Nuclear Waste and Nuclear Ethics

Social and ethical aspects of the retrievable storage of nuclear waste

Report in outlines
(the main report is available only in Dutch)

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PREFACE

Since 1974 there have been plans in The Netherlands for the underground storage of nuclear waste. When the government announced in 1976 plans to start test drilling in salt domes, the policy was directed towards looking for suitable locations and towards conducting such drillings. These plans faced a lot of resistance and gave rise to the conflicts between the technicians and the public. There were no attempts to even out the conflicts.

Government policy changed in 1993: central themes became retrievability and public acceptance of a storage. However, these themes were not worked out any further. The government did not take steps to give meaning to the public acceptance of the storage. In recent years, public interest on the subject gradually disappeared. Of course this development did not bring a solution any nearer.

Another development is that in recent years, nuclear energy and the storage of nuclear waste were regularly linked to ethics and sustainable development. But the exact meaning of ethics and sustainable development remained unclear. This again made clear that nuclear waste is a problem with a technical as well as social aspects, but that these aspects were often separately dealt with till now. More generally, it was noticed that there was no discussion between technicians on the one hand and social scientists and the public on the other.

These two developments provided the reason to bring in a research proposal to the Commission for the Disposal of Radioactive Waste (CORA). The objective was to clarify the different opinions and dimensions that play a role in ethics, sustainability and public acceptance of risks.

With this report, we hope to give the different parties insights and perspectives for a discussion on retrievable storage of nuclear waste. With this report, we hope to link the technical and the ethical and social aspects; we hope to contribute to a well-balanced discussion on the storage of nuclear waste.

In this connection, we wish to thank drs. L. van de Vate (project manager of CORA) and Ir. B.P. Hageman (chairman of CORA) for the realisation of this proposal. The critical remarks by the members of the Advisory Commission, more specifically Dr. H.G.J. Gremmen (Agricultural University of Wageningen), Prof. Ir. H.J. de Haan (member of CORA), Dr. W.A. Smit (University of Twente) and Prof. Dr. C.A.J. Vlek (University of Groningen), were of great influence in the contents of this report, although responsibility for the final text of course rests with the undersigned.

This report is purposely intended to give initial impetus to a discussion about the waste problem, as planned by CORA. We do not pretend to have the final say on this matter. This report deals mostly with the waste of nuclear power plants and less about the dangerous chemical waste. There have been a lot of international developments on the storage of nuclear waste. Reports and studies dated later than 1 November 1998 were not used for this study.

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1. INTRODUCTION AND SUMMARY

Internationally, there has been a lot of discussion about the storage of radioactive waste, also called nuclear waste. Dutch policy involves retrievability. What is the influence of retrievability on the judgements about the storage of this waste? To study this closer, we brought in a research proposal that consisted of two main objectives. On the one hand, we wanted to clarify as much as possible the ethical and philosophical frameworks on which retrievability can be situated. In this report we worked out these frameworks by the themes of ethics, sustainability and risk perception. The second objective was to interview environmental organisations to study the opinions and feelings that play a role in the acceptance of retrievable storage.

In working out the proposal, we faced the problem having no concrete examples to compare. For instance, the ethical framework to judge nuclear waste is still underdeveloped. Collecting relevant literature also seemed a lot of work. Sometimes, we had to contact the authors themselves. We decided first to study and evaluate the literature well, after which a link was made to the retrievable storage of nuclear waste. Because of this, we proceeded less quickly than expected. Another problem was the illness of one of the two project applicants. We had to find somebody to replace him. Naturally, this had influence on the extent the project could reach.

In working out of the three themes ethics, sustainability and risk perception, we faced the following restrictions:

-A thorough analysis and appraisal of the ethical frameworks would have demanded first of all an analysis of the common ethical frameworks and their relations with future generations and with retrievable storage of nuclear waste. This would have required a special study in itself. Upon the advice of the advisory commission, we limited our project to two ethical frameworks, of which we rejected one. A more detailed comparison between retrievable and non-retrievable storage was, in consultation with the advisory commission, not conducted.

-Concerning sustainability, we made an analysis of the concept itself and applied it, on request of the advisory commission, to different fuel options and nuclear waste.

-The chapter on risk perception could very well have been extended to an analysis of its reliability and representation of the data used. This was impossible within the time available, as the advisory commission concluded. This notwithstanding, this chapter indeed is an extensive inventory of the relevant literature.

The discussion about the existing waste problem often links to the discussion about nuclear energy in general. For instance, with a subject like ethics, the question is raised whether (past) production of waste can be justified. Also, from the interviews with the environmental organisations, it appears that the production is important as a theme. The production will continue till at least 2004, when the Borssele nuclear power plant is expected to close down in accordance with a government decision. This, although there are regular discussions about the extension of its operation time, or about further use of nuclear energy after the turn of the century. To a lot of people, the lack of a guarantee to stop nuclear energy means that a discussion about the existing amount of waste is impossible. These considerations are a reason why the production of nuclear waste is mentioned in some places in this report.

That we concentrate on waste from nuclear energy has the following reason: this waste especially is to be isolated from the environment for a long time. From the total amount of waste, it is the biggest fraction that has to be stored. According to research by the Dutch KEMA Institute, it turns out that waste from other sources loses most of its danger in a much shorter time. This will be discussed in more detail in chapter 2.

Nevertheless, this does not mean that in other utilizations, no long-term dangerous waste are produced. For instance, in the High Flux Reactor (Dutch Energy Research Centre), highly

enriched uranium is used for, among others, the production of isotopes for medical use. To answer the question whether these medical applications can justify the use of highly enriched uranium and the production of nuclear waste, we should discuss a number of aspects, including possible alternatives for isotope production and methods of diagnosis. Although we know that there have been quite a number of publications on this subject, there was not enough time to give them due consideration**.**

The research programme of the Commission for the Disposal of Radioactive Waste (CORA) is limited to the waste of existing nuclear power plants (one in operation and another one to be dismantled), and other sources. In chapter 2, it appears that with this assumption, a maximum of 190,000 cubic meters of radioactive waste would have to be stored. Concerning radioactivity, more than 90 percent comes from the nuclear power plants at Borssele and Dodewaard.

With the storage of nuclear waste, it is actually on making choices for the future. This is in the field of ethics, a theme more frequently being mentioned in discussions about nuclear waste. Ethics is the first theoretical framework we describe in this report (chapter 3). In many discussions about nuclear waste, the ethics of utilitarianism is implicitly used. In this type of ethical reasoning, happiness and sufferings, burdens and profits, are weighed. It is also assumed that the present weighs more heavily than the future: it is more difficult to define happiness and sufferings of people of the future than those of the people of the present. Because of this uncertainty, people of the present count for 100 percent, and lives in the future weigh less. This is called discounting.

Instead of the utilitarianist reasoning, we have chosen for what we call the ethics of justice. It is "core ethics", a bundle of elementary ethical standards. These are values that can apply to the whole of humanity in any place and at any moment. On the basis of this ethics, future generations shall be taken into account and discounting is not done. Given this ethics of justice, people of the future should have the same possibilities and should carry as much weight as the people of today.

The storage of nuclear waste has to be justified to the present generation. This is a difficult issue. Firstly, people who benefit from it are not always the same as those who are placed at a disadvantage. The nuclear industry pleads for compensating measures. However, compensation of residents in storage-location communities to spread the burdens more fairly seems not to function just like that. Studies show that inhabitants regard the offer of compensation as a signal of danger that threatens them, and that government is trying to bribe them. The offer of compensation can stir up resistance against the storage.

Storage of nuclear waste can cause damage in the future. This makes the application of the principles of justice difficult: future generations will carry the burden, but did not benefit from the advantages. Justice means that we are willing to have a responsibility for the consequences of our actions. For nuclear waste, it is a long-term responsibility.

Approaching the nuclear waste problem from an ethical point of view raises the question of whether or not the existence of nuclear waste can be justified. We observe that worldwide, the nuclear waste problem has not been solved and that models for the prediction of future consequences are surrounded by uncertainty. Therefore, we state that nuclear waste is a burden that can cause harm. In exchange for this burden, there is electricity from nuclear power plants that would not be necessary in a different societal choice. This fact makes the justification of the production of nuclear waste difficult.

One can imagine a reasoning to justify the use of nuclear energy to prevent a more evil harm, namely, the greenhouse effect due to the burning of fossil fuels. Instead of the greenhouse effect, future generations inherit nuclear waste. We do not think that nuclear energy can contribute seriously to prevent the greenhouse effect and give some arguments: nuclear power is not totally CO_2-free; from the viewpoint of economics it is not an efficient means; the proven amounts of uranium are limited.

For nuclear waste management, the International Atomic Energy Agency and the Nuclear Energy Agency use a set of principles they describe as ethical. We have studied these principles. From our research, it turns out that these principles are not so much that ethical or a "sound ethical thought", but are sometimes controversial recommendations with political compromises. The question of moral justification of the nuclear waste production is insufficiently under discussion. On one hand, the principles argue against retrievability, on the other hand, this is left open.

In chapter 4, we discuss "sustainable development"; this means that satisfying the present generation's needs may not compromise the abilities of future generations. This is the second theoretical framework of our study. For satisfying their needs, each generation must be able to appeal to the natural environment and may not be in a worse position than we are. Sustainable development is therefore in fact an ethical concept. In this way, sustainable development is linked to the ethics of justice we mentioned in chapter 3.

We mention a list of eight criteria for a sustainable energy supply: clean; safe; efficient; reliable; affordable; available for the long term; not obstructive; not discriminating. We conclude that on the basis of these criteria, neither fossil fuels (gas, oil or coal) nor uranium can be called sustainable. Gas is the least unsustainable, so the least harmful, followed by oil, coal, and finally uranium. For nuclear energy, this is mainly determined by the factors clean, safe and affordable.

The storage of nuclear waste may be said to be in harmony with sustainability since the amounts of waste would be smaller in volume. But though small, it presents a high class of danger.The observation that it is of a small amount is not a decisive argument to consider nuclear energy and the storage of nuclear waste in harmony with sustainability.

Chapter 5 is the third theoretical framework. We deal with what Ulrich Beck described as risk society. Here, the themes of distrust in government and public acceptance are under discussion. We observe little public acceptance for the plans for storage of nuclear waste. The negative images created by nuclear energy and nuclear waste are caused by several reasons. Studies show that the creation of images is partly influenced by: a deeply ingrained fear of a technology that has gotten out of hand; in people’s minds, nuclear energy, nuclear waste, nuclear weapons and nuclear war are inextricably bound up with each other; and media coverage. Therefore, it is understandable that people do not, or hardly ever, accept the risk of a nuclear waste storage. From literature, we have derived a list of 14 factors that influence the acceptance of risks:

1. Possibility of serious disasters.
2. Small accidents are a signal that things could go wrong.
3. Distribution over time, and justice: no risks should be passed on to future generations.
4. Globality: the more people that can be victimized, the more unacceptable.
5. Involuntariness: one does not accept risks imposed by government or by industry.
6. Trust in government and in science is of overriding importance in storage plans.
7. Persistent beliefs: after having formed an opinion, it is not easy to change it quickly.
8. Familiarity with the risk: as almost no one is familiar with nuclear waste, a resistance against storage plans is the result.
9. Personal controllability and reversibility: people have the feeling that they are unable to control a nuclear waste storage, and accidents are irreversible when things go wrong.
10. In the perception of risk, there is no difference between aboveground and underground waste storage.
11. In people’s judgement, the risks of nuclear waste, nuclear energy and nuclear weapons are

closely connected to one another.
12. Stigmatization: the fear that because of nuclear waste, a community will acquire a bad reputation and will suffer economic damages.
13. Possibility to avoid the risk: for the perception of risk, there is a difference between the discussion about produced waste from closed nuclear power plants and the discussion about ongoing production from nuclear power plants in service or under construction.
14. The idea that insufficient money is being reserved for future storage costs.

The possibility of controllability, voluntariness and trust in government are important for the creation of images and public acceptance.

The storage of nuclear waste makes warnings to the future necessary, as described in chapter 6. On the whole, there are two approaches: the active and the passive institutional control.

Active institutional control is promoted by researchers Kornwachs and Berndes of the Technical University in Cottbus, Germany. They want to set up appropriate bodies which may be patterned after, say, the internal structures of cloisters and universities. In this way, they look for the attributes that are responsible for the long-term existence of these institutions.

The U.S. Department of Energy is conducting passive institutional control. These are aboveground and underground markings and other methods to keep knowledge about the stored nuclear waste for 10,000 years. During this period, steps should be taken to prevent people from digging up the nuclear waste.

What is the significance of priorly set theoretical frameworks in relation to retrievability? Chapter 7 starts with the history of retrievability in foreign countries and in The Netherlands. We observe that no clear form has yet been given to the concept, especially concerning the period of retrievability. We have chosen for permanent retrievability. We conclude that retrievability can prevent the release of nuclear waste and its becoming uncontrollable. Control, repair and recontaining remain possible. Retrievability requires at the same time more efforts to keep the storage intact. Retrievability has the advantage that one can change the storage concept at a later time. With non-retrievable storage, final disposal and other options are excluded once and for all. The idea of retrievability is in theory ethically less unfavourable than final disposal.

We observe that permanent retrievable storage in salt or clay is less obvious, because of physical properties. This pleads for aboveground retrievable storage as the least ethically unfavourable choice.

The working out of the ethically least unfavourable option raises some questions. It is on the question of stability of institutions that have to manage the waste. There is a threat of contradictions in the argumentation. On the one hand, the human factor is a risky uncertainty. On the other hand, retrievability means trust in the risky human factor for years to come. It may never happen that the aboveground nuclear waste storage site is bombed in a war. A dilemma will remain for which no real solution is on hand.

According to the principles of sustainable development, the needs of future generations may not be endangered. With nuclear waste, this risk exists. Retrievability can prevent eventual damage because of the possibilities of control and repair when it is permanent retrievability. The production and existence of nuclear waste can not be said to be in harmony with sustainability.

In the totality of dimensions for risk perception, controllability is only one. Retrievability will change this factor of judgement in a positive manner. It is, however, not to be expected that retrievability alone will make the storage of nuclear waste acceptable, regardless of whether the storage is aboveground or underground.

The findings in the previous paragraphs are confirmed by interviews with environmental groups (chapter 8). Some of the organisations were not even willing to cooperate as they rejected the use of nuclear energy, distrust government, and fear that cooperation through an interview would be interpreted as willingness to cooperate on a solution for the nuclear waste problem; they feared it would make way for the building of new nuclear power plants. A ban upon nuclear energy is a condition for a discussion, as stated by the cooperating organisations.

All organisations want permanent retrievability; for most of them this means aboveground storage. Considered important are the possibilities for access, control, recontainment and eventual processing into non-hazardous waste. There are doubts on the possibilities of permanent underground retrievability.

In the risk perception of the nuclear waste problem, the factors distribution over time, globality and the possibility to avoid risks are important. Voluntariness, trust in government, controllability and stigmatization play a role in more specified storage plans.

Controllability is the main factor in judgement on future plans and policy. Distrust in government influences the discussion about the nuclear waste problem. Some organisations fear the misuse of retrievability to force through underground storage; that retrievability would make it acceptable. At the moment, the possibility to avoid risks is a dominant factor in judgement. A ban on nuclear energy could change risk perception; in that very moment, the absolute (inevitable) amounts of waste is known that have to be stored.

Which other conditions are necessary for a discussion about the storage of nuclear waste? From literature on risk-management [1] [2] [3] [4] [5] and procedures of storage of nuclear waste in The Netherlands [6] [7] [8] , Great Britain [9] [10] [11] [12] , Canada [13] [14] [15] [16 [17] , Sweden [18] [19] [20] [21] [22] , Switzerland [23] [24] [25] , France [26] [27] [28] , United States [29] [30] [31] [32] , Belgium [33] [34] [35] [36] and Germany [37] , we extract a number of general conditions for a discussion:

- In the starting phase of a discussion, participating parties should make clear their values, ethical principles and criteria for the judgement on nuclear waste storage.

- From the beginning it should be clear that ethical and societal factors play a full role in the discussion. All groups that have an interest in the issue should have the possibility to join the discussion.

- When the discussion starts, conclusions should be open. A discussion to legitimize decisions already taken has little value. A discussion has to deal with general questions about storage and not about the suitability of locations on a prepared list of locations.

- A discussion will not automatically succeed, because of different ethical principles and different judgements about risks. The various parties have to get used to each other and learn from one another. This process, also called social learning, requires time and guidance.

- Since it has taken a clear side in history, government is not the best appropriate authority to organise the discussion.

- An independent authority has to be established for the organisation of a discussion. It could follow the recent Canadian discussion which was chaired by the Environmental Assessment Panel, composed of independent civilians. This Panel gave, besides attention to technical aspects, attention to questions about responsibilities to nature and environment, and obligations to future generations.

- Those who are critical of storage should be given funds to develop their arguments. Among the different parties, there should be no financial inequality.

- Good information and communication is important. It is of importance to give clarity about where the parties agree or disagree. Deeper study is often needed, followed by a confrontation of different arguments.

- Discussion is possible only on the basis of a clear definition of the amounts of waste that are involved. Consistent with the basic assumption of CORA research programme, it is waste from existing nuclear power plants in The Netherlands and that no new nuclear power plants would be built. Given the fear that a discussion is used by government to build new nuclear power plants, government should give guarantees. A possibility is that government only makes a decision to build new nuclear power plants only after a binding referendum.

Sources:

1- Reinhard Ueberhorst and Reinier de Man, "Sicherheitsphilosophische Verständigungsaufgaben - Ein Beitrag zur Interpretation de internationalen Risikodiskussion" (Safety philosophical similarities - a contribution to the interpretation of international risk discussion); in Mathias Schüz (Hg), "Risiko und Wagnis. Die Herausforderung der industriellen Welt" (Risk and risky enterprise. The challenge of the industrial world), Neske Publishers, Germany, 1990, p 81-106.
2- Arbeitsgemeinschaft für Umweltfragen e.V. (Hg), "Umweltmediation in Deutschland. Inovative Formen bei Regelungen von Umweltkonflikten" (Environmental mediation. Inovative forms in regulations of environmental conflicts), Documentation Scientific-Practical oriented Congress in Düsseldorf at 22 June 1995, Germany, Main points of outcome, p 5-13.
3- Arie Rip, Thomas J. Misa and Johan Schot (ed), "Managing Technology in Society. The Approach of Constructive Technology Assessment", Printer Publishers, London and New York, 1995.
4- John Martin Gillroy and Barry G. Rabe, "Environmental Risk and the Politics of Assurance: Alternative Approaches to Waste Facility Siting", in: Risk, Decision and Policy, 2 (3), 1997, p 245-258.
5- Committee on Risk Perception and Communication, Commission on Behavioural and Social Sciences and Education, Commission on Physical Sciences, Mathemathics and Resources, National Research Council, "Improving Risk Communication", National Academy Press, Washington, D.C., US, 1989.
6- Henk C.G.M. Brouwer, "Current Radioactive Waste Management Policy in the Netherlands", in: Charles Vlek and George Cvetkovitch (eds), Social Decision Methodology for Technological Projects, Kluwer Academic Publishers, Netherlands, 1989, p 217-234.
7- Herman Damveld et al., "Kernafval in zee of zout? Nee fout!" (Nuclear waste in sea or salt? No, wrong!), published by Greenpeace Netherlands, Amsterdam, Netherlands, 1994, chapter 7.
8- Chris van der Borgh and Jon Marrée, "Borsele, de plaats Nergens" (Borsele, the nowhere place), Ravijn, Amsterdam, Netherlands, 1990.
9- Stewart Kemp (ed), "Management of Radioactive Waste. The Issues for Local Authorities", Proceedings of the conference organised by the National Steering Committee, Nuclear Free Local Authorities, and held in Manchester on 12 February 1991, Thomas Telford, London, UK, 1991.
10- J. Knill, "Radioactive Waste: Introduction and Overview", in: Stewart Kemp (ed), "Management of Radioactive Waste. The issues for Local Authorities", Proceedings of the conference organised by the National Steering Committee, Nuclear Free Local Authorities, and held in Manchester on 12 February 1991, Thomas Telford, London, UK, 1991.
11- P.J.Curd, "Public Perception of Radioactive Waste Management and LessonsLearned", PIME '89, Montreux, Switzerland, 22-25 January 1989; P.J.Curd, "The Sellafield Repository Project Information Programme",, PIME '93, 31 January - 3 February 1993; The Independent (UK), 23 March 1997.
12- John Knill, "Radioactive Waste Management: Key Issues for the Future", in: F. Barker (ed), Management of Radioactive Waste. Issues for Local Authorities. Proceedings of the UK Nuclear Free Local Authorities Annual Conference 1997 held in Town House, Kirkcaldy, Fife, on 23 October 1997, Publisher Thomas Telford, London, UK, 1998, p 1-17.
13- M.A. Greber, E.R. Frech and J.A. Hillier, "The Disposal of Canada's Nuclear Fuel Waste: Public Involvement and Social Aspects", AECL Research, Whiteshell Laboratories, Pinawa, Manitoba, Canada,

July 1994 (AECL-10712 COG-93-2); this report of 260 pages contains a detailed description of the discussion in Canada till the middle of 1994.
14- C.J. Allan and M.A. Greber, "Social and Ethical Issues Surrounding the Disposal of Nuclear Fuel Waste - A Canadian Perspective", AECL Research, Whiteshell Laboratories, Pinawa, Manitoba, Canada, 1995 (Technical Record TR-705 COG-95-405)
15- J.A.R. Hillier and R.S. Dixon, "Nuclear Fuel Waste Disposal. Canada's Consultative Approach, Notes for a Presentation at ENS PIME'93, Karlovy Vary", 3 February 1993.
16- Fred Roots, "Radioactive Waste Disposal - Ethical and Environmental Considerations - A Canadian Perspective", in: Nuclear Energy Agency, "Environmental and ethical aspects of long-lived radioactive waste disposal", Proceedings of an International Workshop organised by the Nuclear Energy Agency in co-operation with the Environment Directorate, Paris, France, 1-2 September 1994, p 71-93.
17- Report of the Nuclear Fuel Waste Management and Disposal Concept Environmental Assessment Panel, "Nuclear Fuel Waste Management and Disposal Concept", Minister of Public Works and Government Services Canada, February 1998; released March 13, 1998.
18- Lennart Sjöberg and Britt-Marie Drottz-Sjöberg, "Risk Perception of Nuclear Waste: Experts and the Public", Center for Risk Research, Stockholm School of Economics, Stockholm, Sweden, December 1994, Report nr. 166.
19- Marie-Louise Bernström, "Radiation: Risk Perception and Risk Communication in Sweden", Center for Risk Research, Stockholm School of Economics, Stockholm, Sweden, December 1994, Report nr. 16.
20- Nuclear Fuel, 16 June 1997, p 17; Nucleonics Week, 25 September 1997, p 15.
21- Marianne Lowgren, "Nuclear Waste Management in Sweden: Balancing Risk Perceptions and Developing Comunity Consensus', in: Eric B.Herrik and Alvin H.Mushkatel,"Problems aand Prospects for Nuclear Waste Disposal Policy", Greenwood Press, westport, Connecticut/London. 1993, p 105-121.
22- Olof Söderberg, "Who Makes Which Decisions When?", in Proceedings DisTec'98, Disposal Technologies and Concepts 1998, International Conference on Radioactive Waste Disposal, 9-11 September, Hamburg, Germany, p 633-639.
23- Nagra Report (CH), 16. Vol., Nr. 1/96, p 2-3.
24- Nagra Report (CH), 17. Vol., No.2/97, April-June 1997, p.3.
25- Schweizerischer Wissenschaftsrat, ProgrammTechnology Assessment, "Publiforum 'Strom und Gesellschaft' 15-18 Mai 1998 in Bern. Bericht des Bürgerpanels" (Public forum 'Electricity and Society' 15-18 May 1998 in Bern. Report of the Public Panel), Report TA 29/1998/d, Bern, Switzerland, May 199. Schweizerischer Wissenschaftsrat, Programme Technology Assessment, "Publiforum 'Strom 8.
26- Maurice Allegre (ANDRA), Opening Address, Nuclear Energy Agency, "Informing the Public about Radioactive Waste Management", Proceedings of an NEA International Seminar, Rauma, Finland, 13-15 June 1995, Parijs, France, 1996, p 29-30.
27- Jean-Pierre Gages and France Bres-Tutino, department communication Andra, "Public Decision and Opinion - Nuclear Energy and Nuclear Waste Put to Test of Democracy", in: Nuclear Energy Agency, "Informing the Public about Radioactive Waste Management", Proceedings of an NEA International Seminar, Rauma, Finland, 13-15 June 1995, Paris, France, 1996, p 75-90.
28- Nuclear Fuel: 31 January 1994, p 5 and 6; 22 September 1997, p 10; 29 December 1997, p 9-10; 9 February 1998, p 5-8, 13-14; 1 June 1998, p 14-15; 10 August 1998, p 12.
Nucleonics Week: 24 April 1997, p 13-14; 5 February 1998, p 1, 14-15; 25 June 1998, p 11.
29- For a detailed review of the history of plans for storage of nuclear waste in the US we refer to: 1. Ronnie Lipschutz, "Radioactive Waste: Politics, Technology and Risk", Cambridge USA, 1980; 2. A.A. Albert de la Bruh ze, "Political Construction of Technology. Nuclear Waste Disposal in the United States, 1945-1972", WMW-publication 10, Faculty Philosophy and Society Sciences University Twente, Enschede, Netherlands, 1992; 3. Roger E. Kasperson, "Social Issues in Radioactive Waste Management: The National Experience", in: Roger E. Kasperson (ed), "Equity Issues in Radioactive Waste Management", Oelgeschlager, Gunn & Hain Publishers, Cambridge, Massachusetts, USA, 1983, Chapter 2.
30- Ralph L. Keeney and Detlof von Winterfeldt, "Managing Waste from Power Plants", in: Risk Analysis, Vol. 14, No. 1, 1994, p 107-130.
31- Interview Herman Damveld with Robert Loux, in: Herman Damveld, Steef van Duin en Dirk Bannink, "Kernafval in zee of zout? Nee fout!" (Nuclear waste in sea or salt? No, wrong!), Published by Greenpeace Netherlands, Amsterdam, Netherlands, 1994, p 29-30.
32- Audrey Taucher, "Deregulation: Challenges for the Millennium", in: CORE Issues, The Journal of the Uranium Institute, London, UK, June-July 1998, number 3, p 2-6.
33- NIRAS, "Het beheer van het radioaktieve afval" (The management of the radioactive waste), vouwblad

7: De berging van het radioaktieve afval (Folder 7: the storage of the radioactive waste), Brussels, Belgium, unknown date.
34- NIRAS, "NIRAS start een werkprogramma waarin het partnerschap centraal staat" (NIRAS starts working programme in which partnership is central), Press file, Brussels, Belgium, 16 March 1998.
35- NIRAS, "Partnerschap staat centraal in nieuw werkprogrammema van NIRAS" (Partnership is central in new work programme), Press Release, Brussels, Belgium, 16 March 1998, p. 3-4
36- TV Belgium-1, news 19.00 Hr., 28 June 1998.
37- Gruppe Ökologie, "Analyse der Entsorgungssituation in der Bundesrepublik Deutschland und Ableitung von Handlungsoptionen unter der Prämisse des Ausstiegs aus der Atomenergie" (Analysis of the waste management situation in the Federal Republic of Germany and possible acting options under the situation of ending nuclear energy), Hannover, Germany, August 1998.

2. WASTE IN THE NETHERLANDS

The word "nuclear waste" can not be found in Dutch nuclear energy laws. There are, however, regulations in law for the use of radioactive materials. Materials prescribed above standards must be stored at the Central Organisation For Radioactive Waste (COVRA). 100 Bq/g is now the standard for radioactive waste; for material containing natural radioactivity, 500 Bq/g. With the implementation of new European Standards [1] , the free release of certain materials will be more difficult.

In fact, the production of waste by the use of nuclear energy starts with mining. Yearly, the Borssele nuclear power plant can account for about 11,000 MT of mining wastes [2] . In the Almelo Urenco enrichment plant, depleted uranium is produced as a by-product. Because of exports to Russia, it is still unclear what amounts eventually have to be stored at the COVRA. Fuel from Dodewaard and Borssele is being reprocessed in Sellafield (BNFL) and La Hague (Cogema). About 4,320 kilograms of plutonium will be extracted [3] . Around the year 2003, 70-m^3 high level reprocessing waste (HLRW) and 2,810-m^3 other reprocessing waste will be sent back to The Netherlands to the COVRA. HLRW is highly radioactive and counts for a big share (88 percent) of total radioactivity to be stored at the COVRA [4] . Because of the failure of breeder technology, there is no sight of using plutonium, whereas the French government has an obligation to send it back. The contracts with Sellafield also include the sending back of plutonium. The dismantling of Dodewaard and Borssele will result in more than 5,000-m^3 of waste [5] . Apart from the electricity-producing reactors, The Netherlands has three research reactors. Spent fuel will be stored at the COVRA, in total 40 m^3. [6]

Waste from non-nuclear sectors comes from hospitals, ore-processing and the processing industry. The two last mentioned will soon be confronted with the more stringent European Standards. This may have consequences for the amounts that are to be stored by the COVRA. It is yet unknown what the real consequences would be in the Dutch situation.

A final solution for waste is non-existent in The Netherlands. Final underground disposal in salt domes was not realised because of the lack of public acceptance and the demand for retrievability. For the future, the CORA commission sees three possible options. For instance, it thinks about a delay of underground storage for 300 years. CORA requested the Dutch Certification Institute for Electrical Materials in Arnhem (KEMA) to study the consequences for the COVRA [7] . After 300 years, a great amount of low-level radioactive waste could be removed as non-radioactive waste. Most waste from nuclear energy have to be stored for a longer period.

Sources:

1- "Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers from ionizing radiation"; Publication of the European Community; L159 39 (29-6-96).

2- UI Facts, Nuclear fuel cycle material balance, October 1997

3- WISE-Paris, "The Dutch plutonium dead end", October 1997, p. 28-29

4- "Kernafval, (g)een probleem ?!" (Nuclear waste, no problem?!), Report Symposium, 28 January 1998, presentation H. Codee (manager COVRA), Netherlands

5- "Buitenbedrijfstelling en Ontmanteling van de Kernenergiecentrales te Borssele en Dodewaard" (Closure and dismantling of the nuclear power plants Borssele and Dodewaard), Workinggroup Dismantling EPZ/GKN/SEP, 1995, Netherlands.

6- "Milieu-effectrapport behorend bij de aanvraag tot wijziging van de Kew-vergunning van COVRA NV" (Environmental Impact Assessment of the request for change Nuclear Energy Law license of COVRA NV), 1995, Netherlands, p 99-100.

7- "Inventarisatie en mogelijkheden voor bovengrondse opslag voor 300 jaar van laag- en middelactief afval" (Inventarisation and possibilities for aboveground storage of low- and medium-level waste for 300 years), KEMA nuclear, 41436-NUC 97-9225, Netherlands, 1998.

3. ETHICS

3.1 Ethics

Ethics deals with fundamental values, rights and concepts, like justice. Ethics is related to human behaviour: the chosen ethical assumptions have to be expressed in the actions conducted by people.
As one of the parts of philosophy, ethics has in Western tradition its starting point in the texts of Plato, who wrote down the discussions about ethical problems that Socrates conducted in his dialogues. Of importance in this early period were the views of Aristotle who interpreted ethics as a practical science.

After the ancient period, many developments in ethical theory have been under discussion. Roughly, these theories have in common elements to clarify how we ethically judge and which arguments we use therefor. Sometimes ethics is restricted to a description of these facts (descriptive ethics), often an ethical theory has the form of giving prescriptions of legitimate ethical judgements (prescriptive or normative ethics). The concept "ethos" in the broad sense then means moral philosophy or morality.

In this chapter, ethics is restricted to the ethical actions of people. Whether animals or nature or environment have rights would require a separate study. The question whether another attitude of men to nature and environment would be a condition for the solution of the environmental problems -- as stated by the environmental philosopher Wim Zweers [1] -- is not part also of this study. We also give no attention to the theme of whether the principles of radiation protection that are aimed at protecting people are also protective of other life as well. We have confined ourselves to two ethical theories: utilitarianism and the ethics of justice.

3.2 Two ethical theories

3.2.1 Utilitarianism

The term is derived from the Latin word "utilis", meaning useful. Utilitarianism sees the characteristic of morality in the usefulness of an act. An act is good when useful and evil when harmful.
With the Englishman Jeremy Bentham (1748-1832), we find utilitarianism as a worked-out system. He states that people take into account the usefulness and harm that is the result of an act. In the first place, on usefulness and harm for themselves. Human beings know from experience what is useful or harmful. In Bentham's vision, useful is that which gives us goods and harmful is that which gives damage. Good is what makes us happy and gives us joy.
In the last centuries, Bentham's theory has meant: to have material goods as much as possible for the greatest number of people through the market of demand and supply. This is the ideological background of the present economy [2] .
The idea behind the proposed plans for nuclear waste storage is mostly based on utilitarianism: we try to eliminate negative consequences by sealing in the waste; in this way the positive effects of nuclear energy count more than the negative; therefore, the purpose is fulfilled, namely, to contribute to the common good of society through the use of nuclear energy [3] .

Our objection to utilitarianism is based on the fact that weighing the costs and benefits of actions is here the only criterion. After all, it can be at the expense of individual human rights of people now or in future [4] [5] .

3.2.2 The ethics of justice.

On the basis of lectures on the history of ethics, the German ethicist Ernst Tugendhat developed the concept of plausible ethics [6] . Different cultures have so-called "golden rules" [7]. We find it in the proverb: "Don't do things to others you don't want them to do unto you." In itself this rule does not guarantee moral action, but has a connection to minimal standards, making possible the

realisation of concrete action in the long term[8] . The following three items are central: 1. don't harm others (a negative duty, the duty to refrain from certain things); 2. to help others (positive duty); and 3. to comply with cooperation rules like not to lie and to fulfil promises.
Tugendhat states that one may not use others as a means for one's own profit. This concept of ethics is universal and egalitarian, and regards everyone as an equal. Everyone has the same rights but it also involves: equal duties to others. In this context, Tugendhat refers to human rights.

In the Universal Declaration of Human Rights, economic and social rights are included. Anyone has at least a right for a decent existence, a right to work and a right to health care. In the United Nations Conference on Environment and Development in Rio de Janeiro, the right to live in harmony with nature and in an intact environment was added [9] .
The Tugendhat concept of ethics is plausible as everybody can agree with it in theory. It is not that everyone has to agree just like that and in this way the ethics of justice is not universal. It is more the wish that everybody agrees with this concept of ethics as there are good arguments to do so. In the following, the described ethics of justice is our basic assumption for consideration. In order to mark the character of this ethics, we call it the "ethics of justice".

3.3 Justice to the present generation

The establishment of nuclear installations can change the environmental quality of life, eventually involving exposure to dangers and changes in the social climate. Can this be justified?[10]

Geographical justice is an important issue in the establishment of a nuclear installation. This brings a lot of questions as can be concluded from the work of the American ethicist K.S. Shrader-Frechette [11] . Nuclear waste storage sites are built in rural areas far away from densely populated areas. Can it be justified to expose someone to a risk because he or she is living in a rural area? And can it ethically be justified that a particular group, based on the geographic location, has the benefits of nuclear energy even as another group carries the burdens for it?

In this context, Shrader-Frechette distinguishes three dilemmas [12] . First is on consent. The establishment of a nuclear waste storage site as well as the hiring of workers requires the consent of the persons concerned. Those who are most capable to consent, in voluntariness and after weighing the available information, will be little inclined to do so as well as those who oppose it. A person who urgently needs a job because of financial problems is more willing to accept a bigger risk than someone who does not have financial problems.
The second dilemma is decision making. Should the local administration or people have a right to veto, even when research indicates that that location is the best in the country? Or should government designate a location?
The third dilemma is on the standards for protection. When are risks acceptable? An average risk for the whole population does not mean that individual risks will be acceptable.

Shrader-Frechette mentions consent and compensation as a solution for the dilemmas. Risk can not be justified unless the entity imposing it gets the consent of potential victims[13] . It is however unsure whether this solution of Shrader-Frechette is applicable. First, the consent of future generations is not possible. Second, absolute freedom and voluntariness is difficult to conceive in a society.
It can also be doubtful whether compensation will work. A tacit assumption with compensation is that nobody wants a storage site, because the burdens are weighed more than the benefits. Compensation should relieve the burden and thus increase acceptance. Secondly, government and technicians tacitly assume that citizens have little other aims than their material welfare. This is incorrect: compensation is seen as bribery.

American researchers surveilled the preparedness of citizens to accept storage of nuclear waste at Yucca Mountain, Nevada, when they would get tax deductions in exchange. Regardless of the

amount, tax deductions seemed to have no influence on the opinion on the storage. On the contrary, some citizens saw the offer as a signal that storage was of a level of danger that risks had to be sold off [14].
The bad reputation a particular location can get is another aspect of choosing a location. American studies show that this stigmatization occurs or produces apprehension [15].

The Nuclear Energy Agency sees consultation with all parties concerned, including citizens, and in all venues of decision making, as an important method to express responsibility to the present generation [16] . From the way the government and the nuclear industry could start a dialogue with citizens, one can learn from the experience of discussions on ethics and nuclear waste in Canada. Storage plans should be presented as a proposal worthy to think about; plans should be presented as a step in the right direction instead of being the ultimate solution [17].

3.4 Justification to future generations

A reference to the future often has an emotional dimension. It happens that we want to be right by referring to people of the future. M.T. Hilhorst [18] compares it with the appeal to our ancestors, like "grandma would have liked you to...". The appeal to history or to the future is first of all meant to change things in the present. But which responsibility do we have towards posterity and what is our relation with the future?
Justice is embedded in the idea that future generations may not be in a worse position than we are. Hilhorst interprets justice as: what good is it for us and applies to us should also go for people of the future. To pass on to them less than what we have would rightly lead to a moral complaint.

Justice implies responsible acting. The philosopher Jef van Gerwen formulates it as follows. When I see myself as a link in a chain that reaches over thousands of years, rather than as an individual, I can accept that my present choices are in line with my predecessors, even when I am in possession of possibilities that were unknown for my predecessors or were not in their possession. I can have peace with a voluntary restriction of my present possibilities (not to risk all, not to use all possibilities) to keep alive the common good that future believers will take on. This is the concept of ethics of intergenerational common good.

Each moral actor has to take the responsibility for the expected consequences of handling. "Expected consequences" are meant to be the predictable consequences that the actor is prepared to let happen as a consequence of his actions. This responsibility lasts as long as the effects occur in reality [19] . That means that those who allow the production of nuclear waste and benefit from nuclear energy bear the responsibility for the predictable consequences of the storage and custody of the resulting nuclear waste, and this for as long as the waste is radioactive, which is for hundreds of thousands of years**.**
The long-term burden of nuclear waste conflicts with current views on democracy, says Wim Zweers: we shift the burdens to others. A small minority, namely, those living today, decide for several generations to come. That is ethically reprehensible, states Zweers[20] .

Concluding, we state that justice means that future generations should not be in a worse position than we are. Because of the storage of nuclear waste, damage can occur in the future, where future generations have had no benefits from it. This makes the application of the principles of justice difficult. Justice means we bear responsibilities for the consequences of our actions. For nuclear waste, it means a responsibility for hundreds of thousands of years. That is beyond all comprehension. From the point of justice, dealing with nuclear waste is a difficult issue.

3.5 Justification for the production of nuclear waste

Although we want this study to concentrate on the existing amount of nuclear waste, in this chapter we deal with the production of it. There is a number of reasons for this. The existence of

nuclear waste begs answers for the justification of (earlier) production. During our research, it also seemed that in judging the waste problem, the question of production is considered as an important issue (see, among others, chapter 8: analysis interviews with environmental organisations). The reason, therefore, is that in The Netherlands, there is an ongoing production, for instance by the nuclear power plant in Borssele, that will continue until at least the year 2004.
Is there enough moral justification for the production of nuclear waste? First we ask whether nuclear waste is a burden that can cause harm (A). Then we look to the benefits we get in exchange of the harm (B). Finally, we go into the question of whether we can prevent an even bigger harm by the production of nuclear waste (C).

A. Is nuclear waste a burden that can cause harm?
If nuclear waste is no burden that can cause harm, we would have made progress in the justification of the production. We analyze three arguments used in this context.

1. The nuclear waste problem has been solved.
Contrary to the statement that the nuclear waste problem has been solved, we say that nowhere in the world is there a final disposal site for highly radioactive waste[21] . See the table. In a September 1998 conference, Abel J. González, IAEA director of the Division of Radiation and Waste Safety, stated as well that the nuclear waste problem had not been solved [22] .

The earliest time for the final storage of nuclear waste are as follows" [23]

Belgium	2035	Netherlands	?
Canada	2025	Spain	2020
Fniland	2020	Sweden	2008
France	2020	Switzerland	2020
Germany [24]	2030	United Kingdom	2030
Japan	2030	United States	2013

2. Nothing is without a risk.
One often concludes that because of the risks, people now running this risk would be normal. The reasoning is that normal risks are acceptable. One concludes it is a normal and acceptable risk from the facts which occur. The mistake in this reasoning is that one can not derive standards from facts.
Shrader-Frechette raises the question whether a natural or normal risk has to be accepted. After all, natural radiation also causes cancer. With an underground storage, in fact a choice is made to impose an extra risk on top of the natural present risk [25].

3. Full safety does not exist.
An important aspect is the reliability of calculation models. We will shortly examine points put forward in this context by the precursor of CORA, the Commission for the Disposal On Land (OPLA).
The OPLA Final Report on Phase 1 [26] mentions that the outcome of calculations on the rising tempo of salt domes depends on the calculation model that is chosen and on locally unknown values which can strongly differ. In the supplement of this study, it is even stated that the reliability of the outcome is not only dependent on the model used, but also on the person who uses it. In that way, the results are influenced by personal technical judgements. It is pointed out that fundamental knowledge of geochemical processes that occur is often insufficient. And even when this and other data become available, a "forecast for the far future can be made only within certain margins".

In the supplement of OPLA Phase 1a [27] , we find these uncertainties as well. The question is examined when a model has been proved or validated: "A model can be seen as validated only when, without serious doubts, it can be demonstrated that the predictions of the model, with an acceptable degree of accuracy, apply to the whole range of suitability of the model and during the whole period that is simulated. This can only be reached by comparison of the model predictions to field observations of the system that is modelled." This is the comparison of the outcome of calculation models with observations. One has to carry on these observations for a longer time: "This process should take place for a longer period (for instance, 30-50 percent of the simulation period) till the model can be seen as validated. Although this is an "ideal validation process". In practice, especially within the scope of safety analysis, studies where geohydrological models are used to make forecasts for periods of 10,000 years, this type of validation can not be performed."

Therefore, we can conclude that, with the present degree of knowledge, predictions of future consequences are too unsure, especially because of the long period for which predictions have to be made.

B. There are benefits in exchange for the burden.
Now we make a second step. We admit that nuclear waste is a burden that can cause harm, but we examine whether there are benefits in exchange for it.

1. In exchange we get energy.
The Borssele nuclear power plant was built because of the establishment of the aluminium factory in Pechiney. Without Pechiney, the Borssele nuclear power plant would not have been built [28] [29] . For the production of aluminium from alum, much more electricity is needed than for the production from used aluminium. Compared to the production from alum, the production from aluminium scrap requires only 5 percent of the needed electricity. If such production was chosen, the Borssele nuclear power plant would never have been realised.
In exchange for nuclear waste, we have the production of electricity, but this is relative as seen above. In fact it is about choices we can make for electricity from different energy sources.
Apart from the situation in The Netherlands, there is the argument that future generations benefit from our action, namely, the benefits of extra energy for available technology. But the resources of uranium are limited (see chapter 4) and this argument seems to be relative.

2. Nuclear energy is the cheapest solution.
But not for the Dodewaard nuclear power plant. In 1997, it was closed due to economic reasons [30] . And also not for the Borssele nuclear power plant. Electricity from this nuclear power plant is substantially more expensive than electricity from a gas-heated combined heat and power plant [31] . And also not for new nuclear power plants. In the December 1995 "Third Energy Memorandum" on long-term policy, Minister of Economic Affairs G.J. Wijers stated that nuclear energy had "a moderate competitive position". [32]

Conclusion: in exchange for the burden that can cause harm, we get relatively expensive energy that would have been unnecessary in another societal choice.

C. To avoid more grievous harm, namely, the greenhouse effect?
Then only a negative variant remains for the justification of the production and storage of nuclear waste: against nuclear waste is more evil. Nuclear waste is the best alternative and, therefore, the production of this waste is morally justified. The greenhouse effect would be this more grievous harm.

An example of this argumentation is a lecture of Hans Blix in 1997. At that time he was still the director of the International Atomic Energy Agency (IAEA) in Vienna. In his contribution, Blix assumed that nuclear energy was consistent with sustainable development. As criteria for sustainability, he mentioned that resources are long-lasting and that nuclear energy is free of CO_2

emissions. He stated that uranium resources can fulfil 40 times the present use and would last till 2040. With the large-scale use of breeder reactors, as promoted by him, this amount would increase with a factor 50 (so 50 times 40 years). Blix concluded that in this way the resources are sufficient for 2,000 times the present yearly use. [33]

But something can be said about this argumentation. When the expectation in the '70s for the amount of nuclear power plants to be built were correct, uranium resources would have been exhausted in about six years. [34] [35] [36] A more efficient use of uranium with a factor 50 is far too optimistic, in theory we can at most expect a factor 25 by the use of breeder reactors [37] .

The Dutch electricity companies assume that with the presently expected development of nuclear energy, the recoverable uranium resources would be exhausted around the year 2020. [38] Moreover, we have to take into account the following limiting factors which we mention only briefly:

1. Nuclear energy is not totally free of CO_2 emissions; it is the indirect emissions caused by the building of a nuclear power plant itself and the winning and milling of the uranium ore. In future, the indirect emission will increase; caused by the use of poor uranium ore, the poorer the ore the more ground has to be processed to produce a certain amount of uranium, more energy is thus needed. The emission, therefore, can increase to about 80 grams of CO_2 per kilowatt hour (to compare: combined heat and power with natural gas produces 150 grams of CO_2 per kilowatt hour [39]).

2. The winning of uranium is a shrinking market where a lot of people have been dismissed. This is caused by developments since the '70s. That time it was expected that around the year 2000, about a quarter of a million metric tons of uranium would be needed yearly to keep the nuclear power plants running. So a substantial overcapacity was raised on the uranium market as well as stocks in the electricity companies. Therefore, prices lowered and the uranium mines were closed [40] .

3. The nuclear industry has a limited and shrinking capacity for building nuclear power plants because of a stagnation on the world level. In 1991, it was 18 nuclear power plants yearly [41] , but according to the Uranium Institute, this capacity can be set up again relatively quickly [42] [43] . The OECD Nuclear Energy Agency recently pointed to another aspect. In the shrinking nuclear energy market, parts of the infrastructure are getting weak or are lost [44] [45] .

4. The predicted use of breeder reactors has not come true, apart from a small number of plants. No country considers the use of breeder reactors as substantial contribution to energy supply.

5. Nuclear energy is a little cost-effective in fighting the greenhouse effect. The Dutch Centre for Energy Savings studied the amount of money needed to prevent the emission of one metric ton of CO_2. Nuclear energy seemed to be near the bottom of the list of 16 favourable possibilities studied [46] .

6. Finally we point to the fact that, apart from increased CO_2 emissions by the use of poorer uranium ores, the greenhouse effect will not fade away with a planned development of nuclear power plants [47] [48] [49] . On being asked, the Uranium Institute declared that it saw nuclear energy not as the sole solution for the greenhouse effect. In the vision of the institute, nuclear energy can at most

contribute to its decrease, next to a maximum use of hydropower, sustainable energy from sun and wind, and an improvement in energy efficiency [50] .

Above, we have shown that it is a difficult task to justify the production and storage of nuclear waste. In exchange for the burden, we get energy that would have been unnecessary in another societal choice. Therefore, it is difficult to justify the burden that nuclear waste is.

3.6 The ethical principles of the IAEA and the NEA on the management of nuclear waste

3.6.1 IAEA

In 1995, after a long discussion, the International Atomic Energy Agency (IAEA) published principles on the management of nuclear waste. These principles were presented as ethical or as "a sound ethical thought" [51] . First we mention the principles with the explanation that the IAEA gives, followed by a critical comment from us.

Principle 1: Protection of human health.
Radioactive waste shall be managed in such a way as to secure an acceptable level of protection for human health. The management of nuclear waste should be part of the justification of the whole activity that produces nuclear waste. By itself, the managementhas not to be justified, according to the IAEA.
Comment. From the text, it is not clear what an acceptable level is, for whom it is acceptable and who decides on it. According to the IAEA, the justification of the storage of nuclear waste is part of the whole justification of the production of nuclear waste. In the preceding paragraph, we showed that this justification is a difficult task. The risk of a storage site in itself functions as an argument not to justify nuclear energy. We run the risk of a circular argument when, like the IAEA, we accept the justification of storage as a fact.
The storage and management of nuclear waste also has aspects of justification. Voluntariness of accepting a storage and distribution of burdens are important issues for the present generation. No explicit vision can be found in the IAEA text. Therefore, principle 1 seems to be not sufficiently worked out and is thus unclear.

Principle 2: Protection of the environment
Radioactive waste shall be managed in such a way as to provide an acceptable level of protection of the environment. Locally, radioactive waste can have negative consequences for the long-term availability or use of resources, for instance woods, water, land. The management of radioactive waste has to limit these consequences as far as possible.
Comment. The question can be made here as well what acceptable is, etc. It also is not clear what is meant by limiting consequences "as far as possible".

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 be taken into account. This principle was derived from the ethical care for the health of people and environment in foreign countries. It assumes that a country has the duty to prevent that foreign countries suffer those consequences that are unacceptable in its own country.
Comment. In the discussion on this principle, some countries, members of the IAEA, could not accept that their citizens are being exposed to a risk of nuclear waste from other countries. A majority consented to this principle: it is a political compromise.

Principle 4: Protection of future generations.
Radioactive waste shall be managed in such a way that predicted impacts on the health of future generations will not be greater than relevant levels of impact that are acceptable today. This principle was derived from the ethical care for future generations. It was meant to give reasonable certainty that there would be no unacceptable consequences. Besides, one has to take into account uncertainties in the judgements of safety.

Comment. Principle 4 caused a long discussion within the IAEA on radiation doses: should the permissible dose for future generations be lower than the present, because future generations did not benefit from nuclear energy? This discussion was settled to the advantage of the countries that want to maintain present standards. The IAEA leaves many questions unanswered, like the question what radiation doses are now acceptable and for whom; are present activities acceptable? The IAEA does not answer these questions.

Principle 5: Burdens on future generations.
Radioactive waste shall be managed in such a way that will not impose undue burdens on future generations. The care for future generations is of fundamental importance in the management of nuclear waste. This principle is based on the ethical consideration that generations benefiting from an activity also have the responsibility to manage the waste. The responsibility of the present generation implies the development of the technology, building and operation of storage sites, and the provision of funds. As far as possible, the management should not be based on long-term institutional regulations, although future generations might decide to do so. On the other hand, the IAEA states: restricted activities, like ongoing institutional control, may be shifted to future generations.
Comment. In the discussion, principle 5 was disputed by a substantial minority of IAEA-members. The discussion was on the question of what was to be preferred: the shift of burdens to future generations or unnecessarily restricting the freedom of choice of future generations.
Besides it is unclear what "undue burdens on future generations" means. It also remains unclear who should decide about it. What are the criteria for "due burdens"? Unfortunately, the answers are lacking in the plea of the IAEA. The vision on institutional control appears to be conflicting. This principle directly concerns the subject retrievability, where in fact also the choice between definite (underground) isolation and shifting choices to future generations is relevant.

Principle 6: National legal framework.
Radioactive waste shall be managed within an appropriate national legal framework.

Principle 7: Control of radioactive waste generation.
Generation of radioactive waste shall be kept to the minimum practicable.
Comment. The IAEA does not explain the meaning of "minimum practicable", whether it for instance means what is technically feasible or economically feasible.

Principle 8: Radioactive waste generation and management interdependencies.
Interdependencies among all steps in radioactive waste generation and management shall be appropriately taken into account. For instance, the choice for reprocessing implies that nuclear waste is generated with certain properties, with a certain production of heat that is of influence on the method of storage.

Principle 9: Safety of facilities.
The safety of facilities for radioactive waste management shall be appropriately assured during their lifetime. In designing, building, operating and dismantling of installations and storage sites, safety must have high priority. That means: preventing accidents and limiting of consequences when accidents do happen.
Comment on the last four principles. It is not so much that these are ethical principles, but a wish to have laws and rules, and compliance to these safety rules. A formulation like "will be taken into account" is an indication that options are kept open.

Conclusion. After a more detailed look, the IAEA principles appear not to be ethical considerations or a sound ethical thought but are sometimes controversial recommendations full of political compromises, where the question of moral justification of the production of nuclear waste is insufficiently under discussion. On the one hand, the principles (especially principle 5) are a plea against retrievability, where at the same time it is left open.

3.6.2 NEA

The OECD Nuclear Energy Agency in Paris published in 1995 a "collective opinion" on the environmental and ethical basis of final disposal of nuclear waste [52] .
In his introduction, Ron Flowers, chairman of the preceding workshop in 1994, mentioned that the NEA found it useful for policy makers and citizens to make a collective opinion on the ethical arguments that would lay down the foundations for a strategy of final disposal [53] .
In the discussion within the NEA, several utilitarian viewpoints were brought in [54] . The NEA admits that cost-benefit analysis and discounting do not account for the ethical questions of imposing burdens to future generations [55] . It is not explained how this should be. Therefore, the ethical assumption is not sufficiently worked out and not clear.

The NEA does not examine questions on the justification of the production of nuclear waste. The argument is that there is already an amount of nuclear waste and that we have to face the issue, regardless of the future of nuclear energy [56] . So the NEA does not take into account the important issue that a lack of moral justification could mean a ban on nuclear energy.
Such a lack of clear analysis goes also for the attempt to classify the storage of nuclear waste as consistent with sustainable development [57] . The NEA reasons: 1. sustainable development is in being an ethical principle; 2. ethics is a "morally correct human behaviour"; 3. final disposal is a morally correct behaviour; and 4. therefore, final disposal fits into sustainable development.

Apart from that, the NEA gives another interpretation to sustainability. It is on postponed final disposal, on temporal retrievable storage. There must be sufficient funds available for future expenditures. This is the NEA's interpretation of sustainable development. A generation passes a world to its next generation having the "same possibilities". The NEA calls this the "rolling present": the present generation has the responsibility to the next generation to hand over all technics, resources and possibilities to deal with the problem that is handed over by the present generation [58] . This means we have to organise the preservation of technics and knowledge.

According to the NEA, the goal of final disposal is to manage the nuclear waste in a way that possible future consequences are on a level that it is acceptable from an ethical point of view as well as from safety [59] . But how to know for sure that future consequences are of an acceptable level that is ethically acceptable? And in this context, what is the meaning of ethical?

Conclusion. The NEA does not start with clear contents of the concept of ethics. In the preceding discussion, it was discussed on the basis of a definition from a dictionary and no ethicists were present. This resulted in the NEA's "collective opinion" to an unclear environmental and ethical basis for storage of nuclear waste that does not answer the question of moral justification of production and storage of nuclear waste.

Sources:

1- Wim Zweers, "Participeren aan de natuur. Ontwerp voor een ecologisering van het wereldbeeld" (Participate to nature. Design for ecology in world view), Publisher Jan van Arkel, Utrecht, Netherlands, 1995.

2- "Filosofie van het geluk" (Philosophy of happiness), Henk Vos, Publishing house Het Spectrum, Utrecht, Netherlands, 1996.

3- Hardy Stevenson and Associates, "Moral and Ethical Issues Related to the Nuclear Fuel Waste Disposal Concept", Environmental Review Office, AECL Whiteshell Laboratories, Pinawa, Manitoba, Canada, October 1991, TR-549, COG-91-140.

4- K.S. Shrader-Frechette, "Nuclear Power and Public Policy. The Social and Ethical Problems of Fission Technology", Dordrecht, Netherlands, Reidel, 1980.

5- K.S. Shrader-Frechette, "Burying Uncertainty. Risk and the Case Against Geological Disposal of Nuclear Waste", University of California Press, Berkeley/Los Angeles/London, 1993.

6- Ernst Tugendhat, "Vorlesungen über Ethik" (Lectures on Ethics), Suhrkamp, Frankfurt am Main,

Germany, 1995
7- Hans Küng, "Weltethos für Weltpolitik und Weltwirtschaft" (World ethos for world politics and world economy), Piper Verlag, München, Germany, third edition, 1998, p. 135 and 299-312.
8- Christof Hubig, "Technik- und Wissenschaftsethik. Ein Leitfaden" (Technology and Science Ethics. A Guideline), Second edition, Springer, Berlin, Germany, 1995, p 116.
9- Declaration of Rio de Janeiro concerning Environment and Development, in reply to the United Nations Conference on Environment and Development from 3 to 14 June 1992, Principle 1 and 2.
10- John E. Seley and Julian Wolpert, "Equity and Location", in: Roger E. Kasperson (ed), "Equity Issues in Radioactive Waste Management", Oelgeschlager,Gunn & Hain Publishers, Cambridge, Massachusetts, USA, 1983, p 69.
11- K.S. Shrader-Frechette, "Risk and Rationality" University of California Press, 1991.
K.S. Shrader-Frechette, "Research in Philosophy and Technology", in: Frederick Ferré (Ed), Technology and the Environment, 12, p 147-155, University of Georgia, JAI Press inc, 1992.
K.S. Shrader-Frechette, "Nuclear Energy and Ethics", Geneva, Switzerland, 1991, World Council of Churches.
K.S. Shrader-Frechette, "Scientific Method, Anti-Foundationalism, and Public Decision-Making", in: Issues in Health and Safety, 23, p 23-41, 1990.
K.S. Shrader-Frechette, "Helping Science Serve Society: Natural Science, Nuclear Energy, and the Role of Traditional University Disciplines" in: "Hoe toonaangevend is de universiteit?, congresverslag ter gelegenheid van het 75e lustrum van de Rijksuniversiteit Groningen" (How leading is the University?, Report of congres on occasion of the 75th lustrum University Groningen), Magazine for scientific education, 36, 1, 1989.
K.S. Shrader-Frechette, "Planning for Changing Energy Conditions", in: Energy Policy Studies, 4, p 101-137, 1988.
K.S. Shrader-Frechette, "Risk Analysis and Scientific Method, Methodological and Ethical Problems with Evaluating Societal Hazards, D. Reidel Publishing Company (Kluwer-groep), Dordrecht, Boston, London, 1985.
K.S. Shrader-Frechette, "The Plutonium Economy: Technological Links and Epistemological Problems", in: Research in Philosophy and Technology, 8, 1985, p 189-220.
K.S. Shrader-Frechette, "Ethics and Energy", in: Tom Regan (Ed), Earthbound, New Introductory Essays in Environmental Ethics, 1984, p 107-146.
K.S. Shrader-Frechette, "Risk-Assessment Methodology and the Challenge of Jeffersonian Democracy: the Case of Nuclear Fission", in: John Byrne, Mary Helen Callahan, Daniel Rich (Eds), Energy Policy Studies, part 1, Energy Policy Research Group, University of Delaware, 1983, p 29-45.
K.S. Shrader-Frechette, "Environmental Impact Assessment and the Fallacy of Unfinished Business", in: Environmental Ethics, 4, 1982, p 37-47.
K.S. Shrader-Frechette, "Economic Analyses of Energy Options; a Critical Assessment of Some Recent Studies", paper presented at the international symposium: Energy and Ecological Modelling, Louisville, Kentucky, USA, 1981.
K.S. Shrader-Frechette (Ed), "Environmental Ethics", The Boxwood Press, Pacific Grove, California, USA, Fourth Printing, 1988.
12-. K.S. Shrader-Frechette, "Burying Uncertainty. Risk and the Case Against Geological Disposal of Nuclear Waste", University of California Press, Berkeley/Los Angeles/London, 1993.
13- Kristin Shrader-Frechette, "Ethical Dilemmas and Radioactive Waste: A Survey of the Issues", in: Environmental Ethics, Vol. 13, Winter 1991, p 327-343.
14- Howard Kunreuter, Douglas Easterling, William Desvouges and Paul Slovic, "Public Attitudes Toward Siting a High-Level Nuclear Waste Repository in Nevada", in: Risk Analysis, Vol. 10, No. 4, 1990, p 469-484.
15- Paul Slovic, James Flynn and Robin Gregory, "Stigma Happens: Social Problems in the Siting of Nuclear Waste Facilities" in: Risk Analysis, Vol. 14, No. 5, 1994, p 773-777.
16- "The Environmental and Ethical Basis of Geological Disposal", A Collective Opinion of the Radioactive Waste Management Committee of the OECD Nuclear Energy Agency, Paris, France, 1995, p8.
17- Hardy Stevenson and Associates, "Moral and Ethical Issues Related to the Nuclear Fuel Waste Disposal Concept", Environmental Review Office, AECL Whiteshell Laboratories, Pinawa, Manitoba, Canada, October 1991, TR-549, COG-91-140.
18- M.T. Hilhorst, "Verantwoordelijk voor toekomstige generaties? Een sociaal ethische bezinning op bevolkingsaantal, kernenergie, grondstoffen en genetica" (Responsibilities to future generations? A social

ethical reflection on population growth, nuclear energy, resources and genetics), Kok, Kampen, Netherlands, 1987.
19- Jef van Gerwen, "Toekomst en eindigheid" (Future and finiteness), in: I. Lecluyse en T. Vandevelde (ed), Verantwoordelijkheid voor toekomstige generaties (Responsibilities to future generations). Essays from and to Harry Berghs at his leave, Leuven/Apeldoorn, Netherlands, 1993, p 91-106.
20- Wim Zweers, "Reactie op samenvatting en vragen van de Stuurgroep" (Reaction on summary and questions of the Steering group), release of the Foundation Stichtse Milieufederatie, De Bilt, Netherlands, 11 June 1982.
21- P.A. Witherspoon, "Introduction to Second World Wide Review of Geological Problems in Radioactive Waste Isolation", in: P.A. Witherspoon, "Geological Problems in Radioactive Waste Isolation; Second World Wide Review", Berkeley, California, USA, Prepared for the U.S. Department of Energy under Contract DE.AC03-76SF00098, LBNL-38915, UC-814, September 1996, p 1.
22- Abel J. Gonzalez, "The Future of Radioactive Waste Disposal", in: proceedings Distec'98, International Conference on Radioactive Waste Disposal, 9-11 September 1998, Hamburg, Germany, p 19-29.
23- Nuclear Energy Agency, "Radioactive Waste Management in Perspective", Parijs, France, June 1996.
24- Coalition Agreement Government Schroeder, Germany, 20 October 1998, par. 3.
25- . K.S. Shrader-Frechette, "Burying Uncertainty. Risk and the Case Against Geological Disposal of Nuclear Waste", University of California Press, Berkeley/Los Angeles/London, 1993.
26- Commission Disposal On Land (OPLA), "Onderzoek naar geologische opberging van radioactief afval in Nederland. Eindrapport Fase 1, Bijlage 2, Samenvatting van de deelstudies Geologie, Geohydrologie, Gesteentemechanica, Stralingseffecten, Mijnbouwkunde" (Research on geological disposal of radioactive waste in The Netherlands. Final Report Fase 1, Supplement 2, Summary of the sub-studies on Geology, Geohydrology, Rock Mechanics, Radiation Effects, Mining Engineering), Published by Ministry of Economic Affairs, The Hague, Netherlands, May 1989.
27- Commission Disposal On Land (OPLA), "Bijlage Eindrapport aanvullend onderzoek van fase 1. Samenvattingen van de deelstudies" (Supplement of Final Report additional research of fase 1. Summary of the sub-studies), Published by Ministry of Economic Affairs, The Hague, Netherlands, September 1993.
28- A. Lagaaij and G. Verbong, "Kerntechniek in Nederland 1945-1974" (Nuclear technology in The Netherlands 1945-1974), KIvI- department Nuclear technology and Foundation History of Technology, The Hague/Eindhoven, The Netherlands, 1998, p 88.
29- Herman Damveld, Steef van Duin and Dirk Bannink, "Kernafval in zee of zout? Nee fout!" (Nuclear waste in sea or salt? No, wrong!), Published by Greenpeace Netherlands, Amsterdam, Netherlands, 1994, p 8.
30- J. Hoekstra, M.J.J.M. Ruesen and P.J. van der Hulst, "GKN Verleden, heden en toekomst" (GKN History, present and future), Hand out press presentation, Dodewaard, Netherlands, 29 April 1997.
31. Greenpeace Netherlands, "Afrekenen met Borssele" (Finishing with Borssele), Amsterdam, Netherlands, October 1994.
32- Lower Chamber (NL), Meeting year 1995-1996, 24525, nrs. 1-2, 20 December 1995, p 65.
33- Hans Blix, "Energy and Global Sustainable Development", Twenty-Second Annual Symposium Uranium Institute, 3-5 September 1997, London, UK.
34- IAEA, 1974 Annual Report, Wenen 1974; Joop Boer, Steef van duin, Jan Pieter Wind and Herman Damveld, "Atoomafval in beweging. Een overzicht van de problematiek van het radioactief afval" (Nuclear waste in motion. An overview of the problem of radioactive waste), De Haktol, Arnhem, Netherlands, 1982, p 7.
35- IAEA, International Symposium on Nuclear Fuel Cycle and Reactor Strategy: Adjusting to New Realities, Key Issue Papers, 3-6 June 1997, Vienna, Key Issue Paper Nr 1, p. 27.
36- In 1975 the IAEA prognosed in the year 2000 about 2,300,000 Megawatts (MW) of nuclear power plants operating. In 1997 the IAEA prognosed 368,000 MW in 2000. This is a reduction by 6.5. If the 1975 expectations would have come true, the uranium resources could only fulfil 6.5 years of needs, instead of 40 years.
37- Herman Damveld, "Kan kernenergie?" (Nuclear energy allowable?), Vereniging Milieudefensie, Amsterdam, Netherlands, 1980, p 137.
38- H. Visser et al., "Energie en het broeikaseffect. Een antwoord in 60 vragen" (Energy and the greenhouse effect. An answer in 60 questions), Published by EPON, EPZ, EZH, SEP and UNA, Arnhem, Netherlands, November 1997, p 91.
39- Laka Foundation, "Kernenergie geen remedie tegen broeikaseffect" (Nuclear power no remedy to the greenhouse effect), Amsterdam, Netherlands, October 1996.

40- Nuclear Energy Agency, "Uranium 1995: Resources, Production and Demand", NEA, Paris, Netherlands, 4 June 1996.
41- Herman Damveld, "Meer kernenergie verergert broeikaseffect" (More nuclear energy increases greenhouse effect) in: HN-magazine, 21 January 1989;
Herman Damveld, "No Leading Role for Nuclear Power in Preventing the Greenhouse Effect", in: WISE News Communique, nr. 389, 8 April 1993;
Greenpeace Netherlands, "Broeikasproblemen en kernenergie - een nucleaire illusie ontmanteld" (Greenhouse problems and nuclear energy - a nuclear illusion dismantled), Amsterdam, Netherlands, November 1992.
42- Fax of Tim Meadley, Head of External Communications Uranium Instituut to Herman Damveld, 27 October 1997.
43- Caroline Varley and John Paffenbarger, "Electricity Market Competition and Nuclear Power", lecture at: The Uranium Institute, Twenty-Third Annual Symposium, 10-11 September 1998, London, UK.
44- Nuclear Energy Agency, "Infrastructure for Nuclear Energy Deployment", Proceedings of an NEA Workshop 10-11 June 1966, Paris, France, 1996.
Nuclear Energy Agency, Press release 21 October 1997 at publishing the "The 1996 Annual Activity Report", Paris, France.
45- Ivan Vera, Evelyne Bertel and Geoffrey Stevens, "Alternative Nuclear Paths To 2050", Lecture on: The Uranium Institute, Twenty-Third Annual Symposium, 10-11 September 1998, London, UK.
46- Laka Foundation, "Kernenergie geen remedie tegen broeikaseffect" (Nuclear power no remedy to the greenhouse effect), Amsterdam, October 1996
47- Uranium Institute, News Release, "Nuclear power can contribute to limiting climate change", London, UK, 20 October 1997.
48- RIVM, "Zorgen voor morgen. Nationale Milieuverkenningen 1985-2010" (Care for tomorrow. National Environment Survey 1985-2010) Publisher Tjeenk Willink, Alphen aan de Rijn, Netherlands, 1988 p.XXIII.
49- A table is contained in a declaration of the Uranium Institute of 20 October 1997 on nuclear energy and climate change. According to this table the present worldwide emission of CO_2 is 23.7 Gigatons. Also with a huge increase of nuclear energy the scenarios for 2020 and 2050 prognose 30 to 55 Gigatons. On the other hand the CO_2 emission per person yearly may not exceed 2.2 tons to limit a sea level rise to a maximum of 70 centimeters in the next century. For the present 5.7 world population this is 12.5 Gigatons, this is half of the present emissions.
50- Fax Tim Meadley, 27 October 1997.
51- Ch. McCombie, "Ethische Aspekte der Endlagerung langlebiger radioaktiver Abfälle" (Ethical aspects of the final disposal of long-lived radioactive waste), in: Nagra Informiert (CH), Nr 29, April 1997, p37-46.
52- "The Environmental and Ethical Basis of Geological Disposal", A Collective Opinion of the Radioactive Waste Management Committee of the OECD Nuclear Energy Agency, Paris, France, 1995.
53- Ron Flowers, Introductory Remarks, in: Nuclear Energy Agency, "Environmental and ethical aspects of long-lived radioactive waste disposal", Proceedings of an International Workshop organised by the Nuclear Energy Agency in co-operation with the Environment Directorate, Paris, 1-2 September 1994, p 13.
54- NEA, Collective Opinion, p 8.
55- NEA, Collective Opinion, p 17.
56- NEA, Collective Opinion, p 12.
57- NEA, Collective Opinion, p 11.
58- NEA, Collective Opinion, p 16.
59- NEA, Collective Opinion, p 12.

4. SUSTAINABLE DEVELOPMENT

4.1 Sustainable development

The term "sustainable development" was used in 1980 for the first time. A number of United Nations international organisations and the World Wildlife Fund then published its "World Conservation Strategy" [1] .
The term became more widely known in the 1987 report, "Our Common Future", of the Brundtland Commission, also called the World Commission on Environment and Development (WCED) [2] . This commission was established by the United Nations.
The Brundtland report observed a development that more and more people get poorer where at the same time the quality of the environment worsens. According to the report, the environmental crisis, development crisis and energy crisis constitute a whole.
On the basis of this, the Brundtland Commission formulated the sustainable development: "production and consumption develop in a way that satisfies the needs of the present without compromising the abilities of future generations to meet their own needs".
Choices have to be made, and therefore sustainable development is not an economical, ecological or scientific concept but an ethical concept, according to Hans Küng [3] . In that way sustainable development links to the ethics of justice we discussed in chapter 3. The questions we discussed in that chapter are also applicable to the concept of sustainable development.

4.2 Sustainable energy supply

In the June 1996 report "Nuclear energy and sustainable development", the Utrecht professor Wim Turkenburg of the faculty of Natural Sciences and Society wrote: "As observed, an important goal of sustainable development is to create a harmony between humans and nature. In the energy supply, it is hardly a matter especially because of production and emission of waste material in almost all parts of the energy chain and its harmful consequences to people and to the environment" [4] .
Analyzing Turkenburg particularly, we derived eight criteria for sustainable energy supply which we concretise as follows:
1. clean,
2. safe,
3. efficient,
4. reliable,
5. payable,
6. available for the long term,
7. not obstructive: the used technology may not obstruct the development and use of a more preferable technology,
9. not discriminating: not to develop a technology that is allowed in Western democracy but not in countries with a dictatorial regime.

Nuclear energy from uranium can not meet criterion 1 (clean) because of the production of nuclear waste. Nuclear power is not safe, because an accident with serious consequences can not be excluded (criterion 2). In the present Dutch situation, nuclear energy is too expensive and is not efficient in fighting the greenhouse effect (criterion 5). Because of limited resources of uranium, it can not meet criterion 6. The embargo on the export of nuclear power plants to Iran that the United States wants to enforce upon Russia and the Ukraine is discriminatory, although Iran has signed international treaties (criterion 8). [5]

4.3 Nuclear waste and sustainability

At a 1994 workshop on nuclear energy and sustainable development, Gruppelaar of the Dutch Energy Research Foundation (ECN) stated that, in principle, it is acceptable to produce waste that has to be stored safely for tens of thousands to hundreds of thousands of years. There are two reasons: it is a small amount and "in the underground you can find places that have remained

stable for millions of years" [6] . In September 1998, the high IAEA official Morris Rosen emphasized the "small amounts" of nuclear waste as well; he stated that in the United States, nuclear waste counts for only 0.05 percent, and in France 0.015 percent of the total yearly produced amount of waste, including household wastes. [7]
Concerning the "small amounts", we refer to the following. Due to the accident at the Chernobyl nuclear power plant, a big part of Europe was contaminated. A calculation based on the reports of the NEA shows that only 50 kilograms of long-term dangerous fallout like cesium, strontium and plutonium was released [8] . Though these 50 kilograms were responsible for the fact that in Belarussia, Russia and the Ukraine, an extensive area was contaminated for a long time.
Gruppelaar wants a big number of requirements for a disposal location and in addition reduce the amount of radioactive waste through partitioning and transmutation, the separation and transformation of long-lived radioactive substances into short-lived ones.
According to a December 1997 report of the NEA, the separation of these long-lived radioactive substances has a lot of uncertainties. There is lack of basic knowledge and practical experience, whereas the separation process knows a number of inherent restrictions [9] . Besides, the separation requires a number of radical changes in reprocessing plants that have not been foreseen [10] .

The transmutation is still in a stadium of research as well. Transmutation of curium, one of the actinides, seems to be not feasible due to the high alpha, gamma and neutron doses by decay and spontaneous fission, states R.J.M. Konings of the ECN in 1998; he considers transmutation of technetium to be too expensive [11] .
During the 1994 workshop referred to, professor C. Andriesse commented on Gruppelaar's vision. According to Andriesse, the research on and development of transmutation would need decades. Therefore, he concluded: "At present it can not be said that a sustainable application is possible, not even in the realm of principle" [12] .
Summarized, with nuclear waste we deal with relatively small amounts of volume, that nevertheless are dangerous indeed. A small amount alone is therefore not a decisive argument to consider nuclear waste in harmony with sustainability.

Sources:

1- Wouter Achterberg, "Samenleving, Natuur en Duurzaamheid. Een inleiding in de milieufilosofie" (Society, Nature and sustainability. An introduction in environmental philosophy), Van Gorcum, Assen, Netherlands, 1994, p 26-27.
2- WCED, "Our Common Future", Oxford University Press, Oxford, UK, 1987.
3- Hans Küng, "Weltethos für Weltpolitik und Weltwirtschaft" (World ethics and world economy), Piper Verlag, München, Germany, Third print 1998, p 323-324.
4- Wim Turkenburg, "Kernenergie en duurzame ontwikkeling" (Nuclear energy and sustainable development), Study 8 of Technology Assessment HTR, Petten, Netherlands, 1996, ECN-C--96-048, p 15.
5- Atomwirtschaft (FRG), May 1998, p 340.
6- F. Arts, W. de Ruiter and W.C. Turkenburg (red), "Kernenergie en Duurzame Ontwikkeling", verslag van een workshop gehouden te Utrecht op 14 januari 1994 (Nuclear energy and sustainable development; report of a workshop held in Utrecht, 14 January 1994), release of the faculty for Nature Sciences and Society, Utrecht, Netherlands, p 61.
7- Morris Rosen, "Managing Radioactive Waste: Issues and Misunderstandings", lecture on: The Uranium Institute, Twenty-Third Annual Symposium, 10-11 September 1998, London.
8- NEA, "Chernobyl Ten Years On. Radiological and Health Impact", Paris, France, 1996, p 29.
NEA, "Sarcophagus Safety '94. The State of the Chernobyl Nuclear Power Plant Unit 4", Proceedings of an International Symposium Zeleny Mys, Chernobyl, Ukraine, 14-18 March 1994, p 46.
9- NEA Nuclear Science Committee, "Actinide Separation Chemistry in Nuclear Waste Streams and Materials", Nuclear Energy Agency, Paris, December 1997, NEA/NSC/DOC(97)19.
10- Nucleonics Week, 7 January 1993, p 1, 10-11.
11- Technisch Weekblad (NL), 6 May 1998, p 4.
12- F. Arts et al., op. cit., p 69.

5. RISK SOCIETY, ACCEPTANCE AND RISK PERCEPTION

5.1 Risk society

Resistance to the storage of nuclear waste refers to anxiety about the control over technology. On this theme a discussion is taking place in the light of the concept of "risk society".
In 1986, the German sociologist Ulrich Beck published the book "Risikogesellschaft" [1] . The different definitions of risk will be discussed later in this chapter. The concept "society" is not unambiguous as well. For instance, in 1997, an sociologist Niklas Luhmann published a 1,150-page book on the question of what society exactly is [2] . An analysis of his argumentation is beyond our aim. Here we will shortly sketch Beck and Luhmann's interpretation of "risk society". The use of the term "risk society" means that one simplifies complex coherent relations and considers some phenomena representative for the whole society. With "risk society", new risks caused by technology become all the more conspicuous. [3]

In the present society, the dependency on technology has increased, with the result that an unexpected failure of technology (and especially the electricity supply) also leads to a serious failure in the society which we trust. In other words, the technological development has led to several non-natural matters of course. [4]
According to Beck, the role of risks and danger indicates that slowly and almost imperceptively, we have reached another type of society. In his theory, Beck states that social conflicts in society deal less with the distribution of welfare but increasingly with the distribution of risks; about questions of responsibilities for the effects of catastrophes and about the question of decision-making competency on risks for humans, nature and the environment.

5.2 Public acceptance

The Dutch Social and Cultural Planning authority (SCP) studied the public acceptance for environmental policy [5] [6] . The concept "social or public acceptance", in the sense of a more subjective support to policy, is of a relatively recent date. On one hand, a complicated society needs complex regulations, whereas on the other hand, an accurate control on the observance of rules is impossible, states SCP. As if to say that people have to agree among themselves to governmental policy. This is called public acceptance.
On the level of the people, public acceptance can be derived from meanings, public opinions and the opinion climate.

The degree of the public's trust in government is important for public acceptance. In 1991, Reinier de Man observed in a report on the history of the discussion about the storage of nuclear waste: "The previous history provides no favourable climate for an open constructive discussion. It also provides no climate where the different parties bring their own definitions under discussion." [7]
An important reason for distrust is the aftermath of the Broad Public Debate on energy policy. The January 1984 final report on the discussion observed only 21 percent of the public in favour of building new nuclear power plants. Nevertheless, the government decided in the beginning of 1984 to start this building. The former chairman of the debate, De Brauw, stated on May 30, 1984, that these plans increased distrust in democracy. [8]

5.3 Risk perception

5.3.1 Definition of risk

The Groningen social-psychologist Charles Vlek mentions no less than 20 definitions of the concept of risk [9] [10] [11] [12] . Instead of a full review, we will shortly introduce the concept. Most common dictionary definitions of risk are "danger for damages or losses" or "chance of damages or losses". We sometimes can quantify danger and its chances. For instance, insurance companies that want to determine a premium. Therefore, one has to calculate on the chance of damage and the extent of the damage. In the economy as well (the "company's risk") as in statistics (theory of probabilities), measurable definitions of risk are being used.

One definition Vlek mentions is the possibility of an unwanted effect (death, damage or loss). Sometimes risk is called the "chance" of an unwanted effect, or risk is called the seriousness of a maximum possibility of unwanted effect. In technical studies on nuclear energy and nuclear waste, risk is often defined as the multiplication of chances of an accident times the seriousness of it: this is called expected loss. In again another interpretation, it is supposed that an activity is difficult to manage: in that case, risk is a lack of supposed manageability.
Vlek states: "The existence of various definitions of risk is one explanation for the confusion and differences of opinion that can occur in 'acceptable risk' discussions. In almost each risk definition, the measurability of probabilities and the judgement on the seriousness of an accident come as core problems" [13] .

5.3.2 Judgement on risk in nuclear waste.

In the observation and judgement on risk, experts and citizens differ. Research by Paul Slovic and his colleagues show these differences in risk estimations for all risky activities, but especially for nuclear energy [14] . American engineers who are daily engaged in risk analysis put smoking, alcohol and car driving on top of a list of 30 most risky activities. Nuclear energy was put on number 20 and was considered to be less dangerous than flying, cycling or travelling by train. Women put nuclear energy on the first position before the car, hand weapons and smoking. Students put nuclear energy on the first position as well.
With nuclear energy, Slovic et al. speak of a threatening risk marked by the lack of control, the possibility of a big disaster with fatal consequences and an unequal distribution of benefits and costs between generations. Nuclear energy and nuclear weapons score highest on this factor. This is a determining factor: the higher the observed risk, the more the risk should be reduced and the more the people are favourable to strict regulations to reach a reduction.

Slovic et al. also studied the perception of the dangers of nuclear waste [15] . In the US, the researchers asked how far from an underground storage site for nuclear waste one wanted to live. The answer was: 200 miles, two times as far away as from the last in the list of 16, unwanted installations as storage site for chemical waste, and three to eight times the wanted distance to a nuclear power plant, pesticides factory or oil refinery.
In another study, they asked people to associate. This led to exactly 10,000 associations. The researchers themselves were amazed by the extremely negative images of nuclear waste. The two most sizeable categories (danger/poisonous and death/disease) count for 56 percent of the associations. In only 4 percent the associations gave a positive image, like it gives employment, gives income. The negative image was remarkable equally between men and women, youth and elderly people, high- and low-income, and different political convictions.

From studies, it has shown that nuclear waste, nuclear energy and nuclear weapons are closely connected to each other. Slovic et al. state: "The shared imaging of nuclear weapons, nuclear energy and nuclear waste can probably explain why a storage site for nuclear waste is judged by citizens as even dangerous as a nuclear power plant or test site for nuclear weapons."
Also remarkable is the fact that American studies show a relatively small difference in the judgement on aboveground storage on nuclear power plant sites or underground storage. In both cases, citizens see the storage harmful for tourism, employment and the realisation of new industries [16] .

In their research, Slovic and his co-workers made a list of the most important factors that influence risk perception and judgement [17] [18] [19] [20] [21] [22] [23] . On the whole, this list is found in other studies, among others Meertens, Vlek and Van der Pligt [24] . We derived 14 factors that influence judgement:

1. Possibility of serious disasters.
2. Small accidents are a signal that things could go wrong.
3. Distribution over time, and justice: no risks should be passed on to future generations.
4. Globality: the more people that can be victimized, the more unacceptable.
5. Involuntariness: one does not accept a risk imposed by government or by industry.
6. Trust in government and in science is of overriding importance in storage plans.
7. Persistent beliefs: after having formed an opinion, it is not easy to change it quickly.
8. Familiarity with the risk: as almost no one is familiar with nuclear waste, a resistance against storage plans is the result.
9. Personal controllability and reversibility: people have the feeling that they are unable to control nuclear waste storage, and it becomes irreversible when things go wrong.
10. For the perception of risk, there is no difference between aboveground and underground waste storage.
11. In people's judgement, the risks of nuclear waste, nuclear energy and nuclear weapons are closely connected to one other.
12. Stigmatization: the fear that because of nuclear waste, a community will acquire a bad reputation and will suffer economic damages.
13. Possibility to avoid the risk: for the perception of risk, there is a difference between the discussion about waste produced by closed nuclear power plants and the discussion about ongoing production from nuclear power plants in service or are under construction.
14. The idea that insufficient money is being reserved for future storage costs.

Of these 14 factors, we mention five that play a big role in the risk-judging of nuclear waste.

1. Possibility of serious disasters.
Technical experts judge the risk that victimised a lot of people once the same as risks that cost some lives a lot of times. Laymen attach more importance to catastrophic events. Therefore, risks with small chances and huge consequences are estimated more serious than more probable risks with only small consequences [25] . Technical experts emphasise the small chances for accidents. Next to this vision of engineers is the opinion of citizens that, apart from this small chance, anyhow the next day an accident can happen with huge consequences for the surroundings.

2. Distribution over time and justice.
This factor is on the possible time delay between exposure to a certain risk and the occurrence of effects. With this the possible threat to future generations plays an important role. The public knows that only high-radiation doses cause death in the short term but a low-radiation dose can cause cancer in the long term. Laymen find it unjust that people still die in Hiroshima and Nagasaki as a consequence of the atomic bombs [26] .
Swedish researchers have learned that citizens think that present politicians are responsible for the already produced nuclear waste for at least 50 to 600 years from now; they are as much concerned about the consequences 100 years or 200 years from now: it is not that near generations have more weight [27] .

3. Voluntariness.
The public finds that voluntarily taken risks are more acceptable than involuntary risks. From research it seems to be that the degree of voluntariness is of a very high influence in judging a risk as acceptable or unacceptable. It is a question whether one can decide to accept a risk (for instance, go skiing) or one is forced to run a risk (the government that exposes citizens to experience a risky activity like a nuclear power plant). People accept a voluntary risk many times bigger than an involuntary risk [28] .
It is often mentioned about Nimby (Not In My Backyard), that the people protest because they do not want a dangerous installation in their "backyard". De Ruiter, however, points to the fact that "research has proved that one does not actually want to avoid a risk for himself and expose others

to it, but that one wishes to avoid situations in which some of the people are confronted with a risk and at the same time others have benefits from it. In the case of nuclear energy, it is difficult to satisfy the feelings of justice of the public". [29]

4. Trust in government.
If individuals are not able to control a risk they are exposed to, these risks are only seen to be eventually acceptable if these are controlled by competent institutions that enjoy the people's confidence.
Slovic et al. observed in their research a strong distrust in government: 68 percent do not believe that government would immediately report accidents or serious problems with the storage of nuclear waste. De Ruiter concludes: "The fear of the public for nuclear energy is partly caused because of a crisis of confidence, a deep distrust towards the managers responsible for nuclear technologies." [30]
The crisis of confidence causes information to have little effect. If people trust an institute responsible for dealing with risks, communication is relatively easy. If trust is lacking, each form of communication is deemed to fail. Therefore, trust is of more importance for the solution of conflicts than communication. [31] [32] [33]

5. Possibility to avoid a risk.
The possibility to avoid a risk plays a big role in nuclear energy. Energy scenarios without nuclear energy often get broad support from citizens.
In practice, it seems to make a difference whether the discussion is about already produced nuclear waste or nuclear waste still to be produced. Nuclear waste that is to be produced can still be possibly avoided, but already produced nuclear waste is inevitable. According to some organisations, a discussion about this inevitable amount of nuclear waste is indeed possible. For instance, Greenpeace Switzerland employee Wendel Hilti states: "If the nuclear power plants will have been shut down and we have made a comparative study on all options, then we are prepared to discuss storage locations and research needed to be done. But for the time being, we resist any research, against all test drillings." [34]

In their study, Meertens, Vlek and Van der Pligt summarize the considered judgement-dimensions to three factors:
- unfamiliarity with the risk by which one does not want to run the risk voluntarily; one observes the risk as unmanageable and uncontrollable;
- possible consequences and the accompanying fear;
- trust in the degree of controlling an accident by oneself and by experts [35] .

There is as well wisdom as lack of knowledge in the attitudes of people. Unless it is structured as a two-sided process, risk-communication is destined to be unsuccessful. Each side, experts and citizens, can contribute something valuable [36] . A two-sided process implies that the parties should have equal possibilities to firm up their visions.
Besides, we want to point out that not all cases of radioactivity leads to unrest. Radiotherapy in hospitals is broadly accepted. This demonstrates that a radiation technology can be accepted if people are familiar with it, the benefits are clearly visible, and the conductors of the therapy are trusted. [37]

Sources:

1- Ulrich Beck, "Risikogesellschaft. Auf dem Weg in eine andere Moderne" (Risk society. On the way to another modern age), Suhrkamp, Frankfurt am Main, Germany, First print, 1986.
2- Niklas Luhmann, "Die Gesellschaft der Gesellschaft" (The society of society), Suhrkamp, Frankfurt am Main, Germany, 1997.
3- Luhmann, cit., p 1089-1090.
4- Luhmann, cit., p 532.

5- J.W. Becker, A. v.d. Broek, P. Dekker and M. Nas, "Publieke opinie en milieu. Een verkenning van het sociale draagvlak voor het milieubeleid op grond van survey-gegevens" (Public opinion and environment. A survey of public acceptance for environmental policy on basis of survey-facts), Social and Cultural Authority, Rijswijk, Netherlands, January 1996.
6- Masja Nas, Paul Dekker and Carlos Hemmers, "Maatschappelijke organisaties, publieke opinie en milieu" (Social organisations, public opinion and environment), Social and Cultural Authority, Rijswijk, Netherlands, April 1997.
7- Reinier de Man, "Ondergrondse berging van onverwerkbaar afval" (Underground storage of unprocessable waste), Publication series radiation protection, Ministry of Environmental Affairs, The Hague, Netherlands, nr 1991/53, December 1991.
8- Herman Damveld, "Kernenergie, verlichting of conflict" (Nuclear energy, reliance or conflict), Published by the Milieufederatie Groningen, Netherlands, 1984, p 157.
9- C.A.J. Vlek, "Beter omgaan met risico's: Beschrijven, Beoordelen, Beslissen en Beheersen" (Better management of risks: Describing, Judging, Deciding and Managing); in : Eindverslag symposium 'De schijn van kans' (End report symposium 'the ghost of chance'), Risico-acceptatie en Veiligheid in de Civiele Techniek (Risk acceptance and Safety in Civil Technology), Delft, Netherlands, 29 April 1993, p 51-55.
10- C.A.J.Vlek, "Beslissen over risico-acceptatie. Rapport in hoofdlijnen" (To decide on risk acceptance. Report in outlines), Gezondheidsrapport, The Hague, Netherlands, 1990
11- Charles A.J. Vlek, "A multi-level, multi-stage and multi-attribute perspective on risk assessment, decision-making and risk control", in: Risk decision and Policy 1 (1), 9-31 (1996).
12- Charles A.J. Vlek, "Social Psychology on Nuclear Technology: Processes of Risk Assessment, Decision-making and Risk Control", Edited text of lecture held on April 24, 1997, for Belgian Nuclear Society.
13- Vlek, 29 April 1993, p 52.
14- Paul Slovic, Sarah Lichtenstein and Baruch Fischhoff, "Images of Disaster: Perception and Acceptance of Risks from Nuclear Power", in G.T. Goodman and W.D. Rowe (eds), Energy Risk Management, Academic Press, 1979, p 223-245.
15- Paul Slovic, James H. Flynn, Mark Layman, "Perceived Risk, Trust, and the Politics of Nuclear Waste", Science, Vol. 254, p 1603-1607, 13 December 1991.
16- Gilbert W. Bassett Jr., Hank C. Jenkins-Smith and Carol Silva, "On-Site Storage of High Level Nuclear Waste: Attitudes and Perceptions of Local Residents", in: Risk Analysis, Vol. 16, No. 3, 1996, p 309-319.
17- Paul Slovic, "Perception of Risk", Science, Vol. 236. p 280-285, 17 April 1987.
18- Paul Slovic, James H.Flynn, Mark Leyman, "Perceived Risk, Trust, and teh Politics of Nuclear Waste" Science, Vol.254, p 1603-1607, 13 December 1991
19- Daniel Kahneman, Paul Slovic, Amos Tversky (eds), "Judgement under uncertainty: Heuristics and biases", Cambridge University Press, 1982.
20- Baruch Foschhoff, Sarah Lichtenstein, Paul Slovic, Stephen L.Derby and Ralph L.Keeney, "Acceptable Risk", Cambridge University Press, 1981
21- Paul Slovic, Sarah Lichtenstein and Baruch Fischhoff, "Images of Disaster: Perception and Acceptance of Risks from Nuclear Power", in G.T. Goodman and W.D. Rowe (eds), Energy Risk Management, Academic Press, 1979, p 223-245.
22- Paul Slovic, Sarah Lichtenstein and Baruch Fischhoff, "Facts and Fears: Understanding Perceived Risks", in: Richmond C.Schwing and Walter A.Alberts (eds), Societal Risk Assessment. How Safe is Safe Enough? Plenum Press, 1980, p 181-214
23- Helmut Jungermann and Paul Slovic, "Die Psychologie der Kognition und Evaluation von Risiko" (The psychology of cognition and evaluation of risks), in: Gotthard Bechmann (Hrsg), Risiko und Gesellschaft. Grundlagen und Ergebnisse interdisziplinärer Risikoforschung (Risk and Society. Basics and outcome of interdisciplinary risk research), Westdeutscher Verlag, Germany, 1993, p 167-207.
24- R.W. Meertens, J. van der Pligt and C.A.J. Vlek, "Omgaan met milieurisico's: beoordeling, communicatie en besluitvorming" (Dealing with environmental risks: judgement, communication and decision making), in: C.J.H. Midden en G.C. Bartels (red), Consument en milieu: beoordeling van milieurisico's en sturing van gedrag (Consumer and environment: judgement of environmental risks and steering of behaviour), Houten, Bohn Stafleu van Loghum, Netherlands, 1994, p 57-80.
25- W. de Ruiter, "Maatschappelijk draagvlak voor de introductie van de Hoge Temperatuur Reactor" (Public acceptance for the introduction of the High Temperature Reactor), Technology Assessment HTR, study 7, Petten, Netherlands, June 1996, ECN-C-96-047, cit., p 13-17.

26- De Ruiter, cit., p 14.
27- Ola Svenson and Gunnar Karlsson, "Decision-Making, Time Horizons, and Risk in the Very Long-Term Perspective", in: Risk Analysis, Vol. 9, No.3, 1989, p 385-399.
28- Chauncey Starr, "Sozialer Nutzen versus technisches Risiko" (Social benefits against technical risks), in: Gotthard Bechmann (Hrsg.), Risiko und Gesellschaft. Grundlagen und Ergebnisse interdisziplinäre Risikoforschung (Risk and society. Basics and outcome of interdisciplinary risk research), Westdeutscher Verlag, Germany, 1993, p 3-24.
29- De Ruiter, cit., p 14-15.
30- De Ruiter, cit., p 15.
31- Paul Slovic, "Perceived Risk, Trust and Democracy", in: Risk Analysis, Vol. 13., No. 6, 1993, p 675-682.
32- Donald MacGregor, Paul Slovic, Robert G.Mason, John Detweiler, Sphen E.Binney and Brian Dodd, "Perceived Risks of Radioactive Waste Traqnsport Through Oregon: Results of a Statewise Survey", in: Risk Analysis, Vol 14, No 1, 1994, p 5-14
33- Report of the Nuclear Fuel Waste Management and Disposal Concept Environmental Assessment Panel, "Nuclear Fuel Waste Management and Disposal Concept", Minister of Public Works and Government Services Canada, February 1998, p 37.
34- Conversation of Herman Damveld with Wendel Hilti in Zürich (CH), 20 May 1998.
35- R.W. Meertens, J. van der Pligt and C.A.J. Vlek, "Omgaan met milieurisico's: beoordeling, communicatie en besluitvorming" (dealing with environmental risks: judgement, communication and decision making), in: C.J.H. Midden and G.C. Bartels (ed), Consument en milieu: beoordeling van milieurisico's en sturing van gedrag (Consumer and environment: judgement of environmental risks and steering of behaviour), Houten, Netherlands, Bohn Stafleu van Loghum, 1994, p 57-80.
36- Egon R. Frech and Mary A. Greber, "Overcoming the Risk Perception Gap: a Socially Acceptable Approach to Waste Management", IAEA-CN-54/P05, 1995.
37- Paul Slovic, Sarah Lichtenstein and Baruch Fischhoff, "Images of Disaster: Perception and Acceptance of Risks from Nuclear Power", in G.T. Goodman and W.D. Rowe (eds), Energy Risk Management, Academic Press, 1979, p 223-245.

6. MARKING

Responsibility to future generations implies that we necessarily have to do all to prevent future harm. This makes warnings to the future all the more necessary. But how to do it? In broad lines, there are two approaches: the active and passive institutional control.
The active one is promoted by the researchers Kornwachs and Berndes from the Technical University in Cottbus. They want to establish adequate institutions: "We look to the organisation of cloisters and universities, how their internal structures have remained intact. In Germany, the church survived the Nazi regime as well as the GDR regime. Which qualities make the church that tough? That is what we want to study, but we have not solved it yet". [1] [2] In this way they search for the properties that are responsible for the long-term existence of an institution.

The Department of Energy has chosen for passive institutional control [3] [4] [5] . These are aboveground and underground markings and other methods to preserve knowledge of the stored nuclear waste for 10,000 years. During this time, people should be prevented from digging up the waste from the Waste Isolation Pilot Plant (WIPP). A concept has been chosen with a right-angled fence, something larger than the underground storage. The fence measures 720 by 874 meters, at the base 30 meters and on top 4 meters wide, with a height of 10 meters. In addition, 32 identical granite monuments are planned to be buried below ground level. On all aboveground and underground surfaces, messages and pictograms are to be put on.

The Department of Energy sees Stonehenge in England as an example--a historical analogue-- for a marking system. Stonehenge consists of stones in a circle measuring 120 meters in diameter. Blocks of granite were used that in some cases weighed 54 metric tons. Stonehenge was built around the year 3000 before Christ.
There are, however, some problems. Stonehenge is a memorable marking that invites people to visit. This is contrary to the marking the Americans want to realise. The message of the marking after all has to be: keep out of here, do not dig in the ground. The marking has to scare. But sometimes people do not mind about warnings, like warnings on cigarette packages that smoking can harm one’s health. Moreover, the markings may not consist of valuable material because of the chance of theft.

As historical analogue for the preservation of written information, the Department of Energy refers to the Vatican's archives in Rome that are almost 400 years of age. The Department states: "The transfer of the archives to France (1810-1811) and the return to Rome (1817) resulted in the loss of almost one-third of the documents." But that will not happen again: "There will be a multiple storage of documents to guarantee against losses of information of WIPP."

Sources:

1- Klaus Kornwachs, "Wissen für die Zukunft? Über die Frage, wie man Wissen für die Zukunft stabiliseren kann - eine Problemskizze" (Knowledge for the future? On the question how to stabilize knowledge into the future), Institute for Philosophy and Technology History Brandenburg Technical University Cottbus, Germany, PT-01/1995.
2- Klaus Kornwachs, "Entsorgung von Wissen" (Management of knowledge), in: Das Denkmal als Altlast? Auf dem Weg in die Reparaturgesellschaft (The memorial as legacy? On the way to a repair society). Conference German National Committee of ICOMOS and chair for Monument care and Construction Research of the University Dortmund auf der Kokerei Hansa, Dortmund-Huckarde, Germany, 11-13 October 1995, p 26-33.
3- Title 40 CFR Part 191, Compliance Certification Application for the Waste Isolation Pilot Plant, Appendix Passive Institutional Controls, Conceptual Design Report, Revision 0, United States Department of Energy, Waste Isolation Plant, Carlsbad Area Office, Carlsbad, New Mexico, 14 November 1996; hereafter mentioned as Appendix PIC.
4- Kathleen M.Trauth, Stephen C.Hora and Robert V.Guzowski, "Expert Judgement on Markers to Deter Inadvertent Human Intrusion into the Wasye Isolation Pilot Plant", Sandia Report, SAND92-1382. UC-721, published in November 1993.

5- Kathleen M. Trauth, e.a., "Effectiveness of Passive Institutional Controls in Reducing Inadvertent Human Intrusion into the Waste Isolation Pilot Plant for Use in Performance Assessments", United States Department of Energy, Waste Isolation Pilot Plant, Carlsbad Area Office, Carlsbad, New Mexico, WIPP/CAO-96-3168, Revision 1, 14 November 1996, with Addendum of 6 December 1996, p. ix and x.

7. RETRIEVABILITY

7.1 Government's policy on retrievability

Government's policy on retrievable storage of radioactive and dangerous waste was released on May 14, 1993. [1] The government [2] pointed to two aspects: the environmental policy and the technical feasibility. The central goal of environmental policy is to work towards sustainable development that, among others, has been worked out in the concept of "external integration"; that means: reuse, prevention and leakproof removal [3] .
The cabinet stated: "At the moment full prevention of the production of highly toxic waste is not possible without big interventions in the societal process." [4] According to the government, the benefits of those production processes have to be weighed against the disadvantages of the production of highly toxic waste.

These considerations have led to the following view of the cabinet [5] :

a. The production of highly toxic waste is undesirable in the light of sustainable development. Producers of waste have to make clear why the production is justifiable.

b. "For the long-term storage of highly toxic waste, a facility has to be realised," that has to comply with retrievability for two reasons. The isolation and the controllability by human intervention have to be optimal; a storage concept that can not fulfil the criteria of Isolation, Management and Control is rejected; the storage concept should be "reversible as a matter of principle". The waste should be available for reuse if new possibilities arise.

c. Retrievability "has the consequence that future generations will be obligated to take care of the highly toxic waste. The disadvantages of the required efforts in time and money are not expected to weigh up against the benefits of the possibility to intervention, redestination and relocation".

d. Non-retrievable storage in salt formations are rejected because of the "physical properties of salt that will enclose the waste when closing the storage room"; the retrievability "is limited because of this".

This cabinet's policy has a number of effects, according to Environmental Affairs Minister Alders [6] :

a. The policy "is no solution yet ... for the storage of highly toxic waste".

b. The government will view the permission to a process with the production of highly toxic waste as "an exceptional case".

c. "Generic research" should be conducted for a storage fitting the conditions of retrievability "during the whole storage period". This research "shall be aimed at having, within some years, a closer orientation to a possibility of final storage".

d. The answer to the National Environmental Policy Plan-62 question [7] is: the deep underground can be used for the storage of waste, if the condition of retrievability is met.

Salt drops out?

Because of the cabinet's policy, the firm impression is raised that the government rejected the storage of waste in salt formations. The Independent Geologists Platform asked Alders to confirm this in writing. On July 5, 1993, the minister wrote back [8] : "The criterion of retrievability [is] for the whole period of storage and not only for a limited period." The minister also introduced the term permanent retrievability when he stated that he qualified salt as "less attractive for permanent storage". He continued: "Maybe it is in theory possible to create a retrievable storage in salt by means of huge (and costly) efforts; however, I find it a little realistic to assume that storage in salt is qualified."

However, Alders was more careful to the parliament. On June 17, 1993, the parliamentary commission for environmental policy sent a list of 30 questions to the minister of Environmental Affairs [9] , that were answered on October 21, 1993 [10] . The commission asked whether "further research to the storage of waste in salt formations will be given up". Minister Alders answered that salt is "less attractive" for a "permanent retrievable" storage; but "it is not useful to exclude one option, namely, salt mines, beforehand." The minister wrote that apart from salt, clay in the south of The Netherlands can be qualified for "further research".

The November 1993 "File Nuclear Energy", with the then Minister of Economic Affairs Andriessen signing it as first responsible, devoted some passages to nuclear waste. The government decided on retrievability ("permanent retrievability") and research had to be done to storage concepts that are "publicly acceptable" [11] .

On March 24, 1995, the ministers of economic affairs and environmental policy published in the gazette the draft amendment of the Mine Regulation 1964 [12] . It says that if waste "is stored in an underground site that belongs to a mine, the owner of a valid concession of that mine is obligated to, as long as the material is stored, take all necessary measures needed to prevent unacceptable harmful consequences for the environment or to guarantee the safety of this storage". The above means maintenance for centuries. In the discussion on this draft-amendment, Minister of Environmental Affairs De Boer pointed to the undesirability of underground storage [13] .

7.2 Ethics, sustainability, risk perception, marking and retrievability

According to utilitarian principles, the advantage of the production of nuclear waste can be justified when the negative consequences are minimalised. In utilitarianism, people of the future weigh less than those of the present, and this is called discounting. Therefore, it is justified that in future, harmful consequences will occur because of the storage of nuclear waste.

Opposite utilitarianism, we counterpoise what we call the ethics of justice. This ethical theory, also called plausible ethics, considers future generations equal to the present one. If the present generation wants the storage of nuclear waste to meet high requirements to prevent negative effects, then that should also apply to future generations. Permanent retrievability can fulfil this. With permanent retrievability, every succeeding generation has to be presented possibilities to control the waste and eventually take measures. In this way, irreversible consequences can be prevented.

At the same time, the necessary efforts will therefore increase, because one has to keep the storage intact. Each new generation will be duty-bound to maintain and control the storage. Our view is that the idea of retrievability is, because of the possibility to prevent irreversible consequences, ethically less unfavourable than final disposal. However, we choose for permanent retrievability.

We observe that permanent retrievable storage in salt or clay is less obvious because of physical properties. This pleads for aboveground retrievable storage as an ethically less unfavourable choice.

The working out of the ethically least unfavourable option raises some questions. It is on the question of stability of institutions that have to manage the waste. In this context, the Swiss geologist Marcos Buser speaks about contradictions in the argumentation. On the one hand, in nuclear power plants the human factor is a risky uncertainty. On the other hand, according to Buser, retrievability means trust in the faulty human for years to come: "What will happen in a war? The nuclear waste can be released after a bombardment. Then radioactivity will be released into the environment for sure". [14]

A dilemma will remain for which no real solution is on hand. Although retrievability has the advantage, that one can later decide to store the waste in another way. With non-retrievability, definitive storage on another option is cut off once and for all.

According to the principles of sustainable development, the needs of future generations may not be endangered by the present one. Therefore, the storage of nuclear waste has to be designed in a way that no harm will occur in future. In principle, retrievability can fulfil this, for the possibility of control and interference can prevent that harm. On the other hand, we think retrievability is in a certain way in conflict with sustainability. We could ask whether the duty to look after negative influences is based on the "abilities of future generations to meet their own needs". Retrievability on its own is no reason to call the production and existence of nuclear waste in harmony with sustainability.

Concerning the production (of nuclear energy) as well as the storage, little public acceptance was present in the past. The question is which changes in risk perception can be expected with the introduction of retrievability. Of the 14 formulated factors, the one with the most direct relation to retrievability is factor nine: controllability and reversibility. The perception will be influenced positively on this point because of the introduction of retrievability. But controllability is one of the factors. When government wants to create acceptance for the policy on waste, it will have to take into account the other factors.

We want to indicate that the factor "possibility to avoid" (13) still plays an important role in the waste problem. The continuation (or eventually enlargement) of nuclear energy stipulates the judgement of the waste problem highly.

Nuclear waste remains dangerous for a long period of time. The handing over of information to future generations was the theme of chapter 6 (marking). With permanent retrievability, it is mostly on the handing over of knowledge. This means knowledge about the inventory, the types, properties and amounts of the waste. This means active institutional control.

Sources:

1- Lower Chamber (NL), Meeting year 1992-1993, 23163, nr 1.
2- Idem, paragraph 1.
3- Idem, paragraph 3.
4- Idem, paragraph 4.
5- Idem, paragraph 5.
6- Idem, paragraph 6.
7- "A government's position will be determined on the question whether deep underground can be used for the storage of waste, and if so, under which conditions", Lower Chamber (NL), Meeting year 1988-1989, No. 21137, nrs. 1-2, p.147.
8- Letter DGM/SVS/11693001, Netherlands, 5 July 1993.
9- Lower Chamber (NL), Letter 35/93 MB, 17 June 1993.
10- Letter DGM/SVS/20993008, Netherlands, 21 October 1993.
11- Idem, paragraph 3.5.
12- Gazette (NL), "Ontwerp-wijziging Mijnregelement 1964" (Draft-amandment Mine regulation), Netherlands, 24 March 1995.
13- Lower Chamber (NL), Meeting year 1994-1995, 23900 XIII, nr 46, "Algemeen overleg vaste commissie voor Economische Zaken en vaste commissie voor VROM met minister Wijers en De Boer over de wijziging van het Mijnreglement 1964 (brengen van stoffen in ondergrondse werken)" (General consultation permanent commission for Economic Affairs and permanent commission for Environmental Affairs with minister Wijers and De Boer about the amandment of the Mine Regulation 1964 (disposal of material in underground works), Netherlands, 13 June 1995.

14- Marcos Buser, "Hüte-Konzept versus Endlagerung radioaktiver Abfälle: Argumente, Diskurse und Ausblick" (The Hut-Concept versus final disposal of radioactive waste: arguments, discussion and prognosis), Expert report on request of the main department of safety for nuclear installations, Zürich, Switzerland, 1988, p 20.

8. ANALYSIS OF INTERVIEWS

For this study, 12 environmental organisations were interviewed. For a number of these organisations, the ongoing production of radioactive waste was reason not to cooperate. The plans in the past on storage in salt resulted in distrust for government, second reason not to cooperate. Cooperating organisations also see dangers in thinking and looking for a "solution" for the reason that this will open the way for the extension of nuclear energy.

The concept of retrievability was introduced in the discussion about underground storage. The possibility to keep waste accessible and controllable is, for the organisations, reason to see retrievability also as an option for aboveground storage.

For most of the organisations, their opinion on underground storage does not change by the introduction of the concept of retrievability. They do not think this is possible for a long time (permanently). The fear exists that the storage will be converted into a definitive form. A definitive underground storage is not acceptable to any of the organisations.

With aboveground storage, the possibilities for accessibility, controllability and processing into non-hazardous waste are considered to be higher. Aboveground and visible, this would stimulate continuing maintenance and a continuing search for a solution. The organisations think that if the storage were underground, then this stimulation would be absent. With aboveground storage, some think it would give a signal to future generations on the dangers of nuclear energy.

For short-term solutions, the organisations see the termination of the nuclear energy programme necessary. For the biggest part, the organisations think of storage at the present COVRA; the storage in closed nuclear power plants was also mentioned.

For the long term, definite plans have to be made. Some doubt the safety of the COVRA because of the consequences of the greenhouse effect.

In chapter 3, we discussed ethics and responsibilities to future generations. The organisations see nuclear waste as an outstanding example of shifting the harmful consequences of a problem to future generations. The organisations can not justify the existence and further production of nuclear waste.

According to the organisations, nuclear energy can not meet the criteria of sustainable development. Especially the factors clean, safe and affordable score negatively.

The preceding 14 factors were formulated to be of influence on risk-perception of nuclear waste. The factors’ distribution over time, globality and possibility to avoid the risk determine the negative judgement on the waste problem in general. For more specified plans on a waste storage site, the factors voluntariness, trust in government, controllability and stigmatization play a role. Controllability is the most important factor in judging future policy on waste. Retrievability will be of influence on the factor controllability because of the possibilities to repair.

Distrust in government plays an important role in the discussion about the waste problem. For instance, the fear exists that government uses retrievability to push through earlier plans and a discussion about solutions could lead to ongoing production of waste and an extension of nuclear energy.

In the discussion, the factor possibility to avoid plays a dominant role. The organisations make little difference between amounts of waste still to be produced and the already existing amount. The ongoing production strongly influences the judgement. A stop to nuclear energy could possibly change this, after all it is known what absolute amounts (inevitable) have to be stored.

9. CONCLUSIONS AND RECOMMENDATIONS

In this last chapter, conclusions are made about the four theoretical frameworks of ethics, sustainability, risk perception and marking in relation to retrievability. We shortly go into the conditions for a discussion about the storage of existing nuclear waste and give some recommendations to the CORA and policy makers as well.

CONCLUSIONS

Retrievability and ethics

Retrievability can prevent the release of nuclear waste and becoming uncontrollable. At the same time, the necessary efforts increase because we have to keep the storage intact: retrievability means that future generations will be duty-bound to maintain and control and it will cost more.

Retrievability also has the advantage that one can later decide to store the waste in another way. With non-retrievable, definitive storage, another option is cut off once and for all.

It is our view, therefore, that the idea of retrievability is ethically less unfavourable than final disposal. An important condition is the reservation of sufficient money to pay for future storage costs.

Permanent retrievable storage in salt or clay formations is less obvious, because of its creeping properties. Thus permanent retrievability can not be guaranteed. Therefore, we conclude that aboveground retrievable storage is the ethically less unfavourable choice. However, this calls into question the stability of institutions that have to control the nuclear waste and the durability of buildings and location. There remains a dilemma without any real solution.

Retrievability and sustainability

Production of nuclear waste is said to be in consistency with sustainability because it would be in small amounts. But small amounts though these may be, they constitute a higher level of danger. According to the principles of sustainability, this waste has to be stored in a way that future damage is prevented. In principle, retrievability can fulfil this, when the retrievability is permanent. Retrievability on its own is no reason to call the production and existence of nuclear waste in harmony with sustainability.

Retrievability and risk perception

From literature, we found 14 factors to be of influence in judging the risks. The factor controllability and reversibility will be influenced positively by retrievability. Besides, we mention that the 13 other factors influence the risk perception. The factor "possibility to avoid" still plays an important role in the judgements, because of the ongoing use of nuclear energy.

Retrievability and marking

Permanent retrievability means that information on the waste has to be handed over to generations following ours. On the basis of available literature, we conclude that little consideration has been made on this issue.

Retrievability and environmental organisations

From the interviews with the environmental organisations, we conclude that almost all of the formulated factors influence risk perception of nuclear waste. Especially the factors distribution over time, globality and possibility to avoid determine the negative judgements on storage of nuclear waste in general. The factors voluntariness, trust in government, controllability and stigmatization are of influence in specific plans for a storage.

On the question of how to deal with the storage of nuclear waste, the environmental organisations attach much value to the factor controllability. Retrievability implicates controllability, an important factor in judgements about risks, but only one of the formulated factors. We conclude that with retrievability, the risk judgements partly will change.

The past distrust that has grown towards government is an important obstacle to any policy or within any discussion about dealing with the produced nuclear waste.

Discussions about storage of nuclear waste

The character of discussions about the storage of nuclear waste has changed in time. We conclude this from an analysis in a number of countries. Initially, governments choose siting locations and announced it to the population. This led to a fierce resistance to such a degree that plans were generally halted. In the '90s, public acceptance and voluntary participation have become important.

We conclude that a discussion about the storage of existing nuclear waste should meet a number of conditions:

- In the discussion, ethical and social aspects have to play a full role.
- Nobody should be excluded from the discussion and the different parties should get funds to substantiate their standpoints.
- There should be an independent authority that organises the discussion.
- Given the fear that government could seize a discussion to build new nuclear power plants, the government should give guarantees. A possibility is that government orders that a decision for new nuclear power plants can only be made after a binding referendum.
- The discussions should first be held, with the conclusions being drawn or the goals being enunciated afterwards. One should not just draw conclusions from a 100-year-old aboveground storage of nuclear waste at the COVRA in Zealand.

RECOMMENDATIONS TO CORA

1. We recommend that CORA study how far the ideas of citizens and technicians about risk perception correspond. In this, the 14 risk perception factors formulated by us can function as a guide.

2. We advise CORA to develop a proposal on how to link more closely the technical research with social and ethical aspects.

3. Our assertions about judgements on risks are based on empirical studies in foreign countries. Whether the results fully apply to The Netherlands is unknown. Our hypothesis is that this is correct. CORA could test this hypothesis, or take into account that it is correct in developing its policy.

4. Radiation therapy in hospitals is broadly accepted. This shows that a radiation technology can be accepted when people are familiar with it, with the advantages clear and those who handle it are trusted. This might be a starting point for the path CORA can go, when production of nuclear waste halts.

5. In foreign countries, many discussions about the storage of nuclear waste have taken place. There has been no good overview on those discussions, the methodologies used and the decision-

making procedures. We recommend that such an overview be made for an eventual discussion in The Netherlands.

6. CORA assumes a period of retrievability of about 200 years. With this, CORA differs from the government that spoke about permanent retrievability. We recommend that CORA maintain permanent retrievability.

7. Subject to further study should be the way of maintaning knowledge about nuclear waste, the marking of storage sites, and the applicability for The Netherlands of the elements discussed in chapter 6. We recommend that CORA conduct such a study.

RECOMMENDATIONS TO POLICY MAKERS

1. To policy makers, we recommend that clarifications be made on how to give form to permanent retrievable storage.

2. We advise the development of plans to gain public acceptance for permanent retrievable storage.

3. We recommend that a broad discussion will be held about the choices to be made on retrievable storage of nuclear waste.