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WASTE MANAGEMENT IN THE UNITED STATES

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I will speak to four aspects of nuclear waste management: to the wasteful U.S. fuel cycle; to the tragic contamination of US sites dedicated to the pursuit of the cold-war; to the issue of excess-weapons materials; and to the problem of those innocuous wastes arising from our everyday nuclear life.

1 POWER PROGRAM WASTES

The United States has 109 operating plants, about one quarter of the world's operating plants, some of which have been in operation since the late sixties and are approaching the end of their lifetime. On-site fuel storage pools are becoming full without a national location to dispose of the spent fuel.

1.1 Fuel Cycle Issues

Prior to 1975, the US had been developing the breeder reactor to take advantage of the reprocessing of light water reactor fuel for the production of plutonium for use in mixed oxide fuel cycle in the light water reactors. The planned cycle promised nuclear fuel for centuries.

However, in 1975, Jimmy Carter, by Presidential edict, prohibited the reprocessing of nuclear fuel. This was done, without public debate, as a purely visceral response to what the opponents were calling "the *most toxic material known* to man" - plutonium. After five years, this policy was rescinded for twelve years of Reagan and Bush, and then restated again, in 1993, by Bill Clinton, who has the same advisors as Jimmy Carter.

Through the Nuclear Waste Policy Act of 1983, the Department of Energy took the responsibility for building a national repository for the disposal of 'spent' fuel, and of taking receipt of that 'spent' fuel from the various utilities by 1993 (later changed to 1998). The repository was to be funded by a universal citizens' tax of 1 mill per kilowatt hour of electricity used. $11 billion has accumulated in the Nuclear Waste Fund although little has been spent. By 1998 the cost of the repository program could reach $4.5 billion.

Thus, the US is officially dedicated to the throw-away fuel cycle, when after using 3% of the energy in the fuel, the partially used fuel is called 'spent' and designated as high-level waste. The US is one of only three nations which have taken this position. It takes a nation rich in natural resources to be so wasteful.

This policy results in a great number of problems for the US, not the least being the immense volume of material which is designated as "high-level waste." This large volume (about 30 times greater than it would have been in a reprocessed fuel cycle) exacerbates all transportation,

storage, and disposal options. By 2040 the 'spent' fuel inventory could reach 86,049 metric tons of heavy metal.

Furthermore, 'spent' fuel contains all the long-lived actinides so that disposal concepts have to accommodate half-lives up to 2,400 years. Reprocessing would have removed these long-lived actinides from the real waste.

1.2 Repository Disposal

As a result of the Nuclear Waste Policy Act of 1982, an intensive program of site investigation in salt, basalt, granite, and volcanic tuff, was commenced, with five sites being narrowed down to three, and then, in 1988, down to a single site in Nevada. This site at Yucca Mountain is in tuff - a volcanic rock form. The final selection of this site was made, not on technical grounds, but on political grounds. It appeared to be the easiest site to license, since its Congressional representation looked weak. That proved to be wrong.

Thus, the repository program is still aimed at characterizing the Yucca Mountain site - to see whether it is suitable, and the geologists have now bored 650 feet to the first fault zone. However, being a Government program, it is plagued by over-management, inefficiencies, and cost and schedule over-runs. The original date when fuel might be deposited in the repository has moved from 1993, through 1998, to 2010, and there is talk of a more realistic date of 2028. Thus, since the Nuclear Waste Policy Act of 1983, in 12 years the operating milestone appears to have slipped by 35 years. By any measure, that's not good forward progress. DOE had tried to make the case that the agency had no legal obligation to take receipt of the fuel at all.

In August, Congress vented its frustration with the Department of Energy by passing a new bill (Upton-Towns HR 1020) which

- mandated that DOE accept 'spent' fuel, starting in 1998;
- mandated an interim storage facility since the repository could not be ready;
- mandated the development of a new multi-purpose canister to store, transport, and to dispose of 'spent' nuclear fuel;
- mandated a new annual funding mechanism for the work;
- mandated the building of a railroad spur to transport the 'spent' fuel to the site; and
- mandated real intermediate milestones.

The only significant opponent to this bill was the Secretary of the Department of Energy, Hazel O'Leary, who testified that her Department couldn't work to these schedules.

As an initial step however, Westinghouse Electric has won the $ 14 million contract for the design of the multi-purpose canister in two sizes (75 and 125 tons) and has 12 months to complete the design reports ready for Nuclear Regulatory Commission certification review.

1.3 Interim Storage

With this sort of time scale - a repository that might open in 2010 (if it isn't 2028) - the present nuclear power plants will shortly run out of on-site storage capacity for their spent fuel. Originally, the Nuclear Regulatory Commission had refused additional on-site storage but has now relented to allow dry-cask storage on site. Twenty-six units will exhaust their spent-fuel storage capacity by 1998. Thus, presently, ten utilities are following a pattern set by Virginia Power, and Ontario Hydro in Canada, by setting up storage pads with dry-cask storage of

natural-convection-cooled 'spent' fuel. These containers cost about $800,000 apiece.

However, this is no solution to local residents who don't like the idea of their locale being a *de facto* high-level waste storage location. Hence, pressure has been put on Congress to mandate a national interim storage facility for use until the national repository is opened.

Here again, there has been technical and political confusion over the years. Earlier acts of Congress had mandated that a Monitored Retrieval Storage (MRS) location could not be opened until the Repository was open - just in case the MRS became the final resting place of all fuel. Then, an initiative was developed to pay (bribe) any local community to become the site of an MRS. Just when it appeared that an Indian Tribe, the Mescalero Apache Tribe of New Mexico, would take advantage of the offer, and had already received two study grants totaling $300,000, the program was canceled. DOE does not appear to be anxious that a real solution for 'spent' nuclear fuel storage be found.

However, the Mescalero Tribe, disillusioned with the Government are proceeding on their own. They have formed a coalition with 33 utilities to develop an interim storage facility, a MRS, on their tribal lands. They received the approval of tribal members in a public referendum and the new Governor of the State has adopted a wait-and-see, rather than an opposing attitude. Thus, the Mescalero Tribe is presently working on the environmental impact statement and doing site characterization with Stone and Webster. The tribe is also part of the Westinghouse project team which is designing the new multi-purpose canister.

Officially, however, it appears that a Government interim storage facility will be sited in Nevada close to the Yucca Mountain site - some said even within the repository, but no one really knows for sure.

Thus, the story continues - with a geological repository being investigated; an impatient congress pushing a reluctant and inefficient Department of Energy; an Indian Tribe trying an independent approach; and utilities being forced closer to the wall. All this being exacerbated because of a reluctance to consider reprocessing as a means of recycling resources and reducing waste, both in activity and volume.

One day, a new Wagnerian composer may adopt this disastrous piece of U.S. history as being a suitable subject from a grand tragic opera. Unfortunately, we do not yet know how it ends - or if it ends.

2. DEFENSE SITE CONTAMINATION

From the earliest development of the bomb, the US strategy was to mine uranium in the west; to generate the plutonium at a remote location; separate it at an another fabricate plutonium pits in a third; provide other material from a fourth; and build the bomb elsewhere. Thus, a very large number of sites were heavily contaminated as the Government paid special attention to the mission, while ignoring the consequences of waste. Wastes were dumped with very little common sense. Hanford in Washington State, Fernald in Ohio, Rocky Flats in Colorado, Pantex in Texas, Lawrence Livermore in California, Los Alamos in New Mexico, Savannah River in South Carolina, Oak Ridge in Tennessee, and the western slopes of Colorado's Rocky Mountains, were all involved and have paid heavy environmental consequences.

2.1 The Scenarios

The range of wastes produced from 1945 to 1965, includes the mill tailings of old uranium mines; old fuel from the plutonium generating reactors; residues from the reprocessing lines; old contaminated buildings; silos full of radon emitting solid wastes; single-shell tanks of high-level wastes and sludge; contaminated soils from liquid waste spills; open-air evaporative basins; burn pits; sludge ponds; scrap; beryllium contaminated buildings and equipment; tritium stores; laboratory waste, and excess plutonium and high enriched uranium. If you add waste organic material and oils; and even the carcasses of animals on which testing was performed and you have a real devil's brew.

A typical waste site is Pit No. 9 in Idaho. It is the size of a football field, 5 meters deep. It is back-filled with the local sand, over waste that was simply tipped into an open pit. In the pit there are old decayed drums of plutonium-contaminated fire waste from Rocky Flats; there is an old reactor from the Arctic Dew-line; there is a contaminated ambulance that carried corpses from the SL-1 accident; there are oils; there are truck-beds and fuel storage racks. The whole pit has been flooded twice.

In activity, the wastes range from low-level contaminated materials from laboratories, to high-level radioactive actinides, including the intermediate and TRU wastes. (The TRU wastes are a class of highly-radioactive wastes which do not generate heat.) The cost of cleaning the entire complex of US cold-war wastes is estimated to fall in the range of $200 to $350 billion over 75 years, but the $23 billion spent so far since 1990 shows little effect.

2.2 WIPP

The Waste Isolation Pilot Plant (WIPP) east of Carlsbad, New Mexico, consists of engineered caverns tunneled deep in layered salt. This repository exists. It was started in 1980 and has been ready to operate for about 5 years. Rather than civil wastes, it was (is) meant to accept cold-war TRU wastes from sites like Hanford. There is 3.9 million cubic feet of TRU wastes and WIPP could accept 6.2 million cubic feet in 100 excavated acres. However, the WIPP site is not in operation and it is not likely to start operation for several years. It has been overtaken by changing and conflicting environmental regulations, and it is currently a subject of yet another evaluation.

The reason for this is yet another tragic opera story - in establishing the WIPP repository, DOE ignored the need to approach Congress for permission to use Federal lands. When Congress was finally approached, after WIPP was constructed, Congress was so annoyed that it put the Environmental Protection Agency in charge of yet another new characterization and evaluation of the whole repository - thus delaying its opening for many years. So, while tests have been done and packaged wastes have been designed to fit the specifications of the repository, nothing yet has been disposed of in WIPP.

2.3 The Actors in the Drama

Remediation of all the defense sites will take eons - currently estimated at 75 years. Whereas DOE used to be in sole charge, control has now effectively passed to (a) the State in which any site is located; (b) the Environmental Protection Agency (EPA) for non-nuclear contamination; (c) the Nuclear Regulatory Commission for nuclear contamination; and (d) Public Interest groups.

"Public Interest" groups are self-interest groups. They may include some local inhabitants but,

often, their principal interest is to halt any and all nuclear activity. They particularly oppose nuclear power. Thus, making any clean-up action more difficult and, thereby, giving anything nuclear a bad name, fits right into their agenda. Thus, "Public Interest" groups tend to delay and obstruct any progress. To my mind they are the villains of this opera.

The States have been able to force DOE, through Act of Congress, to establish tri-partite clean-up contracts with the States and with the EPA. These contracts contain milestones which must be achieved. If those milestones are not achieved, DOE is fined. DOE has paid non-performance fines, but, unfortunately these fines are not levied on the incompetent management but on the nation. Nevertheless, the Tripartite Agreements do seem to affect DOE, with the result that more time is spent in renegotiating tri-partite contracts than in cleaning anything.

2.4 Clean-up

Most progress has been made in repackaging rather than in disposing - valleys of many thousands of decaying and rusted drums of waste, which were filled 20 to 30 years ago, are being emptied, inventoried, and refilled into new containers. That might complete a milestone, but the waste is still there. At one site, 76,000 drums are being repackaged.

Most activity is confined to the easy-to-do jobs, rather than cleaning-up the most hazardous areas. At Hanford, high-level processing waste was originally stored in hundreds of single shelled tanks in the ground. These leaked, creating much greater volumes of contaminated soils which will also need remediation. Over the years, the contents of most single-shelled tanks have been pumped into double-shelled tanks. However, a few of these tanks then developed a burping phenomenon during which quantities of hydrogen generated in the sludge would periodically burst through the harder crust. The hydrogen, together with nitrous oxides, would have provided, with a small spark, a rocket-explosion which could have distributed the high-level wastes far and wide. It was something of this ilk that caused the widespread devastation in the Soviet Union at Kyshtym in 1957. Those wastes are still there. After many years, a large rotating mixer has been installed in the worst tank (S -101) (v-e-r-r-y carefully) so that the hydrogen can be released continuously without accumulation. However, there is still no coherent analysis of the contents of the tanks nor a workable plan for the processing of the wastes towards a final clean solution.

At Rocky Flats, large evaporative basins contained heavily contaminated sludges. An attempt to mix this sludge with grout for disposal in steel drums failed because the grout had not been suitably selected for the activity and chemical constitution of the sludges. Now, the contaminated friable pond-crete, that was created, constitutes a volume of nuclear waste far beyond the original volume of the sludges.

With mistakes like this it is understandable that DOE managers at the defense sites find a virtue in doing nothing more than moving waste from one place to another.

There are success stories - a few smaller sites have been cleaned; a great deal of research and development into promising processes has been done - including bio-remediation, and in-situ vitrification of moving plumes of contamination. Some buildings have been decontaminated and decommissioned (torn down) but progress is slow and, in the nature of an agency which is better at planning than at implementation, it is very expensive. Unfortunately, it is only in a country rich enough to study a problem to death that nothing much is done. Our opera has an indefinite number of acts.

3. EXCESS WEAPONS MATERIAL

Following the use of nuclear weapons during World-War II, the threat nuclear weapons has been used in a cold-war stand-off, for thirty years. During that time, the military establishments in both the US and the Soviet Union were able to persuade the politicians than it was always a national emergency, and where one nuclear weapon was good, a hundred would be better. Moreover, each one produced was already obsolete, so that another new and improved, bigger and better, weapon had to be developed. The result were large numbers of nuclear war-heads and huge stock-piles of the enriched uranium and plutonium ingredients of future weapons.

3.1 Recommendations

As a result of the disarmament process between the US and its previous enemies, weapons, and the material in process, have become nuclear waste. Thus, around the US at various sites there is over 40 tons of Plutonium in various forms -13 tons of which is at Rocky Flats within sight of my home. There is a national quandary as to what should be done with this.

Elsewhere, the solution would be clear - process the material into mixed-oxide nuclear fuel and use it in existing reactors. However, this obvious solution gives the US Administration a moral dilemma. It is dedicated to not-encouraging the use of plutonium in civil reactors. Therefore, a report, on behalf of DOE, was produced by a group purporting to represent the very prestigious National Academy of Science. The report was produced by a sub-committee lead by Wolfgang Panovsky. Its principle conclusion was that the plutonium should be encased in glass and buried in 3,500 separate bore holes. This recommendation would have turned our tragic opera into high comedy. The licensing of even one site for a plutonium bore-hole repository would be highly unlikely. Fortunately, the group saved their faces by also mentioning the mixed-oxide solution as a fall-back option.

The American Nuclear Society then convened a truly blue-ribbon committee lead by Dr. Glenn Seaborg, the co-discoverer of Plutonium, and chaired by Ambassador Richard Kennedy who had spent many years on Non-Proliferation issues at the IAEA, together with Dr. Myron Kratzer. Members of this panel included eminent scientists from Japan, Russia, Britain, Germany, France, Switzerland and the US. After nine months, their report is complete and the results were released in Washington on August 22nd. The principle conclusion is that while excess-weapons material, including the plutonium, must be carefully guarded as if it were still a weapon, nevertheless plutonium is an energy resource to be used, not a waste to be disposed of. They recommended the mixed-oxide solution, but they did not go so far as to choose one of the many reactor options to be used.

As a result of the publication of this panel's findings, it will be very difficult for the US DOE to do anything other than elect to burn excess-weapons material. On the other hand, this is so much against the ethic of the present administration that they may simply elect to do nothing.

4. NON-POWER PROGRAM WASTES

There are 109 operating reactors in the US - almost 25% of the world's total. They generate 400,000 jobs and an economy of $75 billion per year (1992 figures). Yet, and this may surprise you - the non-power nuclear science industry is larger: 4 to 5 times larger. In 1992, the non-power part of our industry supported 3.6 million jobs with an economic benefit of $357 billion. That's the result of nuclear medicine, food irradiation, industrial applications of radiation and

radioactive sources, biological and environmental research, and waste management.

The one connective issue which spans the whole range of non-power nuclear applications and links them to the power program is the need to dispose of low-level radioactive wastes. A very good global survey of low-level waste disposal practices has been published by the International Nuclear Societies Council (INSC) for technology transfer to countries which are just now developing more extensive nuclear applications programs.

4.1 Low-level Waste Issues

Most people in the US know about nuclear medicine but very few know much how dependent US society has become on the industrial applications of radiation in process quality applications, or the use of radiation-polymerized plastics and organics in the home. However, they have been taught by the self interest groups that low-level radiation waste is a toxic horror.

US experience in disposing of low-level wastes has not been good. In the days of the cold war, the disposal site on government complexes was merely a hole in the ground with little thought being given for remoteness from aquifers, or any protection against wastes leaching in an uncontrolled manner. Maxey Flats, Beatty, West Valley, are synonymous with bad management practices. Liquid wastes were stored; employees took home contaminated items for private use; contaminated equipment was used for public construction; one wet site overflowed its contaminated materials; in another degrading waste released tritium-contaminated gases; and in another the trench caps collapsed and were breached. Those sites have been closed.

Experience at Barnwell in South Carolina, and Hanford, have been much better, and those sites are still operating today.

The public's operating philosophy towards low-level waste sites is NIMBY - "not in my back yard." Thus, Congress in the Low-Level Radioactive Policy Act of 1980, proposed that the States should get together in groups, called Compacts, to arrange for one LLW site to accommodate the wastes from their own Compact of States. This immediately caused a jockeying for position - each state wanting to avoid taking wastes from another, or to be designated as the Garbage Center for that particular Compact. Some "Compacts" were anything but compact: California is in a grouping which includes Arizona, and North and South Dakota, which is like combining Slovenia with Norway and Sweden for a joint disposal of wastes. The existing site at Hanford, fortunately, remained open as the low-level waste disposal site for the Northwestern States.

The sum effect of this congressional action, 15 years later, is that new LLW disposal sites are just being identified. Hudspeth County in Texas could serve as the site for the Texas Compact, which includes Maine and Vermont. Each of the new locations is up against local NIMBY opposition, which has reached its height of absurdity at Ward Valley, in California.

4.2 Ward Valley

The case of the Ward Valley site in Southern California is a whole tragic opera of its own, involving political opportunism, heroic animals, court jesters, and court advisers. Its history is something that we can learn from

After a search of some eighteen geological-closed desert sites in which the drainage would lead to a dry lake, rather than a waterway, a site in Southern California, at Ward Valley was chosen.

Ward Valley fits all the required geologic requirements - it is so dry that water in the ground evaporates upwards rather than draining downwards, it has no drainage features to any active water source, it lies high above groundwater, it is remote from any community, it has good transportation facilities, and it has been licensed by the Nuclear Regulatory Commission. It has one small problem - it is not in operation.

It's most extreme opponents - a local Californian Senator, Barbara BoxerGreenpeace and extreme American Indians, recognize that they can almost shut-down nuclear power in California if they succeed in stopping LLW disposal at Ward Valley. As a result they have a sustained program of opposition: they

- tried to persuade the medical community to declare their wastes less hazardous so they can accept medical wastes while excluding power plant wastes,
- found three geologists (not hydrologists) to announce that any contaminated groundwater (far below a dry desert site) would travel tens of miles across geologic boundaries to the Colombia River,
- argued that a Desert Tortoise, which roams many thousands of hectares in the area, would be endangered by the site and its roads,
- raised technical issues of stabilization, and
- forced a public inquiry, four court suits, and another National Academy of Sciences study after the site was licensed.

The site is still not open and, meanwhile, LLW is stored locally around California in 900 locations, at every hospital, every research laboratory, every manufacturing facility, and every power station. The possibility of uncontrolled exposure to the public is far greater than if all this LLW were disposed at Ward Valley.

Moreover, at a hospital or university which uses isotopes for research or medicine, the isotopes and sources are bought from commercial suppliers. The low level waste is handed on to the administrator of wastes for the facility, and that administrator would provide for disposal - if there was a disposal site. Lacking proper disposal the administrator arranges for temporary on-site storage (possibly after having it compacted). As that storage gets filled, the administrator then has no recourse but to put pressure on the medical or research facility to stop using nuclear procedures to avoid generating more waste.

Thus, in Stanford University Hospital, the doctors are being forced to cut back on nuclear medicine - a tragic result of not being able to dispose of LLW waste in a safe desert location. Likewise, New York Hospital - Cornell Medical Center announced that it would halt indefinitely all research using long-lived isotopes, such as metabolic and structural studies on heart disease. The Cedars-Sinai Medical Center in California has also curtailed potentially life-saving research.

4.3 Barnwell

The case of Barnwell is a comic opera in itself, but with moral overtones.

The South Carolina site is an old one. It has accepted LLW from the length and breadth of the country according to strict receipt specification - waste shipments not in compliance were returned or charged an excess amount - and the management of the site was excellent.

However, when Congress enacted the Low Level Waste Compact legislation, the South Carolinians rejoiced in the idea that somewhere else in their Compact would be selected and their

LLW dump would be closed. The closure date was set for this year, 1995, although it was to be closed to out-of state waste generators earlier. North Carolina was selected as the site for the new waste site for that south-east Compact.

As time went on, the North Carolinians did virtually nothing. A site at Wake county was identified but very little work was done. Yet, Barnwell's closure was moving along. Out of state generators were very concerned. Then, the South Carolina legislature realized that in closing Barnwell, they were losing considerable income. Disposal charges ranged above $200 a cubic foot - $5 to 6 thousand a cubic meter - and State taxes took their share. Thus, in 1995, the decision to close Barnwell was reversed at least for another ten years. Jobs were saved and tax income for the State education fund was preserved. Now Barnwell is open again for LLW generators in the Southeast Compact - except for those from North Carolina next door. The South Carolinians haven't forgotten that North Carolina had done nothing towards receiving waste.

So Barnwell is available again. Costs are high, now over $330 per cubic foot. Yet, Californian waste generators, like the San Onofre Plant, would, if they could, ship their wastes two and a half thousand miles to Barnwell because the costs of Ward Valley are likely to be higher, when it does open.

Yet, despite the Barnwell pragmatic success, still 33 of the 50 US states and DC lack access to a low-level waste disposal facility. Moreover, the Californian impasse prevents the demonstration that low-level radioactive wastes can be handled safely as a normal everyday task.

5. SUMMARY

In summary - hampered by a Pollyanna national policy against reprocessing, the large US volume of 'spent' fuel appears to be heading towards long-term above-ground dry-cask storage, while the DOE and its geologists play at Yucca Mountain for another 20 or 30 years.

The clean-up of cold-war sites will proceed, at very high expense, emphasizing the easy things, rather than the high risk conditions, until such time as the amount of funding available, in a country which is trying to balance its budget, will force a focus on important issues.

The US now has another national site for low-level waste disposal at Barnwell in South Carolina, yet the public at large still has to understand, firstly, that the benefits of our high standard of living do not come without some radioactive wastes being generated, and, secondly, that it is a very simple thing to dispose of low-level radioactive wastes, if self interest groups are recognized for what they are.