Ethical Principles for the Management of High Level Spent Nuclear Fuel (SNF) - 14152

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ABSTRACT

In March 2011 Swedish Nuclear Fuel management Co (SKB) submitted an application to the Swedish Radiation Safety Authority (SSM) and the Nacka Land and Environmental court to build a repository for high-level SNF in the municipality of Östhammar. The purpose of this paper is (1) to present the KBS-3 method for the direct disposal of high-level SNF and the alternative of recycling and processing of SNF in new generations of nuclear reactors and (2) to analyze the ethical principles involved and how to resolve possible conflict between these principles. The paper is divided in three parts. In **part 1** the ethical principles in the application and in the more general debate are identified, i.e. the security principle, the principle of intergenerational autonomy, the principle of responsibility and the principle of conservation. In **part 2** the linkage between these principles and the choice between direct disposal and recycling/transmutation is discussed. **Part 3** contains an analysis of the conflicting principles and how this conflict can be resolved. It is argued that some kind of ethical metanorm might be formulated and that the ethical principles involved in the management of SNF might be assessed in reference to such ethical metanorm or metanorms. Finally, it is discussed if the conflict between different principles for the management of SNF might be resolved through closer consideration of the relationship between ethical principles and technical practice.

INTRODUCTION

This article will present some ethical issues that have emerged in the context of the Swedish programme for disposal of high-level SNF[1]. This programme for direct geological disposal involves a number of ethical principles. The purpose of the present article is, first, to articulate these principles, secondly, to show that they – in certain circumstances - can come into conflict with each other, and thirdly suggest how these conflicts might be resolved.

The expression "ethical principle" is here used in the sense of a more general norm guiding recommendations for the management of spent nuclear fuel. My hypothesis is that this concept is useful in the analysis of statements in, for example, in the application submitted by SKB – Swedish Nuclear Fuel Management Co - in March 2011 to the Swedish Radiation Safety Authority (SSM) and to the Land and Environment Court to build the Spent Fuel Repository in Forsmark. The analysis will show that not only one, but several principles are involved when considering the management of SNF. Moreover, these principles may come into conflict with each other; any solution to the SNF-issue may satisfy one of the principles but not another. How

[1] For short "SNF" if no other kind of SNF is presupposed.

can we solve this problem? It depends on how we view the relationship between ethical principles and practice. I will discuss this problem in the last part of the article.

The article will be divided into three different parts. In the *first* part I will describe the method presented by SKB in their application to build a final repository for high level SNF as well as the main alternatives to that method, particularly partitioning and transmutation methods (P&T methods). The *second* part will consist in an analysis of the different ethical principles which are actualized by these methods for the management of high-level SNF. The *third* part will highlight some of the conflicts that may arise between these different principles and how these kind of conflicts might be resolved.

THE KBS-3 METHOD

SKB:s application is based on the so-called KBS-3 method, which entails that the spent fuel assemblies – encased in approximately 6,000 canisters, each consisting of a cast iron insert with a copper shell – are deposited directly in the Swedish bedrock at a depth of about 500 metres.

SKB has been developing the KBS-3 method since the early 1980s, and in a decision from 2001 the Government declared that SKB should use the KBS-3 method as a planning premise for the upcoming site investigations.[2] The same decision also underscored "that final approval of a specific method for final disposal cannot be given until a decision is made on applications under the Environmental Code and the Nuclear Activities Act for a permit to build a final repository for spent nuclear fuel". But the Government statement from 2001 has given the KBS-3 method special status in the method selection process. The Swedish Nuclear Power Inspectorate (SKI) has also on different occasions made a positive evaluation of SKB's system choice and says in its statement to the Government regarding SKB's RD&D (Research, Development and Demonstration) programme 2007 that "disposal in accordance with the KBS-3 method still seems to be the most appropriate planning premise for disposing of the spent nuclear fuel from the Swedish nuclear power programme".[3]

The KBS-3 method has also attracted a great deal of international attention. The Finnish final repository programme is based on the same method. It can also be mentioned that the American equivalent to the Swedish National Council for Nuclear Waste (SNC), the *Nuclear Waste Technical Review Board* (NWTRB), regards the KBS-3 method as an important design concept.[4] President Barack Obama abandoned the Yucca Mountain Project in 2008 and appointed a *Blue Ribbon Commission on America's Nuclear Future*, which, in its final report in 2012, mentions SKB's final repository programme in positive terms.[5] After considering various alternatives, the Commission also recommends a geological repository, without going into greater detail regarding

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[2] Government decision of 1 November 2001.

[3] See SKI's *RD&D Review Statement 2008*, p. 7.

[4] U.S. Nuclear Waste Technical Review Board, "Technical advancements and issues associated with the permanent disposal of high-activity waste - Lessons Learned from Yucca Mountain and Other Programs," 2011.

[5] *Blue Ribbon Commission on America's Nuclear Future*. Disposal Subcommittee Report to the Full Commission, Updated Report, 2012.

its design.

The KBS-3 method is also the disposal concept at the core of the application for a final repository for spent nuclear fuel which SKB submitted to SSM and the Land and Environment Court at Nacka District Court in March 2011[6].

In parallel with the development of the KBS-3 method, alternative methods have also been discussed for spent nuclear fuel disposal. One example is Deep Boreholes, which on various occasions has been studied by SNC.[7] Another example is different methods for recovery and recycling of spent nuclear fuel. In the KBS-3 method, the spent nuclear fuel is regarded as waste, but several other countries have instead chosen to regard the spent nuclear fuel as a resource in a closed fuel cycle.

ALTERNATIVES TO THE KBS-3 METHOD

The so-called "top document" in SKB's application for a licence for a final repository for spent nuclear fuel describes two approaches to the management of spent nuclear fuel: as resource or waste. Within these two alternative approaches are several sub-alternatives, which are summarized in the following figure taken from an appendix to SKB's application, Choice of Method (MV/CM):

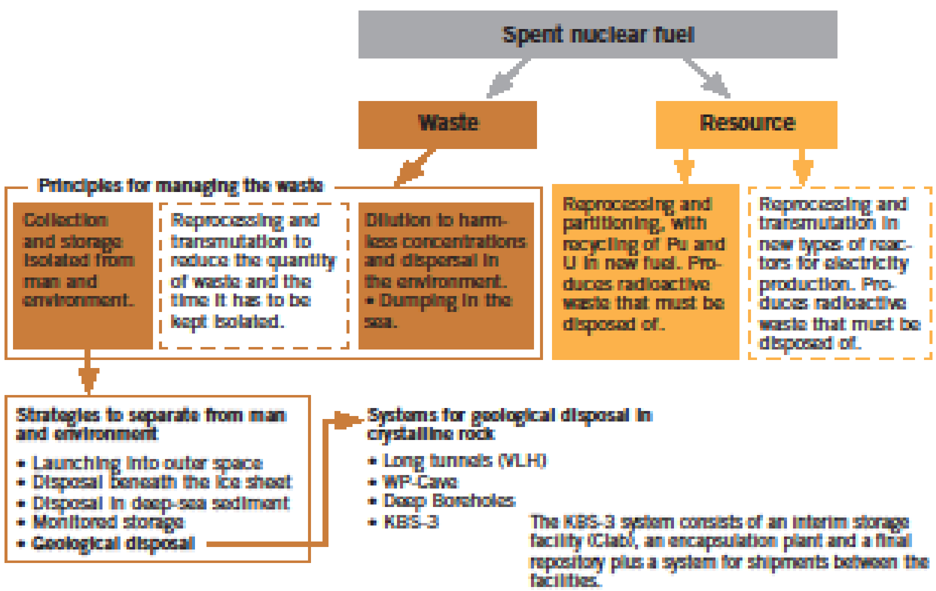

Fig. 1. Principles, strategies and systems for disposal of spent nuclear fuel. The principles in the dashed boxes are based on technology that is not available today.
Source: SKB's application. Appendix CM, p. 20.

[6] A licence application for erection of an encapsulation plant was submitted back in 2006.
[7] See for example Åhäll 2011.

Let us focus on SKB's description and assessment of the various alternatives that exist within the resource approach, or what can also be called the recycling approach:

1. Conventional reprocessing and production of MOX fuel, followed by final disposal of vitrified waste and spent MOX fuel. [8]
2. Transformation (transmutation) of the waste after reprocessing.[9]

Alternative 1 is based on the existing type of light water reactors (LWRs)[10]. The Swedish reactors belong to what is called Generation II. They are moderated and cooled by ordinary water, and the fuel is irradiated by thermal neutrons[11], which are only capable of splitting uranium 235. When the fuel assemblies are taken out of the reactor, approximately 96% recyclable material remains, of which 94% uranium 238, 1% uranium 235 and 1% plutonium (0.25% Pu 238, 0.75% Pu 239). In addition, the fuel contains 4% fission products and 0.1% residual actinides (americium, neptunium and curium)[12]. Plutonium and the residual actinides decay slowly and take about 100,000 years to reach harmless levels.

Reprocessing of the spent nuclear fuel entails first separating (partitioning) uranium and plutonium, and the remaining nuclides comprise high-level waste (HLW). Partitioned uranium and plutonium are converted to MOX fuel, which can be burned in our present-day nuclear reactors. When the MOX fuel has been used, approximately 20% of the plutonium has been consumed. Because it contains plutonium, MOX fuel is more radioactive than ordinary fuel and therefore requires special handling.[13]

According to SKB, reprocessing (in domestic or foreign facilities) is inappropriate for both economic and security-related reasons. "Furthermore, the saving of uranium is moderate: 10–20%, depending on how many times the fuel is reprocessed".[14]

Alternative 2 is based on a technique that transforms (transmutes) radioactive substances (radio nuclides, for example residual actinides in the spent nuclear fuel) to less hazardous substances.[15] This process is called spallation. The process can take place in special accelerator-driven systems (Accelerator Driven Spallation, ADS). An alternative is to irradiate the high-level nuclides in a

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[8] Mixed Oxide Fuel.

[9] Top document in SKB's application, p. 19.

[10] By *light water* is meant water in which the constituent hydrogen atoms consist mainly of ordinary hydrogen, whose nucleus contains only one proton, in contrast to heavy water, in which the hydrogen nucleus has a proton and a neutron.

[11] Thermal neutrons are neutrons that have been slowed down so much by collisions in the water that they are in thermal equilibrium with their surroundings.

[12] Actinides are the series of 15 elements that follow (and include) actinium in the periodic table. Actinides with atomic numbers higher than 92, called transuranics, are formed by nuclear reactions. They all gradually decay to lighter elements while emitting ionizing radiation until a stable end product is reached (lead or bismuth).

[13] See further http://www.stralsakerhetsmyndigheten.se/global/publikationer/ski_import/050621/bc52ca3181a7ed2ab695269ecc131c19/mox.pdf

[14] See further the top document in SKB's application, p. 19.

[15] The method is described in greater detail in the Swedish National Council for Nuclear Waste's *SotAR 2004* (SOU 2004:67), Chap. 8, and *SotAR 2011* (SOU 2011:14), section 4.2.3.

nuclear reactor with a much higher neutron energy that in our present-day reactors. Such reactor technology belongs to Generation IV and is not expected to be available for commercial operation for another 30–40 years or more.[16] Generation IV reactors could be operated with spent nuclear fuel from our present-day nuclear reactors and burn not only plutonium, but also the residual actinides, leaving only about 1% of the original quantity of plutonium and actinides, and shortening the time they remain hazardous to about 1,000 years. The disadvantage is that this technology is not currently available and is not expected to become available on a large scale for the foreseeable future. SKB is therefore also critical of this recycling method.

In its overall assessment (section 4.3), SKB rejects both alternatives. Reprocessing and separation of plutonium and uranium according to *alternative 1* is an established method and has been used in France and the UK. But SKB argues against these alternatives as an option in Sweden:
The reasons for this are both economical and security-related. One of the economic reasons is that new "fresh" nuclear fuel with enriched uranium has been and is still much cheaper than MOX fuel with plutonium from reprocessing. Furthermore, management and final disposal of the high-level waste and the long-lived low- and intermediate-level waste from reprocessing is very costly. The security-related reasons have to do with the fact that there is concern that plutonium from reprocessing could be used to manufacture nuclear weapons.[17]
When it comes to *alternative 2* – reprocessing and transmutation – it is mainly treated as a method of reducing the quantity of waste and the time it has to be kept isolated, and not as a method in new types of reactors (See Figure 1). There are mainly five objections to *alternative 2*. The *first* is that the method requires extensive radiation protection measures and that the relatively low long-term radio toxicity of the residual actinides is exchanged for higher short-term radio toxicity. This may conflict with the legal requirement on optimization and utilization of the best available technology to eliminate radiation doses. The *second* objection is that this type of reprocessing produces pure plutonium, requiring rigorous safeguards. The *third* objection is that the development of a functioning system is expected to be costly and take a long time. The *fourth* objection is that it will take about 100 years to carry out the transmutation. And the *fifth* objection is that the method produces a certain quantity of long-lived, high-level waste (fission products) that have to be disposed of in a safe manner. "SKB therefore does not regard transmutation as a realistic alternative for managing spent nuclear fuel from today's Swedish reactors".[18]

ETHICAL PRINCIPLES IN THE MANAGEMENT OF HIGH LEVEL SNF

Proposals concerning the management of SNF – such as an open or closed fuel cycle - be analysed in different ways. For example, one may focus on the particular technical aspects or on

[16] International efforts to develop Generation IV reactors are coordinated by *Generation IV International Forum* (GIF), with thirteen members (including the EU).
See http://www.gen-4.org/. For a more detailed description of Generation IV reactors, see *SotAR 2011*.

[17] SKB's application, Appendix MV (CM), p. 56 – See further Appendix AH (AG), p. 21: "Objections have been raised to disposing of the spent nuclear fuel in the form it has after interim storage, since more energy could be extracted from the fuel before it is disposed of. Extracting more energy requires reprocessing. It is not currently considered economically defensible, or otherwise appropriate, to reprocess nuclear fuel in new plants in Sweden, or to send spent nuclear fuel abroad for reprocessing."

[18] *Integrated account of method, site selection and programme prior to the site investigation phase* (2000), in particular Part II, Chap. 4, and Grundfelt 2010 (R-10-12). Grundfelt has roughly the same arguments as SKB.

their scientific basis. Alternatively one may focus on the ethical principles involved in the arguments for the proposals. The definition of ethical principles is a large and controversial philosophical issue which will not be discussed in the present context. But, in short, ethical principles may be described as general normative claims concerning the welfare and woe of human and non-human creatures. These principles may be implicit or explicit in the material. Furthermore, these principals may be consistent or inconsistent with each other, i.e. they may or may not be possible to realize using the same proposed management of SNF.

One ethical principles appears central in SKB:s application for a licence to build a repository for the disposal of SNF from the Swedish nuclear programme. It is formulated in the following way:

> **The purpose** of the applied-for activity is to dispose of the spent nuclear fuel in order to protect human health and the environment from the harmful effects of ionizing radiation from the spent nuclear fuel, now and in the future".[19]

We may call this principle *the safety principle* and makes reference to the health of both the present generation and future generations. SKB argues that the KBS-3 method for the direct disposal of SNF fulfils this claim as it is made more precise by the regulatory statutes of the Swedish Radiation Safety Authority (SSM). SSM statesthat the probability that a person in the group that is exposed to the greatest risk will be injured by such a leak may not exceed one in a million. (This group consists mainly of people living in the vicinity of the repository who are exposed to ionizing radiation that has leaked out from the repository through the engineered and natural barriers, for to example groundwater, lakes and watercourses. In the application SKB presents a safety case that claims to demonstrate in practice that a final repository does not pose a higher risk than one in a million.)

The safety principle is clearly embodied in the international regulatory framework for nuclear waste management. In1995 the IAEA issued The Principles of Radioactive Waste Management as a part of its safety series. According to Principle 5, the waste shall be managed "in such a way that will not impose undue burdens on future generations". With reference to these principles, this idea is elaborated on in the IAEA's Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management from 1997. Sweden has ratified thisconvention. According to Article 1, one of the objectives of the convention is "to ensure that during all stages of spent fuel and radioactive waste management there are effective defences against potential hazards so that individuals, society and the environment are protected from harmful effects of ionizing radiation, now and in the future, in such a way that the needs and aspirations of the present generation are met without compromising the ability of future generations to meet their needs and aspirations".

A second ethical principle of significance may be termed *the responsibility principle*. It has been formulated in the following way by the former Environment minister of the Swedish Goverment, Andreas Carlgren.

> … it is morally right that the generation that benefits from the nuclear power should also take responsibility for finding a solution to the waste problem…[20]

[19] SKB's application, top document, p. 4
[20] See Upsala Nya Tidning, 1 st of April 2011.

This responsibilty is closely related to the fundamental principle of producer responsibility i.e. "the holder of a licence for nuclearactivities shall be responsible for ensuring that all measures are taken that are required for ensuring the safe management and final disposal of nuclear waste arising in the activities or nuclear materialarising therein that is not re-used" (Nuclear Activities Act, Section10). This principle of producer responsibility (also called the "polluter pays principle") has been of fundamental importance for the management of spent nuclear fuel in Sweden. It is related to a more general principle of responsibility that has been asserted in various national and international contexts. By "polluter" is mainly meant here the nuclear power producers, but the principle can also be interpreted as applying to those who have used the electricity,i.e. the electricity consumer. This means that we in Sweden bear a common responsibility for our country's radioactive waste. It must not be passed on to future generations, but rather be managed and disposed of by those who have enjoyed the benefits of nuclear energy.

Still another principle might be discerned in the debate concerning the management of SNF in Sweden. The Swedish National Council for Nuclear Waste (SNC) analysed to the question of P&T in a special chapter *SotAR 2004*. The analysis ends up in the following assessment:

> To allocate resources for further P&T research at this stage is … in line with the view that our generation should give future generations the best possible opportunities to decide whether they want to choose P&T as a method for disposing of spent nuclear fuel, instead of direct disposal alone (in accordance with the KBS-3 method, for example).[21]

The basic value hinted at in this quote could be described as the principle of every generation's right to determine for themselves which method they want to use to manage spent nuclear fuel (and other environmentally hazardous material). It could be called *the principle of intergenerational autonomy*.[22] This principle has been asserted in different contexts by SNC and has been called, after SNC:s previous acronym, the *KASAM principle*. It was formulated back in the late 1980s and justified in the following manner in *SotAR 1998*:

> We should also apply to future generations the same attitudes toward human beings that we consider to be fundamental to the view that we have of ourselves and of our own responsibility. According to this attitude, commonly called the humanistic view, future generations should be guaranteed the same rights as ourselves to integrity, ethical freedom and responsibility as we ourselves enjoy. Our assessment of the future consequences of our technical systems must also weigh in this right or, using a key term, provide scope for *freedom of choice*. At the same time, freedom of choice as a value to be weighed into our choice of strategy is given greater weight due to both the inherent uncertainty and the realization that all technical systems are designed by fallible human beings.

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[21] The Swedish National Council for Nuclear Waste returns to the question in *SotAR 2011*, where special attention is devoted to partitioning and transmutation through the development of Generation IV reactors (see *SotAR 2011*), pp. 65–70).

[22] In contrast to the principle of intragenerational autonomy, i.e. that different groups – such as states or nations – within the same generation are autonomous in relation to each other. This autonomy – like intergenerational autonomy – is constrained by other moral principles (even though many states claim that other states never have the right to interfere in a country's "internal" affairs).

This is a brief background to the twin conclusions drawn by the multidisciplinary seminar in 1987, known as the KASAM principle: *A final repository should be designed to render monitoring and controls unnecessary, but not impossible*.[23] *The KASAM/autonomy principle* thus entails that future generations should not only have the freedom to utilize the spent nuclear fuel if they want to, but also the freedom not to do so. The freedom not to utilize it (and to treat it as waste) is just as important as the freedom to utilize it as a resource. The question is then which spent nuclear fuel management method is compatible with this freedom of choice.

Based on the KASAM/autonomy principle, different kinds of arguments can be advanced against the recycling alternatives. The creation of the institutional and technical systems for transport, reprocessing and utilization of fissionable material that are needed to realize recycling alternatives is difficult to reconcile with the autonomy principle. The great financial and knowledge-related investments required by the recycling alternatives will necessarily put constraints on the ability of future generations to choose freely among waste management methods. In a broader societal perspective, the recycling alternatives can also have other negative consequences.[24]

The situation is complicated by the fact that management of the spent nuclear fuel must not only take the three aforementioned principles into consideration (the responsibility principle, the safety principle and the KASAM/autonomy principle). Two other principles – the conservation principle and the sustainability principle – must also guide the choice of disposal method, according to the Environmental Code. The Council refers to the Environmental Code’s requirements in its statement.

According to Chap. 2 Sec. 5 of the Environmental Code, anyone who pursues an activity or adopts a measure shall conserve raw materials and energy and reuse and recycle them wherever possible. This is what is meant by *the conservation principle*. The conservation principle has been interpreted to mean that energy and raw material must be used as efficiently as possible and their use should be minimized; *the sustainability principle* entails that whatever is extracted from nature shall be used, reused, recycled and disposed of in a sustainable manner with the least possible consumption of resources and without harming nature.

SNC has argued that SKB should give greater consideration to the consequences of the possible development and operation of new types of nuclear power reactors, for the timetable and for the nuclear fuel programme. One question that can be asked is what it means for a planned final repository that reactors in the future might use as fuel what we today regard as waste?[25]

In sum, there are at least four different ethical principles involved in the management of high-level SNF: (1) the principle of intergenerational autonomy, (2) the safety principle, (3) the responsibility principle and (4) the conservation and sustainability principle.

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[23] *SotAR 1998, p.* 13, and *SotAR 1987,* p. 92. For a modification of this principle, see Kåberger and Swahn 1993.

[24] See further under 4.5. “Other problems with the recycling alternatives.”

[25] The Swedish National Council for Nuclear Waste’s viewpoints to the Land and Environment Court at Nacka District Court, Dnr 43/2012, p. 32.

POSSIBLE CONFLICTS BETWEEN ETHICAL PRINCIPLES GUIDING THE MANAGEMENT OF SNF

The fact that there are at least four ethical principles for the management of high level SNF, leads to the emergence of a serious problem: is it possible to meet the requirements of all these principles at the same time? Or can they come into conflict with each other, so that it may in practice be difficult to fully satisfy one principle without violating another? In fact, it is obvious that conflict can occur. Here are four examples:

1. One concerns the relationship between *the responsibility principle* and the *safety principle*. It is not completely certain that the current generation will be able to dispose of the spent nuclear fuel so that human health and the environment are adequately protected “from the harmful effects of ionizing radiation from the spent nuclear fuel, now and in the future”.[26]
2. The second possible conflict is between *the responsibility principle* and *the KASAM/autonomy principle*. If we in our generation have to find a safe method of disposing of the spent nuclear fuel, there may be no other alternative than geological direct disposal, which may limit the freedom of choice of future generations.[27]
3. A conflict is also possible between the KASAM/autonomy principle and the safety principle. If we are to safeguard the right of future generations to choose freely between utilizing or not utilizing our spent nuclear fuel, this may require us to manage our nuclear fuel in a manner that is not optimally safe for people who will live in the far future. The only option may be deposition of the spent nuclear fuel in a modified type of KBS-3 repository that can be left without monitoring and controls, but does not prevent monitoring and controls. The current type of KBS-3 repository limits the possibilities of future generations to retrieve the fuel and use it as a resource. But a non-closed repository with copper canisters could entail a higher risk for future generations, compared to a repository that has been permanently closed.
4. It is not only the autonomy principle and the responsibility principle that can be difficult to satisfy at the same time. It may also be difficult for our present generation to both dispose of the spent nuclear fuel safely and at the same time satisfy the conservation principle. The conservation principle speaks against direct disposal and in favour of recycling (according to alternative 1 or 2 above).

In summary, a certain argumentative structure appears in the material. In arguments for direct disposal-alternative primary reference is made to the security principle and the principle of responsibility, while arguments for the recycling/transmutation-alternative highlights the

[26] The Swedish National Council for Nuclear Waste’s viewpoints to the Land and Environment Court, Dnr 43/2012, p. 6.

[27] This is true at least after closure of the repository. “After final closure of the repository, safety- and safeguard-related considerations must be given priority over the principle of freedom of choice of future generations” (see *SotAR 2010*, p. 49). SKB has on different occasions pointed out that a repository according to the KBS-3 method permits retrieval (unlike the Deep Boreholes concept, for example). But there is no doubt that such retrieval is an economically costly and technically complicated procedure and that it can thereby be described as a constraint on the freedom of choice of future generations.

principle of intergenerational autonomy and the principle of conservation (claiming that the alternative takes due notice of the security principle).

RESOLVING CONFLICTS BETWEEN ETHICAL PRINCIPLES

How is the conflict between ethical principles in the process of managing SNF to be resolved? It is not possible give a quick and convincing answer to this question. But let me give some suggestions and begin with some practical reflections and then add a few more philosophical suggestions.

The first strategy would be *put the ethical conflicts in a holding pattern and try to find a technical solution* that can dissolve the conflict. For example, the KBS-3 method could possibly be modified to allow for an easier retrieval of deposited SNF-canisters. This might not totally resolve the conflict between the security principle and the autonomy principle, but it would go some way to lessen the tension. The obligation for the present generation to find a solution could be satisfied and the infringement of the principle of conservation not as definitive as it would be if SNF was directly disposed without considerations of future retrieval. But this method is not without problems. Technical solutions might be hard to find and in the example given new problems could arise. Measures to make retrieval easier might jeopardize long term safety and/or prolong the safe disposal of SNF beyond the life time of the present generation.

The second strategy would be to pu the different principles in some kind of ranking order. For example by formulating *some kind of ethical metanorm* according to which the conflict between ethical principles might be resolved. Philosophers have suggested different such metanorms, for example the utilitarian principle by Jeremy Bentham (1748-1832) ot the categorical imperative by Immanuel Kant (1724-1804). Needless to say, these metanorms come in many shapes and varieties, but the main problem in this context is that invoking such metanorms would clearly beg the question, i.e. presuppose the conclusion. The ulitiltarian principle is most naturally construed in favour of giving precedence to the security principle, while the categorical imperative most naturally is interpreted as an argument for the autonomy principle (and, in consequence, against a direct deposition according to the KBS-3 method). A closer analysis might make this line of thought more fruitful, but it requires broader and deeper ethical study.

The second strategy presupposes a more thorough *reflection on the relationship between principles and practice.* Do principles guide practice or is it practice that justifies principles? Different conceptions about the relationship between principles and practice have been considered in contemporary ethics.[28]

One line of thought advocates a *top-down model*, where the principles determine practice. Classical utilitarian and Kantian theories may serve as an example of this model. Empirical data or moral intuitions suggest the principles we must follow. These principles should then guide our actions in personal life and in the solution of technological problems such as the management of SNF.

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[28] See Lindström. 2013.

Another line of thought argues a *bottom-up model*, i.e. certain practices determine the ethical principles (and their relationship). Casuistry in classical theology and expediency in modern management can be seen as examples of this model. Principles might be formulated to sum up moral experiences.

A third option is an *interaction model*, where a practice gives rise to ethical principles, which in turn are used to assess new situations in a constantly evolving process. So-called experimental ethics belongs to this category (as well as different forms of discourse ethics and virtue ethics). This gives experiences a stronger position than merely summing up of moral experiences. They have a more important guiding force than in the bottom-up model.

Finally, there is a fourth line of thought where certain practices are the basis of morality and do not need to be systematized in certain ethical principles. One example could be the *pragmatic model* exemplified by Hilary Putnam and Richard Rorty. It comes close to the situation ethics in existentialist tradition.

Pending on which model is chosen, conflicts between principles in their application to practice are interpreted and resolved in different ways. Conflict between principles is most serious for the top-down model. The principles must be supplemented with a theory concerning conflict resolution. This can be done in setting up a general ranking of the principles, or managed in a kind of case by case method. As already suggested general ranking runs into serious theoretical problems when is comes to justifying one ranking over another. The case by case ranking involves the bottom-up model. If the second bottom-up model is chosen, the problem of conflicting principles seems easier. A more thorough discernment of practice is required. In the case of the management of nuclear waste, one must simply “muddle through” the different alternatives. At some point of this muddling through the relevant principle will emerge as the most well founded principle. SKB:s application can be seen as the end product of such a process, where the principle of security in harmony with the principle of responsibility stand out as the most reasonable ethical principles for the handling of high level SNF in the Swedish context.

If the interaction model is chosen, the conflicting principles can be interpreted as a description of a certain stage in the constantly evolving interaction between principles and practice. In the present situation, different alternatives with different guiding principles stand in need of being more closely compared and the practical consequences discerned. In due course the relative significance of these principles will become clearer and then reapplied to practice. The interaction model downplays the problem of conflicting principles. Conflicting principles is a natural ingredient in the evolving interaction between principles and practice. Lastly, the pragmatic model simply regards the whole approach of formulating ethical principles as a misguided abstraction. The establishment of a communicative community is of primary importance. In the case of the management of SNF this means facilitating the dialogue between the technical and the scientific community on the one hand with the general public and their political representatives on the other. Any attempt to formulate solutions to the problem of the management of SNF, must be subject to public critical discussion in order to find out whether the consequences can be acceptable to all concerned. “This way of conducting moral philosophy can be interpreted as a discursive intersubjective test of normative propositions...normative statements are interpreted as contingent, fallible and depending of which proposal it is possible to reach an agreement upon."[29]

CONCLUSION

It is my tentative conclusion that the interaction model is to be preferred. The pragmatic model rightly emphasizes the role of social dialogue in a particular context, but underplays the importance of a specific moral articulation of moral experience. Moral language in the form of ethical principles can contribute to the dialogue required by the pragmatists. The interaction model desensitizes the conflict between ethical principles and prevents ethical reflection from stagnation into a static system. Transference of these assets of the interaction model to the dialogue about the management of high-level SNF would be a promising way forward

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