach for a canister of several hundred year old vitrified reprocessing waste containing very long-lived alpha emitters but that has become a very low beta-gamma emitter should not be fundamentally different from the approach to a toxic chemical waste whose life is "eternal".

Yet the formulation of the issues, the search for reliable solutions and the assumption of the corresponding costs are much further along for nuclear waste than for other waste types.

Beyond the concern for protecting the human environment that is the foundation of any ethic pertaining to any type of waste management, a few general principles applicable to all waste types can be discerned:

1 - **The harmfulness and volume of "final waste" must be minimized.**

- Without entering into the "reprocessing or direct disposal" debate, it is clear that the reprocessing industry constantly expends considerable effort to reduce solidified waste volumes substantially.

- To reduce harmful effects, transmutation/incineration studies underway in France as mandated by the Waste Act of December 1991 give rise to hope for long term results on the condition that advanced reprocessing is undertaken. Even if these studies are successful, not everything can be transformed. There is therefore every likelihood that an underground repository will continue to be a necessity, but the type of waste requiring disposal will have been changed.

2 - The waste generator pays.

This principle is followed for nuclear waste more than for any other, since the nuclear industry includes reserves in its operating budgets for facility dismantling and waste management from the very start.

3 - The generation of today must be protected from harm first.

Our ethical deliberations about the future must not cause us to neglect the protection we owe our contemporaries in any way.

4 - The generation that produces the pollution is responsible for future generations, just as the industrial polluter is responsible for the surrounding environment.

What this principle of responsibility means is that the generation benefitting from the polluting activity is responsible for preventing subsequent generations from suffering either the harmful effects or the costs associated with reestablishing the natural order to protect themselves from any "abnormal" risk.

This amounts to saying that any human activity must leave the area where it was exercised as "clean" when the activity ceases as it was in the beginning. In other words, "please leave nature at least as clean when you leave as you found it when you arrived" so that future man begins with as many opportunities for prosperity as present day man.

This is indeed how nuclear power plants should be dismantled. Waste should be managed on a daily basis in a manner that makes strict compliance with this principle ultimately achievable.

5 - Fellowship

Intergenerational fellowship, since how waste is managed today must allow the harmful effects of tomorrow to be avoided.

International fellowship, since it is obviously not a matter of transferring the harmful effects to one's neighbor. The highly sensitive nature of the radioactive waste issue and the abuses committed by some in exporting their pollution to underdeveloped nations without taking the necessary precautions rightly resulted in the recognition that each nation must take care of its own waste. At least, French law recognizes this. In a more or less distant future, and assuming that the necessary precautions are taken on the international level, there is no fundamental ethical principle that prevents countries from joining together to resolve their radioactive waste disposal problems. We are a long way away from this, but such a development is not unthinkable as long as the resulting repository program has provided the necessary guarantees relative to the absence of noxiousness.

National fellowship, since all waste generated domestically would likely be disposed of at a single site. It is perfectly normal that the host community should gain certain benefits from hosting a sensitive industrial activity, but these benefits should under no circumstances be viewed as buying their silence in the face of excessive risk.

6 - Democracy and Accessibility

Disposal studies and decisions must occur in stages in the framework of a democratic and open process that provides widespread public information and education and ensures complete openness, with all the difficulties implied by the highly technical nature of the subject matter. This is the principle on which the French Radioactive Waste Act of December 1991 reposes. This is also the fundamental mission of the independent regulatory authorities.

...and a few remarks on the nuclear sector

1 - One criticism is often formulated: the radioactive waste issue should have been settled before beginning industrial operations. In so doing, did the generation before us transgress the most elementary rules of ethics? As François Michelin said, "when one gets on a train one likes to know where it is going."

First of all, when it comes to a new science, knowledge is gained on all fronts simultaneously. The wider the body of scientific knowledge from which to draw, the easier it is to demonstrate the reliability of a repository.

Furthermore, the nuclear field expended considerable effort on waste management from the beginning, quickly processed it into solid form[1], and international experts have long considered geologic disposal to be a potential solution as long as it is studied in enough detail.

Today, disposal facilities for low-level radioactive waste are in operation at the surface, as are storage facilities for high-level waste. We are in the applied research phase with regard to deep disposal.

2 - Certain purely economic assessments, such as those pertaining to highway safety, put a quantitative value on human life. This type of approach does not seem feasible for our field, because the very designation of a present value, without which there can be no economic assessment, would amount to discounting the relevance of generations several decades hence, and therefore to being totally unmoved by their fate.

3 - The demonstration of safety is an essential aspect of radioactive waste repositories with three unique characteristics:

- It is a prerequisite for a license. In this respect, it actually constitutes the principal guarantee on an ethical level.

[1] In France, vitrification of fission products was examined as early as 1960 and commercialized at the same pace as the nuclear power program.

- The technology (waste package and engineered barriers) and nature itself (geology) work together to create the waste containment system without active maintenance.

- The time interval to be taken into consideration (one hundred thousand or even one million years) is a completely unprecedented time frame.[2]

The most hazardous radioactive waste--vitrified reprocessing waste or spent fuel--contains a mixture of but short- or medium-lived but highly active fission products and less active very long-lived transuranics. To simplify, one can deduce that the safety of a good repository rests:

- on the ability of both the engineered barrier and the geologic barrier to contain very high-level but short- or medium-lived elements for the first few centuries (500 to 1000 years);

- on the ability of the geologic barrier acting alone to contain long-lived alpha-emitting radioactive thereafter.

Insofar as water is the vector for radionuclide transport to the biosphere, the less the water flow (from zero to an infinitesimally small amount) and the lower the mobility-solubility of radionuclides, the better the geologic barrier. These two parameters are essential in the characterization of a deep disposal site.

Geoforecasting, a science that attempts to predict the rate of future geologic change based on study of the past, makes it possible to identify at what point the geologic time scale diverges from the human time scale.

2 One hundred thousand years is a time frame beyond human comprehension and yet, if the thickness of a sheet of paper represents 100 thousand years, the age of the Earth corresponds to a pile of paper 5 meters high.

Natural analogues, such as the natural Oklo reactors in Gabon, show how extraordinarily limited radionuclide transport in the ground may be under certain circumstances. In addition, the numerous deposits of hydrocarbons in existence around the world show that nature knew how to confine much more evanescent substances than radionuclides for tens or hundreds of millions of years before they were discovered by man.

4 - If one accepts this "duty to do our best" in regard to future generations, wouldn't we be lessening their risks by keeping the most hazardous waste at the surface under heavy guard? It would be a cheap way to unload our consciences along with our wallets. "Leave it to science" to find a way to destroy the transuranics some day and keep them at the surface in the meantime would be a gamble as uncertain in its outcome as in its schedule of accomplishment, yet this would still not resolve the overall problem. Since it is not possible to establish a sufficiently definite and early time frame for this type of surface storage, this amounts to speculating on the future in order to appear to be solving the current problem. One cannot reason on the continuity of the social and political order, and therefore of the future of long-lived radioactive waste in surface storage, beyond a few centuries. Conversely, disposing of such waste in a geologic formation shifts the matter from the current time scale to geological time scales and requires that concepts of perpetuity and very low variability be brought into play.

No matter what the man of the future may be, the chosen method of geologic containment must ensure that transport to the biosphere is insignificant. Adopting standards for the man of the distant future which are identical to the very low ones accepted today raises no difficulty as long as they are inscribed within the variability of natural radioactivity. After all, regardless of his sensibilities regarding radiation, future man should still be able to tolerate natural radioactivity.

5 - It is not acceptable to discard the decision-making responsibility completely for future generations to take up. Inversely, is it consistent with the ethic to have all decisions written in stone--for the good of those future generations--without leaving them the possibility of changing them? Herein lies the retrievability issue of deep disposal.

A certain form of retrievability is undoubtedly possible and desirable in the very beginning of the life of a deep repository. During this time period of about one century, one could verify the validity of technical approaches at close proximity and possibly be prepared to recover certain waste packages if warranted by the requirements of scientific research. Leaving repository closure to generation n+2 or n+3 probably doesn't raise any major moral issues, as long as everything has been prepared in advance by generation n.

Conversely, keeping a deep repository open for a very long period of time (which would make it more closely resemble a long-term surface storage facility) would present more risks--mining and otherwise--than benefits. Furthermore, it would be inconsistent with the very concept of long-term safety, since the repository could hardly be considered watertight if it is left open.

We know nothing about the future of our species:

- either our far away descendants will have regressed in relation to us, in which case it is better to have gone all the way in implementing approaches that fully guarantee their future safety;

- or they will be much more advanced than us, in which case they will have no difficulty in recovering the waste with appropriate mining techniques if deemed necessary, as long as the memory of the repository has been preserved. This still applies even if that memory is lost--and one cannot assume otherwise over the very long term--and the waste "deposit" is discovered by chance, for this could only occur with highly advanced descendants.

It must be admitted that closing a repository so that future generations do not bear the burden of waste management is a major drawback in the eyes of the public; it bears the stamp of "irremediable". But non-retrievability is not irreversible for highly advanced descendants, as discussed above. The more scientists succeed in demonstrating that the risk incurred over the long term is truly insignificant. particularly through responsible experimentation in underground laboratories, the better this concept will be accepted. However, one must avoid falling into the reverse extreme: research that lasts too long, is too diversified and costs too much could make the public think that the issue is so complex that it cannot be resolved!

6 - A deep repository draws the accusation that it renders a portion of nature unusable.

A repository may indeed prevent future generations from mining natural resources in its immediate vicinity, and there is no doubt that it makes an approximately one cubic kilometer area of the host rock inaccessible for a long time. Is this so unusual? All human activities render their work sites more or less unusable for other purposes.

Without human intervention, the formations beneath the Antarctic ice cap would be completely out of reach, and for many millions of years at that.

If the repository location is suitably chosen, such drawbacks are truly minor and are in no way inconsistent with ethics.

By way of conclusion

We have reviewed how new ethical issues emerge whenever thousand year time frames enter into our sphere of attention to man and nature. While these questions were initially prompted by industrial waste in a general and rather non-specific way, those of nuclear origin had the educational "merit" of involving quantifiable periods of time and of presenting the issues in clear-cut terms.

Because the immensity of the time periods involved preclude any knowledge about the subjects of our concern, the future human beings who will be affected by our waste, we can only present simple, elementary, and thereby much more restrictive ethical principles as we begin our research into the disposal of this waste.

In the matter of nuclear waste, aside from surface disposal of its less radioactive components, it currently appears that a well-designed deep geologic repository would be particularly conducive to compliance with these principles. This approach has a very high probability of turning out to be unavoidable. Ethics requires us to examine it in detail and without delay, while actively pursuing studies in the other research areas[3]. Conversely, to do nothing and to rely exclusively on major but hypothetical improvements to come would be to commit a real "sin of indifference" and to act unethically.

Once this decision is made, the vast majority of questions raised will undoubtedly show themselves to be of only relative importance and should not be allowed to interfere with progress.

Personal ethics dictate that the radioactive waste manager must assemble as much information as possible to demonstrate that the deep repository presents no harmful effects in the short to mid term as well as over the very long term through a balanced combination of geology and technology. This manager must therefore be deeply convinced that the proposed solution will not result in a risk of radiotoxicity to current or future generations, or at least no more than that resulting from natural phenomena. Isn't this fellowship in time (intergenerationally) and in space (beyond political borders) the very foundation of ethics as we have defined it?

---

[3] As required in France by the Waste Act of December 1991.

The ultimate goal for the nuclear community is to make tomorrow's world not the "strange new world", as some would have it, but rather a "clean new world". By fully committing to the study of a project of this importance, by taking as much time as necessary, by working with the utmost professionalism and skill, by ultimately acquiring the conviction that the recommended solution will be as valid for future generations as it is for those of the present, and lastly by being persuasive enough to make regulatory authorities and the public alike share this conviction, those responsible for deep disposal research will give meaning to Albert Camus's formula, "real generosity towards the future consists of giving everything to the present." In so doing, they will know that they have acted ethically.

Cost Benefit Analysis, Sustainability and Long-lived Radioactive Waste Management

Frans Berkhout
Science Policy Research Unit
University of Sussex
United Kingdom

Introduction

Following the 1992 Rio conference, the concept of sustainability has been placed at the core of environmental policy all around the world. Fundamentally it is an appeal for long-term environmental burdens caused by current human and industrial activities to be reduced to a bare minimum. It is motivated by the fear that these activities may severely affect the future habitability of the planet and therefore the scope of future societies to develop. Although an idea with obvious appeal, sustainability has proven extremely difficult to make operational. For radioactive waste management, an environmental problem for which long-term perspectives have always been regarded as important, sustainability may be an applicable concept.

Cost-benefit analysis is a technique originally developed for the economic appraisal of capital investment projects. In cost-benefit analysis all costs and benefits are given a money value. Typically costs and benefits do not occur at the same time - capital expenditure usually coming some time before the benefits of revenues and profits. Taking account of the changing value of money through time, cost-benefit analysis 'discounts' costs and benefits to bring them all to a 'present value'. For instance, at a 9 percent discount rate, something which will be worth £1.09 in a year's time has a present value of £1. Having given present values to all the costs and benefits associated with a project, its total net benefit can be calculated and compared against other projects.

The notion of discounting has come to be used across a wide range of other problems, including resource management and environmental policy, in which the benefits and costs of a policy occur over time. Increasingly, discounting has been applied to the assessment of radioactive waste and nuclear decommissioning strategy.

The objective of this paper is to examine how far the sustainability concept and the technique of cost-benefit analysis (CBA) can be applied to the problem of radioactive waste management as described above. The paper begins with a a slightly altered definition of the problem to the one carried in the NEA's background document (NEA, 1994). A preliminary attempt is then be made to ascribe burdens to the various phases of long-lived radioactive waste management. The appropriateness of CBA and the sustainability concept for making decisions about long-term waste management policy is then discussed. We end with some conclusions about the appropriateness of systematic assessment approaches in the political process of constructing social consent for technological decisions.

The Problem

Radioactive wastes have been regarded as presenting special management problems since the 1930s. This, together with the physical fact that the primary hazard of these materials (ionising radiation) declines naturally through radioactive decay, has encouraged nuclear planners to seek to impose comprehensive engineered and institutional controls over radioactive wastes. Most high-level wastes have therefore been stored under surveillance, only a small proportion having been disposed of to the environment.

However, there has long been a recognition that this practice is unsustainable in the long-term. First, populations living around storage sites want to be assured that their regions will not become dumping grounds for radioactive wastes. Second, long-term storage imposes a duty of care and the costs of future technological intervention on future generations. Third, storage assumes that future societies will always be in a position to exercise institutional control over these materials. Recent revelations of nuclear weapons material smuggling in Europe demonstrate again that this assumption is unfounded. Fourth, radioactive waste management is an activity which generally provides no net benefit, but only costs. The beneficiaries of waste production live now, in the future waste management will incur only costs.[1]

For these reasons it has become policy in most countries that present generations must set in place options for the final disposal of high-level wastes. It is widely accepted that the most appropriate means of achieving this is to bury them deep underground. The central policy problem is that while present societies must prepare for the day when final disposal becomes fact, they are aware that they will always be faced with some residual uncertainty about the safety of the repository. They are also aware that by disposing of wastes in the short-term they would be foreclosing possibly better options which might be developed in the future. The balance which must therefore be struck is between the benefits to future societies of being free of the burdens of maintaining institutional control, and the costs of uncertainty over safety, and the costs of foreclosure.

Overcoming opposition and building social consensus is likely to take a long time, and final disposal is not likely to begin anywhere for several decades. Even then, there is likely to be a prolonged period over which the repository is monitored and the option of retrievability or repair is maintained. Any decision to end direct control over high-level wastes is therefore still several generations away in most countries. This imposes financial, political and physical burdens on people and societies in the nearer future.

---

[1] It may be argued that if the high-level waste is in the form of spent fuel, some future benefit may be produced through the recycling of plutonium.

Our inability to forecast precisely the behaviour of repositories also means that we must accept that radioactive wastes cannot be entirely excluded from the biosphere. Long-term safety assessments have to assume that some fraction of the radioactivity eventually will be released into the human environment over long periods of time. Releases of radioactivity to the biosphere can be therefore be expected, and these will be translated into radiation doses to humans and other biota.

Defining Wastes, and Costs and Benefits

To simplify matters, the present assessment will be limited to the problem of how to deal with radioactive wastes. The costs and benefits to be considered are therefore those associated with different waste management strategies, rather than a wider assessment including the entire nuclear fuel cycle. The analysis presented here will not be concerned with how to balance the benefits of nuclear power against the long-term risks of radioactive waste management. Nor will it be concerned with trying to compare the risks of the nuclear fuel cycle with those of other electricity generation systems.

In looking at waste disposal strategies we are concerned with two types of radioactive waste: spent nuclear fuel, and high-level waste (HLW) generated from the reprocessing of spent fuel.[2] Spent fuel is a metal or a ceramic containing a substantial proportion of uranium and plutonium and needing to be monitored by international inspectors. HLW will primarily be encapsulated in a glass, contains primarily fission products and other transuranic elements, and generally falls outside safeguards. Most of the world's high-level waste will be stored and disposed of as spent fuel. No more than one-quarter is likely, on current estimates, to be in the form of reprocessing wastes (Albright et al., 1993).

Because of their differing characteristics, the two waste forms will impose differing burdens on future generations. For instance, whereas it is assumed that reprocessing high-level waste will be processed into a glass form soon after reprocessing, spent fuel is not expected to be encapsulated until shortly before final disposal. The costs of HLW vitrification will be borne now, the costs of spent fuel encapsulation will be borne perhaps 50 years hence.

While much attention is rightly given to the financial and health risks of radioactive waste management, there are a number of other burdens which must be considered. These relate mainly to the scientific, industrial and regulatory infrastructures which have grown around the whole nuclear enterprise, and which determine so many of its activities. Over long time periods, when great social and political changes can be expected, the preservation of such infrastructures cannot be assumed. The cost of maintaining these structures, unacknowledged today

[2] Following the work of the United States National Academy of Sciences, a third alternative of waste forms embedded with plutonium extracted from dismantled nuclear warheads has been proposed (USNAS, 1994).

because we assume that they are justified by the benefits of nuclear energy, may prove to be a burden to future generations.

Nuclear waste policy decisions must therefore take into account many factors. A comprehensive list of these might include: the costs of waste management (financial burdens); the labour inputs of waste management (physical burdens); the risks to the health (health burdens); the need to create and maintain regulatory agencies (institutional burdens); the need to resolve political conflict over waste policy (political burdens); and the need to prevent the theft and diversion of nuclear-weapons materials (security burdens).

Management of both spent fuel and HLW is likely to go through a number of phases, and in each of these phases different burdens will be invoked. For several decades at least, the waste will be stored. The primary reason for storage is to permit the decay of heat and radioactivity of the waste. Although there is a natural preference to avoid the handling of radioactive wastes unless for pressing safety reasons, a number of different storage technologies are available, and each will have somewhat different consequences for costs and risks to present and future populations.

Storage may continue for a very extended period, either by design or by circumstance. HLW began to be produced at Windscale in 1951. On past experience, it seems likely that this material will still be in store at the site in 2051. Dutch policy to 'isolate, control, monitor' highly toxic wastes (including radioactive waste) explicitly rejects disposition strategies which eliminate the opportunity for future human intervention. In this case, an explicit policy of monitored retrievable storage of HLW is therefore proposed.

In most countries, however, declared policy is to pursue final disposal. According to the currently accepted concept, this implies the construction and operation of geological repositories. Typically such repositories would be located on the territory of the country where the wastes originated, although international repositories have also been considered. Under a final disposal policy, a decision would eventually need to be taken to seal the repository, although some surveillance might be maintained. A repository with spent fuel waste would probably need to continue to be subject to international verification, even after closure. Some commentators have been concerned that with heat and radioactive decay, a spent fuel repository would become a 'plutonium mine' which would be an attractive source of nuclear weapons material for a proliferating state.

Each stage of the management process produces a differing set of burdens. Table 1 provides a simple allocation of the burdens listed above to the different stages of high-level waste and spent fuel waste management - the darker the shading, the further into the future the burden. It is important to note that the nature of each of these burdens will be different depending on the waste type being considered. As we have seen, the costs of vitrifying reprocessed HLW will be borne in the short term, while those for spent fuel encapsulation would be borne much later. To take another example, since the heat rate from spent fuel is higher than from HLW, spent fuel may need to be either stored for longer in order to conform with heat rate specifications than HLW.

Cost Benefit Analysis and Radioactive Waste Management

Cost benefit analysis is a technique for resolving resource allocation problems. Its main function has been in calculating the net economic benefit of different investment decisions. As explained above, discounting is the main device for giving commensurable valuations to costs and benefits which are not simultaneous.

There are two primary motivations behind discounting future streams of expected costs and benefits. The first is the existence of time preference: the preference for current over future consumption. The second, familiar in business practice, is the opportunity cost of capital: that resources invested now are likely to be productive in the future. Despite many problems of measurement, it is widely agreed that time preference rates will be below opportunity cost rates, and that social rates will be lower than private. This is because while private individuals will be certain of their own deaths and are therefore indifferent about long-term benefits, governments or societies at large will behave as if life continued indefinitely and must therefore be less myopic (Lind, 1982). The discount rate chosen will therefore depend on the problem being analysed.

A simple example where cost benefit analysis works well is the problem of whether a family household should install double-glazed windows. The up front costs and the future benefits in terms of energy savings are reasonably well known. Their monetary values are discounted over a relatively short period of time, and the bearer of the cost and the beneficiary are usually the same person or persons.

CBA has come to be widely applied to public policy issues, including problems of long-term resource conservation and depletion. Such applications have generated a long debate over whether to apply low or high discount rates to slow growing resources (forests) and environmental assets (biodiversity). On the one hand, high discount rates discourage the long term management of these resources, on the other hand, high discount rates also discourage capital investment which may be the main cause of environmental transformation or resource extraction. Low discount rates, while valuing environmental assets more highly would also encourage greater capital investment with possibly adverse environmental effects.

To overcome this paradox, economists concerned with environmental degradation have argued for a dual approach in which market discount rates are applied, but that projects are also be appraised according to a 'sustainability constraint' (see, Pearce, Markandya and Barbier, 1989). A sustainability constraint would involve devising a 'shadow project' which would parallel any environmentally-damaging activity. For instance, proposals have been made for the planting of tree plantations to compensate for the emission of carbon to the atmosphere from fossil fuel power stations. A sustainability constraint applied to radioactive waste management would appear to argue for early final disposal since there is no obvious shadow project that could compensate for the long-term leaching of fission products into deep aquifers.

The welfare of future generations has also been considered in the cost benefit literature (see, Stiglitz, 1974, Solow, 1974 and Krutilla and Fisher, 1975), but has typically been treated as a special problem requiring a social discount rate to be set which provides for a more equitable distribution of welfare between the generations. The question of which rate to set is left unresolved, and where very long periods of time are involved, it appears to be unresolvable.

The obvious concern is that with positive discounting over long periods, the interests of future generations appear to be neglected. If one considers monetary costs alone, it is clear that even using a very low discount rate (2 percent is the rate used for the most secure form of investment, gilts) the present value of any project more than a couple of generations in the future will be reduced to an insignificant figure, and can therefore be ignored. Environmental clean up costing £1 today, which must be borne in 150 years time, discounted at a two percent discount rate, would have a present value of 5p.

This immediate concern is buttressed by ethical, theoretical and empirical arguments against applying discounting to intergenerational transfers of resources and environmental burdens. The ethical argument is that an instrument for efficiently allocating resources in the near term is an inadequate framework for considering the interests of future, unborn generations. Sen (1982) argues that there is '...very little scope for avoiding a deliberate ethical choice in choosing appropriate rates of discount'. This appears to be especially apparent in long-lived radioactive waste management where the benefits accrue only to the present generation, while future generations bear only the cost. Through discounting we are assuming that the burden of waste management will be less onerous for future generations than for us, and undervaluing their rights to be free of it entirely.

Theoretical support for the argument against discounting across generations also exists. Cost benefit analysis takes the existing distribution of resources as a given. Different distributions of resources produce different prices, including different discount rates. Since the distribution of resources will be changed by transfers of resources between generations, so will the discount rate. Playing with the discount rate to produce a desirable distribution of resources is therefore an illogical and inefficient procedure (Norgaard and Howarth, 1991). Norgaard and Howarth argue that where one is concerned with distributional issues, one is primarily dealing with problems of equity, and such problems should be resolved through political processes, not buried in arguments about which discount rate may be appropriate.

Recent debates about regional and global environmental justice demonstrate that distributive equity in risk management are becoming more, rather than less important. The core issue here is that environmental burdens should not be borne by communities which have not benefited from the economic activity which generated the burden. Although, in principle and in economic theory, such inequities can be redressed through compensation, in reality such compensation schemes may be of rather limited value.

Lastly there is an empirical argument. During the heyday of CBA in the 1950s and 1960s, an assumption of sustainable positive economic growth seemed reasonable. That is no longer the case. Having seen growth rates in industrialised countries decline and being more aware of the environmental limits to growth, our vision of the future has changed. A wide range of opinion still exists, but in general there has been a shift from being 'cornucopian' to being rather more 'pessimistic' about the future. The extrapolation of positive economic growth into the future therefore seems less responsible today, and consequently the application of discounting over long time periods appears less legitimate.

The application of discounting directly to non-monetary costs, even over short periods, encounters further objections. How would one set a discount rate for the risk of death due to exposure to radiation? Since individuals are impatient and unsure about the future, they may be able to judge that they prefer life today over life tomorrow, that is, they can discount over their own future lives. But the idea of imposing discount rates over the lives of other people, let alone on an almost infinite set of succeeding generations seems extremely problematic.

Clearly resource allocation decisions are continually being made which imply mortal risks to human health. Many investment decisions are informed by cost benefit analyses which apply monetary values to life and apply discounting to these values (British road safety investment is closely driven by cost benefit assessments where the chief benefit is lives saved). However, such applications of cost-benefit analysis can rarely be decisive and have typically proven extremely controversial. This is primarily because such decisions involve larger, more complex technological systems with many different attributes affecting several different stakeholder groups. These attributes are typically incommensurable (as are the attributes in Table 1) and cannot be captured within a single, monetary value. The money valuation of human life or of a church spire has become a sophisticated art, but it remains a very imperfect means of informing what are essentially political decisions.

More importantly, the social distribution of the costs and benefits of a project or policy are nearly always uneven. The beneficiaries of a private investment are usually not the ones who bear the environmental or other burdens associated with a project. Attempts are typically made to redress this by either changing the discount rate to reflect equity considerations, or by referring to other criteria besides net benefit under CBA. The objective of efficiency thereby becomes tempered by objectives of equity. As we have seen, there is no unambiguous way of deciding on the 'right' discount rate in such cases, so that the result of such an analysis risks being seen as arbitrary from some perspectives.

This problem of distributional equity becomes even more acute where cost benefit analysis is extended beyond currently living people. In particular it is not possible to foresee the preferences of future societies. For instance, what kinds of safety standards will societies 100 years hence insist on when they construct HLW stores or spent fuel repositories? Will the dread of radiation still be as pervasive as it is today? Will future societies be more capable of developing a social consensus over final disposal policy? Will the diversion or theft of nuclear material be regarded as more or less of a threat?

Where monetary costs and benefits are concerned, the problem of intergenerational equity may be resolved by assuming economic growth. In applying discounting an assumption is made that because of increasing wealth, the relative monetary values of most things decline (antiques and unique ecosystems are counterexamples). As the economy grows and general welfare improves, so the value of any given benefit declines relatively. Benefits projected further into the future will have less value, relatively, than those expected in the near future.

But such 'growth' concepts cannot be readily applied to non-monetary costs and benefits. Does the value of the risk of death decline over time? For radioactive wastes there is the in-built reduction of risk with time due to the decay of radioactivity. In this sense discounting is already a central feature of radioactive waste management. It might also be argued that, with improved scientific understanding, cancer will one day be curable, and that therefore over the longer term the risk of a cancer-related death could be discounted. An opposite view would hold that with increased wealth, tolerance of health risks falls and that improved monitoring technology leads to greater concern about environmental risks - witness the recent episode of public concern over air pollution levels in Britain.

We have moved in the present discussion from simple short-term investment decisions to a range of long-term problems of public policy in which a variety of incommensurable and unevenly distributed costs and benefits are at issue, many of which are not well known. The larger the problem, the more we are faced with uncertainty and with problems of distributional equity. And as the problem of distributional equity has loomed larger, so the appropriateness of cost-benefit analysis has become more arguable.

In terms of scale and scope, most aspects of the long-term management of radioactive waste fall in the latter category. Referring again to Table 1, the only set of burdens to which CBA could confidently be applied would be economic assessments of different interim storage strategies for HLW or spent fuel. Such stores would have relatively well-defined costs and benefits, and would have a lifetime of about a generation (30 years).

All the other problems invoke issues of intergenerational equity, or issues which cannot be adequately handled within cost benefit analysis. As we have argued, problems of equity cannot be fitted within a formal procedure designed to secure the efficient distribution of resources. Hence, CBA cannot unambiguously be applied to any of the other problems of radioactive waste management policy, even though it may have some function in placing in context the key decisions over intra- and intergenerational equity which need to be resolved.

Sustainability and Radioactive Waste Management

The sustainability concept can be seen as a response to the inadequacies of cost benefit analysis. Its perspective is over the long-term, and its main appeal is that it is concerned with problems of intergenerational effects. Sustainability is not a relative concept, but seeks to set some absolute rules. In contrast to cost benefit assessment, it is therefore not concerned with allocating costs and benefits according to criteria of efficiency. Nor is it at root concerned with setting rules about social or intergenerational equity. Rather, it is concerned with minimising the transfer of direct or indirect burdens across generations. The basic rule is that irreducible burdens (usually environmental) on future generations should be minimised. It therefore appears to impose more stringent constraints on current activities than would cost benefit assessment. Nonetheless, 'sustainability' still faces the impossible task of accounting for the preferences of future generations since it seeks to secure "...the ability of future generations to meet their own needs." What their 'ability' and what their 'needs' will be remains as unclear as ever.[3]

The sustainability concept has come to be associated with two other principles. The first is the 'precautionary principle' which is defined as "preparedness to take precautionary actions where there are good grounds for judging either that action taken promptly at comparatively low cost may avoid more costly damage later, or that irreversible effects may follow if action is delayed." The second is the 'polluter pays principle' under which the full costs of controlling or cleaning up pollution are borne by those causing it.

The precautionary principle suggests that early action to mitigate environmental effects is preferred, and that irreversible effects should be avoided altogether. Loss of biodiversity is the best example of this, but effects which are not 'reparable' through human effort, or reversible through natural process would also be included - wide-scale radioactive pollution would, in most cases, be regarded as an irreversible environmental effect.

The 'polluter pays principle' is primarily concerned with the monetary costs of pollution control. The most straightforward interpretation of the principle is that if pollution and its various direct and indirect effects are not fully dealt with by those who caused it, funds should be endowed to those who are given the task. Where intergenerational transfers of funds are concerned, as in long-term radioactive waste management, there are two main considerations. First that conservative assumptions are made about the future growth of funds, and second that some account is taken of the real inflation which has affected most nuclear industry-related technologies. Significant contingencies therefore need to be built into waste management funds.

Over periods longer than a couple of generations, and in line with the sustainability concept, the polluter pays principle suggests a cautious approach that would not pre-empt future decisions. Such an approach would assume no

[3] The Brundtland Commission definition is "development which meets the needs of the present without compromising the ability of future generations to meet their own needs."

discounting of costs beyond a certain point, i.e. after the closure of the reactor or other activity which gave rise to the radioactive waste, and would estimate costs on the basis of early disposal to a repository. If net positive economic growth did occur, and the estimation of costs had been correct, then a surplus might be left to those who dealt with the wastes (Thomas, Mackerron and Surrey, 1994). Since sustainability does not require an equalisation of burdens between generations, the balance of economic risk should be skewed towards the current generation.

As we have argued, the sustainability concept appears to be appropriate to radioactive waste policy, but the result is not obvious. On the issue of whether to store or to dispose, no clear guidance appears to be given. On the one hand it seems clear that most of the burdens of waste management would be reduced to a minimum with early final disposal of wastes to a geological repository. In addition, early disposal would ensure that the financial burden of waste management was borne by current or near future generations. On the other hand, by some definitions the final disposal of highly-toxic wastes is an irreversible environmental change, and should be avoided. No decision on relinquishing human control is possible because this would be a pre-emption of the choice of future generations to manage wastes in the way they chose. A decision now also runs the risk of jeopardising access to as yet unexploited resources.

Under a storage strategy what conditions would be commensurate with sustainability? The minimisation of burdens would probably involve emplacing radioactive wastes in a passively safe facility where monitoring and repair of waste containers was automated. Long-term safety criteria for such a facility could be set according to current criteria, or employing a 'risk-added' approach (Goodin, 1983), or according to some tougher standard which would take into account future tightening of standards. Under the risk-added approach, current best practice is applied universally. For instance, the cumulative health risk associated with the storage facility should be comparable to the cumulative hea;th risk to all future generations associated with the final disposal in a geological repository of the wastes. For advocates of this strategy, the minimisation of burdens would not come through improved safety, but in the assurance that if something went wrong, it could be put right. To gain this type of assurance industrial, regulatory and security infrastructures would need to be maintained, although probably at a lower level than at current radioactive waste storage sites.

What can sustainability suggest for a strategy of waste disposal? If the presumption is for early disposal, then the first question is - how early? The key physical criterion here is the heat output of the waste, since to a large degree this determines the design of the repository. The earlier the waste is placed underground, the larger the repository will have to be and the lower will be the certainty that the safety assessment for the repository is reliable. Over a 30-year period the heat output from a standard PWR fuel assembly will have decayed to about 1000 watts/tonne (W/t) of fuel (down from about 10,000 W/t after one year). The decay of heat output then slows dramatically, so that after 100 years the output is still at 500 W/t. The marginal benefits of waiting for further decay to reduce the size of the repository, or improve assurance about repository safety therefore decline sharply after about a generation. This is especially so for HLW which has a lower heat rate, primarily due to the extraction of plutonium and its daughters.

Under sustainability guidelines, safety criteria for a repository might also be based on a risk-added concept. For instance, the health risks associated with a repository might be made comparable to the cumulative risks to all future generations associated with the uranium which generated the wastes, had it been left unmined. A more stringent approach would, as above, attempt to take into account future increased risk aversion. This could be done by taking current standards and adding a further degree of contingency, by for instance improving current radiological objectives by an order of magnitude. The problem of jeopardising future resource extraction appears to be a rather minor one, considering the actual scale of repositories, but could be avoided through foresight studies of mineral resources in the region of a repository.

Financing of the repository project would need to be covered by a levy on nuclear electricity and its deposition in segregated and highly secure funds. A regular review would be made of the estimated costs of the repository system and adjustments made to the levy accordingly.

What we end up with under sustainability guidelines closely resembles many existing policies for radioactive waste management: early disposal under stringent safety criteria and financed out of current nuclear electricity consumption. But while this is the stated objective, there must be grave doubts about whether the objective is achievable. The main reason for this is the inability in many countries to overcome the bitter political conflict which geological repository projects provoke. Although it is possible that new breeds of technological dread will lead to a reduced level of concern in the future, so far as we can see today, the fear of radiation will always be with us. If sustainability guidelines suggest that disposal is the right strategy, its main force may be in putting renewed pressure on the nuclear industry and governments to find a way of achieving public acceptance for repository projects early. As we have argued, the main burdens being placed on future generations through delay are social and political.

Conclusions

We have argued that no assessment methodology, no matter how systematic, can take account of all the ethical and distributional problems thrown up by long-lived radioactive waste management. Rather than depending on a single technique, it is necessary to stress the process of achieving public acceptance of a management strategy, whether it is storage or disposal. The role of systematic assessment is in laying out the main parameters of the problem and to predict what the ramifications of different strategies might be - not to come to a conclusion about which is best. That decision is a political one, and must be left to political processes. What matters is who makes the final decisions and by what authority. In the 'risk society' of today, in which our trust is tied to abstract systems of authority, rather than to individuals or to what can be experienced, the achievement of trust is especially difficult. Logical and comprehensive assessments of the consequences of different courses of action may play a part in achieving that trust, but they should not be used as a means of burying or ignoring the ethical choices which are being made.

References

D. Albright, F. Berkhout and W. Walker, World Inventory of Plutonium and Highly Enriched Uranium 1992, Oxford University Press/SIPRI, Oxford, 1993.

R.E Goodin, Ethical Principles for Environmental Protection, in R. Eliot and A. Gare (eds), Environmental Philosophy, The Open University Press, Milton Keynes, 1983.

J.V. Krutilla and A.C. Fisher, The Economics of Natural Environments, Johns Hopkins University Press, Baltimore, 1975

R. Lind, 'The Rate of Discount and the Application of Social Benefit-Cost Analysis, in R. Lind (ed), Discounting for Time and Risk in Energy Policy, Resources for the Future, Washington D.C., 1982.

R.B. Norgaard and R.B. Howarth, Sustainability and Discounting the Future, in R. Costanza (ed), Ecological Economics, Columbia University Press, New York, 1991.

OECD/Nuclear Energy Agency, Background Document for the Workshop on the Environmental and Ethical Aspects of Long-Lived Radioactive Waste Disposal, Working Document, Paris, 10 June 1994.

D. Pearce, A. Markandya, and F. Barbier, Blueprint for a Green Economy, Earthscan, London, 1989.

A.K. Sen, Approaches to the Choice of Discount Rates for Social Benefit-Cost Analysis, in R. Lind (ed), op cit.

R.M. Solow, The Economics of Resources or the Resources of Economics, American Economic Review, 64:1-21, 1974.

J.E. Stiglitz, A Neo-classical Analysis of the Economics of Natural Resources, in V.K. Smith (ed), Scarcity and Growth Reconsidered, Johns Hopkins University Press, Baltimore, 1979.

S. Thomas, G. Mackerron and J. Surrey, Sustainability and Nuclear Power Plant Decommissioning, Paper presented to the symposium 'Models of Sustainable Development: Exclusive or Complementary Approaches of Sustainability?', Paris, March 1994.

United States National Academy of Sciences, Management and Disposition of Excess Weapons Plutonium, National Academy Press, Washington DC., 1994.

Table 1: Burdens associated with long-term radioactive waste management

		Burdens
Storage		
	Interim storage	Financial Physical Health (workers) Security
	Long-term storage	Financial Physical Health (workers) Institutional Security
Final disposal		
	Building repository	Financial Political Physical Health (workers) Security
	Repository pre-closure	Financial Physical Health (workers) Security
	Repository post-closure	Health (other populations) Security?

Balancing Risks and Benefits Fairly Across Generations: Cost/Benefit Considerations

Bayard L. Catron
George Washington University
(United States)

Introduction

This paper has been prepared for the OECD Nuclear Energy Agency Workshop on the Environmental and Ethical Aspects of Long-Lived Radioactive Waste Disposal. The Workshop is intended as a step toward preparation of a collective opinion on deep geological storage of nuclear waste. As requested, this paper addresses the specific questions raised in the Background Document. Since I was asked to focus on the cost/benefit considerations, the paper is organized around those eight questions. Views on the other ethics questions are expressed in the Appendix.

The ethical concerns here involve the circumstances and extent of imposing risks and burdens on unwitting, involuntary populations and related issues-- for example, the distribution of burdens and benefits on different populations ("environmental justice"), and the relative importance of social values such as safety and principles such as preserving options for future generations. Technical issues like comparing the physical features of possible waste storage sites can often be addressed without asking larger questions. In contrast, dealing with ethical issues characteristically involves asking the larger questions: What should societies be doing to reduce risks to current and future populations (e.g., by exploring alternative types of energy production)? What steps should be taken (e.g., research) to compensate future generations for non-renewable resource use and environmental health/safety burdens? Who should decide (and how) which groups should bear what risks?.

While it is understandable that this workshop will not address such wide-ranging issues as public participation and reducing waste generation, these can be key elements of ethical responses to environmental risks. Also, appropriate ethical principles can rarely be applied simply and often must be balanced against each other. Thus, an ethical analysis should not be expected to provide definitive recommendations on such issues as isolating wastes on-site versus in geological repositories, or the choice of temporary/retrievable versus permanent storage.

Ideas in this paper have grown out of a study for which I am research director, entitled **Deciding for the Future: Balancing Risks and Benefits Fairly Across Generations**. The project, conducted by the National Academy of Public Administration (an organization chartered by Congress to improve government at all levels), has been sponsored by the U.S. Department of Energy through Battelle Pacific Northwest Labs. Nothing said here should be construed as representing the position of any of these organizations.

Cost/Benefit Considerations

a. Discounting of costs with time is a widely applied technique in the evaluation of the impact of economic and industrial decisions. Could or should discounting of long-term health risks due to radioactive waste disposal be envisaged?

While the technique of discounting is specifically designed to make trade-offs between the present and the future, it is problematic when comparisons involve the lives and health of future, unborn people. Indeed, there is broad agreement in the literature [limited here to the literature available in English] that, for various reasons, it is inappropriate to use traditional discounting techniques over long periods of time, especially for projects that affect multiple generations. In a conference on discounting issues held in 1988, Lind[1] stated that, "for long term policies, the benefit-cost rationale for discounting breaks down and must be reestablished on principles incorporating intergenerational equity." In an overview of the same conference, Charles W. Howe[2], then President of the Association of Environmental and Resource Economists, concluded that "a defensible philosophical basis for long term, intergenerational discounting has yet to be found."

One reason the technique does not work well is simple mathematics: since the present value of future benefits declines the farther out into the future they occur, even with a very low discount rate a health benefit saving thousands of lives 10,000 years from now would have a negligible present value. To illustrate this point dramatically, "a complete loss of the world's GNP a hundred years from now would be worth about one million dollars today if discounted by the present prime rate."[3]

But beyond this, there are several substantive arguments that discounting is not ethically appropriate for decisions that affect future generations. Mishan[4] argues against discounting benefits to future generations at all, since they accrue to different individuals. Norgaard and Howarth[5] argue that "discounting is appropriate with respect to the efficient use of this generation's resources but it inappropriate when this generation is primarily concerned with redistributing resource rights to future generations." According to a similar argument, discounting

---

[1] Robert C. Lind, "Reassessing the Government's Discount Rate Policy in Light of New Theory and Data in a World Economy With a High Degree of Capital Mobility," *Journal of Environmental Economics and Management* 18(2), Part 2, 1990: S8-28.

[2] Charles W. Howe, "Introduction: The Social Discount Rate," *Journal of Environmental Economics and Management* 18(2), 1990: S1-2.

[3] Brown, *Greenhouse Economics: Think Before You Count*, Report from the Institute for Philosophy and Public Policy 10, 11 (1991), in Zygmunt, *Environmental Law*, p. 62.

[4] Mishan, 1975, cited in W. R. Cline, *The Economics of Global Warming*. Washington, DC: The Institute for International Economics, 1992, p. 238.

[5] Richard Norgaard and Richard Howarth, "Sustainability and Discounting the Future," in Robert Costanza, ed. *Ecological Economics: The Science and Management of Sustainability*. NY: Columbia University Press, 1991.

"...is designed to help assess only whether an action is efficient, not whether it is equitable. ...Discounting for environmental regulations that span several generations may obscure intergenerational inequities."[6]

The U.S. Environmental Protection Agency (EPA)[7] has described three arguments against discounting future health risks in particular. First, some argue that no discount rate should be used because there is no actual life-saving market mechanism that can value society's benefits from future versus present lives saved.

Second, discounting can lead to inequitable distribution of health benefits: "When using a 10 percent discount rate, for example, we value 100 lives saved 30 years in the future the same as 6 lives saved in the present. Thus, when a high discount rate is used, expenditures made to save lives in the future appear to be much less effective than expenditures that will save lives today."

Third, it may be inappropriate to use the same discount factor for money and for human life. The argument here is that, while the value of money varies with time, the value of human life does not. Raiffa, Schwartz and Weinstein[8] strongly disagree, arguing that discounting is:

> ...merely an accounting device to place the dollars spent and the lives saved at the same point in time. In effect, we discount future lives precisely because dollars invested today should be expected to yield more life-saving in the future than in the present. It is because of our concern that resources be applied at the point in time where they can save the most lives that we "discount" lives. It is, emphatically, **not** because we wish to value future lives less than we value present lives in any absolute or utilitarian sense. It is because we do not want to be wasteful of scarce resources in saving lives, either present or future.

Without agreed-on methods of handling intergenerational benefits and costs, long-term projects cannot be effectively defended or compared adequately to present ones. For example, Richard Howarth[9] states that "we can reasonably speculate that society would be willing to spend extra resources to mitigate the threat of potentially catastrophic risks. But the appropriate sum to pay is beyond the reach of economic analysis and thus depends on the exercise of raw

---

[6] U.S. EPA, "EPA's Use of Benefit-Cost Analysis: 1981-1986," EPA-230-05-87-028, August 1987, p. 6-3.

[7] Ibid.

[8] Howard Raiffa, William Schwartz, and Milton Weinstein, "Evaluating Health Effects of Societal Decisions and Programs", *Decision Making in the Environmental Protection Agency, Selected Working Papers*, Volume IIb, Washington, DC: National Academy of Sciences, 1977.

[9] Richard R. Howarth, "Environmental Risks and Future Generations: Criteria for Public Policy," in U.S. EPA, *Clean Water and the American Economy Proceedings: Ground Water*, Vol. 2, EPA 800-R-93-001b, 1993: GW4-31 - GW4-43.

value judgements regarding what is acceptable and what is not." And D'Arge and Spash[10] argue that: "Because of classical and new problems in valuing public goods, it is currently impossible to quantitatively estimate the amount of optimal compensation [to future generations for environmental damage caused by the present generation]."

Given all these arguments, we are left with a need to make decisions that involve balancing risks and benefits between present and future generations without agreed-on, definitive analytic tools. In the absence of general agreement on how future generations should be treated, no comprehensive treatment of long-term discounting can be developed. A stronger philosophical foundation regarding the equitable treatment of future generations seems to be necessary before adequate discounting techniques can be developed.

However, this is not the end of the matter. Despite the lack of an adequate **technique**, decisions affecting future generations still must be made-- and we do frequently discount the future **in fact**, even when no technique or rate is explicitly used. For example, in all those many situations when current decisions have long-range implications that are not taken into account, the long-term future is effectively discounted at the rate of 100 percent. [Also, when a discount rate is applied over a 20 or 30 year period, longer-term effects are typically totally ignored.] This amounts to a bias in favor of the present. On the other hand, it also seems at least intuitively irrational not to discount the future at all. For example, when the U.S. Department of Energy is not permitted to discount in setting priorities for its clean-up efforts, it must treat hypothetical risks 10,000 years in the future exactly like explicit current concrete risks, such as the risk to workers conducting clean-up activities.

In the absence of a viable and defensible discounting technique, other strategies can provide some guidance (though not "definitive solutions") to decision makers. First, a set of principles to "balance" the interests of present and future generations can help to make these trade-offs. Some principles are suggested under d.2) below, and discussed further in section f. Another strategy that recognizes the limitations of our ability to "balance" between present and future because of vast uncertainty about the far future is to focus on what we pass on to the next generation; this is discussed in section d.2) in relation to the sustainability ethic and the notion of a "rolling present."

b. Is it possible to assess what is passed on to future generations in terms of health risks, other detriments and possible benefits of all sorts, directly or indirectly? Should such an <u>assessment be applied generically to human activities in a broad sense or should it concern only waste disposal issues?</u>

Clearly, assessment should specifically address waste disposal and also the next "higher" level of analysis, waste generation. But broader comparisons are crucial as well, to assure that major resource allocations are not seriously imbalanced, and to assure that important social values are being served. [NOTE: Precise and definitive results should not be expected from the latter kind of analysis. We pass on a heritage to future generations, not just a bundle of risks and

[10] Ralph C. d'Arge and Clive L. Spash, "Economic Strategies for Mitigating the Impacts of Climate Change on Future Generations," in Robert Costanza, ed. *Ecological Economics: The Science and Management of Sustainability*. NY: Columbia University Press, 1991.

benefits; no analytic calculations can do justice to that.] Here, as with any important, complex public problem, multiple analyses and different levels of analysis are warranted.

c. **How can the immediate needs of the current generations, for example for energy generation or public health protection, be balanced with intergenerational equity requirements in the very long term?** **This question is addressed in further detail by the next ones.**

How can we balance risks and benefits fairly across generations, especially over the very long term? While other sections contain more detailed responses, the general outline of an answer to this question is as follows:

– The usual technique for making temporal comparisons, discounting, does not work well over long time frames-- and yet there is a continuing and increasing need to make trade-offs between current and future generations.

– Some principles have been developed that, with further iteration, can help in clarifying issues of ethics and fairness in making trade-offs between generations. These principles (sustainability, the precautionary principle, etc., discussed below) can help to guide decision making while not promising optimal solutions.

– Attempts to understand what is on the "very long term" side of the balance between present and future (for example through computer modelling) are confounded by vast uncertainty of various types. Our limited capacity to conceptualize the far future, much less to act with it clearly in mind, necessitates a simpler method of decision making that doesn't rely on the "balancing" of interests over the very long term.

– For most practical purposes, decision making will continue to be incremental in nature, building on the sustainability ethic and using concepts like the "rolling present" (described below). However, the ethical dangers here-- such as rationalizing our self-interested preference for the present over the future-- should be appreciated. And when our actions will have significant impacts on future generations, as with nuclear waste management decisions, we should continue to do our best to see the implications empathically, from their point of view.

d. **Are resources devoted to assuring safety of radioactive waste disposal appropriately balanced with risks, given that these resources could be applied to other societal goals? This question directly relates to achieving an appropriate balance between securing the resources needed to meet current needs, on the one hand, and conserving resources and protecting the environment to meet the needs of future generations, on the other hand. It is also related to the question of "*how safe is safe enough*" in a given area, and to the management of other risks which need to be kept under control as well.... Are there principles and decision-making processes which could be used to determine where resources should be applied?**

There are two questions here-- the question of "appropriate balance", and the question of available principles and processes to govern resource allocation decisions.

d.1) The question of "appropriate balance" is crucial to both efficiency and equity. When money spent on risk reduction in one area would have higher payoffs if applied to reducing other risks, it may be (although is not necessarily) both inefficient and inequitable.

First, with respect to efficiency, when an increment of risk reduction of one sort requires greater expenditure than a similar increment of another, allocating funds to the latter buys more protection per unit of cost. Risk reduction requirements in the U.S. are notoriously variable: In one area, we will spend many millions of dollars per life saved, while in another only a few thousand dollars.[11] While such variability is easy to criticize as irrational, it is important to bear in mind that many factors enter into the perception of the importance of a risk beyond the probability and magnitude of an event. For example, a risk that is imposed by human decisions is more likely to be perceived as requiring mitigation than "acts of God" or risks that people take on voluntarily. The question of "appropriate balance" therefore requires more than comparative risk assessment which, however important, should only be used to aid in decision making, not dictate it.

From an ethical point of view, it is not sufficient to demonstrate that alternative uses of money would **theoretically** be more efficient or effective in reducing risks. Rather, it may be necessary to show that reprogramming of resources can be accomplished and will in fact provide greater protection over time. [Note that "current unmet needs" can always be cited; this should not be allowed as a blanket rationalization for ignoring future generations. Also, "appropriate balance" in expenditures is not the only relevant ethical consideration; there is an elementary principle that we expect six-year-old children to understand: "If you make a mess that hurts other people, you should clean it up."]

Moreover, there may be ethical limits on applying these resources to other societal goals-- even other, more effective risk reduction efforts-- because the particular people whose lives will be protected are not the same and the original hazard would be ignored. The mere fact that a greater number of **other** lives are at risk as a result of **other** initiatives is not a sufficient reason by itself to conclude that expenditures are inappropriately balanced. Thus, for example, if it is inefficient for the U.S. Department of Energy to spend $6 billion per year on high-level nuclear waste clean-up, perhaps those funds should not simply be reprogrammed to more efficient uses in general. An ethical alternative might be to explicitly reprogram them to reduce long-term risks of radiation exposure-- for example to reduce the amount of nuclear waste generated, and to invest in recycling it, as the Dutch proposal described in the Background Document would require.

d.2) Turning to second question, first "principles" and then "decision-making processes" are discussed. Several caveats are necessary regarding the following set of proposed principles: First, they are provisional, tentative and need to be debated further. Second, in general they should be viewed in relation to each other and not in isolation, since some tend to favor the present over the future and others the reverse. Third, they are stated quite generally, and require further iteration to provide operational guidance to decision makers. Fourth, it would be a mistake to expect that **any** set of principles, no matter how fully iterated, can ever be definitive in giving

---

[11] This variability is captured in a revealing table from the FY 1992 U.S. Budget, Table C-2, Part 2, p. 370. The Table portrays the risks and cost-effectiveness of over 50 health/safety regulations, comparing them specifically on the "cost-per-premature-death-averted." These costs range from a low of $.1 million for regulations like auto passive restraint/seat belt standards (adopted in 1984) to extremely high cost items like the hazardous waste disposal ban (1988; $4,190 million) and the proposed municipal solid waste landfill standards (1988; $19,107 million). The highest cost regulation, the hazardous waste listing for wood-preserving chemicals (1990), is $5,700,000 million per premature death averted! [This Table is also cited in a *Breaking the Vicious Circle: Toward Effective Risk Regulation*, by Stephen Breyer, the judge recently named to the U.S. Supreme Court by President Clinton.]

optimal answers; it is the role of principles like these to be an aid to judgement, not a substitute for judgement. Fifth, they are not claimed to be "original"; this set was developed at a recent NAPA/DOE/Battelle workshop, but they are similar or identical to principles stated in the literature. [Note that NAPA has not yet taken any action with respect to these principles; they have not been endorsed, or recommended to the Department of Energy.]

<u>Proposed Intergenerational Equity Principles</u>

No generation should [needlessly] deprive its successors of the opportunity to enjoy a quality of life equivalent to its own.

1) Every generation is the trustee for those that follow.

2) There is an obligation to protect future generations provided the interests of the present generation and its immediate offspring are not jeopardized.

3) Near-term concrete hazards have priority over long-term hypothetical hazards.

4) However, this preference for the present and the near future is reduced where questions of irreversible harm are concerned.

5) When an action poses a plausible threat of catastrophic effects, then that action should not be pursued absent some significant countervailing need.

6) The reduction of resource stocks entails a duty to develop substitutes.

The overarching principle here may be recognized as a version of the "sustainability" ethic, a concept that has received wide-spread attention in the past decade since the World Commission on Environment and Development (popularly known as the Brundtland Commission) was established by the United Nations. While more than 60 definitions have been enumerated, the best-known is that of the Brundtland Commission: sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[12] [This definition also probably enjoys wider acceptance than any other; for example, it was recently adopted in the U.S. by the President's Council on Sustainable Development.]

Note, however, that the current statement is phrased as an "equal opportunity" principle in a way that the Brundtland Commission version is not. Moreover, the notion of an opportunity for an "equivalent" quality of life is also not part of the earlier definition. In both of these ways, this statement of the principle appears to be more stringent than the Brundtland statement.

The word "needlessly," bracketed in the overarching principle, reflects a fundamental point of disagreement whether living generations are ethically permitted under any circumstances to knowingly deprive those yet unborn of equal opportunity. Some believe that no circumstances would warrant intentional serious degradation of the future quality of life, while others believe that, under some circumstances, the quality of current life takes priority. So this principle acknowledges a strong obligation to the future while the word "needlessly" maintains some undefined latitude to favor the

[12] The World Commission on Environment and Development, *Our Common Future*. NY: Oxford University Press, 1987.

present. [Similarly, there is underlying disagreement about the implications of the sustainability ethic for economic growth and limitations on the use of private property. In the U.S. at least, there has not yet been a willingness to confront these issues in the public discourse.]

Principle 1 helps to identify the nature of the relationship between present and future generations. There are various examples of the trustee concept in U.S. public policy. [Of course other countries could provide many illustrations as well, and often over a far longer period of time.] In some cases, it is written into law (eg., the National Environmental Policy Act), while in many others it is implicitly present. But it is most apparent in U.S. history in the debate about setting aside public lands and the establishment of the National Park system. The analogy here with the use in law of the concept of "trustee" as an instrument for preserving value for others is not perfect, and some people prefer the use of "stewardship." But the point of the principle is to fix responsibility in the present for the implications and consequences of present actions on future generations.

The recent literature on intergenerational equity, which overwhelmingly supports the notion that we do have ethical obligations to the future, also overwhelmingly (though not unanimously) opposes making trade-offs favoring the future that fail to meet crucial obligations to present generations, or that impose an injustice on the present. Principle 2 recognizes both of these, while putting emphasis on "interests" of the present. It might be argued that, as stated, this principle provides too convenient a rationalization for the current generation to pursue its own narrow self-interest. A great deal hinges on the definition of "interests" in the principle: If interpreted broadly, the principle could be invoked to justify much greedy and wasteful behavior. If defined narrowly, only "vital interests" or "basic needs" of the present could be used to justify not satisfying the obligations toward future generations. Given that self-interest is a very strong and pervasive motive, a narrower interpretation seems desirable to provide ethical protection against rationalization. The workshop suggested some operational guidelines to aid in making decisions and setting priorities:

- Emphasize protecting present and near-future generations by: 1) addressing the highest near-term risk first; 2) giving additional priority if high long-term risks are <u>also</u> involved; and 3) seeking to minimize long-term risk consistent with the principles for intergenerational equity.

- Recognize and respond to the obligation to protect distant future generations, but do not do so at the expense of current and near-future generations. [If this provision is to have any force, "expense" cannot just mean "monetary costs," but something like "significant sacrifice."]

The next three principles (3, 4, and 5) are discussed under section f. below. Principle 6 addresses resource depletion; while not as relevant to environment safety and health, the underlying notion of an obligation to provide compensation is quite relevant.

Turning to the question of "decision processes," in the U.S. perhaps more than in most countries, a "process" concept of justice tends to prevail: If certain processes are followed, the resultant outcomes-- decisions, risk distribution, etc.-- are presumed to be just or fair. This is true not only formally (for example, "due process" as embodied in the U.S. Constitution), but is deeply imbedded in the popular mind. For example, "democratic values" are often defined in terms of processes-- voting, majority rule, etc. This accounts in part for the considerable attention paid to citizen ("stakeholder") participation in the decision process, to the question of who decides and how, and to the means of holding various parties to account for their actions. [When various stakeholders are in bitter and intractable conflict and there is deep mistrust between them, paralysis can result, illustrating the limitations of this process orientation toward justice.]

Given our limitations in balancing current needs against those of the far future, such as the vast uncertainty of the latter, we need a simpler decision process. The sustainability concept tends to focus on passing on to the **next** generation a world with "equal opportunity" to enjoy a quality of life equivalent to ours, or a generation that is as "able to meet its own needs" as ours is. Sustainable development practices eliminate the need to second-guess the specific needs and desires of others who will come after us. Since we cannot predict into the distant future either the potential harm or the benefits of specific environmental practices, we can best act by providing for posterity what we ourselves have been provided, and by preserving options for them.

According to the idea of the "rolling present", the current generation has a responsibility to provide the next succeeding generation the skills, resources, and opportunities to deal with any problems the current generation passes on. Likewise, the next generation is obliged to do the same for the generation that follows it, and so on. In this way, future generations are given consideration and compensated for any harms passed on by the previous one. The rolling present concept includes an iterative decision process: Succeeding generations reevaluate the policies of the past using new information and their own values and priorities, and make appropriate policy changes. [Note that the concept behind this process, together with the principle of not foreclosing options for the future (see #2 in the Appendix), support temporary/retrievable storage as opposed to permanent storage of highly toxic wastes.]

This "rolling present" process has the advantage of being familiar, incremental, and easy to implement, but it also has some limitations and deficiencies. One deficiency is that it tends to ignore "time bombs"-- that is, risks that do not threaten immediate generations, but will affect later generations (for example, nuclear wastes that remain isolated for several generations and then contaminate ground water). More generally, this decision process can be criticized for making it too easy for the current generation to ignore the long-term implications of its actions. Even as we use this incremental process to make current decisions, we should perhaps be admonished to develop and refine our capacity and that of the next generation to consider empathically the welfare of future generations.

e. **Is it preferable to take all physical actions today to minimize any bequest of liabilities for waste management actions to future generations. If not, how should financial assets be set aside to meet the liabilities?**

There might be many ethically acceptable ways to allocate the waste management effort between current and deferred actions. In all likelihood, the criterion of efficiency would dictate not attempting to do everything today to minimize future liabilities-- and in fact it might not be possible to do everything in the present. Some way of setting aside dedicated financial resources to meet liabilities-- like a trust fund-- seems ethically unobjectionable as long as the strategy is otherwise ethical.

At the same time, it would probably not be ethical just to defer acting on the problem. Both direct action and investments in research to ameliorate safety hazards, to minimize toxic waste production, to cure cancer, to identify substitutes for key resources, etc. all help to compensate future generations for the burdens we will impose on them. [Note, however, that it should not be assumed that all goods are substitutable, that every risk or burden can be compensated in this way. It is too easy (and a seductive rationalization) for us to assume that a trade-off that sounds good to us in the abstract will in fact be seen as adequate by those experiencing the concrete consequences in the future. Even if we were certain we would find a cure for cancer, this would not entitle us to impose carcinogens freely on future generations.]

f. There is a need to balance the risks to which we expose the current generation (or the immediate next generations), risks that can be more readily identified and to a certain extent quantified, against the risks to which we may be exposing some very far distant future people, risks that are much more difficult to quantify.... What guidelines and principles should we follow to balance these risks? Does the proposition that we should not expose future generations to a risk that is not acceptable today appropriately address this issue?

Three of the principles listed under d.2) above address directly this question of balancing risks:

3) Near-term concrete hazards have priority over long-term hypothetical hazards.

4) However, this preference for the present and the near future is reduced where questions of irreversible harm are concerned.

5) When an action poses a plausible threat of catastrophic effects, then that action should not be pursued absent some significant countervailing need.

These principles taken as a set provide some guidance although, as indicated earlier, they need to be developed further to provide effective guidance to decision makers. Principle 3 indicates that explicit current risks, like the risk to clean-up workers, should be given greater weight than hypothetical risks many generations in the future, such as the possible exposure of people to a hazard through some plausible scenario. Principles 4 and 5 identify exceptions to this rule based on projected irreversible harm and catastrophic effects. They can be seen as aspects of what is known in the literature as the "Precautionary Principle." As articulated by Richard Howarth, the principle holds that "inhabitants of today's world are morally obligated to take steps to reduce catastrophic risks to members of future generations if doing so would not noticeably diminish their own quality of life."[13] (Catastrophic risk or damage would be defined using such notion as increased risk, irreversibility, and the scale of human activity and planetary impact of a project. If an important irreversible decision can be deferred at low cost, it should be, thus preserving options for later generations.) Howarth claims that the precautionary principle can be made operational by reducing it to a two-part test: "Does a particular environmental insult impose catastrophic risks on members of future generations? Can we take steps to reduce those risks without substantively compromising our own well-being." Although he acknowledges that the principle depends on an explicit value judgment, Howarth argues that the principle yields a policy criterion that is operationally decisive under a wide array of circumstances.

With respect to the second question, the proposition that we should not expose future generations to a risk that is not acceptable today is not inappropriate as a baseline, but it can be criticized as inadequate or unhelpful in balancing risks. (See the response to #5 in the Appendix.) Uncertainty about the far future confounds the practical application of the guideline.

g. Should measures of risk acceptability be considered in the context of individual rights or local rights, or the collective rights of the population?

The central question here is the appropriate scale for measuring acceptable risk. While this is

[13] Richard Howarth, "Environmental Risks and Future Generations: Criteria for Public Policy," in U.S. EPA, *Clean Water and the American Economy Proceedings: Ground Water*, Vol. 2, EPA 800-R-93-001b, 1993.

a crucial concern, it would be a mistake to answer it in the abstract. It is like asking what level of magnification in a telescope or microscope is best: Each level will reveal different things of interest, and none is intrinsically more important than the others. Moreover, adequate analysis will consider all of these and other perspectives separately and together.

Having said that, however, one ethical danger in particular should be noted. Utilitarian arguments based on "the collective good" are often used to impose "solutions" (i.e., burdens) on the local level. What is needed to protect against this is some principle of distributive justice (see h. below).

[I believe that it is more useful in general to speak about justice than about the "rights" of different groups as is done in this question. "Justice" calls attention to the issue of fair distribution of risks, whereas "rights" focuses on the claims of one group against another. Moreover, when the intergenerational aspect is highlighted, the concept of the "rights of unborn generations" is problematic. See the response to #2 in the Appendix.]

h. In relation to the previous questions, there is the additional issue of the distribution of environmental risks across population groups, called "environmental justice". All communities and individuals, regardless of economic status or race are entitled to a safe and healthful environment. <u>What measures are necessary in the siting of repositories to assure that disadvantaged populations do not bear disproportionate burdens?</u>

If we collectively lived up to (or even actively embraced) the principle enunciated here that all communities are entitled to a safe and healthful environment, this whole issue and many like it would be transformed. But in fact, we balance this objective of a safe and healthful environment against many other objectives. And in a sense, the whole question-- including the intergenerational aspect-- is one of environmental justice: Who should bear what burdens, in relation to what benefits?

The question of a **disproportionate** burden is especially important. Proportionality is one key element of justice. But this can be a tricky argument to make. For example, it has been suggested by Lawrence Summers,[14] chief economist at the World Bank that "... underpopulated countries in Africa are vastly **under-polluted...**" compared to large urban centers. The idea here is that toxic wastes should be located in low-wage countries since the costs of pollution would be lowest there. It might well be, as Summers argues, that "... the economic logic behind dumping a load of toxic waste in the lowest-wage country is impeccable...." But this would only dramatize (if drama were needed) the extent to which economics has been severed from ethics.

Under a utilitarian principle, sometimes phrased as the "greatest good for the greatest number," imposing greater burdens on small populations might be seen as justified, following the (eminently reasonable) assumption that repository sites should (all else being equal) be located in sparsely populated areas. And sometimes the fact that an area already has toxic wastes is used as a rationale for putting additional wastes there. Such arguments can be effectively countered theoretically by appeals to justice and fairness, but perhaps mobilizing political power would be a more practical response.

---

[14] World Bank internal memorandum published by *The Economist*, February 8, 1992. Summers later maintained that his intent in this memorandum was to "sharpen debate" and not to make policy recommendations.

i. In this respect, <u>is there an ethical basis for a "host" community to receive some form of compensation in recognition of the service that it is providing to society?</u>

Market economists would perhaps not see this as a problem: At some price, some communities will be willing to bear the burden of "hosting" a repository. As long as someone-- whether a private concern or the broader society-- is willing to pay that price, a mutually agreeable bargain can be struck (leaving aside questions of potential risks and burdens imposed on neighboring communities, and whether they can be compensated). At the same time, the "compensation in recognition of the service" will look to many observers like a bribe.

This is to some extent the current situation in the U.S., where a consortium of energy companies is negotiating with the Mescalero Apache Indians of New Mexico (among others) to locate a temporary high-level waste repository on the reservation. To the tribal elders who are pursuing the project, it represents a hope for long-term tribal independence and prosperity. To many environmentalists, it smacks of environmental racism.

The free market ideology would support the idea that communities anywhere should be permitted to enter into a contract to create a repository. Proponents would argue that "anti-dumping" provision that prohibit export of wastes to countries with lower safety standards are too restrictive, and they would champion the tangible value of free choice over some abstract concept of distributive justice. While there is merit in this position, on balance justice seems to require some protection against exploitation (which is not provided by traditional utilitarian arguments).

Appendix
Ethics Questions-- Radioactive Waste Management Workshop

This Appendix provides brief responses to the ethical issues raised (beyond the "cost/benefit considerations") in the Background Document for the Workshop. (The questions are paraphrased.)

1. Can risk, or responsibility for essential action, be imposed (on future generations) when the benefits are perceived to be incurred by others (current generations) and, if so, under what conditions?

There are inevitably situations when risks and benefits are not equally shared-- when, for example, one generation enjoys benefits and imposes risks or responsibilities on subsequent generations. This can be viewed as a core question of justice or equity. Various criteria can be employed to determine when this is justified and, in some instances, what compensation is due.

The current generation will pass on both burdens and benefits in some mix-- a heritage-- and it is not always necessary to consider particular risks in isolation. At the same time, when there is a plausible prospect of a "significant or unacceptable detriment" to future generations, actions should not be taken without systematic review (e.g., life cycle assessment of energy options), and the impacts on future generations should be taken as seriously as if they were to be borne by our own children.

2. Do current generations have the right to take decisions today which would foreclose options of future generations?

It is an unavoidable fact of life that actions today foreclose some options for the future, even as they open others. But we should adopt as a key strategy, and even as a prudent and just principle, to preserve options for the future in major decisions where there is reason to believe those options may have serious impacts for better or worse on their quality of life. [As indicated in section d., this tends to support temporary/retrievable versus permanent storage of nuclear wastes. And, as indicated in section g., I believe that "rights" language is less useful here than a justice framework.]

3. Could or should the responsibility for developing solutions to the radioactive waste problem be transmitted to future generations? Given the uncertainty of the stability of society, would future generations have the knowledge and resources necessary for the construction of appropriate repositories? Could the degree of endowment of resources specifically devoted to this problem affect that choice?

What responsibility can reasonably be put on future generations? It would clearly not be ethical or just to transfer the whole responsibility for developing solutions to future generations-- especially when they won't enjoy the benefits. Even if we had very strong reasons to believe they will have the technical capability to do it more effectively and efficiently (which is open to question), we should accept the principal responsibility for cleaning up our own mess.

At the same time, it might be reasonable to expect a contribution to the solution from future generations. For example, it might be ethical to defer permanent disposal for 100 years-- *as long as* we are doing what we reasonably can in the present to remedy the situation, to keep from adding to the problem, and assuming that we have a reasonable plan.

With respect to such issues as the stability and knowledge of future societies, our uncertainty is so great that no one's guess is solid enough to bear weight.

4. Can the concepts of sustainable development and intergenerational equity be applied in a practical way to address the optimum combination of responsibilities, options and resources to be bequeathed to future generations to care for their health and environment.

Practical applications of sustainability and intergenerational equity principles are now being developed, as described in section d.2). But the phrasing of this question seems to imply unrealistic expectations: It would be a mistake to expect that any applications will be universally accepted without controversy, or that "optimizing" in any strong sense of that word (like "one best answer") will ever be possible. This is not a technical problem to be solved, but a situation to be managed over time.

5. In the radioactive waste disposal field, the intergenerational equity principle has been translated into the apparently simple and straightforward requirement that the safety level in the future be equivalent to that which is currently acceptable, irrespective of time, and without the necessity for active intervention by future generations.

a. Does this approach represent an innovation, at least as far as a long-term safety provision is concerned, and if so why?

The current safety guideline should be seen as an **interpretation** of the intergenerational equity principle, not as a **substitute** for it. It is not so much an innovation as a reasonable baseline or starting place; under many possible scenarios, the requirement might be too loose or too stringent. Nor is the requirement as "straightforward" as it seems: What is "currently acceptable, irrespective of time" is notoriously malleable and dependent on class, culture, knowledge, values, and many other things.

Moreover, I do not believe that the other part of the requirement, "without the necessity of active intervention by future generations," is straightforward, innovative or well-founded. If it is desirable to preserve options for future generations, their "active intervention" might be required.

b. Is it fair to postulate that contemporary safety norms should be the basis for the protection of future generations. Or is there another way to determine the degree of risk acceptable to future generations?

Using contemporary safety norms as the basis for the protection of future generations should be seen only as a default position. It is not defensible as a "postulate" of fairness. If there were a way to determine "acceptable risk" as it will be seen by future generations, that would clearly be preferable. And it is easy to imagine that future generations might have risk standards very much more strict or considerably looser than our own.

6. Does the application of the sustainable development and intergenerational equity concepts require that both benefits and costs passed on to future generations be taken into account in deciding what is equitable and what is not?

It is appropriate that both risks and benefits be "taken into account" in deciding what is equitable. Note, however, as mentioned under section e., that using benefits to offset risks may not always be ethically permissible.

Radioactive Waste Disposal: Taking Societal Views into Account

A. Rip, W.A. Smit and B.J. R. van der Meulen
Centre for Studies of Science Technology and Society
University of Twente

Radioactive waste management and the safe disposal of nuclear waste are not purely scientific or technical problems. Because of different possible conceptualizations of risks, and the inevitable involvement of (ethical) values, radioactive waste management and the question of what are suitable criteria for the acceptability of these risks are societal problems. One immediate implication is that societal groups may have different views on the issue. How can a decision maker take various and often diverging views into account?
The Dutch government, in preparing its position on the question of using deep geological (rock salt) formations for the disposal of radioactive and toxic chemical waste, has organized a public consultation procedure on this issue.[1] It has invited four organizations to give, in a (closed) seminar, their view on the matter. In addition a nation-wide open consultation was organized, inviting, via national and regional newspapers, people to give their arguments pro or contra.
The Centre for Studies of Science Technology and Society (University of Twente) was subsequently asked to analyze these views and arguments.
In this paper the methodological approach of argumentation patterns and argumentation scenarios, and the main results will be presented. It is important to emphasize that such an approach differs from usual policy analysis in that it does not identify and evaluate policy options, but elucidates the argumentative structures in the set of position statements and arguments. Thus, the analysis does not privilege one option or argument above another. Rather, it opens up options for political decision making.

1. Background

The aim of the two consultation procedures was to get a better picture of the arguments that played a role in the debate on disposal of highly toxic waste in deep underground. It should emphasized that the procedures were not intended to be a referendum, so there is no point in counting the numbers of proponents and opponents to certain arguments. Our evaluation of the outcomes of the consultation procedures is to analyze the structure of the argumentation, independent from the question how often particular arguments occur.

In our analysis, and in the evaluation of argumentation, *robustness* is the key concept. In doing so, we depart from the usual approach (which is indeed applicable in a number of cases), where points of view and positions taken are assessed in terms of the correctness and relevance of the arguments on which the position is based. Whether a position is tenable then depends on the correctness of the arguments. If an argument turns out to be incorrect, another argument

---

1 See 'The position of the Dutch Government on deep Burial', Appendix 5 to the background document for the workshop on the environmental and ethical aspects of long-lived radioactive waste disposal, Paris 1-2 September 1994.

supporting the position must be given, or the position must be given up, or at least modified. In this type of discussion, the result will be an evaluation of arguments as correct or incorrect, and a distinction between tenable and untenable positions.

The discussion about acceptability of deep underground disposal of waste differs from such discussions on two points, and this has created problems in reaching acceptable conclusions. First, the participants in the discussion cannot agree on which arguments are correct, and which are not. The results of scientific research are not decisive, either, and become subject of discussion themselves. Second, the relevance of the various considerations cannot be ranked univocally: should retrievability be the dominant consideration, or safety, or the interests of future generations?

Even in cases where there is no consensus about correctness and relevance of arguments, discussion can be productive if it leads to articulation of the *foci* in de debate. Foci in a discussion are the key points of departure and central considerations, of which the importance is recognized by all participants. A further result of discussion can be clarification: which arguments are widely accepted, and which are (hotly) debated; what are the links between certain arguments and certain positions.

There will still be no assurance of the correctness and relevance of arguments, but their *robustness* can now be assessed. Robustness is a pragmatic concept: arguments are robust if they can be supported without too much effort, through accepted principles, widely recognized policy, accepted results of research, agreed goals, or (other) robust arguments. Thus, an argument is robust if it can be defended when challenged. When such a defense is offered, it will lead to a further articulation of the argumentation. The process of discussion will not necessarily lead to consensus, but it will provide elaboration of argumentation which then allows assessment of further action, like the desirability of further research, the usefulness of further discussion, and/or the feasibility of reaching decisions. Robustness, thus, is characterized by (1) consolidation, at least a working agreement how to handle differences, and (2) articulation of the network of arguments, views, interests etc. that lies behind the claim. The second characteristic is necessary, otherwise the claim would collapse at the first attack, or, like a fashion, survive only as long as the circumstances were favourable.

It is this conceptualization of the discussion that allows us to analyze and evaluate the arguments of the participants in the consultation procedures. Analysis and evaluation do not focus on the substance of the arguments as such, but on the coherence between the several arguments and with the subsequent positions.

The contributions of the participants in the seminar were well-articulated position statements, linked to a few key arguments.[2] The contributions to the open consultation procedure varied from documents of several pages to postcards; from individual argumentation to preprinted sheets that had only to be signed; from positions supported by one argument (or none at all) to extensive argumentations, taking a multitude of points of departure, considerations, and arguments into account.[3]

The significance of arguments, and their importance, appears only when their robustness is indicated (by the participant, and/or (especially in the case of submissions in the open consultation procedure) by the analyst) and when it is made clear how they lead to a conclusion that supports a position on deep underground disposal. One useful way to analyze robustness is to draw up *argumentation scenarios*: meaningfully linked arguments and points of departure which lead to a conclusion and a position. If this is possible, links among points of departure, among arguments, and between points of departure and arguments, are made explicit. If not possible, it becomes clear that such links are absent.

---

2 The agreed upon summaries are available in Dutch.

3 77 separate arguments were distinguished, clustered under seven headings: future generations and retrievability (11), prevention and re-use (12), safety, isolation, management and control (30), environment (6), alternatives (7), international (6), political/administrative (5). [The list of arguments is available in Dutch.]

2. Patterns of argument and argumentation scenarios

Every public discussion or controversy has one or more *foci*: themes which are considered important by the majority of the participants (irrespective whether they agree or oppose), in the sense that the eventual decision should take these themes into account. A discussion can be mapped by tracing the foci and their evolution in the course of the controversy. The positions submitted in the two consultation procedures show that the discussion about acceptability of deep underground disposal of highly toxic waste is concentrated around six such *foci*, which are also recognizable in the list of 77 arguments, distilled out of the submissions in the open consultation procedure.

The six foci visible in the debate are:

(1) Taking future generations into account,
(2) Prevention and re-use or recycling (integral chain management[4]),
(3) Safe disposal according to ICM criteria (Isolation, Control, Monitoring),
(4) Retrievability of the waste,
(5) Saliency of the waste problem,
(6) No export of waste.

We have phrased the foci as points of departure, rather than open questions, because the public discussion has accepted that taking future generations into account should play a role, that prevention and re-use or recycling is an aspect to be considered, etc. The discussion is on the how, and on the why behind that. And also, but often less explicitly, about the extent to which one point of departure can dominate another. The construction of argumentation scenarios is a way to make the latter explicit, as we will show below.

Although we can view each of the foci as a point of departure, their consensual/controversial status is different. The last two foci are barely contested. Almost all participants in the consultation procedures agree that waste should not be exported. This is in accord with international standards and agreements. So this can be taken as a shared point of departure. Whether there actually is a waste problem, is not doubted. Scenarios of future waste streams, as presented at the seminar, all conclude that the amount of highly toxic waste will increase. Thus, the recognition of the waste problem as a very real problem, and the requirement to solve the problem in your own country rather than to export it, are boundary conditions for any argumentation that wants to be robust.

The first three foci are closely linked to present environmental and waste policies, as presented in the National Environmental Policy Plan[5] in which the concept of 'sustainable development' plays a central role. Many participants in the consultation procedures indeed refer to sustainable development. In our analysis, we will not use the umbrella concept, but work with the several specifications that are offered.

Almost all position statements refer to one or more of these three foci. That it is necessary to take future generations into account, that prevention and re-use or recycling is desirable, and also disposal according to ICM criteria, is subscribed to by many participants, be it in varying ways, and not necessarily with the same conclusion.

The desirability of retrievability (focus 4) is controversial, and as will become clear later, is closely linked to assessments of safety of deep underground disposal, and of future possibilities to reprocess waste.

There are two reasons why the six foci of the discussion can lead to different patterns of argumentation and different eventual positions.

The first reason is that one of the points of departure is emphasized above another, and overrides the others in reaching the eventual position. For example, if retrievability is considered to

---

4 Integral chain management is the management of the whole product life cycle, with the goal of diminishing the burden on the environment .

5 Lower House 1988-1989, 21 137, nos. 1-2 and 1989-1990, 21 137, no 22.

be more important than safety, only those solutions qualify in which the safety target does not lead to disposal forms which make retrievability impossible. Or alternatively, if more weight is given to safety, the other points of departure will play their role but only in so far as they do not undermine the safety target.

The second reason is that the points of departure will be elaborated in different ways. This is particularly clear in the case of retrievability, where different criteria are used (partly in relation to judgements of desirability of retrievability). "To take future generations into account," while widely accepted as a general aim, is developed in different directions: for one participant, it means that waste must be removed definitively, for another that no waste may be produced that cannot be recycled, and for a third it implies retrievable storage of waste.

While it is possible to detail the variety of elaborations of the points of departure in scenarios, this becomes very complex. To map the present state of the debate and to assess robustness, it is sufficient to start from the different emphasis on the points of departure, and add detail only when necessary.

We shall construct four scenarios, three of them starting with one dominant point of departure and showing how the argumentation pattern branches out from it. The fourth scenario takes the list of foci and the need to take all of them into account as its starting point. The nature and linkages between the arguments are derived from the submissions in the consultation procedures. Thus, they reflect the present structure of the repertoire of argumentation, rather than any timeless ideal of correctness and logical coherence. This approach of mapping the debate also implies that in constructing different scenarios and patterns of argumentation, we are limited by the data . It turned out to be quite possible to take each of the first three points of departure, "taking future generations into account", "prevention and re-use or recycling" and 'safe disposal according to ICM criteria", as starting point for a scenario. It was not possible to create a robust argumentation pattern in which retrievability or definitive removal was taken as the dominant aim, and thus the starting point of an argumentation scenario. The fourth scenario, therefore, takes as its starting point the whole list of points of departure (in practice: the first four, because the other two function primarily as accepted boundary conditions), and asks which choices will have to be made.

The argumentation scenarios are composed from the arguments identified in the consultation procedures. They are structured as trees, starting with one or more central arguments, which branch out with the help of subsequent arguments. The arguments are presented in boxes with arrows between them, indicating the flow of the argument toward a final position. Each scenario thus contains several argumentation patterns; adding up to a total of fifteen. These fifteen argumentation patterns map the debate, highlighting the skeletons of robust argumentation available at this stage of the debate. Here, we will just present the scenarios; in the next section, we shall give a brief evaluation:

The scenarios take the arguments submitted at the seminar, and the majority of the arguments that were identified in the public consultation, into account. The remainder (29 out of 77) do not really belong to forceful foci of the debate. They are rather diverse, and hardly articulated. They can be classified, as was done in the Dutch report, with the help of the labels 'environment', 'alternatives', 'international' and 'politics/administrative'. While these arguments are used in submissions, they often remain unsupported. This is the case for arguments under 'alternatives', like storage in nuclear power plants, or in the Sahara, and for an argument like 'the present Minister responsible for disposal of highly toxic waste is of party X, and the program of that party forbids deep underground disposal,' which we classified under 'politics/administrative.'

We emphasize again that our leaving arguments out of the argumentation scenarios does not imply a decision that they are incorrect or irrelevant. It reflects the fact that they are not part of the main lines of argumentation, are outside the forceful foci, and thus, have not been under pressure to have their support and linkages articulated. Because of this lack of articulation, they are not (yet) robust, and cannot be evaluated with the help of our method.

Argumentation scenario #1

[1]
For the decision about deep underground disposal of waste, it is of great importance to take the interests of future generations into account. The present generation is responsible for the production of the waste, and has to make provisions so that man and environment will be protected, and remain protected, against the negative effects of this waste, also in the future. Because of the responsibility toward future generations, it would be better to produce no waste; thus, the emphasis in waste policy must be on efforts toward prevention and re-use or recycling. This implies that one must always choose for the least polluting forms and methods of production.
Nevertheless, for the time being, waste generation cannot be completely prevented.

[1.1]
Disposal of generated waste in the deep underground is not allowed because, the deep underground may represent a value in the future. The deep underground is the last environmental compartment which is not polluted. It is possible that future generations will want to use the deep underground for other purposes, so we should not trespass on it now.

[1.2]
For some kinds of waste (like heavy metals) it is not desirable that they return in the cycle. Since such substances remain poisonous, they must be isolated from the biosphere. It is irresponsible to force future generations to take care of this waste. Thus, the definitive disposal of this waste must be realized now. Because of natural isolation, the deep underground is the safest solution, and active management is not necessary.

[1.3]
To reduce the negative effects of dangerous waste as much as possible, the aim must be to render it harmless at some moment. Thus, the waste must be stored retrievably. Different kinds of waste must therefore be stored separately.

[1.3.1]
The deep under ground is not suitable for such a type of storage.

[1.3.2]
The deep underground is suitable for such a type of storage.

[1.4]
The waste that is generated must be stored as safely as possible. The deep underground is not suitable, because there are too many uncertainties about long-term behaviour of the deep underground, the influence of the waste on the deep underground, and about the possibility to manage storage in the deep underground over long periods. To intervene when calamities occur is difficult with disposal in the deep underground, perhaps impossible. The risk is thus that future generations will, at some stage, be confronted with the dangers of the waste.

Argumentation scenario #2

[2]
The most constructive solution of the waste problem is to not generate waste anymore. Thus, prevention and re-use or recycling of (highly toxic) waste must be emphasized. The means to do so are available. Where possible, a clean (or cleaner) technology must replace the old way of production. Producers of waste must be taxed more heavily. One can avoid generating electricity through nuclear power, and thus avoid the production of large amounts of nuclear waste. The waste that cannot be prevented, re-used or recycled must be made harmless, or stored retrievably, so that future generations can re-use or recycle the waste.

[2.1]
Disposal of the waste in the deep underground is not a good solution. The safety of the storage cannot be guaranteed. There are too many uncertainties about the long-term behaviour of the deep underground, the influence of the waste on the deep underground, and about the possibility to manage storage in the deep underground over long periods. To intervene when calamities occur is difficult with disposal in the deep underground, perhaps impossible. The risk is thus that future generations will, at some stage, be confronted with the dangers of the waste. Waste disposal in the deep underground therefore does not meet the ICM criteria. Waste disposal in the deep underground also implies that the waste is not retrievable. When in some future time methods to that extent are developed, the waste cannot anymore made or harmless or be re-used.

[2.2]
Waste disposal in the deep underground is the least bad way of waste removal following ICM criteria. With our present technological knowledge, and because of natural isolation, it is possible to store the waste in the deep underground sufficiently safely. Waste disposal in the deep underground is less sensitive to environmental terrorism, war, crashing airplanes etc., because of its natural isolation. Active management (control and monitoring) is thus hardly necessary. The disposal can also be done retrievably, so that one of the most important objections against disposal in the deep underground is removed.

[2.3]
Disposal of highly toxic waste in the deep underground takes the interests of future generations insufficiently into account, and entails high costs. In the sense that high costs are an incentive to search for alternatives, disposal of waste in the deep underground is acceptable as a stimulus for prevention and re-use or recycling.

[2.4]
With disposal of highly toxic waste in the deep underground, a (cheaper) solution to the waste problem is available, while the waste will become invisible and irretrievable. This reduces the incentives for prevention and re-use or recycling.
[2.4.1] Disposal in the deep underground must therefore be rejected.
[2.4.2] It is only present highly toxic waste that may be disposed in the deep underground. After that, one can start with a clean slate.

[2.4.1]
Disposal in the deep underground must therefore be rejected.

[2.4.2]
It is only present highly toxic waste that may be disposed in the deep underground. After that, one can start with a clean slate.

Argumentation scenario #3

[3]
A basic principle of present environmental policy is to make sure that man and environment do not experience harmful effects of non-processable waste. Thus, the waste must be stored effectively *isolated from the biosphere*, and the storage site must be *controlled and monitored* well. In this respect, we must learn a lesson from dumping in the sea. It would be better to prevent generation of waste, but that is not always possible. Neither are, in most cases, new ways to process waste to be expected in the short term. Therefore, one should choose the safest method of storage.

[3.1]
The waste in question remains harmful for a long time (thousands of years). Thus, solutions for a few decades are at best partial. Since it has been proven that the deep underground can isolate harmful substances from the biosphere for long periods, it is sound to move toward disposal in the deep underground. An additional argument is that the soil suffers much more erosion than the deep underground. The safety of the deep underground has been confirmed by the OPLA report.

[3.2]
For waste disposal, the Netherlands follows the ICM criteria. Effective control and monitoring are then essential: they are necessary to be able to intervene when the isolation should fail, and reduce the harmful effects to a minimum. In addition, active management links up with the aim to process the waste eventually.
For disposal in the deep underground, effective monitoring and control is not possible. But these are necessary, because of the many uncertainties about the behaviour of the deep underground. So it is better to store waste above ground.

[3.3]
Disposal of waste has to meet the ICM criteria. Also in the case of disposal in the deep underground, active management is possible. But it is then necessary to store the waste retrievably. Such a reversible storage method in the deep underground is to be preferred to storage above ground, on the basis of safety considerations.

Argumentation scenario #4

[4]
The problem of non-processable waste is a serious problem, and a structural solution is demanded. It would be better for the environment if the waste were not generated; production of waste must thus remain at a low level. In the short term, however, it is not an unsurmountable problem if sizeable amounts of radio-active and chemical waste continue to be generated. These wastes have to be stored, well isolated from the living environment. No method to achieve this should be rejected *a priori*. Space is available in the deep underground, and one should not reject in advance the option to use this space. *Selection of method must occur on the basis of safety, the interests of future generations, ICM criteria, possibility of retrieval, etc.*

[4.1]
From an environmental point of view, it is desirable that the waste will be made harmless at some moment of time. Therefore, the waste should be stored so as to be retrievable. At this moment, there are many uncertainties about the behaviour of the waste in the deep underground. Research must be done to find out if retrievable storage in the deep underground is indeed possible in a safe and economically acceptable way. As long as this has not been clarified, the waste must be stored above ground.

[4.2]
The deep underground guarantees good isolation of the waste (see OPLA report). In addition, the waste is retrievable for 50 to 100 years, so that possible more sustainable solutions can be taken up. If by then no method of processing the waste has been found, it is sensible to move to definitive disposal. The deep underground can therefore be used for storage of waste.

[4.3]
Storage in the deep underground is not consistent with the interests of future generations, does not meet the ICM criteria, cannot be guaranteed to be safe, and is not retrievable. So it must be rejected.

3. Analysis of the argumentation scenarios

The scenarios, and the argumentation patterns contained in them, show how arguments are linked up and lead to an eventual position. This reconstruction does not lead to a conclusion, one way or the other, whether disposal in the deep underground is the right thing to do. But that was not what we set out to do. The aim was to bring out the actual and potential linkages between the arguments identified in the consultation procedures.

Some links turn out to be more easy to make than others. If taking future generations into account (focus 1) is foregrounded, it is almost self-evident (for the participants) to find prevention and re-use or recycling (focus 3) important. While there are different assessments of how far disposal in the deep underground meets ICM criteria, the importance of safety, articulated in terms of the ICM criteria, is a returning element in the scenario's. So safety, and the ICM criteria, are obligatory stepping stones in the argumentative patterns. The difference in eventual positions derives from the different detailed assessments of safety of waste disposal in the deep underground.

Using the metaphor of a landscape, with its hills and valleys, and gradients of inclination and effort to traverse in general, one could speak of the landscape of the argumentative repertoire in the debate on waste disposal in the deep underground. The analyst maps the terrain, by finding out which have become the preferred pathways of the participants in the debate. But it is the shape of the landscape rather than an opinion poll, which is what interests him, and the policy maker.

The four argumentation scenarios are exercises on paper, and can be seen as geodetic experiments: which combinations of arguments can be constructed, and which patterns become visible, which tell us something about the lay of the land (that is, the present "landscape" of the state of the debate, not some unchanging bedrock of correct argumentation that we have to aim for). Other scenarios could be constructed, but we would claim that the patterns – the linkages between arguments that cannot be undermined, or only with great effort, as well as the junctions, where paths diverge – will remain the same.

While the different detailed assessments lead to different positions on waste disposal in the deep underground, one should not let oneself be blinded by the differences in outcomes. The debate has progressed sufficiently for the argumentative landscape to stabilize: participants as well as analysts recognize the peaks and the valleys, and while diverging on the route to take through the landscape, share a recognition of what the important issues are.

It is now possible to make a second step. First, we identified arguments in the consultation procedures, and combined them in a limited number of argumentation scenarios. This enabled us to distinguish between arguments relevant for the main lines of the debate (shared roads as well as separate routes, due to fractures in the landscape), and those less relevant at this stage of the debate (independent of the question whether they are correct or not). The second step is to identify robust patterns, and *loci* of divergence in assessments.

One recurrent and robust pattern (see especially scenarios 1 and 2) is how taking future generations into account (focus 1) is coupled with prevention and re-use or recycling (focus 3), and how this then, *via* the argument that the waste problem remains (in spite of the efforts at re-use or recycling and prevention), leads to a search for solutions that meet the ICM criteria (focus 2). It is only in scenario 2 that retrievability gets greater weight, in the sense that it comes up earlier in the argumentation chain, and helps to determine the nature of the solutions. The reasoning is understandable: when prevention and re-use or recycling are taken as the point of departure, retrievability is a positive factor, because it implies that future possibilities of processing and re-use or recycling can be exploited.

A second recurrent pattern is the divergent assessment of the safety of waste disposal in the deep underground, which is always coupled to arguments about the possibility and desirability of storing waste retrievably. While in the first recurrent pattern the desirability of retrievability was coupled to future possibilities of reprocessing, here it is coupled to an assessment of insufficient safety of disposal in the deep underground. This pattern is fully explicit in scenario 3, and appears in scenarios 1 and 2 in the arguments subsequent to the points of departure 'taking future generations into account' and 'prevention and re-use or recycling'.

Note that we do not discuss the substance of the issue whether disposal in the deep underground meets the ICM criteria. What we highlight is how the diverging assessments form a recurrent pattern, and how this couples, in specific ways, to the theme of retrievability (focus 4). When two problems with divergent assessments interact, there might well be a "wicked" problem. Rather than trying to solve it, we map its features in the argumentative landscape. Participants in the debate, including policy makers, can see their surroundings more clearly now, and plan their route accordingly.

There is a third recurrent pattern: the way that the uncertainty about long-term circumstances of waste disposal in the deep underground surfaces in argumentation patterns. In pattern 1.4 it occurs, and this in relation to focus 1, but it returns in patterns 2.1 and 4.1. If one is risk averse, uncertainties are an argument against (in this case) disposal in the deep underground. Some postpone a decision and ask for more research, others doubt if research will be ever be able to provide conclusive insights on this point.

In addition to the recognition of recurrent patterns, a conclusion is possible about the ordering of the focal themes. Rephrasing our description of the recurrent patterns, we can say that there is a *de facto* argumentative hierarchy:

• Firstly, that there is waste, and that there will be waste, about which the Netherlands should do something, is recognized by everybody. (saliency, focus 5)

• Secondly, that one should take future generations into account is a point of departure that nobody opposes, and similarly for prevention and re-use or recycling, which is linked to the future generations theme.

• Thirdly, safety, and its operationalization in ICM criteria, is accepted as a relevant point of departure by everybody.

• Fourthly, at this level, differences emerge that are practically irreducible, at least for the moment. Can disposal in the deep underground meet the ICM criteria?

• Fifthly, an additional argument about uncertainties (about long-term circumstances of deep underground disposal) shows up difference in attitudes toward risk taking: in a risk-averse attitude, uncertainty is a sufficient argument to reject deep underground disposal, while risk-management attitudes look for solutions, like retrievability, which allow handling of the risk when it materializes.

What is a low-level and, in a sense, technical problem: how to meet ICM criteria, becomes an issue of public debate because of uncertainties and the various attitudes to face uncertainty. Because of this, the issue of retrievability becomes salient, and a focus of the debate which could turn over the present hierarchy. For the moment, it is primarily an open and contested issue: what is retrievability? Which disposal routes are retrievable? Is retrievability at all possible with deep underground disposal? As long as the contest is carried on within the present argumentative hierarchy, in which the higher levels have become stabilized (at least in the Netherlands), one can try to address the issue as a technical problem, where research and other ways of articulation of the issue will contribute to progress.

Our exercise with argumentation scenarios, however, shows that the different assessments of safety, which are foregrounded in scenario 3, are irreducible. If other points of departure are used to construct a scenario (as in 1 and 2), the difference in assessment occurs. What the other points of departure do is to introduce additional arguments, which modify the choice for or against disposal in the deep underground. Thus, the assessment of safety will become further articulated (and more complex). One has to actually go through this process of articulation to find out whether it can resolve the issue of safety or not. So the irreducibility is not a logical point, but what one could call a historical point.

The reason why we reconstructed the argumentative landscape of the debate was to clarify the policy choice for or against deep underground disposal. What has become clear is that there is no logically robust position. Societal robustness, however, which may be even more important for policy, is present, at least to some extent. The importance of future generations, and prevention and re-use or recycling, are stabilized parts of the landscape. After that, the only robust part is the recognition that there is uncertainty. Implicit in our analysis is the point that research *per se* will not resolve such uncertainties; only when it is part of an ongoing articulation process. So it is important to continue, and improve, such articulation processes. Reconstructing argumentative landscapes, and offering the mapping to participants in the debate, is one contribution to such an articulation process. This is what we have done in this report.

If a policy decision has to be made now, policy makers have to anticipate on the outcome of such articulation processes, as well as to elaborate their own way of decision making under uncertainty. Anticipations can be improved through research, especially research in the dynamics of public controversies. Decision making under uncertainty also depends on attitudes of risk aversion or risk embracing.

Reconstructing the argumentative landscape, as we have done, does not have a direct or linear impact on policy making. Rather it opens up spaces for policy action, or in other words, releases the initiative to the polity. Our identification of the importance of 'retrievability' as a contested issue does not foreclose any policy options. Indeed, the importance of the issue is known already. What we have done is to show how it is located in the argumentative hierarchy; or in terms of our metaphor: where the crossing of roads is located in the landscape. Thus, the issue can be put on the policy agenda in a more structured way, and treated accordingly.

APPENDIX ON METHOD

Used in "Radioactive Waste Disposal: Taking Societal Views into Account"

Analyzing the heterogeneous material produced in consultation procedures cannot be done with traditional approaches of policy analysis, which are oriented to the analysis of a problem, or the analysis of one or a few (policy) documents. Here, there are views and arguments of varying nature and status, and their force derives also from the fact that they have been submitted in a consultation procedure.

By viewing the material as a product, and thus an indication, of the repertoire of views and arguments that characterizes the controversy at this stage, other methods of analysis can be mobilized, and we will set them out briefly in this appendix.

We would argue, in addition, that the notion of 'repertoire' is important to understand the dynamics of controversies, and offers new possibilities for policy making. Traditionally, controversies like the one about burial of waste in the deep underground have been seen as reflecting a problem that has not been solved, and policy makers should work towards actually getting this problem solved. Over the last decades, when it became clear that technical problem solutions did not make the controversy go away (partly because different participants see different problems), the policy makers saw their task as one of conflict resolution, or at least conflict management. While important, the substance of the controversy may be lost out of sight in the eagerness to restore the peace. Studies of the dynamics of controversies have shown that there is a third aspect: the improvement of argument, the articulation of views, the learning which positions can and which cannot be maintained, the increase in robustness of certain other positions, and thus a partial closure. We have called such developments 'repertoire learning', because it is not individual learning, but an improvement of the repertoire relevant to the issue and the arena. The controversy, or rather, controversies, about smoking and health provide striking examples (See Rip 1986b).

When policy makers recognize the possibility of this dynamic, they can work towards (further) repertoire learning, and design their measures to suit this purpose. The mapping of the repertoire then becomes an important first step. The methods to do so are then not just a way to handle the heterogeneous material that is produced by a consultation procedure; they are policy-relevant in their own right, and the analysis can lead to policy advice. After setting out the methods, we will briefly come back to this point.

Mapping the repertoire

The notion of 'repertoire' has been used to describe and analyze the content of a culture or a subculture, say of a community, or an occupational group, or an organisation. The repertoire of stories, metaphors and images of an organisation has become recognized as an important factor in shaping atmosphere, work, success, and is now treated as an opportunity to develop management tools.

Repertoires emerge in mutual dependency situations with some shared activities and a certain boundary towards the "outside." Seen in this general way, it can be applied to controversies as well: there is a limited set of issues and participants linked to each other, an (evolving) arena as it were with an (evolving) agenda. One can trace the repertoire by identifying the arena and reconstructing the repertoire of its participants; and/or by identifying the agenda, and reconstructing the repertoire through analysis of documents and other contributions to the agenda.

In the case of the consultation procedures in the Netherlands, a mixed approach was used. For the seminar, key participants were invited to document and discuss their arguments, and this provided us with the data to map the repertoire. For the public hearing, no bounds were set on participants, but the submissions had to relate to the issue. This entrance point into the repertoire allows a broader scope, but may also include noise. One way to distinguish signals from noise, without biasing the analysis by throwing out arguments or views because one thinks they are irrelevant or plain silly, is to have a closer look at their authors. While we did check the source of the submissions, we did not choose to delete possible outliers. The check was important to interpret certain features, like the frequent recurrence of a few standardized arguments. Standardized responses had been printed, and people needed only to sign the sheet and send it off to have a submission.

At a later stage in the analysis, there was a possibility to distinguish relevant from not-relevant-at-this-moment by finding out what could be included in argumentation scenarios, and what was not worthwhile to try to include. We listed the arguments that were not included separately, and discussed our reasons. So others could, if they so wished, create different scenarios with different inclusions. Our contention is, however, that we have mapped the central part of the repertoire as it characterizes the state of the controversy.

Argumentative patterns

In our analysis, we were not interested in all elements of the cultural repertoire of the controversy. For example, we did not consider the style of discussing and the way conflicts tend to be resolved (which is different in different countries), although these are interesting features, and are important to estimate the feasibility of conflict resolution measures.

Our interest was in the arguments and reasoned positions, and in the argumentative patterns that might be important. In the main text, we have used the metaphor of *argumentative landscape* to refer to this aspect of the repertoire. A landscape is shared by the participants, you can move about it, in it, and take different paths. Some paths are easier than others, and the landscape can be moulded, intentionally and unintentionally, and such changes shift the gradients. One should not take metaphors too far, but one can see how putting a lot of work in finding ways to contain toxic waste, and being somewhat successful, is shifting the gradients of argumentation about deep burial in the same way as flattening a hill and building a new road does. The argument about retrievable storage for 50 years and then see how much technical progress we have made, is like keeping the hill as it is (or the town with its narrow and winding streets) and building a bypass.

If this metaphor adequately captures what the argumentative repertoire in a controversy is, the next step is to isolate the building blocks (arguments and positions) and their linkages. If one has one document only to analyze, a variety of methods is available.

One cluster of methods derives from Stephen Toulmin's seminal work on argumentation, and uses his structuring of practical reasoning: data are provided for a claim, there is a warrant to go from data to claim, and there is backing to support the warrant (or the conditions under which the warrant is valid). In practice, argumentation is elliptic, and the analyst has to complete it in order to make the structure, or better, the possible structure, visible. Schellens, who has analyzed a discussion in the Dutch newspapers, 1981-1982, on burial of radio-active waste in salt formations, notes that the Toulminian scheme captures certain types of argumentation very well, but others, like reasonably invoking authority, or reasoning by example or by analogy, much less. His analysis is oriented to the characterization and evaluation of the arguments of the several participants in the debate, not to a characterization of the repertoire.

A second cluster of methods derives from the new rhetorics of Perelman and Olbrechts-Tyteca, where effective argumentation is foregrounded rather than reasonable argumentation (there is a lot of overlap, though; the difference is primarily in the orientation from which the arguments are evaluated). The new rhetorics have broadened out and become fashionable (cf. also Enos and Brown 1993). For our purpose, the methods are important, not the substantial discussions, e.g. about the rhetorics in scientific discourse. Rhetorical analysis, as we see it, is the analysis of how force is exerted in and through text and speech, with particular emphasis on how forceful associations are put up. The Toulminian scheme then is one, and recurrent, form of forceful association, and one where the force derives from the structure of the argument, rather than the content of the data or the backing. But there are other schemes, for example where strategic assessments and inference carry the force. How actors position themselves in a debate or controversy allows inferences as to the strength of argumentative linkages. For example, while the tobacco companies had been fighting the link between smoking and health (particularly, cancer) with data, arguments, and other weapons, at some time during the 1970s, they realized that they were not reaching their audience anymore with this kind of argument, and stopped with their emphatic criticism of the smoking-cancer link. In the public debate, this then led to a new kind of argument: 'If even the tobacco companies do not criticize the smoking-cancer link, it must be true.' This was an irreversible shift in the dynamics of that controversy. (See Rip 1986b for more details.)

A third cluster of methods is of more recent origin, and derives from literature, text analysis and culture studies. It is variously called discourse analysis, narrative analysis or cultural analysis. The force of an argument is seen to derive from the cultural *schemata* into which it fits, or from the story and its emplotment, or from socio-cultural definitions of what is natural and obvious. An example is the way 'the endless frontier' *schema* allowed Kennedy's argument for putting a man on the moon before 1970, to be more convincing than it would have been otherwise. At the level of analysis, one can trace such forces sometimes by looking at the modalities and the sequencing devices in the text. Compare for example the effect of "Until now, gas separation with the help of membrane filtration is not yet applied in our country," with the effect of "Gas separation with the help of membrane filtration is not applied in our country." The data are the same, but the framing is different, and the implicit scenario of the first phrase ("but it will, or should, be applied") derives its force from a cultural *schema* of 'inevitable progress'. (The example is drawn from a detailed analysis in Van Lente 1993.)

For our purposes, the isolation of the main building blocks is important, not the detailed analysis of concrete argumentative patterns. Because the data are drawn from explicit submissions, they are already shaped so as to bring the arguments and their linkages out. When necessary, we fell back on our argumentative intuition, as supported by our experience with rhetorical analysis, discourse analysis and narrative analysis to make sensible choices; for example by looking at the sequencing or the modality.

The modality with which an argument or a claim is expressed is particularly important to find out what is generally accepted. Or, more generally, what is sufficiently robust to withstand critical deconstruction. For scientific articles, such modalities have been traced as evolving from: 'We speculate that ...' or 'X might be caused by ...' or 'Some authors have suggested that ...' for the uncertain; *via* 'It is probable ...' or 'X appears to be caused by ...' or 'Smith and Jones have noted that' for the plausible but still not robust; to 'It is certain that...' or 'As it is well-known that X causes ...' or '...' (i.e. the claim is made without there being any need to refer to sources). In other writing, similar gradings of certainty, acceptance and robustness can be distinguished. In our data, qualifiers like 'naturally' or 'it is obvious that' can be used as indicators of robustness, or, tactics to try and claim robustness for one's less certain or less accepted point.

Once building blocks have been isolated, one can trace their modalities across the whole set of data. Not just as arguments for a particular position, but also in the way the arguments for another position are referred to. If these are addressed, and in a way that it is clear that the author feels s/he is forced to address them (because of the state of the controversy), then we have found a *focus* of the present state of the controversy. The modalities of presentation then allow us to decide whether this focus has been articulated and accepted, so as to become available as a boundary condition to all argumentative patterns, or a point of departure that has to be used, as a starting point or later on in the argument, or whether it is a "wicked" focus which is full of uncertainty and divergence, at least at this stage. Note that we are not interested in everything that is uncertain, but in those problematic issues that have to be addressed, because they are a focus of the controversy.

Up to this point, the analysis maps the state of the repertoire in the same way as a sociologist would do, using certain methods to find out what is the case, even if these are never fully objective, because they require judgements of the analyst in a number of places. In our analysis, we have gone one step further in order to evaluate the argumentative repertoire. We wanted to find out what the structures of the main argumentative patterns were, and whether the "wickedness" of one or more foci was related to a problem in the argumentation, or not (and if not, it might have a variety of causes, including unconstrained interest politics).

So we went back to argumentation analysis, and the basic Toulminian scheme, and used it as a shell to build a number of argumentation scenarios, using only the main building blocks, and leaving out most of the data and backing, only referring to their presence or absence. A path through such an argumentation scenario will specify an argumentation pattern, and one that qualifies as argumentatively sound, because the steps necessary for sound argument are taken.

The argumentation patterns we created in this way need not coincide with any concrete argumentation found in our data, or elsewhere. They highlight what the argumentative repertoire has to offer at this stage. And they have a diagnostic aspect as well: not only do we work with what is available (so the limitations of our scenarios and patterns are limitations of the repertoire), we also try to fit the "wicked" foci into the scenarios, and see what happens. One conclusion which we drew in the main text was that the "wicked" focus of retrievability ("wicked" in the sociological sense, in that participants disagree how to handle the issue) plays indeed a wicked role in the argument: it cannot be used as the starting point of a scenario of its own, and when it appears in another scenario, it creates forks in the sequence. This is not to say, we hasten to add, that the issue of retrievability cannot be resolved. It is a diagnosis of the present state of the repertoire.

Repertoire learning and the introduction of forceful foci

The repertoire in a controversy evolves, and when the repertoire at some later stage is better (in terms that must be specified), repertoire learning has occurred. No particular individual need to have learned; the change could have happened through new participants. As we noted in the introduction: some arguments cannot be maintained anymore, others become easy to mobilize. If a participant tries to press one of the untenable arguments, the reactions will be such that he will quickly learn that he should not (unless he can come up with a new defense, of course). In terms of our metaphor: the argumentative landscape has changed, and the movements through it experience a different gradient. Even if you do not know the new lay of the land, you will quickly learn the difference between an easy slope and a steep hill.

Repertoire learning has been described by Whiteman (1982; 1985), though without using the concept, for the utilisation of OTA reports by the American Congress. He identifies substantive, elaborative and strategic use, and describes outcomes, including repertoire learning: "There were some arguments that people were making that were just dropped because they didn't make sense anymore in the light of the OTA report." (Whiteman 1985, at p. 221). He then goes on to note that strategic use of analytic information (which some might decry as improper) actually increases the sophistication and may shift the focus of Congressional debate, exactly because strategic use occurs in situations where interests are at stake, and proponents and opponents have to be careful about the quality of their weapons, including the analysis and arguments they use. We add that it is not a coincidence that strategic use is more frequent when the topic is controversial. The further implication is that attempts to reduce strategic use might actually diminish the amount of learning that occurs on the basis of an OTA report.

Repertoire learning does not occur automatically, just as new knowledge or new analysis will not be utilized already because it happens to be there. There must be an incentive, and controversy is one incentive. When the socio-cognitive dynamics of controversies are traced (see for such an analysis, and references to relevant literature, Rip 1986b), two features stand out.

One is that forceful foci are necessary for further articulation and possible agreement or accommodation; otherwise, too little is at stake, and parties prefer to go their separate ways. Intended government regulation or policy making can be such a forceful focus; a credibility problem (say, for chemical industry and environmental impact of its processes and products) can be another.

The second feature is that the actual nature and sequence of the forceful foci determines the content of the eventual resolution, including the content of the repertoire then achieved. Those issues will have become articulated and will have led to robust insights that were at stake at some earlier stage. In the 1970s controversy over recombinant DNA research in laboratories, the risk of escaping micro-organisms quickly became a focus, and when it turned out that these could be contained (through the use of 'crippled' micro-organisms and through bureaucratic classification of extent of risk and nature of precautions), and there was no other forceful focus, the controversy closed and the implicated repertoire was consolidated. "The risk of r-DNA research appears to be considerably less than initially believed," (true) became: "The risk of r-DNA research is negligible." In sofar as there still was debate, it centred on the actual use of r-DNA technology in production processes and products, but there different issues were at stake.

The implications of this brief excursion to the socio-cognitive dynamics of controversies are that repertoire learning occurs better when there is something at stake, and that this can be understood because it is in and around a forceful focus that articulation occurs. Consolidation, the second feature of robustness, may be, but need not be, the end result of such a dynamic. It is difficult to decide whether consolidation has occurred prematurely, and should be broken up -- even apart from the question whether some participant might actually be able to break up a consolidated position.

A policy implication is that when lack of articulation and consolidation is diagnosed, the policy maker should stimulate repertoire learning, and the best instrument to do so is to create a forceful focus. In our case, this would be to decide about a policy that addresses retrievability, the "wicked" focus. Not because the policy maker has found the right answer, or has resolved the conflict between the parties, but because he sets learning in motion. Thus, it is not decisive which way the policy takes up the retrievability issue, as long as it does take it up. The learning that occurs then may lead the policy maker to revise his original choices, but that should not be a problem.

Bibliography

Theresa Enos, Stuart C. Brown (eds.)(1993). *Defining the New Rhetorics*, Newbury Park etc.: Sage Publications.

Arie Rip (1986a). 'Societal processes of technology assessment,' in Henk A. Becker, Alan L. Porter (eds.), *Impact Assessment Today*, Utrecht: Uitgeverij Jan van Arkel, 415-434.

Arie Rip (1986b). 'Controversies as informal technology assessment', *Knowledge 8*(2) (Dec. 1986) 349-371.

Peter Jan Schellens (1985).*Redelijke argumenten*, Dordrecht: Foris Publications.

Stephen Toulmin (1958). *The uses of argument*, Cambridge University Press.

Harro Van Lente, (1993). *Promising Technology. The Dynamics of Expectations in Technological Development*, Delft: Eburon.

David Whiteman, (1982). 'Congressional use of Technology Assessment', in David M. O'Brien and Donald A. Marchand (eds.), *The Politics of Technology Assessment. Institutions, Processes, and Policy Disputes*, Lexington, MA: Lexington Books, D.C. Heath & Co., 51-64.

David Whiteman (1985). 'Reaffirming the importance of strategic use. A two-dimensional perspective on policy analysis in Congress,' *Knowledge 6*(3) (March 1985), 203-224.

Discussion Paper for Topic D on
RETRIEVABILITY

Geological Disposal of Long-lived Radioactive Wastes and "Sustainable Development"

Manfred Bloser

Bundesministerium für Umwelt,
Naturschutz und Reaktorsicherheit
D-53117 Bonn

Helmut Röthemeyer

Bundesamt für Strahlenschutz
D-38226 Salzgitter

1. Introduction

On the basis of the results of the "United Nations Conference on Environment and Development" (UNCED) in Rio de Janeiro 1992 which elaborated a concept of "sustainable development" in its Agendas 21, some countries have drawn conclusions on design features of repositories for the final disposal of toxic wastes. This paper explains, why retrievability and reversibility are not favourable design features for the geological disposal of radioactive wastes within the concept of "sustainable development".

2. What sustainable development means

"Sustainable development" means satisfying the needs of the present without compromising the ability of future generations to meet their own needs by

- sustained, long lasting technical development
- fulfilling human and environmental protection goals now and in the future
- saving resources and conserving the environment for future generations
- placing no undue burdens on future generations without denying their right for intervention at a later date.

3. What geological disposal means

Geological disposal of long-lived and/or high level radioactive wastes aims at achieving long-term isolation from humans and the environment with reasonable assurance by means of

- emplacement in a stable geological formation several hundred metres below the surface;

- implementation of the multi-barrier concept; this includes backfilling and sealing of all openings;

- avoiding maintenance-work and surveillance after sealing as a necessary safety feature.

The basic radiological requirements for the protection of humans and the environment arise directly from radiation protection principles.

The arguments for or against retrievability and even reversibility are based on value judgements of a technical and ethical nature. While these judgements usually result in repository designs without the option to retrieve the waste, the supporters of retrievability or reversibility base their arguments on

- a lack of the necessary knowledge to ensure safety

- the conservation of resources

- a possible optimization on the disposal technology in the future.

These arguments are dealt with under item 4. as follows.

4. Arguments and answers

4.1 Necessary knowledge

Prior to designing and construction of a repository for long-lived radioactive wastes necessary knowledge for a sustainable, long lasting development and safe use of the repository is received by careful and thorough reconnaissance by geoscientific and mining procedures supported by the appropriate use of safety assessment methods. Unavoidable uncertainties and lack of detailed knowledge can be compensated by conservative and pessimistic assumptions, uncertainty analyses and observations from natural systems. Wastes that have thus been disposed of in a geological repository are much less accessible than stored wastes designed for retrievability/reversibility; it is therefore better protected against both human activities and natural processes. Thus reasonable assurance can be gained that a safe design and construction of a geological repository will keep its safety features far into the future. Safety of men and protection of the environment can be sustainably maintained without human intervention.

4.2 Conservation of resources

High level wastes may in the future be a potential resource for useful material. Then it can be used within an integrated life cycle management; i. e. recycling prior to conditioning should be pursued, e. g. in a reprocessing plant rather than to retrieve the wastes from a repository and chemical treatment of the retrieved wastes. For the time being a demand for recycling the wastes e. g. from operation of nuclear power plants is not in sight, let alone the re-use of nuclear wastes in repositories.

A sealed repository without the designed option to retrieve the wastes, however, may also be exploited as a "deposit", if this meets the needs of future generations.

4.3 Optimization of disposal technology

Research and development work concerning the waste form and disposal method may provide better options in the future than those existing today. As safety goals have to be met anyway options are not necessary in principle. Nevertheless options, e. g. the separation- and partitioning of long-lived radionuclides may be developed to minimize the residual risks.

The goal for possible future risk - minimisation must be weighed up against a definite risk increase and a higher burden on future generations by postponing a decision needed today. When e. g. partitioning and transmutation are viable ways to get rid of long lived radionuclides this technology could be used for the wastes then produced and not for the wastes already emplaced in a repository.

Permanent retrievability of emplaced radioactive wastes require accessibility. Accessibility increases the risk of a geological repository (geotechnical stability, exposures to the personnel, the general public and the environment) and is in contradiction to the minimisation of radiation exposure. The minimisation principle is met only after the backfilling and sealing of all access shafts, tunnels and other openings are completed. Hence retrievability and reversibility as a design feature violate this proved principle.

5. Final disposal, international consensus documents and sustainable development

5.1 In chapter 22 "Safe and environmentally sound management of radioactive wastes" the "Report of UNCED in Rio de Janeiro" stresses, that states, in cooperation with international organizations, where appropriate, should

- provide for their processing, conditioning, transportation and disposal; (22.4 (a))
- support efforts within IAEA to develop and promulgate waste safety standards or guidelines and codes of practice as an internationally accepted basis for the safe and environmentally sound management and disposal of radioactive wastes; (22.4 (b))
- promote research and development of methods for the safe and environmentally sound treatment, processing and disposal, including deep geological disposal, of high-level radioactive waste (22.8 (a)).

The UN-Commission on Sustainable Development (CSD) stated in its report on the 2nd session in May 1994 and in a resolution, that "efforts had been geared towards identifying and establishing permanent disposal sites for radioactive wastes." The CSD expressed its support for the work of the IAEA and the international cooperation within the framework of the RADWASS-Programme. Apart from that, the CSD urged governments to apply preparatory measures for final disposal. That means, that the CSD relies on the work of the IAEA particularly.

5.2 The international scientific discussion led to the conclusion, that geological disposal can be performed in a safe manner (cf International NEA-, IAEA-, CEC-Collective opinion, OECD/NEA 1991). The respective activities are supported by the existing and the forthcoming international consensus safety objectives and standards. These objectives and standards don't rely on retrievability and/or reversibility. Neither does the Collective Opinion. The forthcoming new safety fundamentals of the IAEA "The Principles of Radioactive Waste Management" and the IAEA "Radioactive Waste Management Glossary" define disposal as "the emplacement of waste in an approved, specified facility (e.g. near surface or geological repository) without the intention of retrieval".The existing IAEA Safety Standard N° 99 "Safety Principles and Technical Criteria for the Underground Disposal of High Level Radioactive Wastes" (published 1989) sets out "the basic design objectives for Underground high level radioactive waste repositories such that humans and the human environment will be protected after the closure of the repository and for the long time periods for which the wastes remain hazardous. It establishes principles for the protection of future generations and quantifies the level to which they should be protected. Finally, it provides guidance on the technical aspect of repository design such that the principles may be complied with".

With respect to the protection of future generations it states in Principles N° 1 und N° 2:

"The burden on future generations shall be minimized by safely disposing of high level radioactive wastes at an appropriate time, technical, social and economic factors being taken into account". "The safety of a high level waste repository in the post-sealing period shall not rely on active monitoring, surveillance or other institutional controls or remedial actions after the time when the control of the repository is relinquished." This means, that present generations should not rely on the means, ability and stable societal conditions of future generations to manage wastes presently produced.

The Safety Standard N° 99 does not "address the need for, nor the form or content of, any retrievability requirements that might be appropriate, either during the period of waste emplacement or during a subsequent testing or observation period prior to final sealing of the repository". In agreement with the afore mentioned principles, however, it defines a disposal system as "a combination of a geological environment, a repository and waste packages emplaced within the repository, without the intention of retrieval".

6. Conclusions

Neither the Rio-Conference nor the CSD directly address the implementation of retrievability or reversibility as design features. The reference to international consensus documents, however, support the conclusion, that retrievability and/or reversibility is not requested as a design feature.

This avoids undue burdens on future generations by not relying on their means, ability and stable societal conditions to manage wastes presently produced.

On the other hand the relinquishement of retrievability and/or reversibility does not deny the right of future generations for responsible actions including reparability and retrievability and even reversibility at least for some time after closure. Future generations may also value a repository as a useful deposit.

On the basis of the above technical scientific and ethical arguments, retrievability should be avoided as a design basis of a geological repository. When retrievability and reversibility are requested, e.g. politically, interim storage - and not geological disposal - is an adequate technical answer.

ワークショップ事前検討資料

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

NUCLEAR ENERGY AGENCY

RESTRICTED

Paris, 10th June 1994

WORKING DOCUMENT

English Text Only

RADIOACTIVE WASTE MANAGEMENT COMMITTEE

BACKGROUND DOCUMENT FOR THE WORKSHOP ON THE ENVIRONMENTAL AND ETHICAL ASPECTS OF LONG-LIVED RADIOACTIVE WASTE DISPOSAL

Paris, 1st-2nd September 1994

RADIOACTIVE WASTE MANAGEMENT COMMITTEE

WORKSHOP ON THE ENVIRONMENTAL AND ETHICAL ASPECTS OF LONG-LIVED RADIOACTIVE WASTE DISPOSAL

BACKGROUND DOCUMENT

(Prepared by the Workshop Programme Committee)

SUMMARY

The present paper has been prepared as a background document to assist in the preparation and conduct of a workshop sponsored by the Radioactive Waste Management Committee (RWMC) of the OECD Nuclear Energy Agency (NEA) on the environmental and ethical aspects of the disposal of long-lived radioactive waste. Such issues may not have been explicitly considered so far to the same extent as technical issues and there is a need to have an in-depth review of their meaning and significance for the management of radioactive waste, including a broad environmental protection perspective. The purpose of this background paper is:

- To set the scene for the workshop discussions through a brief reminder of the main elements of current radioactive waste management approaches, their general environmental and technical bases and the principles which have led most countries to recommend the long-term isolation of radioactive waste under passive conditions in deep geological repositories; and

- To identify for discussion at the workshop a list of non-technical environmental protection and ethical issues raised by the management of radioactive waste (and other hazardous wastes), such as liabilities to future generations in a "sustainable development" context and the application of this principle.

The focus of the workshop will be the concept of deep geological disposal and the associated non-technical issues identified in this document. Invited specialists in environmental protection and ethics will be asked to address these issues and, to the extent possible, offer practical guidance regarding their resolution. Ultimately, the results of the workshop will be published by NEA and used by the RWMC to discuss the appropriateness of the concept of geological disposal of radioactive waste in a broad environmental and ethical perspective. The conclusions of the RWMC review will constitute its next "Collective Opinion".

I. INTRODUCTION

The development and welfare of modern societies depends to a large extent upon the contribution of technology and industrial processes, such as electricity generation. These processes are in general associated with the production of wastes, some of which are hazardous and require careful management systems in order to ensure adequate protection of man and the environment. The timescales over which such protection is required often extend well beyond the period of direct concern to current or forthcoming generations. Hence the ethical imperative to care about future generations and to afford them the possibility of enjoying the same choices and options which we currently enjoy. Such a concern for the protection of human health and the environment in a developing world led to the concept of *"sustainable development"* which was chosen as the main theme of the United Nations Conference on Environment and Development, in Rio de Janeiro in 1992. While this concept can be defined in relatively simple terms, such as *"satisfying the needs of the present without compromising the ability of future generations to meet their own needs"*, the implications of the concept for individual industrial sectors are not always well understood.

The production of radioactive waste resulting from the generation of nuclear electricity and the various applications of radioisotopes in medicine and industry is typical of such a situation. It is a complex issue combining technical and scientific requirements with ethical considerations associated with the long-term protection of the environment. This issue was recognized by those involved in the nuclear industry who had chosen at an early stage to look carefully at the management of radioactive waste, because of:

- the nature of the hazard: the risk of ionizing radiation; and
- the persistence of the hazard due to the presence of very long-lived radionuclides in the waste.

The long-term management of radioactive waste is however only one example of a situation where the future environmental impacts of current practices for the disposal of hazardous waste have to be evaluated and regulated. Logically, the disposal of radioactive waste should be based on the same general environmental protection and ethical principles as those which may apply to similar situations in other fields, recognizing both the existence of specific categories of hazardous waste imposing their respective safety, environmental and technical constraints, and the desirability of promoting coherent and integrated risk management and environmental protection policies.

Against this background, the Radioactive Waste Management Committee of the NEA decided in 1993 *to broaden the basis for an in-depth reflection on long-term waste disposal issues, notably on the fundamental environmental protection and ethical aspects involved*, and to prepare a new RWMC Collective Opinion (i.e., a well-documented consensus statement written for a wide audience) on the appropriateness of long-term waste disposal strategies seen from a non-technical perspective. Indeed, such aspects have not been analysed and explained to the same extent as technical issues and may, therefore, not be fully appreciated. Furthermore, radioactive waste management has been largely developed at the initiative of the nuclear industry and nuclear regulatory authorities, without much interface with other industries and environmental agencies facing similar issues. Obviously, there is a need to broaden the discussion bases to include a more general consideration of long-term management of hazardous wastes. As an initial step in this process, the RWMC decided to organise a workshop to review the information available, stimulate an exchange of views between radioactive waste managers and specialists on ethics and environmental protection, and provide a sound basis for the drafting of the next RWMC Collective Opinion.

II. PURPOSE AND SCOPE OF THE DOCUMENT

The present document has been written to assist in the preparation of the workshop, notably in focusing the discussion to key non-technical issues which play an increasing role in the definition and acceptance of radioactive waste management criteria and strategies, particularly with regard to the disposal of long-lived radioactive waste.

Its first objective is to set the scene for the workshop's discussion and, therefore, to recall the main points behind the radioactive waste management approaches followed currently in most countries and the broad consensus which exist on long-term safety and technical issues at the international level. In particular, the general environmental and technical bases and the fundamental principles which have led most countries to recommend the long-term isolation of radioactive waste under passive conditions in deep geological repositories, are presented as background material. The deep geological disposal concept and possible alternatives will actually constitute the focus of the workshop.

The second objective of this document is to identify the associated environmental protection and ethical issues which invited experts will be asked to address in well-focused presentations and, to the extent possible, provide practical guidance on each of them. This guidance is requested to assist the RWMC in reviewing, reconsidering and restating a consensus on the radioactive waste disposal strategy.

In this context, although the proposed debate may be seen as an integral part of discussions on wider energy and environment issues, the document does not cover the environmental acceptability and justification of nuclear and other energy production systems, which are affected by broader considerations notably of the potential benefits and costs to society. It was not considered appropriate, given the mandate of the RWMC, to review such issues in any detail. In addition, radioactive wastes already exist, and continue to be produced as current applications of nuclear power and ionizing radiation are generally considered beneficial. Issues specific to their management and disposal need, therefore, to be looked at separately from the processes of their origin. However, broad cost/benefit considerations have a role to play at the workshop, particularly in the contexts of choice of strategy and of intergenerational equity, and they will be part of the debate.

The document and workshop do not deal in any detail with specific features of licensing systems and regulatory review processes, such as the setting of safety standards, consultation and decision-making procedures, the use of independent peer reviews, etc. Similarly, perception, communication and other social and public acceptance aspects related to the practical implementation and siting of specific waste disposal systems are not covered either. It is recognized that such aspects are important and can be strongly influenced by the debate on ethical and environmental considerations. However, their inclusion in the workshop scope would divert the attention from the more fundamental and generic issues identified later on in this paper.

III. BACKGROUND ON RADIOACTIVE WASTE MANAGEMENT APPROACHES

This section is a brief description of the approach currently favoured in most of the advanced countries for the management of radioactive waste. It summarizes the general thinking which has evolved in this field on the basis of several decades of research and development efforts, as well as intensive discussion at the international level. The strategies followed at national level are influenced by specific institutional and technical conditions, but they are in general relatively similar.

1. Nature of the Problem

The production of radioactive waste from the nuclear fission process as well as from other applications, for example in medical and industrial activities, results in a wide range of different types of waste products. Some of the waste are long-lived and persist for many thousands of years (such as the nuclear spent fuel itself and the most radioactive waste resulting from its reprocessing), some are short-lived and decay rapidly and become harmless in periods of time corresponding to human life or a few centuries at most. Because of the technical difficulties of modifying the nuclear properties of radioactive materials and, therefore, of diminishing their inherent radiological toxicity, there is no practical means today to avoid or reduce significantly the production of radioactive waste from nuclear fission. The potential for the safe reuse or recycling of some of the elements contained in the waste is also limited. Current studies on the separation and transmutation of long-lived elements present in the waste, such as actinides, are still at a preliminary R&D stage and are unlikely to result into the development of a full solution to the long-lived waste problem. Radioactive wastes have therefore to be managed as such, after suitable chemical and physical treatment to facilitate their handling, storage and disposal .

The relative hazards of radioactive wastes vary according to the nature and particular characteristics of the waste. They are associated essentially with the ionizing radiations emitted by their constituents, and their potential impact on human health and the environment. A great deal of experience with radioactive materials has been accumulated and the current radiological protection principles and regulations provide a good basis to ensure a careful and safe management of radioactive waste.

In practice, two main options, often complementary, are available: to contain and isolate waste from man's environment for as long as may be necessary; or, where practicable, to allow dilution and dispersion in the environment at levels which do not constitute unacceptable radiation risks. The latter option concerns in practice only a very small proportion of the total amounts of radioactivity present in the waste. The nuclear industry has chosen containment and isolation as its preferred strategy for long term management of toxic wastes.

In the case of dilution and dispersion, the presence of radionuclides in the environment represents a potential human health hazard, but one which can be adequately controlled on the basis of current radiation protection criteria. Some impact on the environment itself cannot be totally excluded, notably concerning individual members of living species, but this usually remains negligible when human health is adequately protected.

Various technical means, either temporary or final, have been developed for the containment and isolation of radioactive waste, ranging from interim short-term storage with varying degrees of surveillance and maintenance by man, to final disposal solutions requiring no further intervention by man or institutional control measures. For the relatively large volumes of low-level waste essentially free from long-lived radionuclides, an acceptable disposal solution is the emplacement of waste in near-surface facilities which can be monitored up to about 300 years, the time necessary for almost all the radioactive substances in the waste to decay to innocuous levels.

The major issue is the existence of long-lived radioactive waste remaining toxic for extremely long periods, as compared to human and historical timescales, and requiring, therefore, isolation from the biosphere for comparable periods. Surveillance and monitoring by man cannot be assumed for such long periods and long-term containment systems have therefore to be passively safe. Ultimately in a suitable disposal site, when most of the radioactive waste content has decayed, some dispersion and dilution of the residual radioactivity in the environment may take place without appreciable risks. Although this long-term aspect has always been recognized and given prominence in the context of long-lived radioactive waste, it is actually present also with some other hazardous waste products, such as those containing toxic heavy metals, whose toxicity does not disappear with time. It would be logical, therefore, that the principles for the long-term disposal of radioactive waste be more or less the same as those which should apply to some other non-nuclear hazardous waste materials.

2. Basic Objectives of Radioactive Waste Management

Ethical considerations, notably for the protection of future generations, are an integral part of radioactive waste management principles. Liabilities to future generations and intergenerational equity were at the basis of the requirement for the long-term isolation of radioactive waste identified as early as 1957 in a report by the US National Academy of Sciences, which suggested that geological disposal would be the most promising method for that purpose. Disposal in deep and stable geological formations, could offer a passive system of multiple natural and man-made barriers between waste and the biosphere, remote from man and rendering human intrusion into repositories relatively unlikely, and with an inherent degree of safety so high that it would not require any form of institutional control. The scientific and technical character of R&D activities which followed in many countries had the effect of presenting the geological disposal concept as mainly technological, while its ethical basis and the associated ambitious safety level which were taken for granted by specialists in the fields, were often unnoticed and sometimes even ignored.

In this context, the objectives of radioactive waste management can be stated as follows: *"to manage radioactive waste in a manner that protects worker safety, public health and the environment, now and in the future, and to do so in a manner that minimizes, to the extent possible, the burden placed on future generations"*. Emphasis is placed on safety, both radiological and non-radiological, protection of present and future generations, limitation of burdens to future generations, protection of the environment and preservation of environmental resources, as is illustrated in Appendix 1, which reproduces a more or less final version of waste management principles to be adopted by the IAEA. Existing levels of natural radioactivity in air, water and soil, provide a useful baseline which can be used for comparison of concentrations of radioactive and other toxic minerals in the geosphere and the biosphere.

A fundamental postulate of radioactive waste disposal is that future populations should enjoy the same degree of radiological safety as that acceptable to current generations. In other words, current radiological protection criteria are used as a reference to decide whether potential effects on populations living in the far future would be acceptable, irrespective of the date of occurrence of such effects. Today, the safety of disposal in deep and stable geological formations is assessed over periods of the order of 10 000 - 100 000 years or more, taking into account uncertainties introduced by the theoretical nature of risk calculations and the evolution of societies.

Other disposal concepts have been considered in many countries and even at the international level. They included burial of canisters in polar ice sheets, space disposal and disposal in the sub-seabed, a form of geological disposal in seabed geologies. For various technical and institutional reasons, these concepts do not enjoy much interest now, and deep geological disposal on land has become the central strategy in practically every country for long-lived radioactive waste.

3. Long-term Safety Issues

As potential long-term hazards are explicitly acknowledged, as well as the need to care about future generations, a prerequisite of radioactive waste management is that the long-term safety of a disposal solution must be convincingly shown prior to the implementation of this solution.

In the last 15 years, considerable efforts have been made to evaluate the behaviour of deep geologic repositories with time and their long-term safety. Scientific methods do exist today to establish the safety of particular disposal sites and there is an international consensus among experts that *"appropriate use of safety assessment methods, coupled with sufficient information from proposed disposal sites, can provide the technical basis to decide whether specific disposal systems would offer to society a satisfactory level of safety for both current and future generations"*. This was the conclusion of an international [NEA/IAEA/CEC] Collective Opinion published by OECD in 1991 and reproduced in Appendix 2.

The existence of uncertainties in safety assessments is recognized, both in regard to physical data inputs and in judgements on the state of future societies, and appropriate allowance is made when applying the results of safety assessments. Nonetheless, the credibility of the geologic disposal objective and its practical realization involve value judgements, and there is a need to discuss the ethical considerations involved.

4. Current Practices and Implementation Steps

Most disposal plans for long-lived radioactive waste foresee the opening and operation of the first geologic disposal repositories around 2010-2020 at the earliest. In the meantime, waste are stored in temporary facilities which when properly designed, as is the case generally in OECD countries, provide a safe and flexible interim solution. Currently, national efforts are concentrated on R&D activities, the safety and feasibility of various management alternatives, the selection of suitable disposal sites and optimisation studies covering safety, environmental, industrial and economical issues.

As there is in general little incentive for spent nuclear fuel and the high-level waste resulting from their reprocessing to be disposed of shortly after production, the development and implementation of disposal concepts can be envisaged in a step-wise or incremental basis. The most common elements of this approach consist of concept and technology development/demonstration; evaluation of site characteristics to enable a site specific facility to be designed; assessment of the long-term performance of a facility at a given site with a given design; construction and operation of the facility while site observation and performance assessment activities continue; completion of disposal operations and decommissioning of surface facilities; and eventually the sealing of all access shafts, tunnels and exploratory boreholes to place the facility in a passively safe state.

This step-wise or incremental approach provides ample opportunity for ongoing review and consideration of different management options for the short-, medium or even long-term. As a matter of fact, the progressive approach followed implies a number of milestones, with decisions taken in a relatively open and transparent context. National programmes and their schedules for the various steps are publicly available in most countries, all indicating that no long-lived radioactive waste will be disposed of without prior evidence of the safety of the concept and a series of successive decisions over a period of 20 to 40 years.

When deep geological repositories become available, their operation will last for a few decades, and then a decision will be needed to close the site. Until that stage, waste is more or less easily retrievable. Strictly speaking, the deep geological disposal concept does not rely on the need for interventions after a repository has been sealed, or on environmental monitoring measures to assure long-term safety. However, such interventions are not necessarily to be excluded. In practice, even after a repository is sealed, retrieval of the waste would not be totally impossible, the difficulties increasing, however, with time. The technology required for such an operation could be developed on the basis of current knowledge. Technical difficulties and costs would vary considerably depending on the host rock characteristics, and on the design of the repository which may or may not facilitate such operations. Nevertheless, the option of going back to the waste and possibly retrieving it, whatever the reasons for this, would not be totally foreclosed.

Finally, another feature of geological disposal programmes is that they benefit from close international cooperation activities, including the exchange of information and experience on safety assessments and peer reviews by independent teams of experts. Such activities cover practically every aspect of radioactive waste management and lead to relatively homogeneous and consistent approaches around the world.

As a concluding remark for this section, it can be stated that the isolation of long-lived radioactive waste into deep geological systems, under passive conditions, seems to offer a safe and technically feasible solution specially designed to meet ethical and environmental concerns about benefits, liabilities and risks bequeathed to future generations. This is the central strategy of practically all countries with nuclear power programmes, with progressive implementation schedules giving ample time and flexibility for considered decisions to be taken before waste is actually disposed of. However, there still exist, mostly at the non-technical level, different perceptions and even scepticism about the soundness of the concept, with a diversity of value perspectives concerning the ethical and environmental background, showing the need for an in-depth reflection on those aspects. The next section tries to identify these issues.

IV. ENVIRONMENTAL AND ETHICAL ISSUES TO BE ADDRESSED AT THE WORKSHOP

In recent years, a number of national studies have been made to review the ethical basis of radioactive waste disposal, notably the long-term aspects. Some of the main conclusions are reproduced in Appendices 3 and 4. These studies have provided interesting views on ethical issues, but do not answer all the questions raised concerning the soundness of the geological disposal approach proposed by the nuclear community. Following a survey made among members of the RWMC to prepare the September 1994 workshop, many issues were listed again. They are summarized in this section, with a view to their being addressed by the speakers invited to the RWMC Workshop, together with any other questions the speakers would like to raise themselves. The objective of this procedure is to try to promote relatively pragmatic and focused reactions from the participants, since it is recognized that translating philosophical concepts based on ethical values into practice can be problematic.

1. One of the very first issues raised concerns the right of current generations to take decisions that are going to affect future generations, particularly when the benefits and the risks are not evenly distributed between the present and the future. The basic question can be phrased as follows: <u>Can risk, or responsibility for essential action, be imposed (on future generations) when the benefits are perceived to be incurred by others (the current generations) and, if so, under what conditions?</u>

   In the case of nuclear electricity production, the application of radiation protection principles presupposes that there is a net positive benefit to current generations and no significant or unacceptable detriment to future generations. However, even assuming some benefits to mankind in the longer term as a result of sustained technological advancement leading to the continuing availability of sufficient energy sources, this <u>risk/benefit issue does not seem to have been considered in a systematic way</u>; for example through life cycle assessment of energy production alternatives considering sustainability of the energy source, emissions to the environment and the ultimate disposal of by-products and waste. (See later considerations on cost/benefit evaluation and distribution).

2. Another general question is the following: <u>Do current generations have the right to take decisions today which would foreclose options of future generations?</u> Two main aspects of this question are the following:

   - Disposal solutions are designed to be permanent as long as their long-term safety has been clearly established. However, with the prospects for improved scientific knowledge and technology, other options might prove more satisfactory to future generations from a safety, economic, or other viewpoint. Part of this question which is connected to the retrievability of waste is covered later on in the document;

   - In spite of all the current requirements for safety and siting of long-lived waste repositories, the use of some as yet unidentified environmental resources might be affected by the presence of radioactive waste substances in given areas restricting, therefore, the potential for their future exploitation.

3. A corollary question is: Could or should the responsibility for developing solutions to the radioactive waste problem be transmitted to future generations? Given the uncertainty of the stability of society, would future generations have the knowledge and resources necessary for the construction of appropriate repositories? Could the degree of endowment of resources specifically devoted to this problem affect that choice?

4. The concepts of sustainable development and intergenerational equity seem to have been precisely developed to answer some of the above questions about fairness between generations, particularly with regard to the far future. However, examples seem to be lacking where detailed practical application of these concepts would have led to clear conclusions about environmental or other societal issues likely to affect future generations. The question may be raised, therefore, as to whether these concepts could be applied in a practical way to address the optimum combination of responsibilities, options and resources to be bequeathed to future generations for the care of their health and environment.

5. In the radioactive waste disposal field, the intergenerational equity principle has been translated into the apparently simple and straightforward requirement that the safety level in the future be equivalent to that which is currently acceptable, irrespective of time, and without the necessity for active intervention by future generations.

   a. Does this approach represent an innovation, at least as far as a long-term safety provision is concerned, and if so, why?

   b. Is it fair to postulate that contemporary safety norms should be the basis for the protection of future populations? Or is there another way to determine the degree of risk acceptable to future generations? Assuming that scientific and medical progress will take place, for example in cancer research, would it be possible to take such progress into account in assessing future risks?

6. Recognizing that everything we do in the present has some potential impact in the future, would it be correct to consider that the application of the sustainable development and intergenerational equity concepts requires that both benefits and risks passed on future generations be taken into account in deciding what is equitable and what is not?

7. Cost/benefit evaluations are usually complex and involve value judgements, notably when costs and benefits are not distributed homogeneously in time and space which is generally the case. Hence, a series of questions which it would be useful to discuss in an ethical context.

   a. Discounting of costs with time is a widely applied technique in the evaluation of the impact of economic and industrial decisions. Could or should discounting of long-term health risks due to radioactive waste disposal be envisaged?

   b. Is it possible to assess what is passed on to future generations in terms of health risks, other detriments and possible benefits of all sorts, directly or indirectly? Should such an assessment be applied generically to human activities in a broad sense or should it concern only waste disposal issues?

c. How can the immediate needs of the current generations, for instance for energy generation or public health protection, be balanced with intergenerational equity requirements in the very long-term? This question is addressed in further detail by the next ones.

d. Are resources devoted to assuring safety of radioactive waste disposal appropriately balanced with risks, given that these resources could be applied to other societal goals? This question directly relates to achieving an appropriate balance between securing the resources needed to meet current needs, on the one hand, and conserving resources and protecting the environment to meet the needs of future generations, on the other hand. It is also related to the question of "*how safe is safe enough*" in a given area, and to the management of other risks which need to be kept under control as well. Even for decisions related to our own activities in the present generation, individual and societal goals often conflict. Several approaches have been used in making risk decisions on acceptable risks, including margins of safety, consideration of cost/benefit, and comparison to other risk levels. These techniques have been increasingly questioned and decision-makers are considering alternative techniques, including negotiation and consensus building. Are there principles and decision-making processes which could be used to determine where resources should be applied?

e. Is it preferable to take all physical actions today to minimize any bequest of liabilities for waste management actions to future generations. If not, how should financial assets be set aside to meet the liabilities?

f. There is a need to balance the risks to which we expose the current generation (or the immediate next generations), risks that can more readily be identified and to a certain extent quantified, against the risks to which we may be exposing some very far distant future people, risks that are much more difficult to quantify. If we follow a given course of action today to reduce the risk to the future generations, we need to take into account the risks to which we are exposing the present generation, notably the workers involved. What guidelines and principles should we follow to balance these risks? Does the proposition that we should not expose future generations to a risk that is not acceptable today appropriately address this issue?

g. Should measures of risk acceptability be considered in the context of individual rights or local rights, or the collective rights of the population?

h. In relation to the previous questions, there is the additional issue of the distribution of environmental risks across population groups, called "environmental justice". All communities and individuals, regardless of economic status or race are entitled to a safe and healthful environment. What measures are necessary in the siting of repositories to assure that disadvantaged populations do not bear disproportionate burdens?

i. In this respect, is there an ethical basis for a "host" community to receive some form of compensation in recognition of the service that it is providing to society?

V. THE GEOLOGICAL DISPOSAL STRATEGY FOR LONG-LIVED RADIOACTIVE WASTE AND ITS IMPLEMENTATION

In the light of the general questions raised above, which touch issues much broader than the management of radioactive waste, it is desirable to consider more specifically how the geological disposal strategy developed for long-lived radioactive waste fits within the general ethical and environmental context. In particular, the definition of the long-term objectives and the progressive and incremental character of this strategy, with "demonstration" of the long-term safety prior to the implementation of disposal systems, are of particular importance.

1. Disposal objectives

In spite of the large degree of consensus on the formulation of disposal objectives and safety requirements to be met to cover long-term obligations (see Appendices), these (or similar objectives) do not seem to be considered for possible applications to other types of hazardous waste. It may be appropriate to comment on this situation and raise the following questions:

a. Do the objectives of geological disposal, as defined currently and illustrated in Appendix I, take appropriately into account all the relevant ethical and environmental protection requirements, as discussed above?

b. Are these objectives fair, or perhaps too ambitious, in requesting a level of safety for the future equivalent to the one acceptable today, irrespective of time and without remedial intervention?

c. Should discounting of future health effects be acceptable within a broad cost/benefit approach of present and long-term societal issues? Would it be appropriate to envision the application of discounting to radioactive waste disposal, and, if so, under which possible conditions and timescales? (See IV.7.b above).

2. Strategic decisions

The waste management philosophy is based on the disposal concept which is intended, by definition, to be a final action, as opposed to interim storage situations, which are by definition only intermediate solutions prior to disposal. As mentioned in Section III.4 of this document, until access to a repository is closed, the waste is more or less easily retrievable. Some countries actually require that retrievability should be foreseen for some period of time after waste emplacement, with conditions similar to the ones typical of an interim storage situation. Such a requirement is in general limited in time, for example during the few decades necessary to operate the site and decide whether or not it should be sealed under the conditions foreseen. After closure of a disposal site interventions and possible retrieval would not be required in principle and, usually, they are not foreseen in the design of repositories. However, even under these difficult conditions, the technical feasibility of such operations should not necessarily be ruled out.

The question of retrievability is currently under consideration in research and development studies, taking into account the need to avoid interference with the passive safety of the repository in the long-term, and the very remote possibility of an intervention shortly after closure. In this context, the Dutch authorities have decided that long-term retrieval should be required for both long-lived radioactive waste and highly toxic chemical waste (see Appendix V). The consequence of this decision is to reject for the time being the concept of disposal in the Netherlands. This is not, however, the attitude prevailing in most other countries and, given the sensitivity of this subject, it is appropriate to address it, notably with the following questions: Is retrievability of waste important after closure of a repository? To what extent should it be facilitated by the design of the repository? Would the difficulties involved in retrieval of the waste justify postponing sealing of repository access and closure of the site, or even rejecting the concept of disposal, all safety considerations being taken into account?

The disposal concept may or may not involve measures of institutional control for limited time periods to maintain or enhance safety. It is designed to be a passive, self-maintained long-term safe solution, to be implemented by current generations to discharge their responsibilities vis-a-vis the future. This approach is to be implemented through a series of decisions and steps covering the development, construction, operation and eventually closure of deep geologic disposal systems taking place over a long time span - perhaps as many as a hundred years. In order to make progress towards the objectives, the involvement of our offspring, essentially during the next few generations, will be required. This is a relatively short-term commitment only, leaving to our immediate descendants the task to decide whether and when to close the repository. This does not seem to create major issues as long as this is properly planned and organised. The situation is not the same for the generations after, for example when the repository retains its integrity over thousands of years, or in the very long term (10 000-100 000 years) when some degree of dispersion of its radioactive content may occur. A series of questions may be raised in this context:

a. Does the fact that a final decision on the closure of a disposal site is left to our offspring, about a century from now, raise special concern? Could it be regarded rather as an advantage as ample time will be available for the decision to be taken, including consideration of a better scientific knowledge at the time?

b. Independently from safety considerations, would it be ethically appropriate for a given generation such as our own to postpone proceeding for some period of time and what would be the ethical basis to delay proceeding?

c. Is it preferable to proceed as indicated above and implement disposal plans such that no future intervention is going to be required?

d. What will be the appropriate balance to achieve in constructing a repository such that controls and corrective measures are unnecessary while allowing future generations the option to take advantage of advances in knowledge which may potentially increase safety? Many countries are pursuing a policy which requires a permanent solution to high-level waste disposal requiring that wastes will remain secure without reliance on active monitoring or controls. Wastes are to be disposed of in a manner such that future generations will not be required to take unusual measures to protect themselves or their environment. A question arises as to whether future generations should by design be left the option to correct any mistakes that we may make in waste disposal, taking advantage of advancements in knowledge. (This question is, to some extent, linked to waste retrievability).

e. The *"Polluter Pays Principle"* is largely implemented in the context of national radioactive waste disposal programmes, and many countries have raised funds for disposal programme costs. However, the fees collected on the basis of the amount of electricity produced are based on estimates and take into account the time value of money. Is this an ethically sound approach and is there a need to go beyond for the time being?

f. Are there ethical issues associated with the concept of an international waste repository serving the need of several countries, on the assumption that all safety, technical and economical conditions are satisfactory?

As most countries are already making plans for the implementation of a geological disposal strategy for their long-lived radioactive waste, it would be desirable to examine, at both national and international levels, whether or not this is a sound approach, all technical and non-technical issues being considered: After a review of the relevant ethical and environmental aspects involved, is it possible to conclude that the geological disposal strategy is in principle appropriate and compatible with the long-term requirements for the protection of future generations and their environment? Or, alternatively, in the context of our developing world and the need for a sustainable development approach, is there any fundamental ethical or environmental consideration which would disqualify this strategy? In addition to being addressed at the concluding session of the Workshop, these questions will be examined by the RWMC at its next meeting in 1995, and be the subject of its next Collective Opinion.

APPENDIX 1

Extract from the

INTERNATIONAL ATOMIC ENERGY AGENCY

Division of Nuclear Fuel Cycle and Waste Management

DRAFT SAFETY FUNDAMENTALS

THE PRINCIPLES OF RADIOACTIVE WASTE MANAGEMENT

Safety Series No. 111-F

A PUBLICATION WITHIN THE RADWASS PROGRAMME

(February 1994)

1. INTRODUCTION

Background

101. Research and development in the field of nuclear science and technology have been ongoing since the beginning of the twentieth century leading to wide-scale applications in research, medicine, industry and in the generation of electricity by nuclear fission. In common with other human activities, these practices produce waste that requires management to ensure the protection of human health and the environment now and in the future, and to limit the burden on future generations. Radioactive waste may also result from the processing of raw materials that contain naturally occurring radionuclides. To achieve the objectives of safe radioactive waste management requires an effective and systematic approach to waste management within a legal framework within each country in which the roles and responsibilities of all parties are defined.

102. Radioactive waste occurs in a variety of forms with a wide range of characteristics such as concentrations and half-lives of radionuclides and physico-chemical nature. This waste may occur

- in gaseous form, such as ventilation exhausts from facilities handling radioactive materials;

- in liquid form, ranging from scintillation liquids from research facilities to high level liquid waste from reprocessing of spent fuel; or

- in solid form, ranging from contaminated trash and glassware from hospitals, medical research facilities and radiopharmaceutical laboratories to vitrified waste from reprocessing or spent fuel from nuclear power plants, when it is considered a waste.

The activity in radioactive waste may range from very low levels, as in those generated in medical diagnostic procedures, to very high levels as in high level reprocessing waste or in spent radiation sources used in radiography, radiotherapy or sterilization. Radioactive waste may be very small in volume, such as a spent sealed radiation source, or very large and diffuse, such as the tailings from mining and milling of uranium ores. Even though there are large differences in origin and properties of radioactive waste, e.g. concentration, volume, half-life and radiotoxicity, basic principles have been developed that are generally applicable to their safe management.

103. Radioactive waste, as a source of ionizing radiation, has long been recognized as a potential hazard to human health. Therefore, national regulations and internationally recommended standards and guidelines dealing with radiation protection and radioactive waste management have been developed, based on a substantial body of scientific knowledge. It has also been an exemplary feature of radioactive waste management that special attention has been given to protection of future generations. Considerations related to future generations may include potential radiation exposure, the possible need to perform surveillance or maintenance or economic consequences.

104. Radioactive waste may also contain chemically or biologically hazardous non-radioactive materials and it is important that these hazards are adequately considered in radioactive waste management.

105. Fundamental safety principles for radioactive waste management have evolved through the experience of IAEA Member States and the continuing process of establishing international consensus through the preparation of numerous IAEA documents on radioactive waste management. The Radioactive Waste Safety Standards (RADWASS) series of documents integrates this experience into a coherent set of principles, standards, guides and practices for achieving safe radioactive waste management.

Objectives

106. This document defines the objective and the associated set of internationally agreed principles for the management of radioactive waste. These principles provide a common basis for the development of more detailed IAEA Safety Standards, Safety Guides and Safety Practices under the RADWASS programme and are a basis for the radioactive waste management programme in individual Member States.

Scope

107. This document presents radioactive waste management principles that apply to radioactive material, as determined to be radioactive waste by the appropriate national authorities and to the facilities used for the management of this waste from generation through disposal. The radioactive waste management principles apply to all aspects that are not the specific subject of IAEA documents outside the RADWASS Series or other international instruments, e.g. transportation of radioactive material [1], exports and

imports [2] and safeguards. They also apply when managing radioactive waste containing, e.g. chemically or biologically hazardous materials even though there may be other specific requirements for those hazards.

Structure

108. The Safety Fundamentals contained in this document include the objective of radioactive waste management (Section 2) and fundamental principles of radioactive waste management (Section 3). The fundamental principles fall into the following general subject areas: protection of human health, protection of the environment, protection beyond national borders, responsibility to future generations and implementation procedures. Each principle is stated, and supporting and explanatory information pertaining to the principle is provided.

109. Annex 1 describes the basic steps in radioactive waste management to provide a common understanding among users of RADWASS documents. The document also contains a glossary of terms used in this document.

2. OBJECTIVE OF RADIOACTIVE WASTE MANAGEMENT

201. The objective of radioactive waste management is to deal with radioactive waste in a manner that protects human health and the environment now and in the future without imposing undue burdens on future generations.

3. FUNDAMENTAL PRINCIPLES OF RADIOACTIVE WASTE MANAGEMENT

301. Responsible radioactive waste management requires the implementation of measures that will afford protection of human health and the environment since improperly managed radioactive waste could result in adverse effects to human health or the environment now and in the future.

302. The timely creation of an effective legal framework and an organizational infrastructure within each Member State provides the basis for appropriate management of radioactive waste. The individual steps in radioactive waste management as outlined in Annex 1 may be dependent on each other, and thus, require co-ordination. Taking this interdependence into account will help to ensure safety in all radioactive waste management steps.

303. The fundamental principles enunciated for radioactive waste management will, if implemented and respected, ensure that these important considerations are addressed, and thus allow the achievement of the objective of radioactive waste management. They are presented in the following text of this document.

Principle 1: Protection of human health

> **Radioactive waste shall be managed in a way to secure an acceptable level of protection for human health.**

304. Many of the hazards induced by radioactive waste are similar to those associated with other industries, e.g. mining, chemical plant operations and toxic waste, and should be controlled. However, the nature of the radioactive waste implies another hazard, namely the possibility of exposure to ionizing radiation. An acceptable level of protection therefore needs to be provided. Particular attention needs to be paid to control the various ways by which humans might be exposed to radiation, and to ensure that such exposure is within established requirements.

305 Member States establish their radiation protection requirements for broader purposes than radioactive waste management. When establishing such requirements, Member States typically take account of, among other things, the recommendations of the International Commission on Radiological Protection (ICRP) and the IAEA [3-6] and specifically the three concepts of justification, optimization and dose limitation. However, radioactive waste management as a whole should have been taken into account in the justification of the practice giving rise to the radioactive waste, and therefore need not be justified in itself.

306. For activities extending over long time periods, e.g. radioactive waste disposal, Member States should consider the fact that the benefits and the exposures that might result, will affect populations separated by many generations, and that long time periods lead to increased uncertainties in the results of safety assessments.

Principle 2: Protection of the environment

> **Radioactive waste shall be managed in a way that provides protection of the environment.**

307. When radionuclides are released into the environment, species other than humans can potentially be exposed to ionizing radiation, and the impacts of such exposures must be taken into consideration. Since humans are among the most radiation-sensitive organisms, measures taken to protect individual humans from radiation hazards are in general considered adequate to protect other species, although these measures may not necessarily protect individual members of the species. Therefore, the presence of humans should generally be assumed when assessing impacts on the environment, particularly when assessing impacts of radioactive waste disposal.

308. Radioactive waste disposal, as in the case with, e.g. chemical waste disposal, may have local adverse effects on the future availability or utilization of natural resources, e.g. land, forests, surface waters, ground waters and raw materials, over extended periods of time. Radioactive waste management, therefore, should be conducted in such a way as to limit, to the extent feasible, these effects.

309. Possible future exploration for, or exploitation of, valuable natural resources could potentially result in adverse effects on the containment capability of a repository. Thus, such possible exploration or exploitation should be taken into account when siting and designing repositories.

310. Radioactive waste management activities may result in non-radiological environmental impacts, such as chemical pollution or alteration of natural habitats. These impacts need to be considered and radioactive waste management undertaken with a level of environmental protection at least as good as that required of similar industrial activities.

Principle 3: Protection beyond national borders

> **Radioactive waste shall be managed in such a way as to assure that possible effects on human health and the environment beyond national borders will not be greater than what is acceptable within the country of origin.**

311. This principle is based on the premise that a country has a duty to behave responsibly towards affected countries for ethical reasons.

312. In the case of normal release, potential release or migration of radionuclides across national borders, the country of origin and the affected countries could choose

to find agreement to expand on this principle for example through exchange of information or arrangements between national authorities.

313. Import and export of radioactive waste is the subject of the "Code of Practice on the International Transboundary Movement of Radioactive Waste" [2], which states in part that a state should receive radioactive waste for management or disposal only if it "has the administrative and technical capacity and regulatory structure to manage and dispose of such waste in a manner consistent with international safety standards".

Principle 4: Protection of future generations

> Radioactive waste shall be managed in a way that predicted impacts on the health of future generations do not exceed relevant levels that are acceptable today.

314. This principle is derived from an ethical concern for the health of future generations. While it is not possible to ensure total containment and isolation of radioactive waste over extended time scales, the intent is that there will be no significant impacts on human health when radionuclides enter the environment. In implementing radioactive waste management, particularly for disposal, uncertainties in long term safety assessment should be taken into account, e.g. by the multiple barrier approach.

Principle 5: Burdens on future generations

> **Radioactive waste shall be managed in a way that will not impose undue burdens on future generations.**

315. Consideration for future generations is of fundamental importance regarding the management of radioactive waste. This principle is based on the ethical consideration that the generation that produces waste should bear the responsibility to manage it. Some activities, however, may be passed to succeeding generations, e.g. the continuation of institutional control over a repository.

316. The responsibility of the present generation includes developing the technology, constructing and operating the facilities, and providing a funding system and sufficient controls for the management of radioactive waste. This includes providing the means and the technology for disposal.

317. The timing and implementation of disposal of individual radioactive waste types will depend on scientific, technical and economic factors such as the availability and development of suitable sites and the decay of radioactivity and heat during interim storage. Timing and implementation are also affected by political and public acceptance.

318. Management of radioactive waste should, to the extent possible, not rely on long term institutional arrangements as a necessary safety feature, although future generations may decide, e.g. to monitor radioactive waste repositories. The identity, location and inventory of a waste disposal facility should be appropriately recorded.

Principle 6: Legal framework

> Radioactive waste shall be managed within an appropriate legal framework including clear allocation of responsibilities and provision for independent regulatory functions.

319. Countries in which radionuclides are being produced or used should develop a national legal framework, taking into account overall strategies, and providing laws, guidelines and regulations for radioactive waste management. The responsibilities of each party or organization involved in radioactive waste management should be clearly allocated for all waste management activities that take place in a country.

320. Separation of the regulatory function, including enforcement, from the operating function, is required especially, to ensure safe operation of facilities. This separation will achieve independent review and oversight of radioactive waste management activities. The legal framework should specify the way in which separation of the functions is achieved.

321. Since radioactive waste management can span time-scales involving a number of human generations, appropriate consideration of present and likely future operations should be taken into account. Sufficiently long lasting administration, including continuity of responsibilities, and funding requirements should also exist.

Principle 7: Control of radioactive waste generation

> Generation of radioactive waste shall be kept to the minimum practicable.

322. The generation of radioactive waste, both in activity and volume, shall be kept to the minimum practicable by appropriate design measures and operating practices. This includes the selection and control of material, the recycle and reuse of materials, and the implementation of appropriate operating procedures. Emphasis should be on segregation of different types of waste and materials to reduce radioactive waste to be managed.

323. Safe radioactive waste management includes keeping the releases from the various waste management steps to the minimum practicable. The preferred focus of radioactive waste management should generally be on concentration and containment of radionuclides rather than dilution and dispersion in the environment. However, during the conduct of waste management steps, release of radioactive substances within the authorized limits may occur as a legitimate practice through air, water, soil, residues and reusable materials. Appropriate safety and control should be defined.

Principle 8: Radioactive waste generation and management interdependencies

> **Interdependencies among all steps in radioactive waste generation and management shall be appropriately taken into account.**

324. The basic steps of radioactive waste management are pretreatment, treatment, conditioning, storage and disposal (see Annex I). There are interdependencies among and between steps in waste management. Decisions on radioactive waste management made at one step may foreclose alternatives for or otherwise affect a subsequent step. Such decisions should be consistent with safety requirements for disposal. Further, there are relationships between waste management steps and operations that generate radioactive waste or recyclable materials. It is desirable that those responsible for a particular waste management step or operation generating waste adequately recognize interactions and relationships so that, overall, safety and effectiveness of radioactive waste management is in effect balanced. This includes taking into account the implications of transporting radioactive waste. Conflicting requirements that could compromise operational and long term safety should be avoided.

325. Since the steps of radioactive waste management occur at different times, there are, in practice, many situations where decisions must be made before all radioactive waste management activities are established. As far as reasonably possible, the effects

of future radioactive waste management activities should be taken into account at the time of considering any one radioactive waste management activity.

Principle 9: **Safety of facilities**

> **Safety of facilities for radioactive waste management shall be appropriately assured during their lifetime.**

326. Siting, design, construction, operation and decommissioning of a facility or closure of a repository should be carried out giving safety matters priority in such a way that it seeks to prevent accidents and to limit consequences if accidents should occur. Public issues should be addressed throughout these steps.

327. Site selection should take into account relevant features which might affect the safety of the installation or which might be affected by the installation.

328. Design, construction and operation should provide and maintain, where applicable, several levels of protection to limit possible radiological impacts.

329. Application of the appropriate level of quality assurance and of adequate personnel training and qualification should be addressed throughout the life of radioactive waste management facilities.

330. Appropriate assessments should be performed to evaluate the safety and the environmental impacts of the facilities.

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Regulations for the Safe Transport of Radioactive Material, Safety Series No. 6, 1985 edition (as amended 1990), IAEA, Vienna (1990).

[2] International Atomic Energy Agency, Code of Practice on the International Transboundary Movement of Radioactive Waste, INFCIRC/386, IAEA, Vienna (1990).

[3] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Recommendations of the International Commission on Radiological Protection, ICRP Publication No. 26, Annals of the ICRP, No. 3, Pergamon Press, Oxford (1977).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Basic Safety Standards for Radiation Protection: 1982 Edition, jointly sponsored by IAEA, ILO, NEA(OECD), WHO, Safety Series No. 9, IAEA, Vienna (1982).

[5] **INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Radiation Protection Principles for the Disposal of Solid Radioactive Waste, ICRP Publication No. 46, Annals of the ICRP 15.4, Pergamon Press, Oxford and New York (1986).**

[6] **INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, 1990 Recommendations of the International Commission on Radiological Protection, ICRP Publ. 60, Annals of the ICRP Vol. 21, No. 1-3, Pergamon Press, Oxford (1991).**

APPENDIX 2

DISPOSAL OF RADIOACTIVE WASTE:

CAN LONG-TERM SAFETY BE EVALUATED?

AN INTERNATIONAL COLLECTIVE OPINION

Published by OECD in 1991

EXECUTIVE SUMMARY

Radioactive waste disposal systems are designed to isolate the waste from humans and the environment for the necessary times to ensure that no potential future releases of radioactive substances to the environment would constitute an unacceptable risk. Such systems have been built at or near the surface for low-level and short-lived wastes, and are widely envisaged to be built deep underground in geological formations for high-level and long-lived wastes.

The long-term safety of any hazardous waste disposal system must be convincingly shown prior to its implementation. For radioactive wastes, safety assessments over timescales far beyond the normal horizon of social and technical planning have already been conducted in many countries. These assessments provide the principal means to investigate, quantify, and explain long-term safety of each selected disposal concept and site for the appropriate authorities and the public. Such assessments are based on four main elements: definition of the disposal system and its environment, identification of possible processes and events that may affect the integrity of the disposal system, quantification of the radiological impact by predictive modelling, and description of associated uncertainties.

The NEA Radioactive Waste Management Committee and the IAEA International Radioactive Waste Management Advisory Committee have carefully examined *the current scientific methods* for safety assessments of radioactive waste disposal systems, as briefly summarised in this report. The Committees have also reviewed *the experience now available* from using safety assessment methods in many countries, for different disposal concepts and formations, and in the framework of both nationally and internationally conducted studies, as referenced in this report.

Following this review, the NEA Radioactive Waste Management Committee and the IAEA International Radioactive Waste Management Advisory Committee

- *Recognise* that a correct and sufficient understanding of proposed disposal systems is a basic prerequisite for conducting meaningful safety assessments,

- *Note* that the collection and evaluation of data from proposed disposal sites are the major tasks on which further progress is needed,

- *Acknowledge* that significant progress in the ability to conduct safety assessment has been made,

- *Acknowledge* that quantitative safety assessments will always be complemented by qualitative evidence, and

- *Note* that safety assessment methods can and will be further developed as a result of ongoing research work.

Keeping these considerations in mind, the two Committees

- *Confirm* that safety assessment methods are available today to evaluate adequately the potential long-term radiological impacts of a carefully designed radioactive waste disposal system on humans and the environment, and

- *Consider* that appropriate use of safety assessment methods, coupled with sufficient information from proposed disposal sites, can provide the technical basis to decide whether specific disposal systems would offer to society a satisfactory level of safety for both current and future generations.

This Collective Opinion is *endorsed* by the CEC Experts for the Community Plan of Action in the Field of Radioactive Waste Management.

THE NEED TO EVALUATE LONG-TERM SAFETY

More than ten years have passed since the first comprehensive long-term safety assessments of well-defined radioactive waste disposal systems appeared. Large resources are being devoted to disposal system development, site investigation studies, and safety assessments. For low-level and short-lived wastes, there already exist operating disposal systems in some countries, with new repositories planned or under construction in others. For high-level and long-lived wastes, the process of licensing and implementation for repositories has started in some countries, although the first high-level waste repositories are not expected to begin operation until about twenty years from now.

The practical objective of any radioactive waste disposal system is isolation of the wastes from humans and the environment for the necessary times to ensure that no potential future releases of radioactive substances to the environment would constitute an unacceptable risk. In the planning and implementation of projects for final disposal, two basic premises have been stressed. First, the potential radiological long-term hazard is explicitly acknowledged and the responsibility of ensuring that future generations are protected at a level at least equal to that considered acceptable for ourselves is openly accepted. Second, as a direct consequence of this commitment, it is recognised that the long-term safety of the solution offered must be convincingly shown prior to disposal.

These issues were first addressed by the NEA Radioactive Waste Management Committee in a 1985 report. In particular, with regard to the disposal of long-lived radioactive wastes, the Committee expressed the views that deep geological disposal with a passive system of containment barriers is a feasible approach that could provide adequate safety, and that such disposal should eventually replace storage requiring continued maintenance and surveillance by society.

But what of the second issue, that of showing safety? In radioactive waste management, attempts have been made to analyse the safety of disposal over timescales far beyond the normal horizon of social and technical planning. Debate has arisen, however, on the feasibility of such analyses, and scepticism is often encountered about the validity of their results. In particular, three important questions arise:

- Can the behaviour of the disposal system and its potential radiological impacts on humans and the environment be sufficiently well understood over many thousands of years (for high-level and long-lived wastes), or even over hundreds of years (for low-level and short-lived wastes)?

- Can specialists and the competent authorities be convinced that the predicted behaviour is representative of what might actually happen?

- Can the potential radiological impacts and the means of estimating these impacts be illustrated transparently for a wider audience?

The need to develop capabilities to respond to these questions has stimulated the growth of the discipline of safety assessment over the past fifteen or so years. The objective of this document is to distill into a concise and easily accessible form the consensus that has emerged on the approach and practical methods for assessing the safety of radioactive waste disposal. This objective is achieved in what follows in three ways:

- By pointing out major overall issues on which wide international consensus has been attained;

- By explaining how the quantitative results of long-term safety assessments are generally interpreted;

- By discussing briefly several key issues influencing the acceptability of assessment results.

POINTS OF CONSENSUS

Safety assessment can be defined as an analysis of the future behaviour of the overall waste disposal system and of its potential impacts on humans and the environment, followed by comparison of the results with appropriate safety standards. Over the years, increasing international consensus has been reached on the role of and framework for safety assessment. Three aspects in particular of this consensus can be stressed:

- First, it is recognised that the future behaviour of the disposal system must be understood well enough to assure that no harmful releases of radioactive substances to the environment are likely to occur, even if it is not considered necessary (or possible) to predict this behaviour in every detail. Safety assessments in the broad sense provide the principal means to gain this understanding and to convey it to responsible authorities and the interested public.

- Second, wide international consensus exists regarding the general approach for safety assessments (see Annex 1 for details), as well as the procedures for obtaining data, developing and using models, and performing and reviewing safety assessments. It is clearly understood that safety assessments require effective use of predictive modelling methods and a wide range of scientific information that describes the disposal system and its possible evolution.

- Third, it is recognised that safety assessments must form an integral part of repository development programmes at an early stage of research, and throughout the course of siting, design, construction, operation, and decommissioning and final sealing of radioactive waste disposal systems. Prior to licensing a particular site and repository design, safety assessments must proceed iteratively with disposal system siting and development, to determine if further information is needed and, if so, what type of information is needed. Safety assessments form a crucial part of the licensing documentation for disposal systems.

WHAT CAN BE EXPECTED FROM SAFETY ASSESSMENTS

Absolute proof of continuing safe behaviour is impossible for all technical systems, including radioactive waste disposal systems. What must be achieved is a convincing and indirect demonstration that the proposed disposal system provides a sufficient level of safety to both current and future generations. Accordingly, what is expected and sought is a scientific and regulatory process that properly considers those factors that might significantly affect safety, and in that way provides the basis to decide if the proposed waste disposal system can be considered safe enough in the long term.

For this purpose, calculations are performed to estimate potential releases of radionuclides from the waste repository, and the possible radiation dose consequences of these releases for individuals assumed to be living near the site at some time in the future. Two important observations can be made concerning these calculations:

- Releases of radionuclides from a waste repository are postulated to occur under expected circumstances involving the gradual degradation of the safety barriers of the system, and under less likely circumstances involving a disruption to the series of safety barriers. Consequences must, therefore, be seen in the light of *how severe* they may be and *how likely* they are to occur, in order to assess the actual risks.

- Calculations of doses resulting from releases of radioactivity into the environment several thousands of years or more from now are generally based on current living habits. Any estimate of far future living conditions would be largely speculative. Such calculations are, therefore, generally viewed as an illustration of what the doses would be if the release occurred today, rather than as a prediction of the actual dose to some human living in the far future.

Thus, the assessed long-term radiological consequences of disposal systems are normally considered as *indicators of safety* that can be compared to safety standards.

JUDGING SAFETY

The current state-of-the-art in safety assessment methods is briefly summarised in Annex 1 of this report. There are, however, three topical issues that deserve to be highlighted here:

- The need for integrated assessments,
- The consideration of uncertainties in assessment results, and
- The methods for building confidence in assessment results.

The ultimate goal of assessments of repository behaviour is to determine possible radiological consequences to humans and the environment through an *integrated and systematic approach*. Such an assessment describes the characteristics of a specific disposal system, discusses the important aspects of the expected and predicted long-term evolution, and quantifies - to the extent possible - the impacts of the overall system in terms of radiological risks. All factors that might significantly affect safety are rigorously considered and clearly documented. Some phenomena taken into account in the course of the assessment may prove to be more or less important to the final results, as shown by *sensitivity analyses*. Emphasis is, therefore, placed on the coherent analysis and integration of all relevant safety elements.

Uncertainties are and will always be associated with assessment results. Some uncertainties may be quantifiable - for example, those that reflect the variability inherent in natural systems. Other uncertainties, however, may not be quantifiable in the same way - for example, those inherent in predicting certain future events that may disrupt the integrity of the disposal system. Formal use of expert judgement may be required to provide bounds on uncertainties, particularly for the latter type of uncertainty. An important aim of site characterisation and research concerns understanding of uncertainties and, whenever possible, quantification of these uncertainties, so as to be able to reduce the overall uncertainty in the results of integrated assessments. In this way, a sufficient basis for decisions may be provided.

The treatment of uncertainties in safety assessments is, however, part of a wider issue: the necessity of *building confidence* in disposal system safety. Confidence is achieved by many means. For example, confidence is enhanced through the establishment of appropriate quality assurance and quality control procedures for conducting safety assessments, as well as for the supporting research and site investigations. Confidence is also built through the process of assuring (or validating) that the predictive models used in safety assessments adequately represent the behaviour of the real system. It is impossible to compare directly predicted behaviour with actual behaviour of the disposal system over the long periods for which safety must be shown.To obtain such assurance indirectly requires a systematic evaluation of modelling results against data from experiments in laboratories and in the field, as well as against data from studies of representative natural analogues, such as uranium deposits. Finally, expert judgement and peer review are also part of the confidence-building process. All of these activities, often conducted at international level, will need to be further supported in order to contribute to the enhanced credibility of assessment results.

The safety of a waste disposal system is judged, therefore, only after a clear presentation of the information obtained in an integrated assessment, after due consideration of the uncertainties associated with assessment results, and after a critical review by the competent regulatory authorities and others legally involved in the process. National regulatory systems include such requirements.

CONCLUSIONS : THE INTERNATIONAL VIEW

International co-operation - through information exchange and joint projects - plays a substantial role in the development of methods for safety assessment. In particular, international co-operation promotes periodic and systematic reviews of the state-of-the-art in this field, and contributes to informed and objective debate among specialists.

Following such a review, the NEA Radioactive Waste Management Committee and the IAEA International Radioactive Waste Management Advisory Committee

- *Recognise* that a correct and sufficient understanding of proposed disposal systems is a basic prerequisite for conducting meaningful safety assessments,

- *Note* that the collection and evaluation of data from proposed disposal sites are the major tasks on which further progress is needed,

- *Acknowledge* that significant progress in the ability to conduct safety assessment has been made,

- *Acknowledge* that quantitative safety assessments will always be complemented by qualitative evidence, and

- *Note* that safety assessment methods can and will be further developed as a result of ongoing research work.

Keeping these considerations in mind, the two Committees

- ***Confirm*** **that safety assessment methods are available today to evaluate adequately the potential long-term radiological impacts of a carefully designed radioactive waste disposal system on humans and the environment, and**

- ***Consider*** **that appropriate use of safety assessment methods, coupled with sufficient information from proposed disposal sites, can provide the technical basis to decide whether specific disposal systems would offer to society a satisfactory level of safety for both current and future generations.**

This Collective Opinion is *endorsed* by the CEC Experts for the Community Plan of Action in the Field of Radioactive Waste Management.

Annex 1

SUMMARY OF THE STATE-OF-THE-ART IN SAFETY ASSESSMENT METHODS

General Approach

The general approach to safety assessment consists of a number of interrelated elements:

- Broad identification of the possible future evolution of the selected disposal system (scenario development);
- Development and application of appropriate models;
- Evaluation of potential radiological consequences in an integrated assessment;
- Uncertainty and sensitivity analyses;
- Validation and review of all components of the assessment;
- Comparison of results with criteria;
- Documentation of the assessment.

Feedback between these elements and iteration through the full set of elements are important aspects of safety assessment.

Although wide international consensus exists on this general approach, it is important to note that different specific techniques are being used depending upon the purpose of an assessment and the type of safety criteria to be met. In addition, the models and data being used for safety assessment differ depending upon waste-specific, concept-specific, and site-specific conditions. Finally, identification and characterisation of the wastes to be disposed of, and of the disposal system as a whole, are necessary bases for meaningful safety assessment.

Scenario Development

Scenario development, the starting point for safety assessments, is concerned with defining the broad range of possible futures to be considered in the subsequent modelling and consequence calculations. Human imagination and scientific judgement coupled with existing knowledge of natural systems and man-made barriers form the basis of scenario development. Over the last few years, scenario development methods have been substantially improved by the use of approaches that are systematic and transparent. Extensive lists of phenomena (for example, faulting and seismicity, or erosion) that have to be initially considered in safety assessments have now been developed in many studies, and only a few new phenomena have been identified as potentially important in recent years, and these on a site-specific or concept-specific basis.

One particular area that has received greater attention recently is assessment of human intrusion scenarios. Work on the basic approach for consideration of human intrusion, and on the preservation of information about the site and the content of the repository is being undertaken.

If required by regulation or otherwise undertaken, the estimation of likelihood of occurrence of the final set of scenarios chosen for detailed consequence analyses can be a particularly difficult element of safety assessments. Although several different techniques are used, depending on the type of future events and processes being considered and the data available, all of them rely at least to some extent (and some quite heavily) on the use of expert judgement.

Model Development and Application

The necessity of using predictive models to assess potential radiological consequences in safety assessments is well recognised, and the general procedures for development of models are well accepted. The most important modelling areas were identified a long time ago, and predictive models have been developed in these areas. Substantial improvements toward more realism and detail have been made over the years. There are models available, at different levels of detail and realism, to evaluate and quantify the effects of the key processes determining the performance of radioactive waste disposal systems. Further development is still justified in some areas because better modelling could clarify or reduce uncertainties associated with assessment results. It could also contribute to further improvements in disposal system design.

In recent years, special attention has been given to the interdependence between model development and corresponding data gathering efforts. In addition, a main area of ongoing work is the coupling of models for specific processes into larger integrated models and the simplifications needed to make them practical tools for safety assessments.

A sound basic understanding of the relevant physical and chemical properties of the system's constituents and their evolution remains a main prerequisite for successful modelling.

Integrated Assessments

The ultimate goal of data gathering, scenario development, and predictive modelling is an integrated assessment describing the characteristics of the disposal system and quantifying the performance of the overall system in terms of radiological safety as a function of time. Many integrated assessments of both real and conceptual repositories in various host formations have been made over the years, indicating that it is possible to site and build repositories that can be considered safe for humans and the environment today and in the future (see the CEC/IAEA/NEA Symposium Proceedings for further details and references).

Safety assessment models tend to be of two complementary types: detailed research models and simplified system models. The detailed research models and their results are needed to evaluate design and engineering options, and are used to provide a defensible basis for excluding processes not important to safety in the more robust and simplified modelling. In the robust bounding approach, scenarios, models, and parameter values are chosen conservatively (that is, pessimistically). Thereby, the assessments are simplified and discussion of some uncertainties not significant to system safety are avoided in the licensing procedure.

Uncertainty and Sensitivity Analysis

Uncertainties are and will always be associated with assessment results. Uncertainties can partly be reduced by further model development and by collecting additional and more accurate data, but they can never be completely eliminated because they reflect a genuine variability in natural systems. Statistical methods are being increasingly relied on when extensive measurements of the needed data are unfeasible. Uncertainties sometimes also arise from a limited understanding of controlling processes.

As part of integrated safety assessments, sensitivity studies provide guidance on which areas uncertainties most need to be reduced. This guidance is specific with regard to disposal site and concept, and is being used to direct national resources for research and development to areas where they are most needed. In addition, the information on uncertainties is being provided to those responsible for repository design, enabling possible improvements to the design and siting of the repository.

Confidence Building

The ultimate objective of safety assessments is to provide a basis for well-founded decisions about radioactive waste disposal systems. To this end, it is necessary that scientists, safety assessors, regulators, and those involved in or concerned with the decision-making process have confidence in the information, insights, and results provided by safety assessments. The importance of this topic is reflected in the main text, and only a few additional remarks concerning model validation are given here.

Model validation is the process of assuring that the models used adequately represent the real system behaviour, and efforts have been intensified during recent years in this area. Validation of long-term predictions must focus on the adequacy of modelling the processes that may define system performance under a reasonable variety of possible futures. There is no way to validate system performance predictions over long times, but the adequacy of specific aspects of the modelling may be supported through a variety of laboratory, field, and natural analogue studies. Several international co-operative projects have been established to investigate the possibilities for validation of the models used within safety assessments.

Validation needs depend upon the disposal concept. For some concepts, satisfactory validation can be done only with the help of *in-situ* studies at the potential disposal site. Increasing co-operation is apparent between those designing the repository and the relevant engineered barriers, and those studying the possibility of validating the models to be used in assessing the safety of the disposal system.

Regulatory Criteria for Disposal

In a final licensing assessment, the results of safety assessments are evaluated in the context of the established regulatory standards and criteria. International criteria for the radiological protection of individuals and populations have been used as the basis for development of national long-term safety criteria for radioactive waste disposal systems in practically all countries. Some countries currently have detailed regulations in place for radioactive waste disposal, whereas others have specified general radiological protection objectives, without necessarily as yet having established specific requirements for final disposal of wastes. Both on a national and an international basis, further work is underway to develop specific criteria for the long-term safety of radioactive waste disposal systems, in particular in order to have such criteria available in due course for the licensing of high-level waste repositories.

The details of safety assessment approaches, methods, and data requirements are dependent upon and influenced by the detailed criteria applied. Yet even where the detailed formulation of specific safety standards may differ between countries for legal or historical reasons, it is evident that the same general type of safety assessment work is needed and is undertaken at some stage of the regulatory process.

Documentation of Assessments

The capability to make relatively detailed assessments has increased rapidly with the advance in models, and with the growing capacities of computers and data base systems. It is recognised, however, that clear presentation of the information obtained in an integrated assessment is an increasingly important and challenging task as ever more advanced and complex technical methods are developed. Work is ongoing in this area.

Annex 2

BIBLIOGRAPHY

1. Disposal of Radioactive Wastes: Review of Safety Assessment Methods. OECD/NEA, Paris, 1990.

2. Safety Assessment of Radioactive Waste Repositories. Proceedings of a joint CEC/IAEA/NEA International Symposium. OECD/NEA, Paris, 1990.

3. Safety Principles and Technical Criteria for the Underground Disposal of High-Level Radioactive Wastes. Safety Standard No. 99, IAEA, Vienna, 1989.

4. Feasibility of Disposal of High-Level Radioactive Waste into the Seabed. Volumes 1-8, OECD/NEA, 1988.

5. PAGIS. Performance Assessment of Geological Isolation Systems for Radioactive Waste. EUR 11775 EN, CEC, 1988.

6. Geological Disposal of Radioactive Waste - In Situ Research and Investigations in OECD Countries. OECD/NEA, Paris 1988.

7. Technical Appraisal of the Current Situation in the Field of Radioactive Waste Management. A Collective Opinion by the Radioactive Waste Management Committee. OECD/NEA, Paris, 1985.

8. Long-Term Radiation Protection Objectives for Radioactive Waste Disposal. OECD/NEA, Paris, 1984.

9. Concepts and Examples of Safety Analyses in Continental Geological Formations. Safety Series No. 58, IAEA, Vienna, 1983.

10. Safety Assessment for the Underground Disposal of Radioactive Waste. Safety Series No. 56, IAEA, Vienna, 1981.

APPENDIX 3

ETHICAL ASPECTS

ON NUCLEAR WASTE

SOME SALIENT POINTS DISCUSSED AT A SEMINAR ON ETHICAL ACTION IN THE FACE OF UNCERTAINTY IN STOCKHOLM, SWEDEN, SEPTEMBER 8-9, 1987

SKN REPORT 29

April 1988

6.6. Our Responsibility – The Responsibility of Coming Generations – The Need for Controls

One of the central questions posed at the seminar concerned our generation's responsibility to coming generations. According to the dominating view held thus far, it is our generation's responsibility to find a solution to the problem of nuclear waste that allows it, once it is disposed of, to remain secure without surveillance. KASAM has already questioned this idea in a previous report, mentioning that "we lack the fundamental knowledge to take responsibility for every imagineable consequence to future generations and the basis of their existence", and that, according to a humanistic world-view, "it is of great worth that we guarantee coming generations the same right to integrity, ethical freedom and responsibility that we ourselves enjoy."

The seminar examined this extremely important question in depth and agreed unanimously that we are, in any case, on the way toward a necessary shift in the paradigms of our way of understanding. It remains, now, to plumb the consequences this will have for, among other things, the technical work involved in disposing of nuclear waste.

Basically two lines of reasoning were presented, both of which led, in principle, to the same conclusion. For the sake of clarity, we shall outline both.

According to the first and more detailed of the two, it is natural to demand two things from any technical product that is meant to be in use for a longer period: It must be safe in operation and, furthermore, reparable. The same qualities can be demanded of a nuclear waste repository. Safety in operation means, in this case, that the waste can be disposed of so that as far as we can predict, coming generations will not be obliged to take measures to protect themselves or their environment from it. Reparability means that coming generations can repair any mistakes we may have made in disposing of the waste.

Thus far safety in operation has been, almost without exception, the central theme of all discussion, research and political decisions regarding nuclear waste. This is the case, of course, because all debate on nuclear waste has arisen from the perspective of nuclear power. We have discussed the disposal of nuclear waste as a problem which can or cannot be solved as an argument for or against nuclear power. From that perspective, it makes sense to concentrate on the demand for safety in operation; thus, the reparability issue has remained in the background.

If, however, we proceed from the perspective of waste, i.e. putting emphasis on what we shall do with the considerable quantities of waste that must be dealt with regardless of how we proceed with nuclear power, the need for reparability becomes far more urgent. From this perspective we are forced to take into consideration factors like the difficulty of getting different experts to agree completely on whether or not various systems can be considered absolutely safe without the possibility of getting inside to repair them, not to speak of the human errors and incorrect calculations that can also occur in the construction of a final repository.

It was pointed out that from this aspect, it is difficult to see how we can decide on a method of final disposal which is "irreversible", irrevocable, in the sense that the need for reparability is not met to any reasonable extent. Then too, it also becomes clear that the demands for safety in operation and reparability are, in part, in conflict with each other. Safety in operation requires, at least in a certain sense, a sealed repository. Reparability requires, in a somewhat different sense, an accessible repository. The technical question of how both these requirements can be met simultaneously is still insufficiently explored.

In the second line of reasoning, predicted advances in knowledge played an important role. On the one hand, today we can hardly guarantee that knowledge of how to dispose of nuclear waste will exist for all time. From that perspective, repositories should be constructed so that they will need no surveillance once they are sealed. Thus, it is our responsibility to come up with a system that will not need active surveillance in order to ensure that safety can be maintained.

On the other hand it is also conceivable that advances in knowledge will be such that coming generations will have the capacity to deal with nuclear waste in a way that increases safety and/or allows the energy-resources latent in the waste to be put to use. The choice of what to do must devolve upon the generation in question and be based upon its own assessment of the advantages and disadvantages to be encountered. Furthermore, this implies that the repository be designed in such a way as to enable future generations to control it.

These lines of reasoning lead to a double conclusion: A repository should be constructed so that it makes controls and corrective measures unnecessary, while at the same time not making controls and corrective measures impossible. In other words, our generation should not put the entire responsibility for maintenance of repositories on coming generations; however, neither should we deny coming generations the possibility of taking control.

By means of different formulations and by proceeding from various starting-points, a two- edged objective was established vis-a-vis repository facilities: Safety in operation combined with reparability, with controls not necessary, but not impossible. Pre-requisites for the realization of this objective are the continued advancement of knowledge and refinement of the qualifications required to deal with nuclear waste.

The objective defined here with the multifaceted motivations expressed at the seminar is wholly in line with the assessments made by the seminar in its entirety, and with its main themes which are presented in this paper.

The Consultative Committee for Nuclear Waste Management intends to continue the study of these questions.

APPENDIX 4

MORAL AND ETHICAL ISSUES RELATED TO THE NUCLEAR FUEL WASTE DISPOSAL CONCEPT

AECL ENVIRONMENTAL REVIEW OFFICE
WHITESHELL LABORATORIES

Hardy Stevenson and Associates

Pinawa, Manitoba ROE 1LO
October 1991

"It was conceded that, given the long time frame before a disposal facility is sealed, there is time to identify potential problems and rectify them. It was suggested that we can only make the decisions we are capable of making now, and that people in 75 or 100 years will have to decide whether or not to seal these facilities. All we can do now is decide how things look based upon the best possible information. Given these considerations, it was agreed that we have met our ethical obligations if we make the best decision possible today. We simply have to recognize that in 50 to 100 years, things may be different." (p. 13,14)

"There is a need to consider the extent to which future generations could benefit from future retrieval, but there is also a need to ensure safety. As a moral issue, the issue of retrieving the used fuel for future use can be seen as a compromise between increased safety and the cost of retrievability. There seems to be agreement that we would be willing to accept higher costs for retrieval in order to emphasize the safety of the disposal concept. This appears to be a reasonable way of discharging our responsibilities." (p. 17)

"We are morally obliged to engage in the most thorough and responsible research program we can establish, in order to make a decision. Even if that decision should turn out to be the wrong one, we will have met our moral and ethical obligations. Society makes decisions that affect future generations; such decisions alter their options. So we should try to minimize adverse effects on them and try not to leave them with unpalatable options. Future generations are of course free to make their own choices within what they see as their responsibilities. This includes doing things differently than we would." (p. 17)

The allocation of resources appears to be an important ethical issue, specifically, "How do we allocate resources (and how much do we allocate) in order to maximally reduce risk?" Many members of the public say, for instance, that we should use the most indestructible container. But, in doing so, we take a resource from somewhere else in society (e.g., "With those kinds of funds we can buy a lot of kidney dialysis machines."). It is agreed that this is a fundamental ethical issue that requires further discussion.

On the subject of distribution of resources, there is some feeling that expenditures on waste management should be proportional to the size of harm multiplied by the probability of harm. A particular problem should not receive a vastly disproportionate amount of resources because of its political profile or for some other reason. For example, there are a number of other hazardous-waste management problems that deserve as much attention as this one is getting, but they are not. There is some feeling that a benchmark for the expenditure of resources is required; i.e., we should not be spending vastly more sums of money on one problem than we are spending on others.

We might also ask, "How do we compare the risks of different types of waste?" and "Isn't it important to devote resources in proportion to the degree of hazard?" The latter question raises the issue of perceived versus actual risk.

Application of a distribution of risk concept is problematic because disposal sites for highly toxic waste are sought in less densely populated areas. It is argued that because a site is remote should not by itself lead to lesser standards of protection for people in the remote region. (p. 19)

Taking account of the "non-scientific" cultural view is of great importance, and gives rise to a number of vital questions:

> **Where do we begin the ethical reflection on contentious societal issues - at the level of society or of technology? How do we deal with cultural differences? Cultural conflict (in a traditional way, e.g., native versus non-native, and in another sense, scientific culture versus non-scientific culture) is alive and well in our society. We deal with problems in science and technology by isolating them and casting them in a manner that is manageable. Therefore, how are we to deal with the other voices who are critical of the culture of science and technology?** (p. 21)

APPENDIX 5

THE POSITION OF THE DUTCH GOVERNMENT ON DEEP BURIAL

The Dutch government's position on whether deep burial is a feasible and suitable method of disposal for waste (The National Environmental Policy Plan [NEPP], action point 62)

May 14, 1993

The government's position on whether deep burial is a feasible and suitable method of disposal for waste (NEPP action point 62)

1. Introduction

The National Environmental Policy Plan (NEPP) examines the disposal of non-processable waste in storage facilities or on landfill sites. One of the action points included in the policy plan involves looking at the question of whether such waste can be effectively disposed of by deep burial. Accordingly, the government intends to set out its position on the question of whether deep burial is justified and, if so, under what conditions it might be possible. There are two sides to this question: whether the use of repositories deep underground is consistent with the environmental policy set out by the government in the NEPP and, if this is deemed to be the case, whether it is technically feasible.

Use of deep underground repositories is a particularly strong option for both radioactive and chemical waste which, due to their toxicity, pose a threat to man and the environment. A number of disposal techniques currently used for other types of waste are unsuitable for radioactive and chemical waste. Until suitable disposal techniques become operational, this waste will have to be carefully and completely isolated from the biosphere.

This policy document refers to chemical and radioactive waste which is classified as 'highly toxic waste'. These two types of waste have different characteristics, so joint disposal is not an option. However, the issues involving the use of deep underground storage facilities are the same in both cases. Both categories involve relatively small amounts of waste which, because of its toxicity, must remain isolated from the biosphere for an indefinite period of time.

This joint approach to the problem of disposal obviates the need for a separate set of criteria for the storage of radioactive waste. The Lower House of Parliament was informed accordingly on 22 February 1990[1]. At the same time it was pointed out that the promised public consultation procedure should be adapted to reflect the wording of NEPP action point 62, which calls for an assessment of which method of waste disposal is to be preferred, given the government's stated aim of achieving sustainable development. The ultimate choice may have many repercussions. It is therefore important that the decision be taken with care, based as far as possible on relevant arguments. The consultation procedure which formed part of the preparations for this policy document was designed as far as possible to hear such arguments. In the first instance, the views of four organisations with interests in this issue were sought. These were the electricity producers' organisation (SEP), the chemical industry association (VNCI), an environmental group (SNM) and an association of environmental scientists (VVM). They were asked to set out their position on the matter, with a view to distilling a number of relevant arguments which represent the views of the producers of highly toxic waste (SEP and VNCI),

1 Lower House, 1989-1990, 21 137, no. 17.

environmental scientists (VVM) and the environmental movement (SNM). The four organisations were asked to give their views on the following questions:

1. Should waste be disposed of in deep underground repositories?
2. Why/why not?
3. Do these arguments also apply to other forms of waste disposal (above ground)?
4. If waste were to be disposed of deep underground, what conditions should apply?

The various arguments were compared during a one-day seminar.

During the proceedings it became clear that a broader constituency would have to be given the opportunity to make their views known. It was therefore decided that the procedure should be thrown open to anyone who had a point to make; the House was informed accordingly[2]. The open round of consultations was set in motion on 26 October 1991 with an advertisement in the Government Gazette (*Staatscourant*) and a large number of national and regional newspapers which called for responses to the four questions above. The advertisement attracted a good deal of attention at national and regional level, eliciting in the region of 2,000 responses which were processed by Twente Technical University. A report was drawn up setting out the arguments of the aforementioned organisations and the responses to the advertisement. The report also assessed the accuracy and relevance of the arguments advanced, and identified any connections between them.

2. History

In 1981 the environment and economic affairs ministers of the time set up a committee (known by the acronym ILONA) to supervise research into the possibility of storing radioactive waste underground. This committee commissioned another committee responsible for studying land-based disposal (OPLA) to set up a research programme to look into the possibility of disposal in rock salt formations (particularly salt domes). The programme consists of three phases: (1) research into disposal techniques; (2) identification of potential sites, including field research; (3) detailed study of a particular site. The government of the time was of the opinion that the first phase could go ahead and that, after the results had been evaluated, a decision could be made on starting phases 2 and 3[3].

The OPLA committee completed phase 1 in 1989, and the Lower House was informed of the results on 15 June of that year[4]. The conclusion was that a storage facility for radioactive waste in rock salt formations in the Netherlands would, in principle, be technically feasible. OPLA had done calculations based on

2 Lower House, 1991-1992, 21 137, no. 101.

3 Lower House, 1984-1985, 18 343, no. 6.

4 Lower House, 1988-1989, 20 918, no. 4.

models, which led them to expect that it would be possible to store radioactive waste safely in the rock salt formations which occur in the Netherlands. The policy committee, ILONA, advised the government to commission a follow-up study before taking any decisions on phase 2. Phase 1A was therefore initiated, and involves follow-up studies and laboratory measurements. This phase is due for completion in mid-1993.

The 1980s also saw a growing need for a disposal facility for highy toxic chemical waste. In 1987 a report of an official survey of salt mines for non-radioactive waste disposal was published[5]. The survey had been conducted in order to ascertain how the most toxic chemical waste (particularly that in the C1 and, to a lesser extent, C2 categories) should be disposed of in future. The report agrees in large part with other studies of the use of salt domes for radioactive waste disposal.

The government and Parliament gradually began to realise that, as well as conducting scientific research to establish whether radioactive waste could be disposed of by deep burial, it was also necessary to develop a set of criteria which could be used to determine whether disposing of radioactive waste in this way was desirable from a social and political point of view[6]. The issue of chemical waste disposal also gave rise to the question of whether deep burial is a desirable means of disposal. It has already been indicated in the introduction that, in the implementation of NEPP action point 62, this issue is being considered in connection with both radioactive and chemical waste[7].

3. Environmental policy

The basic principles of Dutch environmental policy are set out in the NEPP and its successor, the NEPP+[8]. The main plank of the policy is sustainable development, which means satisfying the needs of the present without compromising the ability of future generations to meet their own needs. This fairly broad principle is embodied in, among other things, the more narrowly-defined principle of integrated life cycle management. This involves controlling substance flows produced by economic activity, taking into account their effect on the environment. If the use of primary raw materials (such as ores) gives rise to waste, that waste should be used as a secondary raw material. This will lead to a reduction both in the amount of waste produced and in the wastage and dispersal of primary raw materials.

---

5 Disposal of non-processable waste: the alternatives. Lower House, 1986-1987, 19 707, no. 16.

6 In response to the Willems motion of 1 October 1984 (Lower House, 1984-1985, 18 343, no. 9), the environment minister stated in a letter to the Speaker of the Lower House that the government was of the opinion that the development of criteria was an essential part of the research. Lower House, 1984-1985, 18 343, no. 16).

7 For a detailed summary of the development of the debate on the storage of highly toxic waste, see "Underground storage of unprocessable waste" by R de Man (1991) which appeared as part of the environment ministry's series of publications on radiological protection (*Publicatiereeks Stralenbescherming no. 1991/53*).

8 Lower House 1988-1989, 21 137, nos. 1-2 and 1989-1990, 21 137, no. 22.

The memorandum on the prevention and recycling of waste[9] translates the concept of integrated life cycle management into the more concrete aims of waste prevention and "leak-free" disposal. The laws enacted in order to put environmental policy into effect stipulate that production processes must be geared to preventing waste. Any that cannot be prevented must be recycled and, where this is not possible, must be disposed of in an environmentally responsible manner. Recycling involves using a product or material more than once. Some waste cannot yet be recycled. Such waste must be processed or treated so that it can be used in another way, thus extending its useful life. In cases where recycling or processing proves impossible, waste can be used to produce energy; if this, too, is not possible, another form of disposal must be sought; the landfill option is used only as a last resort[10].

Waste storage facilities and landfill sites must operate in accordance with the ICM criteria (Isolate, Control, Monitor), which involves taking measures to isolate the waste from the biosphere. In addition, control and monitoring ensure that it remains isolated for a sufficiently long period, and these are necessary throughout the entire period of storage or residence at a landfill site[11].

4. Factors to be considered concerning the disposal of highly toxic waste

The first step in considering the question of using underground repositories for the disposal of highly toxic waste in the light of the waste policy described above is to determine whether this waste flow can be sufficiently reduced by means of prevention and recycling.

It would not at this time be possible to prevent all highly toxic waste without making drastic changes to society. If, for instance, chemical waste were to be banned, the result would be pressure to stop the use of natural gas, from which compounds containing mercury are removed before distribution, leading to the production of C1 waste. If radioactive waste were to be banned, some medical treatments could no longer be carried out. Highly toxic waste is often created during the production of substances which are an essential part of products designed to enhance our health, safety and prosperity. The benefit of processes which create highly toxic waste must therefore be weighed up against the drawbacks associated with that waste. As a consequence of striking that balance, some of these processes will have to continue for the time being. At the seminar referred to above, all the participants acknowledged that it would be difficult to prevent this type of waste

9 Lower House, 1988-1989, 20 877, no. 2.

10 Waste policy has been incorporated in the new, expanded and amended Environment Management Act, chapter 10 (waste substances), section 10.1, Upper House, 1992-1993, 21 246, no. 60.

11 The ICM criteria are implemented under, among other things, the Soil Protection (Landfill) Decree (Bulletin of Acts and Decrees no. 55; 20 January 1993) which was issued pursuant to the Environmental Management Act and the Soi[illegible]ection Act. The criteria are set out in detail in a report by the Soil Protection Technical Committee: "An assessment framework and ICM criteria for local soil pollution"; TCB A90/01, Leidschendam, December 1990.

entirely, although opinions differed on the extent to which it could be prevented.

One must therefore assume that a number of processes will continue to produce highly toxic waste over the coming years. A considerable quantity of this type of waste has already been produced, and it will have to be recycled or put to some other useful application. In the case of highly toxic waste, recycling is only possible if it is done in an environmentally responsible way, in view of the attendant risks to humans and the environment. As with toxic primary raw materials, toxic waste may only be recycled if a sustainable application can be found for it and if dispersal can be prevented throughout its life cycle. These conditions cannot at the moment be met for a large proportion of the toxic waste which exists. However, it is reasonable to expect that recycling methods will be developed for certain categories of waste.

In view of the limited scope for prevention and recycling, some method of disposing of present and future stocks of highly toxic waste must be found. The only suitable method which rhymes with current waste policy would appear to be some form of storage under the ICM criteria[12].

The government's position on deep underground storage of waste was determined after a number of considerations linked to sustainable development, which were also discussed during the consultation procedure, had been weighed up. The most important of these were:

* Since highly toxic waste cannot be fully recycled and the creation of highly toxic, non-processable waste conflicts with the principle of integrated life cycle management, all steps should be taken to prevent the production of such waste. This consideration has to be weighed up against the effect such a measure would have on a number of useful social processes.
* If waste is stored in such a way that it is naturally isolated, future generations will presumably have few problems with after-care. However, in the long term this would also remove the possibility of control and monitoring, and the option of recycling.
* In normal circumstances, natural isolation makes underground storage a relatively safe means of disposal. However, exceptional or unexpected events may disturb the natural isolating properties of the storage environment, and matters are only made worse by the fact that it is impossible to intervene in such situations.
* Storage in rock salt formations saves space above ground, but means that these formations cannot easily be used for other purposes. This drawback does not arise with storage at the surface, although it does take up more space. However, all types of storage take up a certain amount of space in the surrounding area.

---

12 Other current disposal methods such as distillation, treatment by physical and chemical processes, metal retrieval and incineration are unsuitable since they cannot at the present time be applied to this type of waste. Suitable processing methods are currently being developed or put into operation for some types of waste; see the draft multi-year plan on the processing of hazardous waste, Lower House, 1992-1993, 22 193, no. 6.

5. The government's position on the storage of highly toxic waste

Given the nature of highly toxic waste, the interests of future generations must be carefully considered when determining whether it would be responsible to store it in deep underground repositories. Having considered the overall environmental policy as set out in the NEPP and NEPP+, waste policy and the arguments put forward in the consultation procedure, the government has adopted the following position on the deep underground storage of highly toxic waste.

* In the light of sustainable development, and particularly from the point of view of integrated life cycle management, the production of highly toxic waste is undesirable. The quantity of highly toxic waste requiring permanent storage can be kept to a minimum if opportunities for prevention and recycling are exploited to the full. To this end, incentives must be created and intensive research must be initiated, or continued where it already exists. For instance, in the case of radioactive waste, the option of actinide incineration[13] could be examined more closely.

  Policy remains focused on encouraging the producers of highly toxic waste to adopt the best available technologies in the short term, and obliging them to justify production of this kind of waste[14]. They must also demonstrate that no acceptable environmentally-friendly alternative exists and that the process is beneficial to society, as well as to the company and to employment figures. Producers of highly toxic waste will also be expected to undertake recycling initiatives, but only if they are environmentally responsible (see section 3). The more environmentally- friendly recycling a company undertakes, the better it will be able to justify its position as a producer of highly toxic waste.

* A facility for long-term storage of highly toxic waste must be created. The government is of the opinion that such a facility must allow retrieval of the waste in the long term for two reasons:
  1. Irrespective of its location, a storage facility must be constructed in such a way that it offers maximum safety in normal, exceptional and unexpected circumstances. It must therefore be isolated as well as possible and there must be every opportunity for human intervention in order to carry out control activities; any storage facility which does not meet the ICM criteria will be rejected. To this end the waste must not only be retrievable but the entire process of storage must in principle be reversible in order to render it controllable.

13 Actinide incineration involves transmutation from long-lived to short-lived radioactive isotopes, whereby energy production is possible.

14 This principle has already been incorporated in policy and enacted in law; see for example the Nuclear Energy Act, the Environmental Management Act and the draft multi-year plan on the disposal of hazardous waste.

2. In view of the aim of introducing integrated life cycle management for all substances, even in cases where recycling is not currently an option, waste must remain accessible so that, when the opportunity arises, it can be returned to the cycle in an environmentally responsible manner. The government has not, therefore, opted for a permanent method of disposal.

* The retrievability requirement means that future generations will also have a duty of care for highly toxic waste. However, it is reasonable to expect that any drawbacks this might entail in terms of time and money will be outweighed by the importance of the ability to intervene, redesignate and relocate.
* To date, research on the storage of waste in rock salt has focused on permanent storage without the option of retrieval, as a result of the physical properties of rock salt formations, which causes them to seal once the storage facility is closed. The flow behaviour of the rock salt provides relatively good natural isolation. However, storing waste by this method limits the possibilities of gaining access to the waste in order to recycle it and carry out control activities. A storage method which excludes the possibility of retrieval is not in line with the policy outlined in this document. The government therefore rejects non-retrievable storage of waste in rock salt formations deep underground, which is one of the options being studied by the OPLA committee[15].

6. <u>Consequences of the government's position on the storage of highly toxic waste</u>

The position set out above offers no solution to the problem of disposing of highly toxic waste. However, the government's policy clearly indicates the direction in which a solution must be sought. To reduce the growth in the volume of highly toxic waste, the options of prevention and environmentally sound recycling must be exploited more fully. When applying for environmental licences, producers of highly toxic waste will have to justify its production, as discussed in section 5. A process which produces this type of waste must be shown to be of great social benefit, and licences should be granted for such processes only as an exception. Producers must at least be obliged to seek out environmentally friendly alternatives, such as recycling.

Processes which give rise to radioactive waste are strictly regulated through a licensing system which is governed by the Nuclear Energy Act. Licences for the use of radioactive substances prescribe all kinds of measures designed to reduce the risks and require that the process itself be justified. Radioactive waste is currently recycled after a number of applications, including radiography. Work will be done to establish how and to what extent it can be recycled after other processes.

15 Research into storage of radioactive waste in geological formations in the Netherlands; final report of phase 1, OPLA, May 1989.

Present and future policy on chemical waste centres on maximum prevention and recycling. The policy is set out in the draft multi-year plan on the disposal of hazardous waste[16]. The plan states that the export of chemical waste for dumping will cease by 1996. It also indicates how chemical waste should be disposed of. The plan is expected to be finalised by mid-1993.

It might be worth considering setting concrete objectives and deadlines for prevention and recycling, as recommended by the Association of Environmental Scientists. Objectives and deadlines for thirty priority substances have already been determined in the memorandum on the prevention and recycling of waste.

Generic research will also have to be carried out to discover a method of storage which fulfils the conditions of retrievability (during the entire storage period) and reversibility. This research will be carried out in an international framework, including at EC level, where the retrievability of waste is beginning to attract attention.

Risk studies will be carried out to compare the safety of above-ground and underground storage alternatives insofar as they are in line with the policy on highly toxic waste set out in this policy document. Costs and safety will be compared. The research will be supervised and financed jointly by the economic affairs and environment ministries, and will aim to give a clearer picture of the options for permanent storage within a few years. Finally, the feasibility of separating waste prior to storage so that it can be recycled in future will be examined.

Current research activities, particularly the work being done on the storage of waste on land (by the OPLA committee), will be assessed in terms of the government's position. The results of the OPLA and actinides research will be reported in further detail in the course of 1993, with an indication of the direction which the studies are to take in the future. The results will be assessed in the light of the government's position and this will determine future direction.

Phases 1 and 1A have produced a huge amount of information on deep underground rock formations in the Netherlands in general, and rock salt formations in particular. Phase 1, in particular, showed that storage in rock salt is in principle technically feasible and that it would be safe to store toxic waste in these formations in the Netherlands. This therefore answers one of the questions posed by the NEPP (*can* waste be disposed of underground?). This result will also be important in the future, when the feasibility of using the underground for other purposes is assessed.

---

16 Draft policy position of the Minister of Housing, Planning and Environment and the Association of Provincial Authorities, Lower House, 1992-1993, 22 193, no. 6.

Appendix

Current policy on highly toxic waste

Current policy on the various types of highly toxic waste is summarised briefly below.

Radioactive waste
Each year some 700m^3 of radioactive waste is collected[17]; at the moment this is only low and intermediate level waste (LLW and ILW), which consists largely of contaminated clothing, gloves, laboratory glassware, liquids etc. At a later stage (the late 1990s) highly radioactive waste (HLW) – the waste products of nuclear fission, nuclear fuel, reprocessing waste – will have to be dealt with. This waste is currently in storage at reprocessing plants in Britain and France and at the nuclear power stations in Dodewaard and Borssele. The total volume of HLW created at these two power stations will not exceed the amount of LLW and ILW produced annually.

All radioactive waste is collected by the firm COVRA N.V. and stored at Borssele in such a way that it can be retrieved. The site has enough capacity to last for 50 to 100 years. COVRA's storage methods are entirely in line with policy on highly toxic waste as set out in this policy document. The costs of storage are borne entirely by the producers of radioactive waste, and amount to approximately 7,000 guilders per 200 litres (approx. 500 kilos). No problems are expected to arise while a more long-term solution is being sought.

Chemical waste
Between 300 and 600 tonnes of category C1 chemical waste are produced each year, and consist mainly of mercury compounds released during the extraction of natural gas (several hundred tonnes) and the processing of corona discharge lamps (several hundred tonnes), and from hardening salts used in the steel processing industry (several dozen tonnes). It costs some 600 to 1,200 guilders to dispose of a tonne of C1 waste. A great deal more category C2 waste is produced each year (approx. 30,000 tonnes). C2 waste consists of various types of sludge, pigments, salts and metallic compounds (some containing heavy metals). Storage costs some 500 to 700 guilders a tonne.

C1 category waste is currently being stored in German salt mines, in such a way that it can be retrieved while the mine is in operation, which is expected to be the case for a number of decades. C2 waste is at present in storage above ground in accordance with the ICM criteria and is also retrievable.

17 Site-based environmental impact report; reprocessing and storage of radioactive waste, Sloe site; COVRA N.V., January 1989.