# Do It Together…Or Wait.
# Radioactive Waste Management in the Netherlands

H.D.K. Codée, E.V. Verhoef
COVRA N.V.
P.O Box 202, 4380 AE Vlissingen,
The Netherlands

## ABSTRACT

Fifty years of nuclear industry and the wide spread use of radioactive materials in Europe have resulted in matured programmes for radioactive waste management. According to the self-sufficiency principle, each country collects, processes, stores and disposes of its radioactive waste. National programmes allow close control of possible environmental and safety impacts, but are not the optimal choice for disposal of radioactive waste in countries with small nuclear programmes. Most technical, safety and environmental arguments are in favour of a ‘shared’ disposal. In this paper, it will be shown that although these concerns are the dominant drivers, common sense, historical facts, and economic considerations point to the shared or regional solution as well.

## INTRODUCTION

Most human activities generate waste. Some say that one of the characteristics that make us human is that we produce ‘waste’[1]. In the early days of our existence most waste was degradable, only a few traces are left of the human activities. Some waste, however, was and still is long-lived, such as the stone chisels or arrow points from people living in the Stone Age. This long-lived waste can now be found in museums. It tells us today about the life of the past. Many of the treasures you will find in historic museums are actually wastes: materials and products intended to be forgotten, at the end of their practical use. Centuries-old dumpsites are to this day providing archaeologists and historians with new treasure troves.

Waste production is not new, but we have improved our means of producing it. Since the beginning of the Industrial Age much more (hazardous and long-lived) waste has been produced than in the past. Unfortunately, our waste management methods did not advance at the same speed (see Fig. 1). In general, not much attention was given to the waste management until the ‘discovery’ of the Environment in the seventies. The landfill of the city of New York, Fresh Kills, is the largest man made structure in the world (right photo in Fig. 1). The landfill results from only six decades of the New York way of life. Another example is that the possible adverse effects of $CO_2$ are widely discussed since only a decade!

[1] Ecologists observe that waste does not exist in nature. The mass balances in natural system are effectively closed: each organism produces food for other organism. Garbologists —archaeologists that study, analyse and dig up waste— come to the same conclusion.[1]

The nuclear industry and the wide spread use of radioactive materials started in 1953 with the Atoms for Peace program. In the beginning neither the environment nor radioactive waste got much attention. In the early fifties some radioactive waste was tipped overboard from passenger cruise ships crossing the Atlantic Ocean. At that time of course, it was just a few single drums produced each year. When quantities increased multinational sea disposal started in the late sixties, which called for international surveillance.[2, 3] This practice ended in 1982. The philosophy behind disposal at sea was the dilution principle and this principle was abandoned at the end of the seventies.

Fig. 1.  Disposal of waste in New York around 1900 (left) and 2000 (right).[4]

Waste prevention, reuse and isolation of hazardous materials from the biosphere were the guidelines of the eighties, followed by sustainability in the nineties. As a result the current EU Landfill directive prescribes maintenance, monitoring and control (after-care) for as long as required by the authorities, taking into account the time during which the landfill could present hazards.  This may be up to a thousand years. The price charged by the operator must include the costs for an after-care period of at least 30 years.[5]

The fixed but very long life times of radioactive substances, such as the transuranic elements, imply even longer periods of time that these materials have to be looked after. Radioactive waste management is therefore in the forefront of long-term environmental management.

At the national level most countries in Europe created dedicated waste management organisations (see Table I). COVRA in the Netherlands is one of these organisations. On the time scale of radioactive waste disposal, however, state boundaries and therefore national solutions are meaningless. It can thus easily be seen that rather than the present, purely national approaches, regional approaches are absolutely necessary, together with a multinational or even supranational surveillance system.

In this paper we will argue that although environmental and safety concerns are the dominant drivers, common sense and economic factors point to the shared or regional solutions as well.

Table I. Waste Organisations in Europe, Installed Nuclear Power and Number of Nuclear Research Reactors per Country.

| Country | Waste Management Organisation | Installed nuclear power (MWe)[1] | Research reactors[2,3] | |
|---|---|---|---|---|
| France | ANDRA | 63,283 | 15 | (16) |
| Germany | BfS/DBE | 20,643 | 13 | (33) |
| United Kingdom | NIREX | 12,052 | 3 | (33) |
| Sweden | SKB | 9,439 | 2 | (2) |
| Spain | ENRESA | 7,585 | 0 | (4) |
| Belgium | ONDRAF/NIRAS | 5,760 | 4 | (2) |
| Czech Republic | SURAO (RAWRA) | 3,472 | 3 | (2) |
| Switzerland | NAGRA | 3,220 | 3 | (3) |
| Bulgaria | SSE RAW | 2,722 | 0 | (1) |
| Finland | POSIVA | 2,656 | 1 | (1) |
| Slovak Republic | - | 2,408 | - | - |
| Lithuania | RATA | 2,370 | - | - |
| Hungary | PURAM | 1,755 | 2 | (1) |
| Slovenia | ARAO | 676 (50%) | 1 | - |
| Croatia | - | 676 (50%) | - | - |
| Romania | ANDRAD | 655 | 2 | (2) |
| Netherlands | COVRA | 450 | 3 | (2) |
| Italy | SOGIN/NUCLECO | - | 5 | (9) |
| Austria | Austrian Research Centre | - | 2 | (1) |
| Greece | Demokritos Research Centre | - | 2 | (1) |
| Norway | Institute for Energy Technology | - | 2 | - |
| Denmark | Risø National Laboratory | - | 1 | (2) |
| Poland | - | - | 1 | (4) |
| Portugal | - | - | 1 | - |
| Latvia | RAPA | - | - | (1) |
| Estonia | ALARA | - | - | - |

[1] Source: SVA 2004. 2004. Nuclear power plants worldwide 2004. Swiss Association for Atomic Energy.
[2] A research reactor is under construction in the Russian federation and another is planned in France. The number of shut down or decommissioned research reactors is given in between brackets.
[3] Source: IAEA 1999. Research Reactor Data Base (RRDB). International Atomic Energy Agency. Division of Physical and Chemical Sciences, Physics Section in the Department of Nuclear Science and Applications. Internet: www.iaea.org/worldatom/rrdb/ accessed November 2005.

## LONG-TERM SOLUTIONS

Long term isolation from our living environment is needed for high-level waste and alpha-emitting waste. Long term in this case means periods of time surpassing with many orders of magnitude the scale of human life. It is new to man to address such time scales for events happening in the future. Such periods are only addressed in geology and logically the possibility to dispose of long-lived wastes in geologically stable formations has been studied. Other options have been addressed in the past, such as projection into space and emplacement in subduction zones, but these are no longer considered since safety is not assured.

Already in 1957, the disposal in salt formations was described as the most promising method.[6] Half a century later not only salt formations are considered as possible host rock formations but also granite, argillaceous sediments and tuff. A vast amount of data has been obtained on migration of nuclides in various geologies and on the behaviour of the underground. Safety assessment tools have been developed and brought to high levels of confidence.

In 1991, an international collective opinion was issued, confirming that safety assessment methods are available today to evaluate the potential impact, and considering that use of assessment methods can provide the technical basis to decide whether satisfactory safety is offered for current and future generations.[7] In a status review on geological disposal of radioactive waste, published in 1999, it has been claimed that deep geological disposal is the most appropriate means of long-term management.[8]

Although partitioning and transmutation are promising techniques to be used in the future to shorten the life times of transuranic elements substantially, not all long-lived material will eventually be transmuted. It is most likely that there will always remain a volume of waste that has to be isolated from the environment for hundreds of thousand years. Until a scientific and technological breakthrough occurs in this area, geological disposal is the only long-term solution available.

## PRACTICE IN THE NETHERLANDS

In the Netherlands one nuclear power plant, two nuclear research centres, a uranium enrichment plant and a medical isotope production facility are in operation. In addition, there is a widespread use of radioactive materials in other areas. The Netherlands is a country with a small nuclear power programme, which is foreseen to remain stable the next tens of years. The nuclear power plant Borsele (PWR, 450 MWe) is in operation since 1973 and is scheduled to remain operational until 2033.

The annually produced quantity of radioactive waste in the Netherlands is small and very heterogeneous. A solution to manage this waste, tailor-made to the country's needs, has been set up since the early eighties and is now in full operation. All radioactive waste in the Netherlands is managed by COVRA, the Central Organisation for Radioactive Waste. Its task is to execute the policy of the government. This policy has not changed since it was discussed and approved by Parliament in 1984. The policy lays down that all radioactive waste will be stored above ground in engineered structures allowing retrieval at all times for a period of at least 100 years. After this period of long-term storage final disposal is foreseen. The policy is based on a step-wise decision process in which all decisions are taken to ensure safe disposal in a repository, but without excluding unforeseen alternative solutions in the future.

Buildings for the treatment and storage of all categories of waste have been constructed, commissioned and are now in full operation (see Fig. 2). Information on the siting process, licensing, construction and practical experience in the Netherlands can be found in the literature and in the NEWMDB of the IAEA..[9, 10, 11]


Fig. 2. The different buildings at the COVRA site, clockwise: building for waste treatment (upper left), for storage of low and intermediate level waste, NORM waste, and high level waste (lower left).

## ECONOMY OF SCALE

In general, the volume of radioactive waste is small in comparison with municipal waste or chemical waste. This is an advantage, because it can easily be controlled and contained. But this can also be a disadvantage because of the negative effects of economy of scale. "Small is beautiful" is a nice slogan, but it has its drawbacks.

For the situation in the Netherlands, it was obvious that a period of long-term storage was needed before a deep repository could be constructed. Both the small volume of waste and the limited financial means are determining factors. A direct disposal route is not feasible because of the economy of scale. Moreover, the small volume of waste can easily be kept under control in above ground structures. This ‘interim’ storage provides time to let the volume of waste accumulate and to let the money, needed for disposal, grow in a capital growth fund.

With only 450 MWe installed nuclear capacity in the Netherlands, it can easily be calculated that some 100 TWh of electricity will be produced in a period of 30 years. The estimated costs for a national repository are 1.3 billion Euro. The result is that 1.3 Eurocent per kWh as calculated levy on the nuclear electricity is needed for the repository. Considering the cost price of nuclear electricity is around 2 to 5 Eurocent per kWh [12], this would mean an increase of 65% to 26 %. It follows directly from this simple logic that a national direct disposal route for a country with a small nuclear programme is impossible! The threshold for a direct disposal route is an installed nuclear capacity of some thousand MWe. It can be easily seen from Table I that not all countries can afford this option in Europe. For western economies financial advantage can be found in net value calculations. Practically, disposal will take place after some thirty years of operational lifetime of the nuclear installation. Net value calculations with thirty years delay will result in a reduction factor of two to three in actual money value. The general result is that realisation of disposal is financially only feasible after some thirty years of operation of at least 2500 MWe. Again Table I clarifies the practical problem for many countries.

The small volume of radioactive waste from nuclear activities forms the next reason to wait or to co-operate. For the Netherlands, the volume of all categories of radioactive waste generated by the nuclear power station of 450 MWe over 30 years is only a few thousand $m^3$. Such small volume will make the disposal costs per $m^3$ unacceptable. Other waste generators certainly cannot afford these $m^3$ prices. The total volume after 30 years is still too small to urge for direct disposal.

Because of these reasons, a repository is never available at the very beginning of the waste generation and interim storage is always needed. The costs for interim storage cannot be avoided. Structures for interim storage that will last for 100 years as compared to just some tens of years do not differ fundamentally in costs. The challenge of engineering buildings to last for a hundred years or more is the compliance with present and future environmental legislation and acceptability to the public at all times. It is thus uncertainty that costs money: a policy changing every few years, lack of a clear policy, or lack of political decisions create sub-optimal solutions. Constructing a facility for storage just for a short period of time and then refurbishing it several times because the storage period is not as short as expected, is wasting money and has a negative effect on the image of radioactive waste management.

The reality of today is that radioactive waste is generated already for over half a century. Apart from the waste disposed of in the WIPP facility [13], no other long-lived waste has been disposed of in a deep repository yet.

A small volume of waste can easily be kept under control in above ground structures. Under these conditions, it is not feasible to realise a national disposal facility within, or directly after, the 30 years operating lifetime of just one nuclear plant. Even a lifetime extension to 60 years does not change that conclusion. Time is needed to let the volume of waste grow and to let the money grow in a capital growth fund. Over long periods of time, i.e. 100 years, growth by one order of magnitude can be obtained with a real interest rate of 2.5%. Of course, higher real interest rates as could be easily obtained in the seventies and eighties create better results (see Fig. 3).

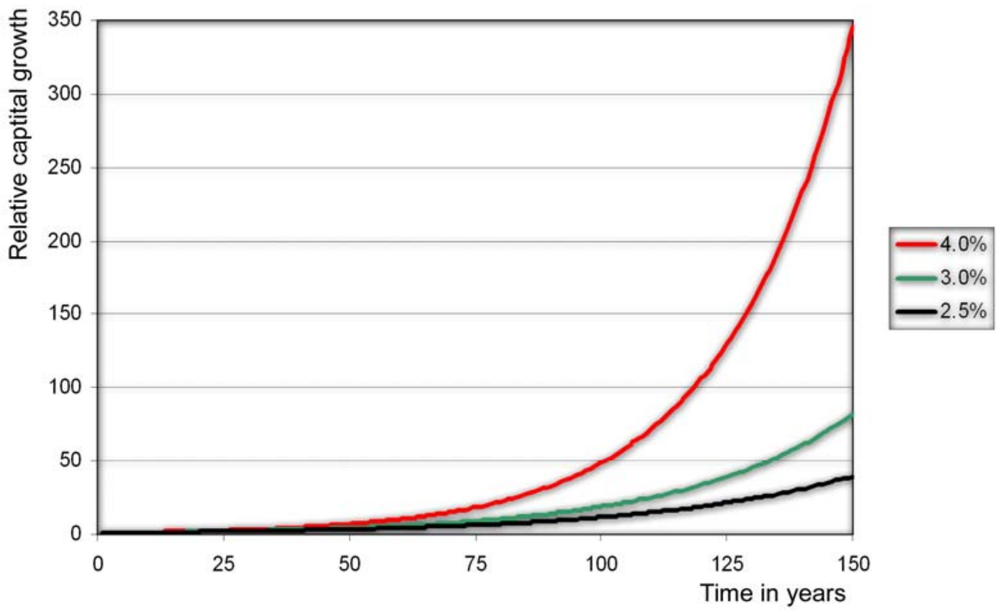


Fig. 3. Relative capital growth in a fund with 2.5%, 3.0%, and 4.0% interest.

## CHANGING BORDERS

There is a widespread preference for national disposal solutions, as this would enable closer control of possible environmental and safety impacts. However, long-term national control appears an oxymoron.

A deep repository is likely to be operational for many tens of years. Then a period of active control and monitoring of some hundreds of years could follow and ultimately the repository could be left for some hundreds of thousand of years with minimal or perhaps even no surveillance. For a period of hundreds of years, national boundaries as well as national structures are uncertain. The history of Europe clearly shows this (see Fig. 4). Any control of the environmental and safety impacts of the chosen disposal solution, that needs to last for times exceeding the lifespan of national structures, has to be as independent as possible of national structures. Hence regional solutions must be preferred to national solutions.

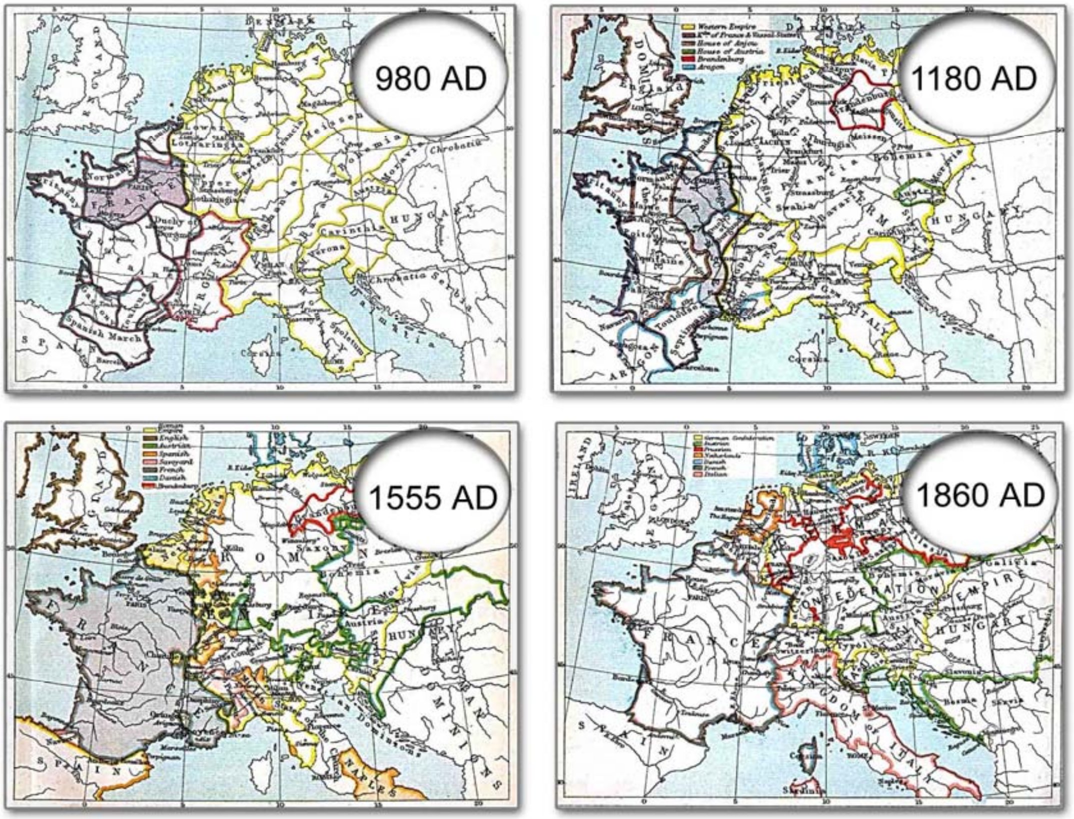


Fig. 4. Maps of Central Europe in 980, 1180, 1555 and 1860 AD show the changes of national borders in time.[14]

## SURVEILLANCE

The materials placed in a deep repository are still hazardous and, within the context of today’s society, should be kept under surveillance. Firstly, surveillance is needed to confirm that the material does not pose adverse effects to man or the environment. Secondly, surveillance is needed to prevent abuse of the materials. Since 2001, awareness has increased on this last point. As security is a global concern, surveillance limited to one national institute or structure is not sufficient. At least, a multinational structure must be present to control that the materials remain in place. Considering the long time frame within which national, and therefore multinational, structures are unstable, a system of supranational surveillance is preferred. Control by an institution such as the IAEA seems logical. A recent survey in the European Union [15] indicated a very broad consensus (89 % of the interviewed agreed) on the need for European monitoring and harmonization of the national programmes.

## DO IT TOGETHER….

Many countries have a nuclear power program smaller than 2500 MWe installed capacity. As was stated in the paragraph on economy of scale, this means that direct disposal is economically not feasible. Either a waiting period is needed to let the money accumulate in a growth fund or the repository has to be shared with others. In the EU, all 25 member states generate radioactive waste. Of course there are large differences in type and quantity between the member states. But even a country with only lightning rods with radium does need a long-term solution. The 1600 year half-life of radium does not fit in a solution with a span of control of just a few hundred years.

When the 25 European countries create each a repository adequate to their needs, this will be a tremendous waste of resources. Volume wise one repository can do for all the radioactive waste in the European Union. Because of the present public attitude as well as legislative obstacles, this will be very difficult to obtain. More realistic is the creation of a few regional repositories.

Until now not much has been done on the subject of multilateral approaches in the Netherlands. All effort has been put into setting up the infrastructure of COVRA and to the construction and commissioning of the facilities needed for long-term storage. Now these are all operational and time has come to start working on the subsequent step: final disposal. This was already foreseen in the policy paper on radioactive waste that was discussed and accepted by Parliament in 1984 in the Netherlands and that forms the base of COVRA’s activities:

> “*Therefore a site must be found in the Netherlands where storage of all categories of radioactive waste can take place. During the storage period further considerations can be given to final disposal, international developments can be followed and even an international facility could be used*”.

Considering the many advantages of a shared repository, it is logical to include it as an option. This has to be done with a very open mind, which means that sharing does not exclude being the host. All possibilities should be kept open and the pros and cons of a shared facility will have to be studied first. A first study of this kind was the SAPIERR project [16] and this is an important first step towards an outline of a European facility. Another important initiative is the creation of ARIUS, the association for regional and international underground storage.[17] This organisation will continuously start discussions with those interested in creating solutions for waste management, knowing the sensitivity of this subject. A first reaction of society on this subject will be that shared solutions are of course to be preferred, but NIMBY will immediately follow. Waste, including household waste, was kept on private premises in the past. Logic development in a complex society is sharing of activities in order to obtain better solutions. Better nowadays does not only mean better in an economic sense but also in an environmental and safety sense.

## CONCLUSION

In practice only one solution exists for the final disposal of long-lived radioactive waste: a deep geological repository. Political and societal constraints have hampered the realisation of such facilities up to now. For countries with small nuclear power programs, economy of scale will force them either to wait and long-term store, or to share a repository with others. Historical development, uncertainty of national borders, the need for supranational surveillance and simple logic also drives towards shared solutions. Repositories should become common!

## REFERENCES

1. W.L. Rahtje and C. Murphy. Rubbish, the archaeology of waste. Tucson: University of Arizona Press. 2001.
2. OECD/NEA. Radioactive Waste Disposal Operation into the Atlantic 1967. OECD, Paris 1968.
3. OECD/NEA. Decision of the OECD council Establishing a Multilateral Consultation and Surveillance Mechanism for Sea Dumping of radioactive wastes. C(77)115(Final), OECD, Paris 1977.
4. R.R. Pinderhughes. Race, Poverty and the Environment. Urban Studies Program (Spring), San Francisco State University, 2004.
5. Council Directive 1999/31/EC on the Landfill of Waste. Official Journal of European Communities. L182: 1-19.
6. National Research Council of the United States. The Disposal of Radioactive Waste on Land. National Academy of Sciences, Washington, USA, 1957
7. NEA. Disposal of Radioactive Waste: can Long-term Safety be Evaluated? An International Collective Opinion. Paris, OECD, 1991
8. NEA. Progress towards Geological Disposal of Radioactive Waste: Where do We Stand? Paris, OECD, 1999
9. H.D.K. Codée. A solution that works! Radioactive waste management in the Netherlands. CNS Waste Management ’05, Ottawa, Canada, May 8-11, 2005.
10. H.D.K. Codée. Safe is beautiful! CNS Waste Management ’05, Ottawa, Canada, May 8-11, 2005.
11. IAEA, Net Enabled Waste Management Data Base (NEWMDB), www.newmdb.iaea.org
12. OECD/NEA Annual Report 2004 III: Nuclear Development and the Fuel Cycle Nuclear. Development Committee (NDC). Paris, OECD, 2004.
13. Internet:www.wipp.ws
14. Atlas to Freeman's Historical Geography, edited by J.B. Bury, Longmans Green and Co. Third Edition 1903. The University of Texas at Austin. www.lib.utexas.edu/maps/historical/central_europe.html

15. European Commission. 2005. Eurobarometer 227
Internet: europa.eu.int/comm/public_opinion/archives/ebs/ebs_227_sum_en.pdf

16. Internet:www.sapierr.net

17. Internet:www.arius-world.org