Paper presented at Valdor 2006, 14-18 May, Stockholm, Sweden,
http://www.congrex.com/valdor2006/

Nuclear Waste, Risks and Sustainable Development

Mikael Karlsson
Swedish Society for Nature Conservation
P.O. Box 4625
SE-116 91 Stockholm, Sweden
http://www.snf.se

Johan Swahn
Swedish NGO Office for Nuclear Waste Review (MKG)
P.O. Box 7005
SE-402 31 Göteborg, Sweden
http://www.mkg.se

1. The Challenge of Sustainable Development

Since the early 1970s, the view on how human society should interact with the environment has undergone fundamental changes. The initial focus on strict environmental and health concerns, such as aspects of air, water or land pollution, has gradually been incorporated in the much wider notion of sustainable development. Even though central elements of the concept goes back quite some time, it entered the international agenda with the definition of the 1987 World Commission on Environment and Development, to meet 'the needs of the present, without compromising the ability of future generations to meet their own needs' [1].

Since then, different interpretations have been elaborated in political assemblies, international treaties and by researchers and other stakeholders. For instance, sustainable development is nowadays an overriding objective in the treaty of the European Union as well as in the Swedish Environmental Code. A number of mainstream interpretations attempt to operationalise the concept in terms of relationships between society and the environment e.g. in terms of maximum sustainable yield, limit values for different pollutants, retained resilience, or maintenance of different types of capital.

Such approaches may work fine in cases of sufficient knowledge and basic common understanding of challenges and solutions. The more uncertain and the more controversial risks become, however, the less workable is the approach. A challenging and complementary way of operationalising sustainable development is through process-related principles for public policy, namely the precautionary principle, the polluter pays principle, and the principle of public participation [2]. In this brief article, we will investigate to what extent the nuclear waste project proposed by the Swedish nuclear industry relates to these principles.

2. The Proposed Nuclear Waste Project in Sweden

The Swedish nuclear industry has for the past thirty years developed plans for a final repository for spent nuclear fuel. The Swedish nuclear power program goes back further than this and was initially an indigenous joint nuclear weapons and nuclear power program based on heavy water reactor designs. As this program was abandoned in the early 1970s, investments were made in commercial light-water nuclear reactors. At the same time the environmental debate took of in Sweden and the environmental effects of nuclear power gradually came into focus, also at the highest political level. Political parties opposing nuclear power pushed for legislation in the field and the Stipulation Act in 1977 [3] was established in order to force the nuclear industry to show that they had a 'solution' to the nuclear waste problem – and the so-called KBS method was born. The act later turned out to be quite weaker than its initiators thought [4].

2.1 The Choice of Method

The KBS method is based on placing the spent nuclear fuel in a mined repository at a depth of approximately 500 m. Before emplacement, the fuel rods are placed in a copper canister, in turn supposed to be surrounded by bentonite clay. The canister and the clay are man-made barriers. Originally, a repository site was searched for, where the surrounding granite bedrock was optimal from a safety perspective, i.e. 'crack free'.

This approach has only marginally been modified since the mid-1970s when it was originally conceived. For example, the thickness of the copper and the inner construction of the canister have been modified. Very little effort has been put into examining alternative methods despite legal requirements and clear signals from both the Government and the regulatory authorities to do so. Even when alternative methods have looked promising in terms of potentially lowered long-term environmental risks, and minimised probability for intentional intrusion, the alternatives have only been superficially examined, followed though by quite firm statements declaring them to be insecure or too expensive. This might be explained by the efforts and money invested over time, as well as the fact that recognition of alternatives (in the eyes of some) would lower the credibility of the KBS method.

2.2 The Choice of Site

The process of choosing the site for a Swedish repository has a long history [5]. The Stipulation Act in 1977 not only forced the nuclear industry to develop a method for the disposition of high-level nuclear waste. The industry also had to show that a site could be found that would provide 'crack-free' bedrock where a repository could be built. After an initial accelerated attempt to find the 'political bedrock' that would meet the requirements in the Stipulation Act, efforts were made to examine the whole Swedish bedrock in order to find the best site for a repository. However, local opposition grew more or less wherever the nuclear waste company (SKB AB) started to drill holes in order to examine a site.

After years of pain to overcome local opposition, a different siting process was initiated. The nuclear waste company suddenly revised the idea of finding the best bedrock for a repository. Instead it stated that man-made barriers would guarantee that good enough bedrock could be found in most places in Sweden. A call went out for municipalities that would allow the company to carry out a preliminary site investigation. The call was answered by two types of municipalities, those that already hosted nuclear activities and those lured by the promise of new jobs. The latter were northern inland municipalities.

The number of municipalities that would allow the nuclear waste company to carry out a more extensive site examination fell however, as local referendum and political hesitation led to one municipality after another to withdraw its interest.

At present, the nuclear waste company is carrying out detailed site investigations in the direct vicinity of two nuclear power plants (Forsmark and Oskarshamn) on the Baltic coast. It is likely that both sites will be found by the company to be adequate for the siting of a repository.

In thirty years the meaning of the objective to find 'the best site' for a repository has changed from environmental safety to siting choices having a short-term political and public acceptance.

3. Risks and Nuclear Waste Management

The risks involved in the management of nuclear waste are high. The spent fuel from nuclear power plants is highly radioactive and directly lethal. It has to be kept separated from mankind and the environment for more than 100 000 years.

Historically, several methods for the final disposal of spent nuclear fuel have been suggested, among them deep space disposal and disposal in the sea-bed. At present, disposition plans for high-level nuclear waste mainly rely on disposal in mined geological repositories at relatively shallow depths of 200-500 meters. The geological characteristics of different examined repository sites has varied (i.e., wet or dry conditions, or in bedrock, salt or clay), but with time the idea of disposal in mined repositories is seen as the 'given and only solution'. The economics and technical feasibility of mined repositories at these relatively shallow depths favour the method. However, the long-term environmental safety of the method, under different geological conditions and in a variety of scenarios, still has to be shown.

The main challenge is to keep the waste separated from the environment and mankind for over 100 000 years. This is probably not possible. Not even with the technically advanced barrier systems that are proposed. Not even if the systems work as anticipated by the nuclear industry. The waste canisters, the buffer material and the surrounding bedrock can be damaged by changing biochemical conditions and the impact of external physical force. For instance, waste canisters, with or without manufacturing defects, will most likely corrode with time and radioactivity will eventually be released. The hazardousness of the waste decreases with time and any release of radioactivity will be diluted in the environment, but release of radioactivity even after 100 000 years will cause adverse environmental effects. The earlier a release takes place the worse the environmental consequences will be.

If no problems would occur before the next ice age they will most likely be seen then. Already 10 000 years from now Sweden will be subject to another glaciation. At this time the nuclear waste will still be very hazardous. In this case there are special difficulties with relying on a relatively shallow repository. During the ice age, the repository will move down and up, with a far from unlikely magnitude of several hundred meters, and be subjected to high physical strain. In addition, the hydrological conditions in the repository will change and there will most likely be periods when water with high salinity may negatively affect a clay buffer. In other periods, melted water may carry oxygen into the repository, which can harm the waste package canisters. In addition, the risks of a large earthquake damaging a repository are greatly increased during an ice age.

The probability for radioactive release from a repository and its resulting effects is only one type of risk. A second type is unintentional or intentional intrusions into the repository, in particular in a long-term time perspective. The passing on of information about the repository hazard to future generations may fail. There is thus a risk for unintentional drilling into the repository in search for minerals or water.

The risk for intentional intrusion into a repository requires special attention. The plutonium in the spent fuel can be used to make nuclear weapons, and other parts of the waste can be used in radioactive so-called 'dirty bombs'. Because the results of intentional intrusion into the repository may have catastrophic consequences there is a tendency to view this scenario as being outside the risks that have to be managed in the long term. Claims are made that future generations have to take responsibility for their own wilful actions. This reasoning is based on neglect of intergenerational responsibility. Take the case that people who lived 2000 years ago had placed a spent fuel repository in the bedrock in what during the Second World War was Germany. If the availability of plutonium had enabled the Germans to acquire nuclear weapons in the early 1940s the consequences could have been tremendously destructive. What responsibility falls on the victims in this scenario? Similar scenarios can be made today. We leave it to the reader to choose the worst location of a 2000 year old spent fuel repository if one was to be found today.

4. The Nuclear Waste Project and Sustainable Development

The risks with the nuclear waste project are, as shown, associated with large uncertainties and a number of controversies have followed the process so far. In the following, each of the three principles of sustainable development will be described and related to the Swedish waste project proposed by the nuclear industry.

4.1. The Polluter Pays Principle

The polluter pays principle has been a cornerstone for environmental policy since at least the beginning of the 1970s. Neo-classical economic theory shows that market failures in cases of e.g. open resource access will be corrected if ‘external costs are internalised’, which thereby increases welfare. The principle is underlined in declarations from various political fora and is implemented in policy and legislation all over the world, including Sweden.

One difficulty when implementing the principle is to assign monetary values to specific environmental problems, in particular when future costs are to be valued, but decisions on implementation have nevertheless been taken, e.g. regarding taxes on greenhouse gases. It is important to underline that already a risk as such might impose external costs, but that the principle can be implemented also in such cases of potential problems. One way is to hold the polluter accountable for any costs that might arise, calculated on basis of e.g. a worst-case scenario, by requiring the build up of monetary funds, or through a mandatory environmental liability system connected to insurance requirements. The valuation of risks could be done either on a market basis, or through a political process. (In the latter case, the two principles discussed in the following could also apply and affect the valuation, by letting the precautionary principle direct the interpretation of uncertainty, and the principle of public participation guide which stakeholders to engage.)

In the case of nuclear energy systems in Sweden, the understanding that the polluter should pay, at least for some costs, was expressed in legislation quite early [4] and is presently stated in e.g. the Act on Nuclear Activities. Concerning the waste issue, a governmental committee initiated in response to commenced commercial operation of nuclear stations in the 1970s, proposed what soon became legalised, that the nuclear industry should be liable to pay the full waste management costs by setting aside a sum per unit of generated electricity [6]. In 1982, the system changed and an annual fee was stipulated for each reactor company, to be deposited in a fund [7]. A new governmental committee in 1993 elaborated the system further and suggested that reactor companies also should provide guarantees to the State, due to uncertainties concerning e.g. the estimation of future costs [8], a proposal that with some amendments was legislated in 1996 [9]. Still though, yet another governmental committee recently showed further shortcomings in the system, in relation to the polluter pays principle, e.g. that the reactor companies liable to pay have limited assets for covering unexpected costs, and therefore proposed to extend the requirements to pay fees to owning companies [10].

Since these new proposals have not yet been implemented, and since calculations of future costs are uncertain and mainly based on the still not permitted KBS 3 method, it thus seems far from clear that the polluter pays principle is implemented.

4.2. The Precautionary Principle

The precautionary principle has been widely debated, but nevertheless constitutes a foundation of political declarations and environmental law on national and international level. The interpretations of the principle vary, but the following general formulae has been derived from several binding environmental treaties: ’if there is a threat, which is uncertain, then some kind of action is mandatory’ [11].

Given the large uncertainties with any nuclear waste storage, the precautionary principle in our view implies that assessments of associated risks should be made from the widest perspective possible, assuming that e.g. leakage will be a fact rather than the opposite, and that alternative management measures need thorough investigations. The burden of proof to show that legal requirements in e.g. the applicable Environmental Code are met rests with the polluter, i.e. the reactor companies and their owners. This means that the nuclear industry must show that the site is chosen so that ‘a minimum of damage or detriment’ (and not only a good location) is achieved, and that the best available technology will be used [12].

With the earlier discussion in mind, the waste project proposed by the nuclear industry obviously falls short of both legislation and the precautionary principle.

As we see it, the precautionary principle also challenges the common decision-criterion to maximise expected utility. In cases of high uncertainty, such as disposal of nuclear waste, a complementary option would be to apply the so-called maximin-criterion, i.e. to firsthand strive for the option that minimises the likelihood for the reasonable worst-case scenario. Analysing the present legal system, such a requirement can be interpreted to follow from the Nuclear Activities Act, but is far from what the KBS method is aimed for.

To conclude, there are legal as well as practical shortcomings of the present disposal project in the light of the precautionary principle.

4.3. The Principle of Public Participation

Since the Rio Conference in 1992, when the importance of a 'bottom-up perspective' in decision-making was clearly underlined, several attempts have been made worldwide to enhance inclusiveness in public decision-making. The need for such approaches is underlined by e.g. the UN Århus Convention, which promotes access to information, public participation in decision-making and access to justice (e.g. the right to appeal) in environmental matters [13].

Managing controversies over nuclear waste storage necessitates public participation, in order to both increase trust, and enrich the risk assessment by adding knowledge to the findings of experts. Participation also enables the values of the public to influence the interpretation of uncertainty and the ideas on a proper risk management approach. Note here, that we have no intention to neglect the expert profession, but we consider experts to not necessarily represent the 'average of values' held in a society, and therefore see increased deliberation as essential.

While some preparatory studies in the Swedish nuclear waste project have meant slightly increased public inclusiveness and deliberation [14], there are more examples of the opposite. In our view the project is clearly expert-dominated and often rests on an old-fashioned view of representative democracy. Since alternative methods and sites are not investigated in a adequate way, the opportunities for the public to grasp the complexities and to understand the full scale of options available are restricted. People are thus hindered to make up their minds about what they would consider to be the truly best alternative.

Clearly, much remains to be desired when it comes to public participation in the Swedish nuclear waste project so far.

5. Concluding remarks

As has been shown, the proposed Swedish nuclear waste project is not in line with the three principles of sustainable development. In some aspects, it is not even compatible with Swedish law and ought therefore not to be given a permit under present circumstances.

In our view, a number of measures need to be taken to improve the likelihood that the waste repository will promote and not further jeopardise sustainable development. One obvious measure would be to follow the recommendations concerning polluter pays principle put forward by the 2004 governmental committee.

Further, it can be credible argued that the focus of the present disposal process has not been to find the best site and method from environmental point of view. If the precautionary principle is to be applied (and Swedish law is to be followed), alternative methods and sites have to be examined to see if they could provide better long-term safety.

Concerning method, there are options that deserve much more attention such as so-called ‘deep boreholes’. In this approach the nuclear waste is placed in deep boreholes at depths of 2-4 km. Studies show that the long-term environmental safety and the possibility of hindering intentional intrusion may improve using the deep borehole method [15, 16].

Regarding localisation, one option would be to avoid siting the repository on the coast, but in what is called a ‘recharge area’. In such an area groundwater on a regional scale travels downwards into the bedrock and it may take 50 000 years for a release of radioactivity to reach the surface, compared to less than 100 years with a coastal siting. In addition, if a repository is sited in an area that lies above what is called the ‘highest coast-line’ the probability decreases that an inflow of damaging saline water into the repository will take place during the next ice age. The siting of a repository in a recharge area above the ’highest coast-line’ would thus increase long-term environmental safety.

Evidently, there may be better methods and sites than those now proposed by the Swedish nuclear industry. These options must be examined in detail before a decision is taken to implement the KBS method at a costal site. If such methods or sites are found better they have to be used in the first place.

Improvements are also necessary when it comes to public participation. We believe it is possible to increase trust in so far as gaining public commitment for a repository, but only as long as long-term environmental safety is made the central objective. Trust will also increase along with continued transfer to a sustainable energy system.

The problems of dealing with nuclear waste are often seen as a ‘show-stopper’ for nuclear power. It must, however, be emphasised that nuclear power does not become compatible with sustainable development even if the best environmental solution is found for the already existing waste. Nuclear power is fundamentally based on finite resources. The technology relies on environmentally harmful mining and creates extremely hazardous waste. It also has an intrinsic risk for catastrophic release of harmful radiation and increases the risk of nuclear weapons proliferation.

The best way to combat global warming is not to choose between two bad things – fossil fuels and nuclear power. The option compatible with sustainable development is increased energy efficiency combined with renewable energy that can be used and upgraded on a global scale in the long run, without leaving a waste category behind that will cause risks longer in the future than man has walked on Earth so far.

6. References

1. WCED 1987. World Commission on Environment and Development. Our Common Future. Oxford, Oxford University Press, p. 40.
2. Karlsson M. 2005. Managing Complex Environmental Risks for Sustainable Development. Ph.D. thesis, Karlstad University. Karlstad University Studies 2005:34.
3. SFS 1977:140

4. Andersson-Skog, L. 2005. Från ren energi till farligt avfall. In: Andrén and Strandberg (eds.). Kärnavfallets politiska utmaningar. Södertälje, Gidlunds.
5. Sundqvist, G. 2002. The Bedrock of Opinion: Science, Technology and Society in the Siting of High-Level Nuclear Waste, Series: Environment & Policy, Vol. 32
6. SOU 1976:30; Governmental Bill 1978/79:39.
7. SFS 1981:669; replaced by SFS 1992:1537.
8. SOU 1994:108.
9. SFS 1995:1544.
10. SOU 2004:125.
11. Sandin, P. 1999. Dimensions of the precautionary principle. Hum. Ecol. Risk Assessment, Vol. 5, 889-907
12. SFS 1998:808, Chapter 2, Sections 3 and 4.
13. UN ECE, 1998. Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters. Done at Arhus, Denmark, June 25, 1998
14. Johansson, H. S. 2004. Samtal om kärnkraftsfrågan och demokratins gränser. STS Research Reports 8. Göteborg, Göteborgs universitet.
15. Åhäll, K-I . 2006. Final Disposal of Nuclear Waste in Very Deep Boreholes: An Assessment Based Bedrock Characteristics. Swedish NGO Office for Nuclear Waste Review (MKG).
16. Swahn, J. 1996. Retrievability and Safeguards Concerns Regarding Plutonium in Geological Repositories. In Merz, E. ed., Disposal of Weapons Plutonium: Approaches and Perspectives, Kluwer, pp 9-22.