MARKING NUCLEAR WASTE DISPOSAL FACILITIES

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September 2012

An issue that has long been on the radioactive waste management agenda is the means of marking a waste repository site, such that future generations will be able to comprehend its purpose and risks. Research into long lasting information carriers is being done, but how do 'future people' know there is a message inside, or even, where do we put it so 'future people' will find it before people start digging? And then the more principal questions, will such a warning not attract people to start digging? Or do we have to forget repositories ever existed? But how? Of course we have to stop producing nuclear waste immediately. But even then, the historical waste has to be stored. 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?
In this article we discuss the three approaches over the past few decades (para 1, 2, and 3), a new emerging vision (para 4) and the question of permanent retrievability (para 5).

1-Passive institutional control

"The disposal of radioactive wastes in deep geologic formations provides a means of isolating the waste from people until the radioactivity has decayed to safe levels. However, isolating people from the wastes is a different problem, since we do not know what the future condition of society will be." This comes from a report of The Human Interference Task Force, convened by the U.S. Department of Energy to determine whether reasonable means exist (or could be developed) to reduce the likelihood of future humans unintentionally intruding on radioactive waste isolation systems. The report was published in May 1984.(*01)

Since then the most comprehensive research about markers has been done in the US, especially for the WIPP, the Waste Isolation Pilot Plant in New Mexico.(*02) The WIPP is a deep geologic repository, designed and constructed to provide underground disposal for the department's defense-generated transuranic waste. This waste consists primarily of clothing, tools, rags, debris, residues and other non-liquid disposable items contaminated with trace amounts of radioisotopes.

The Department of Energy (DOE) began by forming two teams of experts in the early 1990s. They were given the task of coming up with a conceptual design for the warning system. The US decided to focus on creating lasting markers at the site of the nuclear waste, a plan considered to be the 'long-term concept' or passive institutional control. This strategy places very little trust in the flexibility of knowledge, and society's ability to pass down information in a relevant and accurate way to future generations. Information is too rapidly changing and hardly eternal, but physical landmarks that convey danger on an instinctual level are more likely to effectively keep humans away from radiation for thousands of years.

The design eventually adopted for WIPP, and shared with the then planned (but now abandoned) Yucca Mountain depository in Nevada, consisted of a giant earthwork surrounding the site, with monuments, markers and information centers scattered around, which will be erected after closure of the repository. Some 32 identical granite monuments are planned to be buried below ground level. On all aboveground and underground surfaces, messages (written in each of the official UN languages - Arabic, Chinese, English, French, Russian and Spanish - as well as

Navajo) and pictograms are to be put on. Final plans for marking the WIPP repository will not be submitted to the U.S. Government before 2028.

Stonehenge
The DOE 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 realize. 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.
And, more generally, more often people do not mind about warnings, like warnings on cigarette packages that smoking can harm one's health. Of course the markings may not consist of valuable material because of the chance of theft.

But archeologists point out that a much earlier attempt to warn off future excavations, the Egyptian pyramids, were looted within a generation. Six of the "Seven Wonders of the World" identified by the ancient Greeks, which were, in a sense, messages intended to provoke in us remembrance mingled with a sense of awe, and as such, six have failed. They have been plundered by vandals, destroyed by earthquakes or used to build other structures. Most have been reduced to rubble.

Information carriers
If we want to remember we have to find ways to preserve information. It seems that no data storage medium lasts long before becoming obsolete. Recently, French nuclear waste management agency ANDRA began a project to address the issue of preserving data. To preserve records of what they've buried and where for a period of tens of thousands of years. The ANDRA project brings together specialists from as wide a selection of fields as possible, including materials scientists, archivists, archaeologists, anthropologists, linguists, and even artists -"to see if they have some answers to our questions." The initial goal is to identify all the approaches possible; in 2014 or 2015, the group hopes to narrow down the possibilities.

On July 12, 2012, Patrick Charton of ANDRA presented what he called a possible solution to the problem of the short life of information carriers: a sapphire disk inside which information is engraved using platinum. The prototype shown costs €25,000 to make, but according to Charton will survive for a million years. The disk is made from two thin disks, about 20 centimeters across, of industrial sapphire. On one side, text or images are etched in platinum- a single disk can store 40,000 miniaturized pages -and then the two disks are molecularly fused together. All a future archaeologist would need to read them is a microscope. The disks have been immersed in acid to test their durability and to simulate ageing. (*03)

There's only the problem that they have no idea in what language to write the message; what language its discoverers will understand in thousands or hundreds of thousands of years- or even if they will be human beings? Archeologists point out that a much earlier attempt to warn off future excavations, the Egyptian pyramids, were looted within a generation. Another problem is the material the carrier is made of and could be considered to be valuable and thus likely to be stolen when found.

Another assumption that we should not take for granted, is the survival of modern scientific understanding. We should not presuppose the future possession of scientific language, but should also include the most simple messages.

But in short: current thought is that rather than attempt to manipulate the emotions of future generations through ominous symbolic warnings, the structures and messages ought to *inform* those generations that the content of the repository is dangerous and useless.

2- Active institutional control

Under the US Environmental protection Act (EPA) definitions, 'Active Institutional Controls' cover the use of fences, gates, and guards; essentially, those structures and systems which imply continued human presence. Markers are 'Passive Institutional Controls' because they are intended to fulfill their purpose without the need for anyone to remain on site.

The Scandinavians brainstorming for the Onkalo nuclear repository site in Finland, unlike the Americans, have focused their efforts on keeping good archives and information on nuclear waste repository sites, called a "short-term concept" or active institutional control. The motivation behind a short-term concept is that any physical markers, languages, or symbols based warnings would lose their meanings too soon. Considering the fact that even today abandoned mines less than a century old are often drilled into, it is hard to trust future generations to consult archives over the locations of nuclear waste before any kind of excavation or drilling. (*04)

The half life of institutions

The crux of the stewardship problem is that it is hard to believe that any human institution can last the 10,000 years or more. Indeed, history is replete with failed governments. From ancient times to today's world, the typical story is one of rise and fall, of kingdoms, sheikdoms, monarchies, dictatorships, and even democracies. Leaders come and go, bringing with them new ideas, religions, policies, and programs and leaving legacies easily changed by succeeding leaders and generations. In addition to governments, history has seen similar cycles for human settlements and cities, rise and fall, establishment and abandonment, and rediscovery. Modern-day institutions, such as the private corporation, are no more stable. Only a handful of American companies, out of millions, have managed to stay in business over 100 years and few of the survivors remain in the same business. The life expectancy of the average European or Japanese company is less than 13 years. Thus, at first glance, it appears that, institutionally speaking, active human stewardship of nuclear and hazardous waste sites even for hundreds of years into the future is an insurmountable challenge (although not always information –especially when in writing- is lost)

However, a closer look at history reveals numerous human institutions that have indeed survived for hundreds of years and even thousands of years. Many of these institutions are religious, but also universities. Human institutions associated with indigenous cultures can sometimes be traced by very long periods of time. For example, the N/um chai is a curing ceremony trace dance practiced by the Bushman of the Kalahari that can be traced back approximately 40,000 years.

An article called 'Institutional designs for long-term stewardship of nuclear and hazardous waste sites' by Bruce E. Tonn evaluates several designs for an institution to act as the steward for these sites. (*05)

Six alternative institutional designs are evaluated over a set of four evaluation criteria. Tonn recommends (in the US.) to establish a new type of secular non-profit institution, entitled The

Stewardship Institution, to act as steward for the sites. This option is judged most able to focus on the mission of stewardship, meet its technical challenges, survive inevitable periods of political and economic instabilities, and meet current generation cost and implementation concerns.

Atomic Priesthood
The linguist Thomas Sebeok was member of the Bechtel working group. Building on earlier suggestions he proposed the creation of an atomic priesthood, a panel of experts where members would be replaced through nominations by a council. The atomic priesthood would have to preserve the knowledge about locations and dangers of radioactive waste by creating rituals and myths. The priesthood would indicate off-limits areas and the consequences of disobedience.(*06)

"The 'atomic priesthood' would be charged with the added responsibility of seeing to it that our behest [concerning the folkloric relay system] is to be heeded – if not for legal reasons, then for moral reasons, with perhaps the veiled threat that to ignore the mandate would be tantamount to inviting some sort of supernatural retribution."
This approach has a number of critical problems: the reliance on secrecy, manipulation and deceit -- and the accompanying perceived need to create an elite –the atomic priesthood- that holds the secrets and does the manipulating.(*07) And just because the information about waste sites would grant power to a privileged class, people from outside this group might attempt to seize this information by force.

So it seems that all possible solutions to the issue of marking a waste repository site, such that future generations will be able to comprehend its purpose and risks – have unsolvable problems.

3- No markers: just forget about it
Another approach is not marking a nuclear repository site at all; burying nuclear waste hundreds of meters underground in the middle of a barren desert is a better safeguard than any structure or warning signs that could eventually just bring attention to the location, according to this approach. In fact, two of the four teams organized to brainstorm protection ideas for WIPP agreed that no markers was the safest approach, as it defends the nuclear waste from "curiosity seekers." Would it, in fact, be less likely that people would hit the repository by accident than that they would intrude due to the existence of markers?

More importantly, not marking the site, but creating it in secrecy would by default add a layer of protection against anyone seeking to use the radioactive material for harmful purposes. Not marking the site at all completely avoids the problems of language, symbolic, or cultural robustness, but of course adds the moral question of our generation's responsibility to protect future generations, as well as future generations' right to our knowledge.

Michael Madsen says in his award winning documentary 'Into Eternity' about forgetting Onkalo: 'The chamber you must always remember to forget'.

But how do we forget something? Is that an active or a passive process; will rumors about buried 'treasures' end up in myths and survive by oral history. It is obvious that one cannot force oblivion. People are curious in nature. It seems clear that forgetting is not an active process and therefore can not be a policy. Secrecy can of course but, that has nothing to do with forgetting. Forgetting is only the result of bad policy and not of no policy.

4- New emerging vision: proud of disposal

Traditional approaches to markers and institutional controls for geological disposal were based on the premise that safety was best assured by keeping the facility apart and isolated from people and the surrounding community.
But a new –fourth- vision has emerged; that it may be worthwhile to consider the repository as part of a societal fabric. The task of maintaining memory would thus be facilitated by measures that would foster community involvement and would go as far as foreseeing that these communities will in time build their own new markers to replace old ones that have become obsolete or are fading away. Or, as the NEA puts it in 2007 and 2009 reports (*08):
"Because a radioactive waste management facility and site will be present in a host community for a very long time, a fruitful, positive relationship must be established with those residing there, now and in the future. Simply put, designers have to make the radioactive waste management facility and site to suit people's present needs, ambitions and likings, and to provide for evolutions to match at reasonable cost the needs and desires of future generations. A facility that upsets or repels residents or visitors will only be tolerated and will remain a stranger or an unwelcome presence in the community. The challenge is to design and implement a facility (with its surroundings) that is not only accepted, but in fact becomes a part of the fabric of local life and even something of which the community can be proud."

At the end of the workshop 'Archeology meets radioactive waste' held in Dublin during ESOF2012, Cornelius Holtorf, an archeologist leading a working group on that issue at the Linnaeus University, Sweden, put it this way: "Many questions remain that have to be solved sometime in the future".(*09)

5- Permanent retrievability
But the question about how to mark repositories for coming generations, is preceded by the question of retrievability.
In 1999, A.J. González, IAEA Director of the Division of Radiation and Waste Safety, in his opening remarks of an IAEA conference on retrievability of high level nuclear waste, observed that geological disposal was perhaps the only area of safety standards in which the level of international consensus actually "decreased in recent years": in many parts of the world, the development of geological repositories has reached an impasse. According to him that led to a trend towards reconsidering some of the basic orthodoxies of geological disposal; a- the concept that "waste should be disposed of in its country of origin"; and b- the "irreversibility of geological disposal". As a response to these concerns, some countries are beginning to study how repositories might be designed to facilitate retrieval of waste. González is clear about that: "the predominant technical view has always been that such retrievability is not only unnecessary, but probably also undesirable from a safety point of view." (*10)

Not long before this statement, two Dutch researchers, Damveld and Van den Berg, wrote a report on nuclear waste and ethics. According to the authors there should be no difference in detriment between the present generation and future generations. If for the present generation retrievable disposal is the preferred option, this should also be applicable to future generations. Consequently, this approach calls for permanent retrievability. Each new generation should take on the task to take care of the waste which is inherited from the previous one. An irreversible situation is thus avoided. Permanent retrievability is considered less unfavorable than final disposal. Because of the requirement of permanent retrievability rock formations such as salt and clay whose physical properties (plastic deformation) tend to fill the space between the disposed radioactive waste and the host rock, are considered to be less obvious. Therefore a permanent retrievable disposal facility at the surface is the recommended option. It is recognized that both the stability of the institutions charged with the management of the waste and the stability of the society as a whole are questionable for the long term and that deliberate or inadvertent human

actions may lead to a release of radioactivity from the facility. However, this is a dilemma without a possible solution. (*11)

The international waste management agencies were not amused with this. As a rapporteur from a workshop on Ethical Aspect at the aforementioned IAEA conference, puts it: "It is obvious, that the set of values given in that study is certainly not at all represented in what we could call the nuclear waste management community. To most of us, who are present here, I think that the main conclusions of this study are totally unacceptable."(*12)

However, until now there is no (final or retrievable) underground repository for high level waste and spent fuel in operation.

Recently, on July 3, in an opinion article at Nuclear Engineering International (under the title: No to spent fuel 'disposal'), the lack of solution for the radioactive waste produced for more than half a century, was considered to be a positive fact. According to the –anonymous- author, countries should wait until their nuclear power programs ends before deciding on the 'final disposal' of used nuclear fuel. Because by that time, countries would know the exact inventory for disposal; they would not have the 'reprocess-or-not' question hanging over their heads; and, perhaps by the time 'waste' nuclear fuel is ready for disposal advances in reprocessing or recycling technologies will mean there are better options. (*13)

Although this wait-and-see-attitude is policy in more and more countries, it is the result of the impossibility (not only due to social factors –resistance- but also technical factors) to establish a final repository, it is seen as a negative rather than a positive fact, were waste management authorities feel not particularly proud of. But now, this is brought forward as a positive and desirable 'solution'.
Will it be a new trend: "No nuclear waste solution? Thank God, that leaves all options open!" I hope not!!

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BOX 1
Stone markers warning of tsunami danger in Japan
After the tsunami killed 17,000 people in Japan, March 2011, some pictures were showed in western press of ancient stone markers warned of tsunamis. One picture showed a large marker below the village of Aneyoshi. It says "High dwellings are the peace and harmony of our descendants," and "Remember the calamity of the great tsunamis. Do not build any homes below this point." Hundreds of such markers dot the coastline, some more than 600 years old. Collectively they form a crude warning system for Japan, whose long coasts along major fault lines have made it a repeated target of earthquakes and tsunamis over the centuries. Modern generations decided these markers, coming from a more primitive time were no longer needed: technology would protect them. Sea walls were constructed, and power plants and villages were built behind them. On March 11, 2011, tsunami waters reached to near where the Aneyoshi marker stands.
This is the problem with ancient markers. Tsunami signs were ignored because new generations felt themselves more capable of protecting themselves.
See for instance: www.cbsnews.com/stories/2011/04/06/501364/main20051370.shtml
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BOX 2
Waste inventory amnesia

But do we know now, a few decades after the first (low and intermediate level) radioactive waste was stored underground, what is buried in the repositories? Well, no, not exactly.

Just a few examples:
In August 2009, the German Federal Ministry for the Environment, Nature Conservation and Nuclear safety (BMU) disclosed new figures for the amount of plutonium present in the Low-level waste dumped in the 60's and 70's in the underground mine at Asse. According to those new figures, not 9.6 kilogram but an amount of 28 kg of plutonium is present in the waste. Currently 12,000 liters of water per day flows into the salt dome and all the 125,000 barrels are planned to be excavated.

In the UK, in February 2009, the LLW Repository Ltd published in newspapers in the Lake-district area an ad asking for people who worked at Sellafield and "have been involved in the consignment of waste to the Low Level Waste Repository near Drigg". The company responsible for the waste repository was looking for those people "in order to build a comprehensive picture of the waste inventory in the trenches". According to LLWR's managing director, the ad is an act of thoroughness not desperation. But Martin Forwood of Cumbrians Opposed to a Radioactive Environment (CORE) said at the time that, despite the "low-level waste" tag, trenches at Drigg are believed to hold more dangerous material. "Information provided to Core in the 1990s revealed debris from the 1957 Windscale fire, materials from the US Three Mile Island reactor accident, and from the Chernobyl explosion."

During a 2004 cleanup operation at the Hanford nuclear site in Washington state, U.S., personnel digging through a trench uncovered a safe containing a glass bottle. And inside the bottle, white sludge. Tests identifying the substance as a type of plutonium gave way to more tests until, in the Spring of 2009, scientists from the Pacific Northwest National Laboratory revealed what, exactly, the crew had uncovered: A 1944 artifact from the fledgling nuclear weapons program—the oldest existing sample of bomb-grade plutonium from a nuclear reactor, with a half-life of 24,110 years.

Sources: Press release BMU, 29 August 2009 / The Guardian, 14 February 2009 / BBC, 2 March 2009
END OF BOX 2